Effects of Nasalance on the Acoustics of the Tenor Passaggio and Head Voice

Nicholas K. Perna
University of Miami, operna@hotmail.com

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EFFECTS OF NASALANCE ON THE ACOUSTICAL PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

By

Nicholas Kevin Perna

A DOCTORAL ESSAY

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of the University of Miami
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EFFECTS OF NASALANCE ON THE ACOUSTICAL PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

Nicholas Kevin Perna

Approved:

Dr. David Alt
Professor of Vocal Performance

Dr. Terri A. Scandura
Dean of the Graduate School

Dr. Rachel L. Lebon
Professor of Studio Music and Jazz

Dr. Donna S. Lundy
Associate Professor of Otolaryngology

Dr. Esther Jane Hardenbergh
Associate Professor of Vocal Performance
This study aims to measure the effect that nasality has on the acoustical properties of the tenor *passaggio* and head voice. Not to be confused with forward resonance, nasality here will be defined as nasalance, the reading of a Nasometer, or the percentage of nasal and oral airflow during phonation. A previous study by Peer Birch et. al. has shown that professional tenors used higher percentages of nasalance through their *passaggio*. They hypothesized that tenors used nasalance to make slight timbral adjustments as they ascended through *passaggio*. Other well respected authors including Richard Miller and William McIver have claimed that teaching registration issues is the most important component of training young tenors. It seemed logical to measure the acoustic effects of nasalance on the tenor *passaggio* and head voice.

Eight professional operatic tenors participated as subjects performing numerous vocal exercises that demonstrated various registration events. These examples were recorded and analyzed using a Nasometer and Voce Vista Pro Software. Tenors did generally show an increase of nasalance during an ascending B-flat major scale on the vowels [i] and [u]. Perhaps the most revealing result was that six of seven tenors showed at least a 5-10% increase in nasalance on the note after their primary register transition on the vowel of [a]. It is suggested that this phenomenon receive further empirical scrutiny,
because, if true, pedagogues could use nasalance as a tool for helping a young tenor
ascend through his *passaggio*.
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Chapter 1

Dealing with registration issues of the tenor voice and the tenor passaggio has been described by Richard Miller¹ and William McIver² as the most important part of training a tenor. This study aims to measure the effect that nasality has on the acoustical properties of the tenor passaggio and head-voice. Not to be confused with forward resonance, nasality here will be defined as nasalance, the reading of a nasometer, or the percentage of nasal and oral airflow during phonation.

Introduction

It can be argued that the operatic tenor is unique among voice types due to its combination of vocal beauty and power. The tenor voice can be exciting for audiences to listen to due to a certain amount of perceived risk. No other male voice type is asked to sing in full head voice for a higher percentage of time. Therefore, the operatic tenor voice is often difficult to teach. Spanish tenor Jose Carreras said, “The tenor voice is by far the most difficult in the whole range, for the tenor sound is not a natural sound.”³ This difficulty comes from the fact that the normal male chest voice only ranges to somewhere around F₄⁴. Yet, tenors are consistently asked to sing full voice in their


upper or “head” (from G4 to C5 according to Richard Miller\textsuperscript{5}) register in operatic literature. This is where the concept of risk comes in to play. Ingo Titze says,

Tenors, more than any other voice category, are notorious for ‘cracking’ on high notes (changing register involuntarily). Audiences know this and therefore regard tenor production like a high-wire balancing act...there is always a finite chance for a disaster.\textsuperscript{6}

As Titze says, due to this combination of risk and beauty, audiences will forever be drawn to the singing of an accomplished tenor.

If the tenor voice does not naturally sing in the higher range from F4-C5, how does the singer accomplish this vocal feat? That is left to the singer and more debatably, to the singing teacher or pedagogue to figure out. This is arguably one of, if not the most difficult challenge for all classical voice teachers.

Regarding the male voice, the area of tones between the first and second passaggio, simply stated is the transition or “passage” from the register of chest voice into the register of head voice. Tenor voices have two identifiable voice register transitions called passaggi.\textsuperscript{7} The notes produced on either side of a particular passaggio differ by which muscles of the larynx are most active in phonation. In chest voice, below the second passaggio, the thyroarytenoid muscles are most active, and in head voice,

\textsuperscript{5} Richard Miller, \textit{Training Tenor Voices} (United States: Schirmer Books, 1993), 105-117.


\textsuperscript{7} Richard Miller, \textit{Training Tenor Voices} (United States: Schirmer Books, 1993), 105-117.
above the second *passaggio*, the cricothyroid becomes the most active muscle.\(^8\) This is true despite the fact that in operatic singing the thyroarytenoid remains active in head voice above the second *passaggio*.\(^9\) From an acoustical standpoint, trained classical tenors show a decreased second harmonic the closer they get to their second *passaggio*.\(^10\) This is due to the first and second formants losing their respective tuning to the second harmonic and fourth harmonic. If executed appropriately an increased third harmonic, may be reinforced by the second formant once the tenor is above his second *passaggio*.\(^11\)

Learning to negotiate the *passaggio* is the most important part of study for a tenor. Niccolai Gedda has said, “We tenors have those difficult notes in the *passaggio*-F sharp, G-that have to be overcome.”\(^12\) From a pedagogical standpoint, facilitating the transition from chest voice to head voice is the most important concept in teaching young male voices according to William McIver.

With regards to the young male voice, I probably spend the greatest amount of time with registration. This is what separates “good teaching” from “less-than-good teaching.” One must help young male singers understand the area between the first and second *passaggi*; what happens


\(^9\) Ibid.


in terms of mouth opening; and what happens in terms of what I refer to as “moving to a thinner string” while retaining resonantal balance. 13

McIver’s thoughts allow us to see the importance of a teacher having a working understanding of the transition in the tenor voice. Richard Miller agrees with McIver saying, “this work on training tenor voices begins with the subjects of vocal registration.” 14

Another area of difficulty in teaching the tenor voice is the confusion of nasality as perceived brilliance. R. Miller dedicates a section to this issue in Training Tenor Voices. He claims the teacher must be careful that tenors do not confuse sympathetic vibration in the nose, due to forward resonance, with actual nasality coming from an opening of the velopharyngeal port. 15 Nasality then falls to the responsibility of the voice teacher to have a workable knowledge of how to handle its use. Reid claims that teaching nasal resonance can be traced to H. Holbrook Curtis, who taught French tenor Jean de Rezske, and who believed that nasal resonance could reduce muscle tension in the larynx. 16 The great tenor Enrico Caruso was part of an early study where x-rays were taken of him singing, showing a completely closed velopharyngeal port, indicating no nasality was present. He was so outraged by the findings that he refused to be identified as the voice used in the study. 17

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15 Ibid., 118.

Need for the Study

Numerous studies over the last three decades have investigated the concept of nasality, yet none of them has specifically dealt with the tenor voice. Steven F. Austin found that professional female singers use no velopharyngeal opening.18 Yet, in another of his studies on nasality Austin says, “High, light tenor voices seem to be able to use nasality as a part of their singing without dire professional consequences.”19 Scott McCoy comments that some tenors use nasality to encourage the first formant to release its hold on the second harmonic in order to negotiate passaggio.20 However, he notes that technique may not be aesthetically pleasing. Eighteenth-century pedagogue Paolo Francesco Tosi is quoted as saying,

“Let the master attend with great care to the voice of the scholar, which, whether it be di petto or di testa should always come forth neat and clear, without passing through the nose or being choked in the throat (which are the two most horrible defects in a singer, and past all remedy if once grown into a habit).21

17 Burton Coffin, Overtones of Bel Canto (Metuchen: Scarecrow, 1980), 183.


A recent study conducted by Peer Birch et al. found that operatic tenors, in a study on velopharyngeal opening, all had velopharyngeal opening near their *passaggio*.22

Why is there this discrepancy regarding nasality? If Caruso, perhaps the greatest tenor of the twentieth century, thought he sang nasally, why did the x-ray show otherwise? Likewise, why does Austin claim that professional female singers use no nasal resonance, but without evidence, claim that lyric tenors can have successful professional careers while singing nasally? Why did Birch et al. find that all tenors in their study showed VPO near their *passaggio*? McCoy claims nasality may help navigate the *passaggio*, but agrees with Tosi’s claim that nasality is a detriment to the sound quality.

**Purpose of the Study**

The purpose of this study will be to examine the effects that nasality may or may not have on the singing voice, with specific regard to the tenor *passaggio* and head voice. Nasality, for the purposes of this paper, will be regarded as nasal airflow or nasalance, the reading of nasal airflow on a Nasometer. A Nasometer measures the percentage of airflow in regards to nasal and oral airflow during phonation. If dealing with the *passaggio* is the most important aspect of training a tenor voice as Miller and McIver claim, and some professional tenors successfully use nasality as Austin claims and Birch has shown, it will be useful to discover what effect nasalance has on the voice’s acoustic properties.

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Research Questions

1. How does nasalance affect the acoustic characteristics of the operatic tenor
   passaggio?

2. How does nasalance affect the acoustic characteristics of the operatic tenor head voice?
Definition of Terms

*Denotes definition from Vennard.23

**Denotes definition from D. Miller.24

*Aryepiglottic Fold:* One of two muscles extending from the arytenoids to the sides of the epiglottis, and containing the cartilages of Wrisberg. They are the sides of the collar of the larynx.

**Chest Voice:** Register from the lowest pitches up to the primary register transition.

*Cricothyroid Muscle:* One of four muscles attaching to the front of the cricoid cartilage and pulling down on the thyroid. There are two pars recta, with vertical fibres pulling directly; and two par oblique at the sides, with diagonal fibres which not only pull the thyroid down, but also pull it forward.

**Falsetto:** Used here to designate the glottal vibratory pattern characterized by oscillation limited to the upper margins of the vocal folds.


**Formant:** A resonance of the vocal tract, having a variable frequency, depending on the dimensions and posture of the vocal tract. The formants are designated F1, F2, etc., beginning with the lowest in frequency, and the first five make important contributions to the singing voice. F2, and especially F1, are the strongest single formants, and their frequencies determine the perceived vowel.

**Full Head Voice:** The fundamental frequency extension beyond the primary register transition, with a ‘chest’ source. (*Voce piena in testa*)

**Fundamental Frequency:** F0. The repetition rate, in cycles per second, or hertz (Hz), of the oscillating vocal folds, subjectively perceived as pitch. The F0 of G2 (bottom line of the bass staff) is 98 Hz, of C6 (two ledger-lines above the treble staff), 1046 Hz.

**Harmonic:** In the context of voice, sound at the fundamental frequency (designated H1 or F0) and multiples of that frequency (designated H2, H3, etc.), together forming the familiar harmonic series (octave, 5th, 4th, major 3rd, etc.). The harmonics, produced at the voice source in a series that
diminishes in amplitude with increasing frequency, appear in the spectrum of the acoustical signal at varying degrees of strength, depending largely on whether they are close enough in frequency to formants to be enhanced by the vocal tract.

**Mezza Voce:** Italian for ‘half voice,’ a kind of soft voice production.

**Nasalance:** Reading of ratio between nasal and oral airflow registered by a Nasometer. (Author’s definition)

**Passaggio:** In singing, a transition between registers. It is commonly used to designate the several pitches just below the upper register being approached, and is completed when the upper register is fully established.

**Primary Register Transition:** (PRT) In an ascending scale, the point where the vibratory pattern of the vocal folds shifts (or tends to shift) from ‘chest’ to ‘falsetto.’

**Singer’s Formant:** Produced by a clustering among F3, F4, and F5, is, in some male voices, frequently strong enough to lift a higher harmonic (in the range of 2.2-3.4 kHz) to dominance.
**Spectrum Analysis:** The differentiation of a complex sound into its component parts, arranged according to frequency and relative level (amplitude in decibels). Harmonic sound produces a line spectrum, with sound only at the harmonics, while non-harmonic sound (noise) yields a continuous spectrum. A real-time spectrum analyzer gives a nearly instantaneous display of the (changing) acoustic signal.

**Thyroarytenoid Muscle:** One of two complex muscles arising below the notch of the thyroid and inserted one in each arytenoid. The origin of this muscle is not only the thyroid cartilage but also the middle cricothyroid ligament.

**Velopharyngeal Port:** Port connecting the nasal cavity with the pharynx, controlled primarily by the action of the velum.²⁵

**Vocal Fry:** The relatively soft popping sound, with distinguishable individual impulses, produced when air ‘bubbles through’ a lightly closed glottis. Also called pulse register. The frequency of the pulses is very low and usually somewhat irregular, producing a virtually continuous spectrum.

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**Vocal Register:** A region of a particular vocal quality, perceptually distinct to the listener or the singer as pitch or loudness is changed. Registers are in the first instance subjectively perceived, while the studies presented here attempt to identify the objective physical properties that rise to the perception of registers. The ‘natural registers’ result from the distinct vibratory patterns of the vocal folds, ‘chest’ and ‘falsetto.’

*Voce Piena in Testa:* Voice full in head. (Author’s translation) See Full Head Voice.

**Voce Vista:** A software program of real-time spectrum analysis and EGG intended for use as feedback for instruction in singing. (www.vocevista.com)

*Voix Mixte:* Mixed voice. Term usually applied to masculine tones having a large proportion of falsetto.
Chapter 2

Review of Literature

This chapter will present the literature involving tenor *passaggio* and nasality. The subjects have been separated, and the literature of each will be divided into topics. Regarding *passaggio*, physiological and acoustical characteristics will be examined. Also, an overview of vowel formants and source/filter theory will be covered. Regarding nasality, the aspects of perceived “honk” and “twang” will be discussed. Also, physiology of nasality and nasality’s effects on acoustics will be explored. Findings on velopharyngeal opening from current studies will be reviewed.

The literature selected has limitations. If authors do not use the term *passaggio* in their text, it has not been included. Also, if nasality is not defined, the text has not been used. This is not intended to be a comprehensive review of literature regarding the pedagogy of the tenor *passaggio* and nasality.

**Tenor Passaggio**

For centuries the issue of registration has confounded voice pedagogues, but recent discoveries by voice scientists have led to a much clearer definition of vocal registers. According to Scott McCoy, voices have at least two primary registers. He defines these as Thyroarytenoid-Dominant Production (TDP) and Cricothyroid-Dominant Production (CDP).  He states that TDP is primarily used for the lowest pitches of a range up to the first *passaggio*, or in other words for chest voice tones. In comparison

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27 Ibid., 65.
he claims that CDP is primarily used in male voices for falsetto tones. While McCoy does claim that TDP is the primary phonation used in chest voice, he also makes note that in operatic singing, a certain degree of TDP is carried the entire way into head voice. For operatic tenors, he claims they carry TDP the entire way to C5 or higher. Although, for tenors to sing above C5, a great deal of CDP must be employed. Within this theory there seems to be a disagreement. McCoy claims Richard Miller believes that TDP gives way to CDP at the primo *passaggio*.

R. Miller states that changes in timbre occur at certain points of an ascending scale. He claims these are due to changes in the laryngeal muscles. R. Miller agrees with McCoy stating that increased thyroarytenoid activity is a characteristic of chest voice while cricothyroid activity is a characteristic of head voice. He claims that tenors make many dynamic muscle adjustments as they manage their way through the zona di *passaggio*. This shows that in the male *passaggio*, there is a mix of both TDP and CDP being employed, to accomplish what R. Miller refers to as “register equalization.” McCoy claims that men interpret this change as a switch from TDP to CDP, but in actuality it is not. R. Miller and McCoy both state that this transition from male chest to

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28 Ibid., 67.
29 Ibid., 65.
30 Ibid., 69.
32 Ibid., 3.
33 Ibid.
head is more due to a realignment of resonance due to formant tuning, than it is due to a physiological change in musculature.  

In Training Tenor Voices R. Miller claims that tenors have two specific passaggi. He says the first passaggio is around D4, and the second around G4 for a tenore lirico. Miller is very specific in his use of primo passaggio to classify fachs of tenors. A tenore leggiero, he claims, has passaggi around E4-flat and A4-flat, whereas a tenore lirico spinto has passaggi around C4-sharp and F4-sharp. His claim is that a range of about a perfect fourth separates all tenor passaggi. He also believes that the lower the primo passaggio are in pitch the more dramatic and heavy is the voice type.

Donald G. Miller presents another view of male registers, derived from the aspect of acoustics. He claims there are four main registers of the male voice. First, he cites chest voice, or the range from the lowest pitches ascending to the primary register transition or PRT. The second register for D. Miller is full head voice, or voce piena in testa, where the fundamental frequency extends beyond the PRT with a chest source. In other words, this is what McCoy is claiming as head voice, where TDP remains as the primary phonation above the secondo passaggio. His third male register is falsetto which

36 Ibid., 9, 12.
37 Donald G. Miller, Registers in Singing (Ph. D. diss., Rijksuniversiteit Groningen, 2000), 57.
38 Ibid., 57.
he describes as “the upper portion of the total F0 [fundamental frequency] range, produced with a ‘falsetto’ source, and showing substantial overlap with the range of chest register.”[^39] This confirms McCoy’s thoughts again, claiming that the falsetto is a function of CDP and falsetto does overlap with chest or TDP. His final male register is *mezza voce* which he calls “a special adjustment of the ‘chest’ source, used to produce soft tones.”[^40] Pedagogues often refer this to as *voix mixte*.

Before fully discussing D. Miller’s findings, a brief explanation of vowel formants and source/filter theory must be examined. Johan Sundberg claims that the voice source is “the sound generated by the chopping of the air-stream by the vibrating vocal folds.”[^41] This creates a series of harmonic partials that form a multiplication table. If the fundamental frequency of a pitch were 100 Hz its harmonics would be 200 Hz, 300 Hz, 400 Hz, 500 Hz, etc. The fundamental is multiplied by a series of counting numbers (1, 2, 3, 4, 5, etc.).

However, singers must deal with more than the voice source. When the voice source is combined with the vocal tract, the latter produces its own set of resonance frequencies called formants. The vocal tract acts as a filter for the voice source, hence, source/filter theory. D. Miller provides a definition of formants:

> A resonance of the vocal tract, having a variable frequency, depending on the dimensions and posture of the vocal tract. The formants are designated F1, F2, etc., beginning with the lowest in frequency, and the first five make important contributions to the singing voice. F2, and

[^39]: Ibid., 58.

[^40]: Ibid.

especially F1, are the strongest single formants, and their frequencies
determine the perceived vowel. The singer’s formant, produced by a
clustering among F3, F4, and F5, is, in some male voices, frequently
strong enough to lift a higher harmonic (in the range of 2.2-3.4 kHz) to
dominance.\textsuperscript{42}

The goal of the singer is then to appropriately tune the formants to certain harmonics
depending on the vowel and the register. D. Miller defines formant tuning as “the
modifying of formant frequencies of the vocal tract in order to enhance certain harmonics
of the voice source.”\textsuperscript{43}

Therefore, with both vocal source and vocal tract contributing to the resonated
sound of the human voice, the concept of “Source/Filter Theory” of voice production
becomes evident. McCoy provides six basic formant rules that effect the acoustical
spectrum.\textsuperscript{44}

1. A constriction in the front of the vocal tract lowers F1 and raises F2 [i] and [u]
2. A constriction in the back of the vocal tract raises F1 and lowers F2 [a]
3. All formant frequencies lower uniformly when the vocal tract is lengthened
4. All formant frequencies rise uniformly when the vocal tract is shortened
5. All formant frequencies lower uniformly with lip rounding and increase with lip
   spreading
6. An increased mouth opening (dropping the jaw) raises F1

\textsuperscript{42} Donald G. Miller, \textit{Registers in Singing} (Ph. D. diss., Rijksuniversiteit
Groningen, 2000), 229.

\textsuperscript{43} Ibid., 229.

\textsuperscript{44} Scott McCoy, \textit{Your Voice an Inside View} (Princeton: Inside View Press, 2004),
43.
Every vowel has its own set of average frequencies, due to the fact that every vocal tract is uniquely shaped. In the past, the idea was presented that there was an appropriate vowel for every pitch in a singers range. This was widely discussed by Berton Coffin in *Overtones of Bel Canto* and his protégé Barbara Doscher in *The Functional Unity of the Singing Voice*. McCoy claims sung vowel formants would always be somewhat different in individuals.45

With source/filter theory explained, it is now appropriate to return to D. Miller’s findings on male registers. He claims the frequent problem area of male registration is the primary register transition (PRT), which is the *sesto passaggio* for R. Miller. This upper limit of the male chest register (*zona di passaggio*) is represented by the first formant of the open vowels (600-750 Hz) engaging the second harmonic.46 This tuning of F1 to H2 produces the highest sound pressure levels in the chest register, which is easily identifiable on a power spectrum display. This resonance strategy can be employed through the PRT into head voice by the raising of the larynx, which gives the voice an incorrectly “open” sound that D. Miller refers to as a “register violation” or “shout.”47

D. Miller claims the trained singer overcomes this “register violation” by “covering” (keeping F1 low) with a combination of lip-rounding and laryngeal-lowering


47 Ibid.
or at least laryngeal stabilization.\textsuperscript{48} Recall that McCoy said lip rounding and laryngeal lowering both lower formant frequencies.\textsuperscript{49} D. Miller’s strategy for open vowels results in F1 releasing its lock on H2 and possibly a tuning of F2 to H3 once the FO has ascended above the PRT. D. Miller claims this F2 tuning is the most efficient resonance strategy employed by male opera singers.\textsuperscript{50} Figure 1 shows a tenor ascending over the PRT from an F4 to a G4. D. Miller claims that, in regard to the tenor voice “a good command of the full head register is of course most important.”\textsuperscript{51}

Figure 1. Tenor transition from chest (H2/F1 tuning) to head (H3/F2 tuning) resonance.

\textsuperscript{48} Ibid.


\textsuperscript{50} Ibid., 59.

\textsuperscript{51} Ibid., 59.
It is important to note that the use of these resonance strategies is for vowels containing a high F1 such as [a]. McCoy says that low F1 vowels [i], [e] and [u] are much easier for men to ascend from chest to head without conscious effort.\textsuperscript{52} D. Miller’s findings have recently been tested and confirmed by Neumann et al., also finding that on open vowels, as the transition from chest to head occurs successfully, the lock between F1 and H2 is broken and a tuning of F2 to either H3 or H4 does occur.\textsuperscript{53}

Neumann’s pool of participants (eleven) was larger than that of D. Miller, giving the findings even more credence. Also, John Nix is in agreement with this theory citing Luciano Pavarotti and Alfredo Kraus as good examples of F2 tuning in head voice.\textsuperscript{54}

One final note in regards to the male register transition of importance to this study is a claim by McCoy regarding nasality. He states “Some singers employ an alternate strategy for achieving head resonance, using a bit of nasality to break the F1/H2 lock.”\textsuperscript{55} McCoy writes that nasality enables the production of high pitches with TDP, but does so with a sacrifice of basic vocal timbre.\textsuperscript{56} If this strategy is employed, McCoy claims that

\begin{itemize}
  \item \textsuperscript{52} Scott McCoy, \textit{Your Voice an Inside View} (Princeton: Inside View Press, 2004), 71.
  \item \textsuperscript{53} Katrin Neumann, Patrick Schunda, Sebastian Hoth, Harald A. Euler, “The Interplay Between Glottis and Vocal Tract During the Male Passaggio,” \textit{Folia Phoniatrica et Logopaedica} 57 (2005): 326.
  \item \textsuperscript{55} Scott McCoy, \textit{Your Voice an Inside View} (Princeton: Inside View Press, 2004), 72.
  \item \textsuperscript{56} Ibid.
\end{itemize}
the nasal sound becomes a matter of aesthetic. This aesthetic is left to the voice teacher, singer, and more importantly, the listener to decide if the sound is pleasing.

Nasality in Singing

Physiologically, nasality in singing comes from a lowering of the velum (soft-palate) to allow for airflow into the nasal cavity. In singing, nasality seems to have one of Titze’s two perceptual characteristics, “honk” or “twang.”57 He notes that “honk” is what is often heard in speech of the deaf and is related to the low portion of the frequency spectrum. This differs from “twang” which he speculated had more to do with velar coupling and effective air column inertia. More recently Eiji Yanagisawa, et al. found “twang” was more a result of tension in the aryepiglottic sphincter. When constricted, Yanagisawa noted an extra resonator between the vocal folds and the aryepiglottic rim.58 This raised partials in the 3 kHz area of the spectrum. Jean Callaghan noted that aryepiglottic constriction or “twang” could be involved in creating a stronger singer’s formant.59

The function of the velopharyngeal opening (VPO) and the velopharyngeal mechanism is to “vary the degree of acoustic coupling between the oral and nasal


Jean Westerman Gregg suggests this coupling allows for a certain degree of nasality to be acceptable, but a severe nasality is not appropriate. She also contends that if no sound flows through the nose that the perceived sound is possibly an “unacceptable white tone.” Gregg believes this sound may even be dangerous due to excessive pressure on the vocal folds.

Stephen F. Austin conducted a study on VPO in singing when compared to speech. He used a photodetector to measure the use of the velum. Austin had four doctoral level women speak and sing the same sentence and sing all five cardinal vowels. The sentence was sung in recitative style to maintain word inflection at three different pitches: low, medium and high.

Austin makes note that these four singers had far less VPO during singing than speech. Also, as pitch increased from low to medium to high, VPO decreased. That was true for the sung sentences, but in regard to the vowel series, all subjects indicated no VPO at any pitch. Austin notes the fact that a lack of opening occurring in the vowel series is evidence that the sensation of vibration in the area of the hard palate or nose has been misinterpreted over time as nasality. It is important to recognize that Austin’s


participants were few in number and that no men were considered in this study. Even though men were not participants, Austin notes, “Tenors who sing the operatic repertory of Rossini and Donizetti…can be quite nasal at times and quite popular and successful.”

R. Miller and William McIver investigated the effects of nasal consonants on vowels in 1995. They had participants sing each of the five cardinal vowels at a “comfortable pitch.” This was a B3-flat for tenors. Subsequently, participants sang the same five vowels preceded by an [m] consonant at the same pitch, and repeated again with an [m] following the vowels. There were thirty participants, fifteen men and fifteen women, all of whom were pursuing degrees in voice at Oberlin Conservatory. All participants were ages eighteen to twenty-three. The study dealt with nasality as nasalance, which is the measurement displayed by a Nasometer. Recordings of the singers were analyzed spectrographically for acoustic strength as well as nasality.

R. Miller and McIver found that out of the men twelve of fifteen sang [i] with nasality. No women sang [i] with nasality. Two of fifteen men showed nasalance on [e] and [u], and four of fifteen men showed nasalance on [a] and [o]. Strength in the upper region of the power spectrum (2500-3500 Hz) was found in eight of the male samples. This would indicate the presence of a singer’s formant. They found that “within the same phonation, vowels register more intensity in upper partials than does the

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64 Ibid., 220.


66 Ibid., 23.
nasal continuant [m].”67 This is explained in part by “the fact that the soft linings of the nasal cavities damp the acoustic signal, producing smaller formant amplitudes, so that the intensity of the nasal continuants is less than that of the non-nasals.”68 An interesting finding is that in the part of the exercise with the preceding [m], the consonant registered generally above 90% but the following vowel generally registered 0%.69 This finding would confirm VPO on the nasal consonant, and velar constriction and closing on the following vowel. This is slightly odd considering that many of the singers registered nasality when just singing the cardinal vowels with no preceding nasal consonant. This study was conducted using pitches that were all in a comfortable middle register. They do note the usefulness of the Nasometer as an effective tool in measuring nasality.70

When Austin published his study in 1997 he noted that no study could be found directly attributing nasal vocal timbre to VPO. In 2002 Birch, et al. studied VPO in operatic singing to find how VPO attributed to nasal vocal timbre. They used a participant pool of all voice types from high soprano to bass, totaling seventeen. VPO was monitored in three different ways. First they used nasofibroscopy, which revealed numerous VPO shapes.71 Second, Birch and his team measured airflow with a divided mask comparative to a Nasometer. This revealed at least some nasal airflow in a majority

67 Ibid., 25.
68 Ibid.
69 Ibid.
70 Ibid.
of the singers. Finally, they measured the fundamental in oral and nasal airflow
signatures. The singers were all asked to sing the words “panta,” “puntu,” and “pinti,”
consecutively, ascending on each pitch of an A-major triad throughout their range.

Regarding airflow, with the use of the Nasometer, the three tenors all showed
nasal airflow when singing “puntu” at least on some pitches.72 The study does mention
that by using this method, the lack of nasal airflow may not mean a lack of VPO due to
incomplete contact between the mask and face.73 An important feature of this study is
the analysis of the recorded samples by expert listeners to determine nasal vocal timbre.
This proved difficult, as the experts did not agree amongst themselves with any
reliability.74 Only one tenor, who did exhibit a great deal of nasal airflow showed high
ratings of nasal voice quality from all judges.75 With this data Birch and his team were
compelled to say that perceived nasal quality on the vowel [a] is not related to the
existence of VPO. Two other important conclusions were drawn in regard to this study
on tenor passaggio and nasality. First, the varying VPO in all singers suggests singers
use VPO to make fine tuning adjustments of vocal timbre.76 Additionally, all tenors
showed a VPO near their passaggio.77 If that is true, then VPO may be an important

72 Ibid., 63.
73 Ibid., 64.
74 Ibid., 68.
75 Ibid., 69.
76 Ibid., 70.
77 Ibid.
quality for tenors to use in order to negotiate their *passaggio*. This may confirm McCoy’s statement about nasality, or VPO as in this study, breaking the “H2/F1 lock.”

One final study by Sundberg, et al. dealt with acoustic aspects of nasality in singing. While the test was done with an iron tube model of a baritone’s vocal tract, the findings are nonetheless noteworthy. They found two important acoustic phenomenon regarding VPO. First, on an [a] vowel, VPO reduced the level of the first formant and relatively increased the level of the singer’s formant. Second, an increased singer’s formant was present on [i] and [u] as well, but this time the first formant bandwidth widened. Their findings led them to believe that VPO is an effective way to increase the level of the singer’s formant. While this may be true, none of their results were found with human subjects and their model was that of a baritone, no tenor model was tested. This phenomenon requires further research.

**Summary**

As previously stated, the transition for a tenor from *passaggio* to head voice acoustically shows a reduction of H2 due to its releasing its tuning to F1 on open vowels. Another resonance strategy for open vowels is the use of F2 tuning to H3 once the tenor moves into operatic head voice. Also, most tenor *passaggi* show a strong singer’s formant in the region of 3000 Hz. Birch confirmed Austin’s belief that tenors tend to sing with VPO near their *passaggio*, but made no comment about nasality’s effects on the

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80 Ibid. 1.
aforementioned resonance strategies. It will be useful to find out what effects this nasality or VPO has on the previously mentioned resonance strategies of operatic tenors.
Chapter 3

Method

The purpose of this study is to investigate the effect nasality, here nasalance, has on the passaggio and head voice of the operatic tenor. The use of nasality to aid in breaking the lock between the second harmonic and the first formant of open vowels as a tenor ascends through the passaggio was examined. A second part of the study explored the effects of an increase of nasal airflow in head voice compared to passaggio and chest voice. This study is not meant to be the final word regarding this topic. Instead, it is meant to show the need for further research in this area.

Description of Subjects

The subjects used for this study consisted of eight operatic tenors. Previous studies on this subject have consistently used small numbers of participants. Austin used only four subjects for his 1997 study on nasality.81 Birch, et al. only used three tenor subjects in their study on velopharyngeal opening (VPO).82 Therefore, a pool of eight tenors exceeds the number of singers used in previous studies. The subjects were all professional operatic tenors. Professional is qualified as having sung a leading operatic role professionally in the United States or Europe within the last year. The subjects were of differing fachs including leggiero, light-lyric, full-lyric, and lirico-spinto. The decision to not identify the subjects by name or age was made for two reasons. First, there is no

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precedence for that in this type of research, and second, the guarantee of subject anonymity made recruitment of subjects easier.

**Materials**

In order to collect the various acoustic data necessary for this project certain software and hardware was used. The sung samples were recorded with a head mounted electret condenser microphone placed 30 cm away from the mouth. This was used to collect the acoustic samples for harmonics and formants. The microphone has been provided by EGGs for Singers.

The acoustic signals were processed and analyzed using Voce Vista Pro software. Voce Vista was designed by Richard Horne and Dr. Donald G. Miller. It combines power spectrum, spectrographic, audio signal, and electroglossotographic signals in real-time display. The author has trained in Groningen, the Netherlands, with Dr. Miller on the use of the software, and more importantly on the interpretation of the signals produced by Voce Vista. This training involved examining the relationship between the spectrograph and power spectrum, for the purpose of identifying harmonics and vowel formants in the singing voice.

The nasality readings were collected with Glottal Enterprises Nasality Tutor System. This is the same system used by Birch, et al. in their study of VPO. The system uses a divided oro-naso mask or a divider plate that separates airflow between the nose and mouth. The sensors then measure air pressure from both the nose and the mouth. The system displays a reading of nasalance either in percentage or ratio of airflow between the nose and the mouth on the computer screen. In previous research,

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83 Ibid., 62.
Birch et al. noted the possibility for error in reading nasalance. The issue was that the nasometer emphasizes pressure levels around F1. The better option would be to measure only the fundamental frequency component of the sound with regards to nasalance.\textsuperscript{84} Due to equipment limitations, this study was conducted as accurately as possible, with nasalance readings emphasizing frequencies around F1. Singers have also noted that the mask does slightly interfere with jaw opening.\textsuperscript{85} To compensate for this, the divider plate was used in place of the oro-naso mask.

**Procedures**

The tenors were asked to record a series of exercises on the devices noted above. First they were asked to sing the words [pinti], [puntu], and [panta] separately at three pitches: B3-flat (chest), F4 (\textit{passaggio}), and B4-flat (operatic head voice). They were asked to sing them full voice, as they would sing the pitches in an operatic aria. The use of the three pitches was duplicated from Austin’s study,\textsuperscript{86} and the word choices were duplicated from Birch.\textsuperscript{87} The three separate pitches allow for a comparison of the degree of nasality in chest voice, in \textit{passaggio}, and in head voice. Austin noted that women,

\textsuperscript{84} Ibid.

\textsuperscript{85} Ibid.


reduced nasality as they ascended in pitch.\textsuperscript{88} From the Birch study, we expected, and found tenors to do the opposite.\textsuperscript{89}

The word choice is also calculated. The three separate vowels provide one forward [i], one middle [a], and one back [u] vowel. Also, in regards to formants, [i] and [u] both have relatively low F1 and high F2, while [a] provides a contrasting high F1 and low F2. The consonants also are wisely chosen, due to a plosive consonant [p] at the beginning of the word, then following the vowel the nasal [n]. The [n] will give the observer a marking point on the Nasometer with over 90\% nasal airflow.

The next part of the procedure asked the tenors to sing three B3-flats: one on each vowel of the [pinti] sequence [i, u, a]. Immediately after each vowel, they were asked to attempt to vocal fry while leaving their vocal tract in the position of the note they just sang. This determined their F1 and F2 of those vowels at that pitch. D. Miller described the use of non-periodic phonation (vocal fry or inverse filtration) in order to determine vowel formants.\textsuperscript{90}

As a final measure, the tenors were asked to sing a B-flat major scale from B3-flat to B4-flat. This was used to examine the exact moment in the scale the resonance strategy of these tenors changes from a stronger chest voice resonance above the PRT to a more head-voice resonance.


\textsuperscript{90} Donald G. Miller, \textit{Registers in Singing} (Ph. D. diss., Rijksuniversiteit Groningen, 2000), 188.
Data Analysis

The data collected was in the form of audio and visual recordings of the exercises discussed above. The data was analyzed through an ocular comparison of the signals produced by Voce Vista and the Nasometer. The readings of nasality were compared among the eight tenors on each respective vowel. Nasality was also examined within each tenor to see if the percentage of nasal airflow decreases, increases or some combination of both, as pitch ascends. Then, the formants of each tenor were identified from the vocal fry. Next, each tenor's results were compared to see if the resonance strategies used by these tenors match those in the literature. Finally, a visual comparison of each tenor’s data was examined to see if a higher or lower degree of nasalance seems to have aided or hindered appropriate formant tuning.
Chapter 4

Results

This chapter will be divided into four main sections. The first section will show acoustic results of each tenor’s transition over the PRT from chest voice to head voice. It will also identify the dominant formant tuning strategy used by each tenor in the B-flat major scales as he ascends over the PRT. Additionally the results of the release of the H2/F1 lock will be included in this first section. The second section will include the results of nasalance readings. The third section will demonstrate the effect nasalance is having on each tenor’s ability to tune formants appropriately, if any. The final section is an examination of uncharacteristic acoustic phenomena compared to the nasalance readings.

Tested subjects included eight tenors. The results of seven of them are presented. One tenor was unable to complete all exercises and his data has not been included. It is important to note that all eight tenors are currently working as professional tenors in the United States and/or Europe. The subjects will be identified as T1 for Tenor 1, T2 for Tenor 2, etc. It should be noted that the results of the findings on singer’s formant are not presented, because, all subjects but T7 showed presence of a singer’s formant at appropriate levels around 2200-3200 Hz on all recordings. T7’s singer’s formant was consistently higher in frequency, ranging from 2400-3800 Hz.
Acoustic Results

The moment of transition from chest voice to head voice, over the PRT, has been described in earlier chapters. The results of the B-flat major scales are divided by vowel. The [i] vowel showed that six of seven tenors made their acoustic tuning adjustment from G4 to A4. Only one tenor (T1) transitioned from F4 to G4, which is in line with where previous studies have shown this transition to occur. It is interesting to note that T1, who transitioned from F4 to G4, sings the works of Rossini and classifies himself as a leggiero tenor. According to R. Miller, a leggiero tenor should be expected to transition higher, but he is purposefully transitioning lower,91 this probably brings more CDP into the production of his G4, possibly creating an easier transition. Figure 2 and Figure 3 show the signature of both the B-flat major [i] results when transitioning over the PRT. As demonstrated by T1, Figure 2 shows the F4 to G4 transition with the cursor on the G4 showing the coinciding raised H4 being tuned by F2. Figure 3 shows the late transition of T5 from G4 to A4 with the cursor on the A4, which again illustrates the coinciding power spectrum with H4, the dominant peak in the spectrum.

Figure 2. [i] transition from chest (H5/F2) to head (H4/F2) resonance on F4 to G4.

Figure 3. [i] transition from chest (H5/F2) to head (H4/F2) resonance on G4 to A4.
The [a] vowel had varying results. T1, T2, and T5 all made their acoustic adjustments from F4 to G4, which duplicates the findings of D. Miller.\textsuperscript{92} However, T3, T4, and T6 did not transition until G4 to A4. This late acoustic shift in the scale may be a result of these tenors carrying too much TDP into a register too high for such production. T7 had such an inefficient transition through passaggio it was nearly impossible to tell at which moment it actually occurred. Figure 4 illustrates a tenor transitioning from F4 to G4 while Figure 5 shows a tenor transitioning from G4 to A4. It is apparent that both tenors eventually achieve H3/F2 tuning, but on different pitches.

The [u] vowel produced equally differing results. T4 and T7 did not transition until G4 to A4, the step above where the acoustic shift should occur. T1, T2, T3, and T6 shifted appropriately from F4 to G4, which, as previously stated, matches the current literature. T5 shifts earlier from E4-flat to F4, but for this more robust voice (a lirico-spinto), this shift may very well be appropriate.

\textsuperscript{92} Donald G. Miller, \textit{Registers in Singing} (Ph. D. diss., Rijksuniversiteit Groningen, 2000), 139.
Figure 4. [a] transition from chest (H4/F2) to head (H3/F2) resonance from F4 to G4.

Figure 5. [a] transition from chest (H4/F2) to head (H3/F2) resonance from G4 to A4.
The next section reports the results of the dominant tuning strategy that was utilized by each tenor as the ascension over the PRT was made in the B-flat major scale. On the [i] vowel all seven tenors lowered the level of F2 to tune H4 after having tuned to H5 and/or H6 through *passaggio*. As previously shown, Figure 2 demonstrates the H4/F2 tuning on the [i] vowel in head voice. The [a] vowel showed all but one tenor using H3/F2 tuning after the PRT confirming D. Miller’s\textsuperscript{93} and K. Neumann’s findings.\textsuperscript{94} T6 and T7 were not able to break the lock between H2 and F1; this possibly caused T6’s inability to tune H3/F2. Figures 4 and 5 show two examples of H3/F2 tuning in operatic head voice on [a]. For the [u] vowel T1 through T5 all tuned H3/F2 after the PRT. Again, T6 and T7 were not able to tune H3/F2 and showed a decrease in the level of harmonics around F1 and F2. Figure 6 shows a tenor executing H3/F2 tuning on the [u] vowel in head voice, while Figure 7 shows another tenor who is unable to tune H3/F2; as a result he shows a significant decrease in that area of the spectrum. Also F2’s inability to tune to H2 or H3 is apparent.

\textsuperscript{93} Ibid.

Figure 6. [u] transition from chest to head (H3/F2) resonance from E4-flat to F4.

Figure 7. [u] transition from chest to head resonance, no formant tuning G4 to A4.
Finally the H2/F1 tuning that is preferable in chest voice, but needs to be released in operatic head voice, is illustrated in this section. On the [a] vowel, T3 through T5 all transition one note too late for their voice types, and due to that, the H2/F1 tuning is still present below where the PRT should occur. This is true regardless of H3/F2 tuning at the same pitch. T6 and T7 were never able to break the lock between H2 and F1. This is possibly the reason Tenor 7 is not able to tune H3/F2.

**Nasalance Results**

The current section will present the comparison of nasalance within each singer. First, nasalance of each pitch and vowel of the [pinti], [panta], [puntu] sequence (hereafter “the pinti sequence”) will be reported. This will be followed by a comparison of each pitch to the other two pitches within a certain vowel of “the pinti sequence.” The highest level of nasalance will be observed. Finally, nasalance in the three scales will be examined in each tenor.

On the B3-flats, T1 and T3 showed a much higher degree of nasalance on [a] than on their other vowels, while T2, T4, T5, T6, and T7 showed their highest degree of nasalance on [i]. For this pitch T1, T2, T3, and T7 emitted the least amount of nasalance on [u], while [a] was the least nasal for T4 through T6. Figure 8 shows a Nasometer graph of a tenor with a high degree of nasalance on the word [panta]. Figure 9 shows a different tenor with a low degree of nasalance on the same word and pitch. The blue spike in the middle of each graph is the “n” consonant causing over ninety percent nasalance.
Figure 8. B3-flat, [panta], relatively high nasalance.

Figure 9. B3-flat, [panta], relatively low nasalance.

The examination of the subsequent pitch of F4 regarding the most and least amount of nasal emission on vowels of the seven tenors reveal some similarities to B3-flat. Again, five of the seven tenors show their highest degree of nasalance on the [i] vowel. Four of the five are the same; only T1 and T2 have switched. T2 and T3 show higher degrees of nasalance on [a], but in both cases it is a very slight difference (2 percent). Similarly to the results of B3-flat, four of the seven tenors sang [u] as their least nasal vowel. T5, T6, and T7 showed their least nasalance on [a]. Two interesting phenomenon are represented on the pitches B3-flat and F4. First, none of the tenors showed [u] to be his most nasal vowel; second, only T3 sang [i] with his lowest degree of nasality. T3 mentioned during the testing that he was specifically trying not to sing with nasality. Birch et al. found that of all the vowels, the tenors sang [u] with a certain
degree of nasalance.95 Yet, none of the tenors used in this study showed [u] to be his
most nasal vowel. This is possibly a result of culture and language. The subjects in the
Birch et al. study were all professional singers working in Denmark, whereas the tenors
of the current study were all working in the United States or Europe. There is the
possibility that different native languages affect nasalance readings. This phenomenon is
worthy of future study.

The same patterns remained for the B4-flat. T4, T5, T6, and T7 sang [i] with their
highest degree of nasalance, while T1, T2, and T3 sang [a] with their highest degree of
nasalance. In regards to the lowest percentage of nasalance, four tenors (1, 2, 4, and 7)
sang [u] with the lowest percent of nasalance, but two tenors (5 and 6) sang [a] with their
lowest percent of nasalance. Only T3 sang [i] with his lowest degree of nasalance, just as
he did on the F4. As shown in these results, the tenors tend to sing [i] or [a] as their most
nasal vowel, and the [i] vowel confirms findings of McIver and Miller.96 Also, the tenors
tend to sing [u] or [a] as their least nasal vowel. Finally, these tendencies may not be
consistent within all registers. Figure 10 shows a tenor singing a B4-flat with a higher
degree of nasalance on an [i] vowel, while Figure 11 shows a different tenor singing the
same pitch and vowel with lower nasalance.

95 Peer Birch, Bodil Gümoes, Hanne Stavad, Svend Prytz, Eva Björkner, and
Johan Sundberg, “Velum Behavior in Professional Classic Operatic Singing,” Journal of

96 William McIver and Richard Miller, “A Brief Study of Nasality in Singing,”
Journal of Singing-The Official Journal of the National Association of Teachers of
The examination of nasalance in contrast to register for each vowel is the subject of the present section. Each vowel will be examined on each pitch of “the pinti sequence” in order to ascertain the degree of nasalance. This will begin to determine whether these tenors sang with more nasalance in their passaggio (on the pitch F4) than in chest voice or head voice, as was found by Birch et al.\textsuperscript{97}

While singing the [i] vowel, T1, T4, and T5 all showed a higher percentage of nasalance on F4 than on B3-flat or B4-flat. This confirms the finding by Birch et al. which demonstrated all three of their tenor subjects with more nasalance around their

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However, in contradiction to their study, three of the tenors in the current study showed the exact opposite, singing with higher nasalance levels on B3-flat and B4-flat than on F4. T7 followed neither of these patterns, but showed a consistent growth of nasalance as pitch increased. Figures 12, 13, and 14 show the three pitches, all on [i] vowels, of a tenor singing with a higher level of nasalance on F4 (Figure 13), and Figures 15, 16, and 17 show a different tenor singing the same vowel and pitches, yet with opposite results (showing a lower percentage in Figure 13).

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Figure 14. B4-flat, [pinti], relatively low nasalance, demonstrating decrease from *passaggio* to head voice.

Figure 15. B3-flat, [pinti], relatively high nasalance.

Figure 16. F4, [pinti], relatively low nasalance, demonstrating decrease in nasalance in *passaggio*. 
Figure 17. B4-flat, [pinti], relatively high nasalance, demonstrating increase of nasalance in head voice.

The [a] vowel results are similarly split, but with different nasalance percentages. Here, the Birch et al. finding that tenors sing with more nasalance in the passaggio, is not present. T1, T2, and T7 showed a lower level of nasalance on F4 than B3-flat or B4-flat. These were not the same three tenors who sang the [i] vowel in the same manner. The other four tenors all showed a consistent increase in nasalance as the pitch rose.

Finally for the [u] vowel, an increase of the nasalance percentage in passaggio returns for T1, T5, and T6, similar to [i]. T2, T3, and T7 showed a consistent rise in nasalance as pitch ascended, like the [a] vowel. T4 demonstrated similar nasalance on all three pitches, somewhere around 10%, creating somewhat of an anomaly.

The behavior of all tenors on these pitches confirms that men do not behave in the manner women were shown to behave in the Austin study. The four women in the Austin study showed a significant decrease in nasalance as pitch rose.99 Tenors in the present study generally showed an increase in nasalance as pitch ascends, at least with regards to the B3-flat (lowest) and the B4-flat (highest).

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One final examination of nasality within each individual tenor is that of the percentage of nasalance demonstrated during the B-flat-major scales. The [i] vowel showed four different results. The most common was a decrease in nasalance through passaggio and an increase upon the transition into head voice. This was true for T3, T4, and T7. Only T1 showed the opposite with an increase in nasalance through passaggio and a decrease in nasalance in head voice. T2 and T5 showed a consistent increase in nasalance as the pitch ascended. T6 was the only tenor to show no increase in nasalance; in fact, he showed a general decrease in nasalance as the pitch ascended. It should be noted, however, that this tenor sings already with extreme nasalance on this vowel (consistently near fifty percent).

The [a] vowel revealed a much more consistent sample. T1, T2, T4, T6, and T7 all showed a general increase in nasalance as pitch ascended through the scale. This general increase is demonstrated in Figure 18. T1, T2, T4, and T7 sang with this same nasalance pattern in the [u] scale as well. On the [a] vowel, only T3 showed a decrease in nasalance through passaggio, while on the [u] vowel, T3 and T6 repeated this nasalance pattern. Figure 19 shows a decrease in nasalance through passaggio as in T3 and T6. T5 showed an increase of nasalance in passaggio and a decrease of nasalance in head voice on both [a] and [u]. Figures 20 and 21 show T5’s scales on [a] and [u].
Figure 18. B-flat scale on [a], demonstrates consistent rise in nasalance.

Figure 19. B-flat scale on [a], demonstrates decrease of nasalance through *passaggio*.

Figure 20. B-flat scale on [a], demonstrates sudden increase of nasalance on acoustic shift to head resonance.
Figure 21. B-flat scale on [u], demonstrates, increase in nasalance through *passaggio*.

Table 1. Nasalance percentages for “the pindi sequence.”

<table>
<thead>
<tr>
<th>Subject</th>
<th>Bb3 Pinti</th>
<th>Bb3 Panta</th>
<th>Bb3 Puntu</th>
<th>F4 Pinti</th>
<th>F4 Panta</th>
<th>F4 Puntu</th>
<th>Bb4 Pinti</th>
<th>Bb4 Panta</th>
<th>Bb4 Puntu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenor 1</td>
<td>15%</td>
<td>24%</td>
<td>11%</td>
<td>24%</td>
<td>14%</td>
<td>20%</td>
<td>15%</td>
<td>23%</td>
<td>14%</td>
</tr>
<tr>
<td>Tenor 2</td>
<td>14%</td>
<td>5%</td>
<td>8%</td>
<td>8%</td>
<td>10%</td>
<td>7%</td>
<td>16%</td>
<td>23%</td>
<td>15%</td>
</tr>
<tr>
<td>Tenor 3</td>
<td>17%</td>
<td>23%</td>
<td>10%</td>
<td>11%</td>
<td>12%</td>
<td>9%</td>
<td>21%</td>
<td>42%</td>
<td>32%</td>
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<td>23%</td>
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<td>10%</td>
<td>13%</td>
<td>10%</td>
<td>10%</td>
<td>27%</td>
<td>24%</td>
<td>9%</td>
</tr>
<tr>
<td>Tenor 5</td>
<td>11%</td>
<td>5%</td>
<td>9%</td>
<td>25%</td>
<td>13%</td>
<td>25%</td>
<td>19%</td>
<td>17%</td>
<td>18%</td>
</tr>
<tr>
<td>Tenor 6</td>
<td>40%</td>
<td>12%</td>
<td>40%</td>
<td>56%</td>
<td>28%</td>
<td>47%</td>
<td>52%</td>
<td>37%</td>
<td>44%</td>
</tr>
<tr>
<td>Tenor 7</td>
<td>13%</td>
<td>4%</td>
<td>5%</td>
<td>13%</td>
<td>6%</td>
<td>11%</td>
<td>10%</td>
<td>13%</td>
<td>11%</td>
</tr>
</tbody>
</table>

**Nasalance and Formant Tuning**

The third section will show results of what effect nasalance may be having, if any, on the formant tuning and resonance strategies of these seven tenors. First, an examination of the implications that can be drawn from the various PRTs in the B-flat major scales of the tenors will be illustrated. Subsequently, the determination of the major resonance strategy the tenors used in operatic head voice will be addressed; if nasalance seems to have any effect on the ability to tune appropriately it will also be examined. Finally, McCoy’s claim that nasalance will break the H2/F1 lock will be compared to the collected data.
Regarding the tenors PRT on both [i] and [u], there seems to be no correlation between when this occurs (too late or appropriately) and nasalance readings. The only common factor seems to be that all seven tenors used at least 10% and 9% nasalance respectively, on these vowels once their acoustic shift had occurred. Nasalance readings were too varied at many percentages through the *passaggio* to come to any conclusion. This phenomenon may need more research with a larger pool of subjects to reveal a common pattern.

The [a] vowel, which is already one of the most empirically tested vowels, provided more noteworthy results. All three tenors who transitioned late (G4-A4) had a definite increase of nasalance once the acoustic shift to head voice had occurred. Could one surmise then, that allowing this increase of nasalance to come one note earlier would aid in these three tenors transitioning “appropriately,” or is there no bearing for this? T1, who did transition from F4 to G4 showed an 11% increase in nasalance from F4 to G4, but T2 who also shifted from F4-G4 did not show an increase until the A4, which is much more like the tenors who did not shift from F4 to G4. It should be noted that T1 excels in singing the works of Rossini, and the transition from F4 to G4, may be slightly too low for this voice. Perhaps if this tenor waited until the A4 to increase his nasalance the transition would be more efficient. Before making a statement about this phenomenon, an examination of T5’s data needs to be observed.

Tenor 5 showed a large increase of nasalance on F4, and was fully in his H3/F2 tuning on G4. This voice transitioned from E4-flat to F4 on his scale of the [u] vowel, and from both the listener’s standpoint and the spectrogram view, this transition was much smoother. The same could be said for his Nasometer reading. It should be noted
that this voice is a *lirico-spinto* and that the transition from E4-flat to F4, may indeed be “correct” for this heavy voice. It is possible that the F4 to G4 transition on his [a] vowel was not as efficient as this [u] transition. On the [u] scale he showed a much higher nasalance from D4-F4 at 23% than he did on the [a] scale, where E4-flat showed only 18% nasalance approximately. It would seem then that he needed the large flux of nasal airflow on the F4 (37%) to get him over his PRT and into H3/F2 tuning. This would support the theory that allowing a 5-10% increase on the note after the PRT (here G4) may allow the three tenors who transitioned from G4 to A4 to make the acoustic shift into head voice more appropriately from F4 to G4.

T2 does not appear to fit in this equation. His tuning shifted from F4 to G4, which, for this full lyric tenor, would seemingly be appropriate. But, he did not show increased nasalance until his A4. From the rest of the data one would expect him to show a nasalance increase on G4. It should be noted that this particular tenor demonstrated, in general, some of the lowest nasalance readings among all subjects, which could partially explain his data not fitting into the pattern. The benefit of a nasalance-assisted [a] vowel transition needs further investigation.

With regards to nasalance’s effect on formant tuning of head voice, the results showed very little relation. The only common thread seems to be that in head voice a certain percentage of nasalance is always present. For the [i] vowel, 10% was the lowest reading, and for the [a] vowel 13% was the lowest reading, and finally for the [u] vowel 9% was the lowest reading. This suggests that it is completely appropriate for tenors to have a slight degree of nasalance once they ascend past the PRT. A larger pool of subjects would be necessary to confirm this as a standard pedagogic tool.
The unique head voice dominant tuning strategy was more specific to the different vowels. The [i] vowel showed a definite tuning of H4/F2 once ascension into head voice had taken place. This was true in all seven subjects, but had highly varying degrees of nasalance (15-48%), which did not seem to have any effect on this tuning. Concerning the [a] vowel six, of seven tenors showed significant H3/F2 tuning above the PRT with nasalance readings between 14-45%. The tenor who was not able to tune H3/F2 did show a high degree of nasalance at 39%, but Tenor 1, showed 45% nasalance and had a very clear tuning of H3/F2. This drew no conclusion about nasalance’s effect on H3/F2 tuning. Five of the six tenors who showed H3/F2 tuning on [a] were also able to tune on [u].

Both T6 and T7 were not able to tune H3/F2 on the [u] vowel. The other similarity between both of these tenors on [a] and [u] was their inability to break the chest voice resonance between H2/F1. This is quite possibly the reason for their lack of H3/F2 tuning. T6 showed a high degree of nasalance on both vowels, between 21-39%. T7 did not show a high degree of nasalance, with both notes on the low end of the spectrum at 16% nasalance. The data of T6 seems to refute McCoy’s claim that an increased nasality will allow a tenor to break the H2/F1 lock. At least with this tenor, that does not hold true.

**Formant Tuning Discrepancies**

This last section will present cases of tenors, where at a certain pitch and vowel, their formant tuning was not like the rest of the subjects, it will also attempt to make connections to possible nasalance causes for these discrepancies. These results were

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derived from “the pindi sequence.” Reference to Table 1, the nasalance chart, and Table 2, the resonance chart, may be helpful in deciphering this section.

There appear to be three separate inconsistencies on the B3-flat. First, on the [i] vowel, T6 is not tuning H2/F1. All other subjects executed this tuning. Also, there is a drop in energy near F2, after the [nt] in [pindi]. This tenor does sing with the highest degree of nasalance of all subjects. Before the [nt], his reading was 55%, but after the consonant cluster, it dropped to 40%.

This same tenor encountered what appears to be the same problem on his [u] vowel. Here, neither H5 nor H6 was able to tune to F2 appropriately. All other subjects showed tuning to either H5 or H6. T6 sings the [u] vowel with high nasalance as well, around 40%. The [a] vowel was the only vowel on which this tenor was able to appropriately tune formants; he drastically reduced his nasalance to 18% before the [nt] and 12% after the [nt], allowing H2/F1 to tune. However, this is over a 50% reduction of nasalance, and since no other tenor in the study had a difficulty with any of these tunings, it is possible that nasalance over 40% may disable formants under 1000 Hz from tuning properly on the vowels [i] (F1) and [u] (F2). Further investigation into this particular problem is necessary to make a useful pedagogic statement, but from the present data it appears to be possible.

For the [a] vowel on the B3-flat, T3 was not able to tune H5 or H6 to F2. All six other tenors tuned H5/F2. T3’s nasalance was relatively high (23% before the [nt]) compared to his other readings, but T1 had even higher nasalance at 28%. Due to this, discrepancy there seems to be no relation between nasalance and T3’s inability to tune H5/F2 on his [a] vowel. T7 had unusually weak harmonics between the areas of F1 and
F2, and he sang with very low nasalance. This also coincidental, because T2 showed very strong harmonics between F1 and F2 with equally low nasalance.

There seemed to be more inconsistencies with the pitch F4, which was to be anticipated, as it is a transitional tone for these subjects. However, very few of these formant tunings seem to be affected by nasalance. It is easiest to approach each of these by examining each vowel separately.

On the [i] vowel, T1, T6, and T7 tuned H6/F2, and T2, T3, and T5 tuned H5/F2. Nasalance seems to have no bearing on this, because T1 and T5, a mix of both groups had high nasalance percentages (24-25%), while T2, T3, and T7 had a relatively low nasalance percentage (8-13%). T4 was the only subject who did not tune F2 to either H5 or H6. The exact reason for this would be speculative, but his nasalance was very inconsistent. He sang with 28% before the [nt] and only 13% after the consonant. This inconsistency in nasalance may be related to his inability to tune F2 and should be investigated in a future study.

The [a] vowel for the pitch of F4 produced similarly mixed results. T1, T2, and T4 are tuning H2/F1 and H4/F2, which is typical of a signature below the PRT. All of these subjects showed nasalance between 10-14%. T3, T5, T6, and T7 demonstrated a different tuning result; H2/F1 tuned like the other three tenors, but this group did not tune F2 to a harmonic. For these four tenors F2 is between H4/H3, which is most likely indicative of this transition note in passaggio. From a discussion standpoint, this may be a preferable tuning, because it demonstrates that these tenors are preparing to transition into operatic head voice where F2 would shift from tuning H4 to tune to H3. There seems to be no connection to nasalance as T3, T5, and T7 have relatively low nasalance.
percentages between 6-13%. T6, who shared these three tenors tuning strategy, had an extremely high percentage of nasalance at 56%. This further refutes McCoy’s claim of nasalance breaking the H2/F1 lock; however, F4 is still below the PRT, and the H2/F1 tuning does not break until the note after the PRT.

In the [a] vowel spectra, all subjects tuned H2/F1 on F4, but the results were split in the tuning of H4/F2. For [u] the opposite is seen. All seven tenors were able to tune H3/F2, which is most likely due to F2 maintaining a lower frequency on this vowel (c. 750-1050 Hz) than that of [a] (c. 1050-1250). This therefore causes H3 to be closer to F2 on the [u] vowel. Figure 22 shows T6 singing the pitch of F4 on [panta] with F2 lying between H3 and H4 in the power spectrum. Figure 23 shows T7 singing [puntu] on F4 with H3/F2 tuning. It is apparent that the F2 frequency of the [u] vowel is lower in comparison to the [a] vowel. Even though all seven tenors tuned H3/F2 on the [u] vowel, results of the H2/F1 tuning were split. T1, T2, T3, and T6 tuned H2/F1, which more closely resembles a chest voice signature tuning, while T4, T5, and T7 had already released the tuning of H2/F1. This result also seems to be unrelated to nasalance as T1, T5, and T6 show higher percentages (20-47%) while the other four tenors show relatively low nasalance percentages (7-11%). The sample is split differently regarding nasalance and the ability to tune H2/F1, which would lead to the conclusion that nasalance is not having any effect on this resonance.
Finally, an assessment of the formant tuning and nasalance on the B4-flat is necessary. The [i] vowel shows all seven tenors tuning H4/F2, with nasalance varying from 10-52%, which would lead to a conclusion that nasalance is not affecting this
tuning. Figure 24 demonstrates a tenor with H4/F2 tuning on B4-flat with high nasalance while Figure 25 shows the same tuning and pitch with relatively low nasalance.

Figure 24. B4-flat, [pinti], H4/F2 tuning with relatively high nasalance.

Figure 25. B4-flat, [pinti], H4/F2 tuning with low nasalance.
The B4-flat results on [a] continue to be mixed, but are very similar to the results on [u]. For both vowels, T1 through T5 were able to tune H3/F2 utilizing nasalance varying from 14-45% on [a] and 13-27% on [u]. None of these five tenors were still tuning H2/F1. On the [a] vowel, T6 tuned H3/F2, but carried over the tuning of H2/F2 from chest voice. His nasalance is high (37%), but no higher than that of T3 (42%) who tuned this note appropriately. T7 was not able to tune H3/F2, but did release the lock of H2/F1. F2 was unable to tune H3 or H2. His nasalance on this vowel was only 16% which resides on the low end of the spectrum. These same two tenors had difficulty tuning H3/F2 on the [u] vowel as well on this pitch. Both were unable to tune H3/F2, but neither tuned H2/F1. T6’s nasalance was very high, at around 44%, while T7’s nasalance was very low, around 11%. This would lead to the conclusion that nasalance is most likely not playing a role in the tenor’s abilities to tune formants appropriately. However, a larger sample size would be needed to confirm this with certainty. Figure 26 shows T6 singing a B4-flat on [puntu] with high nasalance, while Figure 28 illustrates T7 singing the same word and note with low nasalance. It is apparent that F2 fell between H3 and H2. Figure 27 and Figure 29 show the corresponding Nasometer graphs.
Figure 26. T6, B4-flat, [puntu] relatively high nasalance.

Figure 27. T6, B4-flat, [puntu] relatively high nasalance.
Figure 28. T7, B4-flat, [puntu] relatively low nasalance.

Figure 29. T7, B4-flat, [puntu] relatively low nasalance.
Table 2. F1 and F2 Tuning for “the pinti sequence.”

<table>
<thead>
<tr>
<th>Subject</th>
<th>Bb3 Pinti</th>
<th>Bb3 Puntu</th>
<th>F4 Pinti</th>
<th>F4 Panta</th>
<th>F4 Puntu Tuning</th>
<th>Bb4 Pinti</th>
<th>Bb4 Panta</th>
<th>Bb4 Puntu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenor 1</td>
<td>H2/F1</td>
<td>H3/F1, H5/F2</td>
<td>H2/F1, H4/F2</td>
<td>H6/F2</td>
<td>H2/F1, H4/F2</td>
<td>H2/F1, H3/F2</td>
<td>H4/F2</td>
<td>H3/F2</td>
</tr>
<tr>
<td>Tenor 2</td>
<td>H2/F1</td>
<td>H3/F1, H5/F2</td>
<td>H2/F1, H4/F2</td>
<td>H5/F2</td>
<td>H2/F1, H4/F2</td>
<td>H2/F1, H3/F2</td>
<td>H4/F2</td>
<td>H3/F2</td>
</tr>
<tr>
<td>Tenor 3</td>
<td>H2/F1</td>
<td>H3/F1, F2 between H5/H6</td>
<td>H2/F1, H4/F2</td>
<td>H5/F2</td>
<td>H2/F1, F2 between H3/H4</td>
<td>H2/F1, H3/F2</td>
<td>H4/F2</td>
<td>H3/F2</td>
</tr>
<tr>
<td>Tenor 4</td>
<td>H2/F1</td>
<td>H3/F1, H5/F2</td>
<td>H2/F1, H4/F2</td>
<td>F2 between H5/H6</td>
<td>H2/F1, H4/F2</td>
<td>F1 between H1/H2, H3/F2</td>
<td>H4/F2</td>
<td>H3/F2</td>
</tr>
<tr>
<td>Tenor 5</td>
<td>H2/F1</td>
<td>H3/F1, H5/F2</td>
<td>H2/F1, H4/F2</td>
<td>H5/F2</td>
<td>H2/F1, F2 between H3/H4</td>
<td>F1 between H1/H2, H3/F2</td>
<td>H4/F2</td>
<td>H3/F2</td>
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<td>Tenor 7</td>
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<td>H2/F1, H4/F2</td>
<td>H6/F2</td>
<td>H2/F1, F2 between H3/H4</td>
<td>F1 between H1/H2, H3/F2</td>
<td>H4/F2</td>
<td>no tuning of F1 or F2</td>
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</tbody>
</table>
Chapter 5

Conclusions

In order for information to be included in this section, a majority of the tenors needed to exhibit a certain behavior that could be followed in a pattern. The acoustic patterns, nasalance patterns, and joint patterns will be the focus.

Acoustically speaking, the B-flat scale revealed three consistencies. For the [i] vowel, six of seven tenors made their acoustic shift from G4 to A4, and six of seven tenors employed H4/F2 tuning on the note after the shift. A shift between G4 and A4 is considerably high, but this does confirm the belief that [i] is an easier vowel on which to make the transition from chest voice to head voice.101 Six of seven tenors also showed considerable H3/F2 tuning on the [a] vowel, which confirmed the findings of D. Miller102 and Neumann et al.103 Five of seven tenors tuned H3/F2 above the PRT on the [u] vowel. A conclusion can then be drawn that, above the PRT, professional tenors use H4/F2 tuning on the [i] vowel, H3/F2 tuning on the [a] vowel, and H3/F2 tuning on the [u] vowel. The results of the acoustic data from the B4-flat of the “pinti” sequence further confirm this, with seven of seven tenors demonstrating H4/F2 tuning on [i], five of seven tenors demonstrating H3/F2 tuning on [a], and five of seven tenors demonstrating H3/F2 tuning on [u].

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102 Donald G. Miller, Registers in Singing (Ph. D. diss., Rijksuniversiteit Groningen, 2000), 139.

Similar conclusions can be drawn from the lower notes of “the pinti sequence.” Six of seven tenors showed similar tuning for all three vowels on B3-flat. The [i] vowel tuned H2 to F1, the [a] vowel tuned H3 to F1 and H5 to F2, and the [u] vowel tuned H2 to F1 and H4 to F2. The pitch of F4 produced identical patterns for [a] and [u] compared to B3-flat, but no pattern for tuning on the vowel [i]. All seven tenors tuned H2 to F1 on the [a] vowel and likewise, all seven tuned H3 to F2 on the [u] vowel. The other formants for [a] and [u] and the results of [i] showed no pattern on the pitch of F4.

The data patterns for nasalance do not show as strong a percentage as do the samples for acoustics. With regard to nasalance on the B-flat scale, five of seven tenors sang [i] with increased nasalance as the pitch rose. This same phenomenon was true for four of seven tenors on the [u] vowel. “The pinti sequence” was useful in attempting to determine which vowel tenors sang with the highest percentage of nasalance in a given range. Two vowels stood out in all registers as the most and least nasal. On B3-flat and F4, five of seven tenors sang [i] as their most nasal vowel, while four of seven tenors sang [u] as their least nasal vowel. The numbers only slightly change for the B4-flat, where four of seven tenors sang [i] as their most nasal vowel, and four of seven tenors sang [u] as their least nasal vowel. It could be concluded that, in general, tenors sing [i] as their most nasal vowel in all registers and that tenors sing [u] as their least nasal vowel in all registers.

It could also be concluded that the [a] vowel is the most unique to the individual voice. Some tenors sing [a] as their most nasal vowel, while others sing it as their least nasal vowel on the same pitch. Despite the fact that these numbers represent nasalance and not resonance, the discrepancy on [a] is logical. The [a] vowel is the most central
and balanced vowel in terms of placement and shape of the tongue, which is significantly linked to resonance. This vowel is considered a middle vowel in comparison to [i] which is a forward vowel, and [u] which is a back vowel. The middle ground, in terms of placement and shape of tongue, leads to ambiguity in the sound and feeling of the [a] vowel. Consequently, the differing opinions in sound and feeling of the [a] vowel would lead to varying nasalance percentages.

The patterns that showed effects of nasalance on the acoustic signature were largely drawn from the B-flat scale data. Once the tenors had ascended over the PRT and began singing with a head voice resonance, a minimum percentage of nasalance was noted. For the [i] vowel, a minimum of 10% nasalance was noted after the PRT. The [a] vowel showed similar results with at least 13% nasalance after the PRT. Finally the [u] vowel resulted in a confirmation of this pattern with nasalance of 9% once the tenor was over the PRT. Another finding from the scale data showed that, on the [a] vowel, six of seven tenors increased nasalance on the note after the PRT. Finally, the scale data did not confirm McCoy’s theory that increased nasality would break the H2/F1 lock.\textsuperscript{104} There was more significant evidence that nasalance could aid in finding other appropriate formant tuning such as H3 to F2 on [a] or H4 to F2 on [i]. But, in some cases with increased levels of nasalance, and appropriate F2 tuning, the H2/F1 tuning still remained strong.

\footnote{Scott McCoy, \textit{Your Voice an Inside View} (Princeton: Inside View Press, 2004), 72.}
Future Areas of Research

From the data of the present study, three future areas of research have emerged. The first is possibly most important to voice pedagogues, to whom teaching a young tenor to navigate his passaggio is a challenge. It seems possible that a 5-10% increase in nasalance could help a tenor transition from chest resonance to head resonance on the vowel [a]. Six of seven professional tenors in the current study increased nasalance by at least that percentage. Likewise, it may be possible that a continual increase in nasalance on the vowels [i] and [u] may help a young tenor make a smoother transition from chest to head resonance. Five of seven tenors on [i] and four of seven tenors on [u] support this as a possibility. It may even be possible for this slight increase of nasalance to purposefully allow a tenor to transition lower in the scale. This would mean that a teacher would have a tool to use with a tenor who carries chest voice too high. The teacher may be able to suggest a slight increase of nasalance on the note where head resonance is preferable to encourage the singer to begin singing in head voice at a lower pitch. This may allow the tenor to increase his range. A larger pool of participants, and a test set up to directly evaluate this theory would be necessary to prove the validity of these statements.

Within this same future area of research, the Nasometer with divider plate may prove to be a useful tool for a teacher to use in the voice studio to aid a young tenor in finding that slight increase of nasalance. Also, the use of Voce Vista in the voice studio would prove to be a valuable tool to help a young tenor visualize the appearance of head voice resonance on the spectrogram and power spectrum after a brief explanation. These two devices used in combination may provide pedagogues with new possibilities in the
training of the tenor voice. However, as with all technology, the teacher must keep in mind that no device will ever replace the teacher’s ears. For example, a tenor may sing with an increase of nasalance and transition over the PRT with ease, but if the sound has an inherently nasal “honk” or “twang” it may not be aesthetically pleasing or commercially viable in classical singing. A future test would be necessary to confirm whether or not “in studio” practice using these devices would produce effective results.

Another future area of research that has arisen from the current data is the possibility of nasalance adversely affecting formant tuning in chest voice. For formants under c.1300 Hz nasalance seems possibly to affect tuning. The only tenor who was not able to tune H2 to F1 on the [i] vowel and H4 to F2 on the [u] vowel in chest voice was T6. Similarly, T3 could not tune H5 to F2 on the [a] vowel, however, he was able to tune H3 to F1. T3 showed significantly higher nasalance on [a] than on his other two vowels at this pitch. A future study, specifically set up to deal with this problem would be necessary to confirm the adverse effect of nasalance on formant tuning of formants under c.1300 Hz in chest voice. If it were proven true, the Nasometer would again be a useful pedagogic tool for keeping nasalance low in chest voice.

Finally, the data comparison of the current study’s data with that of the Birch et al. study produced some differing results. In the study by Birch et al., all three tenors who participated sang with increased nasalance near passaggio.105 The tenors in the current study did not all behave in that manner. In fact, the data on that matter disagrees with the current tenor subjects. One possible explanation for this discrepancy is the issue

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of native language. In the Birch et al. study, their subjects were all professional operatic singers working in Denmark. The study makes no mention of nationality, or native language of the subjects, but does lead to the possibility that native language may play a role in the differing results. A repetition of the current study with subjects who natively speak differing languages may provide another unique viewpoint of the current problem.
Bibliography


APPENDIX A

INFORMED CONSENT

EFFECTS OF NASALANCE ON THE ACOUSTIC PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

University of Miami
CONSENT TO PARTICIPATE IN A RESEARCH STUDY

EFFECTS OF NASALANCE ON THE ACOUSTIC PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

The following information describes the research study in which you are being asked to participate. Please read the information carefully. At the end, you will be asked to sign if you agree to participate.

PURPOSE OF STUDY:
You are being asked to participate in a research study. The purpose of this study is to discover any connection between increased nasalance and appropriate formant tuning in the tenor passaggio and head voice.

You are being asked to be in the study because you are a professionally recognized tenor.

PROCEDURES:
You will be asked to record a series of exercises twice. The first time with microphone, and the second time using the Nasometer. All exercises will be recorded.

First you will be asked to sing the words [pinti], [pun'tu], and [panta] separately at three pitches: B3-flat (chest), F4 (passaggio), and B4-flat (operatic head voice). You will be asked to sing them full voice, as you would sing the pitches in an operatic aria. (10-15 minutes).

The next part of the procedure you will be asked to sing three B3-flats: one on each vowel of the [pinti] sequence [i, u, a]. Immediately after each vowel, you will be asked to attempt to vocal fry (light bubbling of air between the vocal folds) while leaving your vocal tract in the position of the note you just sang. (10-15 minutes)

As a final measure, the tenors will be asked to sing a B-flat major scale from B3-flat to B4-flat, on all three vowels. (10-15 minutes)

RISKS AND/OR DISCOMFORTS:
We do not anticipate you will experience any personal risk or discomfort from taking part in this study.

If you feel uncomfortable being audio/videotaped, it can be turned off at your request.
EFFECTS OF NASALANCE ON THE ACOUSTIC PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

BENEFITS:
No benefit can be promised to you from your participation in this study. The study is expected to benefit the larger voice pedagogy community.

CONFIDENTIALITY:
The recorded samples will be coded and only identified as tenor 1, tenor 2, etc.
- Records will be securely kept on Mr. Perna’s personal laptop and external hard drive.
- Mr. Perna and Dr. Lebon will be the only individuals with access to the original recordings.
- Subjects names will never appear in association with this study or its data.

By signing this consent, you authorize the Investigators(s) and his/her/their staff to access your recordings as may be necessary for purposes of this study.

COSTS:
There are no costs associated with your participation in this study.

COMPENSATION:
There will be no compensation for participation in this study.

RIGHT TO DECLINE OR WITHDRAW:
Your participation in this study is voluntary. You are free to refuse to participate in the study or withdraw your consent at any time during the study. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest for you.

If you are an employee or student at the University of Miami, your desire not to participate in this study or request to withdraw will not adversely affect your status as an employee or grades at the University of Miami.

CONTACT INFORMATION:
Dr. Rachel L. Lebon (305-284-4886) will gladly answer any questions you may have concerning the purpose, procedures, and outcome of this project. If you have questions about your rights as a research subject you may contact Human Subjects Research Office at the University of Miami, at (305) 243-3195.
EFFECTS OF NASALANCE ON THE ACOUSTIC PROPERTIES OF THE TENOR PASSAGGIO AND HEAD VOICE

PARTICIPANT AGREEMENT:
I have read the information in this consent form and agree to participate in this study. I have had the chance to ask any questions I have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and signed.

Signature of Participant ____________________________ Date ______________

Signature of person obtaining consent ____________________________ Date ______________

AUDIOTAPING
[ ] I do not agree to the audiotaping of my vocal exercises.

By signing this section you give consent to be audiotaped during your vocal exercises.

Signature of Participant ____________________________ Date ______________

Signature of person obtaining informed consent ____________________________ Date ______________
APPENDIX B

IRB APPROVAL LETTER

EXPEDITED – APPROVAL

March 5, 2008

Rachel Lefon, Ph.D.
University of Miami
Department of Studio Music and Jazz
Campus, Locator Code: 1970

HSRO STUDY NUMBER: 20080053
STUDY TITLE: Effects of Nasaline on the Acoustical Properties of the Tenor Passaggio and Head Voice
IRB ACTION DATE: 3/5/2008
STUDY APPROVAL EXPIRES: 3/4/2009

On 3/5/2008, an IRB Chair approved the following items under the expedited review process:

APPROVAL INCLUDES:

New Research Protocol
Research Materials (English Version Only)

• Informed Consent Form

NOTE: Translations of IRB approved study documents, including informed consent document, into languages other than English must be submitted to HSRO for approval prior to use.

A request to continue this study must be submitted to the HSRO at least 45 days before IRB approval expires. If this study does not receive continuing IRB approval prior to expiration, all research activities must be ceased, and may officially be suspended or terminated.

All principal investigators must abide by and comply with all policies and procedures for the conduct of human subject research as posted on the HSRO website (http://www.miamiunion.edu)

Sincerely,

Annisa Colos-Roja, MPH, CIP
Associate Director
Regulatory Affairs & Educational Initiatives

irs

cc: IRB File
Nicholas Penn