The Effects of Singer Head Position on Listener Preferences and Perceptions of Vocal Timbre

Amelia A. Rollings

Western Kentucky University

Abstract

Some vocal pedagogy textbooks encourage singers to keep the head level with the ground (e.g., McKinney, 1994; Miller, 2004). However, other vocal pedagogy texts and articles recommend singers employ a slightly lowered head position (Davids & LaTour, 2012) or a slightly elevated head position (e.g., Austin, 2013). The purpose of this study was to determine the effect, if any, of 3 extreme alterations in the head position (lowered, neutral, elevated) of a classical female singer on long-term average spectra (LTAS) data and listener (N = 30) preferences and perceptions of vocal timbre. A singer participant performed a portion of an aria 2 times in each of the 3 different focal point conditions that required her to adjust her head position. Listener participants compared 14 pairs of recordings and completed a questionnaire that asked them to select the amount of difference they perceived in vocal timbre between the two recordings in each set and to select the recording they most preferred.

Primary results indicated that (a) when the singer performed in an elevated head position, LTAS relative mean signal amplitude increased, and when the singer performed in a lowered head position, LTAS relative mean signal amplitude decreased with individual harmonic amplitude differences ranging from 0.51-4.18 dB; (b) listeners most often heard “a little difference” when comparing recordings of the singer performing her aria in different head positions, but some listeners erroneously heard a difference in two sets that compared the same recording; (c) listeners most preferred the vocal timbre of the singer in the first performance of the neutral head position condition (neutral 1) followed by neutral 2 and lowered 2, elevated 2, lowered 1, and elevated 1; and (d) listener preferences appeared to follow LTAS relative mean signal amplitude as listeners preferred the recording with the midmost relative mean signal amplitude compared to those recordings with the highest and lowest relative mean signal amplitudes.

Keywords: head position, singing, voice, jaw opening, perceptual, timbre, listener, LTAS

Voice teachers routinely give singers advice concerning the best head position for singing. Many voice pedagogy textbooks advise singers to keep the head and chin level with the ground (McKinney, 1994; Miller, 2004). However, some anecdotal and voice research sources suggest that singers may employ a slightly elevated head position (Austin, 2013), a slightly lowered head position (Davids & LaTour, 2012), or alter head position when singing different vocal styles (Barnes-Burroughs, Watts, Brown, & LoVetri, 2005).

Investigations in orthodontics, maxillofacial surgery, and sleep apnea have found that alterations in head position affected the vocal tract in terms of (a) trachea length [e.g., Harris, 1959], (b) hyoid bone position [e.g., Hellsing, 1989; Muto & Kanazawa, 1994; Gustavsson, Hansson, Holmqvist, & Lundberg, 1972], (c) pharyngeal airway space [e.g., Tong, Sakakibara, Xia, & Suetsugu, 2000; Hellsing, 1989], and (d) tongue position [e.g., Shelton & Bosma, 1962]. Muto et al. (2002) found that a superior head position movement of 10 degrees created a 4 mm increase in pharyngeal airway space.

A superior head movement may be needed in order to maximally open the jaw (e.g., Goldstein, Kraus, Williams, & Glasheen-Wray, 1984; Eriksson, Zafar, & Nordh, 1998; Eriksson, Häggman-Henrikson, Nordh, & Zafar, 2000; Zafar, Hordh, & Eriksson, 2000; Kohno S., Kohno, T., & Medina, 2001; Kohno, S., Matsuyama, Medina, & Arai, 2001; Miyaoka, Hirano, Miyaoka, & Yamada, 2004). Muto and Kanazawa (1994) found maximal mouth opening impossible unless a concomitant superior change in head position occurred.

Speaking voice studies have shown that participants elevated head position in order to speak louder and be understood in noisy environments (Lagier et al., 2010). Kooijman et al. (2005) found that female teachers with persistent voice complaints exhibited an anterior head position posture, and that head position most commonly predicted a low Dysphonia Severity Index score.

Head position studies with singing participants found that (a) singers elevated head position as they ascended in pitch [Scotto Di Carlo, 1998; Miller et al., 2012a]; (b) professional singers exhibited cervical spine abnormalities whereas non-singers did not [Scotto Di Carlo, 1998]; (c) one singer with thyroid cartilage calcification used a forward-tilting head position, most likely in an effort to assist the thyroid cartilage in tilting forward [Scotto Di Carlo, 2002]; (d) participants elevated head position when singing compared to remaining quiet [Johnson & Skinner, 2009]; (e) a majority (n = 4, 80%) of singers lowered head position as shoe heel height increased [Rollings, 2014]; and (f) positive, moderate correlations existed between vocal structures, the craniofacial skeleton, and the cervical spine [Miller et al., 2012b].

Another group of studies investigated the effects of head position adjustments on acoustical measures of voice production. Jones (1972) pulled up the base of one singing female participant's head and found improved integrity and increased richness of spectral harmonics in addition to decreased breath noise. Luck and Toiviainen (2007) studied the relationships between 14 kinematic postural elements and four measures of vocal timbre with singers (N = 15) and found that, more than any other postural variable, the lateral head position angle significantly predicted vocal timbre in individual participants. Participants exhibited increased spectral irregularity when they sang with a lowered head position. However, RMS amplitude increased when participants sang with an elevated head position. The researchers suggested that the greater RMS amplitude in the elevated head position could be attributed to a freeing up of the vocal apparatus that permitted greater airflow.

Only one study found to date incorporated a perceptual component to investigate the effects of singer head position. Barnes-Burroughs et al. (2005) studied real-time listener perceptions ($N = 2$) of singers ($N = 8$) as they performed the same song in both classical and musical theatre voice with four different head and neck movements: (a) head and neck position following the normal melodic curve of the score, (b) head and neck in an elevated posture for the duration of the song, (c) head and neck in a downcast posture for the duration of the song, and (d) head and neck position following the inverted melodic curve of the score. The classical voice pedagogue listener favoured either the downcast head position or inverted melodic contour posture. The musical theatre pedagogue expressed idiosyncratic preferences and favoured the elevated head posture in some participants. Neither listener preferred the head position condition that followed the natural melodic contour. When the researchers combined the ratings of the two listeners, they found that for classical singing, listeners preferred overall the inverted melodic head and neck position compared to the downcast and elevated postures. For the musical theatre singing condition, listeners favoured overall the downcast head position compared to the inverted melodic posture and the elevated posture.

A comprehensive collection of data in the areas of orthodontics, maxillofacial surgery, and sleep apnea suggest that head position affects the anatomy and physiology of the vocal tract. It might be logical to conclude that any observed changes in the vocal tract attributed to head position could be important for singers and voice teachers alike. The previously cited studies have investigated singularly the effects of singer head position on anatomy, physiology, acoustics, or perceptions. However, the limitations of studies to date include (a) a small listener sample size ($N \leq 2$), (b) perceptual data without corresponding singer head position measurements or acoustical data, and (c) singer head position measurements or acoustical data without corresponding perceptual data. The purpose of this study was to determine the effect, if any, of three extreme alterations in the head position (lowered, neutral, elevated) of one classical female singer on long-term average spectra (LTAS) data and listener (*N* = 30) preferences and perceptions of vocal timbre. The following research questions guided this investigation:

1. What effect, if any, does three head positions (lowered, neutral, and elevated) have on one singer's long-term average spectra (LTAS) data?
2. To what degree, if any, do listeners (*N* = 30) perceive differences in vocal timbre with alterations in singer head position?
3. What head position condition (lowered, neutral, and elevated) do listeners (*N* = 30) prefer regarding vocal timbre?

Method and Procedures

Participants

This study required both singer and listener participants. A female Master's student (age 22) from a large Midwestern university recorded all singing examples. A convenience sample of listeners (*N* = 30) ranged in age from 18 (*n* = 1) to 53 (*n* = 1) years old (*M* = 21.43 years, *SD* = 9.25 years). Each listener reported being an undergraduate (*n* = 18), Master's (*n* = 6), or Ph.D. (*n* = 6) student. All students declared music as a major with subspecialties in music education (*n* = 16), music therapy (*n* = 13), and voice performance (*n* = 1). The researcher selected these participants regardless of their primary instruments of study, which included: voice (*n* = 12), percussion (*n* = 2), piano (*n* = 4), cello (*n* = 2), brass instruments (*n* = 5), and woodwind instruments (*n* = 5).

The researcher aimed to include participants of different ages, instruments, education, and vocal experience to represent an audience one may find in a university recital audience. All participants reported participating in a choral ensemble for at least one year. A majority of participants (n = 19, 63.33%) reported previous applied voice lesson study and a few participants (n = 4) reported experience in voice teaching. A majority of participants (n = 26, 86.67%) reported attending at least one solo vocal performance each year. Some instrumentalist participants answered that they did not feel they could identify vocal differences in singers (n = 8); however, a majority of participants (n = 22, 73.33%) felt comfortable doing so. A few listeners (n = 4) reported that they had been told they had hearing loss; however, these participants marked that they did not believe their hearing loss would have an impact on their ability to complete the study.

Focal Point Markers

The researcher informed the singer participant that the purpose of the study was "the effect of focal point on singer performances." The researcher did not inform the singer of the independent variables of interest (head position, LTAS) but instead instructed the singer to look at one of three focal points during each performance. In order to force the singer into elevated and lowered head positions that would require an adjustment of the head and neck rather than the eyes, the researcher adhered one tape marker to the ceiling above the participant's head and one tape marker to a clip positioned on the singer's sternum. The researcher adhered a third tape marker for the neutral condition to the wall at eye level directly across from the singer.

Singer Performance Protocol

The singer entered the research room, warmed up for five minutes, and confirmed that she felt comfortable singing in the room. She performed a 54 sec. selection of the end of the aria, “Laurie’s Song” from *The Tenderland* by Copland. The singer performed the selection six times in a randomized order of head position conditions: (a) neutral, (b) lowered, (c) elevated, (d) lowered, (e) elevated, and (f) neutral.

Postural Analysis

The researcher attached three head position markers to the singer: (a) a PomPom [white, 25.4 mm, with an Avery Hole Reinforcement label, florescent pink, ¼ diameter] to the approximate location of the C7 vertebra; (b) an Avery Hole Reinforcement label [white, ¼ diameter, with a symmetrical open circle in the middle facilitating exact measurement] adhered to the right tragus; and (c) one PomPom [white, 4 mm, with a black point drawn on the right lateral side] adhered to the nasion (see Figure 1).

One Zoom Handy Video Q3 video camera recorded participant head position in .mov format. The researcher digitally transferred the video recordings to a MacBook Pro computer in order to create still picture screenshots using QuickTime (version 10.1) software. The researcher created a still picture screenshot at a juncture where there was no visible participant sway or exaggerated atypical movement.

Following Cuccia and Carola (2009), the researcher measured three angles of the singer’s head position at the midpoint of five vowels in each of the six performances in three head position conditions: (a) “upon,” (b) “stand,” (c) “begin,” (d) “strange,” and (e) “wide.” For vowels with diphthongs, the researcher measured the midpoint of the first portion of the vowel before the participant exhibited any articulator movement. The researcher calculated the mean of each head position angle of the two performances in the same head position condition, which resulted in three mean head position angle measurements (angles 1, 2, and 3) for the lowered, neutral, and elevated head position conditions. The researcher used Onde Rulers (version 1.12.21), an on-screen ruler program with a protractor, for all head position measurements.

An increase in angle 1 (Na-Tr-VP) indicated a superior head position movement, and a decrease indicated an inferior head position movement. An increase in angle 2 (C7-Tr-VP) signified an anterior movement of the head and neck, and a decrease in angle 2 signified a posterior movement of the head and neck. Angle 3 (C7-Tr-Na) denoted the overall head position including the sum of angles 1 (superior and inferior) and 2 (anterior and posterior) (see Figure 1).

Acoustical Analysis

The researcher audio recorded the singer with an AKG C 420^{III} cardioid condenser head-mounted microphone with an attached wind deterrent in a position of 3 cm from the left side of the participant's lip corner (Titze & Winholtz, 1993). The microphone was connected to a Tascam US-122MKII pre-amplifier with an Audio/MIDI interface. The recording level remained consistent between performances. A MacBook Pro Computer equipped with Audacity software (version 1.3.14-beta) recorded the performances in .wav format with a 44.1 kHz (32 bit) sampling rate. The researcher used KayPentax Computerized Speech Lab (CSL) Model 4500 software to analyze long-term average spectra (LTAS) data of the participant recordings using a window size of 512 points with no pre-emphasis or smoothing and a Hamming window with a bandwidth of 86.13 Hz.

Listener Recordings

Due to the length of the entire aria selection (54 s), the researcher chose the same 16 s clip in each of the six performances to use for listeners. The perceptual portion of the study included 12 sets of recording comparisons. Two sets (set 8 and set 14) played the same clip in an attempt to distinguish whether participants erroneously perceived a difference. Participants compared each of the six recordings to all other recordings with the exception of the second performance in the same head position condition (e.g., listeners did not compare elevated 1 and elevated 2). Therefore, listeners had the opportunity to choose each recording, as a preferred vocal timbre, four times throughout the study.

Listener Protocol and Survey

The researcher manually transferred the .wav recordings to a compact disc without any compression of the electronic signal. Listener participants (*N* = 30) evaluated the recordings through AKG 240 headphones on a Tascam CD-150 player connected to a PreSonus HP4 distribution amplifier. Volume remained consistent for the entire study. The researcher informed the participants that the purpose of this investigation was to assess “preferences in vocal sound” and did not inform them of the independent variable (head position). The researcher instructed each participant to only evaluate recordings for overall vocal timbre and to ignore other vocal and musical attributes (e.g., pitch, musicality, diction, perceived acting, vibrato). A practice listening example began the study.

Listeners completed a questionnaire after hearing each pair of the recorded singer performances. The first question asked, “Do you hear any difference between the two clips with regard to vocal timbre?” and listeners could choose answers of (a) no difference, (b) a little difference, (c) much difference, (d) very much difference, and (e) not sure. The second question asked, “If yes, which recording do you prefer?” and listeners could choose answers of (a) first performance, (b) second performance, and (c) both sounded the same. A final, open-ended question asked participants to give overall explanations for why they preferred their chosen recordings compared the others.

Results

Singer's Head Position Measurements

Mean head position measurements from the singer's neutral 1 and 2 performances equalled 104.50 degrees for angle 1 (Na-Tr-VP), 48.90 degrees for angle 2 (C7-Tr-VP) and 153.40 degrees for angle 3 (C7-Tr-Na). When the singer changed her focal point to the sternum marker, which required a lowered head position, she decreased angle 1 to 61.80 degrees and increased angle 2 to 83.90 degrees for a total head position measurement (angle 3) of 145.70 degrees. Therefore, the singer exhibited both anterior and inferior movements of the head and neck. When the singer changed her focal point to the tape marker on the ceiling above, which required an elevated head position, she increased angle 1 to 126.30 degrees, but lowered angle 2 to 30.70 degrees for a total head position measurement (angle 3) of 157.00 degrees. Therefore, the singer exhibited both posterior and superior movements of the head and neck (see Figure 1).

For the angle 1 measurement, the singer moved her head and neck to a greater degree between the neutral head position and the lowered head position conditions (*MD* = 42.70 degrees) than between the neutral head position and the elevated head position conditions (*MD* = 21.80 degrees). For the angle 2 measurement, the singer also moved her head and neck to a greater degree between the neutral and lowered head position conditions (*MD* = 35.00 degrees) compared to the neutral and elevated head position conditions (*MD* = 10.20 degrees).

Research Question One: Long-Term Average Spectra

Long-term average spectra data represents the relative amplitude of all harmonics in a complex sound over time. The perception of vocal timbre changes as different harmonics intensify or attenuate. Therefore, LTAS data can be useful in detecting persisting spectral events and in understanding listeners' perceived differences in vocal timbre.

Howard and Angus (2001) stated that 1 dB constitutes a noticeable difference in the energy of a complex vocal sound. Fletcher and Munson (1933) noted that the spectral area from 2-4 kHz, commonly called the singer's formant region, corresponds with frequencies most sensitive to the human ear. Therefore, any changes greater than 1 dB, especially in the region of 2-4 kHz, will be of interest.

The researcher calculated the mean relative amplitude for each harmonic sampled in the LTAS data of the two performances in each head position condition for statistical analysis. A one-way repeated measures analysis of variance (ANOVA) found a significant difference in LTAS data between all three head position conditions, $F(1, 115) = 310.661$, $p < .0001$, $\eta_p^2 = .844$. Three follow-up paired *t*-tests (two-tailed) found significant differences between all head position conditions: (a) neutral and lowered, $t(116) = 16.448$, $p < .0001$; (b) neutral and elevated, $t(116) = 16.750$, $p < .0001$; and (c) lowered and elevated $t(116) = 24.233$, $p < .0001$.

Overall relative mean signal amplitude comparisons ($N = 3$) of LTAS data (0 – 10 kHz) from the two performances in each head position condition found that the greatest amplitude occurred in the elevated head position ($M = 14.06$ dB) compared to the neutral ($M = 13.16$ dB) and lowered ($M = 11.78$ dB) head position conditions (see Table 1). The singer increased the amplitude of all harmonic frequencies (0.51-4.18 dB) when singing in the elevated head position condition compared to the lowered head position condition. Figure 2 displays LTAS data (2-4 kHz) from each of the singer's two performances in three head positions.

Research Question Two: Perceptual Differences

The second research question asked to what degree, if any, listeners perceived differences in the vocal timbre of one singer as she altered head position. Table 2 displays participant answers for each pair of listening examples. Most participants selected that they heard “a little difference” for all pairs (*n* = 13-22, 43.33-73.33%). However, exactly half of participants (*n* = 15, 50%) selected that they heard “very much difference” in vocal timbre for set 10, which compared the second performance in the lowered head position with the first performance in the elevated head position.

Two sets included the same listening example to determine listener reliability. Set 8 compared identical recordings of the second performance in the lowered head position. A majority of participants (*n* = 17, 56.67%) selected that they heard “a little difference,” while some participants (*n* = 9) answered that they heard “no difference.” Set 14 compared identical recordings of the first performance in the elevated head position. A majority of participants (*n* = 20, 66.67%) reported that they heard “a little difference,” while fewer participants (*n* = 5) heard “no difference.”

Research Question Three: Listener Preferences

Research question three asked what head position condition (lowered, neutral, and elevated) listeners preferred regarding vocal timbre. Figure 3 presents listener preferences for each set of recordings. Overall observations indicated that when given the choice between neutral and elevated or neutral and lowered, participants preferred the vocal timbre from the neutral head position recordings. However, in set 11, a majority of participants preferred the lowered performance 2 recording (*n* = 12, 40.00%) compared to the neutral performance 2 recording (*n* = 6, 20.00%). When participants heard a recording of the singer performing in the elevated head position condition compared to the lowered head position condition, participants tended to favour the lowered head position with the exception of set 4. In set 4, a majority of participants favoured the elevated 2 performance recording (n = 17, 56.67%) over the lowered 1 performance recording (n = 12, 40.00%).

Participants compared each of the six recordings of the two performances in each head position to all other recordings except the second performance in the same head position (e.g., listeners did not compare elevated 1 and elevated 2). Therefore, listeners had the opportunity to choose each recording as their preferred vocal timbre recording four times throughout the study. Table 1 displays how many participants selected each head position recording each time that recording appeared in a set throughout the study. The researcher did not include those participants who selected "both sounded the same," in this table. Listeners selected the neutral 1 head position performance recording more than any other recording followed by (a) neutral 2 and lowered 2, (b) elevated 2, (c) lowered 1, and (d) elevated 1.

The questionnaire asked participants to describe why they preferred the recordings they selected. Some participants commented that they (a) preferred a richer tone quality, (b) felt that in some recordings the singer sounded as if she was "cut off from the breath," (c) preferred a brighter sound with a clearer tone, and (d) did not prefer recordings where they thought the singer may be holding back. Participants also commented that they preferred a "freer" tone or one where "the vocalist wasn't stressing their vocal folds by singing 'tight.'"

Discussion

This investigation yields four primary findings: (a) an extreme change in focal point elicited alterations in one singer's head and neck position, (b) alterations in singer head position produced similar alterations in LTAS data, (c) listeners perceived differences in the recordings of one female singer performing an aria in three different head position conditions, and (d) listeners most preferred the vocal timbre of the singer as she performed in the neutral head position condition. These results are limited to the one singer participant, the group of listening participants, and the particular method and procedures employed in this study. Nonetheless, they raise matters worthy of reflection and subsequent research. The following discussion addresses each of the four primary findings listed above and relates those findings to previous research, provides suggestions for future research, and discusses any limitations of the study.

Firstly, this type of perceptual study, which used recordings of live singing performances, requires measurements of the singer's head position to confirm that she altered her head position with each focal point change. The results from the postural portion of this study show that the singer did alter head position between all conditions (lowered, neutral, elevated), although she did so to a greater degree between the lowered and neutral conditions compared to the neutral and elevated conditions. This study investigates the effects of extreme alterations in head position prompted by largely different focal points with one singing participant. Future research may investigate head position adjustments with a greater number of singing participants and with smaller, incremental changes in focal point and head position.

One may expect both angle 1 and angle 2 head position measurements to concurrently increase (in an elevated head position) or concurrently decrease (in a lowered head position). However, the results of this study unexpectedly demonstrate that an increase in angle 1 (superior movement) corresponded with a decrease (posterior movement) in angle 2, and a decrease in angle 1 (inferior movement) corresponded with an increase in angle 2 (anterior movement). One could speculate that this contrasting movement occurs in order to fully accommodate the specified focal point and to allow the singer to open her jaw to sing. Hypothetically, if a singer only decreased angle 1 (lowered head position) without altering angle 2, it would be very difficult to open the mouth and sing. Instead, a singer could increase angle 2 by moving the head and neck forward and simultaneously decrease angle 1 by lowering the head, which may theoretically better accommodate jaw opening.

This study did not include a jaw opening measurement. Therefore, the hypothesis mentioned above would require further research and cannot be generalized to other singing participants at this time. However, the head position trends of the singer in this study seem to correspond to previous research with non-singing participants that indicates a relationship between head position and jaw opening (e.g., Muto & Kanazawa, 1994). In singing contexts, Lindblom and Sundberg (1971) suggest that increased jaw opening raises the first formant frequency (F1), and Sundberg and Skoog (1997) suggest that female singers may increase jaw opening to formant tune at higher frequencies. If further research finds an interconnected relationship between singer head position and jaw opening, one might suspect that anything that encourages a singer to alter head position, especially to a lowered position (e.g., using choir folders, staging, changing focal point, looking down at a shorter colleague), could impact a female singer's ability to open the jaw and formant tune in the upper range. These findings could also be very important for voice researchers in order to most accurately obtain postural and acoustical data with singers. Head position movement could be limited if participants in a jaw opening study sing in a supine position, and a head position study with singers that limits jaw opening (e.g., by humming) may also disguise the full range of a singer's head position movement.

Secondly, acoustical results from this study show that the LTAS relative mean signal amplitude of this particular singer, especially in the area of 2-4 kHz, increased as the singer performed in the elevated head position and decreased as the singer performed in the lowered head position. The statistical analysis of this singer's acoustical data indicates that head position accounted for a large percentage (84.4%) of the mean harmonic amplitude differences in LTAS data. Data show that this singer exhibited a greater difference in LTAS data between the lowered and neutral head position conditions than between the neutral and elevated conditions. Interestingly, the postural data from this singer also indicate that she exhibited a greater degree of head position movement in both angles 1 and 2 between the neutral and lowered head position conditions than between the neutral and elevated head position conditions. In order to obtain similar postural measurement differences between each condition, the singer's head would have to be positioned and maintained, which may limit her movement and impact her ability to sing. Additionally, this control could possibly draw her attention to the independent variable of head position and confound any findings. Future research may explore alternative methods to adjust head position to exact measurements with equal differences between conditions during a study without introducing confounding variables.

Data indicate that the 2-4 kHz area of LTAS data differed appreciably between neutral and elevated, neutral and lowered, and lowered and elevated head position conditions. Based on previous studies, one may conjecture that these changes in LTAS data could have occurred due to anatomical movements or physiological changes in the vocal tract. Interestingly, LTAS data from this singer demonstrate that a lowered head position attenuated all sampled harmonic frequencies (N = 117). The results from this study support the hypothesis of Austin (2012), who states that singers may employ a lowered head position to artificially stabilize the larynx and create a darker and richer sound. Similarly, Luck and Toiviainen (2007) suggest that an elevated head position produces an increase in amplitude that the researchers speculate came from a freeing up of the mechanism. The results from the singer in this study also indicate an increase in amplitude in the elevated head position condition. Future research may continue to investigate differences in LTAS data with a greater number of singers performing in various head position configurations.

Thirdly, data from this study indicate that on the whole, listeners heard a difference in vocal timbre between the singer's performances in each head position condition. However, one should note that some listeners incorrectly perceived a difference in two set comparisons that played the same performance clips. One could attribute these inaccuracies to the listeners themselves, listener fatigue, or that the listeners simply expected there to be a difference on all recordings even when given the option of "both sounded the same." Future research may replicate this particular study with more experienced voice professionals competent in diagnosing vocal sound to see if the same trends persist. However, it could be important for future perceptual studies to continue to include a group of listeners who represent an audience one may find at a vocal recital with varied ages, musical experience, and backgrounds. One study to date employs a live listening panel hidden behind a wall as singers performed on the opposite side (Barnes-Burroughs et al., 2005). Future research on the effects of head position on perceptions vocal timbre may contemplate using a live listening panel, especially in detecting nuances and amplitude variances that may be harder to detect while listening to recordings.

Finally, listener preferences in this study correspond to LTAS relative mean signal amplitude data. The LTAS data show that the relative mean signal amplitude data order ranked (a) lowered 1 [11.34 dB], (b) lowered 2 [12.22 dB], (c) neutral 1 [12.93 dB], (d) neutral 2 [13.39

dB], (e) elevated 2 [14.04 dB], and (f) elevated 1 [14.07 dB]. Neutral 1 corresponds to the center of the relative mean signal amplitude order and constitutes the recording that most participants preferred followed by neutral 2 and lowered 2. The least preferred recordings have both the lowest and highest relative mean signal amplitudes (lowered 1 and elevated 1). One may speculate that participants did not prefer the recordings with the lowest and highest relative mean signal amplitudes because they may have exhibited a vocal timbre that sounded too dampened or too strident and bright. The comments from the open-ended portion of the questionnaire support this hypothesis as participants commented that they preferred a richer tone quality compared to one that felt “cut off from the breath” or “tight.” While some may attribute an increase in harmonic amplitude (particularly in the 2-4 kHz region) to improved singing efficiency, future research may investigate if listeners can perceive a difference between greater or lesser amplitude achieved efficiently or inefficiently.

Although many studies compare listener preferences to LTAS data in a variety of vocal styles, further studies may explore listener perceptions with LTAS data, singers of all vocal styles, and listeners familiar with and not familiar with that particular style. For example, an opera conductor may prefer increased harmonic amplitude from 2-4 kHz while a choral conductor may not. Furthermore, future studies might use a visual analog scale (VAS) that includes adjectives, such as darker or brighter, to ensure that other musical factors (e.g., pitch, onsets, legato, phrasing) do not affect participant perceptions.

Stage directors may require opera singers to alter head position in order to look up at a taller colleague or down at a shorter colleague, change focal point in a scene, or even sing with the head hanging off the edge of the stage. Choral singers may sing using folders that require them to lower head position in order to read a score. Choral conductors may position themselves below or above a choir depending on the performance venue, which may require choir members to alter head position to view the conductor. Pop singers may accompany themselves and sing while looking down at the piano keys or adjust head position toward a microphone. The results from this study merit consideration by singers, voice teachers, stage directors, conductors, researchers, and any other voice professionals. Head position may not simply be an aesthetic preference or something mentioned only to beginning singers. Head position may be interwoven with vocal technique and listener perceptions of vocal timbre.

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Table 1

LTAS Relative Mean Signal Amplitude and Listener Preferences of the Vocal Timbre of a Singer's Two Performances in Three Head Position Conditions (Lowered, Neutral, Elevated)

	Neutral 1	Neutral 2	Lowered 2	Elevated 2	Lowered 1	Elevated 1
	19	11	10	10	16	9
	16	16	15	17	12	6
	14	12	17	11	5	12
	18	15	12	11	8	11
TOTAL	67	54	54	49	41	38
RANKING	1	2	2	4	5	6
M LTAS SIGNAL ENERGY	12.93 dB	13.39 dB	12.22 dB	14.04 dB	11.34 dB	14.07 dB

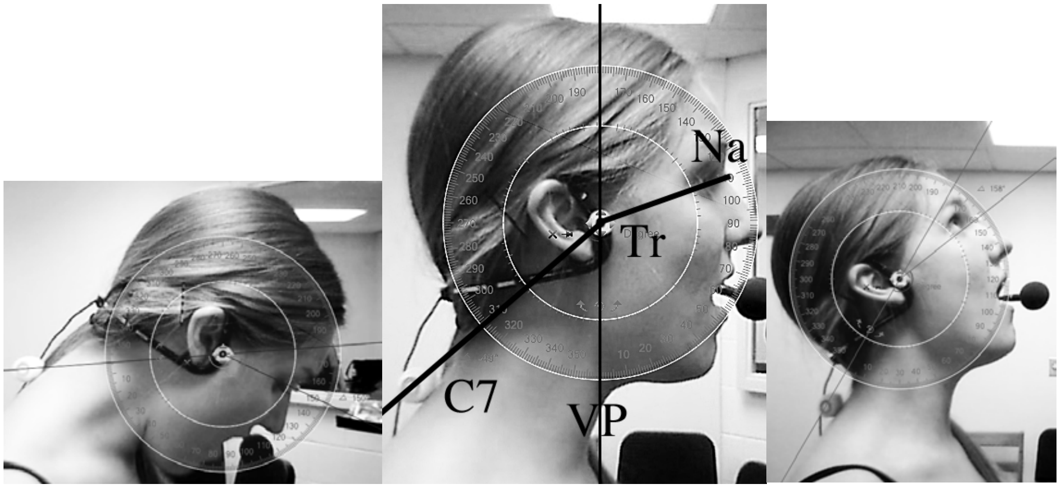
Note. This table presents listener preferences in vocal timbre and subsequent rankings for each performance recording in each head position condition. Each listener had the opportunity to choose each performance four times when compared to other performances.

Table 2

Listener Perceptions of Vocal Timbre Differences of a Singer's Two Performances in Three Head Position Conditions (Lowered, Neutral, Elevated)

	Set 1	Set 2	Set 3	Set 4
	Elevated 1 vs. Lowered 1	Lowered 1 vs. Neutral 1	Neutral 1 vs. Elevated 2	Lowered 1 vs. Elevated 2
No Difference	4	5	2	0
A Little Difference	19	17	13	16
Much Difference	2	7	12	12
Very Much Difference	2	0	2	1
Not Sure	2	0	0	0
	Set 5	Set 6	Set 7	Set 8
	Neutral 1 vs. Lowered 2	Elevated 1 vs. Neutral 1	Neutral 2 vs. Lowered 1	Lowered 2 vs. Lowered 2
No Difference	5	5	9	9
A Little Difference	15	16	16	17
Much Difference	8	6	2	1
Very Much Difference	0	0	1	1
Not Sure	1	2	1	2
	Set 9	Set 10	Set 11	Set 12
	Neutral 2 vs. Elevated 1	Lowered 2 vs. Elevated 1	Neutral 2 vs. Lowered 2	Lowered 2 vs. Elevated 2
No Difference	2	1	5	0
A Little Difference	22	12	17	16
Much Difference	4	15	6	9
Very Much Difference	0	2	0	1
Not Sure	1	0	1	3
	Set 13	Set 14		
	Elevated 2 vs. Neutral 2	Elevated 1 vs. Elevated 1		
No Difference	3	5		
A Little Difference	20	20		
Much Difference	6	1		
Very Much Difference	0	0		
Not Sure	0	2		

Note. "Set" refers to the pair of recordings listeners compared followed by the head position conditions and performance numbers. For example, "Elevated 1" denotes the first performance of the elevated head position condition. The gray shading denotes the answer that most participants selected.



Lowered	Neutral	Elevated
Angle 1: *M* = 61.80°	Angle 1: *M* = 104.50°	Angle 1: *M* = 126.30°
Angle 2: *M* = 83.90°	Angle 2: *M* = 48.90°	Angle 2: *M* = 30.70°
Angle 3: *M* = 145.70°	Angle 3: *M* = 153.40°	Angle 3: *M* = 157.00°

Figure 1. Lowered, neutral, and elevated head positions with postural markers and angle measurements. Postural markers included: (a) the approximate location of the C7 vertebra [C7], (b) tragus [Tr], and (c) nasion [Na]. The researcher used Onde Rulers, an on-screen protractor program, to measure head position angles. Angle 1 measured from Na-Tr-Vertical Plane (VP) and represented the amount of superior and inferior head position movement of the singer. Angle 2 measured from C7-Tr-Vertical Plane (VP) and represented the amount of anterior and posterior head and neck movement. Angle 3 (sum of angles 1 and 2) measured from Na-Tr-C7 and represented the total head position angle including superior, inferior, anterior, and posterior head position movements.

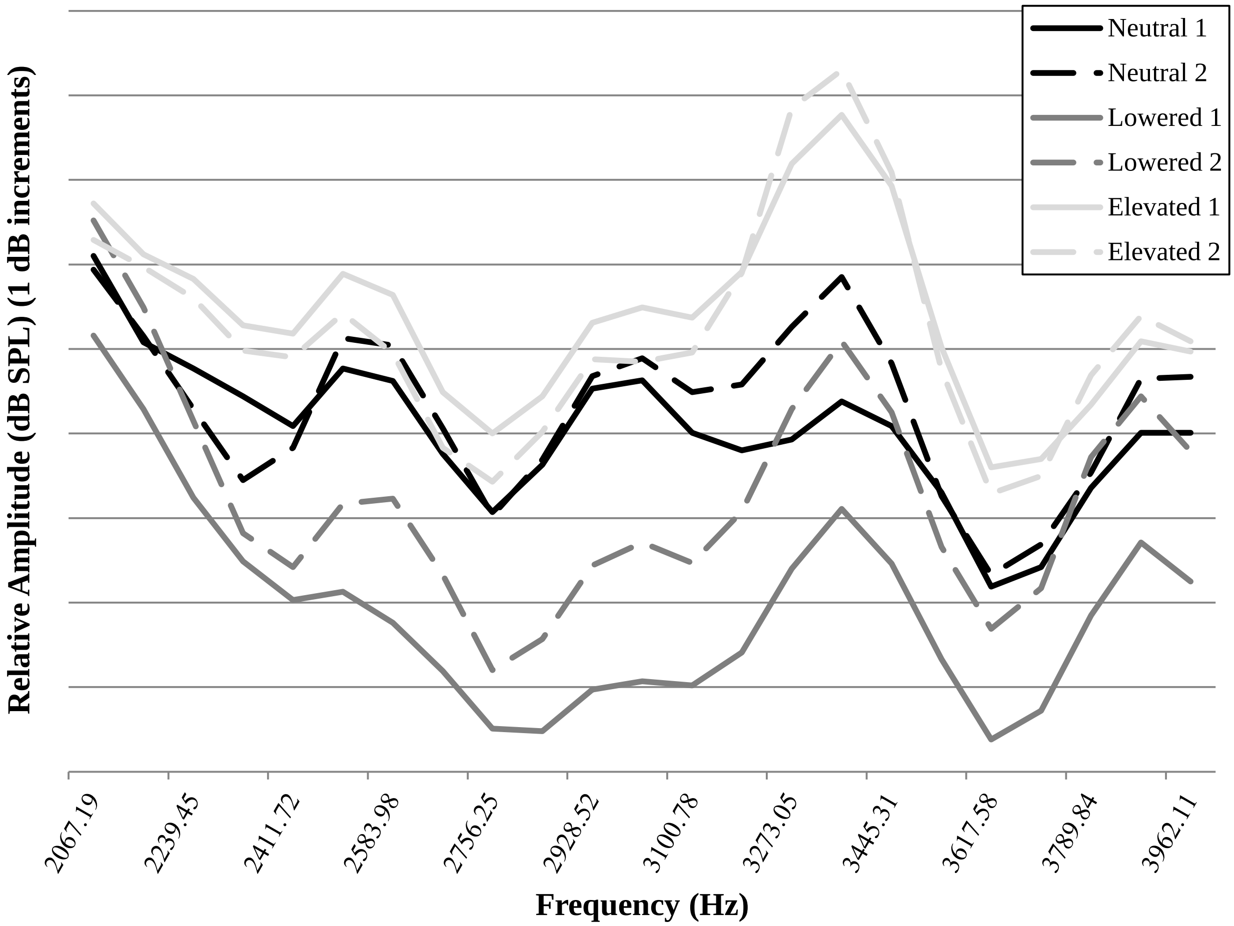


Figure 2. Long-term average spectra data (2-4 kHz) of female participant's (*N* = 1) two sung performances in three different head position conditions.

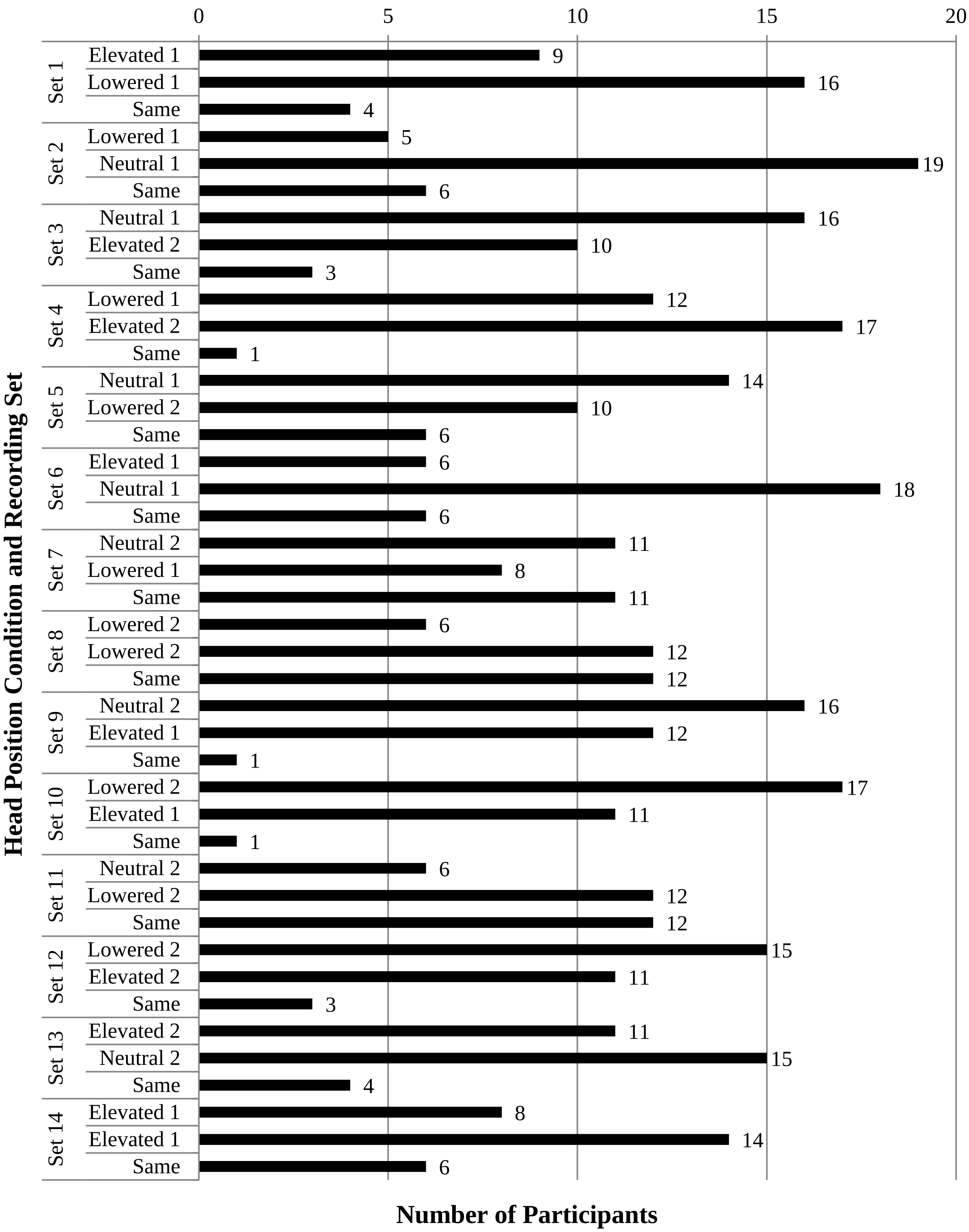


Figure 3. Listener preferences of vocal timbre of a singer’s two performances in three head position conditions (lowered, neutral, elevated).