International Journal of Music and Performing Arts
June 2015, Vol. 3, No. 1, pp. 35-45
ISSN: 2374-2690 (Print) 2374-2704 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/ijmpa.v3n1a4
URL: http://dx.doi.org/10.15640/ijmpa.v3n1a4

The Effects of Three Singer Gestures on Acoustic and Perceptual Measures of Solo Singing

Melissa C. Brunkan[1]

Abstract

The purpose of this investigation was to assess the potential effects of three singer gestures on performances of solo singers (N = 35). Each song ("Over the Rainbow" with low, circular arm gesture; "Singin' in the Rain" with pointing gesture; "Hawaiian Rainbows" with arched hand gesture) was sung seven times: Baseline (without singer gesture), five iterations of each song paired with a singer gesture, and a posttest (without singer gesture). This investigation measured acoustic (F_0, amplitude, formant frequency) and perceptual (expert panel ratings and participant perceptual questionnaire) differences of solo singers. Major findings indicated acoustic changes in intonation, timbre, and relative amplitude. Solo singers were more in tune when singing with gestures. Both the low, circular and arched hand gestures changed singer timbre indicated by lowered formant frequencies for the majority of participants. When performing with the low, circular and the pointing gestures, singers sang with increased amplitude, whereas, the arched hand gesture led to decreased amplitude. Expert ratings were highest for the posttest of low circular gestures and arched hand gestures, and the gestural iterations of pointing. The majority of participant comments related to intonation and timbre when using gestures. Results were discussed in terms of singing pedagogy, limitations of the study, and suggestions for further research.

Keywords: singing, gesture, choir, frequency, amplitude, perception

According to the *New Oxford American Dictionary* (2001), a gesture is "a movement of part of the body, especially a hand or the head, to express an idea or meaning" (p. 712). Gestures have been utilized by singers and teachers throughout history. Guido D'Arrezo (ca. 991 – 1050), for example, noticing that singers experienced difficulty in remembering chants learned by rote, developed a mnemonic, solmization system using the human hand to map out syllables representing scale tones. During the nineteenth century, Sarah Glover (1785-1867) and John Curwen (1816-1880) popularized the use of manual hand signs to assist singers in learning to read a music score at sight. Zoltan Kodaly (1882-1967) refined this procedure by encouraging singers to "see" and internalize the height of a pitch by moving their hands upward or downward in accordance with the steps of the scale signified by a particular hand sign. The basic belief in many of these systems is that movement can be used to strengthen the quality of learning as well as heighten the vividness of its recall at a later time (Dalcroze, 1972, p. 3). However, some pedagogues have suggested that a primary reason for using singer gesture is to evoke changes in vocal sound, and that such changes may occur, because of students' focus of attention shifts from an internal to an external focus (e.g., Eichenberger & Thomas, 1994). Other investigations have examined focus of attention in music listening (e.g., Madsen, 2009; Madsen & Geringer, 1990, 1995). Studies found differences in music listening focus of attention dependent upon level of experience and/or whether participants were music majors. In another study, Stephens (2010) recorded personal experiences, took field notes, and performed interviews with members of a community choir. The choral singing aspect indicated that performers use the aesthetic as well as attention to coordinate actions and that the choral conductor shaped performers' attentional focus to coordinate singers.

[1] Assistant Professor of Music Education, Louisiana State University, 102 New Music Building, Baton Rouge, LA 70803. Email: mbrunkan@lsu.edu

Duke, Cash and Allen (2011) examined how participants performing a 13-note keyboard passage might be affected if their focus of attention was directed to different aspects of their movements. Music majors (N = 16) performed a keyboard passage under four focus conditions in a counterbalanced design. The four focus conditions included focus of attention on either (a) their fingers, (b) the keys of the keyboard, (c) the hammers in the piano, or (d) the sound the piano produced. Results indicated that performance of the piano passage was most accurate when participants focused on the effects their movements produced instead of on the movements. Atkins and Duke (2013) examined tone quality in 30 singers under five focus of attention conditions (a) singing while feeling the vibrations on the throat, (b) directing the sound to the fingertips on either side of the nose (mask), (c) directing the sound to a microphone; (d) directing the sound to a point across the room; and (e) a baseline condition with no focus instructions). Findings showed "best" sung tone quality occurred during mask and microphone conditions. Several factors from two previous studies (Brunkan, 2013, 2015) of such gestures suggest some refinements that are implemented in the present study. The primary singer gesture employed by Brunkan (2013, 2015) was a low, circular gesture moving up and out in front of the torso, and thus a hybrid gesture. Eichenberger (1994), however, suggested a low circular gesture moving from the center of the torso, upward and outward to the sides of the body for more energy. It would seem prudent for this study to test some particular gestures recommended in the methods literature. Thus, in addition to the low, circular gesture recommended by Eichenberger, this study investigates a pointing gesture, recommended by Eichenberger and Jordan (1996), and singer employment of an arched hand gesture, a gesture also recommended by Eichenberger. Finally, if singer gesture is employed as a teaching tool, vocal music educators would likely benefit from data that indicate how long it takes singers to master particular gestures in both solo and choral singing contexts and at what point, if any, in an iterative gestural learning process, employment of a specific gesture begins to influence vocal sound. To date, no study has addressed such matters.

Purpose of the Study and Research Questions

Thus, the purpose of this study was to assess across iterations the potential effects of three singer gesture conditions (low, circular arm gesture; arched hand gesture; and pointing gesture) on performances of three familiar songs by solo singers (N = 35) using selected acoustic and perceptual measurements.

To that end, the following research questions guided this investigation:

1. According to formant profile, fundamental frequency (F_0), and amplitude measures, are there significant acoustical differences in solo sound (a) between baseline and posttest conditions and (b) between baseline performance and each of five successive, intervening performances employing a particular gesture?
2. According to expert listener (N =9) evaluations and singer questionnaire responses, are there perceived differences in solo sound (a) between baseline and posttest conditions, and (b) between baseline performance and each of five successive, intervening performances employing a particular gesture?

Method

Participants

Singer participants (N = 35) constituted a convenience sample recruited byword of mouth from the student body of a large Midwestern University. Participants ranged in age from 18 - 32 years. Participants (N = 35) were male (n = 15) and female (n = 20) singers between the ages of 18 – 31 (M = 23 years). All singers were currently in choir and had varied experience in middle school choir (M = 1.48 years), high school choir (M = 1.68 years), college choir (M = 1.51 years), voice lessons (M = 1.74 years), and conducting experience (M = 1.22 years). A panel of expert listeners (N = 7) participated in this investigation. No listener reported a hearing problem at the time of the study. Solo panel experts (N = 7) were choral conductors (n = 1) and studio voice teachers (n = 6). Male (n = 3) and female (n =4) ranging in age from 34 – 51 years (M = 39.99 years) with choral conducting experience (M = 10.86 years), and studio voice teaching experience (M = 11.89 years) comprised the panel.

Sung Musical Excerpts

Participants sang three sung melodies excerpted from familiar songs. The first sung excerpt was "Somewhere Over the Rainbow," the second selection was "Singin' in the Rain," and the folksong "Hawaiian Rainbows" constituted the third singing task. For consistency across conditions, participants sang each syllable of the lyrics on the neutral syllable "m/i/."

These melodies were selected because (a) they were compositions likely to have been performed or heard at some point by participants, (b) they lent themselves to a moderate tempo, (c) they contained ascending octave leaps, (d) they contained at least two sustained tones on a high d (female voice: 587.33 Hz, male voice: 293.66 Hz),and (e) they were all in the range of D (female: 293.66 Hz, male: 146.83 Hz).

Gestures Employed

Each of the melodies employed one of three singer gestures. The three gestures used in this study were: (a) a low, circular gesture with "Over the Rainbow" (arms moving outward and upward in front of torso), (b) an upward pointing gesture with "Singin' in the Rain"(one arm following an upward and outward point),and (c) an arched hand gesture(raising one hand with downward facing, arched palm to side and front of torso) with "Hawaiian Rainbows."

Research Room and Equipment

This investigation took place in a research room equipped with recording devices. Singers stood at a pre-marked position four feet from the video camera. A head-mounted AKG C-420^{III} (cardioid polar recording pattern) condenser microphone (AKG Acoustics, Vienna, Austria) was then positioned at a constant 7 - centimeter distance from the corner of the each participant's mouth confirmed with a thin 7 - centimeter dowel prior to each iteration of the song selections. The microphone signal was amplified by an M-Audio Mobile Pre-Amplifier, which connected via USB to a Dell Latitude 830 laptop computer with Windows XP operating system and Multi-Speech software (Kay PENTAX, Model 3700, version 3.3.0). All levels were set prior to the first participant and remained consistent throughout data collection. These recordings (16 bit .wav files, 44.1kHz sampling rate) were saved for subsequent analysis. One RCA Small Wonder EZ2000 digital video camera attached to a tripod was utilized to capture video footage of each singer. The camera was placed 4 feet from the singer such that each singer's performance and gestures could be videotaped throughout the process.

Procedure

Upon entering the research room, I asked singers to complete an Institutional Review Board (IRB) pre-approved consent form as well as a demographic questionnaire. Participants were asked on the demographic questionnaire if they could sing the melodies from memory. The melody of each selection was played for the participants on a keyboard until they felt they could sing the phrases from memory if not memorized upon entrance. Each participant was then fitted with a head-mounted microphone and stood on a marked line four feet from the video camera. A Master-Key pitch pipe (C – C range) was used to give a starting pitch (D) prior to each repetition of the melodies. The distance from recording devices was consistent for all participants. All participants were audio and video recorded while doing these tasks for subsequent analysis. Singers first sang each selection without gesture (baseline condition). They then sang each selection five times under one of the three gestural conditions. During "Over the Rainbow" participants performed the low, circular arm gesture throughout the excerpt except during measures 2 and 6. The gestures were performed every other measure in the two other selections beginning in the second measure. Finally, singers sang the song one last time with no gesture and then completed a brief post-test perceptual survey.

Dependent Measures

Intonation. Acoustic measures of solo sound included formant profiles and F_0. Sound samples were edited using Praat version 5.1.32 and loaded onto a laptop computer for playback. For the first selection, "Over the Rainbow," I used the following measurement points: (a) the midpoints of the "m/i/" vowel (corresponding to the /ɛ/ vowel on the word "somewhere") in measure 1, and (b) the midpoint of the "m/i/" vowel (corresponding to the /u/ vowel on the word "true") in measure 8. For the second selection, "Singin' in the Rain," measurement points were: (a) the midpoint of the "m/i/" vowel (corresponding to the /I/ of "singing") in measure 1 and (b) the midpoint of the "m/i/" vowel (corresponding to the vowel /o/ of "glorious") in measure 5. For the third selection, "Hawaiian Rainbows," I used the following measurement points: (a) the midpoints of the "m/i/" vowel (corresponding to the vowel /e:I/ of "rain") in measure 2 and (b) the midpoint of the "m/i/" vowel (corresponding to the vowel /i/ of "sea") in measure 16.As a control for vowel stability, the middle one second of each vowel was extracted and analyzed. The $F_0$of each vowel midpoint extracted by the Praat software for formant profile analysis was used to measure intonation by comparing the extracted F_0 to the scored target frequency.

Praat applied a Gaussian-like window to compute linear predictive coefficients through the Burg algorithm integrated in the software. To do so, I first converted all measurements in Hz to measurements in cents (1200 cents are equal to one octave). Deviations from target frequency were then expressed in cents for comparison and analyses. For purposes of this study, in tune or out of tune solo singing was qualified by the measurement of ±7 cents (Lindgren & Sundberg, 1972; Sundberg, 1982; Sundberg, Prame, & Iwarsson, 1996).

Amplitude measurement. I also used Pratt software to determine any differences in amplitude among sung iterations of each song. The mean of each participant's relative dB SPL for all excerpts served as a referent amplitude. Each sung excerpt was then compared to the referent amplitude, which yielded a dependent variable of ΔdB (change in decibels).

Expert panel evaluations. Expert panelists (N = 7) individually listened to the same recordings used for acoustic analyses. Panelists sat in a quiet room and listened to randomly ordered performances of each song through AKG 240 professional headphones attached to a Continuous Response Digital Interface (CRDI) system interfaced with a MacBook laptop computer. Volume remained consistent for each example. At no time was there compression of the electronic signal. Listeners were instructed to turn the CRDI dial according to how pleasing they perceived the vocal sound to be. The pictorial overlay utilized labeled the dial on the CRDI from "Less Pleasing Overall Sound" on the left to "More Pleasing Overall Sound" on the right side. Following listening, the experts completed a short survey on factors that most contributed to their ratings of the excerpts.

Participant survey. Participants completed a brief exit survey upon completion of the recording session. Singers were asked what differences, if any, they noticed in their singing when doing no movement, low arm circles, pointing, or the arched hand gesture. Finally, they were asked if the gestures had any impact on their focus of attention while singing.

Results

Results are presented in order of the research questions posed for this part of the investigation. A predetermined alpha level of .05 (adjusted as necessary by Bonferroni corrections) served to indicate significance for all statistical procedures.

Research Question One: Acoustical Measures

Measures of Intonation. In order to calculate mean cents deviation from target fundamental frequency per each participant (N = 35) and for each iteration (N = 7) of each song (N = 3), I measured two sung notes at predetermined data acquisition points in each song excerpt. For baseline and posttest conditions, I then averaged the cents differences between scored and sung pitches at each data point to report baseline and posttest condition intonation. Although it does not take into consideration whether overall intonation tended to be sharp or flat in relation to target frequencies, converting data to absolute values affords another view of the data in terms of gross intonation deviation and permits ANOVA testing. A Repeated Measures ANOVA found no significant main effect for intonation between the baseline, gestural, and posttest conditions of "Over the Rainbow," (F [2,51] = 1.699, p = .193). Figure 1 displays centsdeviation means for each iteration of the low, circular arm gesture compared to the means of baseline and posttest (without gesture) conditions. Singers were furthest below the target frequency (M = -5.85 cents) during the baseline condition and closest to the target frequency during the first gestural iteration (M = 2.75 cents).From baseline through posttest conditions, singers tended to raise the pitch slightly.

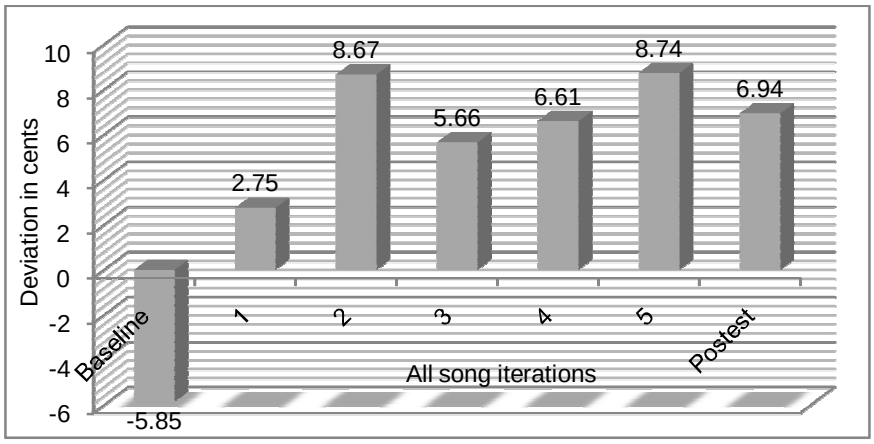

Figure 1: Fo Deviation Means for Each Iteration of the Low, Circular Arm Gesture

A Repeated Measures ANOVA found a significant main effect for intonation between the baseline, gestural, and posttest conditions of "Singin' in the Rain," (F [2, 51] = 1.699, p = .001) between baseline, gestural iteration, and posttest conditions. Follow-up paired t – tests (two-tailed) measure specific differences in the model with a Bonferroni adjustment of alpha levels to provide conservative tests of significance (p = .05/3 = .017). T-test results indicated significant differences between mean of gestural iterations and posttest measures (p< .001) and between baseline and mean of gestural iteration measures (p< .005). No significant differences were found between baseline and posttest measures (p = .563). Figure 2 displays cents deviation means for each iteration (N = 5) of the pointing gesture compared to the means of baseline and posttest (without gesture) conditions. Singers were furthest below the target frequency (M = -14.65 cents) during the baseline condition and closest to the target frequency during the first gestural iteration (M = 3.91 cents). There was a difference of 18.56 cents between the means of the baseline and first gestural iteration conditions, and a difference of 1.19 cents between the means of the baseline and posttest conditions. From baseline through posttest conditions, singers again tended to raise the pitch slightly.

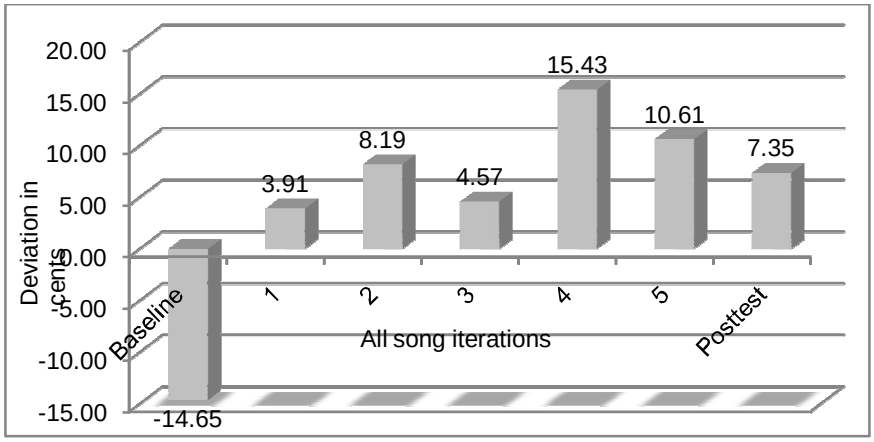

Figure 2: Fo Deviation Means for Each Iteration of the Pointing Gesture

A Repeated Measures ANOVA found no significant main effect for pitch between the baseline, gestural, and posttest conditions of "Hawaiian Rainbows," (F [2, 51] = .096, p = .91). Figure 4 displays cents deviation means for each iteration of the arched hand gesture. Singers were furthest below the target frequency (M = -6.76 cents) during the baseline condition and closest to the target frequency during the first gestural iteration (M = -1.20 cents).There was a difference of 5.56 cents between the means of the baseline and second gestural iteration conditions, and a difference of 10.08 cents between the means of the baseline and posttest.

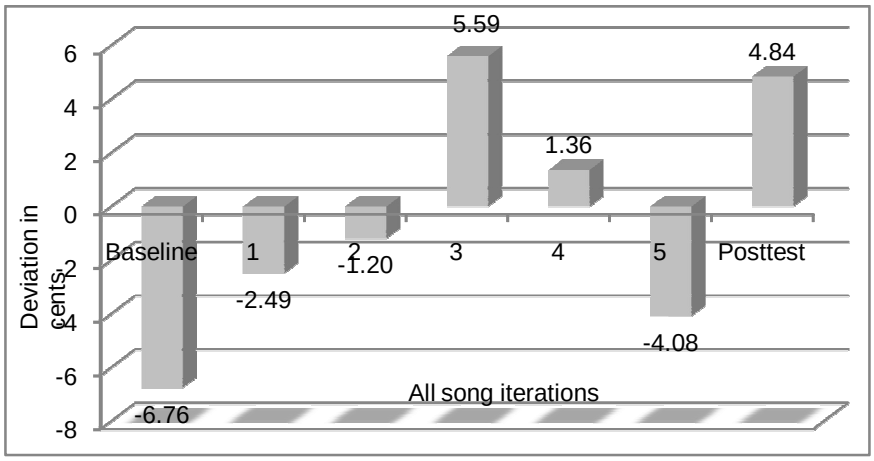

Figure 3: Fo Deviation Means for Each Iteration of the Arched Hand Gesture

Mean Formant Frequencies. Formant frequency data provide an indication of voice timbre or color. Because participants sang an /i/ vowel throughout, formant frequency means acquired from the data points can provide an indication of voice timbre. Because males and females differ in average vocal tract length, which impacts vocal tract dependent formant frequencies, formant frequency data are presented according to participant sex. Lowered formant frequencies may indicate the presence of articulation maneuvers (e.g., lips, tongue, velum) and larynx positioning that would lengthen the vocal tract, resulting in a slightly "darker" or perhaps, depending upon aesthetic and other preferences, a somewhat "richer" vocal timbre. Overall, the low, circular arm gesture appeared to be associated with changes in vocal timbre for over 70% of both female and male participants during their performances of "Over the Rainbow" and "Singin' in the Rain." Whereas, the arched hand gesture appeared to be associated with changes in vocal timbre for over 80% of both female and male participants during their performances of "Hawaiian Rainbows."

Measures of Relative Amplitude (Δ dB). For considerations of overall sung amplitude, decibel (dB) levels were acquired via Praat software at each of the data points for each participant during all iterations of each excerpt. This procedure yielded a Δ dB used for within participant amplitude comparisons. For this investigation, a 1 dB variance in complex, vocal sound constituted, for interpretation purposes, a just noticeable difference (Howard & Angus, 2006). I also calculated variances in Δ dB from individual mean amplitudes for each iteration (N = 7) of the low, circular gesture compared to the means of baseline and posttest (without gesture) conditions. The largest variance from individual mean amplitude occurred during the fifth gestural iteration (M = 2.39 Δ dB) of "Over the Rainbow." A potentially audible (± 1 dB or more) difference was observed between baseline (.04 Δ dB) and all gestural iterations (M = 1.77 Δ dB). Although, not an audible difference, there was an increase in amplitude in the posttest (M = .82 Δ dB) as compared to the baseline (.04 Δ dB).A majority of singers (N = 20, 57.14%) evidenced increased amplitude in the gestural condition compared to baseline. A majority of singers (N = 19, 54.29%) evidenced increased amplitude in the posttest condition compared to baseline. The largest variance from individual mean amplitude occurred during the third and fourth gestural iterations (M = 1.95 Δ dB) of "Singin' in the Rain." A potentially audible (± 1 dB or more) difference was observed between baseline (.14 Δ dB) and all gestural iterations (M = 1.86 Δ dB). Another audible difference was found in amplitude in the posttest (M = 1.38 Δ dB) as compared to the baseline (.04 Δ dB). For "Hawaiian Rainbows," the largest variance from individual mean amplitude occurred during the baseline measure (M = 0.75 Δ dB). A potentially audible (± 1 dB or more) difference was observed between baseline (.75 Δ dB) and all gestural iterations (M = -.23 Δ dB). Although, not an audible difference, there was a decrease in amplitude in the posttest (M = -.45 Δ dB) as compared to the baseline (.75 Δ dB).

Research Question Two: Perceptual Evaluations

Expert Panel Evaluations. Because it was impractical for judges to listen to all 7 iterations of each song, I used a random numbers table to choose 10 singers, 5 of whom were less experienced singers (two or fewer years of singing experience), and 5 who were more experienced singers (five or more years of singing experience).Experts listened to the baseline and posttest condition recordings as well as the middle, or third, gestural iteration condition in each song.

Those procedures yielded a core of 90 excerpts for listening. In order to assist reliability and to control for listener fatigue, a scaffolded approach was employed, such that each expert listener heard a total of 30 excerpts and no two judges heard the same 30 samples. Each judge spent a total of 20 minutes on the listening task. I recorded expert ratings at data points corresponding to instances when participants utilized a particular gesture. These data were entered on an Excel spreadsheet for subsequent analysis. Results of a Cronbach's Alpha procedure indicated good reliability, $\alpha = .86$. Experts' lowest rating occurred during the sung baseline performances in each song. A Repeated Measures ANOVA found a significant main effect (F [2, 8] = 4.732, $p < .05$) for expert ratings of "Over the Rainbow." Follow-up paired *t*-tests (two-tailed) indicated significant differences ($p < .017$) between baseline (GM = 112.17) and posttest mean measures with no significant differences between other measures. Further, a Repeated Measures ANOVA found a significant main effect (F [2, 8] = 7.354, $p < .05$) for expert ratings of "Singin' in the Rain." Follow-up paired *t*-tests (two-tailed) results indicated significant differences ($p < .001$) between baseline (GM = 114.66) and gestural iterations (GM = 134.57) as well as baseline and posttest (GM = 133.95) mean measures, with no significant differences between gestural and posttest measures ($p = .15$). Lastly, aRepeated Measures ANOVA found no significant main effect for expert ratings of phrases from "Hawaiian Rainbows," (F [2, 8] = 21.85, $p = .85$) between baseline (GM = 117.85), gestural iterations (GM = 134.06), and posttest (GM = 136.98) measures. Immediately after listening to the recorded excerpt, judges completed a short survey indicating topics (intonation, tone color, vibrato, other, and volume) that contributed most to their rating of a particular sung excerpt.Judges most often endorsed the terms " intonation" and " breath" to describe primary factors contributing to their evaluations. In several ways, the results of expert listener ratings mirrored tendencies and trends suggested by the acoustical data. For instance, the baseline condition of each of the song selections was furthest from target frequency. These were the same selections given the lowest expert ratings.

Participant Perceptions. Upon completion of the recording session, solo singers (N = 35) responded to an exit questionnaire that solicited overall thoughts and perceptions of singing with gestures in a solo singing context. Participants were asked to, "Please give your overall thoughts and perceptions of singing with gesture." I employed quantitative content analysis procedures (Krippendorf, 2004) to analyze these comments. Participants wrote a total of 61 discrete comments. After reading them, I first sorted the comments according the mutually exclusive and exhaustive categories of "positive" and "negative," a process that yielded 58 (95.08%) positive comments and 3 (4.92%) comments. I further sorted the specific positive comments (N = 45) into these exhaustive and mutually exclusive categories: (a) focus of attention, (b) ease of phonation, (c) intonation, (d) timbre, and (e) breath control. Most (n = 13, 28.89%) of the positive comments addressed breath control. Other frequent comments addressed intonation (n = 10, 22.22%) and timbre (n = 10, 22.22%). Comments about intonation included, "the pointing gesture helped me to hit the leaps" and the "pointing and arched hand helped to reach an appropriate pitch." Comments that addressed timbre included "the pointing gesture made me feel more controlled and pinpointed in my sound production," and "the low arm circles made me feel like I had a 'richer' sound." Among comments (n = 9, 20.00%) about focus of attention were "I focused more on the air I was using instead of being nervous about the sound I was producing" and "the gestures helped focus so your whole body can function as the instrument, not just your throat." Comments (n = 6, 13.33%) about ease of phonation included: "the gestures helped me sing freer," and the "gesture helps relax areas of tension that get in the way of singing." Participant comments referenced "breath control" over twice as much as "ease of phonation." However, chi square analysis revealed no significance in the overall distribution of the 45 positive comments into the five categories, $x^2 = 1.34$, $df = 4$, $p = 0.86$. The three negative comments (4.92% of all comments) voiced by participants were "Pointing and arched hand helped to teach an appropriate pitch, but low circle did not," "I'm not sure they helped me very much," and "The gestures distracted me."

Discussion

Overall measures of F_0, amplitude (Δ dB), and formant behaviors indicate that the gestures employed in this investigation had an effect, although not universally, on the sound produced by the majority of singers in this study. Perceptual measures also seem to indicate a perception of effect or difference when employing gestures simultaneously with singing. Such considerations help to place in broad context the specific findings of this particular investigation.

A ± 7 cents variation in pitch, a ± 1delta dB variance in relative amplitude, a slight lowering or raising of formant frequencies, can be construed as rather minor when viewed in isolation. Yet, as these variables combine and interact, as, of course, they do in human singing, perceptible nuances that either improve or detract from vocal sound may result. For the teaching of singing, nuances matter. Incremental progress in sound production and propagation is just as important from a pedagogical perspective, perhaps even more so in some circumstances, as giant leaps forward. If some of that incremental progress can be achieved non-verbally, then so much the better from the perspective of efficient use of instructional time. Findings are limited to the particular participants in this study, and likewise circumscribed by the particular methods, procedures, and dependent measures employed. Because singing is a widespread human behavior, it would be difficult to assemble truly random populations of solo and choral singers for this kind of study. Results of this investigation should not be generalized to other singers or contexts. For the sake of discussion, results rely more on interpretation of majority trends than robust tests of statistical significance. The individual singers in this study brought different established vocal habits to the gestural singing tasks, and they did not universally move in the same direction when employing the various singer gestures. Some solo singers, for instance, evidenced progress toward desired pitch targets with one gesture, but not another. Some evidenced progress with all three gestures. For some, no gesture appeared to "work."

Formant frequency measures indicated changes during implementation of gestural conditions. Formant frequencies, for example, lowered for a majority of solo singers across gestures. Lowered formant frequencies may also indicate a "darker" timbre or the presence of articulation maneuvers (e.g., lips, tongue, velum) and larynx positioning that would lengthen the vocal tract, resulting in a somewhat "darker" or perhaps, depending upon aesthetic and other preferences, a somewhat "richer" vocal timbre. The presence of a somewhat darker tone could be related to physiological responses not directly involved in the gesture. Findings suggest that the pointing gesture not only effects timbre of sound produced, but also influences singing done after gestures are performed. Further, the arched hand gesture contributes to changes in vocal timbre towards a "darker" or "more balanced" tone production on sung /i/ vowels. Expert listeners cited intonation more frequently than other terms as a factor in their ratings. Accuracy of pitch can be influenced by numerous variables, such as breath, vocal efficiency, and posture. The pitch analysis procedures in this investigation appear to indicate that singer gesture could also be a variable. Some pedagogues claim that intonation may improve with use of gesture because the singer's focus of attention shifts from an internal to an external focus (Eichenberger & Thomas, 1994; Con, 2002). Future studies might examine this possibility. Perhaps the relevant finding from a pedagogical perspective is that most solo participants (62.87%) did trend toward more in tune singing both while employing the low, circular arm gesture, and this trend persisted among some participants (57.14%) during the posttest after this gesture was withdrawn. This finding may support anecdotal claims that a low, circle will assist singers' pitch accuracy (Eichenberger & Thomas, 1994; Jordan, 1996). Yet it also suggests that such assistance may be quite small, or even absent in a substantial number of singers.

The pointing gesture was found to have possible impact as singers sang "Singin' in the Rain" most in tune while performing this gesture and furthest from target frequency during the baseline condition. This finding may support claims that a pointing gesture makes the sung pitch better supported and clearer (Eichenberger & Thomas, 1994; Jordan, 1996). Overall, however, 51.43% of participants sang closer to target frequency during the posttest condition of "Singin' in the Rain." This finding may suggest that for some singers the pointing gesture may enable more sharp singing, but when withdrawn enables singers to approach a desired target frequency. Singers also sang most in tune during "Hawaiian Rainbows" while performing with the arched hand gesture, indicating a possible beneficial effect on intonation of the arched hand gesture. According to measurements of fundamental frequency, solo singer participants in this investigation tended, overall, to sing slightly more in tune when singing with the arched hand gesture (68.57%) and also during the posttest condition (54.28%) after this gesture had been withdrawn. The iteration found to be most in tune were the 2nd and 4th gestural iterations, possibly indicating that there was an effect of employing the arched hand gesture once singers had some experience with the gesture. The low, circular arm gesture appears to offer assistance in moving toward target pitch for more solo singers than the arched hand and pointing gestures. This finding aligns with previous research employing a similar gesture (Brunkan, 2013) that found 67% of singers were closer to target pitch when singing with a low, circular arm gesture. Eichenberger (1994) speculates that the low, circular arm gesture lends the sound more energy. This prediction seems to hold true in relation to the findings of this study.

A majority of solo singers (57.14%) sang with increased energy when employing the low, circular arm gesture and the pointing gesture (74.28%) compared to baseline measures with the majority of solo singers (52.28%, low, circular gesture; 68.57%, pointing gesture) continuing to sing with increased energy during the posttest condition. Moreover, assessments of deviations from individual mean amplitudes show more variance during baseline and posttest conditions, and less variance during gestural iterations. Findings indicate a majority of participants (98%) perceive that gestures positively affect vocal sound. This perceptual rating aligns with acoustical findings that indicate all three gestures in this study brought solo and choral singers closer to target pitch. Overall, participant perceptions indicate the low arm circles were most effective and easiest to do. A majority of singers also said they focused on the gesture instead of the sound. This finding might indicate that these gestures may function as an alternative focus during singing, and, perhaps, that such focus may impact the way in which singers' sound is produced.

Pedagogical Reflections

Pedagogically, teachers frequently explain the goal of teaching strategies to their students depending upon the students' level of understanding, experience level, age, or teaching goals. This type of instruction can impact the outcome of the technique. Singers often employ their personal interpretation of strategies, therefore changing the outcome. Nonverbal gestures, also, may need to be tailored to a student's goals, needs, experience level, and learning styles. Future research might look at the use of gesture with groups at varying levels of development. The gestures used in this study seem to have varying, generally small effects, according to certain individual dependent measures. The pointing gesture, for example, seemed to increase energy overall. Therefore, a voice teacher who aims for a more energized or perhaps, louder sound may want to employ such a gesture. If, however, the goal is pitch accuracy, the pointing gesture may not help all singers. The arched hand gesture, on the other hand, decreased energy and seemed to influence the timbre of the sound. Voice educators might wish to employ this gesture to evoke a tone that my blend more easily. The low, circular gesture seemed to have two main effects – more accurate pitch and increased energy. These effects occurred in both the choral and solo contexts. The low, circular gesture, therefore, might facilitate more accurate pitch or fuller sounds from singers in general.

Potential Confounding Variables

One of the challenges of researching phenomena associated with singer gesture is the need for controlling potential confounding variables. Therefore, three gestures recommended in the literature were chosen for this particular study. However, voice educators would normally choose gestures for singers that aim at a particular pedagogical goal. This type of individualized instruction was not utilized in this study, but it would be important to consider in practice. It is possible that results could be attributed to a "novelty effect" for the first iteration of any gesture. In particular, the low, circular arm gesture was the first gesture performed by all singers. Thus, the acoustic and perceptual differences in measures of the low, circular arm gesture during the first iteration may be attributable to a shift in focus of attention, providing a distraction of sorts from the task of singing.

Future Research

Future studies might measure intonation differently, e.g. using some sort of individual F_0 standard derived by first subtracting from/adding to difference between initial baseline pitch and initial scored pitch. Although a similar procedure was done in this study with amplitude measures, frequency measures were not calculated in this fashion. Utilization of this method might enable researchers to examine changes in intonation based on a singer's tonal center. Eichenberger (1994) suggests that conductors incorporate the singer gestures employed in rehearsal into the conductor's gestural vocabulary in performance. He posits that this integration of gesture causes singers to remember the effect they experienced when performing the gestures themselves. Future research might examine training with gesture, followed by conductor-led performance with same gestures in order to explore the possible lasting effects of singer gesture. As the anatomical structure of singers varies widely, some anatomical and physiological factors might be of interest to future research. These factors may also contribute to the magnitude of an individual's gesture. Therefore, future research may wish to examine the possible correlation of gesture magnitude to amount of change in frequency and amplitude. These findings might also be compared to length of an individual's arm structure.

Among other possible measures for future research investigating singer gesture may be use of surface electromyography (sEMG) to assess electrical activity in muscle regions of interest or use of a motion capture system may enable synchronization of motion and acoustical data. Similarly, respiration bands worn by singers might enable measures of breathing behaviors.

Conclusion

Findings of this investigation indicate that the singer gestures employed in this investigation apparently can affect intonation, amplitude, and timbre of sound produced in both choral and solo singing contexts. Overall perceptions of the expert listening panels and participants tend to confirm that such may be the case. However, these findings must be approached with both caution and discernment. Results are limited to the contexts and procedures of this particular investigation. Even more importantly, from the perspective of vocal pedagogy, the findings of this study suggest that effects of singer gesture tend to be small ones, and that with particular individual singers there may be no effect. The possibility remains, moreover, that the use of many types of gesture could produce such nuances in vocal sound. More research is needed to ascertain whether small differences between particular gestures are "real," or simply an artifact of the particular convenience groups of singers who participated in this study. Singing is an intricate and multi-faceted human behavior entailing simultaneous coordination between and among a variety of physiological, cognitive, and acoustic components (Thurman & Welch, 2000). The teaching of singing, whether in choral or private studio contexts, is likewise a complicated undertaking. Voice teachers, whether in choral or studio contexts, must hear accurately, assess quickly, and make suggestions for improvement based on a holistic understanding of what may be happening with particular voices. Research of singing phenomena can assist voice educators to make informed, vocally friendly decisions about the pedagogical tools they may choose for particular singers in particular circumstances. Singer gesture may be one such tool. Results of the present study, the first to examine particular singer gestures with a variety of lenses (acoustical, perceptual, pedagogical) warrant continued research of a heretofore under-investigated area of keen interest to voice educators.

References

Atkins, R. L. & Duke, R. A. (2013). Changes in tone production as a function of focus of attention in untrained singers. International Journal of Research in Choral Singing 4(2), 28 – 36.

Boersma, P., & Weenink, D. (2010). Praat 5143. University of Amsterdam: Netherlands http://www.fon.hum.uva.nl/praat.

Brunkan, M. C. (2015). Relationships of a circular singer arm gesture to acoustical and perceptualmeasures of singing: A motion capture study. Update: Applications of Research in Music Education. doi: 10.1177/8755123314567782

Brunkan, M. (2013). The effects of watching three types of conductor gestures and performing varied gestures along with the conductor on measures of singers' intonation and tone quality: A pilot study. International Journal of Research in Choral Singing, 4(2), 37–51.

Duke, R. A., Cash, C. D., & Allen, S. E. (2011). Focus of Attention Affects Performance of Motor Skills in Music. Journal of Research in Music Education, 59, 44-55. doi:10.1177/0022429410396093

Eichenberger, R., & Thomas, A. (1994, videotape). What they see is what you get: Linking the visual, the aural, and the kinetic to promote artistic choral singing.

Chapel Hill, NC: Hinshaw Music, Inc.

Howard, D.M., & Angus, J.A.S. (2001). Acoustics and psychoacoustics. Second ed. Oxford, UK: Focal Press.

Jacques-Dalcroze, E. (1972). Eurhythmics, Art, and Education, trans. Frederick Rothwell, ed. Cynthia Cos. New York: B. Blom, 106.

Jordan, J. (1996). Evoking Sound: Fundamentals of Choral Conducting and Rehearsing.Chicago, IL: GIA Publications.

Lindgren, H., & Sundberg, J. (1972). Grundfrekvensförlopp och falsksäng, stencil, University of Stockholm, Department of Musicology.

Madsen, C. K., & Geringer, J. M. (1990). Differential Patterns of Music Listening: Focus of Attention of Musicians versus Nonmusicians. Bulletin of the Council for Research in Music Education, 105, 45-57

Madsen, C. K., & Geringer, J. M. (1995). Focus of Attention to Elements: Listening

Patterns of Musicians and Nonmusicians. Bulletin of the Council for Research in Music Education, 127, 80-87.

Stephens, J. P. (2010). Towards a psychology of coordination: Exploring feeling and focus in the individual and group in music-making. (Doctoral Dissertation). Retrieved from ProQuest Dissertations and Theses Database. (AAT 3406324)

Sundberg, J. (1982). In tune or not? A study of fundamental frequency in music practice (STL-QPSR 1). Stockholm: Department of Speech Communication, Jungl Tekniska Högskolan.

Sundberg, J., Prame, E., & Iwarsson, J. (1996). Replicability and accuracy of pitch patterns in professional singers. STL-QPSR, 36(2 – 3), 51 – 62.

Totsika, V., & Wulf, G. (2003). An external focus of attention enhances transfer to novel situations and skills. Research Quarterly for Exercise and Sport, 74, 220 – 240.