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Effects of Three Conducting Gesture Heights on Acoustic and Perceptual Measures of Choral Sound

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Abstract

In choral literature, the conducting gesture is touted to have nuanced and profound effects on choral sound. Conducting texts suggested a variety of heights at which the conducting gesture should take place, but the most commonly recommended "standard" conducting gesture height was located between the navel and the shoulders. In this investigation, we explored conducting gesture height by testing this "standard," or mid-level, conducting gesture height against high and low gestures. To delve more deeply into other possible implications of conducting gesture height, we also tested each of the three heights at two contrasting tempi. We analyzed the effects of the three gesture heights on acoustic (long-term average spectra) and perceptual (pitch analysis, listener perceptions, singer perceptions) measures of three university choirs' choral sound. We found that gesture height did not markedly affect the choirs' spectral sound energy or overall pitch deviation, and these changes in sound were not readily discernible by listeners (p = .336). However, singer participant perceptions revealed valuable findings for choral teacher practitioners. Singers strongly preferred the mid-level gesture for reasons of clarity and comfort: they could easily follow the conductor and sang with the most ease. They also reported difficulties following the low gesture due to increased proximity between the conductor's hands and face, and some singers perceived a negative effect on vocal technique from the high gesture. Although they most preferred the mid-level gesture ($p < .001$), singers recognized that high and low gestures may be useful in achieving particular musical outcomes. Tempo did not have a profound effect on any of the three gesture heights.

Keywords:

choir, conducting gesture, conducting height, conducting plane, tempo, perceptions, LTAS

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If a picture is worth a thousand words, a gesture may be worth even more. A single gesture can express a directive, communicate emotion, solicit a response, or prompt a conversation. As expert communicators, humans have found ways to express words, feelings, and embedded meanings not only through verbal language but also through gestural language. "A gesture communicates, in fact it represents a more basic or general level of communication than words. It is a natural form of communication, the first one learned, and the last resort when language fails" (Kühl, 2011, p. 128). For the past several centuries, conductors have utilized the benefits of gestural communication to achieve musical goals. While the art of conducting is several centuries old, the scientific study of conducting gesture is still in its infancy. While we know that musicians can be guided and influenced by musical gestures, much is to be learned about the communicative effects of specific gestural elements and nuances therein.

Expressive Conducting

Many researchers have examined "expressive" conducting, essentially conducting gestures that include more than the traditional pattern. In investigations that examined preferences of expressive versus non-expressive conducting, results demonstrated a preference for expressive conducting (Morrison et al., 2009; Price et al., 2016; Silvey, 2011; Silvey & Koerner, 2016). Likewise, researchers showed that instrumentalists and singers improved their performances while viewing conductors demonstrate expressive conducting gestures (Gallops, 2005; House, 1998; Nápoles, 2013; Sidoti, 1990). A series of investigations (Price, 2006; Price & Chang, 2001, 2005) proved contrary when results indicated no significant relationships between conductor expressivity and ensemble expressivity ratings at high school band festivals.

In additional investigations, researchers explored the expressivity of conducting with both a baton and hands. When comparing baton– and hand–conducting effectiveness, Silvey et al. (2017) found that college musicians rated ensemble expressivity and precision higher with baton use during a fast, technical excerpt compared to a slow, lyrical excerpt in both audio and video trials. Nápoles and Silvey (2017) evaluated students' perceptions of both choral and band conductors' clarity and expressivity with baton and hand conducting and found that the choir conductor was more expressive with a baton, but clearer without. The opposite was true for the band director.

Another study tracked college wind–instrumentalists' visual fixation patterns while reading music and following both expressive and non-expressive conductors (Morin, 2019). First, the results of their study showed that, on average, participants looked at the conductor's hands three times more often than the conductor's face in both expressive and non-expressive conducting trials. Second, the calculation of fixation duration revealed that

participants fixated on the non-expressive conductor's hands just two times more than their face and reported nearly equal durations of fixation on face and hands during the expressive conducting condition. In other words, participants spent just as long looking at the expressive conductor's face as they did the hands. These results substantiate Wöllner's findings (2008) where survey participants reported observing the conductor's arms for general information, but the conductor's face for expressive information.

Silvey (2013) also found that conductor facial expression (positive, neutral, negative) affects the perceived expressivity of an ensemble. Participants rated ensemble expressivity significantly higher when the conductor displayed a positive facial expression and lowest when the facial expression was neutral. Results of these three studies offer evidence that a conductor's face, in addition to their hands, may play an important role in how musicians and audiences interpret musical information conveyed by the conductor.

Specific Conducting Gestures

Some researchers investigated specific conducting gestures in terms of singer tension, body movements, breathing, and overall choral sound. Fuelberth (2003a, 2003b, 2004) thrice tested the effects of specific conductor left-hand gestures. They found that a stabbing gesture and fisted hand gesture caused singer vocal tension or anticipated vocal tension. Manternach (2016) similarly concluded that fisted and upward-moving gestures could increase tension-related muscle activity and breath efficiency. Manternach (2011, 2012) also investigated individual singer head and shoulder movements in relation to conductor preparatory gestures. Results indicated that singer upper body movements varied according to the direction of conductor gesture. Duffy (2019) tested singers' breath regulation when responding to stimuli including conductor arm gestures and speculated that conductor arm movements may influence singers' breath efficacy and ability to sing with reduced tension. Grady (2014a) examined the effects of three right-hand conducting gestures on acoustic and perceptual measures of choral sound. Pitch analysis, LTAS, expert listener perceptions, and singer perceptions all demonstrated a preference for the vertical-only conducting gesture.

Conducting Plane Height

An underrepresented area of conducting research concerned conducting gesture height or gestural plane height. While a multitude of conducting method texts offered optimal gesture plane heights or height ranges, only a handful of researchers questioned the importance of gestural plane height, and how, if at all, it affects choral sound.

In their review of conducting literature, Silvey and Fisher (2015) referred to $n = 4$ sources which advocated for a "high" gestural plane (near chin-level), $n = 8$ sources for a "middle-level" gestural plane ("around the sternum"), and $n = 7$ sources for a "low," or navel-level, gestural plane. While these sources lacked research-based reasoning for the vari-

ous suggested heights, Silvey and Fisher summarized the anecdotal reasoning as clarity and visibility for high planes, expressivity for medium planes, and breath support for low planes.

We analyzed additional texts and drew similar conclusions: authors advocated for a variety of gestural plane heights but gave minimal supporting reasoning. Several conductors and teachers described a gesture height around the level of the waist. Decker and Kirt (1988) described a horizontal line drawn across the body at waist-height onto which conducting beats fall. Jordan (2009, p. 121) imagined a table at navel-level on which to place your hands so that the forearms are parallel to the ground. Their gesture window covered the area from the navel to the top of the sternum (p. 178). Garretson specified a window from the waist to the shoulders (1966, p. 62), Johannsen and Nakra defined the horizontal plane as a "virtual table about one handbreadth below the conductor's elbows, on the level of the waist" (2010), and Roe (1970) pointed to a fixed plane level with the elbows. Neuen's (2002) "standard conducting zone" was "from the eyes to the belt and slightly wider than the shoulders" but suggested that most of the "conducting action" stay lower in the conducting zone (p. 218).

Some sources recommended a slightly higher conducting gesture. Hansen (1997) described a "conducting pattern frame" from waist to shoulders with arms "no higher than mid torso" (p. 49). Brown's (2015) plane was "just above the waist," and conductor–teacher Rudolf qualified the center of the "standard" conducting field as midway between the shoulder and waist (1995, p. 308). Demaree and Moses' conducting plane was higher still, sitting approximately two inches below the sternum, with the full conducting "frame" up to the forehead (1995, p. 22).

Several conductor–teachers suggested adjusting the height of gestural planes, usually as a deviation from the "standard" for a specific purpose. Roe (1970, p. 211) stated that the ordinary beat should "go no lower than the waist and no higher than the top of the head," but the plane should be raised slightly for visibility in the case of "exceptionally large" groups. Rudolf (1995) cautioned against "abnormally" high or low gestural fields, but suggested that moving the plane up or down may bring "variety to the beat." Others argued that modifications made to a typical conducting plane illicit a change in sound (Hansen, 1997). For example, Neuen (2002) suggested varying the size of the "conducting zone" for dynamic purposes, while Decker and Kirt (1988) experimented with depth and height of the "horizontal line" to achieve dynamic changes: moving the line higher or closer to the conductor's body for a quieter sound and towards the choir for louder. Kilburn (2016) claimed higher, relaxed gestures encourage a "floating, light sound," whereas Eichenberger (1994) demonstrated that a high gestural plane yields a "brighter tone." In addition to the confusion behind measuring plane height against subjective measures like the waist, there remains a lack of research-based evidence to support these claims.

Peer-reviewed research on the topic of gesture plane heights is limited in both scope and consistent use of terminology. Mann (2014) investigated two gestural plane heights on solo and small ensemble singing. They used ictus points to define gesture height, with

the "high" plane's ictus falling between the clavicle and bottom of the chin and the "low" plane's ictus between the navel and bottom of the rib cage. Their findings neither substantiated nor negated current pedagogical ideas on the topic. Silvey and Fisher (2015) synchronized identical audio recordings to video recordings of a conductor using a low, medium, and high gestural plane and asked college musicians to offer their perceptions of conductor and ensemble expressivity in both a band and choral context. The expressivity rankings were significantly different between all three gestural planes, but the choral conductor was perceived to be most expressive at the medium height. In both choral and band contexts the high plane elicited the most negative comments. In two investigations, Grady (2013, 2014b) examined the potential effects of multiple conductors' nonverbal conducting gestures on choral sound. Gesture analysis, including height and width of the conducting gesture, demonstrated associations (2013) and moderate but significant correlations (2014b) between higher conducting gesture (above shoulder) and larger deviations in overall choral pitch.

The lack of clear definitions and consistent terminology hinders the progress of conducting gesture research, and while the body of research has gradually expanded over the past decade, much remains to be discovered about the effects of gesture height on choral sound, especially in terms of spectral energy, intonation, and singer and listener preferences. Since many resources discussed a "standard" placement for the conducting gesture height, we decided to investigate whether or not the "standard" gesture height was most optimal, or if the extremes above and below the standard were also beneficial. We designed this study for the purpose of examining the effects of three conducting gesture heights (low, mid-level, high) in two tempi (fast, slow) on acoustic and perceptual measures of choral sound. The research questions guiding this investigation were: how does conducting gesture height in two contrasting tempi affect: (a) the energy of choral sound according to long-term average spectra (LTAS), (b) overall pitch deviation, (c) listener perceptions, and (d) singer perceptions?

Method

Conducting Definitions

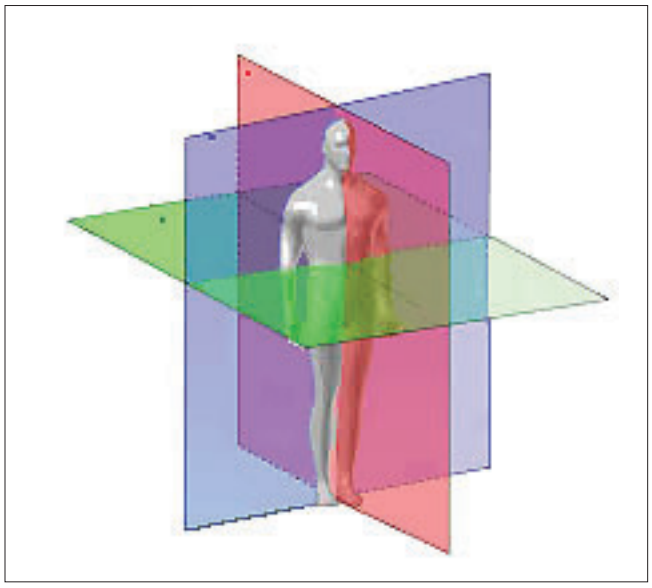
Since terms and definitions utilized in current conducting gesture literature lacked consistency, we synthesized information from multiple sources to formulate definitions (Brown, 2015; Decker & Kirt, 1998; Eichenberger, 1994; Garretson, 1996; Grady, 2013, 2014b; Green, 1992; Hansen, 1997; Johannsen & Nakra, 2010; Jordan, 2009; Kilburn, 2016; Mann, 2014; Neuen, 2002; Roe, 1970; Rudolf, 1995; Silvey & Fisher, 2015; Zabriskie, 2020). All definitions are for the purposes of this investigation in order to clarify meaning. Figure 2 contains visual representations of the definitions, including a conducting window superimposed on a screenshot of the conducting video in order to illustrate the size and placement of the conducting pattern.

Even though a conductor can use their "arms, hands, face, and whole body to convey the quality of the music" (Daley, 2020, p. 55), in this study, the term *conducting gesture* refers to hands and arm movement only and excludes other behaviors exhibited from conductors. Our conducting gesture consisted of a standard conducting pattern with cues and cutoffs.

The conducting gesture operates in relation to three anatomical planes that are dynamic and interactive: (a) *horizontal (transverse)*, (b) *vertical (coronal)*, and (c) *sagittal*. Figure 1 (LibreTexts, 2020) provides a visual representation of these planes, also referred to in conducting literature as "space boundaries" (Zabriskie, 2020, p. 226) or "spatial areas" (Dettwiler, 2020, p. 57). These planes, however, are two-dimensional, and cannot individually describe the three dimensions (height, width, depth) which constitute the conducting gesture. Therefore, we visualize the entire conducting pattern according to Zabriskie's (2020) definition as contained "within a cube," because it encompasses the multidimensional nature of the conducting gesture. The cube can move: (a) up and down, *gesture height*, (b) side to side, *gesture width*, and (c) forward and backward, *gesture depth*. This study focuses solely on the effects of changes in gesture height, or the upward and downward movement of the conducting pattern. We did not intend to study gesture width or depth as a part of this investigation, therefore those variables remained constant throughout the study.

Figure 1

Illustration of Human Anatomical Planes to Demonstrate the Multidimensional Nature of the Conducting Gesture

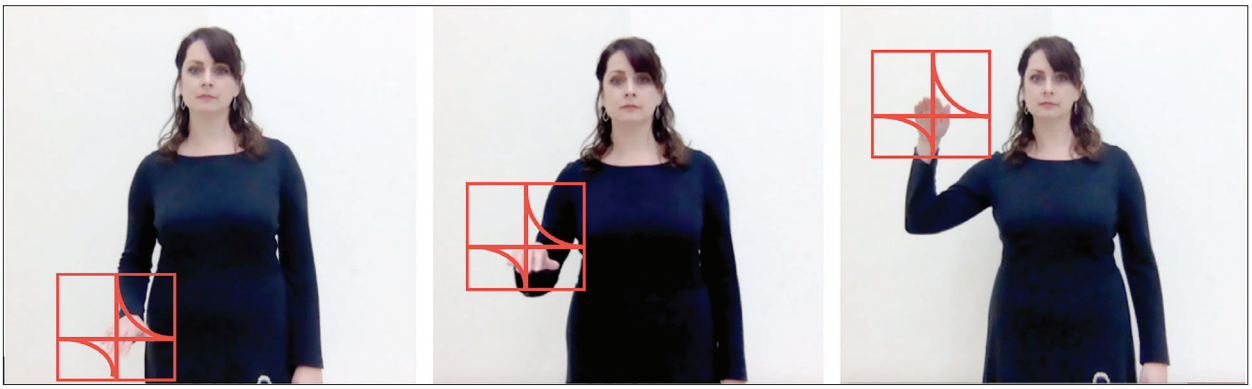


Mid-level gesture height. All but one of our reviewed anecdotal references defined the "standard" or "optimal" gesture height as somewhere between the navel and shoulders. From Silvey and Fisher's (2015) review of literature, the gesture height of 15 out of 19 total references also fell between the navel and shoulders (although they subdivided this larger category into two smaller categories), and only four of their sources suggested a height above the shoulders. Since the majority of combined references defined the "standard" gesture height to fall somewhere between the navel and shoulders, any non-standard heights would fall above or below these markings. Therefore, for the purposes of this study, we defined the "standard," or the *mid-level gesture height* from the navel to the top of the shoulders, with the ictus of horizontal beats falling around the base of the sternum.

High and low gesture heights. Since our mid-level gesture height falls in the "standard" region, non-standard conducting heights would fall above the shoulders or below the navel. Therefore, for the purposes of this study, we specified that the high conducting gesture window falls between the top of the shoulders and the top of the head with horizontal beats around the chin. The low conducting gesture window lies between the acetabulum (hip joint) and the navel, with the horizontal beats approximately halfway between (or around the "beltline," as referred to in the literature). See Figure 2.

Figure 2

Screenshots of the Three Conducting Videos Illustrating the Conducting Gesture Heights of Each Condition



Singer Participants

Three mixed-voice university choirs constituted the participants ($N = 56$) of this investigation. Choir A had 18 participants ($n = 6$ male, n = 12 female) who averaged 20.5 years of age and 50% of whom majored in music. Choir B had 17 participants ($n = 8$ male, $n = 9$ female), an average age of 19.76 years, and was made up of 65% music majors. Choir C had 21 participants ($n = 11$ male, $n = 10$ female) averaging 22.9 years of age with 90% music majors. The grand mean of all participants' choral singing experience was 10.55 years.

Musical Excerpt

Since previous research found that tempo may affect gestural effectiveness (Silvey et al., 2017), we decided to use two excerpts of contrasting tempi. The fast tempo and slow tempo musical excerpts were both selected from Brahms' *Schicksalslied* because the choirs had recently performed the piece in a combined choir concert with full orchestra and could sing the two selected sections from memory. The slow tempo section (measures 41–51) was written in 4/4 time and conducted in a four pattern at a tempo of 50 bpm. The fast tempo section (measures 111–131) was written in 3/4 time but conducted in one at a tempo of 170 bpm.

Conductor Video

For both the fast and slow excerpts, singer participants followed the same video-recorded conductor for the three gesture height conditions (low, mid-level, high). The conductor kept a neutral facial expression throughout the video since previous research suggested that a positive facial expression may be interpreted as more expressive conducting (Silvey, 2013) or may influence singer perceptions (Grady, 2014b). The conductor changed the height of the conducting gesture between each condition, but kept the gesture width, depth, and pattern size consistent between all videos. Three choral conductors verified the videos to confirm that those variables remained consistent between conditions.

The choirs viewed six total videos: one for each gesture height in both tempi. To avoid confounding variables of order effect, all three choirs viewed the videos in different orders: Choir A = S - hml, F - mlh; Choir B = F - hlm, S - lmh; and Choir C = S - mhl, F - lhm (S = slow tempo, F = fast tempo, l = low, m = mid-level, h = high).

Choral Recording Sessions

We used a Roland R-05 digital recorder to audio-record each condition. The recorder was placed at an average conductor's ear height (5 ft 4 in.), 15 ft away from the front row of the choir in the spot where the conductor usually stands in the rehearsal room. We projected the conductor video onto the wall 5 ft behind the audio recorder so reflection of sound off the wall would not affect the recording. In order to control for confounding variables and help the singers acclimate to the different tempi, we played the first ten seconds of the fast conducting video before we recorded the fast tempo conditions and the first ten seconds of the slow video before we recorded the slow tempo conditions.

The singer participants entered the rehearsal space during their scheduled rehearsal time and stood in their regular formations with two-foot inter-singer spacing on three-step risers. They completed a short demographic questionnaire on paper prior to the recording session. After singing in each condition, the singer participants marked a visual analog scale to rate how much of a positive or negative effect each condition had on their ease of singing. Researchers instructed singer participants to complete all questionnaire responses silently as to not influence other participants. Upon the completion of each group of three fast or slow tempo recordings, the participants ranked each condition in order of preference and wrote open-ended comments about their preferences. We also asked them to write what (if any) difference they noticed between conditions.

Post-recording Session Analyses

Long-Term Average Spectra

Acoustic analysis of choral sound is difficult due to its complex nature. Thus, in order to acoustically analyze the recordings, we used long-term average spectra (LTAS) measurements as a means of quantifying sound pressure level over time. These measurements al-

lowed us to compare spectral energy, or differences in loudness and timbre of choral sound, between conditions. Recordings were uploaded into KayPentax software, which computed average amplitudes of each recording's frequencies. From the output, we calculated grand mean decibel differences in order to analyze the spectral energy differences between conditions.

Pitch Analysis

We analyzed the difference in frequency between the first and last pitches of each group's choral recordings to see if gesture height affected overall pitch. Using *Pitch Analyzer 2.1* software, we compared the notated pitch to the sung pitch and calculated overall deviation in cents. Due to the perceptual nature of this measurement, we individually analyzed each of the 72 pitches (SATB first and last pitch for three recordings and three choirs), and counted agreements using Lindgren and Sundberg's (1972) definition of in-tune singing at ±7 cents (interrater reliability = .89).

Listener Participants

Listener participants (N = 22) consisted of choral/vocal teachers. Listeners (13 female, nine male) averaged 40 years of age (range = 25–62), and 16.32 years teaching choir (range = 3–38). For highest degree earned, 12 selected doctoral and 10 selected master's. Listeners received an electronic Qualtrics survey via email. After digitally consenting to participate in the study, they listened to six groups of three recordings and ranked each group of recordings in order of preference. The recordings were grouped by choir and tempo. Both the groups of recordings and recordings within each group were presented in a random order via a survey randomization tool.

Results

We analyzed all results according to tempo (fast and slow) but found minimal differences between tempi results. The majority of the results below are consequently reported as grand means without delineating between tempi, but specific differences according to tempo are noted.

Research Question 1: Long-term Average Spectra

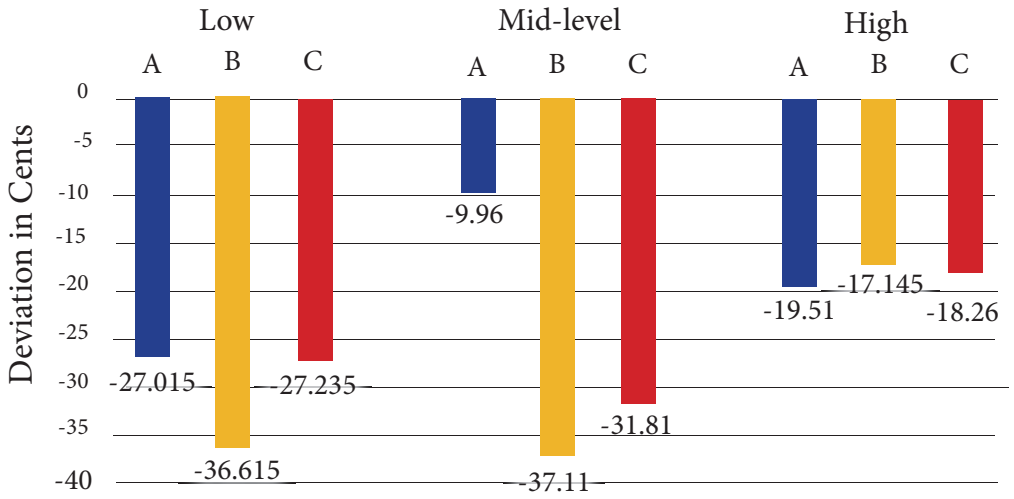
When comparing recordings obtained under the three gesture height conditions in both the fast and slow tempi, LTAS grand mean decibel differences were not pronounced. Howard and Angus (2017) suggested that a difference of 1 dB can constitute a heard difference depending upon the nature of the sound and the hearing acuity of listeners. Three of eighteen comparisons demonstrated a difference of 1 dB or more: Choir A, mid-level vs. high, fast tempo = 1.00 dB; Choir B, mid-level vs. high, fast tempo = 1.32 dB; Choir B, high vs. mid-level, slow tempo = 1.17 dB. For 15 of the 18 total comparisons, there was not a heard difference in loudness or timbre.

Research Question 2: Pitch Analysis

We perceptually analyzed overall pitch deviations for each recording in each condition. In general, choirs deviated the most while following the low conducting gesture and the least while following the high conducting gesture. Figure 3 contains the total deviation in pitch from the first sung pitch to the last for each recording.

Figure 3

Overall Pitch Deviation by Choir and Gesture Height Condition



Note. The letters A, B, and C denote the choirs.

According to Lindgren and Sundberg (1972), "in-tune" singing is classified as within ±7 cents from the notated pitch. None of the choirs sang "in-tune" from first pitch to last pitch in any condition, yet none of the choirs exceeded a quarter step in deviation (half step = 100 cents). Choir B had the largest deviation between height conditions with a difference of 19.96 cents.

Research Question 3: Expert Listener Perceptions

Expert listeners ($N = 22$) evaluated recordings of each gesture height condition grouped by choir and tempo. They ranked the overall choral sound on a scale of 1 to 3, with 1 being most preferred. Table 1 on the next page shows the average listener rankings by choir and grand means for each gesture height condition. Overall grand mean rankings demonstrate minimal differences between listener preferences. According to results from a one-way Friedman ANOVA, listener rankings between the three gesture height conditions were not significantly different, $\chi 2(2) = 2.182$, $p = .336$.

Table 1

Average Listener Rankings According to Choir and Gesture Height

Gesture Height	Choir A	Choir B	Choir C	Grand Mean Ranking
Low	2.14	1.89	2.25	2.10
Mid-level	**1.70**	2.66	**1.64**	2.00
High	2.16	**1.45**	2.11	1.90

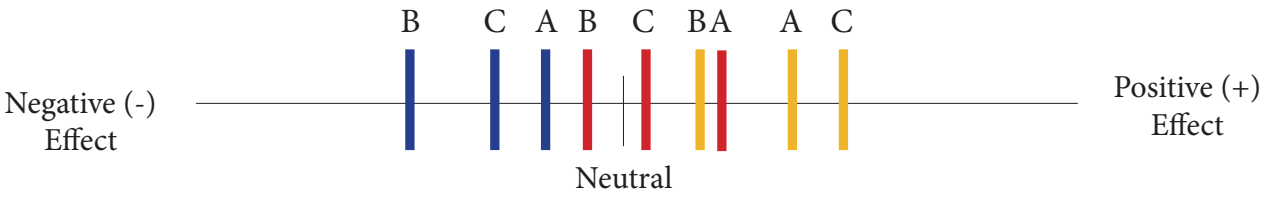
Research Question 4: Singer Perceptions

Singer Ratings of Ease of Singing

In order to determine whether each gesture height positively or negatively affected singers' perceived ability to sing with ease, we instructed singers to mark a single straight line on a visual analog scale anchored by *negative effect, neutral,* and *positive effect.* We measured the distance from the neutral point on the scale to the singers' marking in centimeters, then averaged singer measurements to calculate each choir's average perceived ease. The visual analog scale from the survey is presented in Figure 4 with the grand mean scores for each choir according to gesture height. Generally, singers perceived that the high conducting gesture had a neutral effect on their ability to sing with ease, but the low gesture was always perceived negatively, and the mid-level gesture was always perceived positively.

Figure 4

Average Choir Ratings for Ease of Singing According to Gesture Height



Note. The letters A, B, and C denote the choir while colors delineate gesture height condition (blue = low, yellow = mid-level, red = high).

Singer Rankings

Overall, the singers ranked the gesture height conditions in the following order: 1 = mid-level, 2 = high, and 3 = low. The grand mean rankings (mid-level = 1.42, high = 1.95, low = 2.63) reflected the individual choir ranking orders in all conditions. Results of a Friedman one-way ANOVA revealed significant differences between rankings, $\chi 2(2)$

= 86.530, $p < .001$, and post-hoc Wilcoxon signed-rank tests confirmed that each pair of condition rankings were significantly different (mid-level vs. low, $Z = -8.337$, $p < .001$; high vs. mid-level, $Z = -4.517$, $p < .001$; low vs. high, $Z = -5.446$, $p < .001$).

Singer Comments

We asked singers what difference, if any, they noticed between the conducting videos. Of the 56 singer participants, 53 participants (95%) correctly identified the difference as the height of conducting gesture.

We disaggregated singer participant comments into positive, neutral, and negative categories for each gesture height at each tempo. In total, all three choirs offered the most positive comments about the mid-level gesture height (75.5%) and the most negative comments about the low gesture height (68%). The comment percentages reflected the singer's rankings of the mid-level gesture height as most preferred and the low as least preferred.

Singers offered 78 total discrete comments about the high gesture condition: 31 positive and 47 negative. Singers offered 15 positive comments about the ease with which they could see both the conductor's face and hands simultaneously, allowing them to follow the conducting gesture while still watching the face for breath cues, text reminders, and expression. However, 14 comments negatively described the high gesture, particularly because the extreme height made it difficult to follow the conductor. Additionally, 17 comments revealed that the high gesture height negatively affected vocal technique. Approximately half of those 17 comments described singers' tension, tightness, or vocal strain (e.g., "made me tighten my throat," "felt strained," "caused my larynx to rise and become tense") while the other half described a negative effect on breath use and breath support (e.g., "made me want to take shallower breaths," "caused a less supported sound," "struggled to get a good breath").

The mid-level height condition received 64 total comments from singers: 59 were positive and five negative. The most apparent theme for the mid-level height was that singers could comfortably follow the conductor (27 comments) because they could easily see both the conductors' hands and face simultaneously. While this theme reflected sentiments of the high conducting gesture, the mid-level gesture did not have the perceived negative effect on vocal technique as the high gesture. In fact, 11 singers commented that the mid-level height enhanced their singing in terms of comfort, relaxation, breathing, or intonation.

Out of 82 comments about the low gesture height condition, 10 were positive and 72 negative. In over half of the negative comments ($n = 32$), singers discussed difficulties in their ability to see or follow the conductor. Many specifically noticed too large a distance between hands and face, limiting their ability to see both simultaneously. Eight comments also mentioned that the low gesture induced technique-related difficulties like tension and discomfort.

Woven throughout many of the singers' comments were themes of musicality and its interaction with gesture height. Singers preferred certain gesture heights for certain styles,

articulations, or tempi of music. For example, several singers liked the style of the high gesture in the fast tempo because it felt "bouncy," "lively," and "staccato" but disliked the high gesture in the slow excerpt because it felt "unnatural" and "unsettling." Singers preferred the low gesture in sections where they felt a "warm, full tone" was required, and singers from the bass section preferred a low cueing gesture that was reminiscent of their starting pitch. Meanwhile, others thought the low gesture in the fast tempo was "not indicative of the style" of the excerpt. One singer felt the need to sing "softer" for the low gesture height and "press" for the higher, indicating that singers also take dynamic cues from gesture height. Another felt most comfortable when the conductor "combined the pattern with the voicing of the line." In other words, the singers preferred certain gestures depending on the context and style of the piece.

Discussion

The results of this particular investigation reveal that conducting gesture height may affect perceptual measures of choral sound. However, conducting gesture height did not markedly affect the spectral energy and pitch deviation of choral sound in all conditions. Listeners confirmed that the differences, while present, were not readily discernible. The most useful findings from this particular investigation can be attributed to singer perceptions. Singers strongly preferred the mid-level or "standard" gesture height, but noted the benefits of the conductor using high or low gestures to achieve specific musical or stylistic outcomes. Overall, the "standard" gesture height, indeed, proved optimal. As conductors, we should not necessarily raise or lower the "standard" unless warranted by the music.

Challenges and Limitations

The main challenge we faced in this investigation was the lack of consistent terms and definitions in the conducting field, especially regarding gesture height. Definitions, if provided at all, varied widely in the anecdotal conducting literature and have not yet been provided in empirical studies. While this study attempted to define specific conducting gesture terms, researchers should continue to define and refine conducting terms to establish consistency in the field, allowing for more easily replicable research.

Conducting gesture research is further complicated by the common practice of standardizing gesture heights using a non-standard measuring tool: the human body. The reviewed sources defined gesture heights using reference points on the human body. While this is perhaps the only logical measuring tool, using a specific point on the human body (rather than a range) to define a gesture height unearths a realm of variability since the proportions of human bodies differ greatly between both males and females as well as within sexes. For example, if we attempted to define a gesture height at waist-level (as many of our references endeavored to do), the gesture heights would vary drastically from person to person. Even

with two conductors of the same height, and using the Cambridge Dictionary definition of waist ("the part of the body above and slightly narrower than the hips"), a waist-level gesture plane could still vary depending on conductor proportions (e.g., torso height, leg length, arm length, bodyweight, etc.). Moreover, different gesture heights may be more effective for certain body types: a shorter conductor may benefit from a high gesture where the same may be ineffective for a tall conductor. In order to reduce variability from differences in conductor body types, we decided to use ranges (like navel to shoulder) rather than body-part markers (like waist-level), but future research should continue to explore different ways to label, define, and measure gesture height.

A limitation of this study was the size of the conductor video projection. Due to the size and configuration of the regular choral rehearsal room, the projection was slightly larger than life-size, which increased the distance between the conductor's hands and face. It is possible that the increased distance negatively affected singer perceptions of the low gesture height condition because they could not see both the face and hands simultaneously using peripheral vision, as may be possible with a life-sized conductor video. Since the conditions remained the same throughout all singer recordings, we do not believe the video size affected any other results. Additionally, the singer participants in Mann's study also commented that they had difficulty seeing both the conductor's hands and face in the low gesture height condition (2014, p. 63). Future research could ensure that the choral rehearsal space can accommodate a projection that is truer to life-size, but also further explore the limitations of a choral singer's periphery while viewing conductors.

Since previous research suggested that singers observe both the conductor's hands and face for important information (Morin, 2019; Silvey, 2013; Wöllner, 2008), we decided not to obscure the conductor's face in the conductor videos. Although the conductor's facial expression in the videos may have been interpreted differently by various participants, it remained consistently neutral throughout all six videos to avoid possible confounding variables. Additionally, in order for participants to be able to focus on the changing gesture height between each condition, we selected a memorized piece that had recently been performed in a combined choir concert. Because of the joint nature of the concert and eventual addition of orchestral accompaniment, the piece was taught by multiple conductors in rehearsals leading up to the concert. Rehearsals with different conductors included individual choir rehearsals, combined choir rehearsals, and collective choir and orchestra rehearsals. Thus, due to the interaction with multiple conductors throughout the rehearsal process, we do not believe that the participants' previous knowledge of the piece affected the outcome of tested variables in the experiment.

Implications and Applications

While not particularly groundbreaking, results from LTAS and pitch analyses as well as listener perceptions provide valuable information to guide future conducting gesture investigations. The results from LTAS analysis revealed that the three gesture heights produced

different amounts of spectral energy for all three choirs in both tempi. However, the majority of differences did not exceed 1 dB, the amount necessary for the human ear to perceive differences in volume. Expert listeners did not have a consistently strong preference for any one of the three conditions, further substantiating that sound differences were not overtly apparent. While the gesture height alone did not produce readily discernible differences between conditions, it is possible that gesture height combined with another conducting variable, like expressive gestures or facial expressions, would produce more distinguishable differences in sound. More research is needed to evaluate the combined effects of gesture height with other conducting variables.

For pitch analysis, all three choirs in our study deviated in pitch during each condition, and no consistent patterns were observed between gesture height or tempo. These results do not align with previous studies, where Grady (2013, 2014b) found correlations between high conducting gestures and out-of-tune singing, and Mann (2014) found that singers sang slightly more out-of-tune for the low gesture height condition. The inconsistencies in pitch analysis results between investigations imply that gesture height may be a smaller contributing factor to intonation problems than previously thought. Since so much is still unknown about the effects of conductor gesture choices, more in-depth research is needed to discover which types of conducting gestures affect choir intonation.

Listeners most preferred the mid-level conducting gesture for choirs A and C and the high conducting gesture for choir B. While the video-recorded conductor remained consistent during this study, each choir that participated in the study had a different conductor for regular rehearsals. The regular conductors of choirs A and C generally utilized a mid-level conducting height. However, the conductor of choir B typically conducted using a high gesture height (above the shoulders): this choir not only produced the best overall choral sound in the high gesture height condition, they also sang more in-tune in the high gesture height condition. Silvey and Fisher also speculate that trained musicians may prefer the gesture height to which they are most accustomed (2015, p. 379). Choirs may acclimate to their regular conductor's gesture height and perform better under that condition. This hypothesis, which furthers the debate as to whether or not the meaning behind gestural language is inherently embedded or learned, warrants further study.

The singer participant preferences were perhaps the most noteworthy of this investigation. Singers preferred a mid-level conducting gesture because they could clearly see and follow the conductor, they perceived no negative effects on vocal technique, and they were most accustomed to it. Singers preferred the high and low gestures when they were stylistically appropriate for the musical context. This finding is similar to much of the anecdotal literature, where pedagogues suggested certain heights for particular purposes like eliciting a certain timbre, type of breath, or vocal style (Decker & Kirt, 1988; Eichenberger, 1994; Hansen, 1997; Kilburn, 2016; Neuen, 2002; Roe, 1970; Rudolf, 1995; Silvey & Fisher, 2015). Additional research is needed to ascertain if certain gesture heights actually elicit these changes in choral sound, or if it is simply a matter of perception or training.

A conductor's choice of gesture can affect singers' perceptions and singing technique (Duffy, 2019; Fuelberth 2003a, 2003b, 2004; Grady, 2013, 2014a, 2014b; Gumm, 2020; Manternach, 2011, 2016), and in the case of our study, gesture height affected both singers' perceptions of their sound and their technique. Particularly, the extreme gestures elicited more negative perceived effects than positive. Previous gesture height research also indicated that non-standard (especially high) gestures negatively affected various aspects and perceptions of choral sound (Grady, 2013, 2014b; Silvey & Fisher, 2015) and that gesture height affects singers' individual vocal technique (Mann, 2014). Furthermore, Jordan argues that "over time, choral ensembles will mirror the posture of their conductor," and that poor conducting posture could adversely affect singers' technique, including breathing (2009, p. 28). Healthy vocal technique is paramount to quality choral singing, so researchers should continue exploring interactions between conducting behaviors, gestures, and vocal technique.

This study also lends further insight into where musicians seek expressive musical information from the conductor. Consistent with Morin (2019), Silvey (2013), and Wöllner (2008), we also found that singers are not only obtaining information from the conductor's hands, but also their face. The "standard" height allowed singers to observe both simultaneously, but the increased proximity between hands and face in the low gesture made it more difficult for singers to follow the conductor. The information we gathered from singer perceptions may be the most meaningful results from this study. Correct inferences about others' nonverbal behaviors enable people to more efficiently navigate in the world (Palese & Mast, 2020); therefore, if we as teacher–conductors aim to elicit a more musically expressive product from our ensembles, we must know how our ensembles respond to our behaviors on the podium. If musicians are looking at both our hands and faces, then we must adjust our conductor behaviors accordingly.

Music and gesture quite literally go hand-in-hand. The results of this study demonstrate that various aspects of the conductor's gesture such as conducting height can significantly affect choral sound and the perception thereof. "The musical gesture epitomizes human expressivity. It represents an implied level of communication, in which a musical phrase signifies a gesture. In this way, gesture becomes key to the understanding of musical meaning" (Kühl, 2011, p. 123). If gesture is the key to understanding musical meaning, we must continue to study the role of the conductor's gesture in order to unlock the full potential of human musical expressivity.

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