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A Preliminary Study of the Articulatory and Acoustic Features of Forward and Backward Tone Placement in Singing

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A PRELIMINARY STUDY OF THE ARTICULATORY AND ACOUSTIC FEATURES OF FORWARD AND BACKWARD TONE PLACEMENT IN SINGING

by

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A variety of terms exist for describing tone quality in singing, and voice scientists, voice therapists, teachers of singing, and students of singing use different terms to describe the same sound. One aspect of tone quality is tone placement. Teachers of singing often rely on imagery and imitation to elicit correct tone placement from students of singing. More concrete data about what produces forward and backward tone placement could supplement singing teachers' current practice of using imagery and imitation to elicit a desirable tone quality. This study examined forward and backward tone placement to determine the articulatory gestures and acoustic features that accompany each of the placements, and recorded singer impressions of what constitutes forward and backward tone placement. Participants in this study were 10 singing students who had completed at least 4 semesters of collegiate voice lessons. The singers participated in an interview regarding their impressions of forward and backward tone placement and completed a variety of singing tasks while articulatory motion was recorded with an electromagnetic articulograph system. Results of the interview showed these singers disagreed about the articulatory movements they would tell a student to do to produce forward and backward tone placement. Acoustic analysis revealed that forward tone placement is associated with a higher F2 and F3, whereas backward tone placement generated lower F2 and F3 values. Articulatory analysis revealed that singers make systematic changes with the oral articulators to produce forward and backward tone placement. These postures could be included in teaching tone placement to younger singing students.

ACKNOWLEDGMENTS

The first person I need to thank is my thesis advisor, Dr. Stephen Tasko. I came to him with an idea for a project about singing, and he took my project on even though his research interests have never included studying singers. He took the time to guide me through the entire process, from the beginning of an idea to the defense of my thesis. I'd also like to thank Dr. Helen Sharp for teaching me how to conduct and analyze a qualitative study. The final member of my thesis committee, Mrs. Heidi Vogley, served as an expert in the area of voice. She provided feedback about describing tone quality and placement in the introduction to my paper and the selection of participants and singing tasks. Additionally, Dr. Kimberly Dunn-Adams encouraged her choir to take advantage of the opportunity to participate in my research project, and served as my liaison to the WMU Department of Music.

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CHAPTER I

INTRODUCTION

Voice scientists, speech-language pathologists, voice teachers, and singers offer distinct terminology when describing various dimensions of the speaking and/or singing voice. McKinney (1982) and Vennard (1967) provided glossaries of terms for describing the singing voice. Many of these terms are familiar to trained singers, but may be less familiar to those in the communication sciences and disorders, and only a handful of these terms have been systematically studied by voice scientists (e.g., Henrich, Bezard, Expert, Garnier, Guerin, Pillot, Quattrocchi, Roubeau & Terk, 2007; Grillo & Verdolini, 2008; Hertegard, Gauffin & Sundberg, 1990; Vurma & Ross, 2002).

For the purposes of this paper, "voice quality" will be used to describe the speaking voice, and "tone quality" will be used to describe the singing voice. While voice quality is the term commonly used by speech-language pathologists to describe both normal and disordered voice, tone quality is used by singers and teachers of singing to describe those differences that occur between two sung sounds with the same pitch and loudness. Just as experienced music listeners distinguish between different instruments of a symphony orchestra, trained teachers of singing distinguish between tone quality types. These professionals focus on coaching students of singing who want to improve their technical skill and develop an ideal tone quality across singing contexts. Just as singers modify the vocal tract to create different consonants and vowels, they must also modify the vocal tract to change their tone quality. Achieving an "ideal" tone quality in a sung vowel in isolation is not sufficient for carryover to more advanced music literature. As the vowels and consonants change, the vocal tract must change to produce each phonetic element. The student of singing must be able to maintain adequate tone quality, which requires certain articulatory adjustments, while also modifying the vocal tract to portray the lyrics in the music. Students of singing need the advice of their teachers to sustain tone quality in songs with faster tempo, shorter note durations, and larger leaps between successive notes.

TEACHING TONE QUALITY

One term that is commonly used to describe an aspect of tone quality is "tone placement" (Henrich et al. 2007). This suggests that singers are capable of, at least metaphorically, placing the tone in different locations in the body. Voice teachers and singers tend to describe tone quality in terms of placement, aided by imagery. This imagery cannot be taken literally, as it would be physiologically impossible to place the tone in the mask, for instance. Singing students try to put the tone behind their front teeth or in the bridge of their nose, navigate registers by switching between head voice and chest voice, or focus the tone out into the audience. Based on the suggestions of their voice teachers, singers experiment with visualization and synthesis of the respiratory, phonatory, and articulatory systems to create a tone that pleases both master and apprentice. McKinney (1982) warns the teacher not to confuse terms about "placement, projection, and focus" with scientific, physiological fact. The imagery suggested by the teacher of singing attempts to help the student reach a certain articulatory configuration that will generate the ideal tone quality. One of the most effective tools for identifying the error in a student's tone quality is to mimic his/her sound production (McKinney, 1982). The teacher can then compare articulator placement and any source of tension/imbalance created by the student's production with the articulatory configuration that he/she uses to produce an ideal tone quality.

ORGANIZATION OF TONE QUALITY TERMINOLOGY

There are many terms for describing the quality of a sung tone. Vennard (1967) categorized these terms into types of resonances. McKinney (1982) provided a categorization of the qualities associated with faulty singing, with prescriptions for how to change the undesired tone. Henrich and colleagues (2007) ambitiously attempted to establish a set of common terms for describing tone quality that could be used by voice teachers, voice therapists, and voice scientists. First, a group of voice scientists, voice therapists, singers, and teachers of singing

spoke openly about tone quality to identify and define the many terms. Henrich and her team then created a listening-oriented grid with three main axes: perception of vocal technique, perception of sound, and perception of performance. Each axis was further divided into poles with terms describing different perceptual aspects. Within the axis of vocal technique, they identified a pole labeled "placement" with the following perceptual aspects: forward versus backwards, laryngeal versus pharyngeal, nasal versus twang, pressed versus breathy, and open versus covered. Of these aspects, forward/backward (also called bright/dark), pressed/breathy, and open/covered apply to Western lyrical singing.

To test the effectiveness of the listening grid, Henrich and colleagues had eight professional musicians, eight amateur musicians, and two non-musicians complete a perceptual test using the listening grid. All of the listeners thought the grid could lead to a more consensual dialogue, and 83% of the listeners considered the grid helpful. The authors analyzed the responses of the listening test to see if the listeners perceived the salient characteristics performed in the variations on the sung sentences. The listeners disagreed on placement perception. They agreed on salient qualities like forward and pressed, but also stated that they heard opposing qualities like open and covered. The authors suggested that the notion of placement had no clear meaning and necessitated further research.

TONE QUALITY LITERATURE REVIEW

There are myriad terms related to tone quality and numerous ways to describe how to achieve an ideal tone. Often these terms and descriptions overlap, and refer to the same target sound. May there be set vocal tract configurations that accompany certain tone placements? Voice scientists have examined open and covered tone placement (Hertegard, Gauffin, & Sundberg, 1990), breathy and pressed tone placement (Grillo & Verdolini, 2008), bright and dark tone placement (Lovetri, Lesh, & Woo, 1999), and forward

and backward tone placement (Vurma & Ross, 2002) to determine if certain vocal tract configurations are used consistently by singers to produce these tone placements. If the vocal tract configuration for a given tone placement is produced consistently across singers, could singing instruction requiring movement of the oral structures supplement the standard practice of using imagery and imitation to elicit the ideal tone? If there is agreement between singers about the articulatory gestures used to create acoustical differences in contrasting tone qualities, the results of the research conducted by voice scientists could aid in singing pedagogy. In addition to generating a greater understanding of how to describe a tone quality that may be lacking the right placement, knowledge and application of the vocal tract configurations necessary for correcting a faulty tone could help to rapidly achieve the desired tone quality.

OPEN VERSUS COVERED TONE PLACEMENT

Open and covered singing was examined near the passaggio, which is the transition between the chest and head registers (Hertegard, Gauffin, & Sundberg, 1990). The authors stated that covered singing is used in male operatic singing to maintain desirable tone quality through the passaggio (250-400 Hz, depending on voice category) and create the illusion of one single register over the wide vocal range, while also decreasing vocal tension when singing in the upper range. The study aimed to investigate the physiological and acoustical differences between open and covered singing around the passaggio. Eleven professionally trained male opera singers served as the subjects. The subjects sang a one-octave scale, octave intervals, and a sustained vowel near the passaggio in open and then covered singing on the vowel /æ/. Articulatory movement was monitored with a flexible fiberoptic endoscope. The authors found that covered singing was associated with an elevation of the soft palate and widening of the pharynx, widening of the laryngeal ventricles and forward tilting of the larynx, higher AC airflow, a lower first formant and a higher second formant, and higher sound pressure level for the fundamental frequency. Interestingly, the authors noted that lowering the first formant in

covered singing by increasing the length of the vocal tract and widening the pharynx has the perceptual effect of darkening the tone. Since dark tone is associated with a backward tone placement, the terms covered and backward could be confused by listeners.

BREATHY VERSUS PRESSED TONE PLACEMENT

One study examined how to distinguish pressed, normal, resonant, and breathy tone qualities from each other using measures of laryngeal resistance (LR) and/or vocal efficiency (VE) (Grillo & Verdolini, 2008). The independent variables were pressed (described as high effort phonation mode), normal (spontaneous voicing mode), resonant (easy phonation mode with vibrations in the alveolar ridge), and breathy (easy phonation with audible air escape) tone qualities. The authors recruited thirteen women with vocal expertise, including professional singers, voice teachers, and voice therapists, to serve as the subjects. While wearing a face mask, the subjects sang three strings of /pi/ at A3 (220 Hz) at a constant rate of 88 beats per minute for each tone quality type. Results showed that LR, and not VE, reliably differentiated between voice qualities, except between resonant and normal phonation. VE only reliably distinguished those pairs involving breathy phonation. However, the expert raters perceptually distinguished normal from resonant voice in 50 out of 52 productions, which may suggest that vocal tract manipulations, and not just aerodynamic adjustments at the level of the larynx, are responsible for creating resonant voice.

BRIGHT VERSUS DARK/FORWARD VERSUS BACKWARD TONE PLACEMENT

A common way to describe tone placement is to contrast a tone quality that is placed more forward from a tone quality that is placed more backward. Although singers and teachers of singing alike agree that tone placement is a critical element of the singing voice, and commonly use terms like forward and backward tone placement, there has only been one empirical study that has directly examined the characteristics of forward and backward tone

placement in trained singers (Vurma & Ross, 2002). While forward and backward refer to tone placement, a forward-placed tone may be described as sounding "bright" and a backward-placed tone may sound "dark." One study examined bright and dark tone qualities in singers, examining the articulatory changes that produce each quality (Lovetri, Lesh, & Woo, 1999).

Lovetri, Lesh, and Woo (1999) studied how musical theater singers' changes in tone quality affected vocal tract configurations. The tone qualities examined included head, mix, belt, bright, and dark qualities; head, mix, and belt refer to registers, whereas bright and dark refer to tone quality. The authors operationally defined belt as a powerful chest register, mix as a lighter sound, and head as a strong head voice like that of an opera singer. With a rigid endoscope in place, seven trained professional female musical theater singers sang a dark tone (defined as resonance felt in the back of the mouth near the soft palate) followed by a bright tone (defined as resonances felt in the front of the mouth) on /a/ at 415 Hz in head, mix, and belt registers. The singers were not given operational definitions of bright and dark tone qualities. The authors considered a normal tone quality for female musical theater singers to be mix dark, and this register and placement served as a neutral position for determining articulatory changes in the other registers and placements.

Results showed that when shifting from a dark to a bright tone quality, the amount of space in the back of the mouth was reduced. All singers elevated the tongue, and some depressed the palate and/or brought the oral pharynx in. The reduction in space associated with a bright tone quality was observed in 90% of tasks, regardless of the register quality.

In their discussion, Lovetri et al. (1999) concluded that smaller spaces in the back of the mouth produce bright vowels; some changes from dark to bright were easily visible while perceptually less distinct, and some changes were less pronounced but produced perceptually distinct qualities. The authors suggested that future research examine what other factors may

contribute to tone quality. They concluded that different tone qualities do cause vocal tract adjustments that may be intentional, but that those changes may vary from singer to singer.

One study investigated forward and backward tone placement at three distinct levels of analysis: expert opinion on what constitutes forward and backward placement; perceptual impressions of singers using forward and backward placement; and acoustical characteristics associated with exemplars of forward and backward tone placement (Vurma & Ross, 2002).

Expert teachers of singing were interviewed to determine the level of agreement about the meaning of the terms forward and backward placement, what qualities are associated with forward and backward placement, and what specific vocal techniques are used to achieve forward and backward placement. The experts were eleven instructors at the Estonian Academy of Music (EAM) and two North American professors who responded in writing. All of the instructors responded that the terms forward and backward voice placement had meaning for them, but had difficulty specifically defining the terms. Some responses alluded to timbral aspects of forward placement that were associated with poor tone quality, like nasal, strained, sharp, narrow, lean, or lacking roundness. Backward placement had a negative connotation and was described as stuffy, does not sound, or does not carry in a room. Some teachers verbalized the ideal placement as in the middle, and stated that a voice placed forward is actually divided between the back and front. When prompted to describe how they would elicit forward placement from a student, the instructors noted that they describe perceptual images to the students or mention the link between forward tone quality and vowel quality. Others suggested that instructors should provide demonstrations for the apprentice to elicit the appropriate tone quality.

Next, the authors made a number of research-quality audio recordings of a group of eleven male and nine female singing students who performed triads on /a/, /e/, /i/, /o/, and /u/ in the recommended key of D major first with forward placement followed by a backward

placement. The singers were not provided with a definition of forward or backward tone placement. These recordings were used to conduct the perceptual and acoustic evaluation.

The triads were used in a listening test completed by sixteen experts (8 third-year singing students and 8 voice instructors). Three of the students participated in both the recording of the triads and the listening test. The triads were presented in pairs of the same singer singing the same vowel in the same key. The only difference between each listening pair was the forward and backward placement of the voice. Listeners were required to judge the pair as same or different, and to include the direction of the change, if present. The results of the listening test suggested that listeners had a difficult time distinguishing between forward and backward placement in some samples. Correct identification of forward and backward placement occurred 43% of the time. Only 11% of the pairs were mistakenly identified, while 46% of the triads were considered indistinguishable from each other.

For the final part of the study, two subsets of the recordings were extracted for acoustic analysis. One set contained those samples (21 pairs) that were reliably identified as being placed forward and backward. Another set contained samples (29 pairs) that could not be distinguished from each other. The key dependent measures were the frequencies of the second and third formants as well as the intensity of the so-called singer's formant, which was estimated as the intensity level in the 2-4 KHz range.

The authors focused on the direction of the change in the forward versus backward condition rather than the magnitude of any change, and did not request a maximum expression of the difference between forward and backward placement. Their estimations indicated that the F2 and F3 frequencies and the amplitude of the singer's formant increased during the forward placement condition. Specifically, for the identified triad pairs, F2 was 10.4% higher in frequency, F3 was 3.4% higher in frequency, and the singer's formant increased by 5.3 dB during the forward placement condition. It is important to note that no statistical analyses were performed and the authors acknowledged that they did not tightly control for fundamental

frequency and sound pressure level in singing. They also noted that the high degree of harmonic spacing made formant identification difficult.

In their discussion, Vurma and Ross stated that forward and backward placement has a meaning that can be objectively defined in certain aspects, and that is understood by students and teachers of singing. They interpreted their findings of an increase in F2 frequency during forward placement as due to arching the tongue higher and placing it further forward in the mouth. The lower F2 and F3 frequencies in backward singing are caused by a depressed larynx and protruded lips, and the higher F2 and F3 frequencies associated with forward singing are the result of a shortened vocal tract caused by an elevation of the larynx and lip retraction. The increase in sound pressure level of the singer's formant was elicited by lowering the larynx and widening the pharyngeal space.

It is important to note that the authors interpreted this acoustic finding as evidence that a forward tone placement is associated with arching the tongue higher and further forward in the mouth and that a backward placement was associated with a relatively depressed larynx and protruded lips. However, those were only inferences, since no direct measurement of the key articulatory structures was performed. Expanded analyses to include direct measures of the positions of the oral articulators (e.g. tongue and lips) would provide a clearer picture of the types of articulatory adjustments singers make when altering placement of the singing tone.

THE PRESENT STUDY

The current study attempted to largely expand upon Lovetri and colleagues (1999) and Vurma and Ross (2002). First, Vurma and Ross used acoustic data to make inferences about articulatory movements used to produce forward and backward tone placement. Articulatory interpretation of acoustic data is limited by difficulties measuring formant values at high fundamental frequencies (due to the sparse harmonic structure), and the somewhat complex relationship between articulation and formant values. Lovetri et al. directly examined the

posterior portion of the oral cavity and oral pharynx using a rigid oral endoscope, and generalizations about articulatory movement were made visually. The current study made direct measures of articulatory kinematic behaviors (along with comparable acoustic measures) as tone placement is varied in trained singers. Second, Vurma and Ross only examined forward and backward placements. This study examined three tone placements along the presumed continuum: extreme forward tone placement, neutral tone placement (generally associated with the ideal tone quality singers have been trained to adopt), and extreme backward tone placement. Third, the Lovetri et al. study looked at only one vowel produced with bright and dark tone qualities, and the investigation by Vurma and Ross limited the stimuli to sung triads. This study included three different sung vowels and a 4-measure sung passage as stimuli. Fourth, and finally, while Vurma and Ross surveyed a different group to determine how singers describe tone placement, this investigation interviewed the singer participants regarding their impressions about how to produce forward and backward tone placement.

RESEARCH QUESTIONS

1. When varying tone placement from forward to neutral to backward, do trained singers make the kinds of articulatory adjustments postulated by Vurma and Ross (2002)? That is, is a forward tone placement associated with a measureable upward and forward position of the tongue and a retraction of the lips and is backward tone placement associated with a depressed larynx and lip protrusion?
2. Does tone placement interact with other singing variables such as task complexity or sung vowel?
3. Do singers with a common training background describe forward and backward tone placement in the same way?

CHAPTER II

METHODS

PARTICIPANTS

Ten adult student vocalists (5 females and 5 males) served as participants. The inclusion criteria required that students were between the ages of 18 and 26, had completed four semesters of collegiate voice lessons, had no current voice problems, and passed a standard hearing screening. All participants had to be between the ages of 18 and 26 to limit variation in the participant pool due to voice maturity. Students who had completed four semesters of collegiate voice lessons ensured similar collegiate experience, and that they (1) were familiar with the terms forward and backward placement, and (2) had received instruction about how to produce these tone qualities. The ten students were five females and five males between the ages of 21 and 23. Three of the singers majored in Vocal Performance; two students majored in Choral Music Education; four singers double majored in Vocal Performance and Choral Music Education; and one had a triple major of Choral Music Education, Instrumental Music Education, and Vocal Performance. Seven of the ten students were enrolled in private voice lessons at the time of the study, and were currently studying or had previously studied with one of three voice teachers employed at WMU. Two of the students had also studied with other voice teachers earlier in their education. The number of years the singers studied with a private voice teacher ranged from 3 to 8 years (mean = 6 years, SD = 2.22 years). The number of years the singers had been enrolled in a choir class ranged from 3.5 to 12 years (mean = 8.65 years, SD = 2.96 years). Each of the students sang in multiple singing groups, including various choirs, jazz ensembles, and *a cappella* groups. Considering private voice lessons and ensemble rehearsals, the number of hours spent singing under formal instruction ranged from 7 to 22 hours per week (mean = 12.85 hours, SD = 4.64 hours). The females had to be able to sing a C5 and the males a C4, as those were the pitches required for the singing tasks. Exclusion criteria included failing the hearing screening, having current voice problems, reported aversion to non-

latex medical adhesive, or reported possibility of pregnancy. All of the participants passed a standard hearing screening and agreed that they could sing a C4 (males) or C5 (females) comfortably in the middle of their range. All but one singer reported that they were not currently experiencing voice problems. The student who reported a current voice problem explained the situation as vocal fatigue caused by singing full voice for more than 30-45 minutes. She stated that she had sought treatment for her voice problem and was working on vocal technique with her private voice teacher. She still sang each day in choir and did not believe completing ten minutes of singing tasks for this study would negatively affect her voice. This research project was approved by the Human Subjects International Review Board at Western Michigan University.

PROCEDURE

Interview Portion of the Study

First the participants completed a standard hearing screening, responding to tones at 1000, 2000, and 4000 Hz presented at 25 dB bilaterally. To find out about previous singing experience, each singer completed a history questionnaire (Appendix B). After finishing the form, each participant completed an interview regarding his/her impressions about forward and backward tone placement. Participants responded to questions about how they describe the terms, if they know other terms that mean the same thing, how they have been taught to produce different tone placements, and how they would instruct a young student of singing to produce forward and backward placements (see Appendix C for interview questions). The participants were prompted to expand on parts of their answers by giving examples, such as the types of vocal exercises they would use to elicit a forward placement. The questions were restated if the participant asked for repetition, and presented in a different way if the participant did not understand. All responses to the open-ended questions were recorded and transcribed. The responses were then reviewed to determine themes identified by participants.

Singing Portion of the Study

Articulatory kinematic and acoustic recordings were made as the participant sang a series of vowels and a well-known singing passage. Recording of the movements of the oral articulators was made using a Carstens AG200 Electromagnetic Articulograph (hereafter EMA; Figure 1). Each participant sat in a chair, and a specialized helmet containing a set of three electromagnets was placed on his/her head. Next, a number of small sensors were attached to a number of structures in and around the face and mouth on the midsagittal plane. Sensors inside the mouth were attached using a commercially available, temporary dental adhesive. Sensors attached outside the mouth were attached with double-sided tape used for attaching electrodes. For this particular experiment there were a total of eight sensors used during data acquisition (Figure 2). Two head reference sensors were attached on the bridge of the nose and at the gum line near the central maxillary incisors. For some of the participants, the reference sensor could not be affixed to the maxillary incisors, so it was attached to the nose further down from the other reference sensor. A reference recording was then made with a sensor held to the central maxillary incisors. The next sensor was fixed to the chin, and was used to record mandibular motion. Lip motion was monitored by attaching two sensors to the upper and lower lips at the vermillion border. Three sensors were glued to the surface of the tongue approximately 1, 2 and 3 cm from the tongue tip.

Figure 1. Schematic of participant with EMA system in place.
A condenser microphone attached to the EMA helmet records speech acoustics. A helmet is placed on the subject's head, which transmits a magnetic field. Orofacial motion is transduced with small sensors placed on the face and within the mouth of the subject.

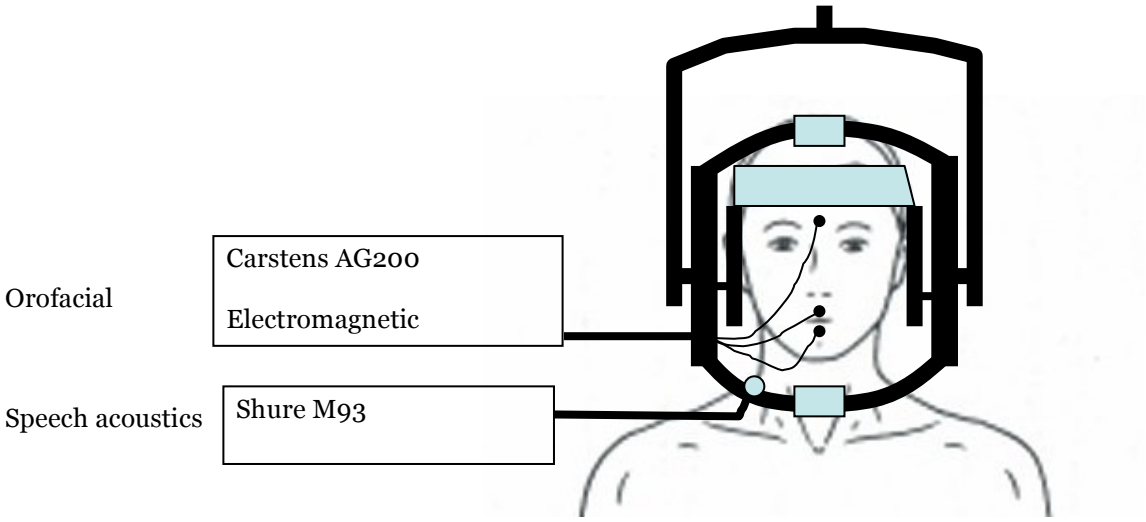
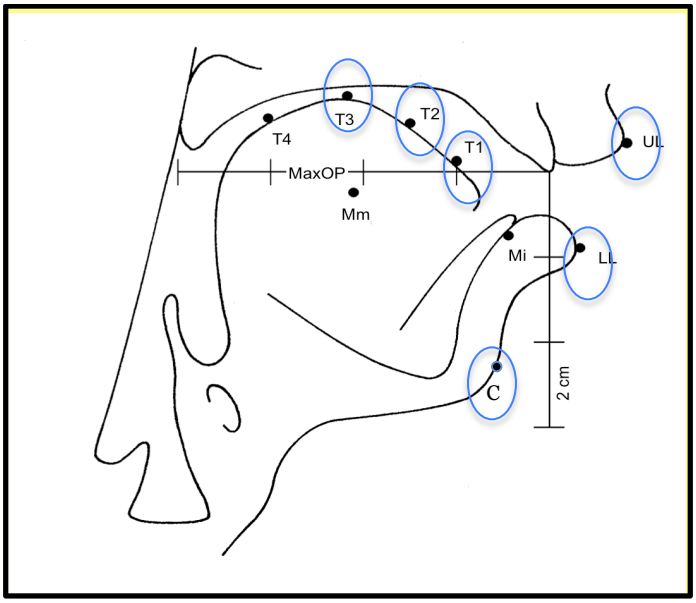
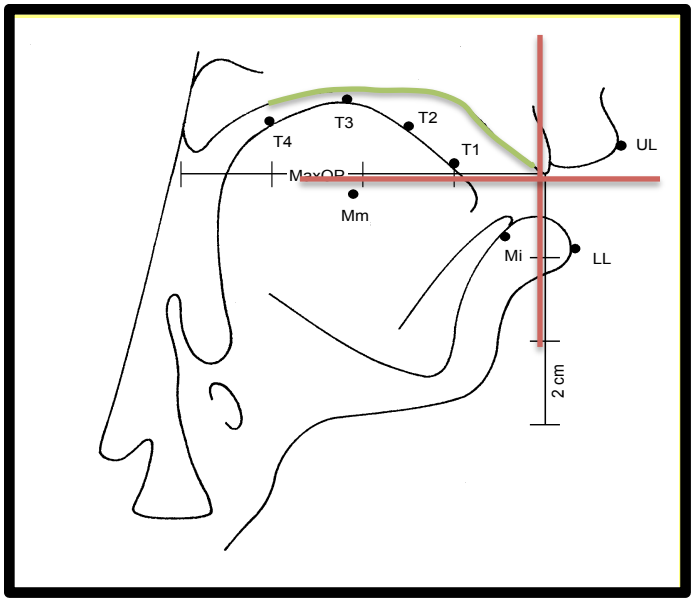


Figure 2. The placement of the articulator sensors.
For the purposes of this study, the three tongue sensors (T1, T2, and T3), the upper lip sensor (UL), the lower lip sensor (LL), and the chin sensor (C) were used.



Prior to data collection, each participant was given a short period of time to speak and sing to allow for some acclimation to the presence of the sensors. Next, two non-singing recordings were made to allow for more uniform interpretation of the data (Figure 3). First, the participant held a Plexiglas biteplate between the upper and lower teeth. This biteplate had two additional sensors attached to it and allowed the data to be expressed in an anatomically-based coordinate system where the occlusal plane served as the horizontal axis. Second, an additional sensor attached to a small plastic wand was traced along the midsagittal contour of the participant's hard palate. This trace allowed for referencing of tongue movement trajectories to the surface of the hard palate.

Figure 3. The hard palate trace and the location of the abscissa and ordinate.
The abscissa is located along the maxillary occlusal plane (MaxOP) and the ordinate is normal to the abscissa where the central maxillary incisor meets the MaxOP.



Articulatory kinematic data was digitally recorded at a sample rate of 250 Hz. Following acquisition, all movement channels were low-pass filtered at 10 Hz and re-expressed into an anatomically-based coordinate system. In addition, all tasks were audio recorded synchronously along with the articulatory kinematic data using a research-quality condenser

microphone and preamplifier. The audio signal was low-pass filtered at 8.6 KHz prior to digital recording at a sample rate of 22.020 KHz (16 bit quantization) using a Dataq DI-720 A-D system.

Singing Tasks

All singing tasks were produced in a quasi-random order. Each trial was presented to the participant by the student investigator. The singing tasks included both sustained vowels and four measures of a short, well-known passage, the Western Michigan University Alma Mater. The sustained vowels were produced for 3-5 seconds and varied by vowel type (/a/ vs. /i/ vs. /u/) and tone placement (neutral to forward, neutral to backward, and neutral to neutral). All vowel tasks began with neutral tone placement, followed by a brief pause and then the experimental condition (forward, neutral, or backward). Male participants sang each vowel at a C4, while female participants sang all vowels at a C5. The pitch was provided at the start of every trial. Each combination of the two factors (i.e. vowel-placement) was repeated twice, yielding 18 vowel samples. For the sung passage task, each participant sang four measures of the WMU Alma Mater twice at each of the three tone placements resulting in 6 samples. Therefore, the data collection included a total of 24 recorded samples for each participant.

INDEPENDENT VARIABLES

The independent variables included (1) gender classification (male vs. female), (2) task complexity (vowel vs. passage), (3) vowel type (low-back /a/ vs. high-front /i/ vs. high-back /u/), and (4) tone placement (front vs. neutral vs. back). Gender classification served as a difference between participants, whereas task complexity, vowel type, and tone placement varied within participants. In addition, for the articulatory kinematic analysis only, articulator identity (tongue vs. lips vs. jaw) was examined within each participant.

DEPENDENT VARIABLES

For the *sung note task* the primary dependent variables included:

1. Mean Center Frequency of Formants 1-4: Formants 1-4 were extracted from the acoustic signal in a semi-automated fashion using a custom-written Time-Frequency Analysis Software Program script. Time-Frequency Analysis Software Program for 32-bit Windows (TF32) is a speech analysis software suite (Milenkovic, 2000). Based on the average formant frequency values determined by Hillenbrand, Getty, Clark, and Wheeler (1995), peaks in the frequency response curve nearest the suggested F1-F4 values for /i/, /a/, and /u/ were measured. The two samples recorded for each condition were averaged and difference values were obtained between neutral and forward and neutral and back. A forward or backward formant frequency was judged higher or lower than the neutral placement if it exceeded the just-noticeable change in frequency (ΔF): 14.5 Hz for F1 below 800 Hz and increasing linearly at a slope of 10 Hz change in ΔF per 1000 Hz change in formant frequency (Kewley-Port & Watson, 1994; Kewley-Port, Li, Zheng & Neel, 1996).

2. Mean Fundamental Frequency: Singing fundamental frequency was automatically extracted from the sung samples using TF32. A 1000 msec. sample was taken from the middle of the signal and the fundamental frequency was averaged over this time period. All measures were visually inspected to rule out any fundamental frequency mistracking that can occur with automated algorithms. The goal of collecting the fundamental frequency estimates was to simply confirm that the vowels were sung at the appropriate pitch.

3. Midsagittal tongue position: To measure tongue position and shape, the three sensors attached along the midsagittal plane of the tongue were grouped and examined for changes in elevation and advancement. Forward and upward movement is likely associated with forward placement whereas backward and downward movement could be associated with backward placement.

4. Lip protrusion: To measure lip protrusion/retraction, the sensors attached to the upper and lower lip were paired and examined for changes in advancement and aperture. Lip aperture is defined as the Euclidean distance between the upper and lower lip sensor. Forward movement and reduced aperture is associated with protrusion whereas backward movement and increased aperture is associated with retraction.

5. Degree of Jaw opening: To measure jaw opening, the sensor attached to chin was examined for patterns of depression and elevation. Students of singing are trained to maintain an open jaw, but it is possible that singers may modify jaw opening when transitioning between forward, neutral, and backward tone placement.

For the *singing passage data*, due to technical challenges associated with measuring formant values at the phrase level, analysis was limited to the articulatory kinematic domain. The above methods were used to estimate mean positions of the articulatory structures across the entire passage.

ANALYSIS

Given the preliminary nature of this study, the primary focus was on a descriptive analysis of the results. Qualitative techniques for analysis of the interview data, articulatory kinematic data, and acoustic data were employed to look for trends in the data.

CHAPTER III

RESULTS

INTERVIEW DATA

Three themes emerged from the open-ended responses to questions about how these singers have been instructed or would instruct others about tone placement: references to articulatory movements, singing tasks, and imagery/metaphors. Phrases from the transcriptions were color coded to reflect which of the three themes they best described. The key phrases were transferred to six tables that answered the following questions: (1) What is forward tone placement? (2) What is back tone placement? (3) How have you been instructed to produce a forward tone placement? (4) How have you been instructed to produce a back tone placement? (5) How would you instruct a student to produce a forward tone placement? and (6) How would you instruct a student to produce a back tone placement? (Tables 12-17 in Appendix D). After reviewing the most frequent responses, the information was summarized into a couple of statements that addressed each of the six questions.

Question 1: What is forward tone placement?

In terms of articulatory movement, a majority (more than 5) of the participants referenced a "buzzing in the mask" when discussing forward tone placement, and proceeded to describe where the mask is (Table 1; the "mask" refers to the front of the face, and includes the nasal cavity, lips, hard palate, and cheek bones, as described by the participants). One singer described forward tone placement as "singing in the mask." This remark was considered a type of imagery, since no reference was made to a physical sensation in the mask. Half of the singers stated they change their lip position to produce a forward sound. Other articulatory movements mentioned by the singers include elevation of the larynx and tongue. While three participants agreed that raising the back of the tongue is necessary for producing a forward tone, another

said this is accomplished by raising the middle of the tongue, while two other singers stated they lower the tongue for forward singing. Some of the singers mentioned the soft palate when describing what they do to produce a forward tone placement, but there was disagreement about what the soft palate was doing. One singer reported to keep the soft palate in the same place as when speaking, two singers said they raise the soft palate, and one singer reported lowering the soft palate to produce a forward tone. Based on the disagreement among singers about tongue and soft palate movement, there appears to be some ambiguity about what articulatory movements accompany a forward tone placement.

Seven of the ten participants brought up the use of singing exercises to describe forward tone placement. Three singers explained the use of brighter vowels like /i/, or exercises with nasal consonants, such as singing descending pentatonic scales on /niæ/, to elicit a forward sound. Three students also alluded to the importance of breath support.

When it came to imagery and metaphors, eight of the ten participants, including all of the male singers, deemed forward tone placement synonymous with a bright tone quality. Four of the five female singers described forward tone placement as "aiming" the sound through different places in the mask, including the forehead, hard palate, and top teeth. Some less common synonyms for forward tone included nasal resonance, buzz, and ping.

Based on the descriptions provided by the participants in this study, it appears that forward tone placement is associated with a buzzing sensation in the mask and elevation of the upper lip. Forward tone placement can also be described as having a bright tone quality, and thought of as "aiming" the sound toward the mask.

Table 1. Most frequent responses to the question: *What is forward tone placement?*

		Number of Participants who Agreed (out of 10)
Articulatory Movements	Buzzing/vibration/sensation/resonation in the mask (nasal cavity, lips, hard palate, between the eyebrows, upper cheek bones)	6
	Raise the upper lip/snarl/pucker the lips/show more teeth	5
	Elevated laryngeal position	3
	Raise the back of the tongue	3
Singing Tasks	Use exercises involving bright vowels and nasals	3
	Engage the breath/increase airflow	3
Imagery/ Metaphors	Bright	8
	"Aim" the sound toward the forehead/hard palate/top teeth	4
	Nasal resonance	3
	Buzz	2
	Ping	2

Question 2: What is back tone placement?

In terms of articulatory movements, a majority of the participants agreed back tone placement is produced by raising the soft palate (Table 2). Half of the singers added that a back placement is associated with a depressed laryngeal position and increased jaw opening. Three of the ten participants listed other responses, such as depressing and relaxing the tongue, creating more space in the mouth, and opening the throat. Tongue movement descriptions varied across singers, with some saying the tongue tenses in the back and others arguing the tongue should relax. A couple participants reported retracting the tongue for back singing, but another stated that the back of the tongue moves forward to create more space in the pharynx.

Few participants spoke to the use of singing tasks when describing back tone placement. Two singers described using high-back vowels to create a back sound, including /u/ and /ʌ/. Two of the singers who discussed breath support for forward singing, also described it as an element of back tone placement as well.

When using imagery or metaphors to describe back tone placement, eight of the ten participants equated back tone placement with a dark tone quality. Half of the singers used the

term “throaty” to describe a back sound. “Warm” and “covered” were used by four of the participants in reference to back singing, while “hooty” and “swallowed” were used by another three. Some of the terms carry a negative connotation, like swallowed and hooty, and the synonyms provided by each singer alludes to their conceptualization of a back tone - whether it is desirable in certain situations or if it should not be used.

Based on the interviews conducted with the participants, back tone placement seems to be produced by lifting the soft palate, depressing the larynx, and opening the jaw more. Back tone can also be thought of as having a dark, throaty, warm, or covered quality.

Table 2. Most frequent responses to the question: *What is back tone placement?*

Articulatory Movements	Raise the soft palate	6	Number of Participants who Agreed (out of 10)
	Depressed laryngeal position	5	
	Increase jaw opening	5	
	Depress the tongue	3	
	Relax the tongue	3	
	More space in the mouth	3	
	Open the throat	3	
Singing Tasks	Use exercises involving darker vowels (/u/ or /ʌ/)	2	
	Breath support/increased airflow	2	
Imagery/ Metaphors	Dark	8	
	Throaty/throat resonance/singing in the throat	5	
	Warm	4	
	Covered	4	
	Hooty	3	
	Swallowed	3	

Question 3: How have you been instructed to produce a forward tone placement?

Only one participant reported receiving instruction about articulatory movements when taught about forward tone placement (Table 3). She stated she was told to feel the vibration in the back of the lips, hard palate, and nose (in the mask). Although the instruction related to a physical sensation in the articulators, no reference was made about how to move the articulators to achieve that vibration.

All of the participants listed singing tasks their voice teachers used to elicit forward tone placement. A majority of the singers had been taught with exercises involving nasal consonants or humming, and/or forward vowels, like /i/, /e/, or /æ/. Some of the exercises demonstrated by the singers include warming up on /i/ or /e/ and then applying that brightness to an /a/ vowel, and singing descending pentatonic scales on /niæ/. Two participants mentioned hand/arm motions used to focus the sound forward; including pointing in front of the face or rubbing the forefingers and thumb together (as if making a money motion) near the front of the face.

Eight of the ten participants listed imagery and metaphors that had been used to teach them to sing more forward, but all of the comments were different. Some examples include: pretend you have a beak and the sound is coming out of the beak, sing through your teeth, ping, imagine a laser through the forehead, make a snarly sound, and make the sound nastier.

Based on the responses provided by the participants, the most common way to teach a forward tone placement is through the use of singing tasks, such as doing warm-ups on nasal consonants and forward/closed vowels. A majority of the participants had been taught using imagery and metaphors, but no two singers listed the same imagery, despite the fact that they have the same choir director and had all studied with one of three voice teachers. Only one singer had been told about where to feel a vibration in the articulators, but no reference was made to how to move the articulators to achieve that vibration.

Table 3. Most frequent responses to the question: *How have you been instructed to produce a forward tone placement?*

Articulatory Movements	Feel the vibrations in the back of the lips, hard palate, and nose	1	Number of Participants who Agreed (out of 10)
Singing Tasks	Use exercises involving nasal consonants/humming and forward/closed vowels (/i/, /e/, or /æ/)	7	
	Using some sort of hand/arm motion	2	
Imagery/ Metaphors	None of the participants' responses coincided		

Question 4: How have you been instructed to produce a back tone placement?

Six of the participants responded that they were taught to produce a back tone placement with instruction regarding articulatory movements (Table 4). The only consistent comment, coming from four singers, was to raise the soft palate to produce a back tone. One participant listed articulatory movements exclusively in response to how he had been taught to sing further back. His answer included raising the soft palate, depressing the tongue, and creating more space by opening the jaw in the back of the mouth.

Half of the participants had been taught back tone placement through the use of singing tasks. The only common exercise used back vowels, like /o/ or /u/, to elicit a back tone.

Nine of the ten participants provided examples of imagery and metaphors that had been used to help them achieve back tone placement. There was little agreement between singers about what imagery was used, but two singers were told to think darker, think round, or to create more warmth. Other responses included pretending there's an egg in the back of the

mouth, using a cavernous sound, and pretend the sound is going up to the ceiling through the top of the head.

Based on the comments provided by the participants in this study, back tone placement is most commonly taught using imagery and metaphors, with some instruction regarding singing tasks and articulatory movements. Less than half of the singers were taught to lift the soft palate to produce a back tone, and to use singing exercises with vowels like /o/ and /u/ to achieve the desired space. A large majority of the participants were taught with imagery and metaphors, but few were used consistently across singers, despite studying with the same choir director and one of three voice teachers.

Table 4. Most frequent responses to the question: *How have you been instructed to produce a back tone placement?*

Articulatory Movements	Lift the soft palate	4	Number of Participants who Agreed (out of 10)
Singing Tasks	Use exercises involving darker/taller/rounder vowels (/o/ or /u/)	4	
Imagery/ Metaphors	Think darker	2	
	Think rounder	2	
	Create more warmth/warmer resonance	2	

Question 5: How would you instruct a student to produce a forward tone placement?

Four of the participants indicated they would instruct a student to produce a forward tone placement with articulatory movements (Table 5). Although none of the singers agreed on what they would tell a student to do, they mentioned opening the jaw more, keeping the tongue tip down while elevating the back of the tongue, lifting the soft palate, and making a snarly face.

All of the participants would include singing tasks when instructing a student to produce a forward tone. Half of the singers mentioned exercises with forward/closed vowels and nasal consonants, such as singing descending pentatonic scales on /niæ/, singing the word "yum," or singing whole passages on an /m/, /n/, or /i/. A couple singers would use lip trills to promote breath support.

Six participants stated they would use imagery and metaphors to teach a student to produce a forward tone placement. Three participants agreed they would encourage a student to aim the sound toward the mask. Two participants would tell their students to sing a bright tone, or to feel a buzz. Other imagery or metaphors used by only one singer include singing a sharp or nasty tone or putting more smile in the sound.

Based on the participants' responses, the most common way to teach a student forward tone placement is to use singing tasks, such as singing on forward/closed vowels and nasal consonants. Some singers would educate students about articulatory movements, but none of the singers agreed on what those articulatory movements were. More than half of the participants would use imagery and metaphors to teach forward singing, but there was little agreement about the terms to use. The most common imagery they would use is to aim the sound toward the mask.

Table 5. Most frequent responses to the question: *How would you instruct a student to produce a forward tone placement?*

Articulatory Movements	None of the participants' responses coincided		Number of Participants who Agreed (out of 10)
Singing Tasks	Use exercises with forward/closed vowels and nasal consonants	5	
	Do lip trills	2	
Imagery/ Metaphors	"Aim" the sound toward the mask	3	
	Sing a bright tone	2	
	Feel a buzz (in the hard palate)	2	

Question 6: How would you instruct a student to produce a back tone placement?

Eight of the participants would use articulatory movements to teach a student to produce a back tone placement (Table 6). Only two of the participants' comments coincided with regard to what the articulators are doing to produce a back tone. These two singers would include instruction about the soft palate; one would tell a student to raise the soft palate, while the other said he would train the soft palate. Other articulatory movements mentioned by the participants include: keeping the neck area open, creating more space, keeping the throat open, opening the jaw, and keeping the lips relatively close together to minimize lip movement.

Seven of the participants would use singing tasks to elicit a back tone placement from a student. The only exercise they agreed upon was to use tall/open/closed vowels like /o/, /u/, /a/, /ɔ/, or /ʌ/ to achieve the space necessary for back tone placement. Other exercises they would use include: singing sirens, singing on a sigh, yawning, using lip trills, or imitating the Julia Childs voice.

Eight of the participants would incorporate imagery and metaphors into their instruction regarding back tone placement. Three singers agreed that telling a student to think about

yawning would elicit a back tone placement. Other forms of imagery mentioned include: making the sound muted, think about the tone as tall and round, "aim" the sound toward the middle of the roof of the mouth, and think about it like Julia Childs' voice, although none of these terms were common across the singers.

Based on the responses given by the participants in this study, the majority would use articulatory movements, singing tasks, and imagery or metaphors to teach a back tone placement. Specific examples varied among singers, but to teach a back tone, they would tell a student to raise the soft palate, to think about yawning, and to sing exercises with central or back vowels (/o/, /u/, /a/, /ɔ/, or /ʌ/).

Table 6. Most frequent responses to the question: *How would you instruct a student to produce a back tone placement?*

			Number of Participants who Agreed (out of 10)
Articulatory Movements	Raise the soft palate/Training the soft palate	2	
Singing Tasks	Use exercises involving tall/closed/open vowels (/o/, /u/, /a/, /ɔ/, or /ʌ/)	5	
Imagery/ Metaphors	Think about yawning	3	

ACOUSTIC DATA

Fundamental Frequency

A measure of the mean fundamental frequency was extracted for each participant to determine if they sang the appropriate pitch (Table 7). The males were instructed to sing middle

C (261.6 Hz) and the females to sing C5 (523.3 Hz). The average frequency sung by the males was 261.8 Hz (SD = 4.6 Hz) and the females sang an average frequency of 520.2 Hz (SD = 9.3 Hz). The men had a mean fundamental frequency closer to the target frequency than the women. Although one woman had a mean fo (506.8 Hz) considerably lower than the target (523.3 Hz), her average pitch was still closer to the C5 target than the next closest pitch, B4 (493.9 Hz). From the fundamental frequencies of all vowels in the experimental conditions, the range was calculated to determine consistency of pitch across all tasks. The women sang pitches closer to the frequency provided more consistently than the men (range for women = 1.09 semitones; range for men = 1.39 semitones).

Table 7. Mean fundamental frequency for all vowels with all placements by participants and by gender.
The first column shows the fundamental frequency averaged across all experimental conditions. The second column displays the standard deviation of the mean fundamental frequencies. The third column shows the range, in semitones, of each participant's fundamental frequencies for the experimental conditions.

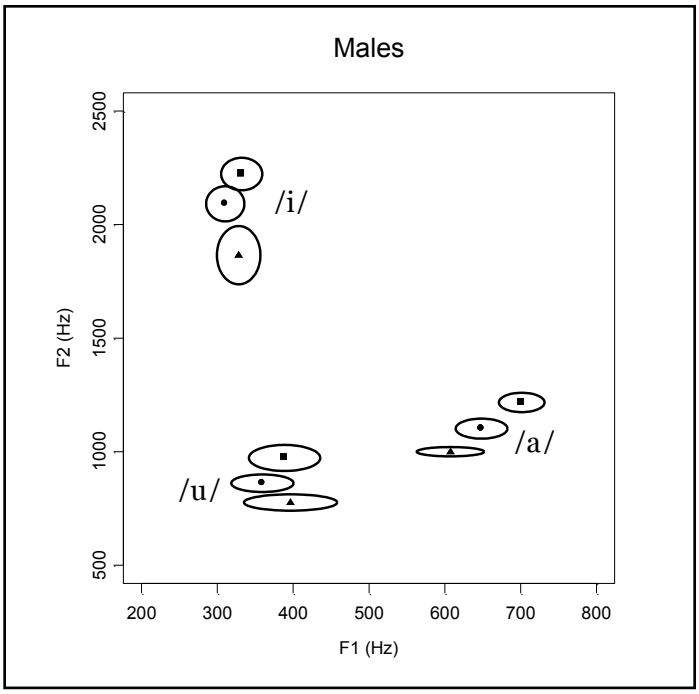
Participant	Mean fo (Hz)	Standard Deviation of mean fo (Hz)	Range of mean fo (in semitones)
M01	269.6	3.3	.78
M02	261.7	3.3	.77
M03	260.3	1.6	.41
M04	260.8	2.6	.57
M05	257.8	1.7	.41
Males	261.8	4.6	1.39
F01	529.4	4.0	.40
F02	523.2	4.2	.45
F03	506.8	2.2	.28
F04	514.8	3.6	.45
F05	527.5	4.5	.43
Females	520.2	9.3	1.09

Formants 1-4

The frequencies of the first four formants were extracted from each sound signal to compare changes in formant values with forward and backward tone placement. The changes in formant values were recorded as higher and lower than the average formant values (Hillenbrand et al., 1995) for neutral tone placement, and compared across all men, all women, and all participants. Measurement of the formant values for women was made more difficult due to the high fundamental frequency and resulting sparsely spaced harmonics. The formant values found for the female participants were particularly dependent on harmonic spacing, and for the /a/ vowel, the first and second formant frequencies collapsed into a single peak. For these reasons, and that the absolute value of male and female formants were different, the women's results were presented both apart from and together with the men's results. Statements regarding changes in formant values for the women should be interpretted with caution, and greater weight placed on the results found for the men, as formant frequencies were measured more confidently and consistently across all men. Although the frequency of the fourth formant was extracted, F4 amplitude (associated with the singer's formant) is a more important factor in tone placement distinction; therefore, F4 frequency was not reported. F4 amplitude was also not reported as SPL was not controlled for the singing tasks.

The male participants demonstrated a systematic elevation of F2 when singing with forward tone placement and lowering of F2 for back placement (in Figure 4). Forward tone placement is denoted by the square symbol, normal singing with the circle, and back placement with the triangle. The symbols are associated with the mean formant values for the group and the ellipse bounds the standard error about the mean. The most obvious expression of this pattern is shown in the vowel /a/.

Figure 4. Average change in F1 and F2 values for /a/, /i/, and /u/ vowels with forward (square), neutral (circle), and backward (triangle) tone placement by all male participants.
The ellipses denote the standard error about the mean.



When singing the vowel /a/ with forward tone placement, the male participants exhibited a tendency to raise F2. Performing /a/ with back tone placement yielded lower values for all formants. To produce /i/ with forward tone placement, the men tended to raise the second and third formants. In the sound signals containing /i/ with back placement, there were lower F2 and F3 values. The male singers raised the second and third formants when singing /u/ with forward tone placement, and lowered the second and fourth formants for singing /u/ with back placement. Considering all vowels, forward singing in men is associated with higher F2 and F3 values, whereas back singing is characterized by lower F2 and F3 values (Table 8).

Table 8. Average change in formant 2 and 3 values for the vowels /a/, /i/, and /u/ with forward, neutral, and backward tone placement by all male participants.
The number of participants who demonstrated each change is noted in parentheses.

Vowel	Placement	F2	F3
/a/	Forward	higher (3) no change (2)	higher (2) lower (2) no change (1)
	Backward	lower (4) no change (1)	higher (1) lower (3) no change (1)
/i/	Forward	higher (5)	higher (5)
	Backward	lower (5)	higher (2) lower (3)
/u/	Forward	higher (5)	higher (4) no change (1)
	Backward	lower (4) no change (1)	higher (2) lower (2) no change (1)

The female participants made no meaningful, consistent change to F1-4 when singing /a/ with forward placement. A majority of the singers lowered F1, but this formant frequency was highly dependent on the fundamental frequency and therefore, difficult to interpret. To produce /i/ with forward tone placement, the women raised F3. In the sound samples containing /i/ with back placement, there were lower F2 and F3 values. The female singers raised the second formant when singing /u/ with forward tone placement, and lowered the third formant for singing /u/ with back placement. Considering all vowels, forward singing in women was not associated with any consistent change in formant values, but back singing was characterized by lower F3 values (Table 9). Although a majority of the female participants demonstrated these trends, the opposite direction of change was also observed in many instances.

Table 9. Average change in formant 2 and 3 values for the vowels /a/, /i/, and /u/ with forward, neutral, and backward tone placement by all female participants.
The number of participants who demonstrated each change is noted in parentheses.

Vowel	Placement	F2	F3
/a/	Forward	lower (1) no change (4)	higher (1) lower (1) no change (3)
	Backward	higher (2) no change (3)	higher (1) lower (2) no change (2)
/i/	Forward	higher (2) lower (2) no change (1)	higher (3) lower (1) no change (1)
	Backward	higher (1) lower (3) no change (1)	higher (2) lower (3)
/u/	Forward	higher (3) no change (2)	higher (2) lower (1) no change (2)
	Backward	higher (1) lower (1) no change (3)	lower (3) no change (2)

The changes in formant values for forward and backward singing were also examined across all participants (Table 10). For all singers, forward tone placement is associated with higher F2 and F3 values as compared to normal singing. Lowering the second and third formants characterizes back tone placement. Although at least half of the participants demonstrated these trends, the opposite direction of change was also observed in the majority of instances. These patterns were consistent across vowel types.

Table 10. Average change in formant 2 and 3 values for the vowels /a/, /i/, and /u/ with forward, neutral, and backward tone placement by all participants.
The number of participants who demonstrated each change is noted in parentheses.

Vowel	Placement	F2	F3
/a/	Forward	higher (3) lower (1) no change (6)	higher (3) lower (3) no change (4)
	Backward	higher (2) lower (4) no change (4)	higher (2) lower (5) no change (3)
/i/	Forward	higher (7) lower (2) no change (1)	higher (8) lower (1) no change (1)
	Backward	higher (1) lower (8) no change (1)	higher (4) lower (6)
/u/	Forward	higher (8) no change (2)	higher (6) lower (1) no change (3)
	Backward	higher (1) lower (5) no change (4)	higher (2) lower (5) no change (3)

ARTICULATORY DATA

Average articulator position for each participant performing the vowels /a/, /i/, and /u/ and the Alma Mater was determined and difference values obtained between forward/backward tone placement and normal singing. The following results are based on group trends, and some participants strayed from the patterns of movement described.

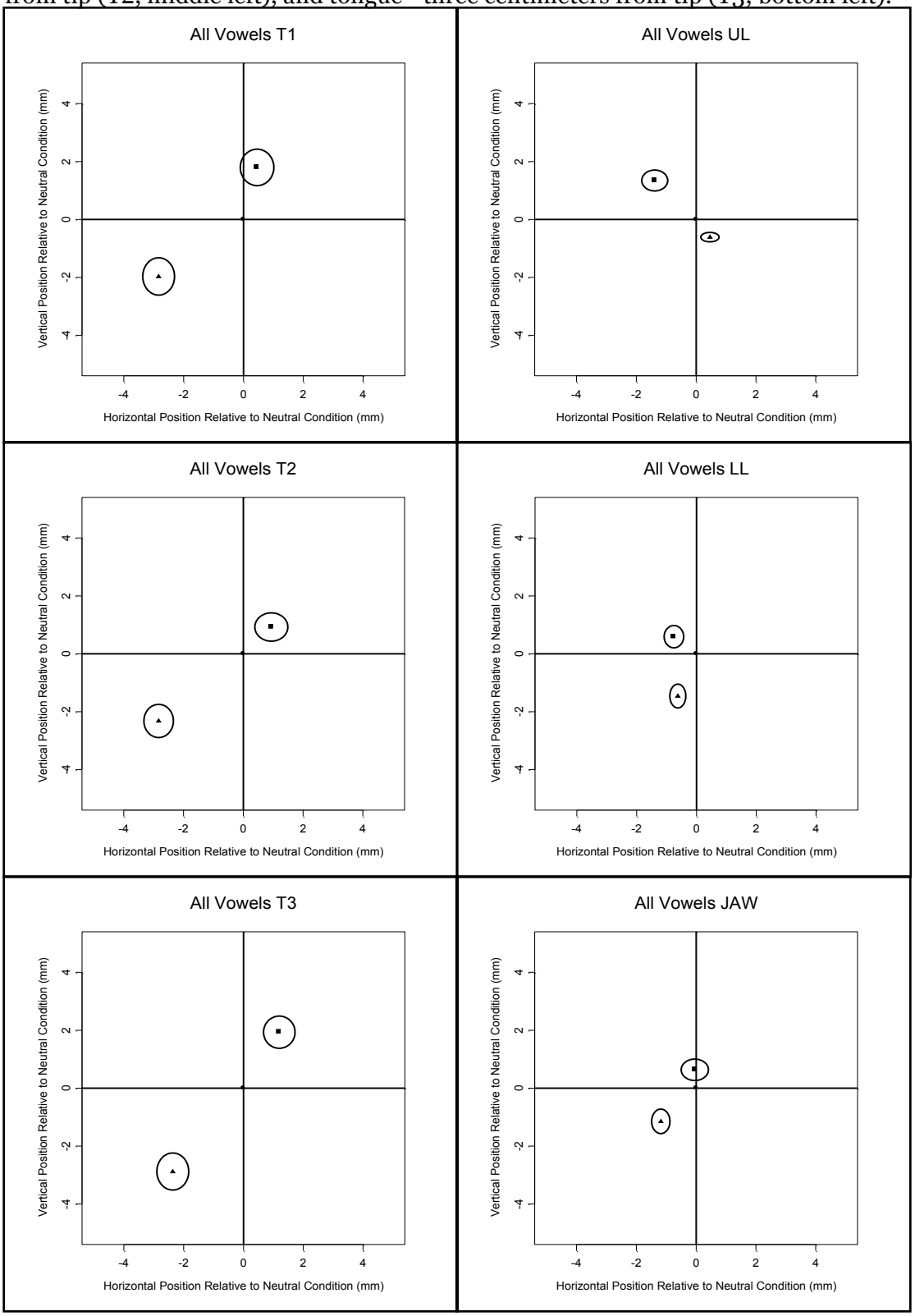
All Vowels

Figure 5 plots the average articulator position extracted from all samples for all vowels. The x-axis of each grid denotes the horizontal position of the sensor and the y-axis represents the vertical position. Positive values on the x-axis indicate a forward movement of the articulator, whereas the negative values correspond to backward movement of the articulator.

Positive values on the y-axis indicate an elevation of the articulatory while negative values signify a lowering of the articulator. Forward tone placement is denoted by the square symbol, normal singing with the circle, and back placement with the triangle. The symbols are associated with the mean formant values for the group and the ellipse bounds the standard error about the mean. Males and females are collapsed.

Average articulator position across all vowels was obtained to examine those articulatory changes that accompany forward and backward tone placement in general (Figure 5). The group of singers tended to retract the upper lip, elevate the tongue, and push the middle and back of the tongue forward to sing with forward tone placement. For back tone placement, they depressed the jaw (which had the effect of increasing lip aperture) and pulled the whole tongue down and back. The female participants pushed the whole tongue forward when singing vowels with forward placement. The male singers pulled the lower lip back slightly and elevated the jaw slightly to sing forward. They protruded the upper lip slightly to sing vowels with back placement.

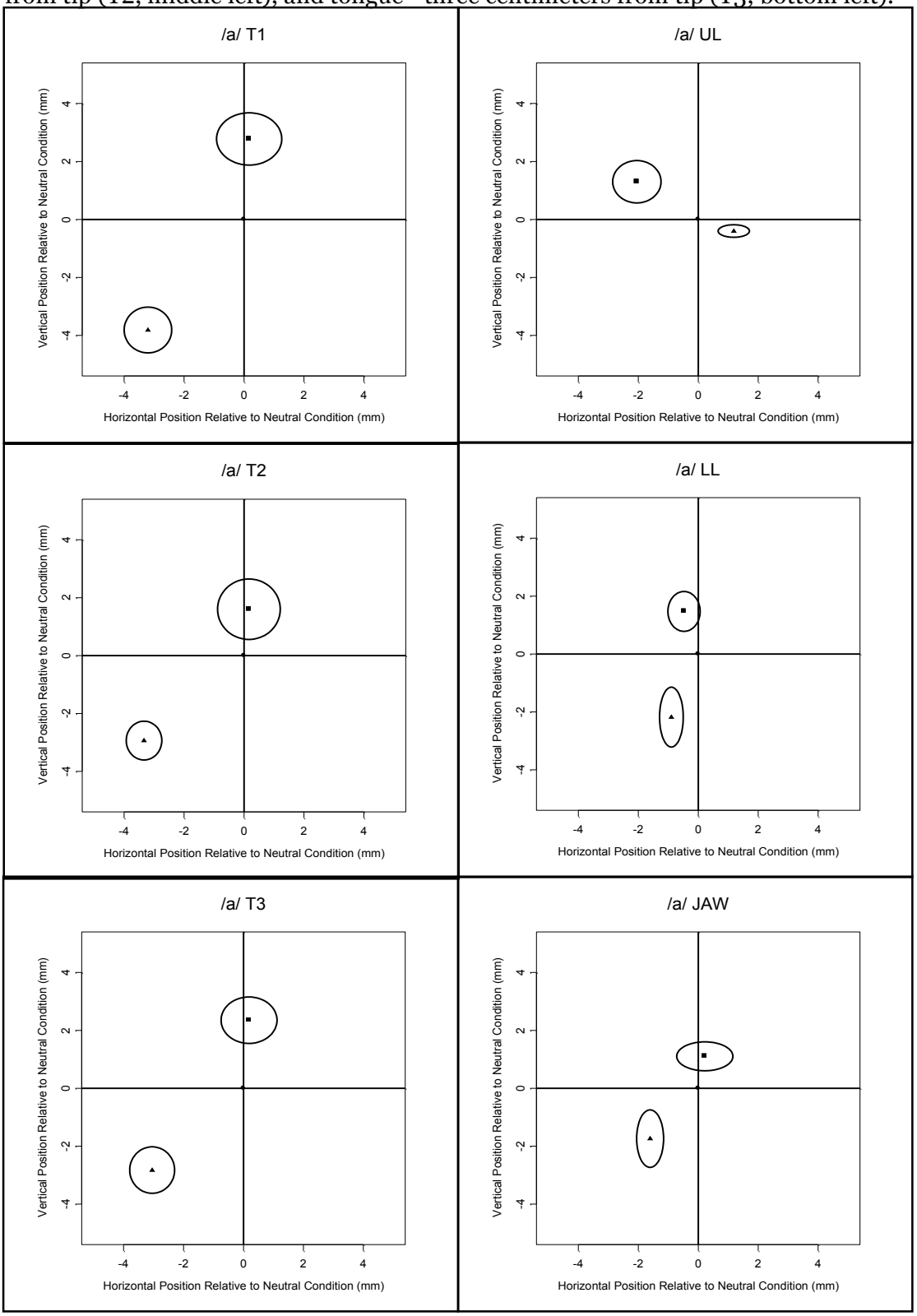
Figure 5. Average articulator position for all vowels with forward (square), neutral (circle) and backward (triangle) tone placement by all participants.
The grids plot the position of the upper lip (UL; top right), lower lip (LL; middle right), chin (JAW; bottom right), tongue - one centimeter from tip (T1; top left), tongue - two centimeters from tip (T2, middle left), and tongue - three centimeters from tip (T3; bottom left).



Vowel /a/

Average articulator position was extracted from all samples containing the vowel /a/ (Figure 6). To produce /a/ with forward tone placement, the participants as a group tended to retract the upper lip, elevate the jaw (which had the effect of decreasing lip aperture), and elevate the whole tongue. To sing /a/ with back placement, the group protruded the upper lip, depressed the jaw (which increased lip aperture), and pulled the whole tongue down and back. Different articulatory movements were noticed when examining the men and women separate from the group. In addition to the movements made by the entire group for /a/ forward, the female participants pushed the front of the tongue forward. For /a/ back, the male participants retracted the lower lip (not shown in Figure 6).

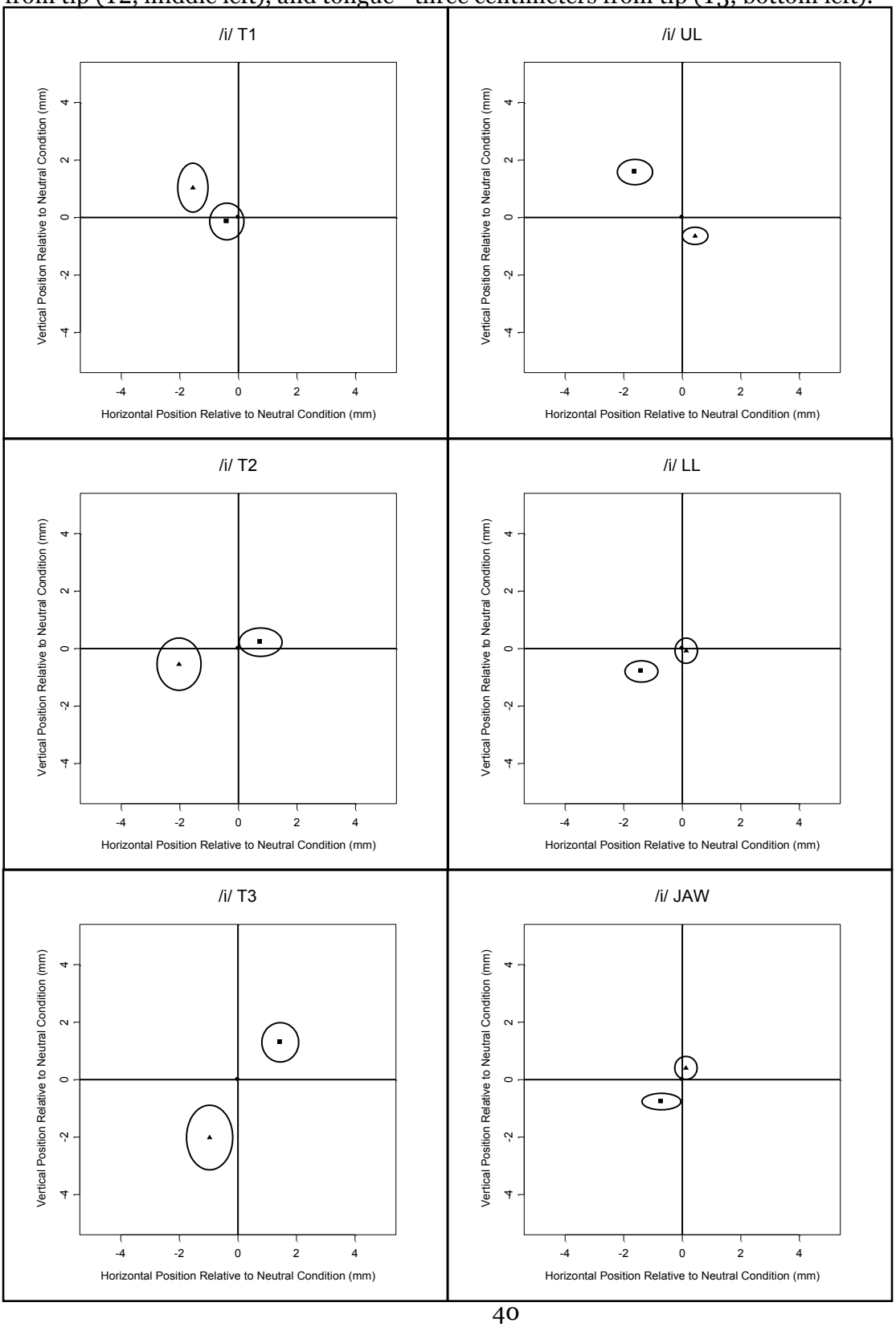
Figure 6. Average articulator position for the vowel /a/ with forward (square), neutral (circle) and backward (triangle) tone placement by all participants.
The grids plot the position of the upper lip (UL; top right), lower lip (LL; middle right), chin (JAW; bottom right), tongue - one centimeter from tip (T1; top left), tongue - two centimeters from tip (T2, middle left), and tongue - three centimeters from tip (T3; bottom left).



Vowel /i/

Average articulator position was extracted from all samples containing the vowel /i/ (Figure 7). To produce /i/ with forward tone placement, the group of singers tended to retract the upper and lower lips (which had the effect of increasing lip aperture), and push the back of the tongue up and forward. To sing /i/ with back placement, the group pulled the whole tongue back, elevated the front of the tongue, and depressed the back of the tongue. The female participants depressed the jaw, pushed the middle and back of the tongue forward, depressed the front of the tongue, and elevated the back of the tongue when singing /i/ forward. When singing /i/ with back placement, they decreased jaw opening slightly (which resulted in a slight reduction of lip aperture). The male participants pulled the jaw and the front of the tongue back to sing /i/ forward (not shown in Figure 7). They protruded the upper lip slightly and depressed the middle and back of the tongue when singing /i/ with back placement. The tongue positions on the vowel /i/ are least consistent with the pattern of pushing the tongue up and forward for forward singing and down and back for back singing.

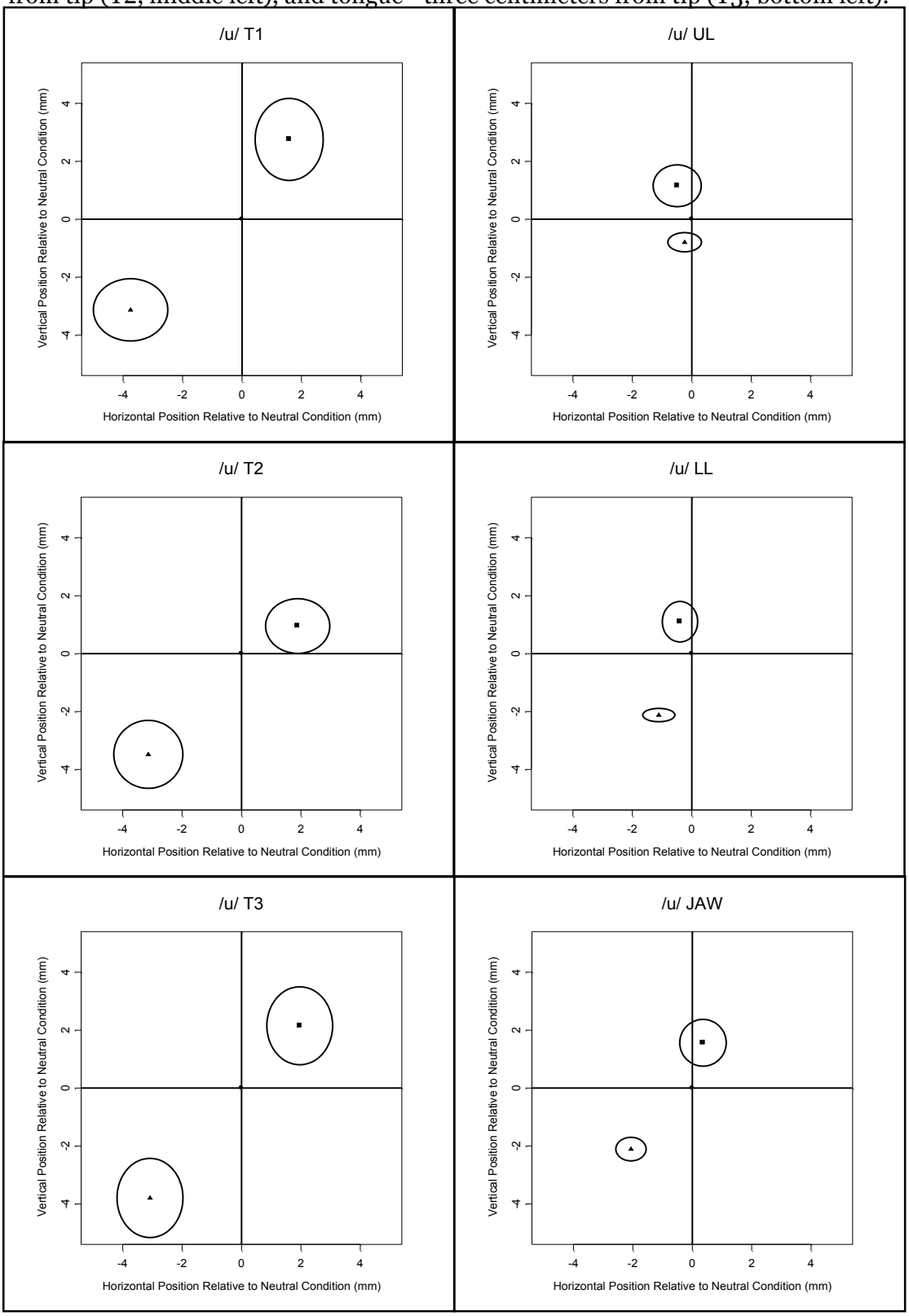
Figure 7. Average articulator position for the vowel /i/ with forward (square), neutral (circle) and backward (triangle) tone placement by all participants.
The grids plot the position of the upper lip (UL; top right), lower lip (LL; middle right), chin (JAW; bottom right), tongue - one centimeter from tip (T1; top left), tongue - two centimeters from tip (T2, middle left), and tongue - three centimeters from tip (T3; bottom left).



Vowel /u/

Average articulator position was extracted from all samples containing the vowel /u/ (Figure 8). To produce /u/ with forward tone placement, the group demonstrated a tendency to elevate the upper lip, elevate the jaw, and push the whole tongue up and forward. To sing /u/ with back placement, they depressed the jaw (which increased lip aperture), and pulled the whole tongue down and back. When singing /u/ forward, the female participants pulled the lower lip back (not shown in Figure 8). The male participants depressed the upper lip to sing /u/ with back placement. The tongue positions on the vowel /u/ show the clearest example of pushing the tongue up and forward for forward singing and down and back for back singing, with the average position and standard error falling completely within quadrants 1 and 3, respectively.

Figure 8. Average articulator position for the vowel /u/ with forward (square), neutral (circle) and backward (triangle) tone placement by all participants.
The grids plot the position of the upper lip (UL; top right), lower lip (LL; middle right), chin (JAW; bottom right), tongue - one centimeter from tip (T1; top left), tongue - two centimeters from tip (T2, middle left), and tongue - three centimeters from tip (T3; bottom left).

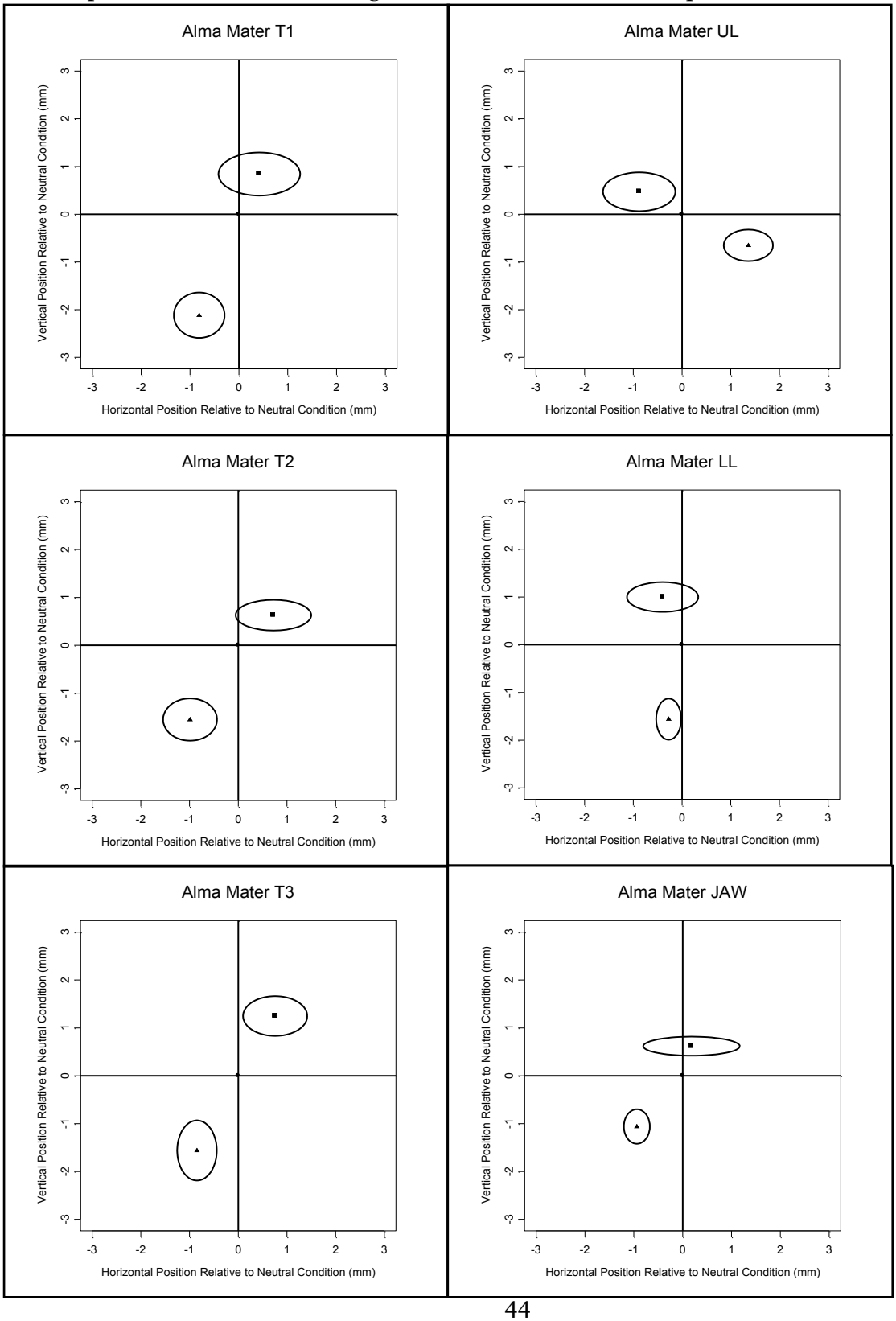


Alma Mater

Average articulator position across an entire sung passage was extracted from the sound signals containing the Alma Mater (Figure 9). When singing the passage with forward placement, the singers retracted the upper lip, raised the lower lip, and pushed the tongue up (particularly the back of the tongue) and slightly forward. To sing with back placement, they protruded the upper lip, opened the jaw more (which had the effect of increasing lip aperture), and pulled the entire tongue further down and back in the mouth. For forward singing, the female participants pushed the chin forward and increased lip aperture (not shown in Figure 9). The male participants retracted the lower lip when instructed to sing the Alma Mater with forward tone placement (not shown in Figure 9).

Many of the patterns found to accompany forward and back singing of the passage were also seen in the singing of the vowels. However, elevation of the lower lip was not observed as a consistent change made by the group when singing vowels with forward placement. In the interview, some of the singers reported puckering the lips when singing forward, which may not have come through in the vowels but appears to be a tendency in connected singing. Singing the passage with back placement yielded the same patterns observed when singing the vowel /a/, as upper lip protrusion was not evident in the other vowels.

Figure 9. Average articulator position for the Alma Mater with forward (square), neutral (circle) and backward (triangle) tone placement by all participants.
The grids plot the position of the upper lip (UL; top right), lower lip (LL; middle right), chin (JAW; bottom right), tongue - one centimeter from tip (T1; top left), tongue - two centimeters from tip (T2, middle left), and tongue - three centimeters from tip (T3; bottom left).



CHAPTER IV

DISCUSSION

Students of singing are taught to produce an ideal tone through the manipulation of tone placement. The singers in this study reported they are instructed to produce a forward tone placement during their voice lessons and choir rehearsals in order to achieve a better sound. Although the students responded that they are infrequently instructed to sing with back placement, they replied that in certain situations, their voice teachers or choir directors ask for a warm or dark sound, which they listed as synonyms for back placement. It appears, then, that for the teachers and students of singing at WMU, forward tone placement is desirable, whereas back tone placement has a negative connotation. In fact, some participants listed synonyms for back tone placement that had a strong negative association (e.g., hooty, swallowed).

INTERVIEW DATA VERSUS ARTICULATORY DATA

Statements made by the singers during the interview about articulatory postures for forward and backward tone placement were compared to the actual articulatory movements observed during the singing tasks (Table 11). Most of the singers accurately described some of the articulatory changes observed, but also listed movements that did not occur in their singing. For example, M01 stated that he elevates the back of the tongue for forward singing, when he actually retracted the tongue when singing vowels with forward tone placement. This articulatory posture conflicted with the tendency demonstrated by the group to push the tongue up and forward for forward placement. His interview response was accurate for most participants, but he did not demonstrate that articulatory movement. M04 only listed articulatory movements related to laryngeal position in his interview, but did make systematic changes to the oral articulators when completing the singing tasks in this study. Some of the interview responses required interpretation (e.g., create more space, push the vowels to the front of the mouth, loosen and manipulate the tongue), but the meaning of their statements

could be fit to the articulatory postures observed. However, a singing student might have difficulty achieving the desired articulatory posture due to the ambiguity of some participants' descriptions. Based on the lack of consistency across singers when describing articulatory movements in forward and back tone placement and the existence of inaccurate descriptions, explicit instruction to those studying to be teachers of singing regarding the articulatory postures that accompany forward and back singing would be required if they intend to teach future students about articulatory movements.

Table 11. Comparison of interview responses about articulatory movements in forward and back singing and actual movements observed in each participant.

Participant	Placement	Interview Response	Articulatory Data
M01	Forward	elevate the upper lip and back of the tongue	retracted the jaw and tongue
	Back	lower the jaw; round the lips; lower the tongue; pull the back of the tongue forward	depressed the jaw; pulled the tongue down and back
M02	Forward	lower the tongue	retracted the lips; protruded the jaw; pushed the tongue forward
	Back	create more space	depressed the jaw; pulled the tongue down and back
M03	Forward	make a snarly face	retracted the lips; pulled the jaw up and back; pulled the tongue up and back
	Back	drop the jaw; retract the tongue	protruded the upper lip; depressed the jaw; pulled the tongue down and back
M04	Forward	elevate the larynx	elevated the jaw; pushed the tongue up and forward
	Back	depress the larynx	protruded the upper lip; pulled the tongue down and back

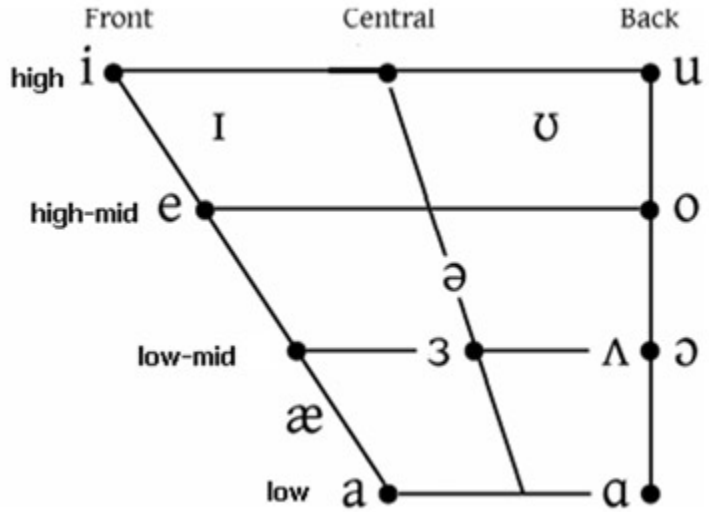
M05	Forward	close the jaw a little; lift the tongue in the middle	protruded the jaw; pushed the tongue forward
	Back	open the jaw; depress the tongue in the middle and back; flatten the tongue	depressed the jaw; pulled the tongue down and back
F01	Forward	push the vowels to the front of the mouth; puckers the lips	elevated the upper lip and tongue
	Back	push the tongue down in the back of the mouth to create more space	depressed the jaw and tongue
F02	Forward	drop the tongue; don't let the tongue swell up in the back of the mouth	moved the tongue up and forward
	Back	open the jaw more; pull the tongue back	retracted and elevated the jaw; moved the tongue further back in the mouth
F03	Forward	pucker the lips; close the jaw a little; arch the back of the tongue; keep the front of the tongue down	moved the tongue up and forward in the mouth
	Back	open the jaw slightly; let the tongue relax	elevated the jaw depressed the tongue
F04	Forward	loosen and manipulate the tongue	retracted the upper lip; moved the tongue up and forward
	Back	open the mouth more; create more space	moved the tongue down and back
F05	Forward	show more teeth; raise the back of the tongue	retracted the upper lip; closed the jaw more; moved the tongue up and forward
	Back	round the lips; relax the back of the tongue	protruded the upper lip; depressed the jaw; moved the tongue back

ACOUSTIC DATA VERSUS ARTICULATORY DATA

Vurma and Ross (2002) found that forward tone placement was associated with higher F2 and F3 frequencies, and a higher SPL of the singer's formant. They stated back placement is characterized by lower F2 and F3 frequencies. The current study corroborated their findings. Forward tone placement was associated with higher F2 and F3 frequencies as compared to normal singing. Lowering the second and third formants characterized back tone placement. The intensity of the singer's formant was not examined in this study.

Speech and voice scientists know the effects articulatory changes will have on formant values based on their knowledge of American vowels. The thirteen American vowels are classified based on tongue height and advancement (Figure 10). Front vowels (e.g., /i/ and /e/) are produced with an anterior tongue position, and back vowels (e.g., /u/ and /o/) are generated by a posterior tongue position. All thirteen vowels fall on a continuum based on tongue advancement, with /i/ being the most forward vowel, /ə/ in the middle, and /u/ being the furthest back vowel. Vowels produced with an elevated tongue position are considered high, and low vowels result from a depressed tongue position. The vowels are grouped as high (e.g., /i/ and /u/), high-mid, low-mid, and low (e.g., /a/). Based on the relationship between vowel classification and tongue position, speech and voice scientists predict what effect tongue modifications will have on American vowels. For example, pushing the tongue further forward will make a vowel sound like the next vowel on the tongue advancement continuum (e.g., /u/ approximates /ʊ/). Speech and voice scientists also know the formant values that correspond with each American vowel. In general, tongue height has an effect on F1, and tongue advancement has an effect on F2; high vowels have a low F1 whereas low vowels have a high F1, and front vowels have a high F2 while back vowels have a low F2 (Behrman, 2007). Lip rounding has the effect of lowering all formant values. Knowledge of this relationship allows voice scientists to infer what changes to the tongue and lips are causing observed changes in formant values.

Figure 10. Vowel quadrilateral for the thirteen American English vowels (Ahmed, 2006).



Vurma and Ross (2002) made conclusions about the articulatory movements that accompany forward and back singing based on their acoustic findings. They postulated that forward tone placement is caused by retracting the lips, elevating the larynx, and pushing the tongue up and forward in the oral cavity. They attributed the increase in SPL of the singer's formant to lowering the larynx and widening the pharyngeal space. They proposed that back placement is caused by depressing the larynx and protruding the lips. The current study made direct measurements of the oral articulators during forward and back singing. To sing a vowel with forward tone placement, the singers tended to retract the upper lip, elevate the tongue, and push the middle and back of the tongue forward. For back singing, they depressed the jaw (which increased lip aperture) and pulled the whole tongue down and back. These findings support the inferences made by Vurma and Ross (2002) about the articulatory posture for forward tone placement. Back tone placement was not associated with systematic lip protrusion for the sung vowels; however, lip protrusion was evident when singing a passage with back tone placement. Due to methodological limitations, direct measurement of laryngeal position was

not made, so no conclusions can be drawn about the veracity of the other authors' claims that the larynx elevates for forward singing and drops for back singing. Some of the singers mentioned laryngeal posture when interviewed about their impressions of forward and back tone placement; therefore, future studies should include a measurement of vertical laryngeal position when examining physiological changes associated with tone placement.

This study's acoustic findings support the articulatory findings, and those of Vurma and Ross (2002); that is, forward tone placement is associated with higher F2 and F3 frequencies caused by lip retraction, tongue elevation, and anterior movement of the tongue, and back tone placement is associated with lower F2 and F3 frequencies caused by jaw depression, tongue depression, and tongue retraction.

MALES VERSUS FEMALES

Acoustic Findings

The acoustic findings for male and female participants were presented together with hesitation. The men sang a lower fundamental frequency, which resulted in a denser harmonic spectrum, and the frequencies at which formants are typically found lined up with the harmonics. The women sang a higher fundamental frequency, which produced a sparser harmonic spectrum that sometimes lacked energy where a formant would typically occur. As the average formant frequencies extracted for the men were less dependent on the fundamental frequency, they were probably more indicative of the acoustic changes made for forward and back singing. The acoustic results for the female singers were presented, but accompanied with a caveat related to the difficulty extracting formant frequencies from samples with a high fundamental frequency. Although the average changes in formant values for men and women were not the same, their results did not conflict. The female participants did not make any consistent change to F2 or F3 for forward singing whereas the men had higher F2 and F3

frequencies. The women had lower F3 values for back singing while the male singers had a lower F2 and F3.

Articulatory Findings

The articulatory findings for men and women were comparable, so these results are presented together. Articulatory results corresponded across gender for the most part, but occasional differences were noted, for example, in the direction of lip movement (e.g., females elevating the upper lip versus males retracting the upper lip) or the part of the tongue that was manipulated (e.g., females elevating whole tongue versus males elevating the middle and back of the tongue).

VOWELS VERSUS PASSAGE

Articulatory Findings

Many of the same articulatory changes were seen when the participants applied forward and back tone placement to the vowels and the passage, which suggests a trend to shift the working space of the tongue up and forward or down and back. For back singing especially, jaw depression, tongue depression, and posterior movement of the tongue were observed in the vowels and the Alma Mater. The only additional movement that was not observed in the sung vowels was protrusion of the upper lip for singing the passage with back placement. For forward singing, the singers made articulatory movements to a lesser degree for the Alma Mater. This trend could be due to anatomical limitations. For example, the hard palate may constrain how much the tongue can elevate for forward placement in connected singing. Elevation of the entire tongue was observed in the vowels. In the passage, elevation of the entire tongue was evident, but only the back of the tongue raised to the degree noted in the vowels. The group retracted the upper lip in forward singing of vowels, but raised the lower lip for the passage. Retraction of the upper lip was observed in the passage, but the degree of change was less and the variability

between participants was greater. The singers pushed the middle and back of the tongue forward when singing vowels with forward placement, and although that movement occurred in the passage as well, the degree of movement was less.

/a/ VERSUS /i/ VERSUS /u/

Acoustic Findings

The difference in changes in formant values between /a/, /i/, and /u/ were minimal; the direction of change was consistent across vowels, but not all of the formant frequencies changed for all vowels within each tone placement condition. For forward singing, a higher F1 frequency was observed in /a/ and /u/; a higher F2 and F3 frequency was observed in /i/ and /u/; and a lower F4 frequency was observed in /i/ only. For back singing, a lower F1 frequency was observed in /a/ only; a lower F2 frequency was observed in /i/ and /u/; and a lower F3 and F4 frequency was observed in /a/, /i/, and /u/.

Articulatory Findings

Many of the same articulators moved to produce forward or back tone placement in all of the vowels, but the degree of movement in a particular direction may have been different. For example, in forward tone placement the upper lip moved for all vowels, but it retracted for /a/ and /i/ and only elevated for /u/. The jaw elevated for /a/ and /u/. In /a/ and /u/, the whole tongue rose, but in /i/ only the back of the tongue was elevated. When singing with back placement, the singers depressed the jaw for /a/ and /u/ but not /i/. They pulled the whole tongue back for all vowels, pulled the whole tongue down for /a/ and /u/, and pulled the back of the tongue down for /i/.

IMPLICATIONS

The purpose of performing this study was to determine if singers make systematic changes to the oral articulators to produce forward and backward tone placement, and if so, to define the articulatory posture that yields each tone placement. The singers who participated in this study did make consistent vocal tract changes when singing three different vowels and a passage with forward and backward placement, the produce of which can be heard by listeners and seen as changes in formant frequencies in the sound signals. Recognition of the fact that certain articulatory postures generate each tone placement and knowledge of those postures could supplement current methods of singing instruction. The singers who participated in this study had been taught to sing forward and back with imitation, imagery, and singing exercises. They listed some corresponding articulatory movements for forward and back placement, but few stated they would instruct students about articulatory movements when teaching tone placement, and those who would disagreed about what those movements were. Understanding how manipulations to the vocal tract can affect tone placement could give them one more tool to use when modifying a student's tone quality.

In addition to using these findings to supplement singing instruction, another possible application of the results would be in the area of voice therapy. Resonant voice therapy is a technique taught to people with voice disorders who are seeking treatment for their symptoms. Grillo and Verdolini (2008) examined resonant tone quality compared to breathy, pressed, and normal tone qualities. They defined resonant tone quality as an easy mode of phonation in which vibrations are felt in the alveolar ridge. Based on this definition, resonant voice is another synonym for the term forward tone placement. Therefore, the articulatory movements that accompany forward singing could be taught to those who are learning to use resonant voice.

LIMITATIONS

This study has a number of limitations to consider when applying the results to the field of singing or voice therapy. First of all, this was a preliminary study appropriate for a master's thesis project; only ten singers participated in the data collection. In addition, the singers were all recruited from Western Michigan University; therefore, the conclusions made about what constitutes forward and backward tone placement may not be true for other regions that teach a Western lyrical singing style. Future research that included more singers from a variety of universities would be necessary to generalize the findings from this preliminary study. In terms of methodological limitations, the laboratory equipment used to capture articulatory movements may not have been well suited for determining all vocal tract modifications that occur in forward and back singing. Many of the participants referred to changes in laryngeal position and soft palate elevation that could not be measured using the EMA system. Vurma and Ross (2002) suggested that the increase in SPL of the singer's formant in forward singing was due to a widening of the pharyngeal space, and that the changes to F2 and F3 observed in forward and backward tone placement were due to laryngeal position. These articulatory changes could not be examined with the EMA system used in this study. Future research should study how pharyngeal changes interact with forward and backward tone placement.

FUTURE DIRECTIONS

Trends in articulatory movement were observed in this study; however, analysis was limited to qualitative techniques due to the small number of participants. A larger sample size would allow for statistical analysis to determine if the trends noted in this study happened consistently across a majority of singers, or if opposing articulatory movements occurred frequently. If the articulatory postures for forward and backward tone placement proved to be consistent for a majority of the participants, it would support the application of articulator

instruction to singing training. Additionally, statistical analysis would quantify the effects of vowel type and task complexity on forward and backward tone placement.

A number of the participants stated that singing on nasal consonants and nasalized vowels (e.g., /niæ/) helped them achieve a forward tone placement. For back placement, the most frequent reference to articulatory movements was about raising the soft palate. Future research could examine nasal versus oral airflow in forward, normal, and back tone placement using a nasometer. Forward tone placement could have a measureable nasal quality. Magnetic resonance imaging would provide a sagittal view of the vocal tract, allowing for observation of velar movement.

CONCLUSIONS

This study examined forward and backward tone placement to gain a better understanding about their articulatory and acoustic features, in addition to comparing singers' impressions of what constitutes these tone placements. Results indicate that forward tone placement can be described as having a bright tone quality, and produced by "aiming" the sound toward the mask, feeling a buzzing sensation in the mask, and elevating the upper lip. Back tone placement can be described as dark, throaty, warm, or covered, and is produced by lifting the soft palate, depressing the larynx, and opening the jaw more. Forward tone placement has the acoustic effect of raising F2 and F3 frequencies. Singing with back placement resulted in lower F2 and F3 values. The singers made systematic changes to the oral articulators when singing with forward and back placement. Forward singing was produced by retracting the upper lip and pushing the tongue up and forward. Back singing was caused by depressing the jaw and pulling the tongue down and back. Because these articulatory postures were seen across participants, it can be assumed that specific articulatory movements accompany forward and backward tone placement. Therefore, instruction about articulator position could supplement current methods of teaching tone placement to achieve a desirable tone quality.

APPENDIX A

HSIRB APPROVAL LETTER

WESTERN MICHIGAN UNIVERSITY
Human Subjects Institutional Review Board

Date: October 30, 2012

To: Stephen Tasko, Principal Investigator
Krista Wyllys, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 12-09-06

This letter will serve as confirmation that your research project titled "A Preliminary Study of the Articulatory and Acoustic Features of Forward versus Backward Tone Placement in Singing" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 30, 2013

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

APPENDIX B

HISTORY QUESTIONNAIRE

HISTORY QUESTIONNAIRE

1. How old are you? _____

2. What is your major? _____

3. Can you comfortably sing a C4 (males) or a C5 (females) in the middle of your range? Yes No

4. Beginning with middle school, for how many years have you been enrolled in a choir class? _____

5. Do you currently study with a private voice teacher? (Please circle) Yes No

5a. If yes, who is your private voice teacher? _____

_____

5b. If no, please list the name(s) of the private voice teacher(s) you studied with at WMU: _____

_____

6. Beginning with middle school, for how many years have you studied with a private voice teacher? _____

7. Do you currently sing with any formal singing groups? (Please check)

☐ Chorale ☐ Cantus Femina ☐ Collegiate Singers ☐ Grand Chorus ☐ Opera

☐ Gold Company ☐ GCII ☐ Church Choir ☐ Other: _____

8. How many hours per week do you sing under formal instruction? (Please include choir, voice lessons, and other singing groups) _____

9. Are you currently experiencing any problems with your voice? (Please circle) Yes No

9a. If yes, please describe the nature of the problem and the treatment sought:

_____

_____

For examiner use only:

Passed hearing screening: ☐ Yes ☐ No

Evidence of current voice problem: ☐ Yes ☐ No

Qualify: ☐ Yes ☐ No

Enrolled: ☐ Yes ☐ No

APPENDIX C

TONE PLACEMENT INTERVIEW

TONE PLACEMENT INTERVIEW

1. If you were working with a new singer, how would you describe what forward tone placement means?

2. How would you describe back tone placement?

3. Have voice teachers used other terms instead of forward and back that you think mean the same thing?

From here on, we will use the term forward tone placement to describe a sensation of vibration felt in the front of the mouth. From here on, we will use the term back tone placement to describe a sensation of vibration felt in the back of the mouth.

4. How have you been instructed by your private voice teacher or choir director to produce a forward tone placement?

5. How have you been instructed to produce a back tone placement?

6. When transitioning from normal singing to a forward tone placement, what changes do you make to do that?

7. You described what you do with your _____, do you make any other changes with other parts of your mouth or throat?

8. When transitioning from normal singing to a back tone placement, what changes do you make to do that?

9. You described what you do with your _____, do you make any other changes with other parts of your mouth or throat?

10. How would you instruct a student to produce a forward tone placement?

11. How would you instruct a student to produce a back tone placement?

Prompts: Tell me more about that.

You gave a sung example, now please describe that in words.

Some instructors use imagery to create a mental picture of forward tone placement whereas other instructors give a sung example.

You described how the imagery changes between normal and forward tone placement, now please tell me what changes in your mouth and/or throat.

APPENDIX D

INTERVIEW DATA TABLES

Table 12. *Question: What is forward tone placement?*

The responses to this question were collapsed from four interview questions: (1) If you were working with a new student, how would you describe what forward tone placement means? (2) Have voice teachers used other terms instead of forward and back that you think mean the same thing? (3) When transitioning from normal singing to a forward tone placement, what changes do you make to do that? and (4) You described what you do with your _____, do you make any other changes with other part of your mouth or throat?

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1	Buzzing in the nasal cavity, hard palate, and front teeth; raised larynx; raised upper lip; lowered soft palate; raised back of tongue to narrow the space in the pharynx		Bright; buzz; ping
M2	Lift the soft palate; feeling a sensation in the forehead; lower the tongue	Plug your nose to see if you're resonant enough; producing more diction; using more airflow	Bright; letting the tone flow; treating your head like a tea kettle; use passaggio [the passaggio is the transition between registers, but M2 seems to equate the passaggio with head voice]
M3	Make a snarly face	Engage the breath	Buzzy, nasty place in the very front of your face; bright
M4	Feel the buzz (sympathetic vibrations) in your mask; raise the larynx	Do exercises like /niæ niæ niæ niæ niæ/	Harsh; bright; brittle; pingy; put a bit more head resonance into it; disconnect the head resonance after the passaggio; feel it in the head and mask
M5	Buzzing sensation in the mask (nose, upper lip, between the eye brows); lift the middle of the tongue to create tension; create an		Sharp; bright

	arch in the tongue from front to back; close the jaw a little; raise the larynx		
F1	Pushing vowels and sound to the front of the mouth; keep the soft palate in the same place as when speaking; pucker the lips	Altering vowels	Singing in the mask; come up out of your forehead; imagining that the tone is vibrating in your hard palate
F2	A light vibration in the forehead and upper cheek bones; tongue drops; don't let the tongue swell up in the back of the mouth	Engage the breath	"Aim" your sound underneath your soft palate through the top of your front teeth; bright; shoot the sound right through my upper lips
F3	Back of the tongue arches up while the front of the tongue stays at the bottom of the bottom teeth; raised soft palate; pucker the lips (to drive the sound forward); close the jaw a little		Think of aiming your sound through your forehead or through your nose; nasal resonance
F4	Loosen my tongue; manipulate my tongue (I don't know to where)	Certain exercises like /n/ and /ŋ/	Putting the sound and the resonation forward in the nasal cavity; bright; think about hitting the hard palate and vibrating the teeth; more focused air stream; less mouth, throat, or chest resonance; more towards the nasal [cavity]
F5	Using the forward articulators; make reference to the front of the teeth; resonance in the nasal cavity; show more teeth; raise the back of the tongue	Use brighter vowels like /i/	Make the sound toothier; put more smile in the sound; bright; make the sound more nasal

Table 13. *Question: What is back tone placement?*

The responses to this question were collapsed from four interview questions: (1) If you were working with a new student, how would you describe what back tone placement means? (2) Have voice teachers used other terms instead of forward and back that you think mean the same thing? (3) When transitioning from normal singing to a back tone placement, what changes do you make to do that? and (4) You described what you do with your _____, do you make any other changes with other part of your mouth or throat?

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1	Lowered larynx; raised soft palate to block off nasal cavity; lowered jaw; rounded lips; lowered tongue; back of tongue pulls forward making the pharynx bigger		Auditory idea; talking like a British person; how you sound when you yawn; dark; swallowed
M2	Making sure you have space inside your mouth; lift the soft palate	Constant airflow; supported	Darker tone; swallowed; Kermit-the-Frog sound; don't sing through your voice in order to feel manly
M3	Drop the jaw; tongue recedes; singing in a yawn-like position; it gets tighter		Dark; cavernous; feel sort of in your head
M4	Drop the larynx	Like the Patrick voice from SpongeBob; say more /ʌ/ in an /a/ vowel; mix more falsetto; like a yawn sound	Throat resonance; warmer color; airy placement; cover; think more /ʌ/; darker; hooty; more head space; thinking taller; think of the sound moving upwards and back instead of out through the sinuses
M5	Depress the tongue in the middle and back; flatten out the tongue; open the throat; lift the soft palate; depress the larynx; more open jaw		Warm; open; muted; covered; hooty

F1	Larynx pushed down; tongue pushed down in the back; lift the soft palate; create more space		Singing in the throat; hooty sound; warmth; darker
F2	Tongue is pulled back and not touching the front teeth; back of the tongue tenses; get rid of tongue tension; mouth opens wider; soft palate raises	Everything relaxes; Takes just as much breath support	It sits in the back of your mouth on top of your throat; swallowed; dark
F3	Let the tongue relax; open the jaw slightly; open the throat		The tone goes out the top of the head or behind your head; head resonance; throaty
F4	Resonation on the upper soft palate and further back; conscious of over- or under-lifting the soft palate; open the mouth slightly; more space in the mouth; drop the larynx slightly		Mouth resonance, throat resonance; covered; dark; rounder
F5	Relax the back of the tongue; lift the soft palate; round the lips	Use darker vowels like /u/	Talk about head space or head resonance; think of sending the sound out the back of your head instead of allowing it to come out of your mouth; warm; dark; cover the sound

Table 14. *Question: How have you been instructed to produce a forward tone placement?*

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1		Hum to achieve buzzing sensation	Lollipop; sunshine; happy; nasal; buzz; ping
M2		Use your head voice	Sing through your teeth; treat your head like a tea kettle; sound more floaty; using your head voice
M3		Has to do with breath	Snarly sound
M4		Warming up on vowels like /i/ or /e/ then modifying to /a/ to keep the brightness of the /i/ or /e/; using exercises like /niæ niæ niæ niæ niæ/	
M5		Pointing of the finger in front of the face	Make the sound nastier
F1	Feel the vibrations in the back of the lips, hard palate, and nose	Exercises with very bright vowels like /i/, /e/, and sometimes /o/ (but doesn't produce as much forwardness)	Sing as if it was being drawn out; pretend you have a beak and it's coming out of your beak
F2		Sing /m/, /n/, and /ŋ/	Like a laser through your forehead
F3		Using nasal vowels in warm-ups like /niæ/, using closed vowels like /i/ as opposed to /u/ (which goes back in the mouth)	Pretend you're pulling a string out of your forehead
F4		Exercises like /ni/ and /ne/ with forward and closed vowels	Letting the sound go forward
F5		Use forward placed vowels like /i/; make money motion [rubbing thumb and forefingers together] near the front of the face or around the nasal cavity; sweep the arms up over the head and down (to get the sound to travel back before forward)	

Table 15. *Question: How have you been instructed to produce a back tone placement?*

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1	Raise the soft palate		Pretend there's an egg in the back of your mouth; be more mature (sound like an older singer)
M2			More chest voice
M3		Like yawning	Described as a cavernous sound
M4		Use vowels like /u/ or /o/; blending some of the /o/ into the sound	Think of it as cover; think darker
M5	Depress the tongue in the back of the mouth; lift the soft palate; open the jaw in the back		
F1	Lift the soft palate		Creating warmth; think of your sound as vertical and rounded
F2	Use a lot of open space	Use taller vowels	Ask for a darker, more rounded sound but still with forward placement
F3			Not instructed to produce back tone placement; if asking for less forward resonance but a rich sound, pretend it's going up to the ceiling through the top of your head
F4	Rounder shape of the mouth	Rounder vowel	Warmer resonance
F5	Lift the soft palate; relax the back of the tongue	Use darker vowels like /u/	Encourage tall space in the back of the mouth

Table 16. *Question: How would you instruct a student to produce a forward tone placement?*

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1		Use vowels or phonemes that are hard to do other than forward; sing /m/, /n/, and /zi/	
M2	Lift the soft palate; make sure you don't move your head up and stick the neck out	First teach posture	
M3	Make the snarly face	Do lip trills; buzzing	
M4		Use an /i/ vowel or /niæ niæ niæ niæ niæ/ warm-up; start on a nasal sound like "m" "n" or "ng"	Feel the buzz; understand the difference between super buzzy, head resonance and back tone placement
M5		Use closed vowels like /i/ and /e/; do exercises that start with a closed jaw position like "yum"	Sing a sharp and nasty tone; sing a bright tone
F1		Modify vowels	Talk about singing through the mask; think of the hard palate as buzzing; think of the tone coming out of your forehead or the top of your head
F2		Lip trills (to promote breath support)	Think of the sound as coming straight out of your sinuses and cheeks; round and not shrill
F3	Keep the tongue tip down and the back of the tongue up; feel certain parts of the face resonate	Using nasal vowels in warm-ups like /niæ/, using closed vowels like /i/; make the sound and have them try to do it	Shoot the tone through the front of your face; describe where they should be feeling the sound
F4	Open the jaw a little more	Using taller vowels; breathing through the vowel or open-	

		mouth position	
F5		Sing the passage on /m/, /n/, or /i/	Use words or metaphors like bright, toothy, or put more smile in the sound

Table 17. *Question: How would you instruct a student to produce a back tone placement?*

	Characteristics		
Participant	**Articulatory movements**	**Singing tasks**	**Metaphors/ Imagery**
M1	Training the soft palate	Sing sirens; sing on a sigh; use something that is naturally sung back; sing tall /a/; sing closed vowels; sing /o/ and /u/	Talk about yawning
M2	Keeping the neck area open; make sure the head isn't down		
M3	Sing with the mouth open		Pretend like you're yawning
M4		Do exercises on an /u/ vowel	Feel the back sensation
M5		Use more open vowels like /o/ or /a/	Make the sound more muted or more in the head
F1	Creating more space	Doing exercises that involve open vowels like /ɔ/, /a/, or /ʌ/	Never suggest singing with a backwards tone but address it as creating warmth; think about your tone as being tall and round
F2	Raise the soft palate	Lip trills (to promote breath support and reduce tension); yawning	"Aim" the sound toward the middle of the roof of their mouth instead of the hard palate in front
F3	Keep the throat open, keep everything relaxed, up, and back		Emulate a yawn
F4	Open the jaw a little more	Using taller vowels; breathing through that vowel or open-mouth position	
F5	Keep the lips relatively close together; minimize lip movement	Imitate the Julia Childs voice	Talk about relaxation and lift; like Julia Childs' voice

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