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Effects of two conductor final release gestures on perceptual and acoustical measures of individual singers' vocal production and vocal sound: A pilot study

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Abstract

A growing research base has indicated that varied conductor nonverbal behaviors may evoke immediate changes in singer muscle coordination and vocal sound. These investigations have generally examined conductor gestures at the onset of sound or over the course of an excerpt. The purpose of this pilot study was to explore and quantify perceptual and acoustical changes in individual singers' vocal production and vocal sound while they observed two different conductor final release gestures. Singers (N = 33) performed a brief melody twice while watching a pre-recorded conductor display two final release gestures (one with each performance) at the end of the excerpts: (a) an open palm inhalation gesture with an upward rebound and (b) a vigorous fisted gesture. Results indicated that most singers (n = 24, 72.7%) believed their final vocal sound changed because of the conductor's nonverbal behaviors. Ten singers (30.3%) specifically noted that the differences between the final release gestures evoked changes in their vocal production, making it the most frequently reported change. Eight of the ten vocal production comments referenced increased vocal tension during the fisted gesture. Ten expert listener participants perceived vocal sound differences in 82.3% of the paired participant recordings. In only seven participant pairings (23.3%), however, did at least seven of the ten listeners share a preference. Acoustical analyses did not reveal consistent amplitude or frequency differences in the final sound. We discuss the results in terms of teacher-conductor preparation, conductor behaviors and chorister vocal efficiency, improved objective reliability procedures, and future research.

Key Words:
choir, spacing, configuration, formation

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Choral conductors often end a piece with a grand gesture. This flourish may culminate in a fisted gesture at the final release. The final moment may be visually appealing for the performers and audience, but the effect of this type of "cutoff" on the choristers' vocal production is unclear.

Some choral pedagogues have posited that such gestures may evoke inefficient and tense vocal production because of the tendency of choristers to mimic gestures or muscular effort contained within some conductor nonverbal behaviors (Finn, 1939; Jordan, 1996; McClung, 1996). Social science researchers have studied the phenomenon of imitative empathic responses extensively, with human beings shown to mimic one another in a variety of ways. Among the scores of studies on the topic, research participants have imitated various gestures (Chartrand & Bargh, 1999), postures (LaFrance 1979; LaFrance & Broadbent, 1976), facial muscular activity (Dimberg, 1990; Dumberg & Thunberg, 1998; Dimberg, Thunberg, & Elmehed, 2000), and arm tension (Berger & Hadley, 1975). Researchers have referred to these imitative responses in such terms as "the chameleon effect" and "the perception-behavior link" (Chartrand & Bargh, 1999). Some neuroscientists assert that these phenomena may be linked to the mirror neuron system, which are said to fire while performing an activity and while observing others perform a similar activity (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). There is evidence to show that the human brain contains similar neurons (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995), which neuroscientist Marco Iacoboni posits are involved in "both voluntary and involuntary motor imitation" (M. Iacoboni, personal email, October 15, 2008). His book, *Mirroring People* (Iacoboni, 2008), discusses the phenomenon in depth.[1]

Imitative responses have also been shown to occur more frequently in context-dependent tasks compared to non-context-dependent tasks (Van Baaren, 2003). If such imitation takes place in conductor-chorister interactions, a specific context-dependent task, it is feasible that tense conductor gestures may evoke increased tension from choristers at various points in a sung phrase. Jordan (1996) has argued that "rigid, angular, and tense" (p. 13) gestures may cause choristers to vocalize with excessive tension. Finn (1939) made similar assertions, noting "if tension seem [sic] to be developing…the obvious duty of the conductor is to relax the vigor and to lessen the orbit of his gestures" (p. 263). In his instructional video, *What they See is What You Get* (Eichenberger & Dunn, 1994), Rodney Eichenberger proposed that "The whole body is the conducting gesture." He has noted, "as some conductors display tense conducting habits, I can see sopranos doing things like holding their throats and rubbing their necks" (McClung, 1996, p. 22). Such reactions may arise out of a phenomenon that Gehrkens (1918) referred to as "*instinctive imitation*; that is, [a conductor's] methods are founded upon the fact that human beings have an innate tendency to copy the actions of others, often without being conscious that they are doing so" (p. 3).

Several vocal pedagogues have recommended that singers avoid this undesirable or ex-

[1] For additional debate on this topic, see *The Myth of Mirror Neurons,* by Gregory Hickok (2014).

cessive tension, particularly in the neck. McKinney (1994), for example, posited that excess tension in the "muscles of the larynx and surrounding areas" leads to pressed voicing and a "tight, tense, hard, edgy, or strained tone" (p. 87). Doscher (1994) contended that some muscles that function to raise the larynx (i.e., suprahyoid) are "enemies of functional freedom," noting that "relaxation of the upper neck area and the tongue muscles is the goal of every successful singing technique" (p. 47).

Until somewhat recently, few researchers had investigated empirically possible imitative or mimicking behaviors between conductors and choristers. In a series of related investigations, researchers have found that participants directly imitated a modeled /u/ vowel by the conductor, in many cases without reporting an awareness of the change in conductor's behaviors. Manternach (2012a), for example, using infrared motion capture technology, found that singers (N = 47) increased their horizontal lip rounding while singing an /u/ vowel during a melody when the conductor modeled rounded lips on two target /u/ vowels. They also increased their eyebrow height during the second presentation of a conductor raised eyebrow stimulus compared to neutral conductor eyebrow conditions. Daugherty and Brunkan (2009) asked individual singers (N = 62) to perform the same melody while watching a videotaped conductor who alternately displayed neutral (baseline) and rounded (experimental) lips on the two /u/ vowels in the phrase. Expert auditors reported that all participants mimicked the conductor's lip rounding on at least one of the experimental-condition /u/ vowels. In a follow-up study (Daugherty & Brunkan, 2013), 90% of participants (N = 114) showed more lip rounding while singing both /u/ vowels in the experimental condition compared to baseline, and 90% of singers lowered all examined formant frequencies (consistent with increased lip rounding) each time the conductor rounded his lips.

Manternach (2012b) studied imitative behaviors during conductor preparatory gestures. Participants (N = 60) observed a pre-recorded conductor who, during some excerpts, modeled upward head or shoulder movements as he cued inhalation prior to and during their singing of a short melody. Results of a grid analysis indicated that singers moved their heads or shoulders more as they inhaled during the conductor upward head or shoulder conditions, respectively.

In these studies, researchers measured direct imitation of lip, eyebrow, head, and shoulder movements. Other researchers have investigated possible indirect effects that conductor arm or hand gestures might have on singers' muscular coordination or vocal sound. In two studies, participants who observed various left-hand crescendo gestures perceived that fisted or stabbing gestures might evoke more "inappropriate" singer tension than other left-hand crescendo gestures (Fuelberth, 2003a, 2004). In another investigation (Fuelberth, 2003b), singer participants were rated to have vocalized with the greatest increase of "inappropriate" vocal tension during the fisted and stabbing gestures. In a related study, Manternach (2016) examined conductor preparatory gestures using surface electromyography (sEMG) to directly measure singer extrinsic laryngeal (i.e., neck) muscle activity during inhalation while following a pre-recorded conductor. The conductor preparatory gestures included

three dichotomous conditions: upward or neutral head, initial upward or downward arm movement, and fisted or open palm. Surface EMG readings indicated two small but statistically significant differences: singers had more suprahyoid muscle (i.e., base of the tongue) activity during the upward compared to the downward gesture and more sternocleidomastoid muscle (i.e., head turning muscle on either side of the larynx) activity during the fisted gesture compared to the open palm gesture.

These investigations align with the claims of some choral pedagogues. Specifically, tense conductor gestures seem to evoke increased singer muscle tension during voicing. Such tension may be detrimental to the sound of the singer, leading to "tight, tense, hard, edgy, or strained tone" (McKinney, 1994, p. 87), and could and increase chances for singer fatigue or vocal injury. These investigations reference the onset or sustaining of vocal sound. Some conducting pedagogues make similar suggestions related to voicing at the final release. McClung (2005), for example, suggests that "cut-offs…achieved by pinching the sound (thumb to index finger)" may produce a "stop-sound-action controlled by throat muscles." Garretson suggests an internal final release gesture in which the conductor would "simply turn the palm over and close it" (Garretson, 1998, p. 20). But Davids and LaTour (2012) caution against cutoffs that include a "rapid clamping shut of the fingers. Singers may respond to this gesture by closing their glottises or their mouths—an unhealthy and poor-sounding means of release" (p. 242). They argue that this "glottal release," although common, "strangles the sound" (p. 56) and may cause undesirable noise and pitch change.

Despite these assertions, we found no investigations in which researchers examined chorister behaviors explicitly at the end of a melody. To that end, we sought to quantify the effects of varied types of conductor final release or "cutoff" gestures. The purpose of this pilot study was to explore possible differences in perceptual and acoustical measures of individual singers' vocal production and vocal sound during a final release when cued by conductor fisted or open palm inhalation final release gestures. The following research questions guided the investigation:

1. Will singers report differences in the conductor gestures, their own vocal sound, or their own vocal production during two conductor final release gestures (open palm inhalation gesture and fisted gesture)?

2. Will acoustical analyses of the final sung moment (i.e., half beat) reveal differences in singer fundamental frequency (f_o) or amplitude (dB SPL) during the final release gestures?

3. Will expert listeners report differences in individual singers' final vocal sound during the final release gestures?

Method

Participants

Participants constituted a volunteer convenience sample drawn from the school of music of a large southwestern university who were recruited through word-of-mouth, posted signs, and listserv email contact. Singer participants ($N = 33$) were 19- to 45-year-old ($M = 22.8$, $SD = 4.9$) males ($n = 19$) and females ($n = 14$) with varied singing experience. They had taken voice lessons for zero to 12 years ($M = 2.3$, $SD = 3.1$). They had varied ranges of recent choral singing experience, having sung in a choral ensemble from 9th grade to the present for zero to 10 years ($M = 4.5$, $SD = 3.4$). We did not inquire about choral participation prior to 9th grade.

Listener participants ($N = 10$) were male ($n = 7$) and female ($n = 3$) graduate students from the same university who were pursuing a Master of Music degree in choral conducting ($n = 1$), Doctor of Philosophy degree in music education ($n = 1$), or Doctor of Musical Arts degree in choral conducting ($n = 5$), vocal performance ($n = 2$), or orchestral conducting ($n = 1$). Seven of these students held a degree in vocal performance and seven held a degree in music education or choral conducting. They ranged in age from 27 to 54 years old ($M = 35.3$, $SD = 8.3$), had taken between four and 22 years of voice lessons ($M = 11.5$, $SD = 5.7$), and had taught between one and 19 years of voice lessons ($M = 7.8$, $SD = 6.2$). They had also sung in choirs between nine and 30 years since 9th grade ($M = 18.5$, $SD = 6.7$) and had between one and 25 years of choral conducting experience ($M = 9.5$, $SD = 7.6$). All listener participants self-reported normal hearing, and none had served as singer participants.

Procedures and Equipment

Singers entered a quiet university classroom sometimes used for choral rehearsals. After completion of an IRB-approved consent form, they took a position on a floor marking 13 feet from a wall-mounted projection screen. This position corresponded roughly to where choristers in the second row of an ensemble would stand during rehearsals in the room.

Recording equipment. Singers wore a head-mounted microphone (AKG C520, cardioid recording pattern) that we positioned four centimeters from the corner of their mouths using a disposable spacer. This positioning ensured that the microphone was outside the singer air stream while maintaining high signal-to-noise ratios for recording (Wheeler, Collins, & Sapienza, 2006). The microphone connected to a Sound Devices USB Pre2 pre-amplifier that connected to a Dell Inspiron 7520 laptop (Intel Core i7, 64-bit operating system, 2.2 GHz, 8 GB RAM). We recorded excerpts using Adobe Audition CS6 software (24 bit, 48kHz WAV files).

Sung melody. After participants had indicated interest in participating in the study, we emailed them to schedule a time to participate. The email included an attachment of the final portion of "America the Beautiful" (Figure 1) that they were to memorize. During the experimental procedures, they sang the melody three times from memory. Prior to each repetition, we gave them the pitch using an electronic keyboard that was not touch sensitive and was set to the same volume for all participants. During the first repetition, they sang with a metronome (MM = 84) to ensure that they could perform the melody from memory and to acquaint them with the tempo. They then sang the melody two more times while following a life-sized pre-recorded conductor on the projection screen.

Conductor gestures. The conductor (one of the researchers) was filmed from his upper thigh to just above his head and was dressed in all black. We used a metronome while creating the stimulus video to help control for tempo and recorded the conditions as many times as necessary to ensure that the final release gesture was the only changing variable. The conductor's left hand remained relaxed at his side.

At the beginning of each excerpt, the conductor slowly raised his right hand to the starting position, pausing with his hand at lower portion of his chest and to the right of his midline. He then gave a palm-down, downward moving preparatory gesture that dropped to the conducting plane (roughly the top of the conductor's belt) and swept to his right (i.e., simulating beat three of a traditional four-beat pattern) while inhaling. He then displayed a traditional four-beat pattern throughout the duration of the melody. On each repetition's final half note, he displayed a right-hand palm-up sustaining gesture prior to the final release.

The two subsequent final release gestures were (a) an open-palm inhalation gesture and (b) a vigorous fisted gesture. The open-palm inhalation gesture moved up from the sustaining gesture while the hand turned such that the palm was facing down and dropped again (palm down) to the conducting plane. Upon returning to the plane, the conductor breathed while his hand rebounded upward and outward as if cueing inhalation. This rebound was based on Hylton's (1995) suggestion that it would encourage "a sense of lift and floating breath support" (p. 110) and was intended to evoke inhalation to stop the sound (Davids &

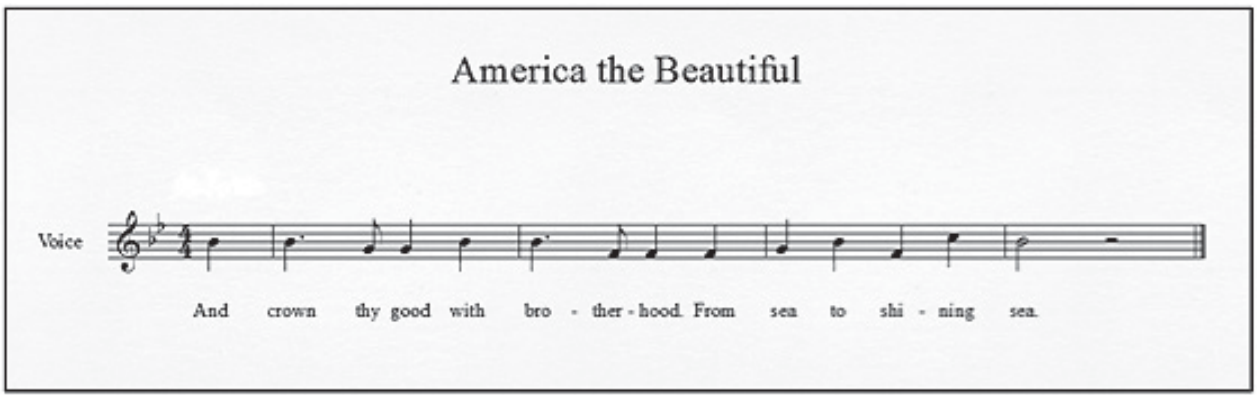

Figure 1. ***The sung melody.***

LaTour, 2012). For the fisted gesture, the conductor moved up from the sustaining gesture in the same way. He then returned to the conducting plane where he closed his palm into a vigorous fist that rose slightly and stopped at lower sternum height. This vigorous fist was modeled after Davids and LaTour's description of a cutoff that includes a "rapid clamping shut of the fingers" (2012, p. 242). The conductor did not inhale during or after the fisted release. Each participant viewed the two gestures one time each. The order of which gesture occurred first alternated by participant, with participant order determined by participant availability, resulting in an equal number of participants viewing each gesture first.

Reliability procedures. Previous researchers have frequently utilized an expert panel to assess the consistency or differences of conducting gesture conditions (Fuelberth, 2003a, 2004; Manternach, 2012a, 2012b, 2016). We sought a methodology that would provide objective data related to conductor reliability. Therefore, in lieu of an expert viewing panel's analysis, we used a pixel analysis software program (MeazureTM 2.0) to identify the precise hand placement and gesture height and width. The program allowed us to move the cursor to any point on a computer screen, where it appeared as a small red square. The program displayed the horizontal (X) and vertical (Y) screen pixels next to the square as well as on a separate window. This window also displayed a close-up view of the area immediately surrounding the square (Figure 2).

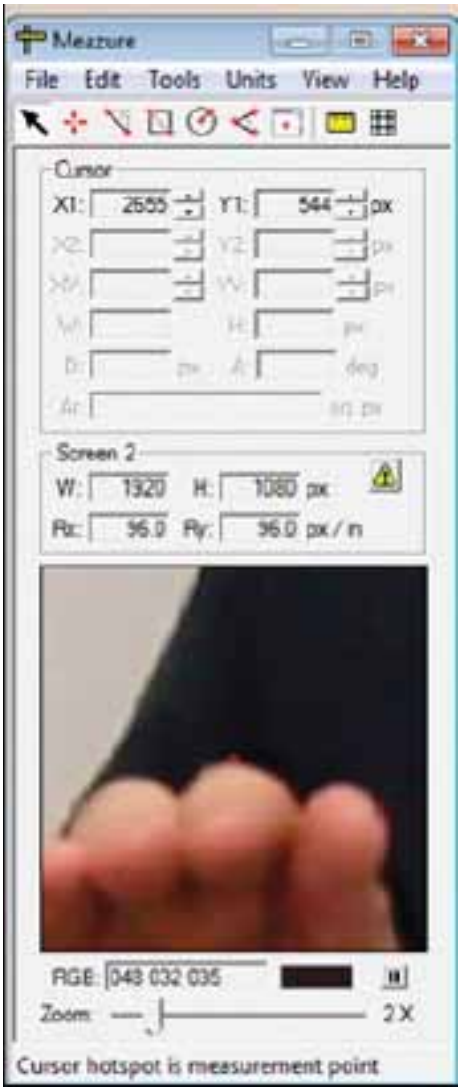

Figure 2. Reliability procedure using pixel analysis software.

For all possible conducting takes, we paused the video at the starting position, at the bottom of each ictus (beat), during the height of each rebounded beat, and during the sustain gesture. We then recorded the vertical pixel locations (1920 x 1080 pixel resolution display) for each location and the horizontal pixel location for each sideways moving rebounded beat (i.e., two and three) in order to compare the size and width of the pattern between excerpts. We selected the two excerpts (one inhalation and one fisted) that were the most consistent with one another throughout the duration of the excerpts. The average difference between the corresponding portions of the two videos was 10.8 pixels (range = 0-32 pixels). Using the conductor's shirt button diameter as a reference (one cm = 14 pixels on the screen), this difference was an average of 0.77 cm against the conductor's body (range = 0.00-2.29 cm).

Singer survey. After completing the sung tasks, singer participants responded to a follow-up questionnaire that asked them to note any differences in the conductor behaviors between the two conducted excerpts. Additionally, they could report whether such differences may have affected their vocal sound and vocal production. Following completion of the questionnaire, participants were free to ask questions about the purposes of the study.

Acoustical analyses. Following the recorded trials, we used Praat software (v. 5.3.04) to examine each singer's WAV file at roughly the final moment of each sung excerpt, which we defined as the final half beat of singing on the final /i/ vowel ("sea"). By doing so, the singer had a half beat to respond to the preparation of the final release gesture before our analysis window began. The steady-state analysis window continued until .05 s prior to the participant's final sound (.307 s at MM = 84), which we chose to remove because of artifacts that were not amenable to acoustical analysis (e.g., glottal stops, inhalation). Once isolating this recording window, we extracted the fundamental frequency (f_o) and amplitude (dB SPL) of each excerpt.

Listener ratings. The expert listeners subsequently evaluated each participant's paired recordings. In a quiet office, they wore a set of AKG K 240 MK II studio headphones (55 ohms impedance) that plugged into the same Sound Devices pre-amplifier and a Dell laptop with the same specifications as the one used to collect the sound files. They then used Adobe Audition CS6 software to listen to a sound file for each participant that contained uncompressed trimmed files of the final sung note of each condition, separated by one second of silence. Each listener evaluated the singer excerpts in a random participant order. They listened to each file as many times as they deemed necessary to assess (a) whether they heard a difference in the vocal tone quality at the cutoff between the two excerpts (*No Difference, A Little Difference, Much Difference,* and *Very Much Difference*) and (b) whether they preferred the vocal tone quality at the cutoff of one excerpt over the other.

Results

Research Question 1: Singer Perceptions

Conductor behavior differences. Two participants (6.1%) indicated that they did not notice any differences in conductor behaviors between the two excerpts. The remaining 31 participants (93.9%) made 46 discrete comments about the differences. We placed these comments into exhaustive and mutually exclusive categories. Twenty-nine of these comments (60.4% of comments, 87.9% of participants) related to differences at the final release. Despite the careful reliability procedures and the fact that the conductor used a metronome in the creation of the video, participants also made 17 comments related to differences in tempo and pattern.

Tempo differences. Six participants (18.2%) gave conflicting reports regarding tempo variations during and between the two conducted conditions. One participant indicated that the conductor's tempo sped up during the opening portion of the inhalation gesture video. Another wrote that it slowed down toward the end. Still another noted that the conductor's tempo during the same video generally slowed down. By contrast, one participant wrote that the tempo during the inhalation gesture excerpt was more consistent than the fisted gesture excerpt. Another believed that the fisted gesture excerpt was faster. Still another participant noted that the fisted gesture excerpt was "out of tempo." In all but one instance, participants perceived that the first randomized condition they viewed varied in tempo more than the second condition they viewed.

Pattern variations. Eight participants' (24.2%) reports regarding conducting patterns were similarly inconsistent. One participant believed that the inhalation gesture excerpt was more precise and another participant reported the opposite perception. One participant noted that the inhalation gesture excerpt contained "larger movements" while another referred to it as having a less active pattern. Another participant referred to the fisted excerpt as more "short and choppy." One participant noted that there were differences in the conducting pattern but did not report specific discrepancies.

One participant wrote that the conductor "used his mouth to signal breath," but did not indicate where in the pattern that had occurred. Finally, one participant noted that the initial preparatory gesture during the first gesture he saw (fisted excerpt) confused him and another noted that the cue for the entrance and release were more relaxed during the inhalation excerpt.

Vocal production differences at the final release. The 31 participants who noted differences in the conductor final release gestures made 32 discrete comments about the change in their vocal production. We again separated those comments into exhaustive and mutually exclusive categories. Six participants believed the gestures did not elicit any vocal changes and one additional participant offered no clarifying comment.

Twenty-four participants (72.7%), therefore, believed the final release gestures affected their singing in some way. Two made vague or unrelated comments about their final sound related to these gestures (e.g., "I tried to do what he said"). Two participants noted singing with more volume or accent on the final note during the fisted gesture. Two others indicated volume differences between the excerpts, with one indicating he sang with more or less volume depending on the height of the hand. Still another participant believed the fisted gesture helped the final pitch to be more consistent.

Eight participants (24.2% of the sample) reported clarity or timing differences related to the final release gestures during the final sound. Six of those participants stated that the fisted gesture was easier to follow. One participant noted that it caused the rhythm to be "more defined." One participant noted that the inhalation gesture was clearer, stating that he knew more precisely where to cut off on the downward motion toward the conducting

plane. One more indicated increased confidence during the inhalation gesture.

Ten participants (30.3% of the sample) reported changes in their vocal production, which made it the most often reported difference. Of the ten, eight indicated that the inhalation gesture allowed for more efficient vocal production. One participant, for example, stated that the fisted gesture caused the singing to feel "clipped" and that his voice cracked at the end. Another participant stated that his throat tightened on the fisted gesture. Others noted that their singing during the inhalation gesture felt "easier," "more free," and had "less tension." Only one participant believed the fisted gesture aided vocal production, noting that her it encouraged her final release to be more "active." One final participant indicated that both gestures led to increased tension.

Research Question 2: Acoustical Analyses

Amplitude. Paired *t*-tests revealed that the mean amplitude difference of .21 dB (*SD* = 1.88) was not a statistically significant difference between the fisted and inhalation conditions, $t(29) = 0.60$, $p = .55$. The mean difference is also less than the threshold considered to be a "just noticeable" amplitude change in vocal sound (1 dB SPL, Howard & Angus, 2001). Individually, 13 singers displayed a difference of 1 dB SPL or greater between the excerpts. Seven participants sang with higher amplitude during the fisted condition (*M* = 2.72 dB SPL, *SD*= 1.89) and six participants displayed the difference during the inhalation condition (*M* = 2.05 dB SPL, *SD* = 0.55). This difference likely indicates no consistent trend between the excerpts.

To test possible order effects, we compared the amplitude of the first sung excerpt with the second excerpt, regardless of the conductor condition. We found that the first excerpt had more than 1 dB SPL greater amplitude eight times (*M* = 1.88 dB SPL difference, *SD* = 0.76) compared to five times (*M* = 3.25 dB SPL difference, *SD* = 1.92) for the second excerpt. The overall means, however, indicated that the second excerpt was only .07 dB SPL higher, indicating little likelihood of an order effect.

Fundamental frequency. Because of the nature of logarithmic scale and the fact that singers used different octaves, comparisons were not amenable to *t*-test analysis. Therefore, we compared the f_o of each participant's fisted and inhalation gesture excerpts to one another and calculated the difference in cents. This process allowed us to determine if either of the final release gestures evoked a consistently higher or lower pitch at the final release and if those differences might be considered "just noticeable," which Sundberg (1982) defined as at least 7 cents difference. Mean differences indicated that participants sang with 2.90 cents higher pitch (*SD* = 18.78) during the inhalation gesture condition compared to the fisted condition. Individually, participants sang with at least 7 cents higher f_o during the fisted condition 11 times (*M* = 22.02 cents difference, *SD* = 13.12) and during the inhalation condition nine times (*M* = 17.84, *SD* = 7.36). This difference also likely indicates no meaningful difference between the excerpts. Participants sang 1.85 cents higher pitch during the

second excerpt, regardless of the condition they were viewing, which corresponded to 10 occasions of greater than 7 cents higher on both the first sung excerpt (M = 18.64 cents, SD = 9.52) and the second sung excerpt (M = 21.63 cents, SD = 12.38). These data are also unlikely to indicate an order effect.

Research Question 3: Listening Panel

Overall ratings indicated that listeners heard a difference in the vocal sound at the final release during 247 paired excerpts (82.3%).[2] These excerpts were rated to be "a little" different (n = 173 ratings, 57.7%), "much" different (n = 58 ratings, 19.3%) or "very much" different (n = 15, 5.0%). Of these excerpts, they preferred the vocal sound during singer fisted excerpts 125 times (41.7%) and during inhalation gestures 122 times (40.7%). They heard no discernable difference in the final vocal sound 53 times (17.7%). We conducted a Chi-square test for the 247 excerpts in which listeners indicated a preference and found that neither condition was preferred more often, χ^2 (1, N = 247) = 0.04, p = .85. To test for listening order effect, we tabulated that participants preferred the first excerpt they heard 130 times and the second excerpt 117 times, regardless of the conductor condition. These differences also did not reflect a significant difference, χ^2 (1, N = 247) = 0.68, p = .41.

At least seven listener participants listed the same preferred excerpt for seven singer participants. They preferred the fisted takes three times (7, 8, and 9 raters agreeing) and the inhalation takes four times (7, 7, 8, and 9 raters agreeing).

Discussion

In the present investigation, we measured perceptions and acoustical data of individual singers' vocal production and vocal sound while they viewed a conductor who displayed varied final release gestures at the end of a sung phrase. Findings indicate that more than 72% (n = 24) of singer participants perceived differences in their singing related to the final release gestures. The most reported effect was related to their vocal production (n = 10, 30.3%). Listening panel participants also noted differences in the singer vocal sound in more than 82% of the paired examples. Results of this study may suggest that conductor hand and arm movements affected singer perceptions of their own vocal production and evoked changes in vocal sound. Such a finding is consistent with a variety of studies that have found differences in singer voicing in response to varied conductor gestural conditions. Though data are specific to the sample in this pilot study and cannot be generalized, the findings could inform pedagogy and future research.

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[2] We eliminated three participants recordings because of recording equipment failure (n = 1) or participant inability to hold the final note until the final release gesture (n = 2).

Singer Perceptions

Most singer participants (87.9%) correctly noted the presence of conductor gesture differences at the final release. We carefully analyzed the videotaped conductor gestures prior to running participants in the study to ensure gesture size and placement reliability. However, some participants still indicated perceptions of variations regarding precision, size, and execution of the patterns that preceded the final release gestures. The shape of the hand, movement of the arm, and other visual idiosyncrasies of each final release gesture may have influenced perceived differences in the gestures and pattern that preceded them. Perhaps the nature of a final release gesture affects a perceived change in tempo, timing, or gesture quality. This perceived change may have evoked differences in vocal production. In addition, these experimental procedures may have "primed" participants to look for other differences in conducting gesture that may or may not have existed. Future researchers may wish to collect data in a rehearsal setting with highly practiced conductors who can re-create the desired gestures as closely as possible. Minor differences in gesture reliability could create an intervening variable, but such a study would have improved ecological validity.

Such findings may also suggest that familiarity of task or gesture can affect vocal production. In this study, participant perceptions were more varied during the first of the two examples, regardless of which final release gesture condition they viewed. Some singers also reported that the fisted gesture was easier to follow. In this study, we sought to examine the immediate, other-than-conscious singer responses to a tense nonverbal conductor gesture, without training. With that in mind, future researchers may wish to employ a training period to familiarize the singers with the prep gesture, tempo, pattern, and the final release gestures themselves. This familiarity may alleviate variations in behaviors related to clarity, gesture idiosyncrasies, and focus of attention. As Grady (2014) found that singers perceived that they sang more efficiently when the conductor gestures were clear to them, a training period may impact singer vocal production.

Perhaps most intriguing, the most frequently noted singer difference ($n = 10$ participants) was the perception that the final release gestures evoked differences in vocal production during their final sound. Specifically, eight participants preferred the inhalation gesture, with some noting that it allowed for more efficient vocal production with a feeling of greater ease and freedom and others stating that the fisted gesture caused their singing to be clipped or tight. Future researchers might wish to test these findings, perhaps utilizing sEMG measurements to assess whether the perceptions of these singers might be confirmed by objective direct measures of singer extrinsic laryngeal muscle activity.

Acoustical Analyses

Results of acoustical analyses of f_o and amplitude do not indicate significant changes. It is possible that other analyses might reveal changes (e.g., spectral or cepstral peak measurements). Also, though the final gesture had a slightly varied preparation between conditions that occurred prior to the "cutoff," the main visual difference occurred at the moment

sound ceased. Because of this factor, and because we omitted the final .05 seconds of the recordings because of various sound artifacts (e.g., inhalation noise, glottal stops) that are not amenable to acoustical analysis, researchers may need to employ other acoustical analysis techniques to detect possible changes. On the other hand, it is feasible that perceptual data may be most likely to detect changes in the overall sound.

Listening Panel

Expert listeners reported a difference in the vocal sound at the final release during most of the excerpts (82.3%), although the perceived degree of that difference varied. Listener preferences also varied, as fisted and inhalation gesture excerpts preferences occurred at approximately the same frequency. This inconsistency may relate to idiosyncrasies of listener preferences. It may also be an artifact of the open-ended nature of the question, which asked only which excerpt the listener preferred. Future researchers may wish to provide more focus to this question, possibly inquiring about perceptions of singer vocal tension, pressed singing, or hard glottal stops.

It is also feasible that the reported differences arise from the minor variations in human behavior. We sought to ameliorate this possibility by giving participants the opportunity to practice the excerpt with a metronome, thus familiarizing them with the room and melody. This effect could be addressed through a repeated measures design in which each singer performs under the same conductor condition multiple times. Such a design, however, would eliminate the immediate and potentially other-than-conscious response that a singer may have to their first viewing of certain contrasting nonverbal conductor behaviors. Nonetheless, future researchers may wish to employ such a design to determine whether singer behaviors may be consistent between the conductor gestures over time.

Finally, the listeners in this investigation had all taught and taken voice lessons and had sung in and conducted choirs; they were all graduate students in music. However, they were not all focused on choral conducting. Future researchers may wish to sample only those with choral conducting or choral pedagogy degrees in order to ensure expertise in the listening panel.

Additional Suggestions for Future Research

We believe this pilot investigation can inform future researchers who wish to study voicing at the final release. For example, we chose two final release gestures that had not yet been tested. In this case, the fisted gesture contained a slight upward movement from the conducting plane after it closed. This movement might indicate to singers such things as a release of tension or continuation of a phrase. That said, this movement seemed to be more akin to the sort of final release gesture we have observed. Regardless, future researchers might test a fisted gesture that stops on the conducting plane as it closes. This release may create a starker contrast between the two gestures and may offer further insight into the effects of the final gestures. Conversely, researchers might choose a fisted gesture that

rebounds to the same height as the inhalation gesture in order to isolate the hand shape as a variable.

We also utilized only one conductor who served as a control for the singers' viewing of the two gestures. Future researchers might seek to examine the effects of these gestures in singers who perform with a wider variety of conductors, potentially through a multi-site study. Such a design would allow the researchers to include both male and female conductors of varied heights, facial structures, etc. Further, because of the focus on choral conductor behaviors, this phenomenon might be investigated by examining conglomerate choral sound with a choir or choirs. Choral sound may offer different insights through group singing behaviors on final release gestures.

Finally, many conducting gesture studies utilize pre-recorded conductors to ensure that the conductor nonverbal gestures remained consistent for each participant. Thus far, researchers in these studies have relied on expert viewers to examine the conducting gestures for consistency (e.g., Fuelberth, 2003a, 2004; Manternach, 2012a, 2012b, 2016). Though this technique is useful, these judges might not always perceive minor differences that occur when simply watching videos in sequence. We believe this study to be the first to use pixel analysis to assess the reliability of the gestures and conducting pattern. By using this technology, we gathered data regarding the exact positioning of the conductor's hand at every ictus and rebound through the conducting pattern. As such, we hope this technique might inform future researchers who seek to obtain reliability data effectively and objectively.

Implications for teacher-conductor preparation and practice

Eight singers (24.2%) believed that they sang with more vocal tension at the final release when cued by a fisted gesture compared to only one who believed that the fisted gesture evoked more efficient voicing. These perceptions appear to align with claims of many conducting pedagogues (e.g., Davids & LaTour, 2012; Finn, 1939; Jordan, 1996; McClung, 1996) and results from extant studies (Daugherty & Brunkan, 2009, 2013; Fuelberth, 2003b; Manternach, 2012a, 2012b, 2016) who have indicated that conductor nonverbal gestures may affect singers' physical coordination or extrinsic laryngeal muscle activity during voicing. Therefore, conducting instructors might discourage pre-service conductors from using tense physical gestures (e.g., fisted final release gestures) in order to avoid unnecessary singer extrinsic muscle tension. Similarly, it may be beneficial for teacher-conductors to practice final release gestures with their ensembles that can evoke a unified final release without displaying muscle tension. Though singer perceptions of increased tension did not lead to consistent preferences in listener ratings or differences in acoustical data in this study, it is possible that they would do so in future research or in a choral setting. For example, if eight of the 33 members of a choir perceive that they sing less efficiently under one condition, such a perception might affect the conglomerate, choral sound.

The findings of this study can inform researchers as they seek to quantify the relationship between teacher-conductors and their choristers. They can also inform teacher-conductors

as they consider their gestural choices and the possible impact they may have on the vocal production and overall sound they may evoke from their choristers. This raised awareness has the potential to benefit both singer vocal production and vocal health.

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APPENDIX A

Listener Questionnaire

Listen carefully to each of these two sung excerpts. After hearing both performances, respond to each item below.

a. Comparing the overall final vocal sound of the singer in these two performances, I heard (circle one):

No difference A Little difference Much difference Very Much difference Not sure

b. I preferred the overall final vocal sound of the (circle one):

First performance Second Performance Both sounded the same

Singer Questionnaire

1. Did you notice a difference in the conductor's behaviors? Yes No

   <u>If yes, please answer the following questions:</u>

2. What differences did you notice in the conductor's behaviors (be specific and thorough)?

3. Did you notice any differences in your final vocal sound based on the conductor's behaviors? Yes No

   If yes, please answer the following questions:

4. What changed about your final vocal sound based on the conductor's behaviors?

5. How much difference did you notice (circle one)?

   No difference A Little difference Much difference Very Much difference Not sure