Examining the results of Teaching a Motor-Based Vocal Pedagogy in a Community Choir Setting: A Study of Inhibitory Control and Self-Perceived Rigor

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This dissertation, *Examining the results of Teaching a Motor-Based Vocal Pedagogy in a Community Choir Setting: A Study of Inhibitory Control and Self-Perceived Rigor*, by Andrew P. Schmidt, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education & Human Development, Georgia State University.

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Examining the results of Teaching a Motor-Based Vocal Pedagogy in a Community Choir Setting: A Study of Inhibitory Control and Self-Perceived Rigor

by

Andrew P. Schmidt

Under the Direction of Dr. Patrick Freer & Dr. Martin Norgaard

ABSTRACT

In the United States of America, millions of adults sing in community choirs, primarily motivated by aesthetic factors like pleasure and performance satisfaction, along with skill development and intellectual challenge. Some researchers suggest that aesthetic satisfaction proves more accessible to those with higher musical abilities. This proposition raises the performance-pedagogy paradox, questioning whether music teaching focuses on performance or the knowledge and skills that enable it. Recent studies highlighted various non-musical benefits of choir participation, yet lacking in those studies were evidence of cognitive gains. This study investigated the effects of a motor-based vocal curriculum on inhibitory control, a component of executive function. To promote growth in executive function, learning must include rigor, novelty, and self-interest. I recruited 51 participants from an adult community choir to learn either a motor-based (n = 26) or traditional vocal curriculum (n = 25) over nine weeks. Participants completed inhibitory control tests and a survey on perceived rigor. Analysis revealed significant growth in inhibitory control for all participants (p = .019, η_p^2 = .05), but no significant difference between the groups (p = .579). However, the motor-based group showed gains from midpoint to

post-testing (p = .014, d = 0.52), while the traditional group did not (p = .678). This suggested that the motor-based curriculum offered greater potential for cognitive gains with a longer intervention. Correlations indicated that motor-based participants' test scores related significantly to their perceptions of rigor, novelty, and self-interest, supporting the benefits of this approach. These findings suggested that incorporating motor-based vocal pedagogy into community choir settings enhanced not only vocal skills but also cognitive function, particularly in areas of executive function. Implications for the field of choral music education are widespread, and include potential changes in pre-service education, professional development, curriculum building, and assessment. This research contributes to the broader understanding of how structured learning environments foster both musical and cognitive development in adult amateur singers.

INDEX WORDS: Community choir, Executive function, Inhibitory control, Powerful knowledge, Perceived rigor

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1 THE PROBLEM

In the United States of America, tens of millions of adults participate in community choirs (Grunwald Associates LLC & Chorus America, 2019). Researchers consistently find that adults list aesthetic factors such as pleasure, musical meaning, and performance satisfaction as top motivations to sing in community choirs (Bell, 2003; Redman & Bugos, 2019). Following these primary reasons, adults also cite motivations like skill development, challenge, and intellectual stimulation. Other researchers acknowledge that many adults quit singing or never begin because they feel lacking in the skills required to participate (Lamont, 2011; Woody et al., 2019). Some researchers suggest the desired aesthetic satisfaction comes easier to those with higher musical abilities (Redman & Bugos, 2019).

This gap between performance needs and learning needs characterizes what Freer (2011) called the performance-pedagogy paradox. Two propositions define this paradox: "1) the performance itself is the primary goal of choral music teaching, and 2) the acquisition of knowledge and skills that lead to performance is the primary goal of choral music teaching" (p.175). While community choir singers may feel more motivated by elements of the first proposition, they may benefit from aspects of the second. Freer ultimately encouraged a "both-and" solution that balances these opposing ideas. This study explored the knowledge and skills side of the scale, and what pedagogies may exist to compliment the performance side. I posed the general research questions, "What are the types of knowledge and skills required to provide this balance in adult, amateur community choirs?" and "What outcomes would these efforts yield?" In addition to gaining performance satisfaction, I hypothesized that learners would recognize an increase in rehearsal rigor due to the knowledge and skills emphasis. I also hypothesized that knowledge and skill acquisition will yield extramusical benefits complimentary to lifelong learning.

Introduction

For a few summers prior to high school, I spent a couple of afternoons a week at a shop called Creative Clay. My siblings and I would paint pre-made ceramic figurines while watching games shows under the hospitable gaze of the store owners. We enjoyed picking out newly clay-oven fired items, sanding off the seams from their baking molds, devising a color palate – sometimes advanced planning occurred where certain colors would look different before and after the second round of firing – meticulously hand-painting various features, anticipating the re-firing to set our colors, and occasionally re-glazing or antiquing our wares. Antiquing involved applying a smelly brown or black, runny lacquer that initially coated the item and its crevices. One then removes the liquid with a cloth to a desired "antiqued" aesthetic. I loved antiquing as it signified completion and presented a "mature" and rarified final object. Many relatives received the bounty of our artistic endeavors, and we enjoyed the multi-hour processes.

Despite the aesthetic fulfillment and overall fondness for this experience, I acknowledge as an adult that I neither possess skills in painting, ceramics, and color theory, nor do I understand how to mold, fire, or re-fire pre-made clay figurines. I do not regret this endeavor, and I recognize that my parents prioritized daycare over an educational experience. I wonder, however, if enhancing the rigor of the pedagogical environment might have led to deeper "powerful knowledge" (McPhail, 2023). That knowledge could have built lifelong visual arts skills I could enjoy.

In my conceptual framework, I establish a philosophical position that likens the community choral educational experience to my ceramics endeavors due to a gap between everyday experiential knowledge, and rigorous structured learning. This structured learning transfers understandings between prior knowledge and new knowledge (McPhail, 2023). I suggest that bridging

this gap relies upon teaching what McPhail called "powerful knowledge" through a clearly articulated epistemological structure. I explain why adult community-based choral programs exist as an academic endeavor under the auspices of lifelong learning, and I explore the pedagogical implications thereof.

As an extension of my conceptual framework, I propose a theoretical framework that positions skill acquisition as one pedagogical tool bridging the conceptual gap. The psychological complexity of skill emphasizes progressive motor learning as central to skill acquisition. To address my first general question (What types of knowledge?), this dissertation study explores the implementation of a rigorous, motor-based vocal pedagogy compared with a traditional vocal pedagogy. Participants provided self-perceptions of challenge and demand to assess this implementation.

To address my second general question (What outcomes would result?), I examined the association between participants' musical learning and the potential for transfer to executive function (EF). Executive function comprises skills that aid in planning, goal-setting, self-control, following multiple-step directions despite interruption, and maintaining focus, among others (Diamond, 2013). Strong EF plays an important role in mental health, physical health, quality of life, academic success, job success, marital harmony, and public safety (Diamond, 2013). To engender growth in EF skills, researchers stress the importance of rigor, novelty, and self-motivation in the pedagogical intervention (Diamond & Lee, 2011). I looked specifically at inhibitory control, a subcomponent of EF (Miyake, 2000). Inhibitory control occurs when one thinks before reacting. I hypothesized that introducing a motor-based vocal pedagogy within an amateur community choir setting would meet all three criteria of novelty, self-motivation, and rigor.

Establishing the Problem, Context, and Overview of Literature

Recent research with community choirs uncovered benefits to physical health (Clements-Cortés, 2015; Moss et al., 2018; Wiech et al., 2020), neurological rehabilitation (Clements-Cortés, 2015; Feng et al., 2020; Särkämö, 2017; Särkämö, 2020; Tamburri et al., 2019), psychophysiological effects (Clements-Cortés, 2015), social and emotional well-being (Clements-Cortés, 2015; Johnson et al., 2013; Johnson et al., 2018; Maury et al., 2022; Moss et al., 2018), and auditory perception and processing (Hennessy et al., 2021; Pentikäinen et al., 2022). Of the six studies I identified that examined executive function, two yielded small positive associations with community singing (Feng et al., 2020; Pentikäinen et al., 2021). A curious contrast exists in the positive associations between instrumental music-making and enhanced executive function in adults (Bugos & Wang, 2022; Columbo et al., 2020; Degé & Kerkovius, 2018; Mansens et al., 2017; Särkämö, 2017; Särkämö, 2020; Vetere et al., 2024; Wang et al., 2024). Generally, these studies demonstrated increased executive function in participants after receiving an instrumentally based musical learning intervention. Therefore, it is possible that similar executive function gains may occur if community choir participants received an experience akin to instrumental learning. A motor-based vocal pedagogy may resemble the button/key pushing found in instrumental techniques. Motor-based vocal techniques require manipulation of vocal tract components through isolation and combination. These components include the muscles of the thorax, neck, larynx, mouth, and head, along with cartilages and tissues that move in unison to produce various sounds. For example, to perform a Broadway belt, a singer would first learn to isolate vocal fold thickness, false vocal fold retraction, neck and spinal musculature engagement, laryngeal height, and cricoid tilting, while monitoring breath flow. Next, they would practice combinations of these components in varying degrees of effort to produce the desired “belt tone” on a

specific pitch or musical passage. This kind of progressive, structured, and sequential learning may appear novel and rigorous to amateur choral singers.

I found only two studies that examined aspects of rigor within a choral setting (Corbalán et al., 2019; Garrett, 2013). Neither investigated vocal pedagogy specifically nor asked participants (learners or conductors) to assess the rigor of the educational experience. Their assessment of rigor appeared inductive rather than deductive. After exploring the field of education, I turned to the field of video gaming and adapted recently created scales for assessing perceived demand and challenge in gaming (Denisova, 2021; Flint et al., 2023). This deductive approach examined challenge and demand in a manner akin to rigor within the progressive nature of Vygotsky's zone of proximal development (1978). Executive function researchers rationalized musical learning's ability to enhance executive function because the learning occurs within the zone of proximal development (Degé, 2021). Finally, as executive function performance deteriorates in middle age, education may play a protective role (Sharma & Shenoy, 2023; Vetere et al., 2024). Lifelong learning promotes adaptability, open-mindedness, interpersonal skills, and sharpens the mind (Laal & Salamati, 2012). Community choirs could potentially facilitate the educational processes needed to promote lifelong learning. In this dissertation study, I draw from multiple disciplines to construct frameworks that support my methodological choices. To facilitate familiarity with terms I use often in this and the following chapters, I provided the following definitions of terms.

Definition of Terms

Horizontal Discourse: Horizontal discourse includes knowledge that is common and accessible to all due to a shared history or because the knowledge arises from common problems or contexts (McPhail, 2023). Singing soothingly to a newborn exemplifies horizontal discourse.

Vertical Discourse: Vertical discourse consists of epistemically structured knowledge, often aligned "vertically" according to conceptual hierarchies and relationships (McPhail, 2023). Learning to sing operatically, or in musical theater, jazz, or other idioms, involves vertical discourse.

Discursive Gap: The discursive gap refers to the liminal space between horizontal (experiential) and vertical discourses, where knowledge transitions from experiential to educational (McPhail, 2023). McPhail borrowed this phrase from British sociologist Basil Bernstein, who characterized the gap as "a site…for alternative possibilities…the site for the unthinkable, the site for the impossible" (2000, p. 30).

Powerful Knowledge: Learners possess powerful knowledge when they connect the facts and ideas of a subject, its internal logic, and the entirety of that subject; they gain the ability to abstract and conceptualize about it (McPhail, 2023).

Perceived Rigor: In this study, I measured perceived rigor, defined as a combination of (a) challenge, or the barriers to achievement, and (b) difficulty, or the likelihood of task failure (Denisova, 2019). In educational psychology, rigor exists within the zone of proximal development (Vygotsky, 1978). This zone characterizes the space between the current capabilities of a learner and the capabilities achievable with guidance from or collaboration with more knowledgeable peers.

Executive Function (EF): Executive function is a collection of top-down control processes used "when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible" (Diamond, 2013). Individuals with strong EF may experience greater success in academics, jobs, and relationships, as well as long-term well-being. EF includes three subcomponents: inhibitory control, working memory, and cognitive flexibility (Miyake, 2000). Numerous

models of executive function exist, including the top-down inhibitory control model (Aron, 2007), the working memory model (Baddeley, 1986), the supervisory attentional system (Shallice et al., 1996), the self-regulatory model (Barkley, 1997), the problem-solving model (Zelazo et al., 1997), Lezak's conceptual model (Lezak, 1995), Miller and Cohen's model (Miller & Cohen, 2001), Miyake and Friedman's model (Miyake et al., 2000), and the cascade of control model (Banich, 2009). For this study, I chose the three-subcomponent model of Miyake and Friedman, as used by Diamond (2013) and Diamond and Lee (2011), due to its prominence throughout the research on musical learning's associations with executive function.

Inhibitory Control (IC): Inhibitory control (IC) involves selective attention and cognitive or behavioral inhibition (Diamond, 2013). Inhibitory control refers to thinking before reacting. This might occur when singers suppress the urge to sing a melody and focus on performing in harmony, or when they follow a preset dynamic phrasing scheme while the conductor gestures a different scheme to another voice part.

Near and Far-Transfer Effects: Researchers hypothesize that musical learning develops EF subcomponents alongside domain-specific skills, resulting in both near- and far-transfer effects of musical training. Degé defined near transfer as the primary effects of practice and learning, and far transfer as effects in unpracticed or learned domains. The purpose of training EF skills is typically to improve far transfer goals, such as academic achievement or organizational skills needed for work (Gunzenhauser & Nückles, 2021). Degé suggested that the broader the range of transfer, the less frequently it occurs (2021). For music practitioners, near transfer includes the development of fine motor skills, temporal processing, and listening skills. Far transfer might involve learning to play the piano in a way that enhances inhibitory skills found in a musical setting, which could improve inhibitory skills in job or academic settings.

Conceptual Framework

Community Choirs as Lifelong Learning Environments

Since at least 1963, at the Yale Seminar on Music Education, educators have positioned classroom music education as "relevant for future musical activity" (Mark & Madura, 2014, p. 37). In 1916, educational luminary Peter Dykema called upon music educators to foster students' desire to participate in community music organizations after formal schooling ended. To Dykema, the growing community music movement emphasized "the necessity of serious choral study" (p. 223). Dykema linked an ever-growing democratic movement to an increase in "the desire to enter into a serious study of music" (p. 221). Historically, music educators, educational and political administrations, and other stakeholders have met in places like Keokuk, Iowa, in 1907; Yale in 1963; and elsewhere to discuss and declare many issues, including music education's purpose and for whom it serves. In 1967, the Tanglewood Declaration reinforced music education as important throughout one's life and for people of all ages (Choate, 1968). In 2000, the authors of the Housewright Declaration clarified that "meaningful music activity should be experienced throughout one's life toward continuing involvement" (Madsen, 2000, p. 205). They noted music educators' roles in coordinating their instruction with a focus on musical activities outside of school. Balancing the performance-pedagogy paradox (Freer, 2011) complements the notion that lifelong music education leads to meaningful musical activity in community choir settings.

Based on these historical suggestions, I submit that community choirs have their own educative purposes as extensions of the formal academic ensemble. Community choirs generally include a conductor who selects and teaches materials, controls the pacing, and manages group interactions within a structured environment (Veblen, 2018). Explicit instruction in classrooms

may appear more identifiable than in community settings. However, community choir pedagogies often involve "good teaching" precepts like enriched contextual relevance, critical thinking, enhanced musicianship, and self-directedness (Veblen, 2018). Veblen contrasted formal learning with nonformal and informal practices. In nonformal settings, practices adjust and accommodate participants, and members often control group interactions (2018). Informal settings comprise environments where individuals acquire skills experientially, unsystematically, accidentally, incidentally, or tacitly. Community choir learners, fall into what Bernstein called the "discursive gap" (2000). This gap results from a blurring of formal, nonformal, and informal practices found in community choir settings. Unreconciled or unbridged horizontal and vertical discourses create an environment that leans more toward my Creative Clay experience than what, perhaps, members of the Yale, Tanglewood, and Housewright symposiums envisioned. My informal Creative Clay experiences provided incidental skills, such as using a small paintbrush, sanding ceramic seams, and following color advice given by the owners. However, those experiences did not generate subject-domain skills in the visual arts or knowledge acquisition via structured, formal practice. I cannot apply this learning outside of similar contexts.

Exploring the Discursive Gap

Horizontal discourse includes knowledge that is common and accessible to all due to a shared history or because it arises from common problems or contexts (McPhail, 2023). Individuals acquire this knowledge ad hoc, and each knowledge component generally exists as segmented from others or as self-contained. Horizontal discourse is context-dependent, utilizes ongoing practices, and fosters strong affective connections between members. It generally prioritizes specific, immediate goals with highly relevant contextual meaning. For community choirs, a non-exhaustive, discursive list might include the ability to sing, some understanding of music

notation, basic choral rehearsal and performance demeanor, and cultural and aesthetic appreciations. Even though individual members might possess enhanced, specialized knowledge in certain areas, vertical discourse (i.e., how singing skills interact with notational understanding or how cultural knowledge informs rehearsal processes) remains absent. As a pitfall of the performance-pedagogy paradox (Freer, 2011), community choir conductors face the temptation to apply a lacquering of horizontally applicable practices directed toward specific, immediate goals. These practices "antique" the singers into a mature or polished sound without considering the vertically crafted practices that would engender deeper, lifelong learning.

Vertical discourse includes propositionally based, structured knowledge, often "vertically" aligned according to conceptual hierarchies and relationships (McPhail, 2023). Learners close the discursive gap when they move from the experiential to the abstract or conceptual, from the horizontal to the vertical. Bernstein noted that this move presents a general response to difficulty, or "pedagogic populism" (2000). Pedagogic populism arises as a recontextualization where procedural or operational elements supersede conceptual elements—the vertical discourse. This "watering down," or removal of rigor, happens when aspects of horizontal discourse facilitate access for certain groups, often the "less able." In community choirs, this might manifest when the conductor decides to remove all American "r" sounds instead of teaching diction or when they create individual practice tracks rather than selecting repertoire all singers could learn together in rehearsal or through teaching literacy skills.

McPhail stressed that without vertical discourses that translate subject abstractions into conceptual understandings, "the full potential of the experience may remain untapped" (2023, p. 33). Although McPhail's text focused on schools, I extend this work to formal lifelong learning settings like community choirs. In this way, one of the community choir conductor's tasks is to

bridge the discursive gap and provide enduring support that extends beyond the experiential. That most adult singers consider themselves amateurs (Moss et al., 2018; Redman, 2016)—"one lacking in experience and competence [emphasis added] in an art or science" (Merriam-Webster, 2023)—potentially highlights the possible absence of a pedagogy that bridges the discursive gap.

Amateur Singers and Powerful Knowledge

Community choirs largely consist of self-described amateurs (Moss et al., 2018; Redman, 2016; Redman & Bugos, 2019). A small study of 135 singers found that 62.2% (n = 84) identified as "talented amateur," compared to semiprofessional (n = 26, 19.3%), professional (n = 17, 12.6%), or "dabbler" (n = 8, 5.9%) (Redman, 2016). A large-scale, multinational study of 1,779 choristers yielded a similar breakdown: amateur choristers (n = 1,583, 89%) and professional choristers (n = 187, 10.5%), with nine participants unaccounted for (Moss et al., 2018). Community choirs often include participants without music degrees, advanced training, or even a robust musical background (Bell, 2004; Bell, 2008; Moss et al., 2018). Amateur singers often do not consider themselves musicians, generally relegating the title to those trained on musical instruments (Lamont, 2011). Research suggests that the myth of "talent," arguably part of a horizontal discourse, does not hold up (Howe et al., 1998). In fact, adults frequently cite a lack of talent as the reason to discontinue or reengage with music (Lamont, 2011). Lamont argued that whether someone reaches their potential depends on the opportunity structures present in their musical environment. Musically active adults attribute their current experiences to their previous musical training. They value technique, reading staff notation, and practicing strategies as skills that contribute to their lifelong participation. Lamont concluded that music education must include these skills that adults find valuable. Both opportunity and time must exist for individuals to explore these skills, enabling them to develop a robust sense of musical identity.

I translate Lamont's suggestions into a call for teaching powerful knowledge that promotes both robust musical identity formation and lifelong learning in community choirs. McPhail defined powerful knowledge as disciplinary, epistemic knowledge, "structured by relationships of concepts that create logical 'systems of meaning'" (2023, p. 30). Through disciplinary concepts, learners journey from description to explanation to understanding, arriving with the knowledge to make informed decisions. Indeed, McPhail argued that a school's (in this case, community music environments) chief purpose is to provide access to systems of meaning, epistemic knowledge that only exists within that context. Learners likely do not access this knowledge outside of formal settings.

The performance-pedagogy paradox becomes unbalanced when conductors yield to pedagogical populism or create practices that adhere solely to the horizontal discourses present in their environment. For example, measuring two fingers' width to approximate a singer's mouth aperture, describing and teaching a muddling of tongue, jaw, lips, and pharyngeal adjustments as "north/south" or "tall/spread" to affect tuning, and utilizing terms like "head voice" and "chest voice" to categorize sounds as desirable or undesirable exemplifies these practices. Bernstein mystically wrote, "whoever appropriates the [pedagogic] device has the power to regulate consciousness…The device itself creates an arena of struggle for those who are to appropriate it" (2000, p. 38). This "arena of struggle" between discourses places responsibility on the conductor as a lifelong educator. It urges the conductor to consider what constitutes powerful knowledge and what pedagogical choices teach it.

Powerful Knowledge: What and How

Learners possess powerful knowledge when they make connections between the epistemic parts (or internal logic) and the whole of a subject; they gain the ability to abstract and

conceptualize that subject (McPhail, 2023). Additionally, these learners transfer their understandings of a subject to other contexts. Powerful knowledge remains context-independent due to its transferability. For example, when teachers instruct singers about the function of the tongue in both vowel formation and resonance creation, and then have them practice tongue techniques, singers may understand the properties of tuning in multiple contexts. They may sing better in tune on their own from one song to another and avoid unnecessary jaw strain by refraining from trying to move something that makes the oral cavity feel "taller/North-South." McPhail noted that horizontal, or everyday knowledge abstractions exist but lack the systemized and interrelated systems of meaning present in powerful knowledge. This knowledge is context dependent. For instance, singing with a "British" sound affects tonal color only when the conductor demonstrates the sound. Otherwise, both choral and non-choral singers may produce an array of "British" affectations.

McPhail also presented a dichotomy between knowledge-that (vertical) and knowledge-how-to (horizontal). They suggested that students learn powerful knowledge when they understand how and why the two connect, bridging the discursive gap.

> The internal logic in the knowledge (its epistemic structure) requires acts of thinking which become built into mental (cognitive) patterns and structures. The recontextualization of the epistemic structure needs to be reflected in the design for learning (curriculum and pedagogy) to make this internal logic visible for students. Interrelated concepts are our prime tools for achieving this cognizance of structure and are the mechanism which enable humans to transfer understandings to multiple concrete examples [and to] develop brain schemata for insightfully seeing patterns and connections between new knowledge and prior knowledge. (McPhail, 2023, p. 75).

Pedagogy, or how a teacher transmits knowledge, must involve understanding and mastering conceptual and propositional relationships. Like Lamont, McPhail viewed bridging the discursive gap as an act of identity building. When learners conceptualize for themselves, their transforming epistemic or musical identity enables them to converse about and contribute to music and music-making. Critical to my study was the integration of two theories that suggested (a) powerful knowledge develops and extends learners' cognitive architecture (McPhail, 2023) and (b) musical learning requires metacognitive skills often found in executive function (Degé, 2021). Music education philosopher Elliott referred to this as "supervisory knowledge," or learners' capacity to monitor, adjust, or regulate their musical thinking (1995).

The pedagogical process for integrating knowledge sources involves daily and explicit naming of disciplinary subject concepts (McPhail, 2023). For music, this consists of naming the processes that connect thinking in sound with the constructional concepts involved in doing so. Practically, this looks like teaching technique, literacy, and practice strategies (Lamont, 2011). For this dissertation study, I adopted a pre-post exploratory design inspired by the concept of powerful knowledge, aimed at teaching the vertical integration of skills and concepts. As part of this study, I compared outcomes from teaching two vocal curriculums. The experimental group learned an epistemically structured, motor-based vocal curriculum, while the comparison group learned a traditional vocal curriculum largely governed by musical abstractions. Although singers might perceive both pedagogies as novel and rigorous, I hypothesized that my motoric-based vocal curriculum would further expand learners' cognitive architecture, enhancing their "supervisory knowledge" or executive function through the psychological complexity of skill.

Theoretical Framework: The Psychological Complexity of Skill

A helpful way to understand motor skills is through a comparison with basic perceptual abilities, such as simple facial recognition versus learning to play the piano (Stanley & Krakauer, 2013). While individuals may improve in both skills (i.e., the ability to perceive a Picasso portrait due to knowledge of the visual arts and playing a Mozart sonata), the basic ability to recognize faces does not require instruction or learning. Learning facts about the motor activity of playing the piano precedes improvement. Skill becomes "practice-related improvement" (Stanley & Krakauer, 2013, p. 3). A component of skill includes the ability to make voluntary errors. Knowing how to do something equates to being skilled at it, which involves making intentional actions. Stanley and Krakauer contrasted motor skill with unintentional movements, such as the involuntary recoil from something undesirable. Possessing skill, then, presupposes knowledge that enables voluntary control over individual actions. Improving skills requires learning about multiple actions that will yield success in an activity. Manifesting that skill draws upon propositional knowledge about the relevant activity. Facts about the motor activity, otherwise known as conceptual knowledge, anchor this skill development.

Fridland built upon this definition by clarifying that skill development occurs through practice rather than through deliberation, reflection, or memorization alone (2019). Fridland linked intelligence and skill by noting that performing a skill requires attentive and deliberate instances of skill-related behaviors—an essential rigor. The development of skill necessitates performing the skill so that an individual intentionally continues to learn while executing the related action. "The means of a task becoming ends in themselves" describes individuals' attempts to improve both how they perform an action and what results from that performance (Fridland, 2019, p. 762).

As skills develop, automaticity arises through motor chunking (Fridland, 2019; Pacherie & Mylopoulos, 2020). Chunking describes a process of combining motor elements into units that individuals store or execute as a unified whole. For example, an operatically trained professional does not consider tongue, lip, jaw, and laryngeal placement or the narrowing of the aryepiglottic sphincter individually while performing an aria. Projecting the singing voice over an orchestra demonstrates the unified execution of chunked motor elements. Researchers believe that chunking reduces cognitive burden (Fridland, 2019; Pacherie & Mylopoulos, 2020), allowing individuals to focus on one unified chunk rather than its disparate elements.

Fridland insisted that intelligence persists during automaticity by breaking chunking into two processes: concatenation and parsing (2019). Concatenation resembles the previous description of chunking, whereby elements A, B, and C could group into [ABCABC]. The grouped elements now show a strong connection to one another and can be executed quickly. This grouping often follows logical patterns learned by the practitioner. Intelligence persists through the second process, parsing. Whereas concatenation is an associative process, parsing serves as an executive control process. Parsing manipulates longer concatenated sequences into smaller sets. In the above example, [ABCABC] segments into [A-B-C] [A-B-C]. The dashes indicate the initial concatenation of elements, while the segmentation indicates parsing. Making choices about how to parse a sequence demonstrates considerations regarding the overall effectiveness of this choice. Parsing, as Fridland suggests, results from cognitive control processes. He summarized that concatenation leads to fluid, smooth, or elegant combinations of tasks navigated without much explicit thought. Parsing illustrates the flexibility and manipulability of varied responses that signify skill.

This flexibility lies at the center of intelligently skilled action (Pacherie & Mylopoulos, 2020). Unlike rigid and uniform habitual behavior, another example of chunked motor elements, flexibility shows variance, modification, and thoughtfulness. Individuals acquire habits through drill, repetition, and conditioning. In contrast, they acquire skills through training. Music learners encounter their fair share of drill, repetition, and conditioning under the umbrella of skilled practice, as opposed to the kind involved with tying shoes or brushing teeth. The integral component of flexibility involves environmental or sensory sensitivity, situational sensitivity, and strategic sensitivity. A skilled individual may parse their chunked elements differently based on the environment, situation, and strategy. For example, a trained singer demonstrates sensitivities to volume and tonal color (environmental or sensory) within a particular song (situation) as performed in various venues (strategy).

I began this framework's explanation of motor skills using the piano as an example rather than singing. While singing also requires motor engagement, such as coordinating laryngeal and thoracic musculature, untrained vocalists usually sing without the skills developed for flexibly implementing this kind of engagement. By tying theory and philosophy together, I note that singing generally develops naturally as a horizontal discourse, while learning to sing occurs vertically. Tensions between these discourses characterize the community choir and amateur/lifelong learner environment. However, researchers uncovered that even simple tasks like pitch matching require cognitive control through auditory imagery and vocal motor planning (Greenspon & Pfordresher, 2019). Inaccurate pitch imitation results from singers ineffectively mapping auditory representations onto motor representations of the vocal tract. While the process of audiation, or the act of forming an auditory image (Gordon, 1975), helps achieve successful pitch matching, simply asking a singer to "listen and then sing" does not impart powerful knowledge or tap into

the psychological complexity of skill. Naming the process as audiation, along with the phenomenon whereby the vocal folds approximate pitch while engaged in audiation, informs pedagogical practices that bridge the discursive gap. This kind of pedagogy involves rigor on both the learner's (singer's) and teacher's (conductor's) part, rather than "pedagogical populism" or "watering down" of the curriculum that avoids difficulty in favor of facilitating experiences through non-conceptualized, horizontal considerations (Bernstein, 2000). McPhail summarized this sentiment, writing:

> Although people can find out how to do things through experience, the role of the school [rehearsal] is special. People are unlikely to be able to name these concepts out of thin air without being introduced to them and once a phenomenon or thing can be named as a concept, a person has more power over what can be thought and done. This is the power of abstract thinking…. Students [learners] are unlikely to have access to this information anywhere else. (p. 288-289).

Purpose and Research Questions

By contextualizing my philosophical stance within a theoretical framework, I propose the adoption of a motor-based vocal curriculum. This type of curriculum may provide a conceptual and rigorous, vertically aligned system of knowledge for teaching singing technique in a community choir setting. The purpose of this study was to investigate the results of teaching this curriculum based on two measurements: the development of inhibitory control, a subcomponent of executive function (EF), and self-perceived rigor. The congruencies between the top-down processes involved in technique building and EF present a likely pairing where the transfer of musical learning may occur. Participants who demonstrate understanding and application of vocal technique across multiple contexts may also enhance their EF skills (planning and meeting goals,

displaying self-control, following multiple-step directions despite interruptions, and maintaining focus). In this case, learning to sing may help individuals learn to inhibit responses to irrelevant stimuli and to think before reacting. As noted in my introduction, researchers link strong executive function skills to lifelong success (Diamond, 2013). The theoretical, philosophical, and scientific evidence (Degé, 2021) suggests that rigor partners alongside the journey of bridging the discursive gap. I looked beyond music to find a deductive approach for assessing self-perceived rigor (Flint et al., 2023). Therefore, I asked the following questions:

1. What is the association of teaching a motor-based vocal pedagogy versus a traditional vocal pedagogy with any change in executive function, specifically inhibitory control, among adult, amateur singers in a community choir setting?
2. How do adult amateur singers perceive the rigor of a motor-based vocal pedagogy in a community choir setting compared to their peers' perceptions of the rigor of a traditional vocal pedagogy?
3. Does a singer's perception of rigor interact with their scores of inhibitory control?

Study Design

The study followed a quasi-experimental design where I investigated the results of teaching a vertically aligned vocal curriculum in a community choir setting. I delivered the curriculum using a motor-based pedagogy aligned with the psychological complexity of skill. In this way, I considered both my epistemological stance on teaching powerful knowledge and my theoretical framework. The curricular intervention included a split-plot design, in which the intervention group received the motor-based vocal curriculum, while a comparison group received a non-motor-based vocal curriculum. I designed both curricula using methods from Understanding by Design (Wiggins & McTighe, 2005). Over a 10-week period, I tested participants at pre-, mid-point,

and post-intervention on measures of inhibitory control. To answer research question 1, I analyzed the test results using a repeated measures ANOVA. Participants initially complete a demographic inventory survey and a baseline IQ test. I used the results from this information for participant matching and as control variables to assess systematic differences between groups. I conducted a series of independent t-tests to analyze any potential moderating factors stemming from the control variables. After the 10 weeks, to assess rigor, I collected results from a skills-based challenge inventory that I adapted from two validated gaming inventories: the Challenge Originating from Recent Gameplay Interaction Scale (Denisova et al., 2019) and the Video Game Demand Scale (Bowman et al., 2021). To answer research question 2, I analyzed these results using descriptive and inferential statistics. To answer research question 3, I conducted Pearson's correlations to assess the association between rigor and executive function.

Dissertation Overview

Chapter 1 of my dissertation outlines the conceptual and theoretical case for teaching a motor-based vocal curriculum in community, lifelong learning choirs. Therefore, I decided to test the outcomes of teaching a curriculum that may bridge the discursive gap. I assessed these outcomes through tests of executive function and an inventory of self-perceived rigor. Chapter 2 explores the literature related to executive function and musical learning, relevant research on community choirs, and literature regarding the assessment of rigor. Chapter 3 details the proposed methodology for my study, and Chapter 4 presents the results. Chapter 5 includes a discussion of the results, implications for music education, limitations, and recommendations for further research.

2 REVIEW OF THE LITERATURE

The philosophical and theoretical frameworks for this study established the precepts of powerful knowledge and the development of technique. I measured the outcomes of teaching these precepts by examining musical learning's associations with executive function (EF) and the self-perception of rigor in a community choir setting. For these reasons, the following literature review covers related research in: (a) musical learning and EF; (b) near and far transfer; (c) vocal motor learning and inhibitory control; (d) a reexamination of musical learning transfer effects; (e) current findings, research trends, and potential gaps in EF studies; (f) the benefits of community choir participation; and (g) assessing rigor, challenge, and demand in the choral learning environment.

Musical Learning and Executive Function

For more than 30 years, researchers have explored the association between musical learning and human cognition. The heavily publicized "Mozart Effect" suggested a relationship between listening to music and enhanced spatial-temporal reasoning (Rauscher, Shaw, & Ky, 1993; 1995). Despite the resultant and lingering controversy surrounding the "Mozart Effect," this early research encouraged other scholars to examine the association of music with various areas of cognition. They hypothesized that musical learning could yield far transfer—non-musically specific effects, such as enhanced academic achievement, emotional well-being, and higher IQ scores. In this literature review, I focus specifically on studies that link musical learning and executive function. In 2017, Sala and Gobet introduced results from a meta-analysis that severely criticized previous assertions claiming the transfer of musical learning to other areas of cognition. Since then, scholars have reclaimed modest ground in demonstrating a positive association between musical learning and executive function, while others continue to debunk any such associations (Hogan et al., 2023; Schellenberg & Lima, 2023). Because of the field-wide shift

following Sala and Gobet's findings, I include almost exclusively research conducted after 2017. While earlier studies certainly influenced current research, changes in methodology and a movement toward the standardization of practices reinforce the legitimacy of data presented in recently published accounts. We cannot assume the same stringent standards for methodology in many earlier studies.

Executive Function

Looking both ways before crossing the street, thinking before speaking, organizing a daily calendar or exercise routine, recognizing your spouse's favorite color in a bouquet of flowers, contracting a third party to deliver those flowers as a surprise, and synthesizing multiple articles into a literature review are all applications of executive function (EF). Diamond (2013) defined EFs as a collection of top-down control processes used "when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible." Scholars separated EF into three distinctly definable areas: inhibitory control, working memory, and cognitive flexibility (Miyake, 2000).

Inhibitory control involves selective attention and cognitive or behavioral inhibition (Diamond, 2013). This might occur when singers suppress the urge to sing one interval in favor of another or when they maintain an ostinato while the conductor guides another singer's phrase shape. Researchers often employ Go/No-Go tasks, where participants respond to or inhibit a response to simple stimuli like repeated letters, or Stroop tests, where participants encounter incongruencies in colored text (e.g., the word "blue" in red ink), to assess inhibitory control (Chen et al., 2021). Among the three subcomponents of EF, researchers most often find positive associations between inhibitory control and musical learning (Schellenberg & Lima, 2023). Musicians may concurrently train their inhibitory control when suppressing the desire to sing or play

specific notes and rhythms in favor of others, or when changing musical patterns in accordance with metrical and structural changes while following conductor cues and adjustments in real time.

Working memory describes the mind's ability to access information and manipulate it, whether the information is perceptually present or not (Diamond, 2013). Unlike long-term memory, which categorizes information collected over a lifespan, working memory readily retrieves small amounts of information for the execution of cognitive tasks (Cowan, 2014). For a musician, working memory could involve knowledge of tuning, technique, or performance practice, as well as implementing this knowledge in real time. A recently conducted meta-analysis proposed that working memory might supplant inhibitory control as the prime component enhanced through musical learning (Aryanto et al., 2024).

Finally, cognitive flexibility includes mental set shifting or task shifting, which refers to the ability and awareness to adjust thinking (Diamond, 2013). Examples include generating novel ideas or shifting from one way of thinking to another. In music, this may involve changing or playing in multiple clefs or key signatures. Composers exhibit high levels of planning, which correlates with cognitive flexibility, when constructing harmony (Winston, 2022). These EF subcomponents influence our ability to reason, solve problems, and plan, thereby impacting overall mental and physical health, school readiness and success, job success, marital harmony, public safety, and quality of life (Diamond, 2013).

Near Transfer and Far Transfer

Researchers hypothesized that musical learning develops executive function (EF) subcomponents alongside domain-specific skills, resulting in both near and far transfer effects of musical training. Degé (2021) defined near transfer as the main effects of practice and learning,

while far transfer refers to effects in domains that the learner has not practiced or learned. For music practitioners, near transfer includes developing fine motor skills, temporal processing, and listening skills. Far transfer might involve the correlated use of working memory during play, which affects overall working memory development. This development potentially leads to the enhanced executive function necessary for academic success, job success, and other desired applications. Degé suggested that the more distantly related a task is to the domain of study, the less frequently far transfer occurs (2021). They asserted that becoming an expert in a specific area could limit the potential for far transfer, as long-term training in particular skills continually reinforce proficiency in that domain. However, Degé also noted that the high adaptability of music lessons presents a special case for promoting both near and far transfer. Specifically, musical learning typically occurs within the zone of proximal development, where a learner's capabilities expand through mentor guidance in collaboration with more capable peers (Vygotsky, 1978). Music remains in the proximal zone because of the instantaneous aural feedback and the subsequent ability to adapt instruction as needed. Additionally, multiple cognitive processes occur in parallel during musical playing (Frischen et al., 2019). Therefore, musicians may train executive function as a near transfer alongside the advancement of musical techniques (Frischen et al., 2021). Skeptics argue that this rationale is only a starting point and may be too broad to account for different types of musical training (Schellenberg & Lima, 2023).

My study explored the effects of learning vocal techniques and their potential for transfer to executive function skills, specifically inhibitory control, in amateur adult community singers. A similar study conducted in 2018 recruited professional choral directors and accompanists, trained in intervention components, to lead 12 communities of adult seniors (Johnson et al., 2018). Researchers randomly selected six communities as intervention sites and assigned the

other six as a wait-list control (delayed by 6 months before starting the intervention). This study examined cognitive, physical, and social benefits of choral participation. Notably, interventionists received supplemental training in physical engagement activities, though not specifically in vocal-motor techniques. The sample (N = 390) included adults aged 60 and older, with a mean age of 71.3 years. Participants learned repertoire over twenty-three weeks, selected by the conductors, and participated in 90-minute weekly sessions.

This program also included three to four informal public performances. Researchers used the National Institutes of Health (NIH) Assessment Center computer-based platform to collect data. For cognitive outcomes, participants took the Trail Making Test from the NIH Toolbox, which assesses the set-shifting component of executive function. For physical outcomes, researchers assessed lower body strength, balance, and walking speed. For psychosocial outcomes, participants completed a questionnaire assessing depressive symptoms, sadness, anxiety, loneliness, positive affect, and interest in daily life. The researchers employed a power analysis calibrated to previous studies for overall health and depression. For an 80% powered study, they selected a two-tailed alpha of .005, with N = 360 (retention at six months) to yield a predicted effect size of d = 0.35.

Results indicated positive psychosocial effects for loneliness (p = .02; d = .34) and interest in life (p = .008; d = .39). However, the results did not indicate any physical or executive function benefits. The researchers provided three possible explanations: First, the *a priori* physical and cognitive outcome measures lacked sufficient sensitivity to detect changes over time, meaning they may have miscalculated the power estimate for those measures, or they selected inappropriate types of physical and cognitive measurements. Second, the 90-minute sessions may have provided too low a dosage for older adults to elicit physical or cognitive changes.

Third, the choir directors may have lacked fidelity to the movement protocols. These three explanations possibly confirm Schellenberg and Lima's assertion that current theories too liberally suggest the far transfer capabilities of musical learning to executive function (2023). Conversely, the study's conclusions suggest a pathway to investigate the capabilities of motor-based vocal learning related to a different measure: inhibitory control.

Vocal motor-learning and inhibitory control

After conducting a meta-analysis of 22 studies, researchers posited that musical learning improves inhibitory control compared to other activities, such as playing video games, sports, visual arts, or drama (Jamey et al., 2024). Musicians focus on their performance and others' performances, respond to cues, and adjust their movements accordingly. Inhibitory skills serve as a foundation for other executive functions (EFs) like set-shifting and selective attention (Diamond, 2013). Thus, developing inhibitory control may positively affect the development of other EFs.

A recent singing study expanded upon a top-down executive approach to developing pitch accuracy through auditory imagery (Pfordrescher, 2022). In this study, participants (N = 632) completed an online singing protocol to measure pitch accuracy. Results demonstrated that singing accuracy improved from childhood through young adulthood, undisturbed by adolescent vocal changes, and remained high throughout the lifespan. Researchers found that musical training reduced the rate of improvement in childhood because participants' pitch accuracy already resembled that of young adults. They attributed these findings to enhanced sensorimotor learning and stronger associations between perception and action. Specifically, enhancing the auditory image through technical training increased pitch accuracy. Researchers asserted that this executive process occurs in a sensorimotor loop whereby auditory perception feeds into sensorimotor translation. This translation results in motor planning, where auditory representations map onto

motor representations of the vocal tract (Greenspon & Pfordresher, 2019). Strengthening this predictive process—or the development of technique through musical learning—stimulates other metacognitive functions. These metacognitive actions facilitate EFs like inhibitory control (Frischen et al., 2022a).

For example, a study on the development of motor inhibition in preschoolers through drumming correlated 34% of the change in inhibition to musical learning (Degé et al., 2022). Relatedly, a literature review of vocal hygiene strategies for music educators revealed studies that found positive effects from a motor-based regimen called Vocal Function Exercises (Hackworth, 2023). More closely related, a recent study of opera trainees found a strong association between cognitive function and EF with decreased physiological stress during performance (Yeganeh et al., 2023). Participants' heart rate variability during performance positively correlated with executive function, resulting in lower stress—an important implication for far transfer capabilities.

A meta-analysis of 48 articles examining skill transfer effects of musical instruction demonstrated that approximately 20% of the research focused on near transfer, while almost 80% focused on far transfer (Porflitt-Becerra, 2021). About 16% of the articles in the meta-analysis studied far transfer to executive function. This meta-analysis did not consider Frischen and Degé's (2021) assertion that musical learning functions primarily as a near transfer activity to EF. These researchers suggested that transfer occurs across similar domains, meaning that individuals use executive functions during musical play. Due to the progressive nature of musical learning, continuous opportunities for challenge and growth exist. This paradigm suggests that individuals practice executive function as they practice their instruments. Examples include using set shifting and inhibitory control when changing key signatures or rhythms as tonalities and

beats shift and engaging auditory and visual working memory while remembering musical passages.

Since the introduction of "The Mozart Effect," scholars have often attempted to correlate musical learning with academic achievement. One article identified 21 inconclusive studies that tested the effect of musical learning on academic achievement (Jaschke, Honing, & Scherder, 2018). Instead, the authors asserted that when analyzing potential far transfer effects of musical learning on academic achievement, executive function emerged as a better fit. This high volume of mixed and inconclusive results prompted skepticism within the field, culminating in the controversial 2017 publication by Sala and Gobet.

A Reexamination of Musical Learning's Transfer Effects

In 2017, Sala and Gobet conducted a meta-analysis of 38 studies published between 1986 and 2016. They concluded that musical training does not reliably enhance cognitive abilities in young learners up to age 16. They argued that confounding variables, primarily issues in study design, led to previous positive findings. In their analysis, they first excluded correlational and ex-post facto studies, noting that researchers could not infer causality between musical training and outcomes. Next, they included only studies that isolated music training as the independent variable, incorporated at least one control group, excluded environmental factors (such as the "Mozart Effect," music in the background, or music videos), measured academic or cognitive skills, and involved participants who initially lacked prior formal musical training and specific learning disabilities. They considered a calculated effect size as the primary statistic of significance. Cumulatively, the 38 articles analyzed included 118 effect sizes from 3,085 participants.

To categorize their findings, Sala and Gobet selected four potential moderators: outcome measure, age, random allocation, and the presence of an active control group. They calculated an

overall meta-analytic effect size of $d = .16$, which was statistically insignificant. Cohen (1998) suggested a standard range for effect sizes, setting $d = .20$ as small, $d = .40$ as medium, and $d = .80$ as large. Sala and Gobet established outcome measure, random allocation, and the use of an active control group as significant moderators, meaning that these factors within the study design impacted the statistical results (2017b). Results showed that only memory and intelligence-related effect sizes positively associated with musical training. Sala and Gobet, along with other researchers (D'Souza & Wisenheart, 2018; Holochwost, 2017; Okada & Slevc, 2018; Schellenberg, 2011; Schellenberg, 2013), attributed many prior findings to placebo effects and a lack of random allocation. They noted that (a) introducing any novel treatment could inspire growth simply due to its newness and the expectation of improvement, and (b) learners with higher intelligence and memory skills often already participate in musical training. Sala and Gobet concluded that a lack of well-designed studies obscured most results indicating a relationship between musical training and far transfer effects (2017b). In fact, they reported that the stronger the study design, the lower the effect size. They insisted that future studies should include both randomization of participants and an active control group.

That same year, Sala and Gobet published a second article questioning the impact of musical training or playing chess on far transfer effects via another, similar meta-analysis (2017a). In 2020, they conducted an updated meta-analysis of 54 articles with 254 effect sizes and 6,984 participants. They found an overall effect size of $g = .184$, reinforcing their previous claims (Sala & Gobet, 2020). Hedge's corrected *g*, like Cohen's *d*, is interpreted using a similar significance scale, where $g = .20$ is small, $g = .50$ is medium, and $g = .80$ or greater is large (Hedges, 1981).

I identified six other meta-analyses published since 2017 that refute Sala and Gobet's findings. Bigand and Tillmann reanalyzed Sala and Gobet's 2020 data and found a significant

effect size of $g = .234$, demonstrating an underestimation of the far transfer effects of musical learning (2022). They asserted that randomization was not a significant moderator based on a two-step sensitivity analysis. They also noted that Sala and Gobet created an unfair comparison for active control group studies. In their 2020 analysis, Sala and Gobet included near-transfer effects in control group studies but only far-transfer effects in musical training studies. Bigand and Tillmann supported the value of a small effect size, citing other studies that found similarly small effect sizes for other types of learning interventions, such as homework, mentoring, homeschooling, and extracurricular activities (2022). They agreed that future studies should include randomization, pre- and post-tests, and baseline IQ measurements.

The first of two meta-analyses conducted by Hernández-Campos et al. examined differences in executive function solely between musicians and non-musicians of all ages (2020), unlike Sala and Gobet's meta-analyses, which specified that participants aged 3–16 had no prior musical training. After analyzing 12 articles with 60 effect sizes and 513 participants, they found an overall effect size of $d = .712$ (Hernández-Campos et al., 2020). Their second, updated meta-analysis examined 11 articles with 62 effect sizes and 261 participants, finding an overall effect size of $d = .51$ (Hernández et al., 2021). While both meta-analyses by Hernández et al. focused on articles published between 2000 and 2017, the updated study included more rigorous inclusion criteria. Notably, the updated criteria required studies to have pre-test and post-test measures, experimental and control groups, and specific measures of executive function. Supporting Sala and Gobet's initial findings, the difference in effect sizes between both meta-analyses demonstrates that better-designed studies yield less significant results.

In 2020, Cooper tested this idea in a rigorously constructed meta-analysis. This study included articles adhering to the following criteria: students between the ages of 3 and 15 years, an

experimental or quasi-experimental design, random assignment or an attempt to match participants (for quasi-experimental studies), measures of cognitive outcomes (not academic achievement), exclusion of effect sizes for musical aptitude or ability, a thoroughly described legitimate musical treatment, pre- and post-test measures, the presence of an active or passive control group (assessed separately as moderators), training exceeding 2 sessions, availability in English (even if conducted globally), and sufficient data to conduct effect sizes. Following these criteria yielded 21 studies, 105 effect sizes, and 5,612 participants. The list of studies analyzed by Cooper overlaps with those identified by Sala and Gobet; however, Hernández-Campos et al. generated a list of studies not found in either of the other meta-analyses. These lists differed due to inclusionary and exclusionary decisions, including Hernández-Campos et al.'s use of studies comparing musicians to non-musicians. Each study employed its own search strategies. Cooper calculated a main effect size of $g = .276$, $p < .0001$, 95% confidence interval [.21, .34], demonstrating small to medium far transfer effects, particularly for ages 4–10, on cognitive measures via musical training. Because the credibility interval [-.11, .66] included instances of 0 within its lower and upper values, Cooper determined that claiming a causal link between musical learning and developing EF would be reckless. A recent small-scale study of preschool-age children, however, claimed causality between musical training and motoric inhibition, which refers to the suppression of unwanted movement (Degé et al., 2022). Cooper also agreed that higher-quality study designs yielded less significant results, questioning the assertion that musical training supersedes other types of interventions.

In 2023, Jamey et al. conducted a meta-analysis of 22 studies, including $N = 1{,}734$ participants between the ages of 3 and 11 years. Their analysis concluded an overall effect size of $g = 0.60$ for improved inhibitory control in children who participated in randomized controlled trials

of musical training compared to those involved in non-musical active controls like playing Legos, video games, drama, sports, and visual arts. For longitudinal studies, they found an overall effect size of $g = .031$. The list of analyzed articles overlapped with Cooper's list and included studies conducted since 2020. Additionally, this analysis considered moderating factors such as age, dosage, setting, and randomization. Only the intervention setting (whether in a school environment) was statistically significant. They also assessed between-study heterogeneity (variations in measurements, type of training, type of control groups, participant demographics) and found a medium to low degree of variability between the studies. To evaluate potential small study bias, they conducted a funnel plot and found no evidence of bias.

Finally, a pre-published meta-analysis of 47 studies, encompassing 235 effect sizes from 4,651 healthy adult participants, found significant associations between music making and EF with an effect size of $g = 0.43$ (Aryanto et al., 2024). This analysis separated the three subcomponents and presented effect sizes for inhibitory control ($g = 0.31$), set shifting ($g = 0.22$), and working memory ($g = 0.49$). Threats of bias moderated the findings for inhibition, and the paradigm used to assess EF moderated working memory. Unlike the other meta-analyses, this study included unpublished undergraduate, master's, and PhD theses written in English. It also focused solely on samples of healthy adults aged 18 years or older. Due to these inclusionary differences, their list of studies overlaps minimally with the other meta-analyses.

Due to Sala and Gobet's contributions as well as others' re-evaluations, current research examining far transfer effects of musical training on executive function employs more stringent protocols. A recent literature review by Schellenberg and Lima presented a multitude of factors that attempt to debunk associations between musical learning and cognitive improvements, including conflicting results, journalistic integrity, poor methodological design, and the influence

of natural ability (Schellenberg & Lima, 2023). However, the authors failed to reconcile insignificant findings with significant ones, gave little credence to studies with high methodological rigor, and contradicted their demands for true experimental design protocols with a call for "real-world" application. Additionally, their study did not consider the quality of pedagogy or intervention protocols in studies that reported insignificant results. Hogan et al. (2023) presented a sobering assessment of the program *El Sistema*, reporting no effects from two years of school-based orchestral music training on young children's executive function, self-perception, and school enjoyment. They further asserted that the field lacks publications of null findings. Consequently, published research often misrepresents correlational findings as causal, obfuscates issues of replication, and sidelines other justifications for music education. The researchers acknowledged that they could not conclude zero benefits to executive function from music education; however, they preferred to refocus advocacy efforts on music education for its intrinsic value.

Current Findings, Research Trends, and Potential Gaps in EF studies

As research in this field continues, scholars have identified distinct areas of interest, including the type of musical intervention, sensitive periods for musical training, focus on specific executive function (EF) subcomponents, intervention dosage, and retention of effects. While encouraging findings exist, significant room for further research remains. Types of musical interventions studied include Orff instruction (Bolduc et al., 2021), extracurricular instrumental instruction (D'Souza & Wiseheart, 2018; Frischen et al., 2021), string instruments (Hennessy et al., 2019; Holochwost et al., 2017; Sperling et al., 2023), piano (Passarotto et al., 2023), general music (Bugos & DeMarie, 2017; Bugos et al., 2022; Degé et al., 2022; Frischen et al., 2019; Jaschke et al., 2018; Shen et al., 2019), Kodály instruction with and without movement (Lukács

et al., 2022), rhythm and movement (Bentley et al., 2023; Wang et al., 2024), jazz improvisation (Norgaard et al., 2019), and harmonic composition (Winston et al., 2022). I found no studies that specifically explored the impact of vocal skill-building instruction on far-transfer effects to executive function. General music studies included singing but also encompassed movement, listening, and instrumental playing. Lukács's study used the Kodály Method, a singing-based pedagogy; however, the intervention focused on and tested the addition or exclusion of movement (2022).

According to Porflitt-Becerra's meta-analysis, about 54% of studies investigating near and far transfer effects of musical training focused on children ages 3–10, another 37.5% on adults ages 18–60, approximately 10% on older adults ages 61 and older, and the remaining 27% on teenagers ages 11–17 (2021). The percentages add up to more than 100% because many studies targeted multiple age ranges. Recent findings suggested a sensitive period during childhood—generally before the age of 7—when musical training best aligns with the development of executive function skills (Chen, 2021; Penhune, 2011). Other data demonstrated that individuals who began their musical training after age 8 exhibit greater decision-making skills (Smayda et al., 2018), suggesting that engaging in musical training may benefit individuals throughout their lifespan. The next largest demographic, adults ages 18–60, likely reflects the relative ease of working with university-age students and individuals of consent-giving age. The other age groups, teenagers ages 11–17 and adults ages 61 and older, remain less explored despite evidence of cognitive changes due to pubertal maturation and age-related cognitive decline. Two recent articles presented EF benefits for older adults (Kakihara et al., 2024; Rogers & Metzler-Baddeley, 2024). In a 10-week study where older adults learned the melodica, Kakihara et al. found significant improvement in an EF composite index among those adults who showed

improved musical performance. Rogers and Metzler conducted a meta-analysis of 13 studies, which included 502 healthy, musically naïve adults over 60 years old (2024). They determined a low effect size on inhibitory control ($d = 0.27$), a low-moderate effect on set shifting ($d = 0.39$), a low-moderate effect on verbal set shifting ($d = 0.39$), and a moderate effect on processing speed ($d = 0.47$). The researchers suggested that learning to play an instrument enhances EF in older adults.

Failure to clarify which specific EFs or cognitive measures researchers selected for testing provided grounds for criticism of studies conducted prior to 2017. More recently published articles included studies of inhibitory control (Bentley et al., 2023; Bolduc et al., 2021; Bugos & DeMarie, 2017; Chen et al., 2021; D'Souza & Wiseheart, 2018; D'Souza et al., 2018; Degé et al., 2022; Frischen et al., 2019; Frischen et al., 2021; Hennessy et al., 2019; Herrero & Carriedo, 2018; Jaschke et al., 2018; Lukács et al., 2022; Norgaard et al., 2019; Okada & Slevc, 2018; Shen et al., 2019; Winston et al., 2022), phonological processing (Bolduc et al., 2021; Lukács et al., 2022), working memory (D'Souza & Wiseheart, 2018; D'Souza et al., 2018; Chen et al., 2021; Frischen et al., 2019; Frischen et al., 2021; Herrero & Carriedo, 2018; Jaschke et al., 2018; Lukács et al., 2022; Okada & Slevc, 2018; Shen et al., 2019; Winston et al., 2022), cognitive flexibility (D'Souza & Wiseheart, 2018; Chen et al., 2021; Frischen et al., 2019; Frischen et al., 2021; Jaschke et al., 2018; Norgaard et al., 2019; Okada & Slevc, 2018; Shen et al., 2019; Winston et al., 2022), decision-making (Smayda et al., 2018), and "hot" EFs that consider affective decision-making associated with gain and/or loss (Frischen et al., 2022b; Wang et al., 2024). Although results varied among tests, with some studies showing insignificant outcomes, tests of inhibitory control and working memory consistently demonstrated a positive relationship to musical training (Aryanto et al., 2024; Schellenberg & Lima, 2023). Tests of cognitive flexibility

generally did not yield significant results, except for Winston et al.'s study, where individuals composed harmonies (2022), and Kakihara et al.'s study of older adults learning the melodica (2024). This finding could suggest that specific types of musical learning relate to specific sub-components of EF; however, more research is needed.

Recent longitudinal studies (D'Souza et al., 2018; Herrero & Carriedo, 2018; Holochwost et al., 2017; Hennessy et al., 2019; Jaschke et al., 2018; Okada & Slevc, 2018; Shen et al., 2019; Smayda et al., 2018) suggested increased development of EF skills through long-term musical training, often showing higher gains for those receiving longer dosages of musical training. Shen et al. demonstrated a 12-week retention of effects, indicating that musical training potentially has a sustained impact on the development of EF (2019). Other studies confirmed enhanced components of EF in adults with long-term prior musical training compared to those without (D'Souza et al., 2018).

Given current research trends and the results of studies conducted in the past seven years, I designed my study to address some of the gaps in the literature. My study examined the effect of vocal training on the inhibitory control of amateur adult singers, including those over the age of 61. This aligned with recommendations for selecting specific EFs (Bigand & Tillmann, 2022; Cooper, 2020) and investigating an underrepresented sample (Porflitt-Becerra, 2021). While robust research with community choirs exists, little of it explores the association between musical learning and executive function. The next section provides a summary of the related research.

Benefits of Community Choir Participation

Research investigating participation in community choir settings and lifelong benefits has yielded findings related to physical health (Clements-Cortés, 2015; Moss et al., 2018; Wiech et al., 2020), neurological rehabilitation or benefits (Clements-Cortés, 2015; Feng et al., 2020;

Moisseinen et al., 2024; Pentikäinen, 2023; Särkämö, 2017; Särkämö, 2020; Tamburri et al., 2019), psychophysiological effects (Clements-Cortés, 2015), social and emotional well-being (Clements-Cortés, 2015; Johnson et al., 2013; Johnson et al., 2018; Maury et al., 2022; Moss et al., 2018), and auditory perception and processing (Hennessy et al., 2021; Pentikäinen et al., 2022). A recent meta-analysis of eight studies sourced from the PubMed database confirmed improved executive function in the aging brain due to exposure to musical training (Alatta et al., 2023). This exposure correlated with positive findings in the memory and auditory cortex of aging brains. Another meta-analysis of 19 studies extended these positive findings to general cognitive function and episodic memory in individuals with mild cognitive impairment and dementia (Ito et al., 2022).

Limited research exists on the association between community choir involvement and the development of executive function. A 2021 study revealed that choir singers performed better than a control group on measures of verbal flexibility, which may relate to the specific demands of producing lyrics while singing a melody within a rhythmic framework in a group, using expression, anticipating future words, and following conducting gestures (Pentikäinen et al.). Participants ($N = 162$) were divided into choral singers ($n = 48$, high activity; $n = 58$, low activity) and control subjects ($n = 56$), who took a battery of neuropsychological tests, including measures of executive function, and completed six self-report questionnaires assessing cognitive function, depression, social well-being, quality of life, and the role of music in daily life. Statistical significance emerged between the verbal flexibility of choral singers and that of control subjects. Choral singers also reported better general health and social integration. Conversely, a 2020 comparison of composite cognitive test scores between a two-year choral singing intervention group and a health education program group of aging adults with cognitive complaints showed limited

advantages for choral singing (Feng et al.). While the weekly choral program included learning the mechanics of singing and breathing techniques, it remains unclear whether the vocal pedagogy employed included motor-based aspects.

Similarly, a study of a large (N = 208), culturally diverse community choir program yielded insignificant results regarding set shifting (Johnson et al., 2018). Researchers remarked that a weekly 90-minute session might be an insufficient "dose" to yield cognitively based results in older adults. Their program included physical engagement activities (such as clapping, stretching, swaying, and breathing exercises), but researchers noted that the trained choral directors applied this component inconsistently. The study did not mention vocal pedagogy or motor-based vocal pedagogy.

An older study based on a 2011-2012 survey of 1,212 adult participants aged 55 and older (137 only sang, 62 only played a musical instrument, 59 did both, and 824 neither sang nor played an instrument) found that those with a musical background scored higher on a general test of executive function (Mansens et al., 2017). The survey, however, failed to inquire whether participants played or sang alone or in groups. Additionally, test scores demonstrated that those who played an instrument scored significantly higher than those who sang or did no music in areas of processing speed and working memory. The researchers attributed this difference to the multimodal aspects of instrumental play: reading music, pressing correct keys, rhythmic attention, and training techniques.

A more recent study specifying types of musical training found significantly better working memory and overall executive function in United Kingdom adults over 40 who played a musical instrument (Vetere et al., 2024). They reported an increase in verbal reasoning for singers. Sampling the PROTECT-UK database, N = 1,570 participated in a study involving a

questionnaire assessing individual musical histories and an online battery of cognitive tests. Of this population, $n = 178$ only sang and never played a musical instrument. The researchers concluded that musical engagement positively affected cognitive health, suggesting potential value in lifelong musical participation. One final study used auditory tests of executive function to measure selective attention, processing speed, inhibitory control, and working memory (Tremblay & Perron, 2023). The participants ($N = 147$) included 75 non-singers and 72 singers, with a mean age of approximately 53.5. The singers all participated in a weekly choir, and many ($n = 68$) rehearsed at home. While singers scored higher in auditory processing—especially those with more experience—the study found no significant differences in executive function between the groups. This study included no intervention.

The benefits of singing in an adult community choir range from social to neurological; however, limited data supports the enhancement of executive function due to participation in a community choir. Many gaps remain. Among the reviewed studies, those that introduced choral singing as a novel intervention or included singers with extensive experience showed positive relationships with top-down processes. None of the studies I reviewed introduced a motor-based vocal pedagogy as an intervention. In contrast, positive associations between instrumental music-making and enhanced executive function in adults exist (Bugos & Wang, 2022; Columbo et al., 2020; Degé & Kerkovius, 2018; Mansens et al., 2017; Särkämö, 2017; Särkämö, 2020; Vetere et al., 2024). Therefore, similar executive function gains may occur if community choir participants receive an intervention akin to instrumental learning. A motor-based vocal pedagogy may resemble the button-pressing techniques found in instrumental methods. This kind of technical skill learning involves the rigor inherent in the novel task of learning an instrument, which is not necessarily present in singing (Degé, 2023).

Assessing Rigor, Challenge, and Demand in the Choral Learning Environment

In my literature review for this section, I used search terms such as "rigor," "challenge," "assessment," "critical thinking," "difficult," "higher order," "measurement," "metacognition," and "cognition." I searched Google Scholar, EBSCO, and primary music education journals published in association with the National Association for Music Educators and the American Choral Directors Association. While several articles emerged, I found only two strands of research relevant to the philosophical and theoretical precepts established in Chapter 1, which I discussed in the next subsection. Due to the lack of findings, I broadened my search to the field of education. Studies focusing on self-perception of rigor, challenge, and demand, or student perception of those elements examined online learning (Duncan et al., 2013; Young, 2010), general evaluations of academics (Draeger et al., 2015), or challenge as part of an overall academic experience (Strati et al., 2017). However, none of these searches yielded a detailed assessment, scale, or inventory of these specific elements. Next, I expanded the search beyond education to look for scales or inventories that comprehensively assessed rigor, challenge, or demand. I discovered that video game research actively investigates these concepts as part of the gaming experience. Like singing in a community choir, gaming requires continuous cognitive, emotional, physical, and often social engagement (Bowman et al., 2022). Players perceive cognitive demands when navigating novel systems and employ relevant strategies in "real time." Emotional reactions arise in response to unfolding events, while physical demands persist across varying levels of difficulty, requiring fine motor manipulation. Social demands emerge through interactions with both human and non-human components.

The performative perception of these demands revealed a tension between difficulty and challenge (Denisova et al., 2019; Flint et al., 2023). Challenges, objectives, or problems generally carry a positive valence, serving as stimulating experiences and key motivating factors. In contrast, difficulties involve the potential for failure due to barriers that prevent a player from meeting the challenges, carrying a negative valence. Perceived challenge encapsulates both the negative and positive valences associated with challenge and difficulties (Flint et al., 2023). Video game researchers have recently developed two scales to assess demand and perceived challenge. The Challenge Originating from Recent Gameplay Interaction Scale (CORGIS) measures perceived challenge in performance (Denisova et al., 2019; Flint et al., 2023), while the Video Game Demand Scale (VGDS) evaluates interactivity as demand (Bowman et al., 2022; Flint et al., 2023). Both scales assess the cognitive, emotional, physical, and social aspects of gameplay. Recently, researchers compared the conceptual dimensions of the two scales to construct a combined scale (Flint et al., 2023).

Measuring Rigor in Choral Music Education

In choral music education, I identified two methods for measuring rigor: assessing the time allotted to critical thinking episodes within a rehearsal (Garrett, 2013) and creating conductor profiles based on self-reported learning tasks and objectives (Corbalán et al., 2019). Garrett built on earlier studies by Watkins (1993, 1996) and Strauser (2008). Watkins's 1993 study of junior high and middle school choruses found that only 0.084% of non-performance time engaged learners in higher-order or critical thinking. In their 1996 study of high school chorus rehearsals, Watkins and colleagues found that 1.3% of non-performance time was dedicated to this type of thinking. For Garrett, Strauser, and Watkins, higher-order thinking encompassed elements of analysis, synthesis, and evaluation of content and performance. Strauser’s 2008 study

included not only student activity during non-performance time but also teacher talk and modeling. Teacher talk and modeling accounted for 47% of rehearsal time, with 15.06% of that time incorporating higher-order thinking skills.

Garrett observed eighteen rehearsals from three public high school choral programs in 2013. The total percentage of non-performance time was 53.89%, with teacher talk constituting the majority of that time. Students spent an average of 45.96% of the time in lower-order thinking and 6.36% in higher-order thinking. Unlike Strauser, Garrett did not account for vocal modeling. All studies found no statistical significance based on years of teaching experience or ensemble ability. Garrett suggested that performance activities might offer more opportunities for higher-order thinking and noted that his study may not represent the entire field but rather a specific geographic region.

Corbalán et al. examined conductors' roles in rehearsal by looking at self-reported goals and strategies, compiling them into profiles (2019). They sent a questionnaire to 41 Spanish-speaking conductors with various levels of experience, dividing the planning process into two phases: personal study and rehearsal plans. Participants ranked three learning points in each phase and explained their choices. They also provided activities for those learning points and methods of assessment. The researchers developed categories based on responses, including complex cognitive processes, procedural outcomes, and conceptual outcomes. After excluding four outlying or incomplete responses, three profiles emerged for the 37 participants.

The "traditional profile" (n = 22) scored lowest on cognitive processes but higher on procedural and conceptual outcomes. This profile also showed lower scores on notational processing. The "focus on reading profile" (n = 6) scored highest on notational decoding/reading and performed better than the traditional profile in cognition but scored lowest on procedural and

conceptual outcomes. The "focus on learning and representation profile" (n = 9) scored highest on cognitive processes and achieved the highest scores on procedural and conceptual outcomes, particularly in managing difficulties associated with outcomes. Regarding experience, teaching status, and choir type, only experience reached statistical significance. Notably, teachers with more than 10 years of experience often fit the traditional profile. However, this study faces significant limitations due to its small sample size and the complexity of the response categories. As a follow-up, the researchers profiled one educator from the traditional category and another from the focus on learning and representation category (Corbalán et al., 2023). For the traditional profile educator, nearly 50% of a 45-minute rehearsal consisted of conductor talk, with approximately 7% allocated to the choir's brief responses to the conductor's questions. About 31% of the rehearsal involved score reading. This case study superficially mirrored Garrett's 2013 findings. In contrast, for the focus on learning and representation profile educator, conductor talk comprised only 27% of the rehearsal, while choral responses accounted for 17%. The remaining 56% of the rehearsal involved a mixed production where both the conductor and choir engaged in singing, rhythmic movement, and gesturing.

In 2015, Tan conducted a literature review of studies exploring concept teaching in instrumental music education. The review suggested that concept-based teaching related to performance skills led to higher ratings from music adjudicators and increased student motivation. Rates of concept-based teaching in instrumental classrooms mirrored the variety of time spent in higher-order thinking found in choral classrooms.

Neither strand of choral research specifically investigated vocal pedagogy nor asked participants (learners or conductors) to assess the rigor of the educational experience. Their authors' assessments of rigor appeared inductive rather than deductive. Furthermore, neither theoretical

framework—Garrett's, which focused on Bloom's Revised Taxonomy, or Corbalán et al.'s, which referenced constructivism and direct theory—aligned closely with my own precepts. Therefore, I chose to adopt a combined adaptation of the Challenge Originating from Recent Gameplay Interaction Scale (CORGIS) and the Video Game Demand Scale (VGDS) (Flint et al., 2023) as my study's assessment of perceived rigor. Additionally, the video gaming framework for balancing challenge and difficulties closely resembles Vygotsky's educational zone of proximal development (1978), which researchers posit may explain musical learning's capacity to enhance executive function (Degé, 2021).

Summary

To summarize, many researchers reported that musical learning positively correlates with enhanced cognition, particularly executive function (EF) (Bolduc et al., 2021; Bugos & DeMarie, 2017; Bugos et al., 2022; Chen, 2021; Degé et al., 2022; D'Souza & Wiseheart, 2018; Frischen et al., 2019, 2021, 2022a; Hennessy et al., 2019; Herrero & Carriedo, 2018; Holochwost et al., 2017; Jashcke et al., 2018; Lukács et al., 2022; Norgaard et al., 2019; Penhune, 2011; Shen et al., 2019; Smayada et al., 2018; Sperling et al., 2023; Winston, 2022). Most notably, a likely relationship exists between musical learning and inhibitory control (Jamey et al., 2024; Schellenberg & Lima, 2023). Conversely, some researchers suggested that either no relationship exists or that findings are confounded by placebo effects and other moderating factors (D'Souza & Wiseheart, 2018; Holochwost et al., 2017; Jaschke et al., 2018; Okada & Slevc, 2018; Sala & Gobet, 2017a, 2017b, 2020; Schellenberg, 2011, 2013; Schellenberg & Lima, 2023). However, six meta-analyses (Aryanto et al., 2024; Bigand & Tillman, 2022; Cooper, 2020; Hernández-Campos et al., 2020, 2021; Jamey et al., 2023) counter this argument, concluding that the more rigorous the methodology, the lower the likelihood or significance of positive associations between musical

learning and enhanced EF. With potentially significant implications for this field, Degé recently presented findings indicating a correlation between musical learning in children and increased IQ, moderated by growth in inhibitory control (2024).

In the domain of community choral singing, little research has examined these associations. Recent studies yielded no significant results or only limited findings (Feng et al., 2020; Johnson et al., 2018; Pentikäinen et al., 2021; Tremblay & Perron, 2023). However, positive associations between instrumental music making and enhanced EF in adults do exist (Bugos & Wang, 2022; Columbo et al., 2020; Degé & Kerkovius, 2018; Mansens et al., 2017; Särkämö, 2017, 2020). I reached out to Degé, a prominent researcher in the field of musical learning and executive function, to discuss the divide between instrumental and vocal subjects (personal communication, July 31, 2023). Degé first noted that rigor, novelty, and self-motivated participants are essential for pedagogical interventions to effect change in executive function (Diamond & Lee, 2011). Degé further explained that for most participants, singing is neither novel nor rigorous; "everyone can sing" (F. Degé, personal communication, July 31, 2023).

As a result of this conversation, along with a review of the related literature and an examination of the philosophical and theoretical topics from Chapter 1, my study employed a motor-based vocal pedagogy as the learning intervention to develop vocal techniques in adult amateur singers. Although untested, it seems plausible that motoric training of the vocal tract would promote predictive processes (Greenspon & Pfordrescher, 2019; Pfordrescher, 2022) involving inhibitory control, thereby training musical learning alongside executive function (Degé, 2021). Community choir settings present challenges to implementing stringent study designs, which I discuss in detail in Chapter 3. Nevertheless, the "real-world" environment of diverse age groups

and skill levels offers unique advantages that enhance both design and ecological validity (Habibi et al., 2022).

3 METHODOLOGY

This study followed a quasi-experimental design. I collected quantitative data from tests of executive function, specifically inhibitory control, and a self-perceived rigor scale to answer my research questions:

1. What is the association of teaching a motor-based vocal pedagogy versus a traditional vocal pedagogy with any change in executive function, specifically inhibitory control, among adult, amateur singers in a community choir setting?
2. How do adult amateur singers perceive the rigor of a motor-based vocal pedagogy in a community choir setting compared to their peers' perceptions of the rigor of a traditional vocal pedagogy?
3. Does a singer's perception of rigor interact with their scores that measure inhibitory control?

Study Description Overview

I recruited members of an adult amateur community chorus to participate in a quasi-experimental study lasting 10 weeks. During this period, participants ($N = 51$) engaged in an amateur community choir experience. I divided the participants into two groups: an intervention group and a comparison group. Members of the intervention group learned a motor-based vocal curriculum. Members of the comparison group learned a traditional vocal curriculum. Group membership served as my independent variable. Over the course of 10 weeks, participants were tested on their inhibitory control three times and completed a final perceived rigor scale. The results from the tests and the scale constituted my dependent variables. I measured inhibitory control using Stroop effect scores (Rezelescu et al., 2020), which represent the difference in

milliseconds between participants' ability to recognize congruent and incongruent trials. I measured perceived rigor using an adapted ratio scale, where participants responded to prompts related to their experience of learning vocal techniques.

After obtaining informed consent, all participants completed an initial questionnaire (see Appendix A) to gather demographic information, including age, race, gender, socioeconomic status, colorblindness, neurodiversity, singing and choral experience, other musical experiences, and self-assessment of amateurism. I created the initial questionnaire using Qualtrics (https://www.qualtrics.com). Individuals who did not provide informed consent still participated in the choral experience, practicing alongside study participants during the combined rehearsal period.

Every participant took a pre-test battery of assessments, which included the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011) to measure general IQ, as well as Go/No-Go and Stroop Tests available on testable.org (Rezlescu et al., 2020). The dependent variable was measures of inhibitory control, with demographic information and IQ scores serving as control variables. Assessing these control variables ruled out systematic differences between groups (Degé et al., 2022).

Initially, I assigned participants to an intervention group (n = 26), which received the motor-based vocal pedagogy, and a comparison group (n = 25), which received a traditional vocal pedagogy. I created matched groups based on covariates identified in the demographic survey, including age, gender, yearly income, years of singing experience, vocal pedagogy training, and years of vocal training. I also prioritized forming balanced choral ensembles for each study group. The motor-based group consisted of 12 sopranos, 10 altos, 2 tenors, and 2 basses, while the traditional group included 11 sopranos, 10 altos, 2 tenors, and 2 basses.

In quasi-experimental designs used in social science research, matching procedures can replicate randomization in two ways (Stuart & Rubin, 2008). The first way involves creating balanced groups with respect to observed covariates, where, at worst, the sub-samples are randomly different. The second way involves the adoption of a two-stage design, where the covariates used for matching are selected prior to knowledge of any outcome data, preventing bias in matching procedures. My matching procedures adhered to these two ways by balancing groups with respect to covariates prior to administering any tests or interventions.

For the first 5 weeks, the motor-based group met with me for 55 minutes prior to a 90-minute rehearsal involving all choral participants. The traditional group received 55 minutes of their curriculum alongside non-participating choir members after the motor-based group concluded their session. During the 90-minute combined rehearsal, I included no discussion of vocal pedagogy or technique. My instruction focused on learning notes, rhythms, diction, and musical expression. After week 5, both groups retook the inhibitory control tests, including an additional Go/No-Go test with an added stimulus. At this time, the groups switched meeting times: the traditional group met with me for 55 minutes prior to the 90-minute combined rehearsal, while the motor-based group participated in their curriculum alongside the non-participating choir members after the traditional group departs. They repeated the inhibitory control tests for a third time at the conclusion of 9 weeks.

Following the culminating performance (week 10), all participants completed an adapted version of the combined Challenge Originating from Recent Gameplay Interaction Scale (CORGIS) and Video Game Demand Scale (VGDS) (Flint et al., 2023), which I created using Qualtrics (https://www.qualtrics.com) to assess perceived rigor of their experience (see Appendix B). I analyzed the quantitative data from the inhibitory control tests using a repeated measures

ANOVA or split-plot design, along with t-tests. I analyzed the results of the perceived rigor scale using descriptive statistics and t-tests. Additionally, I employed Pearson's correlation testing to examine any associations between these two data sets. One survey question yielded qualitative data, which I analyzed through tiered coding (Saldaña, 2021).

Research Ethics and Human Subjects Protection

This study occurred under the supervision of the Georgia State University Internal Review Board. I provided all participants with a detailed description of the project, including its tests, questionnaires, and pedagogies, prior to obtaining informed consent. Additionally, I served as the director of this community chorus. After gaining consent, I assigned each participant a number to maintain confidentiality. I linked all subsequent data to this participant number and stored both the participant key and data in a password-protected folder. Access to this folder was restricted to me and the faculty investigators. Participants could withdraw from the study at any time without fear of reprisal or penalty.

Population and Sample

Participants in this study ($N = 51$) were drawn from a community choir that I directed, located in the Southeastern region of the United States. This choir has been active for over 30 years, attracting a mix of new and returning voices each season. Initially, $N = 57$ participants registered for the study; however, $n = 3$ withdrew after the first week due to potential absences exceeding two rehearsals. An additional $n = 3$ participants ultimately missed more than the allowed two absences and withdrew from the study. Typical seasonal attendance ranges between 80 and 100 voices, with 121 individuals registered for general participation this season. Community choir studies often enroll robust sample sizes (Feng et al., 2020; Hennessy et al., 2021; Johnson

et al., 2013; Johnson et al., 2018; Moss et al., 2018; Maury et al., 2022; Pentikäinen et al., 2022; Tamburri et al., 2019; Wiech et al., 2020) with minimal attrition (Habibi et al., 2022).

A *G*Power* analysis indicated that a minimum sample size of $N = 25$ participants per group would provide sufficient power, achieving at least $1 - \beta = .7$. A power analysis helps researchers determine the probability of achieving predefined significance based on Type I and Type II error rates (Kemal, 2020). It is critical that the sample size accurately represents the overall population—not too small to render statistical analysis ineffective, nor too large to yield statistically significant results due to an unnecessarily large sample. According to the power analysis, my intervention could yield at least a small effect size of $\eta^2 = .25$. I selected this *G*Power* estimated effect size as a compromise between Bigand and Tillman's calculated overall effect size of $g = .234$ (2022) and Cooper's calculated overall effect size of $g = .276$ (2020).

Instrumentation

Testing Procedures

All participants took tests on three distinct occasions. The pre-intervention testing included an IQ test, a Stroop Test, and a Go/No-Go test. Best practices for assessing changes in executive function (EF) due to musical learning suggest including an IQ test as a potentially moderating factor (Bigand & Tillman, 2022; D'Souza & Wisenheart, 2018; Holochwost, 2017; Okada & Slevc, 2018; Sala & Gobet, 2017a; Sala & Gobet, 2017b; Sala & Gobet, 2020; Schellenberg, 2011; Schellenberg, 2013). Similarly, the Stroop and Go/No-Go tests have become standard for evaluating inhibitory control (Chen et al., 2022; Criscuolo et al., 2019; Degé & Kerkovius, 2018; Degé, 2022; Fasano et al., 2019; Harris, 2019; Hennessy et al., 2019; Jascke et al., 2018; Román-Caballero et al., 2022; Sachs et al., 2019; Sperling et al., 2023).

After 5 weeks of instruction, participants retook the Stroop and Go/No-Go tests. Following an additional 4 weeks, all participants again completed these tests. The performative nature of the community choir presented challenges for these testing periods. Since the final performance was a cornerstone of the group's traditions, taking rehearsal time for testing could disrupt ecological validity, real-time motivation, and the researcher-music leader dynamic (Habibi et al., 2022). Therefore, I carefully selected the tests and administration protocols. I recruited two trained graduate students to administer the WASI-II in person during the first rehearsal. Participants accessed the Stroop and Go/No-Go tests virtually during researcher-hosted Zoom meetings. I offered multiple virtual testing opportunities during the week prior to the intervention, during week five, and the week following the final rehearsal. During the Zoom-based drop-in sessions, I explained the testing procedures, sent participants into individual breakout rooms, and remained available for questions and troubleshooting. I administered the demographic survey and perceived rigor scale using the Qualtrics survey platform (https://www.qualtrics.com).

Testing for IQ

The *Wechsler Abbreviated Scale of Intelligence*, or WASI-II, measures IQ for research purposes using either a two- or four-subtest version (Wechsler, 2011). I selected the two-subtest version of the WASI-II to best maintain ecological validity, as it requires in-person administration. The first subtest asks participants to define single words of increasing difficulty. Administrators score responses based on predetermined definitions. For example, a participant may define the word "lamp" as "a kind of light you turn on," which would earn 2 points. Another participant might define it as "it has a bulb and a shade" or "it glows," earning 1 point. Participants who cannot define the word receive 0 points. The test ends after three failed words. Examples of

increasing word difficulty included subsequent words like "bell," "summer," "impulse," "panacea," and "pavid."

The second subtest requires participants to select a shape that best fits a predefined matrix of shapes, also arranged in order of increasing difficulty. Participants begin with a 4x4 matrix containing two apples and one banana. They then choose from five options, one of which includes the missing banana. A more difficult matrix might consist of variously colored shapes oriented spatially, so that the missing option completes a pattern, sequence, or combination of spatial relationships. Test administrators combine the scores from each subtest to yield an IQ score. The derived scale positions 100 as the average IQ, with a standard deviation of 15 points (Wechsler, 2011). The testing took approximately 10 to 15 minutes per participant.

Testing for Inhibitory Control

I selected tests for inhibitory control from the test library available on www.testable.org (Rezlescu et al., 2020). The website saves participant results in individual CSV files and records information about users' machines, including browser version, operating system, and screen resolution. Additionally, each file provides timing performance indicators, such as reaction time and correct or incorrect responses. The website also allows researchers to aggregate responses for import into SPSS or other data analysis software.

A study conducted in 2020 compared timing performance—specifically, accuracy and precision of presentation and reaction times—between Testable and desktop applications (Bridges et al., 2020). The findings suggested no reliable differences between the browser-based and desktop-based experiments. Testable's developers noted that the website has since undergone further optimizations following the initial data collection in 2019 (Rezlescu et al., 2020).

Furthermore, a 2018 study, which did not focus on Testable, similarly found no differences in data quality between web-based and desktop-based experiments (Miller et al., 2018).

More recently, researchers developed a seven step model for validating software programs using Testable's online battery (Ellington et al., 2022). These steps included preparing a checklist of basic features, recording the software interface during procedures, validating timing mechanisms, validating the data collection system, and ensuring proper implementation of independent variables. Researchers conducted this study using the Safari, Firefox, and Chrome browsers on both iPad and iMac devices, as well as in residential and university locations. They found that, apart from the Chrome browser, all basic features on www.testable.org performed with nearly 100% reliability. One identified limitation to validity was an unbalanced randomization of target stimuli within two-, four-, and six-stimulus comparison arrays, which tended to favor positions on the right side of the array. Neither the Stroop nor the Go/No-Go tests used in my study required a comparison array.

Stroop Test

The Stroop Test from www.testable.org (Rezlescu et al., 2020) measures response rates to congruent or incongruent pairings of differently colored words (Golden, 1978; Stroop, 1935). During the test, participants identify the ink color of a word amidst text that includes color word labels. Congruent identification involves saying the color of a correctly colored word, as in the word "red" printed in red ink. Incongruent trials occur when the text and ink do not match, such as when the word "yellow" appears in green ink. In this case, the participant must inhibit the primed reading response of saying the word “yellow” and instead say “green.” The average increase in response time during incongruent trials reflects the "Stroop inhibition effect" (Stroop, 1935). Stroop tests demonstrate high classical test-retest reliability when using response latencies

rather than difference scores (Strauss et al., 2005). The testing takes approximately 10 minutes per participant. Fully colorblind participants did not take the Stroop Test but still participated in the study.

Go/No-Go

The Go/No-Go test from www.testable.org (Rezlescu et al., 2020) measures response rates to targeted versus foiled trials. Participants first see crosshairs at the center of the screen, which serve as a visual fixation point. When the letter "A" appears at this point, participants respond by pressing the space bar. However, if the letter "B" appears, they must inhibit pressing the space bar. Results display the average response time for both targeted and foiled trials. The testing takes approximately 5 minutes per participant. Results from multiple tests examine changes in response rates, or latency, and the commission rate. To determine the commission rate, the number of mistakes made on foiled trials is divided by the total number of foiled trials. I selected the Go/No-Go test as a secondary measure of inhibitory control, as some potential participants' colorblindness may preclude their ability to take the Stroop test. The Go/No-Go test also shows strong practice effects in terms of latency or initial response time (Tyburski et al., 2021). For the purposes of this study, however, the Go/No-Go test primarily served as a check on the validity of the Stroop test, and its test-retest properties factored into data analysis and interpretation.

Adapted CORGIS & VGDS Survey of Perceived Rigor

At the end of the 10 weeks, all participants completed an adapted version of the CORGIS (Challenge Originating from Recent Gameplay Interaction Scale) and VGDS (Video Game Demand Scale) surveys to assess perceived rigor. As described in Chapter 2, the CORGIS and VGDS surveys best align with my conceptual framework. The video gaming framework for

balancing challenge and difficulties also closely resembled Vygotsky's educational zone of proximal development (1978), which researchers posited may explain musical learning's ability to develop executive function (EF) (Degé, 2021).

The adapted survey consists of 29 items organized into six categories: performative, emotional, techniques (adapted from controller), cognitive, social, and physical demand. McDonald's ω for each original category was as follows: 0.951 (5 items), 0.926 (6 items), 0.894 (4 items), 0.875 (4 items), 0.866 (5 items), and 0.874 (4 items), indicating very good internal consistency (Flint et al., 2023). Within each category, participants scored items on a 100-point slider corresponding to five descriptors anchored by "Strongly Disagree" and "Strongly Agree." Each descriptor accounts for 20 points along the slider. Item construction examines the categorical features from multiple, related angles, such as "The techniques were very natural to me," "The training's techniques were like second nature to me," "The training's techniques were easy for me to execute," and "The training's techniques tripped me up." A final, 30th item allows participants to provide a narrative response regarding their experience learning vocal techniques during the intervention period. I included a sample of the adapted survey in Appendix B.

Personal Inventory

At the onset of the study, both groups completed a personal inventory related to their knowledge and understanding of vocal technique concepts pertinent to their assigned group. I added both groups' inventories to Appendix C. Using *Music Assessment for Better Ensembles*, I interpreted Shaw's (2018) examples regarding knowledge self-assessment (p. 93) and skill self-assessment (p. 115) to design each inventory. I also applied Wiggins and McTighe's (2005) concepts of acquisition, meaning, and transfer to create the contents of each inventory. Additionally, participants self-assessed their understanding of how to produce sounds in selected recordings.

The intervention group listened to four recordings: a large-larynx opera singer performance, a small-larynx opera singer performance, a professional choir recording, and a pop singer belting the national anthem. The comparison group listened to three recordings: the same large-larynx and small-larynx opera singer performances, and the same professional choral recording. During the final session, both groups completed the personal inventory by self-assessing their current knowledge and understanding of the same skills while listening to the same selected recordings.

Interventions

Each group received a vocal techniques intervention. Both groups met with me once a week for approximately 60 minutes to receive their prescribed intervention. They also received an additional 90 minutes of combined rehearsal time, yielding a total of 150 minutes of rehearsal. The intervention group met prior to the combined choral rehearsal, while the comparison group met afterward amidst the non-participants. During intervention times, singers not engaged in the intervention attended sectionals to learn notes and rhythms. At the midpoint of the study, I switched the meeting times to balance the effects of small versus large group learning, and the potential effects of having an early and a late meeting time. The 90-minute combined rehearsal focused on learning notes, rhythms, pronunciation, and general ensemble skills, including dynamics, articulations, and interpretative elements achievable without specific vocal technical instruction. Both groups received instruction that incorporated audio, visual, kinesthetic, reflective, and playful elements to deliver the vocal technique curriculum. The intervention group's intervention consisted of a motor-based vocal pedagogy (Estill Voice Training™), whereas the comparison group received a traditional, *bel canto*-based vocal pedagogy.

Intervention Group Intervention: Estill Voice Training™ (EVT)

I crafted the motor-based curriculum using Estill Voice Training (EVT), created by Jo Estill in 1988 (Estill Voice, 2024). This training focuses on the discrete control of 13 individual anatomical structures within the vocal tract. Both the teacher and students use hand signs to accompany the manipulation of these 13 structures, referred to as "figures." The "figures" combine into "recipes" that categorize six EVT-established vocal idioms: "nasal twang," "oral twang," "speech," "opera," "sob," and "belt." Using hand signs that mimic the changes in anatomical structures facilitates learning and manipulation of each "figure."

Over the 9-week period, participants explored the 13 "figures" and their associated hand signs and applied them to choral repertoire. This process involved visual, aural, and kinesthetic understanding of each structure through video, audio, and playful activities. Participants created a "choral recipe" to implement in their repertoire. A typical instructional period consisted of approximately 20 minutes of explaining EVT using visual and audio examples, 20 minutes of large and small group exploration, and 20 minutes of individual coaching and group reflection.

I developed the intervention using Understanding by Design (UBD) (Wiggins & McTighe, 2005), a curriculum design method that emphasizes backward design and encourages top-down thinking from the educator's perspective. The core conceptual device for conveying pedagogy involved what Tan (2015) called negative and positive instances of the concepts. I characterized the "figures" and "recipes" into two opposing modalities. Participants demonstrated their understanding of concepts through transfer activities involving practice and performance. I added a summary of the curriculum and accompanying materials in Appendix C.

Comparison Group Intervention: Traditional Vocal Pedagogy

I created the traditional vocal pedagogy curriculum based on techniques developed by European classical practitioners. I primarily sourced materials from Richard Miller's seminal

work, *National Schools of Singing: English, French, German, and Italian Techniques of Singing Revisited* (1977), as well as from my personal experiences as a vocal pedagogue. Miller's book examined the Western European practices of teaching classical voice in detail, from the inception of Renaissance-era treatises to the advent and adoption of voice science in vocal pedagogy. Unlike the intervention group, which explored multiple singing modalities, the comparison group refined one modality. Another distinguishing characteristic of the comparison group was its lack of a motor basis or the development of independent control of the vocal apparatus, including any codified hand signs. Instead, the comparison group focused on understanding aesthetic abstractions such as *chiaroscuro*, *appoggio,* and *messe di voce*, which teachers commonly feature in Western classical vocal pedagogy. They transferred their understanding into the pre-selected repertoire for the ensemble. I also used Understanding by Design (UBD) in crafting the comparison group pedagogy. I included a summary of the curriculum and accompanying materials in Appendix C.

Quantitative Data Analysis

To answer research question 1 (What is the association of teaching a motor-based vocal pedagogy versus a traditional vocal pedagogy with executive function, specifically inhibitory control, among adult amateur singers in a community choir setting?), I analyzed the results of the Stroop and Go/No-Go tests using *IBM® SPSS® Statistics 29*. I conducted a 2x3 between-subjects (intervention vs. comparison group) and within-subjects (pre-mid-post testing) repeated measures ANOVA. To assess potential systematic differences between groups, I conducted independent t-tests on each of the control variables: IQ, socioeconomic status (SES), age, previous musical experience, and gender. I hypothesized that the intervention group would achieve a

greater percentage of change in accuracy and latency results of the Stroop and Go/No-Go tests at the midpoint and post-test phases.

To answer research question 2 (How do adult amateur singers perceive the rigor of a motor-based vocal pedagogy in a community choir setting compared to their peers' perceptions of the rigor of a traditional vocal pedagogy?), I conducted independent t-tests on the mean scores from the adapted CORGIS and VGDS combined scales. First, I used *IBM® SPSS® Statistics 29* to calculate descriptive statistics for each group's categorical responses (performative, emotional, techniques, cognitive, social, exertional, and decision-making). In basic Likert scale analysis, the median is the most appropriate measure (Analysing Likert scale/type data, 2023). Using means and standard deviations to describe the scale aids the analysis, as when combined, they describe a personality trait or attitude. Next, I performed independent t-tests to compare the categorical means as inference testing. I hypothesized that the novel introduction of conceptual knowledge would engender perceived rigor in both groups. Due to the multimodal activities and additional performative responsibilities of the intervention group, I anticipated higher perceived rigor responses. Based on my personal experience with learning vocal technique, I also hypothesized that response values would be higher overall in the categories of performance, techniques, and cognitive understanding.

To answer research question 3 (Does a singer's perception of rigor interact with their scores of inhibitory control?), I used *IBM® SPSS® Statistics 29* to run Pearson's correlations, by group, of categorical means from the perceived rigor scale and post-test Stroop effect scores. I hypothesized that the motor-based group would show more correlations between the perceived rigor scale results and the Stroop effect scores than the traditional group. Researchers in the field of executive function suggested that rigor is a necessary element for developing executive

function (Diamond & Lee, 2011). Finally, I collated responses from the participants' personal inventories and used *IBM® SPSS® Statistics 29* to calculate descriptive statistics for each group's self-assessment of knowledge and understanding. I conducted an independent t-test to determine statistical significance between groups and a dependent t-test to determine statistical significance within each group from session 1 to session 9.

Qualitative Data Analysis

The final item on the perceived rigor survey states, "This season you spent dedicated time learning and applying vocal techniques. How would you describe these efforts' impact on the overall challenge, demand, or rigor of your choral experience?" I analyzed participant responses using a multi-tiered coding protocol (Saldaña, 2021). In this protocol, researchers select a code—usually a noun or phrase—that encapsulates participant responses. I established my first-tier codes by grouping similar adjectives found within each narrative. In subsequent tiers, I further categorized participants' statements within the higher-tier codes by selecting additional codes.

Researcher Positionality

At the time of this study, I possessed 15 years of experience as a music educator and choral conductor. I earned my bachelor's degree in choral music education and a master's degree in choral conducting. Additionally, I achieved my Certificate of Figure Proficiency from Estill Voice International, which inspired the development of the motor-based pedagogy. I had over a decade of experience teaching voice in both group and individual settings at collegiate and adult levels. My background reflects a strong interest in voice science and the intersection of vocal and choral pedagogy. I also acknowledge my status as a white, male, highly educated individual and the social privilege and power that may intersect with my role as the primary researcher and interventionist.

As the director of the study chorus, I adhered to ethical safeguards for community-based research to minimize bias in participants and data interpretation (Wood & Kahts-Kramer, 2023). I received the appropriate training and experience in the study's methodologies. In my fourth year as conductor and seventh as a community member, I built relationships with many potential participants. As a performance-based ensemble, I maintained an agreement with potential participants to continue achieving our organizational performance goals. I provided detailed consent forms that outlined the study's purpose, confidentiality, privacy, roles and responsibilities, and the freedom to withdraw at any time. I clarified how the dissemination of research would occur to potentially benefit others. I presented a clear methodology, maintaining the use of first person throughout my paper and in any IRB proposals. I formulated research questions and data generation methods through planning, acting, evaluating, and reflecting. I positioned myself as a participatory member, allowing me to serve as a facilitator and insider researcher. Participatory research aids the translation of theory into action by developing praxis (Freire, 1970). This translation occurs through collaboration and critical reflection, shortening the distance between my inherent power as a researcher and respect for the rights of the participants (Wood & Kahts-Kramer, 2023). Finally, I constructed and delivered two equally considered curricula and further minimized bias by switching intervention times at the study's midpoint.

Limitations

Despite significant findings in multiple community choir studies, the quasi-experimental nature of this study posed several challenges (Habibi et al., 2022). First, although careful pretesting and matching procedures enhanced internal and ecological validity, community choirs represent a specific, self-selected population. I prioritized maintaining ecological validity given the nature of the community choir. Aside from the online surveys and tests, which total about 2

hours of additional time, I required no extra time or travel commitment outside of the traditional rehearsal schedule. While the intervention focused on building vocal technique, I utilized the ensemble's performance repertoire as the training vehicle rather than relying on commonly used art songs or supplemental repertoire. Additionally, despite awareness of the two study groups, both the intervention and comparison groups typically practiced the same repertoire each week. I also provided the same sectional opportunities for all singers, regardless of their intervention time. My overall intention was to facilitate an experience that felt like previous seasons, integrating this study into the existing rehearsal expectations.

To enhance methodological rigor, I created matching groups based on the demographic intake survey (Stuart & Rubin, 2008). I analyzed the survey data as control variables to account for variances within the sample that might otherwise create statistical outliers or inconsistencies. Additionally, repeated testing helped address moderating factors. Within-group variability arises from individual differences between participants, which quasi-experimental designs must navigate. One major advantage of analyzing data through repeated measures ANOVA is that it minimizes individual differences, thereby reducing overall statistical error (Stevens, 2007). This feature increases the overall power of a quasi-experimental design. Both the lack of participant randomization and clinical testing procedures make it difficult to achieve methodological rigor according to the "gold standard" of randomized experimental design. Because this chorus mounted a performance at the end of the ten weeks, I chose a quasi-experimental design with a comparison group to maintain balanced voice parts and numbers for effective practice. For example, true randomization might place all but one tenor into a single group, making the experience difficult for the solitary tenor and the other voice parts. I believed that success for both the intervention

and comparison groups hinged on establishing a functioning ensemble, meaning all voice parts needed workable representation. This compromised some of the matching procedures.

Next, using an online testing portal and procedures presented a threat to internal validity. While this approach seemed unorthodox and vulnerable to issues of testing validity, other virtual data collection methods with musicians yielded significant results (Duffy, 2018; Greenspon & Pfordrescher, 2019; Pfordresher, 2022). In these cases, the testing interfaces occurred entirely between participants and the online platform. In my study, I monitored all testing. Indeed, ensuring best methodological practices within community choir settings presents many challenges (Habibi et al., 2022). However, these design difficulties are balanced by enhanced ecological validity. Community choir studies generally show less attrition than randomized control studies due to higher levels of participant motivation. In fact, in one randomized control group study, choral participants excluded from the intervention reported disappointment, which may have negatively affected the study's results (Skingley et al., 2013). Conversely, research in executive function (EF) indicates that engagement and motivation are critical for developing EF (Diamond & Lee, 2011). While some researchers advocate for more randomized control research in community choir settings (Galinha et al., 2020), others support non-randomization to avoid framing music interventions as clinically therapeutic and prescriptive (Habibi et al., 2022). Additionally, as mentioned in Chapter 2, many studies with community choirs yielded beneficial results across various research contexts.

To achieve better methodological practices, I adopted recommendations from two publications that suggested best practices in community choir research (Dingle et al., 2019; Habibi et al., 2022). Concurrently, I recognized my importance as a musical leader and primary researcher in influencing the findings. Habibi et al. noted the occasional lack of fidelity in musical

interventions when a disconnect exists between the researcher and the interventionist. Dingle et al. emphasized the importance of the leader's personal qualities in creating a positive singing and study experience, especially in a performative setting (2019). I also included a robust theoretical framework that encompassed comprehensiveness, precision, testability, empirical validity, heuristic value, and applied value. Results of this study may not extend beyond comparisons of similar populations.

Finally, typical introductory training for Estill Voice Training (EVT) lasts approximately 40 hours within a 5-day period. Participants in this study received approximately 9 hours of EVT exploration over 10 weeks within a choral context. While this intervention aligns in dosage with other studies examining the association between musical learning and the development of EF skills, the participants did not demonstrate the same level of technical understanding and acumen as typical EVT participants. I also know of no other instances of EVT training studies within an adult community choir setting. While I designed the curriculum for this purpose, I could not predict how the participants would respond to the training.

Methodological Changes Post Prospectus Defense

The pre-testing phase yielded many perfect Go/No-Go tests (n = 31); therefore, I made two changes to the testing and analysis procedures. First, instead of using the commission rate from the Go/No-Go test, I calculated the latency after a no-go trial as a loose measure of inhibitory control. Next, I added a second Go/No-Go test during mid-point testing and post-testing. This second test introduced an additional stimulus, the letter C, which also required participants to press the space bar. This added Go stimulus increased the likelihood of maximizing false alarms, or incorrectly pressing the space bar for the letter B, without taxing working memory (Young et al., 2018).

I anticipated recruiting two trained graduate students to administer the WASI-II in person during the first rehearsal. Due to the staggered start times for each group, the singers' desire not to miss rehearsal or study group time, and the duration of the WASI-II, it took three trained graduate students five weeks to collect and tabulate the IQ scores. Fortunately, I found no statistically significant difference between the groups; however, IQ did not factor into the matching procedures for group formation.

Initially, I planned to split intervention sessions into three 20-minute sections: first for learning a new technique, second for practicing it, and third for receiving individual and group coaching. It took five weeks to teach each group their set of techniques, which left four weeks for refining those techniques within each group. After the first rehearsal, I realized that I needed more time to teach each new technique and that immediate application to repertoire better facilitated learning.

For the motor-based group, during the first 5 weeks, I spent about 20 minutes each session reviewing previous techniques, another 25 minutes learning new techniques, and about 10 minutes applying those techniques to performance repertoire. During the final 4 weeks, when the motor-based group rejoined the larger choir, each session consisted of approximately 50 minutes of technical reinforcement directly related to the performance repertoire. I spent an average of about 5 minutes on exercises that targeted individual techniques.

For the traditional group, during the first 5 weeks, I spent about 15 minutes reviewing previous techniques and learning new techniques, followed by about 40 minutes applying those techniques to performance repertoire. During the final 4 weeks, when the traditional group met with me outside of the larger choir, each session consisted of about 40 minutes revisiting and refining techniques. I spent an average of about 15 minutes applying their techniques to repertoire.

These changes in time distribution mainly reflected the difference between meeting each intervention group within or outside the larger ensemble. The small group setting facilitated a classroom-like laboratory for in-depth exploration of technique, while the large group setting enabled direct application within a rehearsal context. The addition of non-study participants required more direct application to maintain ecological relevance for all singers during that hour.

4 RESULTS

Organizing and Cleaning Data

Due to the use of multiple data collection methods (WASI-II, Qualtrics, Testable, Personal Inventory), I compiled a primary database using Numbers. Before importing the Stroop data from Testable, I cleaned the data within the site's .csv files. Approximately 5% of the N = 51 participants experienced freezing during their testing, which varied based on individual computer, microphone, and Wi-Fi capabilities. Individual .csv files captured this issue by recording a latency, in milliseconds, that reflected the pause. Since each trial lasted 2000ms, I considered deleting any trials that recorded a latency exceeding 2000ms. To confirm these deletions, I listened to the audio playback of each participant's tests to verify any freezes. After this process, I calculated the scores and imported them into the primary database. The freezing occurred for the same participants at each testing phase.

Sample demographics

I display the demographic characteristics of the participants by study group in Table 1. A total of N = 51 individuals participated, with an attendance rate of 91.23%. The motor-based group had an attendance rate of 91.5%, while the traditional group attended at a rate of 90.67%. After conducting several independent t-tests and Chi-square analyses between the two study groups, I found no significant differences in age, gender, yearly income, years of singing experience, vocal pedagogy training, or years of vocal training. The overall mean age was 54.76 years (SD = 18.62), with the youngest participant aged 18 and the oldest aged 83. Participants reported a mean income of $74,706 ($SD$ = $35,488), a mean of 31.39 years (SD = 20.06) of singing experience, and a mean of 11.73 years (SD = 13.65) of vocal training. Testing for IQ revealed a mean score of 113.04 (SD = 11.89). Racially, both groups skewed white (n = 44), with the motor-based group including n = 4 non-white singers (n = 3 Black, n = 1 Other) and the traditional group

including $n = 2$ non-white singers ($n = 1$ Asian, $n = 1$ American Indian). Two participants reported colorblindness, but both expressed full confidence in their ability to take a color-based test like the Stroop color-word test. These participants were in the traditional group. Thirteen individuals reported neurodiversity ($n = 6$ attention deficit hyperactivity disorder, $n = 1$ autism and ADHD, $n = 1$ dyslexia and ADHD, $n = 1$ autism, $n = 1$ attention deficit disorder, $n = 1$ migraines, $n = 1$ reported "yes"). Two participants reported surviving a stroke ($n = 1$ subarachnoid, $n = 1$ right central). I assigned $n = 5$ individuals to the traditional group because they previously encountered the motor-based instruction in other contexts. I assigned $n = 3$ individuals to the motor-based group because I knew they previously encountered traditional instruction. All other participants ($n = 43$) were matched by age, income, years of singing experience, years of vocal training, and vocal pedagogy experience while ensuring representation of all voice parts in each study group (Stuart & Robin, 2008). The motor-based group included 12 sopranos, 10 altos, 2 tenors, and 2 basses, while the traditional group included 11 sopranos, 10 altos, 2 tenors, and 2 basses.

Neurodiverse Participants

Fourteen participants reported either surviving a stroke ($n = 2$), neurodiversity ($n = 12$), or both ($n = 1$). Since their pretesting scores were not statistically different, with one exception, from those of the other participants, I included their scores in the overall data set for the study, according to Welch's t-test. The groups showed a statistically significant difference in Go/No-Go commission rates, $t(49) = -1.85$, $p = .032$, which contributed to the ceiling effect observed during pretesting. As a follow-up, I conducted Welch's t-test on the post-testing scores, and the results were statistically insignificant. I present these results in Table 2.

Table 1.

Demographic Characteristics of the Participants.

Variable	Motor-Based Group	Traditional Group	*p*-value
Age	56.65 (18.61)	52.80 (19.79)	$.47_t$
Gender	F = 21, M = 5	F = 22, M= 2, G =1[a]	$.32_{\chi 2}$
IQ	110.96 (12.08)	115.2 (11.54)	$.21_t$
Years of Singing Experience	34.58 (19.92)	28.08 (20.05)	$.25_t$
Years of Vocal Training	12.46 (14.72)	10.96 (12.69)	$.7_t$
Income	74,808 (35,142)	74,600 (36,570)	$.98_t$
Self-Reported Skill[b]	A = 9, P = 4, S = 13	A = 5, P = 3, S = 17	$.41_{\chi 2}$
Vocal Pedagogy Experience[c]	N = 13, Y = 4, L = 9	N = 17, P = 1, L = 7	$.26_{\chi 2}$

Note. Data are mean (standard deviation) unless otherwise reported. Abbreviations: $\chi 2$ = chi-square test, t = independent-samples t-test. [a] G = genderqueer. [b] A = amateur, P = professional, S = skilled amateur. [c] N = no, Y = yes, degree related training, L = yes, limited exposure.

Table 2.

Welch's t-test results for pre- and post-testing scores of neurodiverse and stroke survivor participants compared to neurotypical participants

Variable	Neurodiverse and Stroke Survivors	Neurotypical	*p* - value
Stroop pre-congruent trials	865.86 (103.35)	847.85 (107.04)	.588
Stroop pre-incongruent trials	978.77 (136.5)	981.30 (144.97)	.954
Stroop pre-effect	112. 91 (61.30)	133.45 (71.56)	.318
Stroop pre-accuracy	1.00 (1.11)	2.11 (3.73)	.111
Go/No-Go pre-commission	.02 (.04)	.05 (.06)	.032
Go/No-Go pre-latency	481.68 (104.74)	450.49 (72.15)	.319
Go/No-Go pre-latency after no-go	456.98 (99.24)	430.98 (65.76)	.376
Stroop post-effect	98.36 (33.97)	92.11 (54.83)	.628
Stroop post-accuracy	1.07 (1.21)	1.57 (1.74)	.258
Go/No-Go post-commission	.09 (.26)	.05 (.05)	.526
Go/No-Go post-latency	404.73 (49.85)	403.69 (53.29)	.949
Go/No-Go post-latency after no-go	410.74 (47.94)	401.64 (56.95)	.571

Note. Data are mean (standard deviation) unless otherwise reported.

Pre-testing results

All participants ($N = 51$) took two tests of inhibitory control (Go No-Go and Stroop color-word). See Table 3. Overall, participants demonstrated a mean Stroop effect of 127.81ms ($SD = 68.92$) with a mean 1.84 ($SD = 3.28$) accuracy score. Participants showed a mean latency of 459.05ms ($SD = 82.45$) in the Go/No-Go test and a mean latency of 438.12 ($SD = 76.23$) in trials occurring after the No-Go stimulus, with a mean commission rate of .04 ($SD = .05$). After conducting a series of independent t-tests, no significance was found between groups by Stroop congruency trials, $t(49) = 1.366$, $p = .18$, Stroop incongruent trials, $t(49) = 1.853$, $p = .07$, Stroop effect score, $t(49) = 1.671$, $p = .101$, Stroop accuracy score, $t(49) = .27$, $p = .788$, Go/No-Go latency, $t(49) = .098$, $p = .922$, or Go/No-Go latency after No-Go, $t(49) = -.553$, $p = .585$. The pre-testing phase yielded many perfect Go/No-Go tests ($n = 31$), which indicated the potential for ceiling effect during subsequent testing phases. Due to this, I omitted commission rates, but rather tracked the mean response latency of Go trials and mean response latency of Go trials occurring after No-Go trials as a loose measure of inhibitory control.

Table 3.

Inhibitory control pretesting results.

Variable	Motor-Based Group	Traditional Group	*p*-value
Stroop congruent trials	872.38 (99.46)	832.43 (109.35)	$.18_t$
Stroop incongruent trials	1015.73 (142.71)	944.08 (132.96)	$.07_t$
Stroop effect score	143.35 (74.82)	111.65 (59.42)	$.1_t$
Stroop accuracy score	1.96 (2.25)	1.71 (4.16)	$.79_t$
Go/No-Go latency	460.17 (82.32)	457.89 (84.26)	$.92_t$
Go/No-Go latency after No-Go	432.29 (67.52)	444.18 (85.34)	$.58_t$

Note. Data are mean (standard deviation) unless otherwise reported. Abbreviations: t = independent-samples t-test.

Usability of Go/No-Go Testing Results

I include the results and analysis of all Go/No-Go tests in Appendix D due to usability issues, and therefore these results did not contribute to my main analysis. Three main factors led to this decision. First, as mentioned in Chapter 3, the Go/No-Go test demonstrates strong practice effects, especially regarding latency (Tyburski et al., 2021). With the addition of the second Go/No-Go test, participants ultimately took this test 5 times over nine weeks. Second, I observed a possible ceiling effect on commission rates during the pre-testing phase. Other studies have reported similar ceiling effects with reaction time deadlines set at 1000ms (Johnstone et al., 2013a; Johnstone et al., 2013b). Testable.org sets its default reaction time deadline at 1000ms. Finally, while testing my hypothesis with the Go/No-Go data, I encountered an issue of logic and reason: I anticipated that both groups would improve over the duration of the study, with the motor-based group surpassing the traditional group. However, with 61% of the participants (n = 31) achieving perfect scores, these participants could not improve further. Following the addition of the second Go/No-Go test, 33% (n = 17) of participants made 1 or 0 errors, and 69% (n = 35) made 2 or fewer errors. Given that participants only took this test twice (at midpoint and post-testing) and had already completed it 4 times before the final iteration, there was little room for improvement.

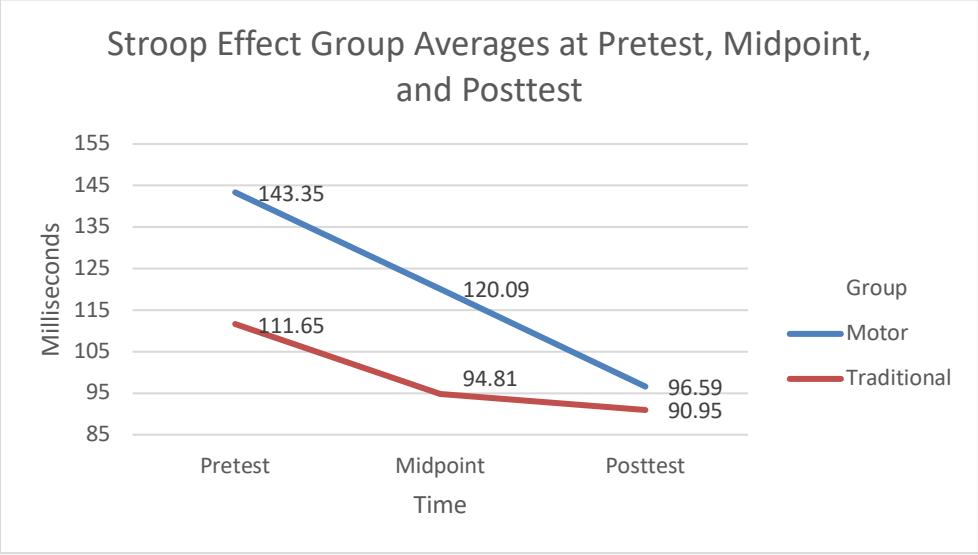
Post testing Results

After the 9th week, participants (N = 51) retook the Stroop Color-Word test. Overall, participants demonstrated a mean Stroop effect of 93.83ms (SD = 48.73), and a mean accuracy of 1.46 (SD = 1.62). I initially performed a statistical analysis by way of repeated measures ANOVA (time*treatment), to account for the mean change in the testing results from pretesting to post testing for the two groups, however, both the final Stroop effect and accuracy data failed

Mauchly's test of sphericity, $\chi^2(2) = 11.33$, $p = .003$, $\chi^2(2) = 22.64$, $p < .001$, respectively. Likely, the data did not meet the assumption of sphericity because of an overall positive skew and the existence of outliers. Instead, to analyze the between variables time and treatment, I conducted a factorial ANOVA, and for the within variable time*treatment, I adopted the Greenhouse-Geisser correction, a more conservative test than Mauchly. I present these results in Table 4. I include a midpoint analysis, and all other post testing analyses, including Stroop accuracy, and Go/No-Go testing analyses in Appendix D. The results of the repeated measures ANOVA show no significant interaction between time and treatment for the Stroop Effect, $F(1.65, 80.98) = 1.53$, $p = .221$, $\eta_p^2 = .03$. Figure 1 shows the change in each groups' average Stroop effect score from pretest to posttest.

Figure 1.

Stroop Effect Group Averages at Pretest, Midpoint, and Posttest.



Results of the factorial ANOVA showed significant differences between time, $F(2, 147) = 4.08$, $p = .019$, $\eta_p^2 = .05$. A post hoc analysis using Tukey's procedure ($\alpha = .05$) revealed the mean scores for the posttest were significantly lower than at the pretest. The analysis also showed significant differences between treatment, $F(1, 147) = 4.64$, $p = .033$, $\eta_p^2 = .03$. The mean difference between the motor-based group participants' and traditional group participants' final Stroop effect scores were significantly different.

The results of the repeated measures ANOVA showed no significant interaction between time and treatment for the Stroop accuracy scores, $F(1.45, 69.46) = 1.65$, $p = .579$, $\eta_p^2 = .01$, meaning one vocal pedagogy intervention did not outperform the other. Results of the factorial ANOVA showed no significance for either time $F(2, 147) = 1.44$, $p = .240$, $\eta_p^2 = .02$ or treatment $F(1,147) = .08$, $p = .773$, $\eta_p^2 = .001$.

Table 4.

Stroop effect post testing repeated measures ANOVA results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Time*Treatment	4698.486	1.65	2843.15	1.53	.221	.03	-7.67 – 49.42
Error	150361.59	80.98	1856.88				
Time	29346.26	2	14673.13	4.08	.019	.05	10.26 – 57.20
Treatment	16658.42	1	16658.42	4.64	.033	.03	1.71 – 40.03

Note.[a] Effect size, η_p^2 = partial eta squared

Perceived Rigor Scale

After the culminating performance participants (N =50) filled out a Qualtrics survey of perceived rigor. I conducted independent t-tests between groups based upon data yielded from the 29 survey prompts. I organized the prompts into six categories: techniques (4 prompts), performative (5 prompts), emotional (5 prompts), cognitive (6 prompts), social (5 prompts), and physical (4 prompts). I present the results in Table 5. Results of the independent t-test found four of the prompts statistically significant between groups.

In response to performance prompt 1, $t(48) = -2.30$, $p = .014$, the traditional group reported needing to listen to themselves more when performing techniques ($Mdn = 90$, $M = 85.96$, $SD = 13.32$) than the motor-based group ($Mdn = 81.5$, $M = 72.81$, $SD = 25.66$). In response to emotional prompt 3, $t(48) = -2.20$, $p = .034$, the traditional group reported a greater perception that applying the learned vocal techniques as a group would better convey emotion to the audience ($Mdn = 99.5$, $M = 95.5$, $SD = (6.49)$ than the motor-based group ($Mdn = 92.5$, $M = 88.58$, $SD = 14.52$). In response to cognitive prompt 5, $t(47) = -2.69$, $p = .010$, the traditional group reported requiring greater mental gymnastics when learning vocal techniques ($Mdn = 66$, $M = 62.08$, $SD = 23.87$) than the motor-based group ($Mdn = 40$, $M = 41.20$, $SD = 30.03$). In response to physical prompt 4, $t(45) = -2.19$, $p = .034$, the traditional group perceived learning vocal techniques as more physically demanding ($Mdn = 60.5$, $M = 61.04$, $SD = 26.36$) than the motor-based group ($Mdn = 40$, $M = 44.09$, $SD = (26.80)$.

Table 5.

Perceived rigor scale independent t-test results

Variable Survey Prompt	Motor-Based Group Median	 Mean (*SD*)	Traditional Group Median	 Mean (*SD*)	*p*-value
T1. Applying the vocal techniques was very natural to me.	80	65.77 (31.85)	85	77.96 (22.47)	.123*
T2. Singing with the vocal techniques was like second nature to me.	70	65.00 (29.75)	62	60.52 (27.26)	.590
T3. The vocal techniques were easy to produce.	70	69.00 (27.51)	71	70.67 (21.85)	.815
T4. Applying the vocal techniques tripped me up.	10	25.55 (30.76)	14	25.70 (24.75)	.986
P1. I had to listen to myself more when performing vocal techniques	81.5	72.81 (25.66)	90	85.96 (13.32)	.027*
P2. I had to listen to others more when performing vocal techniques	50	54.24 (32.26)	70	64.26 (22.42)	.222
P3. Performing vocal techniques required careful, deliberate thought.	82	76.65 (23.65)	90	85.43 (13.32)	.112*
P4. Quickly responding to things that I heard was an important part of performing.	81.5	77.81 (22.49)	80.5	79.96 (18.86)	.717
P5. I had to make quick vocal adjustments when performing vocal techniques.	80	74.52(19.60)	80	76.42 (21.83)	.750
E1. The sounds I made while applying the learned vocal techniques prompted strong personal feelings.	58.5	62.73 (29.58)	72.5	64.17 (28.58)	.862
E2. I was moved by the sounds the choir made while applying the learned vocal techniques.	84.5	82.58 (19.45)	89	83.96 (16.68)	.738
E3. Applying the learned vocal techniques as a group will better convey emotion to the audience.	92.5	88.58 (14.52)	99.5	95.5 (6.49)	.034*
E4. My emotions remained constant while applying the vocal techniques we learned.	60	60.31 (27.35)	45	48.67 (31.74)	.170
E5. The sound from the choir, after applying the learned vocal techniques, made me feel emotional.	64	68.92 (19.57)	85.5	80.54 (22.23)	.055

C1. Learning the vocal techniques was cognitively demanding.	71	63.48 (30.31)	76	72.54 (19.75)	.220*
C2. I had to think very hard when learning vocal techniques.	60.5	56.46 (30.23)	68	66.08 (22.35)	.210
C3. Learning vocal techniques doesn't require a lot of mental effort.	21.5	30.62 (28.15)	20	23.67 (18.28)	.303*
C4. Learning vocal techniques made me draw on all my mental resources.	65	53.48 (30.81)	70.5	66.17 (20.64)	.097*
C5. Learning vocal techniques required a lot of mental gymnastics.	40	41.20 (30.03)	66	62.08 (23.87)	.010
C6. I had to think actively when learning vocal techniques.	79.5	74.65 (23.81)	90	84.38 (18.45)	.115
S1. When practicing and learning the vocal techniques, I was aware of others in the choir.	70	67.88 (22.27)	83	78.79 (20.92)	.084
S2. When practicing and learning the vocal techniques, being around others in the choir hindered my ability to learn.	10	16.25 (16.93)	10	17.13 (18.11)	.864
S3. It was easier to learn vocal techniques when interacting with others in the choir.	57	60.60 (25.99)	70	65.33 (25.69)	.525
S4. The social aspect of choir was an important part of learning vocal techniques.	50	56.40 (28.31)	56	65.21 (25.77)	.261
S5. I felt obligated to others in the choir, while learning vocal techniques.	50	46.08 (28.57)	67	62.67 (28.86)	.051
Ph1. My body/voice felt drained after learning vocal techniques.	30	35.33 (28.24)	35	42.21 (28.87)	.409
Ph2. I was physically/vocally exhausted after learning vocal techniques.	15.5	24.68 (25.46)	32.5	36.38 (26.54)	.135
Ph3. I felt physically/vocally energized after learning vocal techniques.	82	75.58 (20.42)	77	77.79 (13.94)	.659
Ph4. Learning vocal techniques was physically demanding.	40	44.09 (26.80)	60.5	61.04 (26.36)	.034

*****The assumption of homogenous variances was not satisfied according to Lavene's test; therefore, p-values are based upon Welch's test.

Short Answer Response

The final survey item stated, "This season you spent dedicated time learning and applying vocal techniques. How would you describe these efforts' impact on the overall challenge, demand, or rigor of your choral experience?" Of the motor-based group, 22 individuals provided feedback. Of the traditional group, 24 individuals provided feedback. I analyzed participant responses ($N = 46$) following a two-tiered coding protocol (Saldaña, 2021). Participant responses categorized into three first-tier codes: experience, rigor, and no impact. Second-tier analysis revealed eight additional codes. Under the tier of experience, participants referenced their experience (a) overall, (b) as a learner, (c) as a singer, and (d) for the choir. Under tier of rigor, participants noted rigor (a) overall, (b) as a learner, (c) as a singer, and (d) in physical or mental terms. The first-tier code of no impact only occurred in two responses, one from each group.

When comparing the groups, it appeared that participants in the motor-based group more frequently discussed their overall experience, while the traditional group viewed the overall experience and the rigor of that experience as nearly equal. Within the overall experience, participants from both groups most often mentioned their role as a singer. The motor-based group prioritized their role as a learner, whereas the traditional group focused more on the experience as a whole. Both groups tended to mention their experience for the choir less frequently than their individual experiences.

Regarding the rigor of technical learning and application, the traditional group most often expressed an overall perception of rigor, while the motor-based group focused more on the demands of being a learner. The traditional group highlighted challenges primarily as a singer and

then as a learner, while the motor-based group reflected equally on their perception of rigor overall and their role as a singer. Mentions of the physical or mental aspects of the experience occurred least frequently among both groups.

Inhibitory Control Correlations to Perceived Rigor Scale

To examine whether a correlation existed between inhibitory control and perceived rigor, I conducted a series of Pearson correlations between participants' post-testing Stroop effect scores and the categorical means from the perceived rigor survey, analyzed by group. To create categorical means, I first calculated internal consistency within categories using Cronbach's alpha. If this value is $\alpha = .70$ or higher, then it is acceptable to add up the score on all the items to form a single measure of that category (Statistics used with surveys, n.d.). In the case of negatively worded items, I transformed the scores to an analogous positive scale using *IBM®SPSS®Statistics* 29. When assessing the emotion category, I uncovered that removing transformed emotion item 4 raised the categorical alpha from $\alpha = .69$ to $\alpha = .80$. I, therefore, removed all emotion 4 data from the correlational analysis. Omitting this item yielded an overall survey reliability of $\alpha = .81$. Each of the six categories achieved at least $\alpha = .70$ as I show in Table 6.

Table 6.

Cronbach alpha scores for perceived rigor categories.

Category	Cronbach's α
Technique – 4 items, 1 reversed	.92
Performance – 5 items	.70
Emotion – 4 items, 1 removed	.80
Cognition – 6 items, 1 reversed	.88
Social – 5 items, 1 reversed	.70
Physical – 4 items, 1 reversed	.77
Full Scale – 28 items, 4 reversed, 1 removed	.81

Using the categorical means, I then calculated, by group, Pearson's correlations between categories and post testing Stroop effect scores. For clarity of interpretation, a lower Stroop effect score indicates higher inhibitory control. Pearson's *r* exists as positively or negatively correlated (Stevens, 2007). An absolute value of 0-0.30 indicates a weak linear relationship, 0.30-0.50 indicates a moderate, 0.5-1 indicates a strong linear relationship. I share the motor-based results in Table 7 and the traditional results in Table 8. There was a significant correlation between motor-based participants post testing Stroop effect scores and Technique, $r(26) = -.47$, $p = .017$, meaning a higher perception of technical rigor in learning vocal techniques correlated to a lower final Stroop effect score. A significant interaction also existed between motor-based group Stroop effect scores and Emotion, $r(26) = -.45$, $p = .021$, meaning a greater emotional response to learning and applying the techniques correlated to a lower final Stroop effect score.

Additionally, motor-based participant's perceptions within one category correlated with another category. This significance occurred between Technique and Performance, $r(26) = .49$, $p = .011$, meaning a higher perception of technical rigor in learning and applying vocal techniques correlated with a higher perception of rigor in performing techniques. Significance also occurred between Technique and Emotion, $r(26) = .48$, $p = .014$, meaning a higher perception of technical rigor in learning and applying vocal techniques correlated with a greater emotional response garnered by applying techniques. Performance and Emotion positively correlated, $r(26) = .81$, $p < .001$, meaning a higher perception of rigor in performing vocal techniques highly corresponded to a greater emotional response garnered by applying techniques. Finally, significance occurred between Cognition and Physical categories, $r(26) = .41$, $p = .040$, meaning a greater perception of cognitive demand in learning and applying vocal techniques correlated to a higher perception of physical demand in rehearsing techniques.

For the traditional group, there were no statistically significant correlations between perceived rigor categories and final Stroop effect scores. Between categories correlations, however, existed. There was significance between Technique and Performance, $r(24) = .48$, $p = .017$, Performance and Emotion, $r(24) = .42$, $p = .04$, Performance and Cognition, $r(24) = .46$, $p = .022$, meaning the greater perception of rigor in performing vocal techniques correlated with a greater cognitive demand in learning and applying techniques, and Physical and Emotion, $r(24) = -.46$, $p = .025$, meaning a greater emotional response to learning and applying vocal techniques correlated to less physical demand in rehearsal.

Table 7.

Pearson's correlations for motor-based group and perceived rigor categories.

Variable	Stroop Score	Technique	Performance	Emotion	Cognition	Social	Physical
Stroop Score	-						
Technique	-.47*	-					
Performance	-.25	.49*	-				
Emotional	-.45*	.49*	.81**	-			
Cognition	-.20	-.21	.26	.24	-		
Social	-.15	.22	.22	.35	-.06	-	
Physical	.02	-.35	-.32	-.37	.41*	-.23	-

Note. *Correlation is significant at the .05 level. **Correlation is significant at the .01 level.

Table 8.

Pearson's correlations for traditional group and perceived rigor categories.

Variable	Stroop Score	Technique	Performance	Emotion	Cognition	Social	Physical
Stroop Score	-						
Technique	-.03	-					
Performance	-.13	.48*	-				
Emotional	-.38	.20	.42*	-			
Cognition	-.02	-.11	.46*	.02	-		
Social	-.18	.09	.09	.18	.08	-	
Physical	.34	-.37	-.17	-.46*	.29	-.03	-

Note. *Correlation is significant at the .05 level.

Correlation Between Tests of Inhibitory Control

As a final analysis, I examined any possible correlations between the post testing scores from the tests of inhibitory control, by group, using Pearson's *r*. There were no statistically significant results for the motor-based group. These results are located in Appendix E. There were statistically significant correlations for the traditional group. I display these results in Table 9. Statistical significance occurred between posttest Stroop effect scores and the Go/No-Go commission rate, $r(25) = .42$, $p = .035$, meaning a higher Stroop score correlated with a higher commission rate. Significance also occurred between posttest Stroop accuracy scores and the first Go/No-Go commission rate, $r(25) = .41$, $p = .040$, as well as the second Go/No-Go commission rate, $r(25) = .51$, $p = .009$, meaning lower Stroop accuracy correlated with a higher commission rate.

Table 9.

Pearson's correlations between the post testing scores of inhibitory control, traditional group.

Variable	Stroop score	Stroop Accuracy	Go/No-Go 1 After No-Go Latency	Go/No-Go 1 Commission	Go/No-Go 2 Commission
Stroop Score	-				
Stroop Accuracy	.05	-			
Go/No-Go 1 After No-Go Latency	.42*	.41*	-		
Go/No-Go 1 Commission	.14	.01	-.04	-	
Go/No-Go 2 Commission	-.08	.51**	.23	-.04	-

Note. *Correlation is significant at the .05 level. **Correlation is significant at the .01 level.

5 DISCUSSION

This chapter contains a synthesis between the study results and my research questions, literature review, and frameworks outlined in chapter 1. I follow this synthesis with implications for music education, a review of study limitations for the generalizability of my results, and suggestions for future research. Over 10 weeks, $N = 51$ participants engaged in a community choir experience, which included nine vocal pedagogy sessions, three rounds of executive function testing, a culminating concert featuring over 100 singers, organ, and brass, and a final survey on perceived rigor. These singers learned one of two distinct vocal pedagogy curricula. The motor-based experimental group ($n = 26$) followed a curriculum grounded in voice science, while the traditional comparison group ($n = 25$) adhered to a curriculum based on the historical vocal tradition of bel canto. Each curriculum was delivered using the same design (Wiggins & McTighe, 2005) and analogous materials (videos, PowerPoint presentations, vocal exercises, personal inventory assessments), with applied vocal techniques set to the same repertoire within a shared choral context.

I began my inquiry in consideration of Freer's (2011) suggestions regarding the performance-pedagogy paradox, emphasizing the need for balance within this dichotomy. Other researchers suggested that a stronger emphasis on pedagogy can enhance performance (Lamont, 2011; Redman & Bugos, 2019; Woody et al., 2019). Inspired by this pursuit of balanced reciprocity and the historical role of community singing as a lifelong learning vehicle (Choate, 1968; Dykema, 2016; Madsen, 2000; Mark & Madura, 2014), I sought to answer: "What types of knowledge and skills are necessary to provide this balance in adult, amateur community choirs?" and "What outcomes can these efforts yield?"

Adult singers typically identify as "amateurs" (Moss et al., 2018; Redman, 2016; Redman & Bugos, 2019) and often regard instrumentalists as more skilled (Lamont, 2011). I, therefore,

explored the effects of balancing the paradox by addressing vocal skill acquisition. I selected a motor-based vocal skill development as the primary pedagogical focus as it fit within the psychological complexities of skill framework (Fridland, 2019; Pacherie & Mylopoulos, 2020; Stanley & Krakauer, 2013) and the lack of skill that often leads singers to disengage from music-making as adults (Lamont, 2011; Redman & Bugos, 2019; Woody et al., 2019). This inquiry addressed my first core question.

In relation to my second core question, I investigated gaps in learning outcomes between adult instrumentalists and amateur singers in community choirs. Despite the numerous benefits of participating in a community choir (Clements-Cortés, 2015; Feng et al., 2020; Hennessy et al., 2021; Johnson et al., 2013; Johnson et al., 2018; Maury et al., 2022; Moss et al., 2018; Pentikäinen et al., 2022; Särkämö, 2017; Särkämö, 2020; Tamburri et al., 2019; Wiech et al., 2020), there is a lack of studies indicating positive associations between this activity and growth in executive function (Feng et al., 2020; Johnson et al., 2018; Mansens et al., 2017; Pentikäinen et al., 2021; Vertere et al., 2024). However, research has shown that adults engaged in instrumental learning demonstrate growth in executive function (Bugos & Wang, 2022; Columbo et al., 2020; Degé & Kerkovius, 2018; Mansens et al., 2017; Särkämö, 2017; Särkämö, 2020; Vetere et al., 2024; Wang et al., 2024).

I hypothesized that a pedagogical difference occurs due to the inherent processes of developing motor skills through instrumental learning, suggesting that a motor-based vocal pedagogy could similarly enhance executive function among adult community choir singers. To test this hypothesis, I constructed a study that examined the effects of learning a motor-based vocal technique on the growth of executive function, the first of its kind. I focused on the development of inhibitory control, a subcomponent of executive function, due to its strong association with

musical learning (Aryanto et al., 2024; Jamey et al., 2024; Schellenberg & Lima, 2023). Analyzing the results yielded rich opportunities for discussion within the frameworks I established in Chapter 1, in the context of the literature reviewed in Chapter 2, as well as the field of music education. Ultimately, the results indicate that explicitly teaching vocal technique through a systematic, curricular approach yields growth in executive function regardless of the pedagogy type. Singers in both the motor-based and traditional group increased their inhibitory control. Discussing the results as related to my research questions provides nuance to this primary finding.

Research Question 1: What is the association of teaching a motor-based vocal pedagogy versus a traditional vocal pedagogy with any change in executive function, specifically inhibitory control, among adult, amateur singers in a community choir setting?

Data analysis of the Stroop test results from pre-to-midpoint, midpoint-to-post, and pre-to-post showed statistically significant changes in inhibitory control for both groups: $F(1,49) = 7.568$, $p = .008$, $\eta_p^2 = .134$; $F(1,49) = 4.61$, $p = .037$, $\eta_p^2 = .09$; $F(2,147) = 4.08$, $p = .019$, $\eta p^2 = .05$, respectively. Overall, participants demonstrated improvement in inhibitory control over the 9 weeks. These findings align with and even exceeded recent meta-analyses that reported small to moderate effect sizes of musical learning on executive function (Aryanto et al., 2024; Bigand & Tillman, 2022; Hernandez et al., 2021). Seminal researchers in executive function, Diamond & Lee (2011), noted that growth depends on the novelty, rigor, and self-interest associated with an intervention.

While the repeated measures ANOVA showed no significant interactions between time and group, Figure 1 suggests potential interactions with a longer study period or other intervention changes. In this study, the motor-based group did not demonstrate greater growth in inhibitory control compared to the traditional group, although their growth did surpass the traditional

group's during the final 4 weeks. A dependent t-test confirmed the experimental group's change in Stroop effect scores, $t(25) = 2.66$, $p = .014$, $d = .52$, while the comparison group showed no significant change, $t(24) = .42$, $p = .678$, $d = .08$. This analysis appears in Appendix D.

The motor-based group continued to show growth in inhibitory control, likely due to the cognitive benefits of chunking (Fridland, 2019; Pacherie & Mylopoulos, 2020). They learned 13 individual figures designed for chunking into vocal "recipes." By week 9, many singers still needed improvement on each figure and could not demonstrate complete vocal recipes, suggesting that further improvement might arise from additional practice. The unfamiliarity of the motor-based curriculum, along with the additional need to learn vocal anatomy, may have delayed the onset of skill acquisition. Participants might have needed the first few weeks to "digest" the new information before applying it in the choral context. In contrast, the traditional group learned 14 terms related to vocal abstractions. Many items elicited similar vocalizations (e.g., mask resonance, forward resonance, chiaroscuro). While some of the terminology was new to participants, the technical goals were delivered in a relatively familiar manner. For these participants, skill acquisition may have occurred more quickly but then lost some novelty by the end. Neither group, however, mastered their vocal technique curriculum, so the potential for further growth in executive function remains. Further research is needed to determine why the motor-based group continued to grow in inhibitory control while the traditional group did not.

The motor-based group worked individually to understand and manipulate various voice science components to achieving a bel canto-like sound. They experienced an idiomatic prompt that isolated and typified a vocal figure, learned the accompanying terminology and hand sign for that figure, visualized the anatomical properties and processes associated with it, and then practiced the figure in multiple contexts. I provided feedback on the execution of each figure.

This approach, combining vocal figures into a chiaroscuro- or messe di voce-like recipe, aligns with auditory predictive processes (Greenspon & Pfordrescher, 2019; Pfordrescher, 2022) that may involve inhibitory control—illustrating a connection between musical learning and executive function training (Degé, 2021). Similarly, individuals in the traditional group worked to understand and manipulate various vocal abstractions like chiaroscuro or messe di voce to achieve the same aesthetic. I modeled a sound, provided multiple prompts and contexts to practice the sound, and provided feedback on their reproduction. This kind of learning likely also aligns with auditory predictive processes that may involve inhibitory control.

Research Question 2: How do adult amateur singers perceive the rigor of a motor-based vocal pedagogy in a community choir setting compared to their peers' perceptions of the rigor of a traditional vocal pedagogy?

After the culminating performance, participants completed an adapted scale of perceived rigor, derived from a combined scale used in video game development (Flint et al., 2023). To my knowledge, this is the first scale of its kind in music education, allowing participants to assess curriculum quality across six domains: technical rigor, performance rigor, emotional response, cognitive demand, social constraints, and physical demand. The scale demonstrated high reliability, with a Cronbach's $\alpha = .81$, indicating good internal consistency. All categories, except one item from the Emotion category, maintained internal consistency at $\alpha = .70$ or above. This item, "My emotions remained constant while applying the vocal techniques we learned," was removed from statistical analyses due to ambiguous wording that may have elicited broad and varied responses. A revised version of the scale would likely exclude or revise this item. Overall, the scale effectively captured participants' perceptions of their experience with acceptable to good

accuracy. Additionally, the final item allowed for a narrative response, providing further context for their scores.

In 23 out of 29 items, the traditional group reported higher median scores than the motor-based group, as shown in Table 9. Four items reached statistical significance through independent t-tests: the traditional group felt a greater need to listen to themselves when performing vocal techniques ($t(48) = -2.30$, $p = .014$), believed applying learned techniques conveyed more emotion to the audience ($t(48) = -2.20$, $p = .034$), required more mental effort when learning techniques ($t(47) = -2.69$, $p = .010$), and experienced greater physical demand in learning ($t(45) = -2.19$, $p = .034$). The motor-based group had slightly higher median scores in three items: feeling more physically and vocally energized after learning techniques, valuing quick responses to auditory cues in performance, and that singing with learned techniques felt second nature. However, in reversed items aimed at eliciting lower scores, the motor-based group reported feeling less physically exhausted, less drained, and less tripped up when applying techniques, though these differences were not statistically significant.

Given my philosophical framework of powerful knowledge (McPhail, 2023) and theoretical framework of the psychological complexity of skill (Pacherie & Mylopoulos, 2020), these were not the results I expected. I had hypothesized that the motor-based pedagogy would be perceived as more rigorous. Several factors may explain this unexpected outcome. First, the traditional group had better initial test scores and higher average IQ. As an experienced educator, I also noticed greater "buy-in" to the learning process from this group, week to week. They were a “better” class of students who seemed to try harder.

Second, while I was careful to avoid any cross-contamination of vocal curricula—never discussing vocal technique during the 90-minute combined rehearsal—I did not forbid

participants from discussing their experiences with each other. It is possible that members of the traditional group sensed their role as the secondary, comparison group, which may have heightened their desire to perform well.

Next, I designed two equally considered curricula using the Understanding by Design (Wiggins & McTighe, 2005) model. In most choral contexts, the delivery of traditional curricula occurs less explicitly throughout the course of a rehearsal, either through preparatory vocal exercises or repertoire rehearsal. In some cases, vocal technique is taught tacitly through conductor feedback regarding issues such as tuning or blending of voices. By treating both pedagogies as explicit curricula, participant growth was, in part, due to direct instruction.

Because the motor-based curriculum presents the internal logic of a vocal "recipe," along with corresponding hand signs for reinforcement and a sequential delivery of hierarchical relationships, participants may have perceived it as "user-friendly" and therefore less rigorous. Conversely, despite learning a range of skills through sequential delivery, participants in the traditional group may have perceived increased rigor due to the complexity of each abstraction. According to Cognitive Load Theory (Sweller, 2011), participants in this group may have experienced extraneous cognitive load. Learning vocal abstractions required them to simultaneously process many elements of information, whereas participants in the motor-based group processed fewer elements at a time.

For example, the musical alphabet contains seven letters, A to G. When a musician sings or plays notes from one A to another A, they perform a scale. For instrumentalists, to reduce extraneous cognitive load, most will first learn the C scale, as it requires no altered pitches (sharps or flats). Next, they learn scales with one sharp and one flat, then progress to scales with two altered tones, and so on. Starting with the A scale, despite it being the first letter of the alphabet,

would require the alteration of three pitches, thus presenting unnecessary cognitive load to an instrumentalist unfamiliar with scales.

For members of the traditional group, learning chiaroscuro required simultaneous processing of multiple elements. In contrast, motor-based group participants first learned to produce a thin vocal fold body cover, then a narrowed aryepiglottic sphincter, a tilted thyroid cartilage, and false vocal fold retraction—adding one element at a time to produce the same chiaroscuro vocalism. While both pedagogies share the same intrinsic cognitive load due to the shared vocal aesthetic, Cognitive Load Theory adherents (Sweller, 2011) would categorize the motor-based pedagogy as having less extraneous cognitive load. In contrast, the traditional pedagogy's higher extraneous cognitive load may have led participants to perceive it as more rigorous.

Research Question 2, narrative feedback

The final survey item allowed for open-ended responses to the prompt, "This season you spent dedicated time learning and applying vocal techniques. How would you describe these efforts' impact on the overall challenge, demand, or rigor of your choral experience?" Responses indicated an added rigor to the choral experience, as well as insight into participants perceptions of novelty and self-motivation. Both groups provided similar responses regarding rigor and self-interest but differed in their views on novelty.

Rigor

Perceived challenge reflects both negative and positive aspects of difficulty (Flint et al., 2023). Difficulties involve barriers that can lead to a sense of failure, carrying a negative connotation. One participant noted, "It took a lot of effort for me to adjust mentally to the techniques, as it was new to me, but it came more naturally as the season went on." Another stated, "While very demanding to learn, practice made it much easier." Participants expressed sentiments like

"greater mind-body connection," "improved concentration," "focus up," and "pushed me." A participant from the motor-based group summarized, saying, "They [vocal techniques] allowed me to reach a next level in my singing that I did not previously have the training or techniques for. Surprisingly, learning the vocal techniques made reaching this next level less physically demanding than it would have been with my previous techniques."

Regarding difficulties, participants reported feelings of tiredness or exhaustion but framed these in a context of gratitude for the resulting rehearsal and vocal growth. One participant remarked, "Even though I was consistently exhausted by the end of rehearsal, the challenge of learning and incorporating the techniques energized and clarified my efforts." Another shared, "I was physically tired but not vocally tired. That surprised me. I had a lot of singing in a short amount of time, and I wasn't vocally stressed." This added exertion led to higher musical abilities and greater aesthetic satisfaction (Redman & Bugos, 2019). Many participants felt that learning vocal techniques "added to" or "enhanced" their choral experience. One wrote, "I believe the sound that we created was the best I've heard over the last eleven years singing with the ensemble." Individually, participants reported a "better sound," "greater endurance," and "improved vocalizations" or "vocal coordination."

Self-Interest

While not directly measured, the narrative responses indicated that participants felt interested and motivated by the experience. One participant wrote, "It was exciting to hear the difference in my singing." Another participant offered, "I was excited to learn more about the mechanics of vocal production." A few participants mentioned they would "continue to use these techniques in the future." Lamont (2011) proposed that amateurs rate technique as the most valued skill contributing to their lifelong musical participation. Tan (2015) reported that teaching

cognitive skills led to higher learner self-motivation. One participant described this skill-building experience, writing, “[it was a] unique experience of immediate application and practice. I felt I was better prepared to access my voice since my 'instrument' was physically and mentally ready.” Another participant reflected, “By the end of the season, I could tell that I had greater vocal flexibility and strength than before. I also felt as though I had a better grasp on some of the techniques.”

Novelty

Like self-interest, I did not measure the novelty of either intervention. However, participant responses indicated a difference in the novelty of the experience. One motor-based participant honestly offered, “At first, it was a lot to comprehend.” Another motor-based participant wrote, “It wasn't the technique I'd been using in choir, church choir, or otherwise.” A few from the traditional group noted things like, “reinforcing skills that are universally accepted by many choral directors/teachers,” or “I had learned bel canto techniques before,” but then followed with “having the opportunity to relearn and expand on them during rehearsals was both enjoyable and challenging,” or “but not as concentrated or intense as the study groups provided.”

Therefore, the motor-based curriculum likely proved more novel than the traditional curriculum. One motor-based participant summarized the experience, writing, “It made us all speak a similar language, so I could both picture physically and audibly what sounds you were looking for us to produce and where.” Pacherie and Mylopoulos (2020) suggested that this flexibility sits at the center of intelligently skilled action. Participants in the traditional group offered summary assessments involving increases in “confidence,” “preparation,” or “ease overall in the experience.” One traditional group participant wrote, “I noticed that I didn't always feel like I got certain techniques right away, while others felt more natural to me and were easier to produce.

When I figured out which ones I needed to pay attention to, I still found that it was a process of trial and error to determine what I needed to do differently."

This statement likely indicated a struggle with the abstractions inherent in the traditional curriculum, the extraneous cognitive load (Sweller, 2011). Despite creating a scope and sequence for delivering this curriculum, it consisted of horizontal discourses, generally segmented from each other or bound by context (McPhail, 2023). In addition to this context dependence, the curriculum utilized ongoing practices more akin to typical choral experiences and employed strong affective connections between members. Indeed, compared to the motor-based group, the traditional group more often wrote about the entire choral experience. Fourteen traditional group members reported on the overall experience, compared to only four from the motor-based group. Perhaps both groups experienced versions of powerful knowledge, "structured by relationships of concepts that create logical 'systems of meaning'" (McPhail, 2023, p. 30). Results of this study show that adding rigor, outside of novelty, yielded beneficial growth to inhibitory control for both groups. The recently quoted traditional group member echoed the flexible mindfulness of the motor-based participant, writing, "There were places in the program where we had talked about applying a certain technique or aiming for a certain type of sound, and when we got to those parts, it was easier to think, 'I know how to do this' and try to make it happen intentionally."

Research Question 3: Does a singer's perception of rigor interact with their scores that measure inhibitory control?

Notably, the Pearson's correlation analysis revealed that perceptions did not necessarily reflect statistical findings. Despite higher median scores on 23 of the 29 inventory items, the traditional group scores of inhibitory control showed no statistically significant correlations with

perceptions of rigor. The post-testing Stroop effect scores of the motor-based group, however, significantly correlated with two survey categories: technique, $r(26) = -.47$, $p = .017$, and emotion, $r(26) = -.45$, $p = .021$. In other words, motor-based participants who perceived a greater demand in learning and applying vocal techniques exhibited a lower Stroop effect—they demonstrated higher inhibitory control. Similarly, participants who felt a greater emotional impact from their or the choir's sound due to applying vocal techniques also possessed higher inhibitory control.

This discrepancy may stem from the epistemological differences between the interventions. Although both curricula included sequencing, similar activities, and scope—both groups worked toward the same vocal aesthetic—the motor-based pedagogy offered more internal logic, and less extraneous cognitive load (Swellers, 2011). According to McPhail (2023), the pedagogical process for integrating knowledge sources involves daily and explicit naming of disciplinary subject concepts. In music, this process includes naming the actions that connect thinking in sound with the concepts involved in executing those actions. The motor-based group learned a choral recipe that began with thinning the vocal fold body cover, followed by adding vocal "twang" through narrowing the aryepiglottic sphincter and then tilting the thyroid cartilage while lowering the larynx. They also practiced strategies for specific situations, such as retracting false vocal folds and engaging neck muscles when notes approached the top of their individual ranges.

Conversely, the traditional group began their choral recipe by finding their head voice, followed by balancing their vocal chiaroscuro and monitoring their breath management or use of appoggio. They learned to combine these concepts by applying messe di voce to vocal lines within their repertoire. Both curricula connected thinking in sound with constructional concepts, but the motor-based curriculum perhaps revealed more relationships between concepts.

Participants from this group likely possessed more interconnected supervisory knowledge (Elliot, 1995), which possibly aided in adjusting or regulating their thinking. If simple tasks like pitch matching require the use of top-down cognitive control through auditory imagery and vocal motor planning (Greenspon & Pfordresher, 2019), and if enhancing the auditory image through technical training increases pitch accuracy (Pfordrescher, 2022), then the motor-based group may have made more connections between the epistemic parts (McPhail, 2023) due to the explicit internal logic of the curricular materials. Thus, the motor-based curriculum likely contained more powerful knowledge than the traditional curriculum.

Statistically, the motor-based group showed more interactions between scale categories than the traditional group. Both groups' perceptions of demand in learning techniques and applying those techniques in performance positively correlated, $r(26) = .49$, $p = .011$, $r(24) = .48$, $p = .017$, with a slight increase in significance for the motor-based group. These results likely speak more to the reliability of the perceived rigor scale than to any differences between the interventions. Both groups' perceptions of demand in applying techniques in performance also positively correlated with their feelings about applying vocal techniques. Both groups experienced positive and beneficial interventions. It is also possible that because traditional group participants perceived greater rigor overall, that the consistently high rigor scores could not correlate with the variability in Stroop effect scores.

Lamont (2011) and McPhail (2023) suggested that learning contributes to identity building. Community choirs largely consist of self-described amateurs (Moss et al., 2018; Redman, 2016; Redman & Bugos, 2019). For adult singers, learning technique aids in building a robust musical identity (Lamont, 2011). The motor-based group began their treatment as a small group apart from the larger choir; their narrative responses primarily focused on individual experience.

The correlation of their perceptions of performance demand and emotional impact was very high, $r(26) = .81$, $p < .001$. Their survey responses also positively correlated technical demand and emotional impact, $r(26) = .48$, $p = .014$.

The traditional group began their treatment within the larger choir; their narrative responses balanced somewhat between the group and individual experiences. The correlation of their perceptions of performance demand and emotional impact was moderate, $r(24) = .42$, $p = .04$. Their survey responses also negatively correlated physical demand and emotional impact, $r(24) = -.46$, $p = .025$, meaning that individuals who experienced less physical demand in rehearsals reported a greater emotional response to applying vocal techniques—it felt good to sing in this manner.

Finally, statistical differences between groups illuminate how members perceived cognitive demand in correlation with another scale category. The motor-based group's cognitive demand scores correlated with physical demand, $r(26) = .41$, $p = .040$. The traditional group's cognitive demand scores correlated with performance demand, $r(24) = .46$, $p = .022$. Based on median scores for individual items, the motor-based group perceived learning their vocal techniques as less cognitively and physically demanding than the traditional group. The traditional participants' greater physical demand in learning their techniques likely correlated positively with the performance demand because they perceived higher effort, or rigor, overall. Their higher median scores on 23 out of 29 items corroborate this conclusion.

Implications for Music Education

In consideration of the performance-pedagogy paradox (Freer, 2011), this study provides one pathway through which concerted efforts in pedagogy enhances perceptions of performance. Both groups perceived the interventions positively. For adult amateur singers, this rigorous

attention to vocal technique resulted in cognitive gains, aesthetic satisfaction (Redman & Bugos, 2019), and possibly even identity building that promotes lifelong engagement in music (Lamont, 2011). For these types of learners, music education may protect against executive function deterioration (Sharma & Shenoy, 2023; Vetere et al., 2024) and promote adaptability, open-mindedness, and interpersonal skills (Laal & Salamati, 2012). Although community choirs generally include a conductor who selects and teaches materials, controls pacing, and manages group interactions within a structured environment (Veblen, 2018), singers risk falling into the "discursive gap" (Bernstein, 2000). A muddling of formal and informal practices (Veblen, 2018) intensifies this risk, whereas explicit instruction, like the motor-based curriculum, offers an opportunity for learners to make connections between the epistemic parts (or internal logic) and the whole of a subject (McPhail, 2023).

This process enables singers to develop abstraction and conceptualization skills regarding that subject. This acquisition of powerful knowledge carries implications for choral music education at large. In the case of adult community choirs, conductors should consider including opportunities for singers to act as lifelong learners by explicitly teaching skills like vocal production. Too often, these ensembles function more like Creative Clay, a space for singers to rekindle or continue their love for singing, demonstrate pride in a varnished performance, and connect with others through a shared appreciation of the art form. Without diminishing these goals, conductors could enhance the performative aspects through more attention to skill building. This refocusing towards skills and concepts impacts school-aged learners as well.

According to McPhail (2023), a school's chief purpose is to provide access to systems of meaning—epistemic knowledge available only within that context. Learners likely do not access this knowledge outside of formal settings. Compared to their instrumentally focused peers,

school-aged choral students demonstrate significantly reduced or even no improvements in academic achievement due to musical learning (Guhn et al., 2019; Kinney, 2008; Shaw, 2022). Strong executive function impacts academic achievement as well as other desirable outcomes like job success, marital harmony, and public safety (Diamond, 2013). The existence of this gap in cognitive growth throughout the lifespan of amateur vocalists highlights the need to address conceptual learning within choral environments.

Generally, students of most ages characterize a concept through action first, followed by visual understanding or iconic representation, and finally through cognition or symbolic understanding (Gault, 2005). Pedagogic "populism" (Bernstein, 2000) may persist in choral classrooms, where teachers "water down" propositionally based, structured knowledge with techniques that prioritize procedural and operational elements (McPhail, 2023). Additionally, often-used curricular knowledge may lack the internal logic necessary for learners to transition from the experiential to the abstract or conceptual. For example, many choral educators prioritize subdividing at the eighth note for all sight-reading practice, which supplants teaching rhythmic concepts such as tactus, metrical stress, and syncopation. This practice also obscures learning the inherent sound or feel of the musical score and the rhythmic components therein. Another example includes the use of misnomers like "supporting or engaging from the diaphragm," along with misunderstandings about the function of the soft palate/velum. Insisting on this language disrupts the building of conceptual hierarchies and relationships between the actual muscles of breath support, the diaphragm's function, air pressure, and tonal production. In the case of the soft palate, students may confuse ideas about resonance, vocal fold mass and closure, tongue position, and laryngeal positioning rather than making connections between the epistemic parts and the whole of a subject.

Reorienting choral educators towards implementing powerful, fact-based knowledge requires potentially systemic change. For pre-service teachers, this might include required vocal pedagogy coursework in genre-free methods like Estill Voice Theory or other contemporary commercial methods like Somatic Voicework™ (LoVetri & Woodruff 2011), or Complete Vocal Technique (Complete Vocal Institute, 2024). Currently, nine institutions of higher education, five of them located in the U.S.A., serve as Estill Voice Educational Affiliates (Estill Voice, 2024). Should more schools follow, future preservice teachers and students in K-12 education may reap the benefits of this type of concepts-based teaching. Choral methods students might focus on identifying musical and vocal concepts embedded within repertoire rather than techniques that aid in achieving performance goals. Their ensemble directors should spend more time modeling concepts-based teaching—balancing the performance-pedagogy paradox—rather than reinforcing practices that eschew powerful knowledge for procedural or operational elements. *Choralosophy* podcaster Munce (2019-present) regularly calls out educators who serve as "high priest," or those through whom students must go through to achieve musical excellence. Rather, the educator's job includes teaching the knowledge and skills for students to find musical excellence without them.

Practicing educators must rely upon professional development or self-initiated opportunities to fill in knowledge gaps that may prohibit teaching powerful knowledge. This might include learning more about non-bel canto singing techniques, procedures for teaching notational literacy, or practices that engender musical independence. In the case of vocal pedagogy, Estill Voice Theory relies upon learning voice science terminology. In level 1 and level 2 training, individuals demonstrate skill proficiency to certified practitioners. To achieve certification, a master trainer must assess individuals in their proficiency of knowledge and execution of figures and

recipes. Elementary teachers wanting to incorporate Estill Voice Theory might explore all thirteen figures through age-appropriate materials, games, musical play and body mapping. For instance, a figures-based approach to singing *Wake the Cows* might have the teacher characterize the A-section "wake up, you sleepy head and go and fetch the cattle. Wake up, you sleepy head and go and fetch the cows!" through thick vocal fold body cover. The teacher would then characterize the B-section, "The cows are lost. The sun is gone. I think I'll rest. 'Till they come home." Through thin vocal fold body cover. Accompanying the singing with related hand signs for thick and thin vocal fold body cover would enhance the experience.

In middle school, educators might assess students' ability to distinguish between and execute various figures, as well as their knowledge of vocal anatomy. A choral work in French may incorporate high, mid-, and low velum sounds. Students could demonstrate the resultant non-nasal, partially nasal, and fully nasal resonances by showing related hand signs as they sing the French text. Their ensemble teacher might teach one or two vocal recipes that represent the vocal sounds endemic to their student population. For instance, students singing a gospel arrangement might demonstrate thicker vocal fold body cover and greater torso anchoring as compared to a Classical-era motet.

High school and university choral educators might then experiment with multiple vocal recipes, refinement of vocal figure execution, or promote exploration of student-identified vocal goals. Choir retreats might include Estill Level 1 or Level 2 training explicitly. Afterwards, teachers could create a listening assignment where students identify the vocal recipes used in four contrasting genres. Teachers could then craft a choral program that included a Renaissance motet, Broadway ballade, pop anthem, and American folksong with a unifying theme of unrequited love songs. Students would identify the four different vocal recipes for each piece and

practice the figure manipulation required to produce each genres' sound. They might empower students to develop their own recipes for a variety of repertoire. To implement this kind of teaching, practicing educators must not over-program for their choirs. Rather they would need to select repertoire appropriate to the musicianship level of their singers.

Regional organizations might alter their demands concerning large and small group evaluations accordingly. At all levels, choral educators must consider their prioritization of performance over pedagogy. Class offerings at all levels might include an ensemble not oriented or solely oriented towards performance, but towards building musicianship. Currently, to achieve choral excellence, many educators rely upon data such as enrollment, performance adjudications, and whether an ensemble can sing in 8 to 12-part harmony acapella. To achieve this invites the temptation to create practice tracks, utilize vocal misnomers, teach from the piano, or other instances of "watered down" pedagogy.

Practices that yield to pedagogic populism (Bernstein, 2000) likely reinforce an educational environment lacking conceptually based assessments (Chism, J., 2022; Kambs, 2024; Russell & Austin, 2010). A study of 182 secondary choral educators in Indiana revealed that these teachers relied chiefly on data such as attendance and participation as their primary mode of assessment (Kambs, 2024). This finding aligned with a 2010 survey of 352 secondary choral educators in the southwestern USA (Russell & Austin, 2010) and another study of 50 collegiate choral directors (Chism, J., 2022). The persistence of non-conceptually based assessments reveals an imbalance in the performance-pedagogy paradox. Focusing on the cognitive dimension of music learning articulates a holistic and objective set of assessment criteria and shared academic language (Hanna, 2007). Without incorporating powerful knowledge, educators risk applying a

choral “lacquering,” like my Creative Clay experience, rather than teaching the skills that contribute to lifelong participation.

By implementing conceptually based assessments, in this case the acquisition of vocal techniques, educators might increase time spent in critical, higher-order thinking (Garrett, 2013; Watkins, 1996; Strauser, 2008) They would accrue what music education philosopher Elliot (1995) termed “supervisory knowledge.” For example, the development of a sensorimotor loop (Greenspon & Pfordresher, 2019) involves predictive processes enhanced through technical training. Auditory representations mapped onto motor representations, learned through vocal technique training strengthens the predictive process. For example, when the thyroid tilts, the sound “sweetens” due to thinning of the vocal folds, a sensation of sonic direction occurs, and vibrato production may start or increase relative to the effort used in this action. Refining this kind of technical training potentially extends learners’ cognitive architecture and empowers them to think conceptually about singing (McPhail, 2023). Students might then receive an assessment based upon their ability to demonstrate a singing technique or create a vocal recipe through a combination of vocal manipulations.

Finally, the prevailing vocal timbre typically found in choral settings reproduces a tonal culture that exacerbates the existential crisis of relevance facing the field of music education (Bennett, 2021; Kos Jr., 2010; Koza, 2008; Shaw, 2016). Recently, however, motor-based contemporary commercial music methods, like the one used in the motor-based group, have emerged as effective, vertically structured vocal pedagogies (Fantini et al., 2016; Rodgers, 2020). Students of contemporary commercial music methods include those seeking to sing in multiple vocal styles, especially non-Western classical ones. Incorporating this kind of vocal

learning may ameliorate some of the relevance issues between sounds created in choral environments and the bodies of those participating or choosing not to.

Limitations

As an exploratory study and the first of its kind, many limitations exist that affect both the results and the interpretability for a larger population. Firstly, the quasi-experimental design helped maintain ecological validity (Habibi et al., 2022); however, it posed many challenges to methodological rigor. To achieve their primary performance goal, the community choir required a substantial portion of time for full-group rehearsals. This setup meant that the motor-based group started in a classroom-style setting before the main rehearsal, while the traditional group learned their techniques within the choir at large. Despite a swap in settings midway, the onset of knowledge acquisition may have influenced the characterization and quality of that process. In the future, researchers might employ a within-subjects design, where all participants experience both conditions, allowing for a consistent overall learning environment. Additionally, the classroom setting provided opportunities to watch videos, listen to recordings, and offer one-on-one instruction. Many community choir rehearsal spaces, including the one I used, lack the technologies necessary for effective instruction of this kind; therefore, rehearsals with the larger group could not include audio, video, or projections. Future researchers may require capital investments in equipment that facilitates specific curricular integration into the rehearsal process.

To maintain ecological validity, I chose online testing procedures to minimize the impact of testing on rehearsal time and expectations. Despite this choice, in-person IQ testing took many weeks and required participants to miss between 10 and 20 minutes of study group or rehearsal time. Fortunately, no statistically significant difference existed between groups. Unfortunately, I could not use IQ as part of the matching procedures, which may have altered the makeup of the

groups. Additionally, participants on average held high IQs and were aware of their participation in a study. These factors could have influenced test taking and motivation factors related to learning and applying techniques. The online tests ran relatively smoothly; however, their novelty presented a scarcity of research to find comparable studies and data. Additionally, my lack of familiarity with the features embedded in Testable.org contributed to problems with the Go/No-Go tests. Better utilizing the customizable parameters on Testable.org in relation to traditional testing studies and data may have yielded better results. I mistakenly relied on default settings instead of anticipating future issues.

As another attempt to maintain ecological validity, I formed each study group as its own choir, ensuring representation of all voice parts. In hindsight, I should have grouped all tenors together and placed basses in another group. Due to attrition and occasional absences, some groups only had two tenors or basses present, which potentially negatively impacted their learning experience. When re-assimilated within the larger choir, these singers may have felt overwhelmed by the vocal production of others in their voice part. A larger cohort of study-trained tenors and basses may have performed better and found more consistent practice. Fortunately, for both curricula, the choir at large amicably and enthusiastically learned and applied the vocal techniques.

In contrast to real-world accuracy, I taught both pedagogies with the intention of delivering equally valid curricula. This meant that I taught every participant in both groups to the best of my ability as an educator and conductor. In typical choral environments, traditional vocal pedagogy is often employed implicitly or tacitly throughout rehearsals. Comparing the motor-based pedagogy, which requires explicit time for explaining physiology, learning hand signs, and developing techniques, to the traditional pedagogy—as conceived in this study—may have created

a false equivalency to the typical choral setting. Teaching traditional pedagogy explicitly may have affected the cognitive and perceptual outcomes of learning those techniques. Without suggesting the superiority of one teaching method over another, designing a study with a motor-based control group and a separate group without an explicit comparison might yield different results.

Next, despite conducting a *G*Power* analysis to determine a minimum number of participants, a larger sample size, within reason, would yield more robust results. Due to the wide range of testing scores and participant responses, some of the statistical analyses failed initial tests of homogeneity of variance and sphericity. These scenarios prompted additional analyses, resulting in a wealth of additional and alternative data that occasionally muddled efforts at clear statistical interpretation. Additionally, among the total participants ($N = 51$), 14 reported neurodiversity. While no statistical difference existed between these 14 participants and the overall group regarding the measurements chosen in the study design, my study lacked a scientifically "healthy" population. Future researchers with larger sample sizes might exclude certain participants from analysis while still allowing them to participate.

Finally, I included no formal assessments of learning. I collected participant surveys, inventories, and scales based on self-assessment. Without formal assessments, I could not confirm whether participants learned each technique correctly or to what degree. I conducted various assessments for learning, which confirmed the sonic results of the correct application of technique within both small and large ensemble settings. To the best of my knowledge, the ensembles adjusted their singing according to the techniques I taught as we practiced them. Certainly, future researchers, especially in formal academic environments, should include individual assessments of technical proficiency.

Future Research

Aside from the previous suggestions, future researchers may implement longer interventions. While each group effectively learned its respective vocal techniques, neither group's intervention simulated a full-scale vocal curriculum. Initial Estill Voice Technique training takes about 40 hours, while traditional bel canto vocal studies occur over several years. This extended training provides time for individuals to combine and flexibly adjust techniques. Researchers believe chunking reduces cognitive burden (Fridland, 2019; Pacherie & Mylopoulos, 2020), meaning individuals may focus on one unified chunk rather than its disparate elements. Study participants likely lacked sufficient time to develop this ability. Allowing more time for this development might further elucidate differences between the vocal techniques in terms of testing an epistemologically structured curriculum versus one governed largely by vocal abstractions.

Additionally, future researchers should examine other executive functions, including "hot" executive functions like decision-making and delay discounting. They might also consider different age groups and other demographic factors. In this study, I focused on perceived rigor; however, other studies could examine perceived novelty or self-interest. While I may have presented equally rigorous vocal curricula, examining differences in novelty or self-interest could yield additional valuable insights. Other researchers could also explore different aspects of choral music learning, such as comparing concept-based instruction with vocal pedagogies, including notational literacy strategies, music theory, and diction techniques (e.g., the International Phonetic Alphabet). Future researchers might assess full Estill Voice Technique courses compared to other contemporary commercial methods in terms of their effects on developing executive functions.

Finally, while I did not explore the effects of learning vocal techniques in relation to neurodiversity and speech-language pathology in this study, connections may exist. Estill Voice maintains a relationship with the American Speech-Language-Hearing Association (Estill Voice, 2024). Two participants provided feedback related to this domain. One participant wrote:

> I had been diagnosed with laryngeal dysphonia last year…and was unable to sing for six months. Working with a speech therapist, I was able to work through most of my technical problems. The Estill Technique reinforced everything my speech therapist had me working on earlier in the year. As a seasoned professional singer and educator, I was grateful for the refresher course that this offered. It not only made me look at the way I sing differently, but it also inspired me to approach my choir students in a different manner as well. The simplicity with which this technique allows for immediate results is fantastic.

Another participant shared:

> My experience of the study was a noticeable improvement in my vocal coordination. There were even hints of the tone my voice produced prior to having a stroke. Focusing on the minutiae of the vocal apparatus within the 'voice box' proved beneficial to my rehabilitation, and some of those old neuron connections were either restored or successfully rerouted. For a somewhat humorous example of how these connections formed bit by bit without my even being aware, one of the videos mid-study featured a man sticking out his tongue and speaking briefly as an example. As I watched, I unconsciously stuck out my own tongue and noticed that it was more central; whereas before, when doctors tested for neurological damage, I could not do that; my tongue went to the side.

Conducting future studies with individuals or ensembles consisting of participants with speech-language issues or those undergoing stroke rehabilitation may yield interesting results.

Conclusion

I would be remiss to minimize the many and varied benefits of singing in a choir (Alatta et al., 2023; Clements-Cortés, 2015; Feng et al., 2020; Hennessy et al., 2021; Ito et al., 2022; Johnson et al., 2013; Johnson et al., 2018; Maury et al., 2022; Moisseinen et al., 2024; Moss et al., 2018; Pentikäinen et al., 2022; Pentikäinen, 2023; Särkämö, 2017; Särkämö, 2020; Tamburri et al., 2019; Wiech et al., 2020). Aside from these extra-musical benefits, the simple joy of singing and being part of a community perhaps surpasses any other reason to join a choir. I continue to sing for this reason. It feels good to know that other benefits also exist now or await me as I age. Similarly, I would still enjoy an afternoon spent hand-painting ceramic bowls and figurines, recalling fond childhood memories and anticipating a finished, antiqued product to share with friends and family. Without diminishing the inherent value and joy of singing in a choir, I endeavored through this study to highlight that learning powerful knowledge about singing enhances this value and joy. Taking the time to do so, while balancing the performance-pedagogy paradox, yields greater performance satisfaction and results in cognitive growth.

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APPENDICES

Appendix A

Demographic Intake Survey

Please supply the following information.

- ○ Age (1) _____
- ○ Gender (2) _____
- ○ Years of choral singing experience (3)

_____

- ○ Years of combined private vocal or instrumental training (4)

_____

Please select the race/ethnicity that best describes you.

- ○ White (1)
- ○ Black or African American (2)
- ○ American Indian or Alaska Native (3)
- ○ Asian (4)
- ○ Native Hawaiian or Pacific Islander (5)
- ○ Other (6)

Please select the option that best describes your average household income.

- ○ $30,000 and below (1)
- ○ $30,000 - $55,000 (2)
- ○ $55,000 - $80,000 (3)
- ○ $80,000 - $105,000 (4)
- ○ $105,000 and above (5)

Do you experience colorblindness?

- ○ No (1)
- ○ Yes (2)

Do you experience neurodiversity? (ADHD, ADD, ASD, Dementia, Alzheimer's, Dyslexia, Epilepsy, etc.) If yes, please list below. If not, please write N/A.

How would you describe yourself as a singer?

- o Novice (1)
- ○ Amateur (2)
- ○ Skilled Amateur (3)
- ○ Professional (4)

Appendix B

Perceived Rigor Scale

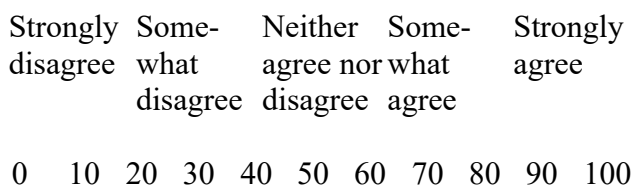
Techniques. Please use the slider to select your response to the following prompts. We learned and applied vocal techniques during the summer.

	Strongly disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Strongly agree 0 10 20 30 40 50 60 70 80 90 100
Applying the vocal techniques was very natural to me.	
Singing with the vocal techniques was like second nature to me.	
The vocal techniques were easy to produce.	
Applying the vocal techniques tripped me up.	

Performative. Please use the slider to select your response to the following prompts. This summer you performed using vocal techniques that we learned together.

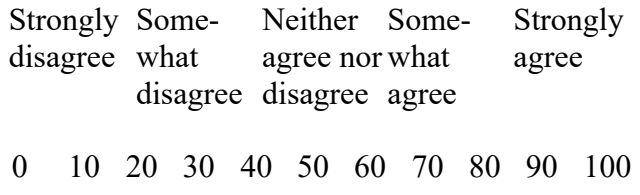
	Strongly disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Strongly agree 0 10 20 30 40 50 60 70 80 90 100
I had to listen to myself more when performing vocal techniques	
I had to listen to others more when performing vocal techniques	
Performing vocal techniques required careful, deliberate thought.	
Quickly responding to things that I heard was an important part of performing vocal techniques	
I had to make quick vocal adjustments when performing vocal techniques	

Emotional. Please use the slider to select your response to the following prompts.



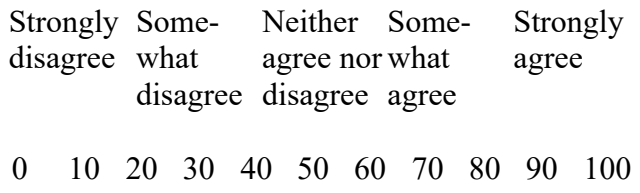
The sounds I made while applying the learned vocal techniques prompted strong personal feelings.	
I was moved by the sounds the choir made while applying the learned vocal techniques.	
Applying the learned vocal techniques as a group will better convey emotion to the audience.	
My emotions remained constant while applying the vocal techniques we learned.	
The sound from the choir, after applying the learned vocal techniques, made me feel emotional.	

Cognitive. Please use the slider to select your response to the following prompts.



Learning the vocal techniques was cognitively demanding.	
I had to think very hard when learning vocal techniques.	
Learning vocal techniques doesn't require a lot of mental effort.	
Learning vocal techniques made me draw on all of my mental resources.	
Learning vocal techniques required a lot of mental gymnastics.	
I had to think actively when learning vocal techniques.	

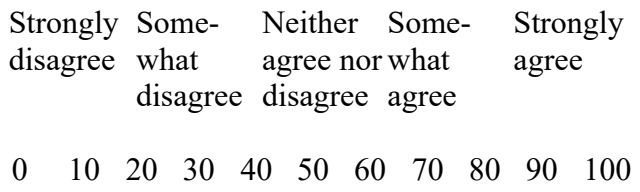
Social. Please use the slider to select your response to the following prompts. We learned vocal techniques this summer as a group.



When practicing and learning the vocal techniques, I was aware of others in the choir.	
When practicing and learning the vocal techniques, being around others in the choir hindered my ability to learn.	
It was easier to learn vocal techniques when interacting with others in the choir.	
The social aspect of choir was an important part of learning vocal techniques.	
I felt obligated to others in the choir, while learning vocal techniques.	

Physical Demands. Please use the slider to select your response to the following prompts.

Learning and applying the vocal techniques from this summer required physical movement.



My body/voice felt drained after learning vocal techniques.	
I was physically/vocally exhausted after learning vocal techniques.	
I felt physically/vocally energized after learning vocal techniques.	
Learning vocal techniques was physically demanding.	

Short Response. This season you spent dedicated time learning and applying vocal techniques. How would you describe these efforts' impact on the overall challenge, demand, or rigor of your choral experience? If you would prefer to answer via video or audio formats, please write N/A here and skip to the next question.

_____

Alternate Response. Instead of writing, please contact Andrew at aschmidt@festivalsingers.org to set up an audio or video response.

_____

Appendix C

Understanding By Design Curriculum

Established Goals, Understandings, and Essential Questions

I sourced these elements from the Georgia State Music (Georgia Department of Education, 2018) and National Music Standards (National Association for Music Education, 2014).

Transfer, Meaning, Acquisition

Wiggins & McTighe conceptualized understanding through transfer (T), meaning (M), and acquisition (A) (2005). Transfer refers to the capability of a learner to utilize their understanding in a variety of ways or environments, the long-term end of education. Meaning refers to the learner making sense out of an important concept. Acquisition refers declarative knowledge and skills learners pick up during the educative experience.

Intervention, Motor-based Group

<table>
<tr><th colspan="3">Stage 1 – Desired Results</th></tr>
<tr><td rowspan="5">Established Goals
PR4.1 Select varied musical works to present based on interest, knowledge, technical skill, and context.
PR4.3 Develop personal interpretations that consider creators' intent.
PR5 Evaluate and refine personal and ensemble performances, individually or in collaboration with others.
PR6 Perform expressively, with appropriate interpretation and technical accuracy, and in a manner appropriate to the audience and context.
ESBC.PR.2 Develop and refine musical techniques</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Learners will be able to independently transfer:
1. Their understanding of vocal, technical figures to a variety of repertoire
2. Their acquisition of vocal techniques to authentically create vocal recipes.
3. Their understanding of personal, vocal intersectionality to select and perform repertoire.</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>Understandings
1. Performers' interest in and knowledge of musical works, understanding of their own technical skill, and the context for a performance influence the selection of repertoire.
2. Performers make interpretive decisions based on their understanding of context and expressive intent.
3. To express their musical ideas, musicians analyze, evaluate, and refine their performance over time through openness to new ideas, persistence, and the application of appropriate criteria.
4. The context and how a work is presented influence the audience response.</td><td>Essential Questions
1. How do performers select repertoire?
2. How do performers interpret musical works?
3. How does understanding the context of musical works inform performance?
4. How do musicians improve the quality of their performance?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
</table>

and works for presentation	**Knowledge** *Students will know.* 1. Describe 13 vocal figures anatomically and the sonic results of their manipulation. 2. Describe thin and thick fold modalities according to figures and sounds. 3. Identify when various figures or vocal recipes would apply to selected styles of singing. 4. Identify their vocal intersectionality and preferences.	**Skills** *Students will be able to* 1. Produce manipulations of thirteen vocal figures. (Onsets/Offsets, Vocal Fold Cover, False Vocal Folds, Thyroid Cartilage, Cricoid Cartilage, Velum, Tongue, Jaw, Lips, Head and Neck Anchoring, Torso Anchoring, Aryepiglottic Sphincter, Larynx) 2. Maintain thick and thin vocal modalities for at least one phrase.

Stage 2 – Evidence

CODE (A M or T)	**Evaluative Criteria** (for final rubric)	**Goal:** The goal is for the learner to perform *Good Trouble* by Thomas Keesecker demonstrating both thick and thin modalities. **Role:** Learner as performer and repertoire selector **Audience:** Teacher as adjudicator **Situation:** Learner is an individual artist with their own vocal intersectionality. Learner demonstrates their ability to technically produce vocal sounds that authentically represent the literature. Learner integrates their vocal knowledge with the ensemble. **Product, Performance, and Purpose:** Individual and ensemble performance **Standards and Criteria for Success:** Teacher observation and performance product
M • A • A • A M • A • A M • A M • A M • A • A • A	Learner will be evaluated using these criteria. *Vocal Fold Modality* • Vocal fold cover • Mixing • Necessary breath effort *Cartilage Usage* • Thyroid tilt • Cricoid Tilt *Twang* • *AES narrowing* *Resonance* • Nasality/Orality *False Vocal Folds & Anchoring Effort* • Retraction effort • Head & Neck Anchoring • Torso Anchoring	Performance Task(s) *Students will demonstrate meaning-making and transfer by…* 1. Individually performing thick and thin modalities in *Good Trouble* with the context of a group performance/rehearsal. T 2. Employing their understanding of *vocal fold modality, cartilage usage, twang, resonance, false vocal folds, and anchoring effort* throughout the score. T Other Evidence (e.g., formative) 1. Learner self and peer assessments 2. Personal skills inventory and development log 3. Aesthetic identification quizzes

Stage 3 – Learning Plan

CODE (WHERE[2] TO)	Pre-Assessment At the beginning of the unit, learners will complete a personal inventory of their vocal technical skills as related to this unit. The inventory will include anatomical terminology which may uncover lack of knowledge or understanding. Learners will also complete an initial aesthetics quiz where they listen to various choirs and singers and categorize the types of sounds, they hear and identify with.	
• A • A • A • A • A • M • M • M • T • T • T	**Learning Activities** • Learner participation in daily skill building exercises. • Teacher led activities defining and exemplifying proper techniques. • Learner participation in discussions of technique and aesthetic • Listening to audio examples and watching video exemplars • Utilizing software to visualize technical application. • Learner reflections on technical acquisition • Learner assessment of peer and exemplar performances • Learner participation in discussion and exploration of how techniques apply to their own vocal interests. • Learner application of concepts (mentioned above) to exercises. • Learner application of concepts to repertoire • Learner demonstration of vocal growth	Progress Monitoring (e.g., formative data) • Observation: visual, aural, potentially kinesthetic • Questioning • Learner self and peer reflections/assessments • Class discussions • Simple and progressive rubric assessments • Specific Feedback • Inventory/Progress journal

Audio/video Resources:

Week 1: https://www.youtube.com/watch?v=Rg4L5tcxFcA (Casta Diva)

https://www.youtube.com/watch?v=suj-2sbSFKs (Nessun Dorma)

https://www.youtube.com/watch?v=0rntr6gWcdc (O Magnum Mysterium)

https://www.youtube.com/watch?v=N_lCmBvYMRs (Star Spangled Banner, Houston)

Vocal Folds: https://www.youtube.com/watch?v=5rJ8nCTgZ2Q (choral vocal folds)

Onsets: https://www.youtube.com/watch?v=lTZuIiU36Bk (Alleluia, Sumi Jo)

Week 2: https://www.youtube.com/watch?v=hVqrW-fPOQ0 (Bulgarian Women, AES narrow)

https://www.youtube.com/watch?v=qWZubrbAS-o (slack)

https://www.youtube.com/watch?v=73jqt-pOLQI (thin, thick, stiff)

Week 3: https://www.youtube.com/watch?v=D2o30ditNm8 (Thyroid Tilt)

https://www.youtube.com/watch?v=zoE6CLdJBog (False Vocal Folds)

Week 4: https://www.youtube.com/watch?v=n4Y4EQaw5oU (velum/soft palate)

Week 5: https://www.youtube.com/watch?v=jaIquq_4560 (lips, tongue, jaw)

Week 6: Poor Technique: https://www.youtube.com/watch?v=Ne3rn0R1sBI (diagnose why)

https://www.youtube.com/watch?v=v63YbkAh2k8 (diagnose why)

https://www.youtube.com/watch?v=gBI6L4GUlG4 (diagnose why)

Week 7: https://www.youtube.com/watch?v=N_lCmBvYMRs (Star Spangled Banner, Houston)

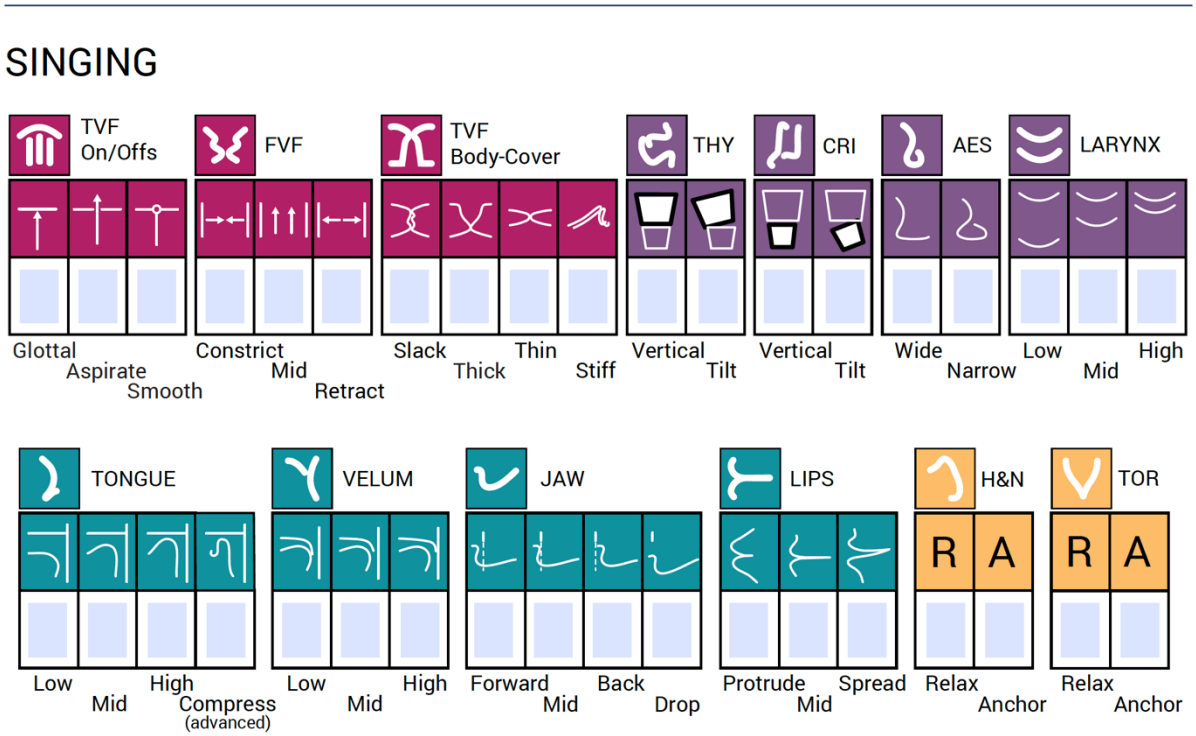
Week 8: https://www.youtube.com/watch?v=Rg4L5tcxFcA (Casta Diva)

https://www.youtube.com/watch?v=suj-2sbSFKs (Nessun Dorma)

https://www.youtube.com/watch?v=0rntr6gWcdc (O Magnum Mysterium)

https://www.youtube.com/watch?v=N_lCmBvYMRs (Star Spangled Banner, Houston)

Estill Voice Theory™ Epistemological Structure of Figures



Personal Inventory, Group A

First Rehearsal			Final Rehearsal		
Concept	I have heard of it	I can apply my understanding of it to singing	Concept	I have heard of it	I can apply my understanding of it to singing
Tongue			Tongue		
Jaw			Jaw		
Lips			Lips		
Head and Neck Anchoring			Head and Neck Anchoring		
Torso Anchoring			Torso Anchoring		
Larynx			Larynx		
Velum/Soft Palate			Velum/Soft Palate		
Vocal Onsets			Vocal Onsets		
False Vocal Folds			False Vocal Folds		
True Vocal Folds			True Vocal Folds		
Thyroid Cartilage			Thyroid Cartilage		
Cricoid Cartilage			Cricoid Cartilage		
Aryepiglottic Sphincter			Aryepiglottic Sphincter		
I understand how I might make these kinds of sounds			I understand how I might make these kinds of sounds		
Example	YES	NO	Example	YES	NO
1			1		
2			2		
3			3		
4			4		

Comparison, Traditional Group

Stage 1 – Desired Results

Established Goals

PR4.3 Develop personal interpretations that consider creators' intent.

PR5 Evaluate and refine personal and ensemble performances, individually or in collaboration with others.

PR6 Perform expressively, with appropriate interpretation and technical accuracy, and in a manner appropriate to the audience and context.

ESBC.PR.2 Develop and refine musical techniques and works for presentation

Transfer

Learners will be able to independently transfer:

4. *Their understanding of the choral aesthetic to a variety of repertoire*
5. *Their acquisition of vocal techniques to consistently reinforce a traditional choral tone*

Meaning

Understandings

5. Performers make interpretive decisions based on their understanding of context and expressive intent.
6. To express their musical ideas, musicians analyze, evaluate, and refine their performance over time through openness to new ideas, persistence, and the application of appropriate criteria.
7. The context and how a work is presented influence the audience response.

Essential Questions

5. How do performers interpret musical works?
6. How does understanding the context of musical works inform performance?
7. How do musicians improve the quality of their performance?

Acquisition

Knowledge

Learners will know.

5. Describe elements of the traditional choral aesthetic.
6. Describe the European, historical contribution to choral singing.
7. Describe vocal components for eliciting a choral tone.
8. Identify when the traditional choral is and is not employed.

Skills

Learners will be able to

3. Consistently produce the five pure, singing vowels [i, ɛ, a, o, u]
4. Consistently produce the ü and ö Germanic vowels to develop individual *chiaroscuro*: a clear, balanced, resonant tone
5. Consistently employ breath management using *messe di voce* to demonstrate *appoggio*: the wedding of breath, tone, and resonance as a feeling of "leaning against" or "effortful opposition".
6. Modify vowels and manage breath to enable shifts in vocal *passaggio* that help unify head and chest registers across vocal *tessitura* and dynamic range.

Stage 2 – Evidence

CODE (A M or T)	**Evaluative Criteria** (for final rubric)	**Goal:** The goal is for the learner to demonstrate their ability to consistently transfer technical components for producing the traditional choral tone to a variety of repertoire selections. **Role:** Learner as performer **Audience:** Teacher as adjudicator **Situation:** Learner is a member of the choir, and their tone must match the tone of the rest of the group. This assessment demonstrates what it means to sing with a traditional choral tone through technical, vocal production. **Product, Performance, and Purpose:** Individual and group performance **Standards and Criteria for Success:** Rehearsal observation and performance product

M • A • A • A M • A • A • A M • A • A M • A • A	Learners will be evaluated through the following criteria. *Chiaroscuro* • Vowel formation • Clarity of tone • Balanced Tone *Messe di voce* • Dynamic range • Breath management • Tone *Appoggio* • *Chiaroscuro* maintenance • *Messe di voce* as basis *Tessitura* • Vowel modification • *Passaggio* management	Performance Task(s) *Learner will demonstrate meaning-making and transfer by…* 3. Performing the ensemble repertoire with consistency of vocal production. T 4. Employing their understanding of *chiaroscuro*, *messe di voce*, and *appoggio* throughout their range and dynamic abilities. T Other Evidence (e.g., formative) 1. Learner, self, and peer assessments 2. Personal skills inventory and development log 3. Aesthetic identification quizzes

Stage 3 – Learning Plan

CODE (WHERE[2] TO)	Pre-Assessment	
	At the beginning of the unit, learners will complete a personal inventory of their vocal technical skills as related to this unit. The inventory will include European, singing terminology which may uncover lack of knowledge or understanding. Learners will also complete an initial aesthetics quiz where they listen to various choirs and determine fidelity to the traditional choral sound.	
• A • A • A • A • A • M • M • M • T • T • T	**Learning Activities** • Learner participation in daily skill building exercises. • Teacher led activities defining and exemplifying proper techniques. • Learner participation in discussions of technique and aesthetic • Listening to audio examples and watching video exemplars • Utilizing software to visualize technical application. • Learner reflections on technical acquisition • Learner assessment of peer and exemplar performances • Learner participation in discussion and exploration of how techniques apply to concepts like *chiaroscuro, messe di voce, appoggio, passaggio, and tessitura*. • Learner application of concepts (mentioned above) to exercises. • Learner application of concepts to repertoire • Learner demonstration of vocal technical consistency	Progress Monitoring (e.g., formative data) • Observation: visual, aural, potentially kinesthetic • Questioning • Learner self and peer reflections/assessments • Class discussions • Simple and progressive rubric assessments • Specific Feedback • Inventory/Progress journal

Sample Audio Resources:

Week 1: https://www.youtube.com/watch?v=Rg4L5tcxFcA (Casta Diva)

https://www.youtube.com/watch?v=suj-2sbSFKs (Nessun Dorma)

https://www.youtube.com/watch?v=0rntr6gWcdc (O Magnum Mysterium)

https://www.youtube.com/watch?v=LQCooL_q91k (Va Pensiero)

Mask Resonance: https://www.youtube.com/watch?v=hVqrW-fPOQ0 (Bulgarian Women)

https://www.youtube.com/watch?v=CZYL3gfAh5c, (O Mio Babbino Caro)

Week 3: https://www.youtube.com/watch?v=utXiGCnxexs (Rutter Mvt 2, messe di voce)

Week 6: https://www.youtube.com/watch?v=Ne3rn0R1sBI (diagnose why)

https://www.youtube.com/watch?v=gBI6L4GUlG4 (diagnose why)

Week 7: https://www.youtube.com/watch?v=v63YbkAh2k8 (diagnose why)

Week 8: https://www.youtube.com/watch?v=Rg4L5tcxFcA (Casta Diva)

https://www.youtube.com/watch?v=suj-2sbSFKs (Nessun Dorma)

https://www.youtube.com/watch?v=0rntr6gWcdc (O Magnum Mysterium)

https://www.youtube.com/watch?v=N_lCmBvYMRs (Star Spangled Banner, Houston)

Personal Inventory, Group B

First Rehearsal			Final Rehearsal		
Concept	I have heard of it	I can apply my understanding of it to singing	Concept	I have heard of it	I can apply my understanding of it to singing
Breath Management			Breath Management		
Breath Support			Breath Support		
Hook Up			Hook Up		
Appoggio			Appoggio		
Vocal Register			Vocal Register		
Head Voice			Head Voice		
Chest Voice			Chest Voice		
Tessitura			Tessitura		
Resonance			Resonance		
Singing into the Mask			Singing into the Mask		
Forward Placement			Forward Placement		
Chiaroscuro			Chiaroscuro		
Messe di Voce			Messe di Voce		
Vowel Modification			Vowel Modification		
I understand how I might make these kinds of sounds			I understand how I might make these kinds of sounds		
Example	YES	NO	Example	YES	NO
1			1		
2			2		
3			3		

Weekly Lesson Plans

Week 1

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Welcome & Thanks 2. Explanation of Hour each week 3. Take Personal Inventory	8:30-8:50	1. Welcome & Thanks 2. Explanation of Hour each week 3. Take Personal Inventory
6:20-6:40	1. Introduction to Onsets and True Vocal folds (connect to each other Production/Sound Quality/ a. Identify Pictorially b. Audio/Video examples c. Learn Hand signs and Prompts	8:50-9:10	1. Mask Resonance and Forward Placement a. Imagery/Sounds Like: Puppy Dog, Taunting, sing-speech b. Vocalise to practice (step/skip/ng) c. Audio/Video examples
6:40-6:55	*Locus Iste* m. 1-12 smooth/thin m. 13-20 glottal/thickish m. 21-29 aspirate/stiffish *Refine if time	9:10-9:30	*Verleih Uns Frieden* a. Neutral syllable from vocalise/ng b. Unison, duet, parts c. Count-sing w/mask
Transition 1		End Rehearsal	
7:00-7:25	Welcome & Sing- thru: *Verleih uns Frieden* *Cantique de Jean* *Locus Iste* *Os Justi*	7:00-7:25	Welcome & Sing- thru: *Verleih uns Frieden* *Cantique de Jean* *Locus Iste* *Os Justi*
7:25-7:50	Listening: *Gloria* Mvt 1,2,3	7:25-7:50	Listening: *Gloria* Mvt 1,2,3
Break + Announcements		Break + Announcements	
7:50-8:25	Sing-thru *The Dream Isaiah* If time: *Locus Iste* & *Verleih* practice	7:50-8:25	Sing-thru *The Dream Isaiah* If time: *Locus Iste* & *Verleih* practice
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 2

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Onset/TVF Remind 2. Introduction to AES and connection to TVF a. Identify Pictorially b. Audio/Visual Examples c. Learn Prompts and Hand signs	8:30-8:50	1. Mask/Forward Review 2. Introduction to Chiaroscuro & Vowel Modification a. Mixed vowel [y, œ], vocalizes (steps, skips) b. Vowel Modification vocalizes and open/closed
6:20-6:40	*Gloria* Mvt 1 Box 2: Narrower AES Box 3: Wider AES Box 4: Narrower AES Box 6: Narrower AES	8:50-9:10	*Cantique* m. 39-51 with d[y, œ] m. 72-end with d[y, œ]
6:40-6:55	Box 8: ST AES Bass Thick! Alto Thin + Narrow! Box 9: Wider AES Sing to End *Individual Coaching/Groups	9:10-9:30	*Os Justi* Alleluja from [y, œ] m. 61 – end m. 43-51 m. 1-9
Transition 1		End Rehearsal	
7:00-7:25	*Gloria* Mvt 3 to box 24	7:00-7:25	*Gloria* Mvt 3 to box 24
7:25-7:50	*Dream Isaiah Saw* – Choruses *Cantique* – French + Homophonic sections, ST & AB double intro	7:25-7:50	*Dream Isaiah Saw* – Choruses *Cantique* – French + Homophonic sections ST & AB double intro
Break + Announcements		Break + Announcements	
7:50-8:25	*Gloria* Mvt 1	7:50-8:25	*Gloria* Mvt 1
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 3

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Recap 2. Introduction to FVF & Thyroid + connections a. Identify Pictorially b. Audio/Visual Examples c. Learn Prompts and Hand signs	8:30-8:50	1. Recap 2. Introduction to Messe di voce & Appogio a. Audio/Visual of *Gloria* Mvt 2 b. Vocalise (steps, skips, sustain)
6:20-6:40	*Gloria* Mvt 2 To m. 25 – ATB tilted thyroid, TB retracted FVF m. 25-32 – SA tilted, retracted FVF Recap to m. 70	8:50-9:10	*Gloria* Mvt 2 To m. 25, use long notes to build phrase m. 25-32, SA same Recap to m. 70 **use mixed vowels and modification/Chiaroscuro
6:40-6:55	m71-77 – Tilt, Retract, Thin/Mix, Narrow Box 20 – End, Tilt et al. *Individual Coaching/Group	9:10-9:30	m. 71-77 how Appogio increases/leaning, macro and micro messe di voce Box 20 – End, reinforce
Transition 1		End Rehearsal	
7:00-7:25	*Verleih* – Countsing to Text *Locus* – Countsing to Text	7:00-7:25	*Verleih* – Countsing to Text *Locus* – Countsing to Text
7:25-7:50	*Os Justi* – m.10-42 Divisi, Notes, Rhythms	7:25-7:50	*Os Justi* – m.10-42 Divisi, Notes, Rhythms
Break + Announcements		Break + Announcements	
7:50-8:25	*Gloria* mvt 2 (focus end backwards)	7:50-8:25	*Gloria* mvt 2 (focus end backwards)
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 4

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Recap 2. Intro to Anchoring, larynx, and Velum a. Identify Pictorially b. Audio/Visual Examples c. Learn Prompts and Hand Signs	8:30-8:50	1. All things Breath a. Support, Management, Hook-Up, Appoggio b. Solo Audio/Visual Examples a. Activities/Vocalise
6:20-6:40	*Cantique* – Nasal and non-nasal vowels *Dream Isaiah Saw* – TB opening verse & Final Chorus for Anchoring	8:50-9:10	*Dream Isaiah Saw* – TB opening verse & Final Chorus *Cantique* – Clean up of opening TB and Add-on section
6:40-6:55	Individual Coaching/Group Coaching	9:10-9:30	Small Group/Individual coaching available
Transition 1		End Rehearsal	
7:00-7:25	*Gloria* Mvt 3 2nd half - End	7:00-7:25	
7:25-7:50	*Gloria* Mvt 1 Clean Up	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	*Locus Iste* Clean Up	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 5

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Recap 2. Introduction to Lips, Jaw, Tongue a. Identify Pictorially b. Audio/Visual Examples 2. Learn Prompts and Hand Signs	8:30-8:50	1. Recap 2. Putting together Chiaroscuro, Appoggio, & Messe di voce b. Choral Examples Y/N 3. Vocalise (steps, skip, sustain) c.
6:20-6:40	*Os Justi* – Latin homophony & Soli sections Tongue medialization and relaxed jaw/lips (inner resonance)	8:50-9:10	*Os Justi* – Soli sections
6:40-6:55	Individual Coaching/Group Coaching	9:10-9:30	Individual and Group Coaching or *Gloria* Mvt 2 soft sections
Transition 1		End Rehearsal	
7:00-7:25	*Gloria* Mvt 2	7:00-7:25	
7:25-7:50	*Cantique* Clean Up	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	*Verlieh* Clean Up	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

MIDPOINT! -flip groups

Week 6

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Putting together the Choral Recipe a. Construct the recipe as a group via figures c. Audio/Visual Examples of Y/N	8:30-8:50	1. Revisit All Things Phonation a. Registers, Tessitura, Head/Chest Voice b. Audio/Visual Examples Y/N c. Activities & Vocalise
6:20-6:40	*Verleih* – Unison, Duet, 4-part – Listen big, identify parts of recipe	8:50-9:10	*Verleih* – Unison, Duet, 4-part
6:40-6:55	Individual and Group Coaching	9:10-9:30	Individual Coaching/Group or TBD as needed
Transition 1		End Rehearsal	
7:00-7:25	*Gloria* Mvt 1 Clean Up	7:00-7:25	
7:25-7:50	*Gloria* Mvt 2 Clean Up	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	*Gloria* Mvt 3 Clean Up	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 7

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	2. Putting together the Choral Recipe b. Construct the recipe as a group via figures c. Audio/Visual Examples of Y/N	8:30-8:50	1. Revisit all things Resonance! a. Mask, Forward, Messe, Vowel Modification b. Audio/Visual Y/N c. Activities/Vocalise
6:20-6:40	Individual Lines: *Verleih, Cantique, Os Justi, Dream* Lots of listening to identify recipe	8:50-9:10	Individual Lines: *Verleih, Cantique, Os Justi, Dream* Lots of listening to identify recipe
6:40-6:55	Individual Coaching/Group	9:10-9:30	Individual & Group Coaching, or As Needed
Transition 1		End Rehearsal	
7:00-7:25	*Dream Isaiah Saw* – Clean Up	7:00-7:25	
7:25-7:50	*Locus Iste* – Clean up	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	*Os Justi* – Clean up	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 8

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Thick Fold Recipe Week! a. Construct Recipe b. Audio/Visual Examples	8:30-8:50	1. Choral Tone Reinforcement a. Reconstruct Recipe + c. Vocalises
6:20-6:40	*Star-Spangled Banner* Thick it up! + Cricoid Tilting	8:50-9:10	Sing-Speaking homophony & polyphony in slow/sustain
6:40-6:55	Individual and Group Coaching	9:10-9:30	Sing-Speaking homophony & polyphony in fast/articulative
Transition 1		End Rehearsal	
7:00-7:25	*Verleih & Cantique* touch up	7:00-7:25	
7:25-7:50	*Locus* & *Os Justi* touch up	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	*Gloria* – Mvt 2 clean tuning	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Week 9

Intervention Group: Motor-Based		Comparison Group: Traditional	
6:00-6:20	1. Return to Thin Folds a. Reconstruct Recipe + **Personal Inventory revisit** b. Vocalises	8:30-8:50	2. Choral Tone Reinforcement b. Reconstruct Recipe + **Personal Inventory revisit** c. Vocalises
6:20-6:40	Reinforce recipe in *Locus Iste,*	8:50-9:10	Addressing *Bel Canto* technique in choral repertoire
6:40-6:55	Reinforce recipe in *Os Justi* and *Gloria*	9:10-9:30	Individual & Group Coaching
Transition 1		End Rehearsal	
7:00-7:25	Run Program	7:00-7:25	
7:25-7:50	Run Program	7:25-7:50	
Break + Announcements		Break + Announcements	
7:50-8:25	Run Program	7:50-8:25	
Transition 2		Transition 2	
8:30-8:50	SECTIONALS	6:00-6:20	SECTIONALS
8:50-9:10	SECTIONALS	6:20-6:40	SECTIONALS
9:10-9:30	SECTIONALS	6:40-6:55	SECTIONALS

Appendix D

Additional Inhibitory Control Testing Analysis

Midpoint Stroop effect testing results

At the midpoint, participants (N = 51) re-took the Stroop color-word test, Go/No-Go test, and a second, revised Go/No-Go test. Overall, participants demonstrated a mean Stroop effect of a 107.69ms (SD = 61.41) slower response to incongruent trials and a mean 1.18 (SD = 1.38) incorrect responses. I performed a statistical analysis by way of repeated measures ANOVA (time*treatment), to account for the mean change in the testing results from pretesting to midpoint for the two groups, and dependent t-tests, to account for the mean change in testing results for each group. I display the repeated measures results in Table 10, and dependent t-test results in Table 11. Results from the Stroop Effect repeated measures ANOVA showed statistically significant changes in time, F (1,49) = 7.568, p = .008, η_p^2 = .134, however there was no statistically significant interaction between time and treatment, F (1,49) = .194, p = .662, η_p^2 = .004, or treatment, F (1,49) = 2.993, p = .09, η_p^2 = .058. Simply, while both groups tested better during the midpoint as compared to pretesting, no statistically significant change indicated one treatment surpassed the other. Results of the Stroop Accuracy repeated measures ANOVA showed no statistically significant interaction between time and treatment, F(1,48) = .161, p = .690, η_p^2 = .003, time, F(1, 48) = 2.91, p = .095, η_p^2 = .057, or treatment, F(1, 48) = .03, p = .871, η_p^2 = .001.

Table 10.

Stroop effect midpoint testing repeated measures ANOVA results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Time*Treatment	262.58	1	262.58	.194	.662	.004	-4.604 – 61.583

Time (Between)	10251.54	1	10251.54	7.568	.008	.134	5.41 – 34.70
Error	66371.83	49	354.53				
Treatment (Between)	10344.43	1	10344.43	2.993	.090	.058	
Error	169363.62	49	3456.40				

Note.[a] Effect size, η_p^2 = partial eta squared

In consideration of midpoint testing as an inconclusive, though perhaps predictive, milestone, I include both one-tailed and two-tailed significance results in Table 10. If this academic intervention fostered achievement in inhibitory control, a one-tailed test provides higher power in directional hypothesis (Coladarci & Cobb, 2014). Given a two-tailed test, results of the Stroop dependent t-tests uncovered statistically insignificant changes in the motor groups' Stroop effect, $t(25) = 1.96$, $p = .06$, and the traditional groups' Stroop effect $t(24) = 2.03$, $p = .054$. Given a one-tailed test, the effect size ($d = .39$) suggested a medium treatment influence for the motor-based group as well as the traditional group ($d = .41$) on the change in their inhibitory control based upon their Stroop effect scores.

Table 11.

Inhibitory control midpoint testing, dependent t-tests.

Variable	Pretesting	Midpoint	p-value (one-sided/two-sided)	Effect size[a]	95% Confidence Interval
Motor Stroop effect	143.35 (74.82)	120.09 (61.60)	.03/.061	.39	-.018 - .78
Traditional Stroop effect	111.65 (59.42)	94.81 (59.71)	.027/.054	.41	-.006 - .81

Note. Data are mean (standard deviation) unless otherwise reported. [a]Effect size = Cohen's *d*.

I also calculated changes in Stroop effect scores from midpoint to post testing by way of a repeated measures ANOVA. I display the results in table 12. At the time of post testing, the motor-based group averaged a Stroop effect score of 96.60ms (*SD* = 48.29) compared to a mid-point score of 120.09ms (*SD* = 61.60). At post testing, the traditional group averaged a Stroop effect score of 90.95ms (*SD* = 52.01) compared to a midpoint score of 94.81ms (*SD* = 59.71). Results of the ANOVA showed no statistically significant interaction between groups, $F(1,49) = 2.37$, $p = .130$, $\eta_p^2 = .05$. A statistical significance was found for the main effect of time, $F(1,49) = 4.61$, $p = .037$, $\eta_p^2 = .09$, but not for the main effect of treatment, $F(1,49) = 1.18$, $p = .283$, $\eta_p^2 = .02$.

Table 12.

Stroop effect mid-post testing repeated measures ANOVA results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Time*Treatment	2457.93	1	2457.93	2.37	.130	.046	-13.14 – 44.06
Error	50722.90	49	1035.16				
Time	4767.29	1	4767.29	4.61	.037	.09	0.87 – 26.48
Treatment	6092.51	1	6092.51	1.18	.283	.02	

Note.[a] Effect size, η_p^2 = partial eta squared

Dependent t-tests

To mirror the statistical procedures from pretesting to midpoint, I conducted a series of dependent t-tests to analyze changes in mean scores from the midpoint to post testing for all executive function tests. I present these results in Table 13. I, again, included both one-tailed and

two-tailed significance results. If this academic intervention fostered achievement in inhibitory control, a one-tailed test provides higher power in directional hypothesis (Coladarci & Cobb, 2014). Results of the dependent t-test indicated a significant change in mean scores for the motor-based group's Stroop effect, $t(25) = 2.66$, $p = .014$. The effect size $d = 0.52$ indicated a moderate effect of the treatment on these changes. Changes in the mean Stroop effect scores from midpoint to post testing for the traditional group, however, were statistically insignificant, $t(24) = .42$, $p = .678$.

Table 13.

Inhibitory control post testing, dependent t-tests.

Variable	Midpoint	Post test	*p*-value (one-sided/two-sided)	Effect size[a]	95% Confidence Interval
Motor Stroop effect	120.09 (61.60)	95.59 (48.29)	.007/.014	0.52	.11 - .93
Traditional Stroop effect	94.81 (59.71)	90.95 (52.01)	.339/.678	0.08	-.31 - .49

Note. Data are mean (standard deviation) unless otherwise reported. [a] Effect size measured with Cohen's *d.*

Go/No-Go and Stroop Accuracy Analyses

Participants showed a mean latency of 459.05ms (*SD* = 82.45) in the Go/No-Go test and a mean latency of 438.12 (*SD* = 76.23) in trials occurring after the No-Go stimulus, with a mean commission rate of .04 (*SD* = .05). I performed a statistical analysis by way of repeated measures ANOVA (time*treatment), to account for the mean change in the latency after a no-go trial from pretesting to midpoint for the two groups, and dependent t-tests, to account for the mean change in testing results for each group. I display the repeated measures results in Table 14, and dependent t-test results in Table 15. Finally, with the addition of the second Go/No-Go test, I conducted an independent t-test to investigate any statistical significance between groups. I present these

results in Table 16. Results of the Stroop Accuracy repeated measures ANOVA showed no statistically significant interaction between time and treatment, $F(1,48) = .161$, $p = .690$, $\eta_p^2 = .003$, time, $F(1, 48) = 2.91$, $p = .095$, $\eta_p^2 = .057$, or treatment, $F(1, 48) = .03$, $p = .871$, $\eta_p^2 = .001$. Results from the Go/No-Go repeated measures similarly showed statistically significant changes in time, $F(1,49) = 4.419$, $p = .041$, $\eta_p^2 = .083$, however no statically significant interaction between time and treatment, $F(1,49) = .366$, $p = .548$, $\eta_p^2 = .007$, or treatment, $F(1,49) = .090$, $p = .765$, $\eta_p^2 = .002$.

Table 14.

Inhibitory control midpoint testing, repeated measures ANOVA.

Variable	*Sum of Squares*	*DF*	*Mean Square*	*F value*	*p-value*	*Effect Size*[a]	*95% Confidence Interval*
Stroop Accuracy Time*Treatment	.591	1	.591	.161	.690	.003	-1.12 – 1.32
Stroop Accuracy Time	10.671	1	10.671	2.91	.095	.057	-0.12 – 1.43
Error	176.02	48	3.67				
Stroop Accuracy Treatment	.12	1	.12	.03	.871	.001	
Error							
Go/No-Go Time*Treatment	1162.87	1	1162.87	.366	.548	.007	-39.537 – 29.255
Go/No-Go Time	14038.80	1	14038.80	4.419	.041	.083	1.03 – 45.9
Error	155683.85	49	3177.22				
Go/No-Go Treatment	673.77	1	674.77	.09	.765	.002	
Error	182957.12	49	3733.82				

[a] Effect size, η_p^2 = partial eta squared

Results of the dependent t-tests uncovered statistically insignificant changes in the motor groups' Stroop accuracy, $t(25) = 2.02$, $p = .054$, and the traditional group's Stroop accuracy, $t(24) = .75$, $p = .46$. Similarly, results of the two-tailed dependent t-test demonstrated no statistical significance in the motor groups' latency score after a No-Go trial, $t(25) = 1.27$, $p = .22$, and the traditional groups' latency score after a No-Go trial, $t(24) = 1.66$, $p = .055$. The analysis showed statistical significance for the change in Go/No-Go latency scores for the motor group, $t(25) = 2.54$, $p = .009$, and the traditional group, $t(24) = 2.77$, $p = .005$. Result of the independent t-test on the second Go/No-Go test showed no statistical significance between groups in latency, $t(49) = 1.64$, $p = .11$, or accuracy, $t(49) = .656$, $p = .52$.

Table 15. *Inhibitory control midpoint testing, dependent t-tests.*

Variable	Pretesting	Midpoint	*p*-value (one-sided/two-sided)	Effect size[a]	95% Confidence Interval
Motor Stroop effect	143.35 (74.82)	120.09 (61.60)	.03/.061	.39	-.018 - .78
Traditional Stroop effect	111.65 (59.42)	94.81 (59.71)	.027/.054	.41	-.006 - .81
Motor Stroop accuracy	1.96 (2.25)	1.15 (1.05)	.027/.054	.40	-.007 - .79
Traditional Stroop accuracy	1.71 (4.16)	1.16 (1.68)	.231/.463	.15	-.25 - .54
Motor Go/No-Go 1 latency	460.17 (82.32)	421.55 (65.89)	.009/.018	.50	.085 - .90
Traditional Go/No-Go 1 latency	457.89 (84.26)	409.07 (65.61)	.005/.011	.55	.127 - .97
Motor Go/No-Go 1 latency after No-Go	432.29 (67.52)	415.57 (64.18)	.108/.216	.25	-.14 - .64
Traditional Go/No-Go 1 latency after No-Go	444.18 (85.34)	413.96 (73.55)	.055/.110	.33	-.07 - .73

Note. Data are mean (standard deviation) unless otherwise reported. [a]Effect size = Cohen's *d*.

Table 16.

Second Go/No-Go independent t-test results.

Variable	Motor-Based Group	Traditional Group	*p*-value
Go/No-Go 2 latency	427.94 (61.70)	404.63 (35.68)	.11
Go/No-Go 2 accuracy score	.14 (.09)	.12 (.07)	.52

Additional post testing results

The results of the repeated measures ANOVA showed no significant interaction between time and treatment for the Stroop accuracy scores, $F(1.45, 69.46) = 1.65$, $p = .579$, $\eta_p^2 = .01$. Results of the factorial ANOVA showed no significance for either time $F(2, 147) = 1.44$, $p = .240$, $\eta_p^2 = .02$ or treatment $F(1,147) = .08$, $p = .773$, $\eta_p^2 = .001$. I display these results in Table 17.

Table 17.

Stroop post testing ANOVA results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Stroop Accuracy Time*Treatment	2.39	1.45	1.65	.45	.579	.01	0.79 – 1.30
Error	257.31	69.46	3.70				
Stroop Accuracy Time	14.09	2	7.04	1.44	.240	.02	-0.22 – 1.51
Stroop Accuracy Treatment	.41	1	.41	.08	.773	.001	-0.603 – 0.81
Error	718.21	147	4.89				

Note. [a] Effect size, η_p^2 = partial eta squared

Go/No-Go Test 1

Participants ($N = 51$) also retook the first Go/No-Go test after nine weeks. Again, I initially performed a statistical analysis by way of repeated measures ANOVA (time*treatment), to account for the mean change in the testing results from pretesting to post testing for the two groups, however, the commission rate data and latency after a no-go scores both failed Mauchly's test of sphericity, $\chi^2(2) = 42.16$, $p < .001$, $\chi^2(2) = 25.32$, $p < .001$, $\chi^2(2) = 12.70$, $p = .002$, respectively. Likely, the data did not meet the assumption of sphericity because of an overall positive skew and the existence of outliers. Instead, to analyze the between variables time and treatment, I again conducted a factorial ANOVA, and for the within variable time*treatment, I adopted the Greenhouse-Geisser correction. I present these results in Table 18.

Results of the repeated measures ANOVA showed no significant interaction between time and treatment of the Go/No-Go 1 commission rate, $F(1.26, 61.85) = .72$, $p = .429$, $\eta_p^2 = .02$. Results of the factorial ANOVA showed no significance for time, $F(2, 147) = .60$, $p = .549$, $\eta_p^2 = .01$, or treatment, $F(1, 147) = 1.00$, $p = .319$, $\eta_p^2 = .01$. A second repeated measures showed no significant interaction between time and treatment of the Go/No-Go latency scores after a no-go trial, $F(1.62, 79.52) = .73$, $p = .458$, $\eta_p^2 = .02$. Results of the factorial ANOVA showed significant differences between time, $F(2, 147) = 3.40$, $p = .035$, $\eta_p^2 = .05$. A post hoc analysis using Tukey's procedure ($\alpha = .05$) revealed the mean scores for the posttest were significantly lower than at the pretest. There was no significance for treatment, $F(1, 147) = .004$, $p = .949$, $\eta_p^2 = .00$.

Go/No-Go Test 2

Participants ($N = 51$) additionally retook the second Go/No-Go test after 9 weeks. I performed a statistical analysis by way of repeated measures ANOVA (time*treatment), to account

for the mean change in the testing results from midpoint to post testing for the two groups. There was no significant interaction between time and treatment for commission rate, $F(1,49) = .242$, $p = .632$, $\eta_p^2 = .005$, or latency, $F(1,49) = 1.07$, $p = .305$, $\eta_p^2 = .021$. There were no significant main effects for time in either commission rate, $F(1,49) = .102$, $p = .002$, $\eta_p^2 = .002$, or latency, $F(1,49) = .28$, $p = .609$, $\eta_p^2 = .005$. I presented these results in Table 19.

Table 18.

Go/No-Go 1 post testing ANOVA results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Go/No-Go 1 Commission Rate Time*Treatment	.01	1.26	.01	.72	.429	.02	-.02 - .05
Error	.81	61.85	.01				
Go/No-Go 1 Latency After No-Go Time*Treatment	3772.53	1.62	2324.76	.73	.458	.02	-29.19 – 30.59
Error	252646.42	79.52	3177.32				
Go/No-Go 1 Commission Time	.01	2	.01	.60	.549	.01	-0.06 - .02
Go/No-Go 1 Commission Treatment	.01	1	.01	1.00	.319	.01	-0.02 - .05
Error	1.30	147	.01				
Go/No-Go 1 Latency After No-Go Time	31223.47	2	15611.74	3.40	.035	.05	7.85 – 60.59
Go/No-Go 1 Latency After No-Go Treatment	18.76	1	18.76	.004	.949	.00	-20.83 – 22.23
Error	667107.52	147	4538.15				

Note. [a] Effect size, η_p^2 = partial eta squared

Table 19.

Go/No-Go 2 post testing results.

Variable	Sum of Squares	DF	Mean Square	*F* value	*p*-value	Effect Size[a]	95% Confidence Interval
Go/No-Go 2 Commission	.001	1	.001	.232	.632	.005	-0.04 - 0.06
Time*Treatment							
Error	.24	49	.005				
Go/No-Go 2 Latency	534.03	1	534.03	1.07	.305	.02	-7.44 – 44.92
Time*Treatment							
Error	24391.02	49	497.776				

Note. [a] Effect size, η_p^2 = partial eta squared

Dependent t-tests

Changes in the mean scores of the motor-based group's Stroop accuracy were statistically significant, $t(25) = -2.16$, $p = .041$, however the effect size $d = -.42$ indicated they performed worse at the end of the study than at the midpoint. There was no statistically significant change in the traditional group's Stroop accuracy, $t(23) = .10$, $p = .922$. Regarding the first Go/No-Go test there was no statistically significant change in the motor-based group's latency, $t(25) = 1.15$, $p = .261$ or latency after a no-go trial, $t(25) = .65$, $p = .521$. Similarly, there was no statistically significant change in the traditional group's latency, $t(24) = 1.43$, $p = .166$, or latency after a no-go trial, $t(24), = 1.34$, $p = 1.92$. Regarding the second Go/No-Go test there was no statistically significant change in the motor-based group's commission rate, $t(25) = .52$, $p = .609$, or latency, $t(25) = 1.11$, $p = .276$. Likewise, there was no statistically significant change in the traditional group's commission rate, $t(24) = -.13$, $p = .897$, or latency, $t(24) = -.36$, $p = .720$. I present these results in Table 20.

Table 20.

Inhibitory control post testing, dependent t-tests.

Variable	Midpoint	Post test	*p*-value (one-sided/two-sided)	Effect size[a]	95% Confidence Interval
Motor Stroop effect	120.09 (61.60)	95.59 (48.29)	.007/.014	.52	.11 - .93
Traditional Stroop effect	94.81 (59.71)	90.95 (52.01)	.339/.678	.08	-.31 - .49
Motor Stroop accuracy	1.15 (1.05)	1.73 (1.63)	.020/.041	-.42	-.82 - -.02
Traditional Stroop accuracy	1.16 (1.68)	1.13 (1.60)	.461/.922	.02	-.38 - .42
Motor Go/No-Go 1 latency	421.55 (65.89)	413.52 (54.59)	.131/.261	.23	-.17 - .61
Traditional Go/No-Go 1 latency	409.07 (65.61)	394.04 (47.95)	.083/.166	.29	-.12 - .68
Motor Go/No-Go 1 latency after No-Go	415.57 (64.18)	410.21 (56.97)	.261/.521	.13	-.26 - .51
Traditional Go/No-Go 1 latency after No-Go	413.96 (73.55)	397.82 (51.79)	.096/.192	.27	-.13 - .67
Motor Go/No-Go 2 Commission	.14 (.09)	.12 (.12)	.305/.609	.10	-.29 - .49
Traditional Go/No-Go 2 Commission	.12 (.07)	.12 (.09)	.449/.897	-.03	-.42 - .37
Motor Go/No-Go 2 Latency	427.94 (61.70)	421.09 (53.79)	.138/.276	.22	-.17 - .61
Traditional Go/No-Go 2 Latency	404.63 (35.66)	406.93 (39.91)	.360/.720	-.07	-.46 - .32

Note. Data are mean (standard deviation) unless otherwise reported. [a]Effect size = Cohen's *d*.

Appendix E

Additional Perceived Rigor Scale Analysis and Personal Inventory Analysis

After the culminating performance participants (N =50) filled out a Qualtrics survey of perceived rigor. I conducted independent t-tests between groups based upon data yielded from the 29 survey prompts. These prompts fell into six categories: techniques (4 prompts), performative (5 prompts), emotional (5 prompts), cognitive (6 prompts), social (5 prompts), and physical (4 prompts). All statistically insignificant results are included here.

Technique Prompts

In response to prompt 1, traditional group participants reported a greater perception of naturally applying vocal techniques (Mdn = 85, M = 77.96, SD = 22.47) than the motor-based group (Mdn = 80, M = 65.77, SD = 31.85), however there was no statistical difference between groups, $t(48) = -1.55$, $p = .127$. In response to prompt 2, motor-based group participants reported a greater perception of singing the techniques as second nature (Mdn = 70, M = 65.00, SD = 29.75), than the traditional group (Mdn = *62*, M = 60.52, SD = 27.26), however there was no statistical difference between groups, $t(46) = .542$, $p = .590$. In response to prompt 3, the traditional group reported barely greater ease producing the vocal techniques (Mdn = 71, M = 70.67, SD = 21.85) than the motor-based group (Mdn = 70, M = 69.00, SD = 27.51), however there was no statistical difference between groups, $t(48) = -.236$, $p = .815$. In response to prompt 4, the traditional group reported that the vocal techniques tripped them up slightly more (Mdn = 14, M = 25.70, SD = 24.75) than the motor-based group (Mdn = 10, M = 25.55, SD = 30.76), however there was no statistical difference between groups, $t(43) = -.02$, $p = .986$.

Performance Prompts

In response to prompt 2, the traditional group reported needing to listen to others more when performing techniques (*Mdn* = 70, *M* = 64.26, *SD* = 22.42) than the motor-based group (*Mdn* = 50, *M* = 54.24, *SD* = 32.26), however there was no statistical significance between groups, *t*(46) = -1.24 *p* = .222. In response to prompt 3, the traditional group perceived more careful and deliberate thinking when performing vocal techniques (*Mdn* = 90, *M* = 85.43, *SD* = 13.32) than the motor-based group (*Mdn* = 82, *M* =76.65, *SD* = 23.65), however there was no statistical significance between groups, *t*(47) = -1.625, *p* = .112. In response to prompt 4, the motor-based group reported a slightly higher median perception that quick response to what they heard mattered in performance (*Mdn* = 81.5, *M* = 77.81, *SD* = 22.49) than the traditional group (*Mdn* = 80.5, *M* = 79.96, *SD* = 18.86), however there was no statistically significant difference between groups, *t*(48) = -.37, *p* = .717. In response to prompt 5, the traditional group reported a similar perception that vocal techniques required quick vocal adjustments during performance (*Mdn* = 80, *M* = 76.42, *SD* = 21.83) than the motor-based group (*Mdn* = 80, *M* =74.52, *SD* = 19.60), however there was no statistical significance between groups, *t*(47) = -.320, *p* = .750.

Emotional Prompts

In response to prompt 1, the traditional group reported higher strong personal feelings when applying the learned vocal techniques (*Mdn* = 72.5, *M* = 64.17, *SD* = 28.58) than the motor-based group (*Mdn* = 58.5, *M* = 62.73, *SD* = 29.58), however there was no statistical difference between groups, *t*(48) = -.174, *p* = .862. In response to prompt 2, the traditional group reported a stronger reaction to the sound of the choir while applying the learned vocal techniques (*Mdn* = 89, *M* = 83.96, *SD* = 16.68) than the motor-based group (*Mdn* = 84.5, *M* = 82.58, *SD* = 19.45, however there was no statistical difference between groups, *t*(48) = .41, *p* = .738. In response to prompt 4, the motor-based group reported more constant emotions while applying

learned vocal techniques (*Mdn* = 60, *M* = 60.31, *SD* = 27.35) than the traditional group (*Mdn* = 45, *M* = 48.67, *SD* = 31.74), however there was no statistical significance between groups, *t*(48) = 1.39, *p* = .170. In response to prompt 5, the traditional group reported feeling more emotional based upon the sound of the choir after applying the learned vocal techniques (*Mdn* = 85.5, *M* = 80.54, *SD* = 22.23) than the motor-based group (*Mdn* = 64, *M* = 68.92, *SD* = 19.57), however there was no statistical difference between groups, *t*(48) = -1.97, *p* = .055.

Cognitive Prompts

In response to prompt 1, the traditional group perceived learning the vocal techniques as more cognitively demanding (*Mdn* = 76, *M* = 72.54, *SD* = 19.75) than the motor-based group (*Mdn* = 71, *M* = 63.48, *SD* = 30.31), however there was no statistical significance between groups, *t*(47) = -1.25, *p* = .110. In response to prompt 2, the traditional group reported thinking harder when learning vocal techniques (*Mdn* = 68, *M* = 66.08, *SD* = 22.35) than the motor-based group (*Mdn* = 60.5, *M* = 56.46, *SD* = 30.23), however there was no statistical significance between groups, *t*(48) = -1.27, *p* = .105. In response to prompt 3, the motor-based group reported a greater perception of mental effort in learning vocal techniques (*Mdn* = 21.5, *M* = 30.62, *SD* = 28.15) (traditional: *Mdn* = 20, *M* = 23.67, *SD* = 18.28). There was no statistical significance between groups, *t*(48) = 1.03, *p* = .155. In response to prompt 4, the traditional group reported drawing on more metal resources when learning vocal techniques (*Mdn* = 70.5, *M* = 66.17, *SD* = 20.64) than the motor-based group (*Mdn* = 65, *M* = 53.48, *SD* = 30.81), however there was no statistical difference between groups, *t*(47) = -1.70, *p* = .097. In response to prompt 6, the traditional group reported thinking more actively when learning vocal techniques (*Mdn* = 90, *M* = 84.38, *SD* = 18.44) than the motor-based group (*Mdn* = 79.5, *M* = 74.65, *SD* = 22.81), however the results were not statistically significant, *t*(48) = -1.60, *p* = .115.

Social Prompts

In response to prompt 1, the traditional group reported more awareness of others in the choir when practicing and learning the vocal techniques (*Mdn* = 83, *M* = 78.79, *SD* = 20.92) than the motor-based group (*Mdn* = 70, *M* = 67.88, *SD* = 22.27), however there was no statistical significance between groups, *t*(47) = -1.77, *p* = .084. In response to prompt 2, both groups reported equally at the median to having others around them as a hinderance to learning vocal techniques (motor-based: *Mdn* = 10, *M* = 16.25, *SD* = 16.93) (traditional: *Mdn* = 10, *M* = 17.13, *SD* = 18.11). There was no statistical significance between groups, *t*(45) = -.17, *p* = .864. In response to prompt 3, the traditional group reported greater ease learning vocal techniques while interacting with others in the choir (*Mdn* = 70, *M* = 65.33, *SD* = 25.69) than the motor-based group (*Mdn* = 57, *M* = 60.60, *SD* = 25.99), however there was no statistical significance between groups, *t*(47) = -.64, *p* = .525. In response to prompt 4, the traditional group reported greater importance to the social aspect of learning vocal techniques (*Mdn* = 56, *M* = 65.21, *SD* = 25.77) than the motor-based group (*Mdn* = 50, *M* = 56.40, *SD* = 28.31), however there was no statistical significance between groups, *t*(47) = -1.14, *p* = .261. In response to prompt 5, the traditional group felt greater obligation to others in the choir while learning vocal techniques (*Mdn* = 67, *M* = 62.67, *SD* = 28.86) than the motor-based group (*Mdn* = 50, *M* = 46.08, *SD* = 28.57), however there was no statistical significance between groups, *t*(46) = -2.00, *p* = .051.

Physical Prompts

In response to prompt 1, the traditional group perceived their bodies and/or voices as more drained after learning vocal techniques (*Mdn* = 35, *M* = 42.21, *SD* = 28.87) than the motor-based group (*Mdn* = 30, *M* = 35.33, *SD* = 28.24), however there was no statistical significance between groups, *t*(46) = -.83, *p* = .204. In response to prompt 2, the traditional group reported

greater physical and/or vocal exhaustion after learning vocal techniques (*Mdn* = 32.5, *M* = 36.38, *SD* = 26.54) than the motor-based group (*Mdn* = 15.5, *M* = 24.68, *SD* = 25.46), however there was no statistical significance between groups, *t*(44) = -1.52, *p* = .135. In response to prompt 3, the motor-based group reported feeling more physically and/or vocally energized after learning vocal techniques (*Mdn* = 82, *M* = 75.58, *SD* = 20.42) than the traditional group (*Mdn* = 77, *M* = 77.78, *SD* = 13.94), however there was no statistical significance between groups, *t*(48) = -.44, *p* = .659.

Personal Inventory

During the final session, members of the motor-based, intervention group (*N* = 20) and members of the traditional, comparison group (*N* = 23) completed and returned their personal inventories. They began these inventories during the first session. I collated responses and calculated mean scores and standard deviations per group. I also conducted dependent t-tests to assess the change from session 1 to session 9, and independent t-tests to assess differences between groups. I display these results in Table 21.

Each inventory listed 13 concepts related to the vocal pedagogy intervention each group received. The traditional group reported slightly higher prior acquisition or knowledge of vocal technique concepts (*M* = 8.3, *SD* = 2.96) than the motor-based group (*M* = 8.1, *SD* = 3.37), however there was no statistical significance between groups, t(41) = -.21, *p* = .833. The motor-based group reported slightly higher post-acquisition or knowledge of concepts (*M* = 12.35, *SD* = 1.87) than the traditional group (*M* = 12.30, *SD* = 2.36), however there was no statistical significance between groups, *t*(41) = .07, *p* = .945. The traditional group reported possessing greater prior conceptual meaning or understanding of the vocal techniques (*M* = 8.17, *SD* = 1.85) than the motor-based group (*M* =4.75, *SD* = 3.26). This difference was statistically significant, *t*(41) = -4.31,

p = <.001. The traditional group reported possessing greater post conceptual meaning or understanding of the vocal techniques (M = 12.17, SD = 1.99) than the motor-based group (M = 10.60, SD = 3.17). This difference was statistically significant on a one-tailed test, $t(41) = -1.98$, p = .027, given the assumption that participant responses would only move in one direction (Coladarci & Cobb, 2014). On a two-tailed test, this difference was not statistically significant, $t(41) = -1.98$, p = .055. The motor-based group reported slightly greater prior transfer of concepts to selected styles of singing (M = 2.25, SD = 1.33) than the traditional group (M = 2.09, SD = 1.16), however there was no statistical significance between groups, $t(41) = .43$, p = .671. All participants of both groups rated full post transfer of concepts to selected styles of singing. The motor-based group listened to one extra selection than the traditional group.

Results of the dependent t tests confirmed statistically significant changes for all first and final session pairings for both groups. For the motor-based group, concept acquisition changed with statistical significance, $t(19) = -4.71$, p = <.001, as did concept meaning, $t(19) = -6.56$, p = <.001, and concept transfer, $t(19) = -5.87$, p = <.001. For the traditional group, concept acquisition changes with statistical significance, $t(22) = -4.60$, p = <.001, as did concept meaning, $t(19) = -6.36$, p = <.001, and concept transfer, $t(22) = -3.76$, p = <.001. Simply, participants reported that they perceived an increase in their acquisition, understanding, and transfer of vocal technique knowledge.

Table 21.

Personal Inventory Results

Variable	Concept Acquisition First Session	Concept Acquisition Final Session	Concept Meaning First Session	Concept Meaning Final Session	Concept Transfer First Session	Concept Transfer Final Session
Motor-Based	8.1 (3.37)	12.35 (1.87)	4.75 (3.26)	10.60 (3.17)	2.25 (1.33)	4 (0)

Traditional	8.3 (2.96)	12.30 (2.36)	8.17 (1.85)	12.17 (1.99)	2.09 (1.16)	3 (0)
Independent *p*-value[a]	.417/.883	.472/.945	<.001/<.001	.27/.055	.335/.671	N/A[b]
Dependent *p*-value[c]						

Note. [a] Data reflects one-tailed and two-tailed significance. [b]A p-value cannot be calculated when standard deviation is zero in both groups. All participants rated 100% transfer in their response. [c]Results of all dependent t-tests yielded $p < .001$.

Correlation Between Tests of Inhibitory Control: Motor-Based Group

As a final analysis, I examined any possible correlations between the post testing scores from the tests of inhibitory control, by group using Pearson's *r*. There were no statistically significant results for the motor-based group. I present these results in Table 22.

Table 22.

Pearson's correlations between the post testing scores of inhibitory control, motor-based group.

Variable	Stroop score	Stroop Accuracy	Go/No-Go 1 After No-Go Latency	Go/No-Go 1 Commission	Go/No-Go 2 Commission
Stroop Score	-				
Stroop Accuracy	.11	-			
Go/No-Go 1 After No-Go Latency	.38	-.10	-		
Go/No-Go 1 Commission	.12	-.20	.23	-	
Go/No-Go 2 Commission	.03	.33	-.16	-.01	-