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The Effect of Nonverbal Conductor Lip Rounding and Eyebrow Lifting on Singers' Lip and Eyebrow Postures: A Motion Capture Study

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Abstract

This investigation, the first to use 3-D infrared motion capture technology to measure singer responses to nonverbal conductor behaviors, sought to determine whether changes occurred in participants' (N = 47) lip and eyebrow postures when following a conductor who exhibited varied lip and eyebrow positions. Participants sang the first phrase melody of Mozart's "Ave Verum Corpus" while watching a video screen under two sets of circumstances: point light pre- and posttest conditions without a visible conductor; and while viewing a videotaped conductor who displayed four counterbalanced sets of behaviors, presented in random order. The conductor exhibited a traditional conducting pattern throughout in combination with the following lip and eyebrow behaviors: (a) eyebrow raise first half of the sung phrase and modeled /u/ vowels second half, (b) neutral eyebrows first half and modeled /u/ vowels second half, (c) eyebrow raise first half and neutral lips second half, and (d) neutral eyebrows first half and neutral lips second half of the sung phrase.

Among primary results: (a) participants rounded their lips significantly more during conductor lip rounding, (b) participants raised their eyebrows significantly more during the second occurrence of the conductor raised eyebrow condition compared to the second occurrence of the conductor neutral eyebrow condition, (c) participants rounded their lips more in posttest conductorless singing compared to a pretest, and (d) most participants did not notice changes in conductor eyebrow lifting, but did notice changes in conductor lip postures.

These results were discussed in terms of possible mimicking behaviors of choristers, conductor nonverbal facial behaviors in choral rehearsals, limitations of the study, and suggestions for further research.

Keywords

conducting gesture, conductor pedagogy, motion capture, chorister imitation, chorister mimicry

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Some choral conducting pedagogues suggest that choristers may imitate particular nonverbal conductor behaviors. Gehrkens (1918), for example, notes, "the conductor works largely through the instrumentality of *instinctive imitation*…his 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). Rodney Eichenberger's instructional video, *What They See is What You Get*, is based largely on the premise that choristers imitate conductor nonverbal behaviors because "the whole body is the conducting gesture" (Eichenberger & Dunn, 1994).

Various choral music educators have advised that conductors attend to facial affect. Hylton (1995), for example, suggested that varied conductor facial affect promotes expressive communication by the ensemble. Other writers, however, have posited that conductor facial affect can change ensemble members' vocal production in particular ways. Freed (2006), for instance, suggested that a conductor who raises his or her eyebrows might encourage a lighter or brighter choral sound. Wis (1999) recommended that choristers should employ an eyebrow raise as one strategy to counteract flat singing.

Vowels, as acoustical phenomena of the vocal tract, have been shown to have a primary impact on the blend of a choral ensemble (Hunt, 1970). Choral pedagogy literature has exhibited particular interest in the /u/ vowel. Neuen (2002), for instance, suggested that choir directors establish this vowel prior to teaching all other vowels. According to Neuen, the /u/ vowel should be formed with the lips "purse[d] out just a bit, relaxed and rounded" (p. 52). Hylton (1995) recommended an /u/ vowel posture with the lips "away from the teeth" (p. 23), while Collins suggested it should be executed with a "pucker" (p. 287). Sundberg (1987) indicated that a more rounded, pursed, or puckered formation of the /u/ vowel increased vocal tract length, thus accomplishing a lowering of formant frequencies. Collins (1999) described the resulting vocal timbre as having a more "rounded, richer" color that "enhances blend" (p. 309).

Chartrand, Maddux, and Lakin (2005) posited a "perception-behavior link," whereby viewing a behavior, expression, or gesture performed by another person makes humans more likely to carry out the same activity. Other social science researchers have suggested that mimicry helps the observer to predict action outcomes (Wilson & Knoblich, 2005) or communicate empathy with a subject (Bavelas, Black, Lemery, & Mullett, 1986).

Chartrand and Bargh (1999) demonstrated that participants imitated the actions of a confederate, a phenomenon they referred to as "the Chameleon Effect." Specifically, participants who were engaged in a task with a confederate (a) imitated face rubbing or foot shaking, (b) reported better interactions when imitated, and (c) tended to imitate more as their self-reported perspective taking scores increased.

Berger and Hadley (1975) used electromyography (EMG) to investigate mimicry, noting that participants' arm and lip muscles engaged while watching videos of an arm wrestling match or of a person stuttering. Such effortful actions have also been shown to increase observer breathing rates (Paccalin & Jeannerod, 2000). In several studies, Dimberg (1990) used EMG to demonstrate that participants engaged corresponding facial muscles while viewing photos of emotional facial expressions. These responses happened quickly (Dimberg & Thunberg, 1998) and, in one study, (Dimberg, Thunberg,& Elmehed, 2000), appeared to be nonconscious, because the photo was not displayed long enough (20-30 ms) for participants to identify having seen it.

Studies of college classrooms (LaFrance & Broadbent, 1976; LaFrance, 1979) indicated that students tended to take on the posture of their instructor. This "posture sharing" increased with higher levels of rapport. Similarly, Lakin and Chartrand (2003) found that participants tended to mimic more as their desire to affiliate increased. Conversely, other studies (e.g., van Baaren, Maddux, Chartrand, de Bouter, & van Knippenberg, 2003) have demonstrated that participant independent self-construal, that is, "focus on the personal self and deemphasis of others," (p. 1093) decreased mimicry.

Some studies have investigated indirect or empathetic mimicry in singing contexts. Fuelberth (2003a, 2004) found that among a videotaped conductor's left hand crescendo gestures, participants rated tense fisted and stabbing gestures as likely to evoke the most inappropriate vocal tension. In another study (Fuelberth, 2003b), judges perceived that participants displayed the most inappropriate vocal tension while singing under the fisted and stabbing gesture conditions.

Three investigations to date have explored direct singer mimicry of nonverbal conductor behaviors. Manternach (2011) used grid analysis to measure participant head and shoulder movements. Results indicated that participants seemed to imitate conductor upward head or shoulder movements during a conventional upward moving preparatory gesture.

In two investigations, Daugherty and Brunkan (2009; in press) examined choristers' mimicry as they sang the first phrase melody of Mozart's "Ave Verum Corpus" while following a videotaped conductor who first displayed a traditional conducting pattern with neutral facial expression (baseline) and then added rounded lips on the /u/ vowels of the words "verum" and "corpus" (experimental condition). In the first study (Daugherty & Brunkan, 2009), panel ratings of full length videos indicated that nearly all participants displayed more lip rounding on at least one experimental condition /u/ vowel.

In the second study (Daugherty & Brunkan, in press), panel ratings of counterbalanced participant still photos indicated increased lip rounding during the experimental condition of both vowels in more than 90% of participants. Acoustical measurements of formant frequency profiles indicated that more than 90% of participants evidenced lowered formant frequency profiles each time the conductor rounded his lips. Additionally, only 22.81% of participants specifically and accurately noted conductor lip rounding during the two /u/ vowels.

While these studies suggested that choristers mimicked certain nonverbal conductor behaviors, no investigation to date has utilized motion capture (mocap) technology to measure potential singer mimicry of conductors. First developed in the 1970s for use in biomechanics research, mocap has been used extensively in the production of video games and movies, perhaps most famously in the recent films *Lord of the Rings* and *Avatar*. A series of infrared cameras tracks sensors that are placed on various parts of the body, providing a three dimensional (3-D) representation of the participant. Although speech and language specialists have used motion capture technology in their research, few studies of singing have done so. In one such study (Livingstone, Thompson, and Russo, 2009), mocap and EMG analysis revealed that participants (*N* = 7) instructed to imitate the emotions of singer models displayed imitative facial gestures during perception, planning, production, and post-production stages. No study to date, moreover, has examined potential singer mimicry of two conductor facial postures discussed in choral pedagogy literature (lip rounding, eyebrow raise) that occur at separate moments in one sung phrase.

The purpose of this investigation was to determine whether changes occurred in participants' (*N* = 47) lip and eyebrow postures while singing the first phrase of Mozart's "Ave Verum Corpus" during conductorless pre-and posttest conditions and also when watching a videotaped conductor, who displayed a traditional conducting pattern in combination with four counterbalanced sets of facial behaviors, presented in random order: (a) eyebrow raise first half of the sung phrase and modeled /u/ vowels second half, (b) neutral eyebrows first half and modeled /u/

vowels second half, (c) eyebrow raise first half and neutral lips second half, and (d) neutral eyebrows first half and neutral lips second half of the sung phrase.

The following research questions guided this study:

1. To what extent, if any, does participant lip rounding vary when watching a conductor model neutral or rounded lips during two /u/ vowels ("verum" and "corpus") and during two counterbalanced trials (first occurrence and second occurrence)?
2. To what extent, if any, does participant eyebrow height vary when watching a conductor who models neutral or raised eyebrows during two counterbalanced trials (first occurrence and second occurrence)?
3. Do pre- and posttest conductorless measurements indicate possible training effects?
4. Will singers accurately report specific differences in conductor facial postures during the sung trials?

Method

Participants

Participants ($N = 47$) constituted a convenience sample drawn from a large university. I selected them in order to represent a diverse sample with regard to (a) sex, (b) age, (c) previous choral singing experience, (d) years of private voice study, and (e) conducting experience.

Participants completed an IRB-approved consent form that titled the study "choral singing characteristics," but did not indicate the motion capture purpose of the study. Participants then completed a short demographic survey that outlined their previous musical experiences and familiarity with Mozart's motet, "Ave Verum Corpus." Males ($n = 14$, 29.8%) and females ($n = 33$, 70.2%) ranged in age from 19-55 years ($M = 29.3$ years). Just under half of the participants ($n = 21$, 44.7%) were current choir members.

Overall, participants had varying previous choral experiences. Most participants had high school ($n = 37$, 78.7%) or college ($n = 39$, 83.0%) choral singing experience. Some participants ($n = 35$, 74.5%) also had taken private voice lessons and some had more than two years of conducting experience ($n = 15$, 31.9%). Slightly more than half of the participants ($n = 24$, 51.1%) reported having performed the "Ave Verum Corpus" motet.

Sung Melody

A research assistant asked participants if they could sing the first phrase melody of the motet from memory. If they replied negatively, they viewed a copy of the score while listening to a wordless MIDI file of the melody as many times as necessary in order to ensure that they could perform the piece from memory.

Sensors

As soon as participants indicated that they could perform the phrase from memory, the research assistant guided them in placing seven passive reflective sensors on their faces: one above each eyebrow, on the bridge of the nose, on each corner of the mouth, and on the top and bottom of the mouth (see Figure 1). They also wore a black headband with reflective sensors, which was required for the motion capture device.

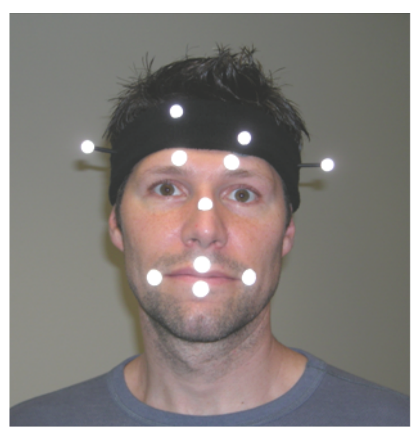


Figure 1. Participant with sensors and headband

Research Room

Participants then entered the research room and stood six feet from a projection screen that was set on a table in the corner of the room. The screen was on a slightly lower plane than participants' eye level, which approximated the angle that choristers would view a conductor when standing on a set of choral risers. A 3-D infrared motion capture system (OptiTrack by Natural Point) with seven small infrared cameras (model V100) sat on the table facing the participants but arranged such that the cameras did not obstruct the view of the conductor on the screen.

Stimulus Videos

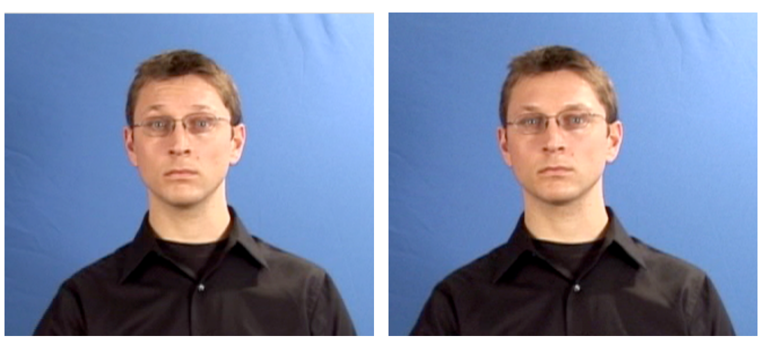
To control for possible inconsistencies in conductor movements between the conducted conditions, I utilized a videotaped conductor who was filmed from the mid-thigh to slightly above his head. The conductor wore eyeglasses and a black dress shirt, undershirt, and dress pants. He used a metronome (MM = 84) and a mirror in preparing the stimulus videos. Muting the playback volume insured that participants did not hear the metronome.

Five experienced choral conductors (*M* = 17.4 years' conducting experience) watched the conducting stimulus videos as many times as they wished in order to evaluate conductor movements using a series of nine 10 cm visual analog scales (VAS). Each scale addressed the consistency of one of the following conducting parameters (anchors of "no visible difference" or "consistent" and "lots of visible difference" or "inconsistent"): (a) prep gesture starting position, (b) prep gesture size, (c) prep gesture placement, (d) conducting pattern size, (e) conducting plane, (f) hand shape, (g) arm movement quality (e.g., ease of movement), (h) body stillness, and (i) facial affect. Ratings that fell within .5 cm of the left edge of each scale were considered "agreements." These ratings resulted in a conducting stimulus video reliability of .93 (agreements divided by agreements plus disagreements).

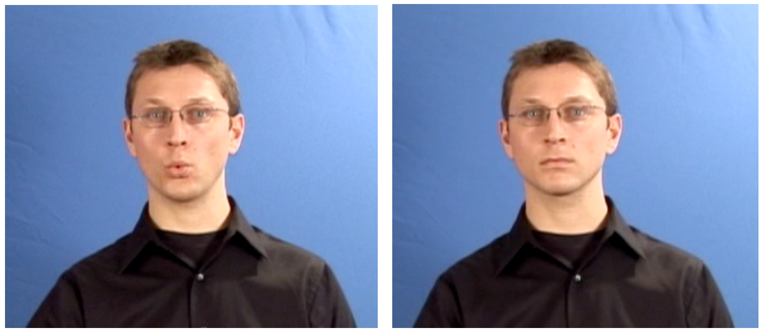
Experimental Procedures

Participants heard the starting pitch (A4, 440 Hz) sounded on a pitch pipe (Master-Key) prior to each sung condition. To establish a conductorless pretest measurement, participants sang the first phrase melody of the motet while following two lighted points on the projection screen that simulated a traditional conducting pattern (point light condition).

Participants then sang the phrase four more times while watching the conductor display the following counterbalanced conditions, presented in random order: (a) eyebrow raise first half of the phrase and modeled /u/ vowels second half, (b) neutral eyebrows first half and modeled /u/ vowels second half, (c) eyebrow raise first half and neutral lips second half, and (d) neutral eyebrows first half and neutral lips second half. Participants then sang the phrase under the point light condition for posttest conductorless measurements (See Figure 2).



Above left to right: Raised eyebrow condition; neutral eyebrow condition



Above left to right: /u/ vowel modeling for "verum"; neutral face during "verum"

Above left to right: /u/ vowel modeling for "corpus"; neutral face during "corpus"

Figure 2. Conductor stimulus conditions

Measurements

Six of the infrared cameras measured facial movement. Arena Motion Capture software (version 1.4.0) trajectorized participant face sensor movements on X (horizontal), Y (vertical), and Z (depth) planes. The seventh camera recorded the audio. I used WaveSurfer acoustical software (version 1.8.5) to place labels at the beginning and end of the measurement windows in each audio file. I then analyzed a temporal subset of the motion data to account for a variable asynchrony between the motion and acoustic data inherent in the OptiTrack recording system.

The lip recording window spanned from the onset to the offset of the modeled /u/ vowel, which was two conducted beats (approximately 1.43 seconds). I extracted the sensor locations with an MS-DOS batch file, which calculated the average horizontal distance (mm) between the corners of the mouth during the /u/ vowel on the words "verum" and "corpus" to determine the extent of participant lip rounding. According to Trask's (1996) definition of lip rounding, "horizontal or vertical compression of the lips" (Trask, 1996, p. 209), a reduced distance between the corners of the mouth indicated increased lip rounding. The /u/ vowel, in particular, is defined by horizontal lip rounding.

The eyebrow recording window spanned from onset (beginning of the preparatory gesture) to the offset of the eyebrow raise, which was nine conducted beats (approximately 6.43 seconds). I used a second MS-DOS batch file to extract the average vertical distance (mm) between the nose bridge sensor and each of the eyebrow sensors during the same time span for all conditions. I averaged the resulting distances to determine participant eyebrow height during each trial.

Questionnaire

Following the investigation, a research assistant asked participants to complete a survey with the following questions: (a) Did you notice a difference in the conductor's behaviors over the course of the four examples? If so, describe the differences in the space below; and (b) Where did you focus your attention while singing?

Results

Preliminary Considerations

The motion capture system required that a majority of the cameras track each sensor in order to accurately trajectorize movements. Depending on each participant's height, facial structure, and idiosyncratic movements, the sensors occasionally moved out of view of the required number of cameras, particularly on eyebrow movements. The following statistical tests ($\alpha = .05$) utilized casewise deletion, which eliminated participants who may not have had reliable measurements (i.e., at least 80% of eyebrow data points and 90% of lip data points) for all of the conditions in a particular comparison. Each section of results below indicates the number of participants used for the particular comparison. All participants ($N = 47$) were included for at least one statistical test.

Research Question One: Lip Rounding

I ran a 2x2x2 Repeated Measures ANOVA to compare participant ($N = 40$) /u/ vowel lip rounding between (a) conductor rounded and unrounded conditions, (b) "verum" and "corpus," and (c) the first and second occurrence of each conductor lip rounding stimulus. Results revealed differences in all three main effects. Participants displayed significantly more lip rounding during the rounded conductor conditions (F [1, 39] = 18.209, $p < .001$), on "verum" as compared to "corpus" (F [1, 39] = 4.946, $p = .032$), and during the second occurrence of both rounded and unrounded conductor conditions (F [1, 39] = 6.228, $p = .017$). There were no interaction effects in the model.

Research Question Two: Eyebrow Raise

I ran a 2x2 Repeated Measures ANOVA to compare participants' ($N = 28$) eyebrow raise between (a) raised and neutral conductor eyebrow conditions and (b) the first and second occurrence of each conductor eyebrow stimulus. Results showed a significant interaction effect between the conditions (F [1, 27] = 5.985, $p = .021$). Figure 3 displays the plotted means of this interaction.

I ran four follow-up paired t-tests to explore specific differences in the model utilizing a Bonferroni correction ($\alpha = .05/4 = .0125$). Results indicated significantly less eyebrow raise on the second occurrence of the neutral eyebrow condition compared to the first (t [27] = 2.796, $p = .009$) and on the second raised eyebrow condition compared to the second neutral eyebrow condition (t [27] = 3.823, $p = .001$).

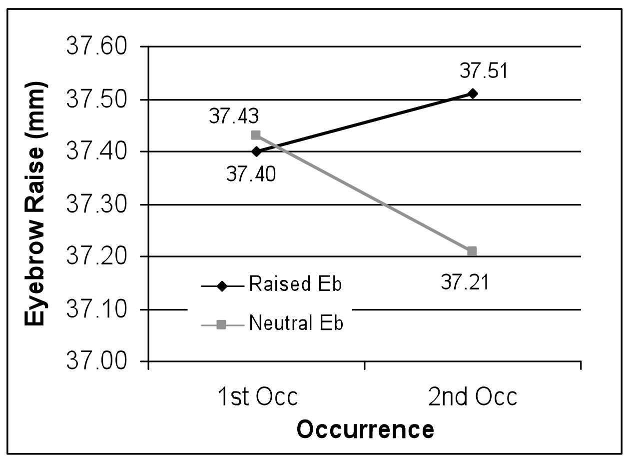


Figure 3. Eyebrow raise by occurrence

Research Question Three: Training Effect

To examine possible training effects for lip rounding, I ran a 2x2 Repeated Measures ANOVA to compare participant ($N = 41$) /u/ vowel lip rounding during (a) pre- and posttest conditions and (b) between "verum" and "corpus." Results indicated significantly more lip rounding in posttest measurements compared to pretest measurements (F [1, 40] = 7.941, $p = .007$). This result indicated a possible training effect for lip rounding. There were no differences between "verum" and "corpus" (F [1, 40] = 1.014, p = .320).

To investigate a possible training effect for eyebrow raise, I ran a paired t-test comparing participant (N = 25) pre- and posttest eyebrow measurements. There was significantly less eyebrow raise during the posttest than the pretest (t [24] = 2.36, p = .027), suggesting no eyebrow raise training effect.

Research Question Four: Awareness

Participants reported varied levels of awareness of the conductor conditions. Most participants reported noticing changes in the conductor's lips (n = 41, 87.2%), with 44.7% of them mentioning the /u/ vowel specifically. Six of these participants (12.8%) specifically and accurately reported the syllables that the conductor modeled. Others noted that the conductor modeled /u/ vowels without identifying specific syllables (n = 15, 31.9%). Six participants (12.8%) noted conductor vowel shaping, seven (14.9%) noted word mouthing, and seven (14.9%) reported more vague mouth changes (e.g., "he cued me"). Five participants (10.6%) did not notice lip differences and one participant (2.1%) incorrectly noted tempo changes. Because the conductor used a metronome and reliability ratings confirmed the steady tempo, this response was classified as a mistake.

Most participants (n = 32, 68.1%) did not report differences in conductor eyebrow movements. Nine participants (19.1%) mentioned the eyebrows specifically. Of the nine, six participants mentioned an eyebrow lift, though four mentioned seeing it only one time. Another participant mentioned an eyebrow "shift" and two others thought they "maybe" saw eyebrow movement. Six participants (12.8%) mentioned various other facial changes (e.g., facial affect or expression, "some sort of…smile or something").

Participants' reported focal point varied. Of the 40 participants who described their focus during the study, 14 (35.0%) reported focusing on the hand or arm exclusively. One singer did not mention the hand or arm, but noted primarily focusing on tempo. Six participants (10.0%) reported solely focusing on the face or mouth during the study. Nineteen participants (47.5%) reported focusing on both the hand or arm and the face. Combining those who mentioned two focal points, 33 participants (82.5%) reported focusing on the hand or arm and 24 singers (60.0%) reported focusing on the face, though four (10.0%) of these participants mentioned that they focused on the arm or hand first.

Discussion

Primary findings of this study suggest that participants mimicked conductor lip rounding and eyebrow raise. Increased lip rounding by singers during conductor lip rounded conditions is consistent with previous findings (Daugherty & Brunkan 2009, Daugherty & Brunkan, in press). In addition, data from this investigation show significantly increased eyebrow height during the second raised eyebrow condition compared to the second neutral eyebrow condition.

Such findings are limited to the particular participants in this study, and likewise circumscribed by the particular procedures and dependent measures employed. Nonetheless, these results raise matters of interest for future research and for choral conductors who may wish to explore nonverbal conductor modeling as a time efficient rehearsal strategy.

Most participants report they noticed changes in the conductor's lips (n = 41, 87.2%), with 44.7% of these singers mentioning the /u/ vowel specifically. These data may suggest that imitation of conductor lip rounding may be, at least in part, voluntary. Future research might replicate the procedures of this investigation with other participants to explore whether such is the case. Researchers can also include more in depth debriefing of participants to determine the extent to which participants were aware of the purpose of the investigation.

On the other hand, only six responses (12.8%)

specifically note conductor eyebrow raise. Of the six, four reference an eyebrow raise occurring only one time, with the other two reporting that it was "infrequent" or occurred "sometimes." Some participants later stated that they were simply concerned with singing on time and did not notice conductor facial affect. Despite this reported lack of awareness of conductor eyebrow modeling, measurements in this study still seem to indicate some degree of eyebrow mimicry. This finding may suggest the presence of nonconscious mimicry. More research is needed to confirm this hypothesis.

The equipment required for the motion capture system may inhibit slightly some of the movement measured in this study. Sensors placed on the corners of one's mouth, for example, may reduce the flexibility of the skin, potentially affecting lip movement. The headband that participants are required to wear for the motion capture system to function properly is placed immediately above the eyebrows. It rests, therefore, on the occipitofrontalis muscle, which is responsible for raising the eyebrows (Parker, 2007). Such placement may cause a constriction of the muscle that could inhibit participant eyebrow raise. Other studies, as technology advances and becomes more widely available, may benefit from sensors that do not inhibit movement.

It is also possible that the placement of sensors on the face and the wearing of a headband might serve to cue participants that facial movement is being measured. On the other hand, the sensors may increase participant self-construal, which has been shown to function as a mimicry inhibitor (Van Baaren, et al, 2003). Despite these factors, many participants did not correctly identify changes in conductor behaviors. Future research can continue to study chorister behaviors using less invasive equipment. Researchers might also consider placing "decoy" sensors to draw attention away from the face.

This study focuses on two conductor facial postures (eyebrow raise and lip rounding) that occur at separate moments (not simultaneously) in one sung phrase. It is possible that these two gestures occurring in the same sung phrase may affect one another. This investigation addresses such possible confounds by fully crossing, counterbalancing, and randomizing the experimental stimuli. Future studies might also consider if concurrent gestures may affect mimicking behaviors.

Marco Iacoboni, a neuroscientist who studies human mirroring behaviors, states, "if I were a conductor, I would try to make movements that do not interfere with what the choir is supposed to do" (M. Iacoboni, personal email, October 2, 2008). Mixed messages from a conductor (i.e., incongruent verbal instructions and nonverbal conductor gestures) may require choristers, consciously or nonconsciously, to choose which message to follow. While vocal training may ameliorate a chorister's tendency to imitate detrimental movements, these mixed messages may inhibit the time efficiency of a choral rehearsal. Future studies might investigate whether such is the case.

This investigation did not quantify the effect that mimicry of conductor facial postures might have on the chorister's individual vocal efficiency or the resulting aggregate choral sound. Additional lip rounding in one investigation (Daugherty & Brunkan, in press) led to changes in choristers' acoustical formant frequency profiles. However, chorister eyebrow raise has not been investigated empirically, though this behavior is often cited by choral pedagogues (e.g., Wis, 1999) and amateurs (e.g., way2tall89, 2008) as a component in correcting flat singing.

One study to date (Fuelberth, 2003b) seems to indicate that conductor gestures that utilize muscular tension may evoke more singer tension. Future investigations might examine a variety of conductor gestures that utilize muscular tension (e.g., furrowed brow) or that alter posture (e.g., raised chin during breathing, bent or leaning postures) to determine whether or not singers may directly or indirectly mimic conductor muscular tension and postural inefficiencies, and whether such inclinations affect vocal production and beauty of sound.

Given results of singer mimicry studies to date, one could speculate that choristers might mimic these potential vocally inefficient behaviors as well, and if so, exhibit less efficient vocal production and less desirable vocal sound. Future research can make perceptual and acoustical measurements in combination with chosen facial postures or body movements in order to determine potential effects they may have on efficient vocal production and the beauty of sound.

Pre- and posttest data from the present investigation suggest that the lip rounding techniques modeled in the investigation may continue even after the removal of the modeled stimulus. This effect may suggest that nonverbal conductor behaviors can help develop desired habits of vocal production. Because they are communicated quickly, behaviors modeled nonverbally can save time in a choral rehearsal. Such data may also suggest that less efficient vocal habits could be established if detrimental nonverbal movement behaviors are modeled. Further study can examine whether such is the case, and for how long the effect would continue.

Conducting stimulus videos are of vital importance for studies of this kind. For example, the conductor in this investigation wore eyeglasses. It is unclear if the presence of eyeglasses might draw attention to or mask the presence of eyebrow or other facial gestures. Future studies can investigate mimicry of particular gestures while following a conductor with or without eyeglasses to explore potential confounds.

In addition, the reliability of the conductor conditions was confirmed by a panel of experienced choral directors, as has long been the case in studies that employ conductor stimuli. Future studies might employ, either in addition to or in place of perceptual assessments, more rigorous evaluations such as grid overlay analysis or motion capture technology to confirm the consistency of the conducting gestures.

In this study, 3-D infrared motion capture technology allowed for discrete measurements of chorister movements. Future studies might employ other dependent measures, such as grid analysis or surface electromyography (sEMG), either singularly or in combination with motion capture procedures, to examine how singers respond to a variety of specific, nonverbal conductor behaviors. Such investigations can further understandings of specific nonverbal, choral conducting behaviors and gestures as a means of engaging choristers in vocally efficient and intended ways. ❂ IJRCS

Institutional Review Board Approval and Compliance
The author obtained approval from an appropriate Institutional Review Board to conduct this research in a manner that assured the ethical treatment of participants and the confidentiality of participant information.

Declaration of Conflicting Interests
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