INGRESSIVE PHONATION IN CONTEMPORARY VOCAL MUSIC

Amanda DeBoer

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Committee:

Jane Schoonmaker Rodgers, Advisor

Ronald C. Scherer
Graduate Faculty Representative

Sean Cooper

Elaine Colprit
ABSTRACT

Jane Schoonmaker Rodgers, Advisor

The use of ingressive phonation (inward singing) in contemporary vocal music is becoming more frequent, yet there is limited research on the physiological demands, risks, and pedagogical requirements of the various ingressive phonation techniques. This paper will discuss ingressive phonation as it is used in contemporary vocal music. The research investigates the ways in which ingressive phonation differs acoustically, physiologically, and aesthetically from typical (egressive) phonation, and explores why and how composers and performers use the various ingressive vocal techniques.

Using non-invasive methods, such as electroglottograph waveforms, aerodynamic (pressure, flow, flow resistance) measures, and acoustic analyses of recorded singing, specific data about ingressive phonation were obtained, and various categories of vocal techniques were distinguished. Results are presented for basic vocal exercises and tasks, as well as for specific excerpts from the repertoire, including *temA* by Helmut Lachenmann and *Ursularia* by Nicholas DeMaison.

The findings of this study were applied to a discussion surrounding pedagogical and aesthetic applications of ingressive phonation in contemporary art music intended for concert performance. Topics of this discussion include physical differences in the production and performance of ingressive phonation, descriptive information regarding the various techniques, as well as notational and practical recommendations for composers.
This document is dedicated to:

my husband, Tom Bartlett

my parents, John and Gail DeBoer

and my siblings, Mike, Matt, and Leslie DeBoer

Thank you for helping me laugh through the process – at times ingressively – and for supporting me endlessly.
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INTRODUCTION

Since the mid-20th century, vocalists and composers have been experimenting with and developing non-traditional singing techniques, sometimes called “extended” vocal techniques, which are often outside the pedagogical conditions suitable for certain traditional styles of classical singing. Although many of the extended vocal techniques replicate phonatory patterns which occur during normal speech, when used in a musical setting, the phonatory conditions can be intensified by increased volume, duration, frequency in occurrence, and vocal range, leading many vocalists to seek specific training for these techniques.

The list of extended techniques in current use by practicing musicians is extensive, diverse, and inconsistently designated so that there is no encompassing pedagogical resource for instructors and users of extended vocal techniques. It is beyond the scope of this project to investigate the multitude of techniques available to the contemporary performer and composer. Instead, this project will isolate a single technique that is one of the more challenging, complex, and under-researched of the extended vocal techniques: ingressive phonation.

Ingressive phonation, or “inward singing,” is not considered an essential part of traditional collegiate-level vocal instruction. It does not appear in the most common pedagogical resources, and has not been significantly studied from a musical perspective by voice researchers within the community at large. Thus, even though ingressive phonation occurs intermittently during normal speech throughout the world, the implications of its usage in contemporary art music with respect to laryngeal conditions, acoustics, and aesthetics have hitherto been overlooked.

In this study, a group of vocal tasks were chosen to represent various ingressive vocal techniques found in contemporary vocal music. The author performed these tasks, along with
their egressive counterparts, using various voice recording methods, to gain descriptive information about the aerodynamic and acoustic characteristics of ingressive phonation. By creating conditions of comparison between ingressive and egressive phonation, it may be possible to account for some of the kinesthetic and aural discrepancies between the two modalities of singing.

With further understanding as to the nature of ingressive phonation from an acoustic and aerodynamic perspective, readings of several musical works from the past 40 years were developed which effectively incorporate ingressive phonation. Included in this discussion are *temA* by Helmut Lachenmann, *Eight Songs of a Mad King* by Peter Maxwell Davies, *Ursularia* by Nicholas DeMaison, and *Various Terrains (= of similarity)* by Michael Baldwin.

With improved descriptions and aesthetic information about the nature and use of ingressive phonation in its many forms, we can continue to develop a more universal, accessible, and specific vocal pedagogy for extended vocal techniques.
CHAPTER 1. AN EXPERIMENTAL STUDY OF INGRESSIVE PHONATION

1.1 A SURVEY OF RESEARCH ON INGRESSIVE PHONATION

When the vocal folds are adducted sufficiently, phonation occurs when transglottal pressure causes the vocal folds to vibrate, thus creating a modulated airflow. When the modulated airflow creates a sufficiently loud enough acoustic signal, the auditor hears a phonated sound. When the airflow comes from the lungs and moves toward the upper airway, phonation is called “egressive”, and when the air moves toward the lungs from the upper airway, phonation is called “ingressive”.

Egressive phonation (EP) is regarded as the most common and efficient form of voice production for humans because of the advantageous configuration of the vocal folds and subsequent economical use of air which allows for increased length and volume of phonation.

Many factors contribute to the resulting quality, duration, and loudness of phonation. The cyclic laryngeal airflow waveshape and size during phonation is most important in determining the quality of the resulting phonation. The laryngeal airflow is highly associated with glottal adduction and vibratory aspects of the vocal folds, including the length and duration of vocal fold contact, the vocal fold length and thickness, and the mucosal wave of the vocal folds. The laryngeal sound is further altered by acoustic effects due to the shape of the pharyngeal, oral, and

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sinus cavities, thus determining the acoustic properties of the output sound, including pitch, color and timbre, and the perceived vowel.\(^5\)

During ingressive phonation [IP], however, vocal sound is produced on the inhalation. The reverse airflow moves through the glottis from above, causing fully or partially adducted vocal folds to vibrate. According to Ng, “Reverse or inspiratory phonation (IP), however, requires a reverse flow of air when the airstream is drawn into the lungs through the glottis when subglottal pressure is lower than supraglottal pressure…Voluntary IP, in contrast, takes place when the vocal mechanism is orchestrated in a deliberate attempt to phonate with an ingressive airflow.”\(^6\)

The properties that determine the characteristics of normal phonation, described above, are the same physical properties that are used to understand the nature of ingressive phonation. The morphology of the speech mechanism, including the oral, nasal, pharyngeal, pulmonic and esophageal cavities,\(^7\) as well as the form of the mucosal wave, the contact quotient, the rate of airflow, the amount of lateral pressure, and other physiological elements may assume significantly different characteristics during ingressive phonation compared to egressive phonation.

The physiological discrepancies alter the resulting sounds dramatically. As Eklund notes, “[n]ot only is pulmonic ingressive phonation in general less sonorous and harsher-sounding than its egressive counterpart but it is also less suited to the production of certain specific sounds.”\(^8\) In

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7 Eklund, 2008.
8 Eklund, 2008.
his research, Eklund has notably worked primarily in a nonmusical context with vocalists who do not typically practice ingressive phonation in non-speech tasks.

Although the most commonly used term is ingressive phonation, which can refer to both ingressive speech and ingressive singing, the numerous designations for ingressive phonation point to the varied approaches and objectives in researching the technique. Alternative designations for ingressive phonation include:

i. inward singing
ii. inhalatory voice
iii. inhalatory phonation
iv. imitations
v. nonperiodic phonation
vi. ingressive speech
vii. inspiratory voice
viii. reverse phonation

“Inward singing” is typically found in musical contexts such as printed music, and can refer to either ingressive phonation or to the more metaphorical idea of accessing inner emotions and creativity in music, as when Alan Hovhaness said “I was very touched when John Cage said my music was like inward singing.” Inhalatory voice and inhalatory phonation refer specifically to the directional airflow. It is much less common, however, to find the counterpart “exhalatory voice.” Donald Miller describes ingressive phonation as both “nonperiodic phonation,” and an “imitation” of egressive phonation. Michael Robb et. al. use the term “reverse phonation.”

10 Miller, 1997.
Early Research on Ingressive Speech

Some of the earliest research on ingressive sounds occurred in the late 19th century, as noted by Eklund: “…Havet (1875) points out that ingressive t is used to express doubt; and ingressive palatal t expresses surprise, but can also be used to call horses.”

Through the 20th century, linguistic research continued to isolate important and common examples of ingressive speech internationally, although many of these sounds are “non-linguistic,” e.g. emotive vocal gestures to express surprise, delight, disgust and other general sentiments.

Therapeutic Use of Ingressive Phonation

Particular ingressive phonation research in relation to singing focuses on the therapeutic benefits of inhalatory speech. Ng noted that ingressive phonation is useful in patients exhibiting ventricular phonation, spasmodic dysphonia, and psychogenic voice disorders, either as behavioral assessment or in treatment. This occurs because ingressive phonation “triggers an appropriate physiology for dysphonic patients…Kelly and Fisher (1999) observed significant reduction in membranous vocal fold contact length…With the reduced force of vocal fold approximation, IP can facilitate effortless phonation in patients with vocal hyperfunction and adductory spasmodic dysphonia, and it has been accordingly used as either a preparatory step for easy voice production using EP or a preferred mode of speaking for severely dysphonic patients.”

14 Eklund, 2008.
15 Eklund, 2008.
16 Ng, 2010.
17 Ng, 2010.
**Airflow and Airflow Resistance**

Several studies have noted a higher airflow rate during ingressive phonation than during egressive phonation, including Orlikoff et al.\(^{18}\) Observing 16 men and women, Orlikoff et. al. found that “the absolute airflow rate was significantly greater for inspiratory phonation, on average 48.5% higher than during normal expiratory voice...The supraglottal airway cannot match the conus elasticus in its ability to funnel a laminar flow toward the glottis. Furthermore, when viewed superiorly, the vocal folds naturally assume a divergent operating point. In theory, this divergence would increase glottal resistance while hindering aerodynamic coupling to the vocal fold mucosa (Gauffin et al., 1983; Scherer and Titze, 1983; Gauffin and Liljencrants, 1988; Scherer and Guo, 1991)\(^{19}\) Furthermore, Ng states that,

“The properties of the unique voicing mechanism of (voluntary) IP have been investigated visually, acoustically, and aerodynamically... It was found that, IP was associated with increased airflow, decreased amount of vocal fold contact, and higher fundamental frequency (F0) when compared with [egressive phonation]. Kelly and Fisher examined the acoustic and stroboscopic data obtained from sustained vowel /i/ using IP and found similar results.”\(^{20}\)

While ingressive phonation is useful to patients exhibiting certain hyperfunctioning disorders, in musical contexts it creates inefficient conditions for prolonged phonation due to limits in lung capacity. The shelf-like edge of the superior surface of the vocal folds creates a more obstructive condition for ingressive phonation, which can lead to increased adductory pressure, especially during vocal onset.

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19 Orlikoff, 1997.
20 Ng, 2010.
**Fundamental Frequency**

Orlikoff\(^2\) observed that in both men and women, a majority of participants produced higher fundamental frequencies (pitch) during ingressive phonation. The study found that “[Fundamental frequency] increased by 5.1 semitones (on average) during inspiratory phonation.” Similar findings have been produced by Kelly & Fisher\(^2\) and Robb et al.\(^2\) Robb also observed that “[a]cross female and male groups, the mean Hz difference was approximately 74 Hz, with reverse phonations typically higher than normal phonations,” and found that formant frequency values for F1 and F2 varied (in both directions) as a function of the particular vowel being produced.\(^4\)

The cricothyroid muscles, which are primarily responsible for lengthening the vocal folds, apparently engage during inhalatory processes.\(^5\) Without skilled control and awareness, this natural lengthening process will cause a slight increase in F\(_0\) during IP.\(^6\) As Orlikoff explains, “Inspiratory voice production was also associated with thinner and more elongated vocal folds, on average represented by roughly a 14% increase from their length during EP, which is consistent with the observation of higher vocal F\(_0\)’s associated with voice produced during inhalation.”\(^7\)

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Adduction and Glottal Closed Quotient

Hartlieb, Luchsinger & Pfister\textsuperscript{28} compared expiratory and inspiratory phonation at low, middle, and high frequencies, and observed among other things that the inspiratory voice had a shorter closed phase, and Moore & von Leden\textsuperscript{29} note in the description of the vibratory cycle during ingressive phonation that the “[v]ocal folds begin to vibrate with a small lateral displacement at the edges.”\textsuperscript{30}

Along with duration, a smaller percentage of the membranous folds become fully adducted during ingressive phonation. Kelly\textsuperscript{31} observed significant reduction in membranous vocal fold contact length, yielding a unique posterior glottal chink during IP. Orlikoff\textsuperscript{32} noted similar findings, although the posterior glottal chink was more pronounced in the male participants.

As mentioned above, Moore and von Leden produced a clear description of the vibratory cycle during ingressive phonation, which is contrary to that of egressive phonation. As Eklund remarks, “[w]hen [Moore and von Leden] looked at a single vibratory cycle, they observed a ‘marked difference from the vibrations of expiratory phonation’, including ‘an unusually long opening phase and a very brief closing phase’, and also that it ‘is evident that all points on the glottal margins do not move at the same time, at the same rate, or the same degree.’”\textsuperscript{33} The vibratory cycle observations that Moore and von Leden listed are as follows:\textsuperscript{34}

\textsuperscript{30} Von Leden, 1958.
\textsuperscript{31} Kelly, 1999.
\textsuperscript{32} Orlikoff, 1997.
\textsuperscript{33} Eklund, 2008.
\textsuperscript{34} Von Leden, 1958.
1. Vocal folds stop vibrating during the moment exhalation ceases
2. During this transition the motionless vocal folds are partially abducted
3. The arytenoid cartilages are abducted and remain so throughout inspiratory phonation
4. Vocal folds begin to vibrate with a small lateral displacement at the edges
5. This motion is followed by a sudden medial sweep of the folds that accomplishes the vibratory closure of the glottis

Moore and von Leden also noted that the vibratory cycle of ingressive phonation was a reversal of the vibratory cycle during egressive phonation. As Orlikoff describes, “For the two men and two women examined by rigid stroboscopy, [ingressive phonation was] characterized by approximation of the upper margins of the vocal folds that preceded that of the lower margins, the reverse of what was observed during EP.”

**Lowered Larynx**

Many researchers have noted a natural lowering of the larynx, coupled with a lengthening and thinning of the vocal folds during ingressive phonation. Because of laryngeal lowering the supraglottal structures become increasingly visible during ingressive phonation. Orlikoff states that “[s]troboscopic examination of four of the subjects showed caudal displacement of the larynx and lengthened vocal folds associated with inspiratory phonation.” Both of these actions would typically occur to reduce flow resistance to make inhalation easier.

**Intelligibility**

Understandability (intelligibility) is paramount when practitioners request ingressive phonation as a means to effectively treat certain hyperfunctioning disorders. As Ng expresses, if

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ingressive speech is not understandable, then it will be of no use to ingressive phonation users.\textsuperscript{37} So too, in the musical setting, if text becomes unintelligible during ingressive phonation, it will be less viable as a compositional and performance tool. Miller found that certain vowel sounds may be easier to articulate than others during ingressive phonation. He notes, for example, in examining “the vowels [a], [ae], and [i], the mean discrepancy was 10.4\% for the first formant and 12.5\% for the second formant. For /u/, the discrepancies were 19\% and 54\% for F1 and F2, respectively.”\textsuperscript{38} Strikingly, Miller found that the ingressive imitation on the part of the subject was predominantly aural:

Contrary to our hypothesis concerning the similarity of vocal tract postures for similar formant frequencies, the differences between phonation types are readily distinguishable on visual examination… Comparing the acoustic with the spatial data, one is faced with a puzzle. On the one hand, the subject demonstrates the ability to produce accurate acoustic imitations, with respect to the first two formant frequencies, among various phonation types. On the other hand, the MR images reveal markedly, and in some respects systematically, dissimilar vocal tract articulations among the phonation types.\textsuperscript{39}

Ng observed that understandability of consonants decreased during ingressive phonation.\textsuperscript{40} Using voice onset time as a means to gauge coordination between consonant articulation and the start of phonation, Ng measured the effectiveness of Cantonese speakers to articulate consonant stops during both egressive and ingressive phonation - the longer the voice onset time, the longer the interval between consonant articulation and “glottal pulsing.”\textsuperscript{41}

\textsuperscript{37} Ng, 2010.  
\textsuperscript{38} Miller, 1997.  
\textsuperscript{39} Miller, 1997.  
\textsuperscript{40} Ng, 2010.  
\textsuperscript{41} Ng, 2010.
Observations of voice onset time revealed that “Cantonese stops produced using [ingressive phonation] were identified at a significantly lower level of accuracy (<65%).”

Catford compared the production of egressive and ingressive consonant sounds, and found that there are distinct differences in production that hinder pronunciation of ingressive consonant sounds. In comparing [f↓] and [s↓] (where the arrow refers to ingressive airflow), Catford found that imitation of egressive [f] was much more effective, as the production conditions are only slightly altered during ingressive production. Imitation of [s] using ingressive airflow was nearly impossible, however, since,

[i]n the pulmonic pressure [s] . . . the egressive airstream first squeezes through a narrow channel between the tongue and the ridge behind the upper teeth (alveolar ridge). As it passes through this channel it is accelerated, becomes turbulent (‘channel turbulence’), and issues from the channel in a high-velocity turbulent jet. This jet strikes the teeth, and this imparts further turbulence to it: beyond the teeth, ‘downstream’ from the teeth, there is a turbulent wake, full of swirling movements or ‘vortices’. The turbulence of the wake (‘wake turbulence’) contributes an additional rather high-frequency component to the hiss-noise of [s]. In the pulmonic suction [s↓] . . . however, the ingressive air-stream coming from outside of the mouth flows rather slowly and non-turbulently past the teeth and inwards through the narrow [s]-type articulatory channel. Once again, it is accelerated as it passes through the channel, and emerges as a turbulent high-velocity jet. But this inflowing, ingressive, jet, as it shoots into the interior of the mouth, meets with no obstacle comparable to the teeth and so acquires no additional wake turbulence. Because of the absence of wake turbulence the ingressive, pulmonic suction [s↓], sounds noticeably different from the egressive, pulmonic pressure [s].

Summary

This body of research, while incomplete with regard to the musical applications of ingressive phonation, has strong implications about the nature of ingressive phonation with regard to singing and will continue to influence current and future research on the topic.

Unfortunately, the subjects of these studies have almost exclusively been non-singers or singers

42 Ng, 2010.
who are untrained in ingressive phonation, and therefore did not have the vocal training and nuanced muscular control that a specialist might apply to ingressive phonation techniques. As the body of research involving ingressive phonation grows, inclusion of singers trained in this technique will possibly illuminate further dissimilarities between ingressive and egressive phonation and highlight the range techniques possible within this mode of singing. The study reported here attempts to provide such illumination and greater understanding.
1.2 METHOD

Motivation Summary

Ingressive phonation has been studied by voice scientists from a therapeutic and linguistic perspective. These studies have included non-musicians as subjects, and have never provided quantified data from a musical perspective. Useful quantitative differences between ingressive phonation and egressive phonation are unknown for singers. Knowing such differences may benefit composers, singers, musicologists, voice scientists, linguists, and speech pathologists. For example, analysis of objective data regarding the nature of ingressive phonation with regard to airflow, air pressure, acoustic measurements, and electroglottogram waveforms may better enable voice instructors and singers to perform in a more efficient, safe, and effective manner of production while achieving higher artistic goals.

Composers may benefit from this knowledge as well, since by having more information about the nature of ingressive phonation versus egressive phonation, they may more effectively and safely write for the technique, increasing the likelihood of multiple satisfactory performances of their work. From a singer’s point of view, ingressive phonation compared to egressive phonation is a very different experience due to the highly contrasting nature of the two styles of phonation, as will be discussed below.

The increased demands placed on the larynx during ingressive phonation within a musical context illustrate unique characteristics of laryngeal function. Qualitative descriptions of such demands may help in the overall understanding of laryngeal function and phonation, such as balanced production, efficient breath management, range limitations and possibilities, and avoidance of undue vocal fatigue.
Subject

This investigation engaged a classically trained singer (Amanda DeBoer, the primary investigator) as the subject in the study. The subject has received 14 years of voice training, including postgraduate training. She has specialized in contemporary music for 8 years, and has extensive professional experience performing contemporary music, including several pieces that incorporate ingressive phonation. Because the subject has had adequate professional performance experience with ingressive phonation, it was not necessary for the subject to undergo further training for the purposes of this study. The tasks were devised with enough advanced notice of the recording, so that the subject was able to practice them sufficiently before recording began.

Vocal Tasks

The subject was asked to perform several vocal (singing) exercises (melodic scales and other musical figures) using both ingressive (inward airflow) and egressive (outward airflow) phonation. The subject performed these exercises while numerous signals were being recorded (see below). The subject was also asked to describe the physical sensation of ingressive phonation compared to egressive phonation.

The musical elements and excerpts used in this research relate to and directly quote the art music of composers and performers active after 1945 who have contributed to the body of work and performance practice relative to ingressive phonation. Music excerpts were drawn from two sources, Helmut Lachenmann’s *temA* for flute, voice, and cello\(^ {45} \) (Figure 1.2a), and Nicholas DeMaison’s *Ursularia*\(^ {46} \) (Figure 1.2b), a chamber opera in one act. The excerpts were

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46 DeMaison, 2006.
chosen for their singability, and for their use of multiple techniques within a short section (about 30 seconds). These works also demonstrate valuable contrasts in style, presentation, chronological distinction, and the national origin of the composers.

The techniques used in Lachenmann’s *temA*, which were isolated for this purpose, include vocal fry glissando, pitched ingressive phonation – sustained, alternation from ingressive to egressive phonation, and ascending ingressive glissando in the middle range. Measures 48-55 were chosen, and were performed solo, without aid of cello and flute.

DeMaison’s use of ingressive phonation in *Ursularia* occurs in the final scene, during the opening solo sung by the character Ursula’s Immortal Soul. This excerpt was selected for its wide range of pitch material, along with multiple instances of alternation and the frequent sustained moments, allowing for adequate testing material within a musical context.

It was essential to demonstrate vocal tasks excerpted from existing musical compositions in order to demonstrate ingressive phonation within a context that singers may actually perform. By comparing the non-excerpted musical tasks with those excerpted from existing pieces allows a check on similarity of phonatory function.

The non-excerpted tasks designed specifically for this investigation were chosen to demonstrate expected vocal behaviors by composers, and basic and simple vocal exercises. A voice scientist with extensive experience with these procedures (Ronald Scherer, along with his research assistant, Brittany Frazer) guided the experiment and oversaw all tasks, helping in both the selection and performance of each exercise. Each task, excluding musical excerpts, was performed both ingressively and egressively, to obtain data for comparison between the two manners of phonation. The tasks were designed to be limited with regard to pitch material and rhythmic complexity.
Figure 1.2a: from *temA* by Helmut Lachenmann
Scene 18

Wherein Ursula and Her Immortal Soul Lose the Power of Speech and Their Luminescence

...like slow breathing, somewhat unsteady (con rubato)
Sustain all events until the next event.
Scene 18 should be unconducted; Ursula's Immortal Soul determines pacing.
Pronunciation of letters need not be consistent throughout.
Dashed vertical lines indicate alignment of single events.
The non-excerpted tasks included:

- Glissandi – Sustained pitch sweeps from E4-E5, and from lowest possible note to highest possible note
- Arpeggios – Major triads beginning on D4 and G4 on an [a] vowel
- Messe di voce – Crescendo and decrescendo on A4 and D5
- Onset – Produced breathy and normal onset for both ingressive and egressive phonation.
- Alternating – Continuous phonation changing between ingressive and egressive phonation on A4
- Variations of vibrato – Transition from straight-tone to normal vibrato, and from vibrato to wobble on F4
- Vocal fry – Produced sustained vocal fry and with the repeated word [pæ]
- Vocal fry glissandi (that is, formant glissandi) – Produced by using vocal fry and shifting between vowel shapes [o] to [a] to [æ]
- Repetition of [pæ] - Repetition of the syllable [pæ] (as in “pattern”) on a single pitch with subsequent pressure and flow analyses

All tasks were performed within a comfortable range for the subject, and within comfortable loudness and glottal adduction levels.

*Please see Figure 1.2c Vocal Tasks*

**Recording Method and Equipment**

**Audio**

The microphone was a unidirectional condenser microphone designed by Crown Audio. The microphone was secured in place by a stand. The microphone remained 4-7 inches from the
subject’s mouth, and consistent recording volume levels were used throughout the recording process.

**Aerodynamics**

The Glottal Enterprises aerodynamic system was used to record airflow and the oral air pressure signals. The subject held the vented mask against her face, ensuring that the subject could remove it easily at any time.

Included in the vented mask was a small tube attached to a pressure transducer. Some exercises involved using the /p/ sound (as in "pop"), in which the lips were placed around the small plastic tube (used to measure air pressure in the mouth). By measuring the oral pressure of the /p/ consonant in smoothly produced /pæ pæ pæ/ sequences, the subglottal pressure during the vowel could be estimated. This allowed the calculation of flow resistance, measured as the mean flow divided by the estimated tracheal pressure (translaryngeal pressure).

An electroglottograph from Kay Elemetrics was used to obtain waveforms of the assumed changes in vocal fold contact area. The device includes two small plates which were placed on the right and left sides of the thyroid laminae of the larynx. The signal obtained is a demodulated variation of the impedance (very high frequency, very low amperage) through the neck as the vocal folds vibrate. The waveshape pulse width of the electroglottographic signal allows an estimate of the relative vocal fold adduction level.
Figure 1.2c Vocal Tasks

Experiment Tasks
Tasks which require both egressive and ingressive phonation should mimic each other with regard to amount of effort used during phonation.

EP: Egressive Phonation
IP: Ingressive Phonation

Group 1: Pressure (sung on A4)
Pitch 1 (P1): E4
Pitch 2 (P2): E5
Loudness 1 (L1): Normal (mp)
Loudness 2 (L2): Louder (mf)
Adduction 1 (A1): Normal
Adduction 2 (A2): Breathy

1. Task A: With quarter note = 60, using EP combination P1/L1/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
2. Task B: With quarter note = 60, using EP combination P1/L1/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
3. Task C: With quarter note = 60, using EP combination P1/L2/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
4. Task D: With quarter note = 60, using EP combination P1/L2/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
5. Task E: With quarter note = 60, using EP combination P2/L1/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
8. Task H: With quarter note = 60, using EP combination P2/L2/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
9. Task A: With quarter note = 60, using IP combination P1/L1/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
10. Task B: With quarter note = 60, using IP combination P1/L1/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
11. Task C: With quarter note = 60, using IP combination P1/L2/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
12. Task D: With quarter note = 60, using IP combination P1/L2/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
13. Task E: With quarter note = 60, using IP combination P2/L1/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
14. Task F: With quarter note = 60, using IP combination P2/L1/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
15. Task G: With quarter note = 60, using IP combination P2/L2/A1, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
16. Task H: With quarter note = 60, using IP combination P2/L2/A2, repeat the phoneme /æːæːæː/ on the quarter note using both the flow mask and the pressure tube.
GROUP 2: Alternating

17. **Task A**: With quarter note = 60, alternate between IP/EP every two beats on comfortable pitch using an [a] vowel and A4
18. **Task B**: With quarter note = 60, alternate between IP/EP every eighth note on comfortable pitch using an [a] vowel and A4

GROUP 3: Glissandi and Arpeggio

20. **Task B**: Using IP, octave glissando from E4 to E5.
21. **Task C**: Using EP, glissando from lowest comfortable pitch to highest comfortable pitch
22. **Task D**: Using IP, glissando from lowest comfortable pitch to highest comfortable pitch

GROUP 4: Vibrato

26. **Task B**: Using IP, on an [a] vowel and on F4, transition between straight-tone and vibrato.
28. **Task D**: Using IP, on an [a] vowel and F4, transition between straight-tone and wobble.

GROUP 5: Vocal Fry

29. **Task A**: On comfortable pitch, sustain a vocal fry on an [a] vowel using EP for approximately 4 seconds
30. **Task B**: On comfortable pitch, sustain a vocal fry on an [a] vowel using IP for approximately 4 seconds
31. **Task C**: Using IP, perform an ascending (pitch and formant) vocal fry glissando from a comfortable low pitch to comfortable high pitch
32. **Task D**: Using EP, perform an ascending (pitch and formant) vocal fry glissando from a comfortable low pitch to comfortable high pitch

GROUP 6: Loudness and Tone

33. **Task A**: On A4, perform messa di voce using EP.
34. **Task B**: On A4, perform messa di voce using IP.
35. **Task C**: On D5, perform messa de voce using EP.
36. **Task D**: On D5, perform messa de voce using IP.

GROUP 7: Onsets to a Normal Adduction

37. **Task A**: Using IP, produce a breathy onset.
38. **Task B**: Using IP, produce a normal (balanced) onset.
39. **Task C**: Using IP, produce a glottal (pressed) attack.

Group 7: Excerpts

40. **Task A**: Sing the opening solo of “Scene 18” from Ursularia by Nicholas DeMaison.
41. **Task B**: Sing measures 48-55 of temA by Helmut Lachenmann.
1.3 RESULTS

In Examples 1.3.a1-3 and Examples 1.3.b1-3, the subject sang a major triad with the tonic beginning on D4 and then on G4 respectively using egressive phonation and then ingressive phonation in example. Strength and consistency starting near the third formant shows relatively less during ingressive phonation than seen in Example 1.3a1 for egressive phonation. The formants during ingressive phonation occur in the same range as during egressive phonation, but the higher harmonics are much weaker, indicating that the intensity of the output is lower and the laryngeal source has a steeper spectrum during ingressive phonation.

While Example 1.3.a1 using egressive phonation displays upper partials stretching above 4,000 hz, Example 1.3.b1 using ingressive phonation displays aperiodic noise content around 3,000 hz.

Using both egressive phonation and ingressive phonation, the subject performed glissandi through her entire range using an [a] vowel, shown in Examples 1.3.c1 and 1.3.d1. The ranges were similar for both egressive and ingressive phonations, about 200 Hz to 1,500 Hz, with slight increase in frequency using ingressive phonation. The spectrograms displaying the task show similar tendencies with formant response during ingressive phonation. The first and second formants are seen as the locations of relative darkness corresponding to the formant structure, but the third and fourth formants for the ingressive phonation (Example 1.3.d1) are relatively weak and inconsistent compared to that shown in Example 1.3.c1 for egressive phonation. There is also a significant amount of instability in the beginning of the ingressive sample, which is visible in the spectrogram.
The EGG waveforms for the arpeggio and glissando exercises show different amplitudes and pulse widths. The amplitude and width are both greater for D5 than for A4 for egressive phonation, which is consistent for the pitch difference. The relative reduced amplitude for the ingressive EGG waveforms suggest less vocal fold tissue contact and thus less adduction. This is consistent with the reduced spectral energy in the higher frequencies for ingressive phonation. It is more difficult to derive the adductory implication from the EGG pulse width and waveform shapes of the ingressive EGG signals.

Example 1.3.a1. Spectrogram of egressive phonation major triad arpeggios on [a] vowel beginning on D4 and G4
Example 1.3.a2. EGG for egressive phonation major triad arpeggios on [a] vowel beginning on D4 and G5. EGG is taken from A4. The top trace is the EGG signal and the bottom trace is the derivative of the EGG signal.

Example 1.3.a3. EGG for egressive phonation major triad arpeggios on [a] vowel beginning on D4 and G4: EGG of D5
Example 1.3.b1: Spectrogram of ingressive phonation major triad arpeggios on [a] vowel beginning on D4 and G4

Example 1.3.b2: EGG for ingressive phonation major triad arpeggios on [a] vowel beginning on D4 and G5. EGG is taken from A4.
Example 1.3.b3: EGG for ingressive phonation major triad arpeggios on [a] vowel beginning on D4 and G5. EGG is taken from D5.

Example 1.3.c1: Spectrogram of egressive phonation [a] vowel through entire range
Example 1.3.c2: EGG of egressive phonation [a] vowel through entire range obtained at the indication of the arrow in example 1.3.c1.

Example 1.3.d1: Spectrogram of ingressive phonation [a] vowel through entire range
Example 1.3.d2: EGG of ingressive phonation [a] vowel through entire range obtained at the indication of the arrow in example 1.3.d1.
The subject performed “formant glissandi” using vocal fry and shifting between vowels, shown in Examples 1.3.e1 and 1.3.f1. The vowel sequence was [o]→[a]→[æ]. The spectrograms display the expected upward shift in the first formant during the tasks. Notably, the formants appear stronger during ingressive phonation, and with stronger intensity in the area of the second formant, as well as higher intensity around 3,000 Hz. The EGGs of ingressive vocal fry indicate a longer glottal closed time. The ripple in the Example 1.3.f2 could reflect a physiological instability.

An excerpt from *temA* by Helmut Lachenmann is shown in Examples 1.3.g1-4. There are three notes sung in this excerpt, the first is a D4 sung ingressively, the second is a D5 sung ingressively, the third is a D5 sung egressively with a crescendo. This excerpt demonstrates that the higher pitched ingressive phonation engaged harmonic and formant energy more than the lower pitch ingressive phonation, and that egressive phonation had stronger harmonics and formants, especially during louder singing. The transition from ingressive phonation to egressive phonation appears slightly weak and unstable at first, but as the egressive note continues, the formants became stronger. Note that the EGG is wider for egressive phonation, Example 1.3.g2, suggesting longer glottal closed time each cycle, even though the effort seemed less. Thus, the ingressive EGG waveform suggests that it is more abducted even though it seems more effortful.

Spectrograms of messe di voce (crescendo and decrescendo) in Examples 1.3.h1-3 and 1.3.i1-3 illustrate once again the relative lack of upper harmonic and formant energy during ingressive phonation. These examples also clearly display the lack of natural vibrato during ingressive phonation. During egressive phonation, especially at the peak of the crescendo, the vibrato cycle is very clearly displayed in the
spectrogram. The inconsistancies in pitch and vibrato content during ingressive phonation are evident in the spectrogram (Example 1.3.i1).

Example 1.3.e1: Spectrogram of egressive vocal fry formant glissando.

Example 1.3.e2: EGG of egressive vocal fry formant glissando  [o] vowel
Example 1.3.e3: EGG Egressive phonation vocal fry glissando [a] vowel

Example 1.3.e4: EGG Egressive phonation vocal fry glissando [æ] vowel
Example 1.3.f1: Spectrogram of ingressive vocal fry formant glissando

Example 1.3.f2: EGG of ingressive vocal fry formant glissando [ae] vowel
Example 1.3.f3: EGG of ingressive vocal fry formant glissando [a] vowel

Example 1.3.f4: EGG of ingressive vocal fry formant glissando [o] vowel
Example 1.3.g1: Spectrogram of excerpt from *temA* by Helmut Lachenmann.

Example 1.3.g2: EGG of excerpt from *temA* by Helmut Lachenmann: Ingressive D5
Example 1.3.g3: EGG of excerpt from temA by Helmut Lachenmann: Egressive D

Example 1.3.g4: Score excerpt of temA by Helmut Lachenmann
Example 1.3.h1: Spectrogram of egressive messe di voce singing A4 on [a] vowel and using [pæ] syllable

Example 1.3.h2: EGG of egressive messe di voce singing A4 on [a] vowel
Example 1.3.i1: Spectrogram of ingressive messe di voce singing A4 on [a] vowel and using [pæ] syllable

Example 1.3.i2: EGG of ingressive messe di voce singing A4 on [a] vowel
Examples 1.3.j1-2 illustrate power spectral density for vocal fry using egressive and ingressive phonation, see respectively. Both examples were produced on an [a] vowel within formant glissandi. The ingressive vocal fry was taken slightly earlier in the glissando than the egressive sample. The first and second formant frequencies are very similar between egressive and ingressive phonation, but the ingressive sample illustrates higher relative power than the egressive sample (the first and second formants, near 700 Hz and 1,100 Hz, are 40 and 30 dB above the noise floor, respectively, whereas the egressive first and second formants are 35 and 25 dB above the noise floor). The third formant is also greater in the ingressive phonation relative to the noise floor.

Examples 1.3.k1-2 show power spectral density for egressive and ingressive phonation while singing a sustained [a] vowel on E5 using normal volume and effort. The first harmonic is similar in strength between egressive and ingressive phonation (egressive is only 3 dB greater than ingressive), but the second and third harmonic are much weaker during ingressive phonation. The fourth, fifth, and sixth harmonics are visible during egressive phonation, but are not as visible. They are about -20 dB lower for the ingressive phonation.

It is therefore interesting to note that during vocal fry, when extreme glottal adduction is expected, the spectral characteristics for the ingressive phonation are more intense (greater intensity) compared to egressive vocal fry, but for non-fry phonation, the opposite is found. That is, that the spectrum has greater intensity in all harmonics for the egressive phonation.
Example 1.3.j1: Egressive vocal fry using [a] vowel

Example 1.3.j2: Ingressive vocal fry using [a] vowel
Example 1.3.k1: Egressive phonation on E5, [æ] vowel

Example 1.3.k1: Ingressive phonation on E5, [æ] vowel
Airflow and subglottal pressure measurements are displayed in two ways. Table 1.3.a displays a comparison between egressive phonation and ingressive phonation for all 8 tasks, including the aerodynamic parameters average pressure, average flow, average flow resistance, and the percentage change between them from egressive to ingressive phonation. Table 1.3.b displays a comparison between the lower octave E4 and the higher octave E5 for each task for both egressive and ingressive phonation.

There was more similarity between egressive and ingressive phonation for the aerodynamic parameters, at higher pitch in general (Table 1.3.a). The highest percent change for the E5 pitch was 37%, but 10 out of the 12 comparisons changed by 20% or less. For the E4 pitch, there were greater differences between ingressive and egressive phonation, with ingressive having higher values for the pressure and flows for all conditions. The highest percent change was 50%, and 8 out of 12 comparisons changed more than 20% between egressive and ingressive phonation.

Ingressive phonation displayed a higher rate of airflow in all but one example (table 1.3.1), and that example is one of three in which the flow resistance was higher for ingressive phonation. The most similar results occurred during the higher octave pitch using normal loudness and breathy adduction (where pressure and flow resistance are nearly the same, Table 1.3.a).

There was always a relative (absolute) pressure increase during ingressive phonation at the lower pitch (Table 1.2.a). Furthermore, three out of the four ingressive phonation examples at the lower pitch had a pressure increase of more than 20% compared to the corresponding egressive phonations. In context, for three out of the
four conditions at the higher pitch, the pressure was lower during ingressive phonation than during egressive phonation.

The majority of the samples, 5 out of 8, yielded less flow resistance during ingressive phonation. This appears related to ingressive phonation using a higher airflow rate for those five conditions. For 2 of the 3 other conditions, the flow resistance was greater for ingressive phonation, the airflow was less for ingressive phonations. The normal loudness, breathy, higher pitch example is the only instance in which egressive airflow was higher than the ingressive phonation example, and it is only an 8% difference. Thus, airflow differences appear to be the primary phenomenon determining flow resistance, and may be related to the inferred greater abduction for ingressive phonation.

Pressure and flow resistance show large increases during egressive phonation using normal loudness between the lower and higher pitches (table 1.3.b). Specifically, there was more than 50% increase in pressure change, along with 47% and 38% flow resistance increases, respectively. Ingressive phonation shows similar increases in pressure and resistance between octaves for normal loudness with both normal and breathy adduction, but not as much as during egressive phonation (Table 1.3.b). During the louder tasks, the egressive tokens show a decrease in flow resistance for both breathy and normal adduction between the lower and higher pitch, while the ingressive phonation examples demonstrate an increase in flow resistance to only one of the loud tasks (loud, breathy) in the higher octave.

During ingressive phonation with normal loudness and normal adduction, there was a large increase in flow resistance between octaves (Table 1.3.b), but during
normal loudness with breathy phonation, there was less change in flow resistance between octaves during ingressive phonation, especially compared to egressive phonation, even though both pressure (33%) and flow (25%) increased for the higher pitch. Ingressive phonation shows a 7% increase between octaves during normal volume with breathy adduction, while egressive phonation shows a 38% change for the same task. The lowest pressure difference between the two pitches was between ingressive phonations during the louder volume, normal adduction task, which could be because pressure and airflow were already high during the lower octave for this ingressive task.

The pressure always increased between octave pitches (lower to higher), except during the loud and normal adduction ingressive task, for which there was a 7% decrease in pressure.

The lowest flow change occurred during the louder tasks using breathy adduction during ingressive phonation, changing less than 10% in both cases. During egressive phonation, there were increases in flow of 45% and 20% for the same tasks. There was always an increase in flow between octaves except for the ingressive phonation, normal adduction, normal loudness task, during which there was a 24% decrease is airflow between the lower and higher octave.
Table 1.3.a: Comparative chart: averages of [pæ] vocal tasks between egressive and ingressive phonation

<table>
<thead>
<tr>
<th></th>
<th>Egressive</th>
<th></th>
<th>Ingressive</th>
<th></th>
<th>Difference (absolute value)</th>
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<tbody>
<tr>
<td></td>
<td>Pressure (Cm H\textsubscript{2}O)</td>
<td>Flow (CC/s)</td>
<td>Resistance (kPa/(L/s))</td>
<td>Pressure (Cm H\textsubscript{2}O)</td>
<td>Flow (CC/s)</td>
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<tr>
<td>Pitch: E4</td>
<td>Loudness: Loud (f)  Adduction: Breathy</td>
<td>10.59</td>
<td>539.56</td>
<td>1.922501</td>
<td>-11.19</td>
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<tr>
<td>Pitch: E5</td>
<td>Loudness: Normal (mf)  Adduction: Breathy</td>
<td>14.61</td>
<td>583.64</td>
<td>2.465523</td>
<td>-14.39</td>
</tr>
</tbody>
</table>
Example 1.3.11: Subglottal pressure comparison: Egressive vs. Ingressive phonation

Example 1.3.12: Mean Flow Comparison: Egressive vs. Ingressive phonation
Table 1.3.b: Averages of [pæ] vocal tasks between octaves

<table>
<thead>
<tr>
<th>Loudness and Adduction</th>
<th>E4 (Lower Octave)</th>
<th>E5 (Higher Octave)</th>
<th>Difference (absolute value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure (Cm H₂O)</td>
<td>Flow (CC/s)</td>
<td>Resistance (kPa/(L/s))</td>
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<td></td>
</tr>
<tr>
<td>Loudness: Normal (mf)</td>
<td>7.13</td>
<td>455.94</td>
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<td>Adduction: Breathy</td>
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<td></td>
<td></td>
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<tr>
<td>Loudness: Loud (f)</td>
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<td>213.66</td>
<td>4.772562</td>
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<tr>
<td>Adduction: Breathy</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Loudness: Loud (f)</td>
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<td>539.56</td>
<td>1.922501</td>
</tr>
<tr>
<td>Adduction: Breathy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loudness: Normal (mf)</td>
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<td>-390.33</td>
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</table>

Flow Resistance Comparison:
Egressive vs Ingressive Phonation

Example 1.3.m1: Flow resistance comparison for egressive and ingressive phonation
1.4 DISCUSSION

Spectral Analysis

Spectral analyses suggest a reduced strength and consistency throughout the frequency range during ingressive phonation compared to egressive phonation. It is hypothesized that intensity is generally lower during ingressive phonation due to diminished efficiency in phonatory production. Decreased intensity during ingressive phonation results in weaker harmonics and diminished resonance. While egressive phonation often demonstrates upper partials stretching above 4,000 Hz, the harmonic content of ingressive phonation typically weakens above 1,500-2,000 Hz especially. It is hypothesized that less glottal adduction accounts for these differences. In contrast, vocal fry spectra have greater intensity across the relevant frequencies for ingressive phonation compared to egressive phonation. It is hypothesized that effectively greater glottal adduction accounts for these differences.

Pressure and Flow

When comparing the subglottal pressure and airflow between ingressive phonation and egressive phonation, there was more similarity between egressive and ingressive phonation for the higher octave pitches (E5) in general. It is hypothesized again that this may be due to relatively similar adduction conditions. In context the lower pitch results suggest that ingressive phonation typically will require higher subglottal pressures and flows.

The subject experienced difficulty sustaining the tasks during ingressive phonation due to limitations in lung capacity, and also found the ingressive samples to
be less stable with regard to pitch consistency and overall vocal quality. She noted that pitch and vocal quality did improve slightly with practice, and with these improvements, breath management became easier.

Using power spectral density plots, it is clear that the formants lie within the same frequency range for both egressive and ingressive phonation, but that the harmonics occurring during ingressive phonation have weaker levels within the formant envelopes. Harmonics during ingressive phonation demonstrated by the subject were typically 5-10 decibels weaker than the same harmonics during egressive phonation.

**Pitch**

The phonatory range was similar (about 200 Hz to about 1,500 Hz). There is a significant amount of instability in the beginning of the ingressive sample, which is visible in the spectrogram. Notably, the lower range is difficult to access during ingressive phonation. The subject noted that the high range, and especially the highest register, required nearly equal amounts of effort to produce between ingressive and egressive phonation, although, typically egressive phonation maintained higher intensity throughout the range.

**Vocal Fry and Formant Glissandi**

Vocal fry was produced using both ingressive and egressive phonation. The subject observed that vocal fry was easier to produce during ingressive phonation, especially the initial onset, and that ingressive vocal fry was easier to sustain. Perhaps
this is related to the experienced lowering of the larynx during ingressive phonation. Formants are stronger during ingressive vocal fry, with stronger content easily seen in the area of the second formant, as well as at around 3,000 hz.

The subject also performed formant glissandi using vocal fry by shifting between vowels. The vowel sequence was \[o\]→\[a\]→\[æ\], demonstrating a gradual increase in first formant frequency. During ingressive phonation the subject experienced easier shifts between formants.

*temA* by Helmut Lachenmann

In order to demonstrate and observe ingressive phonation within a musical context, an excerpt from *temA* by Helmut Lachenmann was analyzed because of the variety of tasks used in the piece. The excerpt that was recorded contained three notes which alternate between egressive and ingressive phonation. The first is a D4 sung ingressively, the second is a D5 sung ingressively, the third is a D5 sung egressively with a crescendo. Since a natural increase in intensity occurs in higher registers, the ingressive D5 contains stronger harmonics, including the first formant. Naturally, the egressive D5 displayed stronger harmonic content than the ingressive example, especially during the crescendo.

The initial transition from ingressive phonation to egressive phonation appears slightly weak and unstable. The subject produced a slightly breathy transitional onset between ingressive and egressive phonation, which is common and can be lessened with experience. Similar differences were found in the vocal permutations of Table 1.3.a and 1.3.b. The subject experienced more similarity in the production of egressive
and ingressive phonation in the higher octave pitches, whereas the lower octave pitches were more effortful using ingressive phonation as compared to egressive phonation.

**Messe di Voce**

The subject performed messe di voce (crescendo and descrescendo) on both A4 and D5 using egressive and ingressive phonation. Spectrograms of the tasks illustrated diminished intensity during ingressive phonation compared to egressive phonation. The crescendo is also more dynamic during egressive phonation. In general, the dynamic range is much greater during egressive phonation, especially with regard to louder dynamics. During messe di voce produced on both A4 and D5, ingressive phonation displayed significantly higher airflow rate throughout the task, but similar pressure levels as compared to egressive phonation. It is hypothesized that this occurs due to lower levels of glottal adduction during ingressive phonation as compared to egressive phonation, coupled with the generally lower efficiency in phonatory production of ingressive phonation.

The tasks were significantly more challenging for the subject during ingressive phonation, as the increased air flow required for crescendo severely limited the ability to sustain the vocal task for the same during ingressive phonation as was possible during egressive phonation.

**Vibrato**

Vibrato does not appear to naturally occur during ingressive phonation. The subject attempted to produce intentional vibrato and wobble during ingressive
phonation, in order to compare with the naturally occurring vibrato during egressive phonation. The resulting vibrato is slightly slower during ingressive phonation, occurring at a rate of approximately 4 pulses per second compared to approximately 5 pulses per second during egressive phonation. She compared the experience of producing vibrato during ingressive phonation to that of producing tremolo during egressive phonation, which is produced by rapid, intentional pitch fluctuation. Producing intentional vibrato during ingressive phonation was more effortful for the subject, and required increased airflow.
CHAPTER 2. THE USE OF INGRESSIVE PHONATION

IN CONTEMPORARY VOCAL MUSIC

2.1 THE HISTORICAL USE ON INGRESSIVE PHONATION

As a demonstration of how to use and interpret ingressive phonation in contemporary vocal music, works by Helmut Lachenmann, Georges Aperghis, Michael Baldwin, and Nicholas DeMaison have been analyzed with regard to vocal technique, notation, aesthetic orientation, and dramatic implications (where applicable). In these pieces, each composer incorporates ingressive phonation distinctively, creating integrated musical applications for the technique and successfully expressing their intentions with efficient and clear musical notation, score notes, and notational guides. They will be used as examples of successful use of ingressive phonation.

Use of ingressive phonation by composers throughout the latter 20\textsuperscript{th} century is also described, noting the aesthetic leanings of the composers and performers using the technique, as well as historical performances of the works listed.

The Historical Use of Extended Vocal Techniques

Extended vocal technique is a term applied to vocalization and phonation in art music which falls outside of traditional classical singing styles typically used in opera, art song, chamber music, choral repertoire, and other traditional genres, especially before 1950.\textsuperscript{47} Gwenellyn Leonard defines extended vocal techniques as “one which is trained and active as an instrument of conveying sounds but not limited to conveying texts…The sonic vocabulary which

\textsuperscript{47} Kavash, Deborah. "An Introduction to Extended Vocal Techniques: Some Compositional Aspects and Performance Problems." \textit{Reports from the Center for Music Experiment at the University of California, San Diego} vol.1, issue 2. 1980.
has been developing recently in New Music is a vocabulary of non-traditional sounds for the voice.”

Some of the first and most innovative extended technique users were the sound poets of the early-20th century, including Italian Futurist Luigi Russolo and DADA-ist Hugo Ball, who included whistling, murmuring, shouting, and other production “noises” in their performative sound poetry.

Extended vocal technique is a term applied to vocalization and phonation in art music which falls outside of traditional classical singing styles. Composers such as Luciano Berio and Karlheinz Stockhausen manipulated the human voice in their fixed media pieces *Ommagio a Joyce* and *Gesang der Jünglinge*, both of which had a great impact on vocal writing to follow. John Cage wrote *Aria* and *Solo for Voice 1* in 1958, and influential performers such as Cathy Berberian were dedicating themselves to contemporary and experimental art music performance, including the exploration of extended vocal techniques.49

Extended vocal techniques flourished in the 1960s and ‘70s thanks to prolific composers, performers, and improvisers who specialized in exploring experimental sounds and performance techniques. In the late 1960s and early 1970s, Meredith Monk formed her first experimental performance ensemble that developed large-scale works through improvisatory processes. Cathy Berberian continued to pioneer new works by Berio and many other living composers, helping to bridge the divide between classical vocal performance and vocal experimentation. The Extended Vocal Techniques Ensemble (EVTE) – who were responsible for labeling and classifying many of the techniques in use today – formed at the Center for Music Experiment at the University of Oregon, 1990.

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48 Leonard, Gwenellyn. *A proposal to expand solo vocal pedagogy to include selected extended vocal techniques*. University of Oregon, 1990.

Revolutionary performers such as Joan La Barbara, Julius Eastman, Roy Hart, and Jan DeGaetani continued to push the boundaries of contemporary voice composition and performance.

The Extended Vocal Techniques Ensemble was a leading force in the development and proliferation of contemporary and experimental vocal performance through the 1970s, with members such as Deborah Kavash and Trevor Wishart acting as performers, improvisers, and composers. Some of the notated works, including *The Owl and the Pussycat* were notated following extensive improvisatory work within the ensemble. The improvisations would delve into new techniques and draw on the individual performers’ interests, which included a large variety of divergent genres such as electronic music, traditional music from around the world, and sound poetry.

Other composer/performers working with extended techniques operated under a similar model to the Extended Vocal Techniques Ensemble, using various improvisational techniques and experimental processes to develop new vocal and musical languages, which were often notated after performance. Joan La Barbara, Meredith Monk, and Paul Dutton are notable for their work in improvisation and composition using extended vocal techniques. Monk and Dutton are known for the influential work created with their performing groups, while La Barbara is primarily recognized as a solo artist.

When composers choose to work with extended techniques, but do not plan to perform the composition, they often turn to performers to develop works specifically for their vocal capabilities. Luciano Berio with Cathy Berberian, George Crumb with Jan DeGaetani, Hans

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50 Kavash, 1980.
51 Kavash, 1980.
53 Kavash, 1980.
Werner Henze and Peter Maxwell Davies with Roy Hart – these collaborations led to revolutionary performances and works that have created a vast repertoire of extended techniques that new generations have continued to draw on for inspiration.

Many performer/composer/improvisers have carried on the tradition of experimental vocal exploration through the 20th and 21st centuries. Michael Edgerton, a composer and author of *The 21st Century Voice*, has taken great influence from his work in electronic media. Ken Ueno, Shelly Hirsch, David Hykes, Pauline Oliveros, Laurie Anderson, Theo Bleckman, Jenece Gerber, Nicholas DeMaison, Julia Feeney, Amirtha Kidambi, Cory Dargel, Jeff Gavett, Mary Nessinger, Pamela Z., Ted Hearne, Gelsy Bell, Paul Haughtaling, and other performers across disciplines and throughout the world continue to work with extended vocal techniques and develop works specifically tailored for their voices.

Composers still look to performers such as Tony Arnold and Donatienne Michel-Dansac for collaborative vision when creating new works for voice and the next generation of performers continue to be challenged by the inventiveness and ingenuity of living composers.

**Extended Techniques**

Extended vocal techniques vary greatly in production, style, usage, notation, and frequency within the repertoire. The more common extended techniques include whistling (using lips), diction-related techniques such as percussive consonant sounds, straight-tone (non-vibrato) singing, breath sounds, ululation, and vocal glissandi. More technically advanced and virtuosic techniques include reinforced harmonics, overtone singing, vocal fry, multi-phonics, complex

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vocal percussion patterns, and ingressive phonation, which typically appear less frequently in concert repertoire.

Since extended vocal techniques are not a common element of classical voice training, professional voice users have different levels of comfort with them, and some choose to avoid them altogether. Others successfully incorporate them in their practice while maintaining their involvement with standard repertoire and traditional vocal technique.

Other names for extended vocal techniques include “oral mode,” and “extra-normal voice.” A complete list of techniques would be vast and as diverse as the users of the techniques, but a list of some of the most common techniques found in the repertoire of the past 60 years is included as an appendix to this chapter.

The Historical Use of Ingressive Phonation

As noted above, some of the most significant developments in extended techniques, including ingressive phonation, stemmed from improvisation and experimentation within contemporary vocal ensembles, including the Extended Vocal Techniques Ensemble, as well as individuals such as Joan LaBarbara and Roy Hart. These pioneers of vocal technique have found idiosyncratic methods of involving ingressive phonation, along with other extended techniques, in their work. Within the classical concert music repertoire, ingressive phonation gained increased usage among performers and composers through the mid-late 20th century, as demonstrated by the increase in repertoire which involves the technique beginning in the late 1970s, 1980s, and after.

There are, of course, many reasons and motivations for incorporating ingressive phonation into a piece or performance. Some composers and performers utilize the practicality of inhaling while singing, therefore minimizing the amount of breaths required during performance.\footnote{La Barbara, Joan. \textit{Circular Singing}. Joan La Barbara. Rec. 2003. CD.} Another approach seeks to assimilate the voice into an instrumental or electro-acoustic aesthetic, attempting to blend seamlessly the vocal elements of a piece with non-textual, noise-based elements. Others seek the dramatic qualities inherent in ingressive phonation. Naturally, these delineations are not concrete, but rather serve to clarify certain aesthetic motivations behind the use of ingressive phonation.

**Musique Concrète Instrumentale**

As observed above, composers and performers in the latter half of the 20\textsuperscript{th} century sought to defamiliarize live music performance and the resulting acoustics through a variety of means. In 1968, Helmut Lachenmann, who was reaching a transformative period in his development,\footnote{Griffiths, Paul. \textit{Modern Music and after}. Oxford: Oxford UP, 1995.} had moved away from serial composition and had begun to manipulate the musical material of his pieces from a more textural approach. His “energetic” approach to musical composition aimed to revitalize our experience of classical music performance by focusing on the energetic process behind the music production, rather than suiting the performative technique to the desired acoustic result.\footnote{Hockings, Elke. “Helmut Lachenmann's Concept of Rejection.” \textit{Tempo} Vol. 3.No. 193. 1995.} Chris Swithinbank describes the musique concrète instrumentale ideology as such, “This method is particularly useful in approaching the elements of Lachenmann’s post-serial musical language that break away from easily divisible hierarchies of
pitch and rhythm and move towards what might be called timbral composition.”63 In an interview with David Ryan, Lachenmann explains:

The idea of ‘instrumental musique concrète’ - i.e. sound as a message conveyed from its own mechanical origin, and so sound as experience of energy, marked the compositional material of my pieces between 1968 (temA) and 1976 (Accanto). It remains part of my thinking as composer to this day. It signifies an extensive defamiliarization of instrumental technique: the musical sound may be bowed, pressed, beaten, torn, maybe choked, rubbed, perforated and so on. At the same time the new sound must satisfy the requirements of the old familiar concert-hall sound which, in this context, loses any familiarity and becomes (once again) freshly illuminated, even ‘unknown’. Such a perspective demands changes in compositional technique, so that the classical base-parameters, such as pitch, duration, timbre, volume, and their derivatives retain their significance only as subordinate aspects of the compositional category which deals with the manifestation of energy.64

The true import of temA in this study is the diversity of techniques used. Even when a technique is repeated, it is used in a different “energetic” manner, which, in turn, alters the method of production. For example, breath sounds appear multiple times throughout the piece, yet each iteration imitates different vocal respiratory situations including gasping, panting, sighing, etc.65 His use of extended technique was grounded in the physiology and gravity of sound production, with less concern for the specific aural result.66 The sound quality was representative of an energetic release. In the notes of temA, Lachenmann requests that the singer perform the techniques without emotion in order to avoid undue tension.67 However, the

65 Lachenmann, 1971.
theatrical and dramatic effects in the piece allow for interpretation, if not specific emotional narrative.

**Programmatic Intentions**

Extended vocal techniques have long been associated with madness and delusion. The sprechstimme in Arnold Schoenberg’s *Pierrot Lunaire* is an early and famous example, followed by Alban Berg’s *Wozzeck*, and numerous subsequent pieces. One of the most foundational demonstrations of extended techniques within a dramatic, programmatic context is Sir Peter Maxwell Davies’ *Eight Songs for a Mad King*. Composed specifically for baritone/actor Roy Hart, the piece incorporates a vast collection of techniques suited specifically to Hart’s unique vocal abilities and dramatic capacity. Although Hart tragically died shortly after the premiere of the work, subsequent performances have been frequent, and the piece remains one of Davies’ most recognized works.

The technical demands on the singer are immense in *Eight Songs for a Mad King*, including screaming, glissandi, Sprechgesang, an unusually wide pitch range, breath sounds, grunts, howls, vocal fry, and a complex and extensive list of multi-phonics. Davies worked closely with Hart in rehearsals to decide which multi-phonics to use based on Hart’s capabilities. Later performers have typically approximated the multi-phonics as closely as possible based on their own individual abilities.

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73 Manning, 2005.
The programmatic intent in using extended techniques as part of *Eight Songs for a Mad King* results directly from the characterization of King George III, the central character of the piece. Davies portrays George III, who descended into psychosis toward the end of his life, as fantastical, delusional, and demented, through both dramatic presentation and musical material. Davies describes his use of extended vocal techniques, stating that:

> The vocal writing calls for extremes of register and a virtuoso acting ability…

> The sounds made by human beings under extreme duress, physical and mental, will be at least in part familiar: with Roy Hart’s [Roy Hart was the first Mad King] extended vocal range, and his capacity for producing chords with his voice, the poems presented a unique opportunity to categorize and exploit these techniques to explore certain extreme regions of experience.74

Alan Shockley finds that the piece is not representative of a characteristic “mad scene,” typical in operatic tradition. Instead, he notes:

> There is no essential aspect of madness. So what do the extreme demands on the vocalist in *Eight Songs for a Mad King* tell us about reason and unreason: the insane king screams, he tortures his voice, he becomes fixated on phrases and repeats them, he shrieks, he sobs; during the fifth song’s “Pianoforte Rondino” he howls as a dog. But, he also sings as a well-trained baritone (in songs Four and Seven certainly). He sings as a conventional high-voiced lead at the opening of song seven’s “Country Dance (Scotch Bonnet)”. He even oversteps the bounds of time and performs not only as a singer of Handel, but as a Schoenbergian monodramatic…A ‘sane’ part would remain fixed in a single style, with a single message, probably with even a single vocal timbre or ideal voice. Sanity is denied. Sanity has its limits…it does so by reveling in the multivocality of a

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This interest in madness and loss of subjectivity in relation to extended vocal techniques finds home in many recent works, including Nicholas DeMaison’s *Ursularia*. Over the course of the one-act opera, the contradicting myths surrounding the life of St. Ursula are intertwined as the central character, St. Ursula, and her companion character, Ursula’s Immortal Soul, navigate the complex world of early Catholicism and the process of becoming a saint. The piece culminates in a dramatic “death” scene, during which Ursula and Ursula’s Immortal Soul become symbolically separated, thus concluding Ursula’s loss of subjectivity and ability to communicate.

“Scene 18: Wherein Ursula and Her Immortal Soul Lose the Power of Speech and their Luminescence” depicts the final struggle as a duet accompanied by fixed-media pre-recorded voices. After a vigorous cadenza performed by Ursula’s Immortal Soul, in which she describes the massacre of Ursula and the 11 (or 11,000) virgins, Ursula and her Immortal Soul begin the final duet. The musical material of the duet, in contrast with much of the opera, is somewhat simple, centering mostly around a diminished c# triad which eventually leads to a unison D natural as the final resting pitch. The textual material is derived from a graphic poem by Jessica S. Smith called *Poetry is Like Music*, and within the context of the performance translates into nonsensical phonemes, consonants, and vowels.

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Example: “Scene 18” from *Ursularia* by Nicholas DeMaison

It is in the context of this final scene that DeMaison introduces ingressive phonation. Ursula’s Immortal Soul begins by alternating between ingressive and egressive phonation over a two-octave melodic figure. The tempo marking is flexible, recit-like, and, as DeMaison describes, “…like slow breathing, somewhat unsteady.” This scene depicts the struggle, both emotional and physical, of loss, death, and subjective forfeiture. Ursula’s (and, by proxy, her Immortal Soul’s) voice is being drawn inward, both metaphorically and physically, creating disturbances within the momentum of the musical line, but also within the vocal quality and textual comprehensibility.

In performance, DeMaison allows for vocal disturbances (cracks, breathiness, instability), and prefers them to add to the dramatic execution of the piece. It seems as though he may have intended some vocal disturbance, since some of the ingressive vowels occur in transitional parts
of the range (E5), although the consonants which occur ingressively are some of the more easily reproducible consonants during ingressive speech/singing, namely [t], [b], [h], [w], etc. The most difficult of the consonants to produce during ingressive phonation of those selected is [v], since it is bilabial, fricative, and voiced.

The opera terminates with a stream of random, spoken consonants uttered by Ursula and Ursula’s Immortal Soul, becoming weaker and higher in pitch as they progress. Meanwhile the ensemble members rest their instruments, and play slide whistles as the two singers complete their physical and metaphorical separation from each other and from the physical world.

Circular Singing

In her piece Circular Song, Joan La Barbara sings continuously, using alternation of ingressive and egressive phonation, for 8 minutes and 29 seconds. The alternation between egressive and ingressive phonation is clearly audible in the recording, but the intention is not to disguise the shift between airflow directions. Rather, La Barbara nearly seamlessly vocalizes with clarity in tone and ease in production for what would typically be an impossible duration. Her tone is similar between egressive and ingressive phonation, and the alternations occur within ascending or descending glissandi, which illustrates her facility with the technique. She exhibits no apparent difficulty in producing a wide vocal range with either technique, and is able to produce smooth register shifts in both.

In his Récitations pour voix seule, Georges Aperghis skillfully dictates numerous extended techniques for the vocalist to exhibit both dramatic intent and virtuosic showmanship. Each recitation presents dramatic, vocal, and notational challenges to the performer, and often all

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three. For example, in *Récitation 1*, the performer must gauge the tempo and dynamic of each fragmented phrase based on its position within the page. The pitch material may be specified, but it could also be approximate, and the dramatic intention of each phrase is indicated below each fragment.

In *Récitation no. 9*, Aperghis requests that the vocalist sing continuously for the duration of the piece, which typically lasts around 6 minutes. The vocal lines consist of fast, wide leaps imitating percussive sounds and cover over a two octave range. In order to perform the piece according to instruction, the vocalist is required to select certain notes within the continuous line to perform ingressively without disrupting the vocal line. Unlike *Circular Song*, in which the vocalist alternates freely within a continuous vowel glissando, in performing *Récitation 9*, the vocalist must also consider specific pitches and consonants.

**Textural Intentions**

Two living composers have recently presented the author with pieces involving a considerable amount of ingressive phonation, and with some similarities in intention with their use of the technique. Aaron Einbond created his work *Without Words*\(^8\) using pre-recorded material, source recordings of natural sounds, large chamber ensemble, and high soprano voice. Michael Baldwin, by contrast, produced an unaccompanied vocal solo titled *Various Terrains (≡ of similarity)*\(^8\) using 11 staves, each indicating an individual parameter for the voice.

The stylistic divergence of Einbond and Baldwin’s works, especially philosophically, is great, yet there is similarity in their specific approaches to the voice. Both composers fragment and dissect the voice through various means, seek the limits of human performance, and desire a

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unique, textural landscape woven from the various parts and created through the transparent, and sometimes unstable, material interplay at work in their music.

Einbond’s use of ingressive phonation in *Without Words* is quite virtuosic. In the score, he asks the vocalist to phonate ingressively as high as D6, and as low as F#3. He also indicates the amount of breathiness or pressure in the resultant sound and often includes elements of vocal fry in addition. Moreover, Einbond asks for this complex combination of techniques as the vocalist articulates various text fragments. Typically, the text is comprised of nonsensical or out of context fragments, and at times, entire phrases are to be delivered ingressively, which prevents narrative understandability.

Example: *Without Words* (2012) by Aaron Einbond
Soprano

- Breath only (whispered).
- Half breath, half-sung.
- Sung *ordinario*.
- Sung at approximate pitch (*sprechstimme*).
- Spoken at approximate pitch.

- *Staccatissimo*: tongue palate explosively with almost no diaphragm support.
- *Inspirando* (inhaled); may be combined with other techniques.

Exhaled when not otherwise indicated.

- Glottal fry on inhale, exhale.

Bracketed text to be sung or spoken in a speech-like rhythm for the duration indicated.

Example: Performance notes for *Without Words* by Aaron Einbond (2012)
The ensuing aural landscape is one that Einbond describes as a “woven musical tapestry.” Unlike Lachenmann’s energetic approach to sound production, Einbond is very specific about the resultant sound of the diverse techniques he uses throughout the piece. Members of the ensemble, including the vocalist, take turns as soloist, which allows brief flickers of sparse clarity in which the dramatic extended techniques are featured. When the entire ensemble is playing, the instrumental techniques and electronic material blend seamlessly with the vocal line, creating a harmonious framework.

Michael Baldwin’s *Various Terrains (≡ Degrees of Similarity)* is an unaccompanied vocal solo that stems from a school of complexity relating to Brian Ferneyhough, Michael Finnissy, Jason Eckardt, Aaron Cassidy, and others. The score is presented as an impossibility, a contradiction. Consisting of 11 staves, which are to be performed simultaneously by a single vocalist, the synchronized performance of all eleven staves is physically, if not visually, paradoxical. Baldwin acknowledges this predicament, intending that the performance result from an attempted translation of the score.

This translation, beginning as the composer interprets his thoughts into notated form and finishing with the performer aurally transmitting their personal translation, completes a semiotic cycle in which no two resultant performances will be identical. The composer maintains rigid, extreme control over the material during the notational process, producing a visually stunning, if intimidating, score, without genuine awareness of the aural result of the notation. The performer’s interpretation creates another layer of meaning within the semiotic process.

The ingressive phonation techniques Baldwin incorporates are pretty basic in principle. He uses pitched ingressive phonation, some ingressive vocal fry and breath sounds, and some ingressive consonants. The difficulty of using these ingressive techniques occurs when the
vocalist is asked to simultaneously produce a sound, such as whistling, that is difficult to produce ingressively. The performer, in turn, must make a choice, must interpret and translate. The outcome is a tenuous musical texture with momentary flickers of clarity, popping through the surface.

Example: Various Terrains (≡ Degrees of Similarity) (2011) by Michael Baldwin
### Example: Common Extended Techniques and Their Definition

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaryngeal Speech</td>
<td>Speech created with non-laryngeal airflow including esophageal, buccal, and pharyngeal air manipulation</td>
</tr>
<tr>
<td>Bi-labial Trill</td>
<td>Air directed between closed lips so as to cause them to vibrate</td>
</tr>
<tr>
<td>Flageolet</td>
<td>The extreme upper range of the laryngeal voice, producing a whistle-like vocal tone, during which the vocal folds remain slightly separated</td>
</tr>
<tr>
<td>Ingressive phonation</td>
<td>Laryngeal voice produced during inhalation</td>
</tr>
<tr>
<td>Ingressive Whistle</td>
<td>Whistle produced at the lips during inhalation</td>
</tr>
<tr>
<td>Gibberish</td>
<td>Production of non-linguistic or pseudo-linguistic phonemes</td>
</tr>
<tr>
<td>Growls, grunts, howls, etc.</td>
<td>Imitation of animal sounds or “primitive,” non-linguistic sounds</td>
</tr>
<tr>
<td>Other breath sounds</td>
<td>Sounds produced by exaggerating common breath noises such as inhalation, exhalation, breathing through the teeth or other obstructions, breathing loudly through the sinus cavity, etc.</td>
</tr>
<tr>
<td>Reinforced Harmonics</td>
<td>Using alternate positions of the tongue and lips, certain harmonics can be enhanced resulting in a whistle-like tone above the fundamental frequency</td>
</tr>
<tr>
<td>Screaming</td>
<td>Extreme form of phonation typically produced in the upper register characterized by pressed phonation and very high subglottal pressure</td>
</tr>
<tr>
<td>Sprechgesang</td>
<td>A hybrid of speech and singing in which the singer will often slide to and from a notated pitch</td>
</tr>
<tr>
<td>Sustained Fricatives</td>
<td>Consonants such as [f] [s] [ʃ] [ʧ] [v] and others sustained beyond typical speech duration</td>
</tr>
<tr>
<td>Tongue Clicks</td>
<td>Clicks created through suction between the tongue and other areas of the oral cavity including the alveolar ridge, the teeth, the soft palate, and the lips</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Tongue Trill</td>
<td>Air directed between the tongue and either the alveolar ridge, the lips, or the teeth, causing tongue vibrations</td>
</tr>
<tr>
<td>Tremolo</td>
<td>Periodic, voiced pitch alternation of more than a semitone</td>
</tr>
<tr>
<td>Ululation</td>
<td>Periodic voice alternation, typically in the high register, resembling a trill and produced by either aspiration[h], or through glottal stops</td>
</tr>
<tr>
<td>Vocal Fry</td>
<td>Produced in the extreme low register with very high adductory pressure with very low airflow; produces “pulse” or “click-like” sounds</td>
</tr>
<tr>
<td>Voiced Whistle</td>
<td>Producing voice while whistling</td>
</tr>
<tr>
<td>Whistling</td>
<td>Tone produced with airflow through slightly rounded lips, causing turbulence in the airflow</td>
</tr>
<tr>
<td>Yodeling</td>
<td>Fast shifts between upper and lower registers, emphasizing the change in tone between registers</td>
</tr>
</tbody>
</table>
2.2 PEDAGOGICAL CONSIDERATIONS OF INGRESSIVE PHONATION

Without effective instruction, singers risk becoming injured or developing pathologies in any style of singing, including ingressive phonation. As Elsa Charleston stated in a classic interview with Bruce Duffie in 1995, "What ruins the instrument in the throat is bad singing. It’s not the music." Ingressive phonation presents a unique challenge to the singer and a singular opportunity for researchers. The challenges of ingressive phonation serve to expand our knowledge of laryngeal function, vocal pedagogy, and style in vocal music.

Ingressive phonation lies outside the scope of most voice pedagogy resources. There has been continuous development of pedagogical research concerning vocal technique and instruction for singers for centuries, yet current mainstream research still largely overlooks extended vocal techniques. Several texts on contemporary vocal technique have been produced in the past 20 years, but the central pedagogical texts that are typically used in educational settings (including wonderful resources by Dame Meribeth Bunch, Richard Miller, James McKinney, and Ingo R. Titze) generally exclude extended vocal techniques.

The importance of developing a pedagogy for ingressive phonation, as well as other contemporary singing techniques, which is suitable for the developing singer, is paramount. The ability to instruct a variety of students is already expected of voice professionals, as reasoned by Richard Miller when he states that “a good teacher must be able to objectify the components of performance and convey them to the student, regardless of the student’s voice category.”

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basic understanding of the principles behind contemporary techniques is essential in training the complete singer, who is likely to be called upon to perform works of 20th and 21st century composers.

As the group of professional singers who identify as “contemporary music specialists” continues to grow in number, it is imperative that the voice community accumulate a body of research to understand the techniques and implications of contemporary vocal music and contribute to the lineage of pedagogical research.

Breathing and Breath Management

During normal, egressive phonation, the first step during the phonatory process is inhalation. For most classical voice training, a balanced inhalatory process includes the abdominal muscles, the diaphragm, the external intercostal muscles, and the lower and middle back muscles. The larynx naturally lowers during inhalation, and the soft palate might rise as though the singer is approaching a yawn.

To produce ingressive phonation, the process necessitates that the singer exhale prior to the phonatory process. Following exhalation, air is pulled inward, as though the singer in inhaling, through partially- or fully-adducted vocal folds. Air moves from the sinus and/or oral/pharyngeal cavities, through the glottis and into the lungs. The muscles involved in balanced ingressive phonation are similar to those used during inhalation for egressive phonation, although they will be used in reverse order. Efficient inhalatory coordination will involve a low feeling of support, with diaphragm activation, a widening of the lower back, expansion of the ribcage, and relaxed chest and shoulders. It is important that the exhalatory process preceding

88 Bunch, 1982.
gressive phonation does not cause the chest to collapse or the posture to slacken. This requires that the abdominal muscles control most of the exhalatory process, allowing the chest to stay elevated and stable.

Due to the limitations imposed by lung capacity, as well as the natural increase in airflow required during ingressive phonation, potential phrase-length decreases slightly, but with training and improved efficiency in breath management, singers can extend the length of phrases they are able to produce during ingressive phonation. Orlikoff notes that:

[A]dult anatomy and physiology is not well-suited to prolonged phonation driven by an inspiratory airflow. The supraglottal airway cannot match the conus elasticus in its ability to funnel a laminar flow toward the glottis. Furthermore, when viewed superiorly, the vocal folds naturally assume a divergent operating point. In theory, this divergence would increase glottal resistance while hindering aerodynamic coupling to the vocal fold mucosa.\textsuperscript{90}

The conus elasticus is a ligament sheet continuous with and inferior to the vocal ligament. The convergent shape of the inferior vocal fold surface from the trachea to the glottal entrance is less ideal for ingressive phonation, as noted by Orlikoff.\textsuperscript{91}

**Onset and Release**

Contradictory muscular processes must be trained in order to phonate ingressively,\textsuperscript{92} including adducting the vocal folds. That is, during inhalation, the vocal folds naturally abduct, creating the necessary opening of the glottis required for respiration. During phonation, however,

\textsuperscript{90} Orlikoff, 1997.
\textsuperscript{91} Orlikoff, 1997.
\textsuperscript{92} Eklund, 2008.
the singer must resist this natural tendency by either partially or fully adducting the vocal folds.

As Kelly points out:

Mechanical forces also may contribute to smaller [membranous contact quotient] during [ingressive phonation]. Increased vocal fold abduction during [ingressive phonation] for example, is consistent with speculation that tracheal pull by descent of the diaphragm might serve to dilate the glottis. A caudally directed force on the larynx is thought to be exerted by descent of the diaphragm, lowering of the carina, and, subsequently, an indirect pull on the elastically coupled tracheal rings. 93

To counteract the tendencies indicated above requires either the initiation of a suction effect between the two vocal folds created through the pull of airflow by subglottal forces, or a more aggressive, “glottal” onset. The former will produce a breathier onset, similar to a surprised gasp. The latter option initiates the sound with increased adductory pressure, and could be slightly fatiguing at first, but will eventually lead to increased muscular facility, and will be lessened in pressure over time.

Especially during early interaction with ingressive phonation, there may be a longer phonatory onset time as the adductory muscles are retrained to adduct during inhalation. 94 The onset time typically decreases with training and experience. To aid in ingressive onset training, ingressive lingua-velar plosives such as [g] can be applied before a vowel. Or, by contrast, [h] can be useful early in the training process to lessen adductory tension and aid in gentle ingressive onsets.

**Resonance**

93 Kelly, 1999.
94 Ng, 2010.
Researchers have noticed increased breathiness during ingressive phonation, probably due in part to the decreased vocal fold adduction. This breathiness can be counteracted with training in coordinated ingressive onsets as well as increased vocal resonance. Similar to egressive phonation, clarity in tone and increased resonance during ingressive phonation is aided by a raised soft palate, sufficient vocal fold adduction, stable and relaxed larynx in a comfortably low position, and “engagement in the resonating cavities” including the oral, pharyngeal, and sinus cavities.

The oral and pharyngeal cavities are incredibly malleable, and manipulation of the cavities greatly alters resonance during ingressive phonation. The position of the tongue and soft palate, the resonance of the sinus cavities, and the amount of space within the oral cavity greatly affect the quality and clarity of ingressive phonation. As with egressive phonation, each singer will require a different balance of acoustics within the pharyngeal and sinus cavities, but in general, a lifted soft palate and relaxed jaw and tongue will aid in establishing acceptable resonance and warmth in vocal timbre.

Range and Register

Some vocalists have noticed an increased pitch range during ingressive phonation, especially in the upper part of the range. Others experience a similar vocal range with easier access to the extreme areas of the upper range including whistle register. The increased upper range is possibly owed to the natural lengthening and thinning of the vocal folds during ingressive phonation.

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96 Orlikoff, 1997.
In some cases, the range may be diminished in the lower end of the range. The lengthening of the vocal folds during ingressive phonation counteracts the ability for some singers to access this range and encourages vocal fry at a higher range than during egressive phonation.

During ingressive phonation, most individuals are able to access head and falsetto register and it seems that the transition between registers happens lower. Again, this is possibly due to the natural lengthening and thinning of the vocal folds during ingressive phonation. As a result, “thyroarytenoid dominant” production is hard to execute and “cricothyroid dominant” production tends to be more accessible during ingressive phonation.

Pitch Accuracy

Findings from several studies suggest that there is a natural pitch increase during ingressive phonation due to the lengthening and thinning of the vocal folds. The studies dedicated to these findings typically requested non-musical (i.e., speech-based) tasks.\(^97\) Other studies have noted an increase in perturbations such as jitter, which will also detract from perceived pitch accuracy.\(^98\) Jitter is the deviation from periodicity of a signal. Simple vocal tasks, including scales and other basic musical phrases, can aid in the training of pitch accuracy.

Loudness

Findings are inconsistent as to whether ingressive phonation results in increased or decreased loudness,\(^99\) however many singers experience a decreased range of dynamics. This could result from reduced air capacity, decreased vocal fold contact during each vibratory cycle,

\(^{97}\) Ng, 2010.  
\(^{98}\) Orlikoff, 1997.  
\(^{99}\) Ng, 2010.
lack of experience/training, and specifically a reduced translaryngeal pressure. Singers can help offset this challenge with increased resonance.

**Fatigue and Dehydration**

Loss of moisture on the surface of the vocal folds is a great risk for singers during ingressive phonation. If the onset is too breathy, or the airflow is too sudden or fast, or the phonation period is exceedingly long, the vocal fold exposure risk is higher, and they may become dried out or produce a coughing reflex.

It is possible to create a slight protective barrier between the oral cavity and the glottis with the tongue, but this could increase the amount of overall tension during phonation, and could also negatively alter the vowel. Singers can work to balance their onset so that the vocal folds do not experience a sudden burst of airflow, and as coordination increases, the amount of airflow required during phonation will lessen. Practicing onsets which being with a closed-mouth consonant such as [m] or [n] will provide some moisture from the nose, resonance reminder, and aid in the adduction process.

Some singers, especially those with less experience using ingressive phonation, may experience vocal fatigue as a result of using the technique. To lessen the risk of fatigue, singers should only produce ingressive phonation for short amounts of time when training, and should alternate between periods of ingressive and egressive phonation. As the muscles are trained to resist the process of abducting during inhalation, their ability to sustain ingressive phonation should increase.
Table: Ingressive Phonation Techniques

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternation</td>
<td>Change between ingressive and egressive airflow while maintaining continuous phonation</td>
<td>The change between ingressive and egressive airflow is typically audible, but the airflow remains mostly continuous.</td>
</tr>
<tr>
<td>Breath Sounds (e.g. gasping, sobbing)</td>
<td>Imitation of typical breathing sounds within a musical context. Often the sounds are intensified or exaggerated for performance.</td>
<td>Often unpitched and “unvoiced,” meaning little to no pitch content.</td>
</tr>
<tr>
<td>Ingressive Glissando</td>
<td>A continuous pitch slide from low to high, or from high to low. It can be between two specific pitches, but is not always specified.</td>
<td>Some singers will experience register shifts during ingressive phonation which do not occur during egressive phonation. These become more obvious during ingressive glissandi.</td>
</tr>
<tr>
<td>Ingressive Multiphonics</td>
<td>Production of multiple pitches simultaneously by a single voice using a variety of techniques.</td>
<td>While many performers prefer to produce multiphonics egressively, due to the decreased lung capacity of ingressive phonation, it is possible to produce multiphonics ingressively.</td>
</tr>
<tr>
<td>Ingressive Vocal Fry</td>
<td>Extreme low register produced with high adductory pressure with very low airflow, produced on the inhalation.</td>
<td>Some performers find this preferable to egressive vocal fry, due to the easy access to vocal fry during ingressive phonation. It can often be difficult to avoid vocal fry during ingressive phonation. Ingressive vocal fry sounds nearly identical to egressive vocal fry.</td>
</tr>
<tr>
<td>Ingressive Whistle Register</td>
<td>Extreme high pitch register produced with partially adducted vocal folds, high tension in the vocal ligament, high airflow.</td>
<td>Some singers may be able to access ingressive whistle register who cannot typically access egressive whistle register.</td>
</tr>
<tr>
<td>Pitched Ingressive Phonation</td>
<td>Phonation on the inhalation that most closely imitates a normal, egressive method of singing.</td>
<td>Ingressive phonation typically sounds different from egressive for most singers.</td>
</tr>
</tbody>
</table>
2.3 COMPOSING WITH INGRESSIVE PHONATION

There are multiple methods of notating ingressive phonation. The two most common forms are a \( \vee \) above the note or a directional arrow \( \leftarrow \). Both of these methods can be clear, depending on how they are incorporated. There is no strict method for notating ingressive phonation as long as the notation is consistent and does not require further visual marking from the performer.

The \( \vee \) is an effective method of notation and is used by many composers including Helmut Lachenmann. The \( \vee \) typically appears above the staff but can occur within the stem of the note as well. When included within the stem, it is important to make the \( \vee \) large enough to be clearly visible from performing distance. Since the \( \vee \) will be competing with both the note stem and the staff visually, it can easily become lost or muddled within the context of the score.

To signify a return to egressive phonation, a bracket-down symbol such as \( \sqcap \) is very common. Some composers choose to forgo the bracket indication, but in certain cases, if there are numerous or continuous shifts between ingressive and egressive phonation, it can be quite helpful. As with the \( \vee \) indication, the bracket can be placed above the staff or within the note stem. Lachenmann places both the \( \vee \) and \( \sqcap \) above the staff in *temA*:

Example: *temA* by Helmut Lachenmann
Aaron Einbond’s use of the ∨ symbol in *Without Words* (2011) works seamlessly with the complex notation of the piece. He uses multiple symbols within each note, so the clearest place for the ingressive phonation symbol is above the note. He does not indicate the return to egressive phonation:

Example: *Without Words* by Aaron Einbond

The ∨ within the stem of the note is used well by Michael Baldwin in *Various Terrains* (=of Similarity) (2011). For this piece, a variety of techniques are used simultaneously, requiring multiple notational devices within single notes both above and below each of the 11 staves. In this case, it is best to use the ∨ on the stem of the note to avoid over cluttering the visual space above the staff. Baldwin also indicates the return to egressive phonation within the note stem:
Example: *Various Terrains* (= of Similarity) by Michael Baldwin

Indicating ingressive phonation using arrows is also very effective and can often be more visually immediate than a \( \uparrow \). In *Ursularia* by Nicholas Demaison, the arrow indications occur only on the ingressive notes and not on the egressive notes. The opening lines require a good deal of back and forth between ingressive and egressive phonation, and the arrow helps increase clarity of the fast changes:

Example: “Scene 18” from *Ursularia* by Nicholas Demaison (2006)
These four examples demonstrate the most basic form of ingressive phonation indication within a score. Each score is indicating further delineations of ingressive phonation as well, including ingressive vocal fry, snorting, and Sprechstimme, to name a few. As with performing ingressive phonation, there are endless variations of how to notate the different variants of ingressive singing. The goal should be to make the score as descriptive and clear as possible when seen from a performance distance.

**Breath Sounds**

Breath sounds can be indicated with the note head on the stem, or above the note. The most common way to indicate an “unvoiced” sound is with a hollow note head, often using a variation of the note head shape, such as a square. Any further specifications (gasp, sob, etc.) can effectively be notated with text indications in the score, or the composer can indicate further combinations within the legend. For example, an empty note head with an arrow upward and a ▼ above the staff might indicate a gasp.

**Glissandi**

Ingressive glissandi are notated similarly to egressive glissandi. In *temA*, Lachenmann indicates glissandi with a line – either curved or straight, depending on the contour – in the direction of the pitch change. Note in the excerpt directly below the combination of ingressive and egressive markings, the relative-pitch note heads, and the further text indications above and below the note. The most challenging aspect of ingressive glissandi is the onset, since it may take longer for the vocal folds to begin vibrating, delaying the pitch slide. Lachenmann alleviates this difficulty by beginning the ingressive glissando with an [h] in the first example. He does not
begin the egressive glissando directly after with an [h]. Simple variations of this technique include multi-directional glissandi, indication of specific pitches to begin or end the glissando, vibrato or tremolo during the glissando indicated by a wavy line, and character indications such as gasp, shriek, sob, etc.

Examples: *temA* by Helmut Lachenmann
Alternation

To notate alternation, composers can simply utilize the arrow notation or the \( \triangledown \) and \( \sqcap \) symbols. Another option is to use alternating note heads. This system works best if the note heads are not being used to notate other directives such as Sprechstimme, pitch, etc. In Chris Chandler’s *Through a Glass Darkly* (2011), he alternates between directional triangle noteheads to indicate the direction of airflow:

Example: *Through a Glass Darkly* by Chris Chandler

Later in *Through a Glass Darkly*, Chandler uses a different alternating technique which resembles panting. It is notated freely, allowing the vocalist to control the tempo and airflow rate. He indicates phonemes for the vocalist, but allows them to control the syllabic output.

Example: *Through a Glass Darkly* by Chris Chandler
Lachenmann also uses a panting technique in *temA*, indicating the alternation with \( \checkmark \) and \( \nabla \) notation, but making note that the technique is “ad lib.” He does not specify vowel, consonant, pitch, or rhythm:

![Notation Example](image)

**Example: temA by Helmut Lachenmann**

When using alternation techniques, it is helpful if there are pauses in order for the singer to reset themselves. Often, singers can maintain the alternation technique for long periods of time, as Joan LaBarbara does in her piece *Circular Song* in which she sings continuously for over eight minutes. It is also possible to become lightheaded when using alternating techniques which require a large volume of airflow.

In “Hot” from *Haiku* by Jenece Gerber, the composer uses “x” note heads to indicate relative pitch, illustrating the contour of the vocal line, and notes at the beginning that the singer will alternate between ingressive and egressive airflow to produce the line. She does not specify which pitches should be ingressive, instead allowing the vocalist to choose. The alternation is very fast, similar to panting, and the melodic line covers a very wide range. The effect is something like a squeaky dog toy. The alternation technique, when used in this way, can easily cause lightheadedness, but Gerber allows breaks within the line during which the vocalist can reset their airflow.
Georges Aperghis uses a pitched alternation technique in the *Récitations pour voix seule* (1978). In *Récitation 9*, he indicates that the singer should perform the piece continuously, without pause, for the duration of the piece. Aperghis does not indicate which pitches within the continuous melodic line the vocalist should produce ingressively, allowing the singer the agency to choose which pitches and consonant/vowel combinations are comfortable for them during inhalation. Some of the consonant combinations are difficult or impossible to perform ingressively with the same result as their egressive counterparts, but the consonants assist in the ingressive phonation, allowing for breath activation before the vocal onset. This is a very virtuosic use of alternation techniques, and many vocalists perform the piece with quick breaths rather than ingressive phonation.

**Vocal Fry**

Vocal fry sounds nearly identical between ingressive and egressive phonation and may be easier for some to produce ingressively. Since it is such a similar aural result, the composer could allow the vocalist to choose the direction of the vocal fry based on their preference.

Some scores will indicate a pitch, either relative or specific, using vocal fry. Since vocal fry is inherently produced below pitched singing range, it is not possible to produce vocal fry within the singing range. A vocalist can alter the perceived pitch and overtones of the vocal fry by tuning the formants with various vowel shapes.

Sometimes it is indicated for the singer to “glissando using vocal fry,” but this is also inherently impossible, since vocal fry occurs at the lowest vocal range and is nonperiodic. Using either egressive or ingressive phonation, the composer may indicate a “formant glissando” which is achieved by shifting between vowels, and tuning the resonating cavities to the formant spectrum from the first formant for the [u] vowel to the highest formant for the [i] vowel.
Ingressive Whistle Register

Ingressive whistle register does not require a unique form of notation or score indication, but it should be used sparingly and can often be indicated effectively with only relative pitch indication. In “Miss Leaf Bug” from *Haiku*, Gerber uses an upward arrow to indicate “highest comfortable pitch.”

Much of Einbond’s *Without Words* hovers in the extreme whistle register. He indicates both ingressive and egressive techniques in the extreme register, but often designates only relative pitch area. He indicates “relative pitch” or “Sprechstimme” using an “x” on the stem of the note.

Consult with a Vocalist

The most important step to take when using ingressive phonation as a composer is to consult with a singer. If it is possible to consult with the vocalist who will be performing the piece, that is preferable, since each singer will have different comfort levels and abilities with ingressive phonation. Some singers choose not to use ingressive phonation, and some will only perform some ingressive techniques or techniques within a certain pitch range.
2.4 IMPLICATIONS AND CONSIDERATIONS FOR PERFORMERS AND COMPOSERS

The following discussion is a summary of information, research, personal performance, and pedagogical experience by the author regarding performance, training, and composition for ingressive phonation.

There are unique considerations when composing or performing with ingressive phonation, including dissimilarities in breath support, phrase length, register, loudness, vibrato, range, and diction. The implications for composers go beyond notation and include issues of singability and health considerations. Performers should consider the particulars of practicing works with ingressive phonation and develop individual approaches appropriate for their vocal capabilities and sensibilities.

Frequency, Duration, and Intensity

The level of experience and comfort singers have with ingressive phonation will determine the amount and intensity of ingressive phonation they will likely be willing and able to perform. For less proficient vocalists, ingressive phonation should be limited to very short phrases or single notes within the central octave of the vocalist’s range, focusing primarily on non-pitched techniques such as breath sounds and unvoiced sounds. For example, in The Body Electric (2011) by Jamie Leigh Sampson, she incorporates brief moments of ingressive phonation in the middle register within the context of longer, egressive phrases:

Example: from The Body Electric by Jamie Leigh Sampson (2011)
In general, ingressive phonation techniques that are less voiced and within the central portion of a singer’s range are safer and easier to approach. As the vocalist develops facility with ingressive phonation, using pitched techniques in higher and lower extremes of the range, vocal fry, and other timbral variations, increased duration and frequency of ingressive phonation may be possible.

**Phrase Length**

The efficient, funnel-like entrance to the glottis during egressive phonation creates ideal conditions for sustained phonation with use of coordinated breath management. Due to the limits of lung capacity, however, sustaining capacity is severely diminished during ingressive phonation. Ingressive phonation styles that are especially breathy, such as gasping and ingressive whispering, are particularly difficult to sustain.

Techniques which are more voiced, either using pitch or not, allow for longer phrase length. As the volume and register increases, the duration may shorten, as higher and louder phrases generally require more airflow.

**Register**

The register shifts during ingressive phonation may occur at lower pitches than during egressive phonation. Some singers may not be able to access chest register at all, making it difficult to produce notes within their lower range. If singers are able to access the chest register using ingressive phonation, they may find that it is particularly prone to slip into vocal fry and might feel more tenuous. The safer and more consistent option is to emphasize the head register during ingressive phonation, especially for new users of the technique.
Composers may consider consulting with a vocalist about the location of their register shifts during ingressive phonation. The areas of register shifts may be slightly unstable for some singers during ingressive phonation and may cause audible transitions during glissandi or moving melodic lines.

**Loudness**

Loudness and resonance are diminished during ingressive phonation, causing the voice to be more easily covered during loud or dense musical textures and to disappear faster in large spaces and other acoustically unfriendly situations. As with egressive phonation, the higher range has more natural volume and resonance.

Along with diminished volume and resonance, dynamic range may be limited during ingressive phonation. Whereas during egressive phonation, a singer may be able to access a dynamic range of $pp$ to $fff$ depending on the musical range and style of singing, during ingressive phonation, some singers have difficulty producing very quiet or very loud dynamics. This is not consistent between singers, and dynamic control during ingressive phonation may develop with increased experience.

**Vibrato**

Vibrato does not naturally occur during ingressive phonation, but some singers may be able to produce a vibrato-like ornament, trill, or wobble to imitate vibrato.
Pitch

The frequency range available to singers during egressive phonation will likely be different during ingressive phonation. Some singers may experience an increased upper register or easier access to whistle register and falsetto during ingressive phonation. Male singers may find it easier to access falsetto register, and female singers may find it difficult to access chest register. Female singers, in particular, may have a diminished lower pitch range, or may find that vocal fry register begins earlier in their range.

Diction

Issues of diction arise during ingressive phonation. Most vowels can be easily understood during ingressive phonation, but certain consonant sounds are difficult or impossible to precisely reproduce. The reversal of airflow can destroy the necessary airflow-acoustic interaction such as with [s], unless modifications (such as lip protrusion) are used to create approximations.

Hydration

As a result of the airflow direction, there is a danger of becoming dehydrated during ingressive phonation. The flow of air directly against the vocal folds during phonation without the benefit of added moisture from the lungs along with the risk of microscopic debris in the unfiltered air (typically filtered through both the nose and lungs) is a serious obstacle during ingressive phonation. To reduce the risk of dehydration, the singer can create a slight barrier with the tongue by raising it slightly in the back of the mouth, especially during onset. Composers should be mindful of this risk and allow for adequate recovery time between bouts of ingressive phonation.
Endurance

If a singer has little experience with ingressive phonation, they may become fatigued quickly when using the technique. Composers working with vocalists who are less familiar with the technique may benefit from working directly with the singer to obtain better understanding of their limitations with regard to duration and amount of ingressive phonation within the context of a piece. It is advantageous to provide adequate recovery breaks during the instances of ingressive phonation, either complete rests or moments of egressive phonation, to allow the singer to equalize their breath, moisten their vocal folds, and allow the muscles to rest.

Practicing and Rehearsing

When developing ingressive phonation technique, singers must be mindful of their vocal limitations and begin with very short practice sessions using the technique. In the early stages, as the muscular processes are trained to allow for phonation during inhalation, they may become fatigued more quickly than during egressive phonation. To begin, work only in the comfortable middle register and approach the technique with very simple tasks, such as sighing or humming ingressively. As the comfort level increases, tasks incorporating pitch and increased range can be incorporated.

There are countless ways to practice works with ingressive phonation, depending on the vocalist’s preferences. If there is pitch content, it could be useful to learn the pitch material egressively first, before attempting to perform the pitched material ingressively. As the pitched material is practiced ingressively, incorporating the material one note at a time will allow the physicality of each note to be gently introduced to the vocal folds. When each ingressive note
and technique is incorporated gradually, with intentional focus on variations in breath management and register adjustments, it is less likely to cause undue fatigue and trauma during practice and performance.

Practicing the coordinated breathing patterns of a piece, without phonating, is a beneficial use of practice time that does not cause vocal fatigue. This may seem very basic and obvious, but it requires additional practice to remember to exhale before singing ingressively. If this step is forgotten, it can result in unsupported singing, increased tension, and decreased phrase length. Making notes in the score is also helpful.

**Working with Singers**

The most important step in performing ingressive phonation is to be collaborative during the process. Composers should consult with the vocalist(s) who will be performing their pieces. If they do not have access to singers, they should attempt to perform the techniques to the best of their own ability to determine the safety and effectiveness of their work.
CHAPTER 3. GENERAL CONCLUSIONS

Experimental study of ingressive phonation

1. Spectral slope is steeper for ingressive phonation than for egressive phonation for non-fry phonation, so that there is relatively less intensity in higher harmonics and formants for ingressive phonation.

2. The reduced electroglottographic waveform amplitude for ingressive phonation suggests less vocal fold medial surface contact than for egressive phonation.

3. The first two points above together suggest less vocal fold adduction for ingressive phonation compared to egressive phonation.

4. In contrast to non-fry phonation, vocal fry productions suggest greater adduction for ingressive phonation compared to egressive phonation, evidenced by wider EGG pulses for ingressive phonation and greater spectral intensity in the formants for ingressive phonation.

5. Vibrato appears to be a less-than-natural phenomenon in ingressive phonation compared to egressive phonation.

6. Across the range of two pitches (E4 and E5, and thus two registers), two loudness levels (normal and loud), and two adduction levels (normal and breathy), egressive mean subglottal
pressures ranged from 6.37 to 16.97 cm H2O, and ingressive pressures -9.65 to -16.15 cm H2O (where the minus sign reflects the fact that lung pressure is negative during ingressive flow maneuvers). Also, egressive mean flow ranged from 213 to 671 cc/s, and ingressive -314 to -723 cc/s, and egressive flow resistance 1.53 to 5.20 kPa/(L/s), and ingressive 1.63 to 4.18 kPa/(L/s). Thus, ingressive aerodynamic parameters have similar ranges compared to egressive aerodynamic parameters.

7. Ingressive phonation typically is associated with higher pressures, higher flows, and lower flow resistance values than for egressive phonation for the lower pitch E4, but less consistently so for the higher pitch E5.

8. Both egressive and ingressive phonation typically correspond to higher pressures and flows for E5 compared to E4, with differences being higher for E4. The flow resistance for both egressive and ingressive phonation is higher for E5 for normal loudness, but tends to be less for E5 for loud productions. An important exception is for loud, breathy ingressive phonation, for which flow resistance was higher for E5.

The Use of Ingressive Phonation in Contemporary Art Music

1. Extended vocal technique is a term applied to vocalization and phonation in art music which falls outside of traditional classical singing styles.
2. Extended vocal techniques became a more regular part of the repertoire in the 1960s and ‘70s due to increased use by composers, performers, and improvisers who specialized in exploring experimental sounds and performance techniques.

3. Without effective instruction, singers risk becoming injured or developing pathologies in any style of singing, including ingressive phonation. Ingressive phonation lies outside the scope of most voice pedagogy resources.

4. Several pedagogical and physiological differences are associated with ingressive phonation as compared to egressive phonation, including decreased loudness, decreased phrase length, minimal natural vibrato, longer voice onset time, limitations with certain diction tasks, register shifts occurring at lower pitches, and diminished resonance.

5. There is increased risk of dehydration and fatigue of the vocal mechanism when using ingressive phonation.

6. The use of ingressive phonation is linked with diverse compositional styles and aesthetic motivations. Composers have developed multiple forms of notation for ingressive phonation.

7. When composing with ingressive phonation, composers should consider the limitations of the technique, and should consult with a singer or attempt the techniques themselves to gauge what is practical, effect, and safe for the vocalist.
In conclusion, ingressive phonation demonstrates several unique characteristics when quantifiably compared to egressive phonation. It offers a multitude of dramatic, aesthetic, and functional possibilities for composers and performers. With continued investigation and application of the techniques associated with ingressive phonation, greater understanding of laryngeal function can be achieved and effective guidelines for notation and performance developed. Safe and effective use of ingressive phonation is paramount for performers seeking to incorporate the technique within the context of healthy, balanced vocal production, and the ability to communicate ideas clearly is essential to the work of a composer.
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APPENDIX I

DATE: April 12, 2012
TO: Amanda DeBoer, DMA
FROM: Bowling Green State University Human Subjects Review Board
PROJECT TITLE: [296626-3] Ingressive Phonation in Contemporary Vocal Music
SUBMISSION TYPE: Revision
ACTION: APPROVED
APPROVAL DATE: April 12, 2012
EXPIRATION DATE: March 16, 2013
REVIEW TYPE: Expedited Review
REVIEW CATEGORY: Expedited review category # 4

Thank you for your submission of Revision materials for this project. The Bowling Green State University Human Subjects Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the HSRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

You have been approved to enroll 1 participant. If you wish to enroll additional participants you must seek approval from the HSRB.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on March 16, 2013. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or hsrb@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.
This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Bowling Green State University Human Subjects Review Board's records.