Cover: Colorado performer Nina Storey,
in concert at the NCVS' World Voice Day, April 2004

Photo by Melanie Simonet
The Second International Physiology and Acoustics of Singing Conference

Funded in part by grant R13 DC006937 from the National Institutes of Health

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The historic Tramway Building, at left in the picture above, was formerly the home of Denver’s horse-drawn streetcars at the turn of the century. After an extreme makeover, it is home to the production offices and rehearsal studios of the Denver Center Theatre Company and the Education Department. In the penthouse level are sparkling new quarters for the National Center for Voice and Speech (NCVS).

On the newly-added fourth floor, the NCVS has joined forces with the University of Colorado Hospital. This partnership between the nation’s foremost voice professionals and on-site medical personnel is a groundbreaking collaboration for both the arts and the sciences.

The view of the Rocky Mountains from the penthouse lobby (above) is surpassed only by the view of mountains, city and Cherry Creek from the lobby balcony (right).
Conference Objectives

The Second International Conference on the Physiology and Acoustics of Singing brings together performers, voice educators, voice scientists, medical doctors and behavioral therapy specialists in a unique format of lectures, demonstrations and performances. Just as the field of medicine has benefited from work done with astronauts and athletes, we believe what is learned from the exceptional vocalizations of singers (not just “classically trained” singers, but singers from all genres) can help all voice professionals in understanding “normal” behavior and in developing new habilitative approaches, including those which integrate technology into vocal training.

Purpose of the Meeting

The Groningen conference was the first meeting of its kind exclusively devoted to the physiology and acoustics of the singing voice. The organizers intentionally limited it to a small group of invited participants. While other conferences have had sessions devoted to singing, none had ever focused exclusively on singing voice research. It was the desire of attendees at the 2002 meeting to have a second meeting soon, to build upon the momentum and communication that was fostered in Groningen, and to expand the participation at the meeting to include more artists, teachers and therapists. The National Center for Voice and Speech at The Denver Center for the Performing Arts offered to host the meeting, and the conference dates were chosen after exploring when other voice conferences were being held in 2004 and 2005. The NCVS is well suited to hosting a conference on the science of singing. As the only voice research and clinical care facility in the world that is a division of a performing arts center, the NCVS is a unique intersection of the performing arts, medicine and science.

Focus of the Meeting

The first Physiology and Acoustics of Singing Conference in Groningen dealt more with reviewing the past history of singing voice research and addressing the current knowledge base about singing. The Denver conference seeks to answer the following questions:

Where is singing voice research going?
What new directions are being explored, and what areas demand further examination?
How does singing voice research relate to and assist other voice disciplines?
<table>
<thead>
<tr>
<th>Time</th>
<th>Wednesday, October 6</th>
<th>Topic</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00</td>
<td>Gathering and tours</td>
<td>Open House at the NCVS</td>
<td>NCVS (2 blocks from hotel - see map)</td>
</tr>
<tr>
<td>7:30</td>
<td>Voice Recital</td>
<td>Mary Enid Haines, soprano; J.R. Fralick, tenor; Robert Spillman,</td>
<td>NCVS (2 blocks from hotel - see map)</td>
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<td></td>
<td></td>
<td>piano; vocal music of English composers</td>
<td>NCVS (2 blocks from hotel - see map)</td>
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<tr>
<td>8:20</td>
<td>Refreshments</td>
<td>Biscotti, coffee, tea, sparkling water</td>
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<td>8:00</td>
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<td><strong>Time</strong></td>
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<tr>
<td>9:40</td>
<td>Topic</td>
<td>Refreshments available in meeting room</td>
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<tr>
<td>10:10</td>
<td>Topic</td>
<td>The role of the laryngeal collar in vocal tract acoustics</td>
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<tr>
<td>10:40</td>
<td>Topic</td>
<td>Refreshments available in meeting room</td>
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<tr>
<td>11:00</td>
<td>Topic</td>
<td>Overlap of hearing and voicing ranges in singing and a</td>
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<tr>
<td>11:30</td>
<td>Topic</td>
<td>Acoustic, Aerodynamic, and Kinematic Description of “Taan”</td>
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<tr>
<td>12:00</td>
<td>Topic</td>
<td>Discussion moderated by Sundberg</td>
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<tr>
<td>12:30</td>
<td>Topic</td>
<td>Lunch break 12:30-2pm</td>
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<tr>
<td>2:00</td>
<td>Topic</td>
<td>Postural Changes in the Throat: an Attempt to Correlate Visual</td>
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<td>2:40</td>
<td>Topic</td>
<td>The Open Throat in a Closed-Voice Culture</td>
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<tr>
<td>3:10</td>
<td>Topic</td>
<td>Singing with the whole self</td>
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<tr>
<td>3:40</td>
<td>Topic</td>
<td>Refreshments available in meeting room</td>
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<tr>
<td>4:00</td>
<td>Topic</td>
<td>Muscular patterns and muscular loading levels by classical</td>
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<td>4:30</td>
<td>Topic</td>
<td>Breath Management in Singing: Men vs. Women</td>
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<td>5:00</td>
<td>Topic</td>
<td>The Influence of the Menstrual Cycle and the Oral Contraceptive</td>
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<tr>
<td>5:30</td>
<td>Topic</td>
<td>Discussion moderated by Miller</td>
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<tr>
<td>6:00</td>
<td>Topic</td>
<td>Dinner break until 7pm; evening sessions will be drop-in-type</td>
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<td>7:00</td>
<td>Topic</td>
<td>Popeil: Classical versus Belting Techniques; Miller: Voce Vista</td>
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<td>7:00</td>
<td>Topic</td>
<td>Objectives and Potential in Developing Singers</td>
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<td>7:00</td>
<td>Topic</td>
<td>Significance of analysis window size in</td>
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<tr>
<td>7:00</td>
<td>Topic</td>
<td>maximum flow declination rate</td>
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<tr>
<td>12:00</td>
<td>Topic</td>
<td>Therapeutic Protocols for the Vocally Injured University Singer</td>
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<tr>
<td>12:30</td>
<td>Topic</td>
<td>Discussion moderated by Ternström</td>
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<tr>
<td>1:00</td>
<td>Topic</td>
<td>Poster paper presenters may set up their displays over this lunch</td>
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<tr>
<td>7:00</td>
<td>Topic</td>
<td>Refreshments will be available in the meeting room</td>
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<tr>
<td>9:00</td>
<td>Topic</td>
<td>Mixed Registers</td>
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<td>9:40</td>
<td>Topic</td>
<td>Technology in the singing studio: evaluation by users</td>
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<td>10:10</td>
<td>Topic</td>
<td>Practical Pedagogy and VoceVista</td>
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<tr>
<td>10:40</td>
<td>Topic</td>
<td>Refreshments available in meeting room</td>
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<tr>
<td>11:00</td>
<td>Topic</td>
<td>Objective Measures of Craft and Potential in Developing Singers</td>
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<td>11:30</td>
<td>Topic</td>
<td>Significance of analysis window size in</td>
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<td>1:00</td>
<td>Topic</td>
<td>Poster paper presenters may set up their displays over this lunch</td>
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<tr>
<td>Time</td>
<td>Saturday, October 9</td>
<td>Topic</td>
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<tr>
<td>2:00</td>
<td>Sundberg</td>
<td>The nasal tract as a resonator in singing — some experimental findings</td>
<td>ETI Columbine Conference Room</td>
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<tr>
<td>2:40</td>
<td>Wolfe</td>
<td>Resonance strategies and glottal behaviour in singing</td>
<td>ETI Columbine Conference Room</td>
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<tr>
<td>3:10</td>
<td>Callaway</td>
<td>A study of Spectrographic Analysis with young female voices in the college voice teaching studio</td>
<td>ETI Columbine Conference Room</td>
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<tr>
<td>3:40</td>
<td>Thurman</td>
<td>Addressing vocal register discrepancies</td>
<td>ETI Columbine Conference Room</td>
</tr>
<tr>
<td>4:10</td>
<td>DISCUSSION/BREAK</td>
<td>Discussion moderated by Titze; refreshments will be available in the meeting room.</td>
<td>ETI Columbine Conference Room</td>
</tr>
<tr>
<td>4:40</td>
<td>Poster Paper Session</td>
<td>Session will last until at least 6pm. Attendees are welcome to stay as long as they wish; poster titles listed below</td>
<td>ETI Broadway Hall outside Columbine</td>
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<tr>
<td></td>
<td>Amir</td>
<td>Birth Control Pills and Voice</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td></td>
<td>Bishop</td>
<td>The Three R's of the Egoscue Method as applied to Vocal Production</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td></td>
<td>Gorman</td>
<td>An alternative hypothesis about how humans stand, sit and move within earth's gravitational field</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td></td>
<td>LeBorgne</td>
<td>Belters Pathology? Three Case Presentations (presented by Martin Spencer for Dr. LeBorgne)</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td>Malde</td>
<td>Translating Imagery into the Language of Body Mapping</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td></td>
<td>McCoy</td>
<td>Acoustic Differences in Voice Self-perception in Male and Female Singers</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td></td>
<td>McNaughton</td>
<td>Singing and voice work for those with Alzheimer's, Parkinson's and special needs as well as stroke patients and the carers for these groups</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td>Nix</td>
<td>Vowel Modification, Revisited</td>
<td>Eti Broadway Hall outside Columbine</td>
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<td>Wicklund</td>
<td>Current pedagogical methods in singing voice rehabilitation</td>
<td>Eti Broadway Hall outside Columbine</td>
</tr>
<tr>
<td>6:00</td>
<td>DINNER BREAK</td>
<td>No evening sessions/events scheduled. Please enjoy an evening on your own in Denver!</td>
<td>On your own</td>
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<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>10:10</td>
<td>ETI Columbine Conference Room</td>
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<td>4:00</td>
<td>ETI Columbine Conference Room</td>
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<tr>
<td>6:00</td>
<td>King Center Recital Hall (see map)</td>
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<tr>
<td>8:00</td>
<td>King Center Recital Hall (see map)</td>
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</tbody>
</table>
Executive Tower Inn
Conference meeting area
Keynote and Podium Presentations will be held in the Columbine Room.
Poster Presentations will be held in the Broadway Hall immediately outside the Columbine Room.
Directions from the Executive Tower Inn to the National Center for Voice and Speech
Wednesday and Thursday evening events at 7pm (both nights)

Exit the Executive Tower Inn and turn to your right (on Curtis Street). Directly in front of you is the Denver Performing Arts Complex, under glass arches.

At the corner of 14th and Curtis streets, turn right. Walk one block west to 13th street.

Turn left toward the mountains in the distance, crossing 14th Street. Walk one block to Arapahoe Street.

On one side of Arapahoe Street, you will see a large parking garage that is connected to the performing arts complex. On the other side of the street, you will see a large four story red brick building. This is the Tramway Building. The street address is 1101 13th Street.

Cross Arapahoe Street to enter the Tramway Building and proceed up to the fourth floor. Signs will direct you.

Directions from the Executive Tower Inn to The King Center Recital Hall
Saturday evening recital at 8pm

Exit the hotel and turn to your right (on Curtis Street). Directly in front of you, you will see the Denver Performing Arts Complex.

At the corner of 14th and Curtis Streets, turn right. Walk two blocks to Lawrence Street.

Turn left and cross 14th Street. Walk west (toward the mountains), crossing over Speer Boulevard (a multi-lane divided thoroughfare with a small stream running down the middle between the two sections of traffic). Directly in front of you, as you cross Speer Boulevard, you will see an urban college campus. There will be a large brick building in front of you, which has lettering on it reading “The University of Colorado at Denver.”

Walk through the campus on the lighted pathway—continuing straight as if you were still on Lawrence Street. The King Center will be the fourth building on your right.

As a landmark, to the left as you approach the King Center is a large Spanish-style Catholic Church building. Please see the campus map at left.
Nonlinear Source-Filter Interaction in Singing
Ingo R. Titze, Ph.D.
Distinguished Professor of Speech and Voice, University of Iowa
Executive Director, National Center for Voice and Speech

The classical linear source-filter theory of voice production is compared to a nonlinear theory that includes interaction between the vocal tract and glottal airflow. By including the subglottal tract, it is shown that the combined vocal tract impedance can be primarily inertive (exhibiting positive reactance) over a wide range of FO. The epilarynx tube and the glottal entry tube contribute to this heightened inertive reactance and serve as impedance matchers for the rest of the vocal tract. It is shown that a high degree of glottal flow waveform skewing is attributable to source-tract interaction, with skewing quotients ranging from 1.0 to 10.0. To a large degree, epilarynx tube diameter governs waveform skewing and the peak glottal flow. For high levels of interaction, a speaker or singer can conserve glottal flow without loss of maximum flow declination rate (MFDR).

Thus, the interactive system is more efficient from a flow consumption point of view, but it does not yield favorable conditions slightly above the first formant frequency, where the combined subglottal and supraglottal reactance is compliant for a small range of fundamental frequencies. Inferences are drawn with respect to voice quality adjustments for speaking and different styles of singing.

The Role of the Laryngeal Collar in Vocal Tract Acoustics
Wim G. J. Ritzerfeld, M.Sc., Donald G. Miller, M.Mus, Ph.D
Harm K. Schutte, M.D., Ph.D.
Groningen Voice Research Lab.
University of Groningen,
The Netherlands

In “Acoustic Interpretation of Resonant Voice,” Titze has presented a theory stating that the vibrational movements of the vocal folds can be reinforced by vocal tract resonance (2001). In order for this reinforcement to take place, vocal tract impedance needs to have a positive phase angle. In other words, the supraglottic pressure wave needs to be pulled forward in time with respect to the glottal airflow wave. Titze presented calculations indicating that this favourable condition is enhanced when:

the passage to the pharynx from the vestibulum via the laryngeal collar is narrow. In the present study, experiments were carried out that were aimed at investigating the above theory empirically. Two subjects produced several phonations, which were simultaneously measured by a pressure transducer located inside the laryngeal collar, just above the vocal folds, an electroglottograph, and a microphone placed in front of the subject. Results were established that support the conclusion that just above the vocal folds the acoustical wave shows the theoretically desired phase shift. Titze, I. R. (2001). Acoustic interpretation of resonant voice. Journal of Voice, 15, 519-528

Correlations Between Measures of Cepstral Peak Prominence, Long-Term Average Spectrum, and Perceptual Ratings of Singing Voice Quality
Authors: Deirdre D. Michael, Ph.D.
Susan Buesgens, M.A.
Jennifer Swanson, M.M.
Katherine Lindsay, B.A.

Introduction: An ongoing concern in the scientific study of voice is the quest for objective measures of voice quality that correlate with the “gold standard” of reliable perceptual ratings. Acoustic measures have been used with varying degrees of success to quantify voice quality for dysphonic voices, but they have been less often and less successfully to quantify singing voice quality. This may be due both to the lack of acoustic measures and the difficulty obtaining reliable ratings of singing voice quality.

The acoustic measure of Cepstral Peak Prominence has been shown in numerous studies to correlate with measures of dysphonia, most especially the perceptual measure of “overall grade of dysphonia” in samples of voice ranging from normal to the most severely dysphonic. This study examines the correlations of CPP with ratings of singing voice quality, ranging from normal to most supranormal. The acoustic measure of Long-term Average Spectrum (LTAS) has been used to measure singing voice quality, and has been moderately successful in correlating with ratings of dysphonic voice quality. This study compares LTAS to CPP in quantifying singing voice quality. In studies of dysphonic voice quality, speech-language pathologists have shown high reliability in rating qualities of voice that are related to laryngeal function. This study examines whether singing teachers can achieve the same level of reliability for ratings of singing voice quality, when using similar procedures.

Methods: Recordings of a vocalise and a passage from a song were recorded from singers ranging in proficiency from beginners to elite performers. These recordings were subjected to CPP and LTAS analysis. The samples were also rated for degree of overall quality of voice, breathiness, roughness, strain, and pitch stability by singing teachers.

Pearson correlation coefficients were used to compare CPP and LTAS measures to the perceptual ratings. Results: Results from a pilot study using 34 samples of singing rated by four singing teachers show that after a training procedure, the teachers’ ratings were highly and significantly correlated, so that a single average rating could be used to correlate with the CPP and LTAS ratings. CPP measures correlated with ratings of breathiness, but generally not with the other perceptual ratings. In general, LTAS measures correlated with ratings of breathiness and overall quality, and occasionally with measures of roughness and pitch stability.

Discussion: In this study, CPP was useful as a measure of breathiness, as opposed to studies of dysphonia in which it has correlated better with ratings of overall grade of dysphonia. Measures of LTAS were also most useful in measuring breathiness. The possible reasons for this are explored, as are the possible uses for these two measures in quantifying singing voice quality. More importantly, in this study, singing teachers were able to differentiate a continuum of singers along parameters that are associated with laryngeal function and more typically used in ratings of dysphonia. It is possible that those measures can serve as a point of departure in the ongoing quest for objective and reliable measures of singing voice quality.

Overlap of Hearing and Voicing Ranges in Singing
Eric J. Hunter and Ingo R. Titze
National Center for Voice and Speech

The frequency and absolute intensity ranges (in dB SPL at one meter) of voice production in trained and untrained
singers were superimposed onto the average normal hearing range. The vocal output for all subjects was shown both in Voice Range Profiles (fundamental frequency only) and Spectral Level Profiles (all harmonic frequencies). Trained singers appeared to take greater advantage of the dynamic range of the auditory system with harmonic energy (45 percent of the hearing range compared to 38 percent for untrained). In particular, trained singers were able to exploit the most sensitive part of the hearing range (around 3 to 4 kHz) through the use of a vocal ring or singer’s formant. The professional vocalists’ average maximum third-octave spectral band intensity was 95 dB SPL at one meter, compared to 80 dB SPL for untrained vocalists.

Acoustic, Aerodynamic, and Kinematic Description of “Taan” Gestures in Indian Classical Singing

Nandhakumar Radhakrishnan Ronald C. Scherer
Bowling Green State University

The two major divisions in Indian classical music, the North Indian, or Hindustani, and South Indian, or Carnatic, require extensive training and are considered sacred. We studied the vocal physiology of an Indian classical singer during “taan” production, an important aspect of ornamentation (like vibrato, trill, and trillo) in the North Indian style of vocal music. Taan is a melodic embellishment consisting of asymmetric rapid pitch rise and fall, the rate of which can be varied by the singer.

Methodology:

• A 44 year old male, well-known Hindustani professional classical singer was the subject. Acoustic, kinematic (EGG), and airflow signals were recorded when the singer produced taan gestures while seated in a sound treated booth.

• Each local rise then fall of the Fo contour was defined as a “taan gesture.” A series of taan gestures was produced during constant pitch and during an octave increase and decrease.

Results and Discussion:

a. Taan produced while singing a constant pitch:

(i) Acoustic: Average frequency extent: 1.87 ST (0.34 SD). Average frequency rate: 3.41 Hz (0.36 Hz SD).

(ii) Kinematic: Within-taan frequency increase resulted in an increase in EGGW (i.e., greater adduction for higher frequencies.)

(iii) Airflow: For most of the taan gestures, the AC flow decreased with increase in pitch.

b. Taan produced while singing octaves:

(i) Acoustic: On average, the number of semitones on the ascending side of the octave-up of each taan gesture was 4.00 semitones, and 1.55 semitones on the descending side. On the octave-down side there were 3.31 and 1.94 semitones on the descending and ascending sides, respectively. Within the taan gestures, when the frequency was lower-higher, the intensity was usually higher-lower-higher, an inverse relationship.

(ii) Kinematic: EGGW adduction measures increased with within-taan pitch rise, suggesting an increase in vocal fold adduction.

(iii) Airflow: The glottal AC flow measures did not indicate a trend with pitch.

(iv) DC shifting: Based on the DC shifting behavior of the flow waveform, the larynx was estimated to rise and fall by approximately 1 cm.

Conclusion: “Taan gestures” by the professional singer-subject appears to be characterized by control via glottal adduction and wide pitch fluctuations. The asymmetric frequency modulation appears to be controlled voluntarily, unlike vibrato. The rate of taan of 3.41 Hz is slower than vibrato, trillo, or trill. The extent of 1.89 ST is wider than vibrato but similar to trillo and trill. During taan, this subject appeared to increase and maintain a relatively high glottal adduction, perhaps to maintain a consistent timbre. The AC flow varied with Fo for the taan gestures produced while singing a “constant pitch,” but did not vary with Fo for the octave scales. It is hypothesized that a continuous change in laryngeal height (a 1 cm rise and fall) created a pumping action of the flow and contributed to the DC shift of flow and the modulated EGG waveform during the octave scales.

Averages from literature and current study

<table>
<thead>
<tr>
<th>Taan</th>
<th>Vibrato</th>
<th>Trillo</th>
<th>Trill</th>
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<tr>
<td>Extent (Semitones)</td>
<td>1.9</td>
<td>1-2</td>
<td>2</td>
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<tr>
<td>Rate (Hz)</td>
<td>3.4</td>
<td>5-7</td>
<td>9</td>
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The Open Throat in a Closed-Voice Culture

An historical, pedagogical and scientific review of an ancient concept in singing

Stephen F. Austin, M.M., Ph.D.
College of Music
University of North Texas

The concept of the ‘open throat’ has been used through the years to describe a pedagogical tenet that in part defines the ‘bel canto’ tradition of singing in western opera and art song. In this presentation the concept of the open throat will be explored. Garcia defined two timbres of tone; the voix clair or ‘clear voice,’ and the voix sombre, or the ‘somber voice.’ His teaching and a long line of successors into the 21st century promote the voix sombre as the desirable timbre for the classically trained singer. It will be shown from important historical sources that the concept of the ‘open throat’ meant the ‘comfortably low larynx’ and that this was the means of producing the voix sombre. This practice led to the evolution of the do di petto, or the male high voice produced with the full, ringing quality of the chest voice. The concept of the open throat has been credited as the primary means of equalizing register transitions and for freeing the intrinsic laryngeal musculature from unnecessary tensions. The open throat is also credited as being a possible source for the singer’s formant. However, a recent comment by Titze suggested that the emphases on the lower laryngeal posture may not be necessary. The case will be made that the open throat is no longer commonly taught and that the absence of this concept in contemporary vocal pedagogy often leads to voice mis-classification and can limit the potential of the student. Contemporary music trends in singing do not require the open throat and the dominant prevalence of more popular musical styles in our culture may be in part responsible for the changing tradition.

The Effects of Feldenkrais Work on the Singer’s Voice as Documented by Spectographic Analysis: A Preliminary Study

Elizabeth Blades-Zeller, DMA
Nazareth College Music Department, Rochester, NY

“While in principle it is possible to use the spectrum analyzer for feedback in the training of the singing voice, the cost of the equipment and the required expertise to use it effectively make it unlikely that it will soon have widespread use in vocal pedagogy.” Miller, Donald G. and Schutte, Harm K. Feedback from spectrum analysis applied to the singing voice. Journal of Voice 1990;4:329-334

Ah, how far we’ve come in 14 years! Thanks to affordable and downloadable computer programs such as “GRAM” and “VOCE VISTA,” and the training available to the neophyte acoustic researcher through texts such as Garry...
Nair’s very accessible manual, Voice: Tradition and Technology,” (Singular Press, 1998) the once unattainable spectrum analyzer is within grasp of any vocal pedagogue and student. This development is particularly exciting to any voice teacher who values the body-mind work so essential to vocal production, but heretofore has not been able document such work in scientifically measurable results.

With this in mind, my colleague, Dr. Samuel Nelson (Certified Feldenkrais Practitioner) and I initiated a pilot study to measure the effects of the Feldenkrais Method on the singer’s voice through spectral analysis. Preliminary results have been most revealing, enlightening, convincing and encouraging. Benefits of such mind-body work, which have previously been dependent upon anecdotal and qualitative evidence can now be measured and supported by the quantitative visual display available through spectographic analysis.

The Feldenkrais Method is fundamentally a learning system which incorporates self-discovery using movement. In applying the Feldenkrais Method, individuals are led through movement sequences designed to introduce or clarify a function. Thus, they are led to “discover” a better way to perform this function, a way to do it that involves more of themselves than what is habitual. This discovery involves that part of the nervous system that controls movement - the proprioceptive, “sub-conscious self” as opposed to the analytical, “thinking” consciousness. As a result, changes tend to be retained and amplified.

In this preliminary pilot study, six singers (all voice types) in private individual appointments were asked to arrive vocally warmed up and ready to sing a portion of an art song or aria while real-time spectographic analysis displayed visual documentation of vowel formants, resonance intensity, amplitude (loudness), and consonant execution (clarity). Each singer was then led through a portion of a Feldenkrais “Awareness Through Movement” lesson of approximately 10 minutes duration (each singer was led through the same ATM lesson). The singer then sang exactly the same excerpt while spectrographic analysis documented the results.

The results were stunningly uniform—in every case, the visual display showed an increase in frequency and intensity in the range of the “singer’s formant,” increased vibrancy, enhanced vowel formants, resonance (overtones) and clarity in consonant execution. At the same time, each singer reported an increase in vocal ease and freedom, improved breath function, articulatory efficiency and a feeling of more “ring” or “bloom” in the voice with less effort. None of the singers were shown the visual display before or after each singing episode; in this study, the spectral analyzer was employed to scientifically document the changes which occurred with Feldenkrais work.

Future research will examine the differences measured by spectographic analysis when singers receive a lesson chosen to specifically address “issues” particular to that singer’s needs, as opposed to all receiving the same generic ATM Feldenkrais lesson.

While this research is still in the preliminary stage, it holds exciting implications for expanded exploration. The availability and relative ease in using spectral analysis to quantitatively measure changes in vocal production provides support for anecdotal qualitative reports. The Feldenkrais Method has proven to effect positive kinesthetic changes which impart improvements in vocal production; these changes are now visually and scientifically measurable through use of spectral analysis.

Muscular Patterns and Muscular Loading Levels by Classical Singers Recorded by Surface Electromyography.

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Introduction. Sporadic electromyographic (EMG) investigations have earlier been performed on classical singers (1-3). To further survey muscle activation levels and muscular patterns during inhalation and phonation, we have the last five years performed surface EMG recordings on primary and auxiliary breathing muscles of classical singers.

Material and Methods. Singers in their first or second year of conservatory study, advanced student singers and professional opera singers served as subjects. Muscle activity was recorded from the shoulder and neck region (the upper trapezius (TR), the sternocleidomastoideus (STM) and the scalenus muscles (SC), and the muscles in the posterior neck (PN)), and the trunk (the intercostals (INT), the lateral abdominal muscles (OBL) and the rectus abdominis muscle (RC)). In some studies EMG biofeedback (BF) was used to lower the activity in the TR and STM muscles, and the activity levels before and after BF were compared in the analyses.

Results:

1: In a study of the student singers, in their first or second year of conservatory study, it was discovered that during phonation, these students had higher EMG activity levels in TR than required by postural needs. BF was in this study shown to lower especially TR activity, but also, to some extent, STM activity (4).

2: Professional opera singers’ EMG activity was recorded from TR, STM, SC, PN, INT, OBL and RC. It was concluded that STM and SC showed correlated activity patterns during inhalation and phonation. Substantial muscle activity was observed at the PN site during inhalation and phonation. BF performed on TR and STM had a secondary effect of lowering EMG activity in SC and PN (5, 6), while INT, OBL and RC activity were not influenced by BF to TR and STM (7).

3: In a follow-up study of professional opera singers and advanced student singers, the phasing of TR activity to upper and lower thorax movement and to the phasing of activity in INT and OBL was investigated. A phasing of upper TR activity to INT and OBL activity was shown, all muscles supporting the expiration phase. The group results from both opera singers and student singers showed that TR EMG activity was significantly lowered after BF. Lowered TR activity resulted in an expanded upper TX circumference and less TX respiratory movement after BF. Thus, during phonation the upper TR contributed in the compression of upper TX, serving as an accessory muscle of expiration (8).

Discussion: The main finding in these studies is that TR supports exhalation by classical singers. The high resolution of the recordings made the number of data points entered in the correlation analyses high (600-1000), thereby reaching statistical significance for quite low correlations. However, visual inspection of the EMG recordings confirmed that the TR, INT and OBL support exhalation and had a consistent activity pattern for the individual breaths, ensuring that the results are trustworthy (8). The finding of relatively high neck and shoulder activity by the student singers, could be explained as lack of vocal technique in an early stage of their individual development (4). Nevertheless, this assumption was contradicted by a study on professional opera singers, showing activity peaks during inhalation and also high STM and SC activity during start of
phology (5). With non-singers, both muscles have been shown to support inhalation (9-12). With singers, the term “muscles of inhalation” could be expanded from mainly the diaphragm (13) and the external intercostals (14) to include STM and SC. As the recruitment of these muscles was required during both inhalation and phonation, they could be included in the term “muscles of inhalation” by classical singers. When a balancing of the subglottal pressure during phonation is needed, the interplay in the upper trunk area would be between STM, SC and the upper external intercostal muscles, supporting inhalation forces, and the expiratory phased upper internal intercostals and TR supporting exhalation forces. Thus, the interplay between these muscles has for upper TX movement a similar function to the interplay between the lower external intercostals and the diaphragm vs. the lower internal intercostals and the abdominal muscles in the control of lower TX.

References

**Breath Management in Singing: Men vs. Women**

Scott McCoy, DMA
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It has long been known that singers employ a variety of methods to manage breathing. Numerous breathing techniques have been described in pedagogical literature, generally differentiated by physical sensation/location and control mechanism (e.g. clavicular, thoracic, abdominal, etc.). This presentation examines the issue of gender-specific differences in breath management. The following questions are raised:

1. Do contemporary and historical pedagogical writings on breath management vary according to the gender of the author?
2. Do male and female singers describe breath support in different ways?
3. Are male and female singers observed to manage breathing in different ways?
4. Do singing teachers approach breathing in different ways for male and female students?
5. Is there an anatomical basis for gender-specific breath management techniques?

Discussion of these questions will be based on review of pedagogical/anatomical literature, interviews with professional singers and singing teachers, and direct observation of singers in the Westminster Voice Laboratory (video and Respirac).

**The Influence of the Menstrual Cycle and the Oral contraceptive Pill on the Female Operatic Singing Voice**

Filipa Låå, Jane Davidson1, William Ledger2, David Howard3
Music Department, University of Sheffield - 1; Academic Unit of Reproductive and Developmental Medicine, University of Sheffield - 2; Electronics Department, University of York - 3, U.K.

The purpose of the research is to study the effects of the menstrual cycle and the intake of a third generation oral contraceptive pill (OCP) on the quality of the operatic singing voice. This study involved two major assessments: (i) a preliminary questionnaire assessing the singer’s perception of vocal changes associated with specific phases of the menstrual cycle and the intake of an oral contraceptive pill; (ii) an experiment involving 10 young healthy operatic singers, who took a placebo and a third generation oral contraceptive pill, Yasmin®, following a double blind randomized placebo controlled trial.

The perceptual evaluation of vocal changes in female operatic singers involved 102 participants from five different music colleges in the U.K. The responses were obtained and analyzed concerning the following parameters: the number of singers complaining about vocal changes associated with the menstrual cycle; the vocal symptoms mostly associated with the menstrual cycle; the phases of the menstrual cycle mostly associated with vocal problems; the degree to which singers were vocally affected; number of singers taking an oral contraceptive pill; the number of pill takers complaining about vocal changes. Results will be presented in the presentation, but the key findings were that: a) 83% of all respondents experienced vocal problems associated with the menstrual cycle; b) singers who were pill takers experienced milder vocal changes when compared to those who were not taking an OCP.

The second part of this research involved 10 healthy young singers, students at three music colleges in the U.K., aged between 20-29 years old. An initial consultation and health screen with these volunteers was carried out by a gynecologist, to establish safety of intake of a placebo and an OCP. Advice on the use of other contraceptive methods during the whole experiment was given, since they were randomly allocated to receive the OCP or placebo as the first medica-
tion in the study. Vocal and blood tests were undertaken to establish a relationship between voice quality and hormonal levels. Voice assessment involved record the participants reading along and singing using an electrolaryngograph. This device is noninvasive and allows the study of larynx closed quotient (CQ) and associated fundamental period, measured using the automated Lx-based analysis technique. Levels of sexual hormones were assessed via blood samples, which followed each recording session. Blood tests measured the levels of LH, FSH, testosterone, sex hormone binding globulin, androstenedione and dihydroepiandrosterone sulphate, oestradiol and progesterone. Six voice recordings and six blood tests were carried out; three during the third month whilst on OCP; three during the third month whilst on placebo. All six recordings and blood samples were done at menstruation, during follicular phase and luteal phase. Preliminary results will be presented.

**“Mixed” Registers in Singing**

**Donald Miller**

**Groningen Voice Research Lab**

In “classical” singing technique, the transition between “chest” and “middle” registers in the female singing voice is generally recognized as the primary register transition, a change in the vibration pattern of the vocal folds from deep vertical contact and a relatively large closed quotient to a pattern of contact of the upper margins and a reduced closed quotient. One of the usual goals of classical singing technique is to minimize any perceptual discontinuity in the execution of this transition. This study uses electroglossograph (EGG) signals for monitoring the closed quotient, as well as acoustic analysis, in examining the approaches of some highly trained singers to this task. The so-called “mixing” of the registers, a frequently encountered concept in practical vocal pedagogy, is a point of particular interest.

**Technology in the Singing Studio: Evaluation by Users**

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Real-time visual displays have the potential to be useful in the context of vocal pedagogy. Previous experience with a real-time vocal pitch analysis and display system designed for primary school children in UK [1] indicated that it was very successful at enabling pitch-to-behavior to be developed and assessed, and that children as young as six could successfully use the system in pairs without teacher intervention [2]. This experience also demonstrated the importance of keeping the displays simple and ensuring that the users are clear about what is being displayed.

This work is now being extended into the professional singing studio in a project to investigate the usefulness or otherwise of computer displays in the singing studio. Specially prepared Windows-based software known as WinSingad has been written which makes available analyses plotted against time, which relate to: pitch, spectral ratio, larynx closed quotient and vocal tract area. These can be viewed singly, multiply or in combination. The purpose of the project is to determine whether or not displays such as these can be used in the professional singing studio to any useful advantage, and what are their advantages and disadvantages.

An action research methodology is being employed in which the researchers in conjunction with the students and teachers keep records of activities during lessons in order to evaluate their effectiveness or otherwise at a later date. Two experienced professional singing teachers are involved, one based in Guildford, the other in York. Control subjects are involved to provide an indication of current teaching techniques in the absence of computer displays in the singing studio. Specially prepared Windows-based software known as WinSingad has been written which makes available analyses plotted against time, which relate to: pitch, spectral ratio, larynx closed quotient and vocal tract area. These can be viewed singly, multiply or in combination. The purpose of the project is to determine whether or not displays such as these can be used in the professional singing studio to any useful advantage, and what are their advantages and disadvantages.

An action research methodology is being employed in which the researchers in conjunction with the students and teachers keep records of activities during lessons in order to evaluate their effectiveness or otherwise at a later date. Two experienced professional singing teachers are involved, one based in Guildford, the other in York. Control subjects are involved to provide an indication of current teaching techniques in the absence of technology, and a number of experimental subjects are making use of the technology on a regular basis. Lesson observations began during the late Summer of 2003, and are due to end around Easter 2004. Informal results to date suggest that the use of technology is being welcomed by student and teacher alike; indeed, one teacher is already making use of the software with other students who were not included in the original schedule. The ability to configure the displays easily via a simple user interface has been shown to be an essential feature of software being employed in such a situation. This paper will describe the system itself and how it is being employed, and also explore the action research outcomes in detail.


**Practical Pedagogy and Voce Vista**

Daniel Ihasz
Dillon R. Farmer

In an effort to understand more fully the function of the singing voice, many practitioners and teachers have turned to the discipline of voice science. This turn has been reflected to some degree in the vocal pedagogy curricula in which there has been an increased emphasis on understanding vocal anatomy and physiology. From the point of view of the practitioner, however, such an emphasis is possibly counterproductive because much of the vocal mechanism involves involuntary muscle action and therefore lies beneath conscious control. However interesting and important anatomical and physiological knowledge is, having that knowledge does not necessarily facilitate the physical co-ordinations that constitute singing. From the practitioner’s point of view, the resultant sound is a byproduct of a set of balanced co-ordinations usually solicited by suggestive imagery. These co-ordinations yield internal sensations (both physical and aural) that the singer experiences in the act of singing. Unfortunately, the singer does not experience the resultant sound product in the way that listeners do and it is for this reason that a singer always requires feedback from an auditor who knows what the desired sound product ought to be. The process of learning how to sing, therefore, becomes an exchange in which the singer learns which co-ordinations yield the desired result. It is in this exchange that voice science and its attendant technologies can give the voice practitioner tools that provide real-time feedback, tools which help to hone the aural, visual and physical discernment of the singer. This is an effort to develop specificity and commonality in language and produce more correctly and consistently the desired results, while at the same time reducing confusion and frustration. In this respect, the potential of the software program Voce Vista has yet to be tapped. A spectrographic analysis of famous voices from the past reveals both the acoustic properties that constitute elite singing and the factors that give each voice its distinguishing qualities.

The program also includes an overlay feature allowing the comparison of acoustic signals, which could be from a
famous singer of the past and the student
(singing the same passage) or a student
saving a "perfect" sample during his/her
own lesson and using it as a model for
practicing. Real-time spectrography can
show the practitioner and singer in real-
time precisely when slight adjustments
of vowel size and shape yield significant
boosts across the resonance spectrum,
and as such can guide the singer towards
a more precise deployment of the tech-
nique known as vowel modification or
formant tuning. To be sure, this technolo-
y can never replace the vocal peda-
gogue, but it can assist him by helping
the singer relate the physical co-ordina-
tions of phonation with the visualization
of the resultant sound product. In this
way, art and science, craft and technolo-
gy, need not part company but can
embrace each other in a joint effort to
raise the level of vocal technique and
artistry. We intend to demonstrate
through recordings and a live demonstra-
tion the practical application of this tech-
nology in the practitioner's studio

An Historical, Pedagogical and
Scientific Review of an Ancient
Concept in Singing: Objective
Measures of Craft and Potential
in Developing Singers
Martin L. Spencer, M.A. CCC-SLP & L.
Arick Forrest, M.D.
The Ohio State University Department
of Otolaryngology, Voice Institute

This presentation will present and dis-
cuss results obtained from three and four
years of successive measurement of
undergraduate singers in the Ohio State
University, Department of Music. Each
subject was tested in fall and spring
quarters of their freshman year, and sub-
sequent measures were obtained annually
in the spring quarter. Each data collec-
tion session yielded samples of both the
speaking and singing voice:
1. Speaking voice samples, obtained via
reading of the Rainbow passage, were
subjected to acoustic Multi-Dimensional
Voice Profile analysis (Computer Speech
Lab). Of greatest interest has been inves-
tigation into potential changes in mean
speaking Fo and pitch range.
2. Messa di voce. Each subject was test-
ed for dynamic control and associated
spectral presence and perturbation via
three messe di voce performed on each of
four test pitches. The test pitches sam-
ped low, low-mid, high-mid, and high-
pitched phonation.
3. Voice range profiles (VRP) were sub-
ject to gross analysis via pitch-intensi-
ty maxima and minima. Additionally, the
Voice Category Template and Ratio sys-
tem (VCTR), a system of VRP analysis
developed by the primary author, was
utilized to ascertain whether individual
pitch and intensity characteristics could
yield objective verification of singing
voice categorization.

The VCTR system is an interpretive
tool which may aid in the quantification
of voice category presence and potential
through composite analysis of voice vol-
ume areas (VVA) which have been fil-
tered through user-defined pitch ranges
(VVA is calculated as the sum of intensi-
dity differences for individual pitches with-
in a chosen range). The VCTR system
divides the gross VVA contained within
upper and lower VRP boundary contours
into four sub-areas; upper and lower
within-category areas, and “free” high
and low ranges which lie outside of the
main area. In this way, the Category Area
Ratio (CAR) is the ratio of VVA to total VVA:

\[
\text{VVA} = \text{Category Area Ratio (CAR)}
\]

2. Category Weight Ratio (CWR): the
CWR indicates relative intensity poten-
tial within the VVA category. The CWR
is used for discrimination of within-cate-
gory VVA allocation, via an upper cate-
gory area (UCA) and lower category area
(LCA). The Category Weight Ratio
(CWR) was calculated as the ratio
between UCA and LCA:

\[
\text{Upper Category Area (UCA)} = \text{Category Weight (CWR)}
\]

3. Free Area Ratio (FAR): the two outer
remaining sub-areas are indicated as the
Free High Range (FHR) and Free Low
Range (FLR). The Free Area Ratio
(FAR) was calculated as the ratio of FHR
to FLR:

\[
\text{Free High range (FHR)} = \text{Free Low range (FLR)}
\]

Such analysis may prove to be a useful
tool which may aid the quantification of
voice category presence and potential in
singers.

Significance of Analysis Window
Size in Maximum Flow
Declination Rate (MFDR)
Linda M. Carroll, PhD
Department of Otolaryngology, Mount
Sinai School of Medicine

Goals: (1) To determine whether a
significant difference exists for mean
MFDR across 4 different data extraction
methods on the same data set; (2) To
determine interaction between subject
skill level and fundamental frequency on
MFDR.

Background: Examination of laryn-
geal aerodynamics remains crucial to our
understanding of voice function in nor-
mal and non-normal subjects. Extensive
research over the past 40 years has
focused on subglottal pressure and tran-
glottal flow, particularly as it relates to
frequency and intensity control. More
recently, the speed of closure at the max-
imal negative slope of the differentiated
inverse-filtered waveform, or maximum
flow declination rate (MFDR), has
emerged as a valuable measure of laryn-
geal function (1-8). Although subglottal
pressure and transglottal flow have estab-
lished measurement techniques for data
extraction methods (e.g.: peak pressure
value during [p] for subglottal pressure),
such standards do not exist for MFDR.
As such, it becomes difficult to compare
results across studies which have used a
wide range of measurement techniques.
Assumptions: MFDR is the point of
sharpest change in the closing velocity of
the vocal folds, and reflects the velocity
when the vocal fold surfaces are nearly
parallel and touching in the anterior
(membranous) glottis (1-4, 9). It is
hypothesized that a more rapid decrease
(or stoppage) of the flow yields a more
efficient and powerful glottal source,
thereby allowing improved acoustic
intensity (3,4,5,7,9). Previous investi-
gators have reported MFDR values for
speaking and singing using a range of 1-
60 periods of analysis (3,6,7,10,11).

Summary of findings: A moderate
sized window segment appears to be suf-
cient for determining mean MFDR.
There does not appear to be a significant
advantage to using a large (1000 ms)
analysis window. Among the profes-
sional singer population, there does appear
to be a difference at the glottal level in
management of airflow shut-off when
fundamental frequency increases among
subjects who are employed in regional/
national level opera companies vs. those
employed at international level opera
companies. Both groups were found to
increase MFDR as fundamental frequen-
cy increased.
References:

Therapeutic Protocols for the Vocally Injured University Singer: Rehabilitation through Collaboration
Dr. Karen Wicklund, Soprano and Singer's Wellness Specialist Of Special Note, Inc., Chicago Center for Professional Voice;
Heidi Vogley, M.S., CCC-SLP

All new vocal music students to Western Michigan University are encouraged to schedule a voice baseline screening, at the University Speech and Hearing Clinic, which includes laryngeal imaging. This is necessary to comprehensively assess laryngeal structures and functions at the onset of vocal training.

This baseline information will be helpful for comparison purposes should future vocal problems present. Upon suspicion of vocal concerns, the student vocalist is encouraged to seek appropriate intervention through his/her vocal music teacher, a certified speech-language pathologist and voice rehabilitation specialist, or an otolaryngologist. Referrals are typically coordinated between the Schools of Fine Arts and Health and Human Services, through direct contact between vocal music teacher and speech-language pathologist/voice laboratory. An appropriate consultation is then arranged, based on communication between the student vocalist, music teacher, physician and the speech and hearing clinic.

After a diagnosis is made, voice teacher, speech pathologist and physician carry out a collaborative treatment plan. The voice teacher assesses the current abilities of the student's injured voice. The voice teacher's assessment of the student should include but is not limited to technical exercises emphasizing middle range, reduced intensity levels, messa di voce and vowel equalization; evaluation of upper and lower range quality and technique, and student-provided feedback regarding proprioception while vocalizing. Student also demonstrates two songs (one which student performs well, and another in which problems are observed). The vocal teacher should then suggest strategies for rehabilitation, which proceed from the assessment exercises, which, in collaboration with speech pathology sessions and medical intervention aid in restoring the voice.

Weekly or biweekly speech pathology sessions emphasize breathing and tension-releasing techniques, resonance balancing and vocal hygiene documentation. Medical intervention can include pharmaceutical treatment, further laryngeal imaging, EMG assessments if paresis is suspected, and surgery, when necessary.

The process of voice rehabilitation can take from as little as four to six weeks to several months or longer. The university music department cooperates in this process by allowing the injured student to follow an alternate plan of vocal study during the semester of injury. This plan of study allows the student to use the vocalizes and technical exercises, as well as songs with reduced ranges as part of his/her required repertoire for the semester, as long as all regularly required repertoire is learned and performed upon the singer's return to vocal health. This presentation will contain information on how to modify repertoire requirements of a typical undergraduate semester applied voice program of study for injured singers, and will be presented by a speech-language pathologist, and voice teacher with a speech-language pathology degree.

The Nasal Tract as a Resonator in Singing
Some experimental findings
Johan Sundberg
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KTH, Stockholm

In an earlier investigation we measured nasal DC airflow and other signs of a velopharyngeal opening (VPO) in the production of the vowels /a, i, u/ as sung by 18 professional operatic singers of different classifications (Birch, Gümös, Stavad, Prytz, Björkner, Sundberg 2002, J Voice 16, 61-71). Our results indicated that the vowel /a/ but not /i/ and /u/ quite commonly was sung with a VPO. In the present investigation the same group of researchers attempted to find out what benefit a VPO may have to offer singers.

Two copies of a model of the vocal and nasal tracts, based on CAT scan data of a baritone singing the vowel /a/, were cast in epoxy. The models were divided into three blocks, one pharyngeal, one oral, and one nasal. In one of the models the pharyngeal tongue constriction and the VPO were eliminated. By inserting lumps of Plasticine into the model, approximations of the vocal tract shapes for /a/ and /u/ were obtained and combined with different VPOs. The transfer function was measured in terms of the response to a sine sweep from an earphone fastened to the glottal end. The results revealed a highly resistive nasal tract. It was also found that a VPO considerably increased the bandwidth of the first formant for /i/ and /u/ but much less for /a/. On the other hand, a wide bandwidth typically produces a nasal quality,
so this may be the reason why evidence for a VPO was rarely found in /u/ and /i/.

The results further revealed that a VPO substantially decreased the level difference between the first and the third formant in all three vowels, such that it enhanced the singer's formant. As this would be a desirable effect, our results appear to explain why singers tend to sing the vowel /a/ with a VPO.

**Resonance Strategies and Glottal Behaviour in Singing**
Nathalie Henrich[1,2], Elodie Joliveau[2], John Smith[2] and Joe Wolfe[2]

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In Fant's classic model[1], the spectrum of sound radiated by a singer depends on the 'source' and the 'filter.' The source is the nearly periodic vibrations of the vocal folds, which we study here with electromyography[2,3]. The filter is the vocal tract, which acts as a variable impedance matcher (a 'megaphone') between the vocal folds and the external radiation field. The impedance matching is most efficient (and so produces enhanced vocal power) around the resonances of the vocal tract. The resonances thus produce formants (local maxima in the power spectrum) in the sound, of which the first two are important in vowel identification, and the next few in vowel quality and speaker identification. We study the vocal tract response directly by injecting a carefully synthesised, broad band acoustic current at the mouth[4,5]. The simultaneous use of these techniques allows us to identify spectral features in the singing voice (recorded at the same time) with the behaviour of the glottis and the tract. We find that, in the high range of the female voice, singers trained in the Western tradition tune the lowest resonance (R1) of the tract to match the pitch frequency f0. This has the musical advantages of increasing radiated power and improved vocal homogeneity, but probably contributes to the difficulty of discriminating vowels at high pitch[6]. The variation with pitch of the higher resonances (R2, R3, R4 and R5) is not associated with analogous tuning. In the high range of the male voice, some singers tune lower resonances to higher harmonics of the voice, but only for some vowels. We also compare the higher resonances (R3, R4 and R5) with those measured in speech in search of the singers' formant[7].


**The Use of Spectrographic Analysis of Female Voices in the College Voice Studio**
Patricia Callaway, D.M.A.
Department of Music
LaGrange College

The purpose of this study was to examine the potential usefulness of spectrographic analysis technology for the training of female singers in a college voice studio. Specifically, the following questions guided the study: (1) What information can be satisfactorily delivered through the study of spectrographic wave files? (2) Will subjective data, including the teacher's evaluation and subjects' self-evaluation of their performance in the vocal studio, be consistent with the objective data from the spectrographic wave files? (3) Will the subjects find the use of the spectrograph helpful? (4) Will the use of spectrographic technology prove to be compatible with traditional teaching techniques? Subjects were 10 students, ranging from ages 18-23, assigned to the investigator's voice studio at a small private women's college. Data collection took place during 10 sequential weekly lessons. After the warm-up segment of the lesson, students repeated three sequences of the same vocalise in ascending keys. A wave file recording was made of the third (highest) repetition. After recording the wave file, each subject completed a Likert-type questionnaire regarding her perception of the usefulness of the spectrograph. The teacher completed a comparable ques-

**Addressing Vocal Register Discrepancies: An Alternative, Science-Based Theory of Register Phenomena**
Leon Thurman, Ed.D., Graham Welch, Ph.D., Axel Theimer, D.M.A., Carol Klitzke, M.S., CCC/SLP

Vocal registers are controversial in the pedagogical, clinical, and scientific domains of vocology. For centuries, concepts and practices related to vocal register phenomena, including their linguistic labels, have been somewhat varied and commonly contradictory. Yet, within both the voice science and the voice education communities of the early 21st century, discrepancies remain in the conceptual frameworks, terminologies, and practices that are related to vocal registers. To people who are not familiar with the jargon of the voice-related professions, these incongruities are puzzling, confusing, and can even call into question the credibility of voice profession members.

Seven explicit or implicit assumptions that are imbedded in the jargon of vocal registers: (1) There are speaking-voice registers and singing-voice registers. [implicit assumption: all human beings have two voices (larynges), one for speaking voice, one for singing voice]; (2) Chest register is associated with lower singing pitch range and a comparatively "thicker" voice quality. [implicit assumption: it is activated by neuromuscular coordinations, or other phenomena, that occur within the chest and thus produces perceivable vibration sensations therein]; (3) Head register is associated with higher singing pitch range and a comparatively "thinner" voice quality. [implicit assumption: it is activated by
neuromuscular coordinations, or other phenomena, that occur within the head and thus produces perceivable vibration sensations therein; (4) Falsetto register is associated with highest singing pitch range, or with all pitches produced above chest register, and a comparatively "thinnest" (or "thinner") voice quality. [confusing implications: in Western cultures, it is strongly associated with a female-like voice quality produced by males; a "false" or "fake" voice that is of little or no practical use except in comedy; is falsetto the register of the entire pitch range above chest in both genders?] (5) Middle register is associated with a middle singing pitch range and a voice quality that is a "mixture" of chest and head (or falsetto) registers. [confusing implication: How does this fit with #4 above?]; (6) When voices change from one register to another, unskilled vocalists typically experience register breaks (abrupt transitions), but skilled vocalists have learned how to blend the transitions. A lower and an upper passagio pitch area are in all voices; they define the pitch range of middle register; (7) Each register can be performed throughout the entire capable pitch range of all singers, from lowest capable pitch to highest.

Among singing teachers, three perceived vocal characteristics are correlated when registers are categorized and labeled: (1) pitch range (based on frequency), (2) voice quality (spectral characteristics), and to some extent (3) volume (amplitude/intensity).

Scientific voice research has assembled anatomical, physiological, and acoustical parameters that may be correlated with these perceived register phenomena: vocal fold length (longer-shorter), vocal fold thickness (thicker-thinner), vocal fold tautness (greater-lesser), vocal fold adduction force during vibration, vocal fold contact area during vibration, vocal fold tissue depth during vibration, mode of vocal fold vibration, and the interaction of the vocal tract and tracheal resonance with vocal fold vibratory function.

This paper will present a reconciliation of the varied and conflicting register concepts, terminologies, and practices by: (1) presenting a brief historical context of vocal registers, (2) proposing a documented science-based theory that accounts for all vocal register phenomena from perceptual, physiological, and acoustical perspectives, (3) proposing criteria for selection of categorical word labels for register phenomena and suggest terms that meet them, and (4) suggesting how the theory can be beneficially applied to the teaching of efficient, skilled singing and speaking among music educators, choral conductors, singing teachers, speech teachers, theatre directors, and to therapeutic clinical settings.

Synthesizing Singing: What's the Buzz?
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The voice quality of synthesizers that are based on source-filter modeling is often perceived as being too mechanical and lacking in naturalness. Some of this criticism can be ascribed to phonetic shortcomings such as inappropriate prosody and improbable renderings of transitions between phonemes. Even on sustained vowels, however, source-filter formant synthesis is often found wanting, for example as regards appropriate perturbations of fundamental frequency (F0), realistic aspirative noise, and source spectrum control. In particular, source-filter synthesizers seem to have a strong tendency for vowels to sound buzzy and metallic, to a degree that is rarely found in the output from live speakers or singers. In this investigation, we attempt to identify some acoustic features that cue the perception of buzziness.

Guided by informal experimentation, we hypothesize the following: perceived buzziness will increase when (a) there is more energy in a frequency band between 5 and 8 kHz; and/or (b) the F0 is more stationary.

Listening tests are underway in which subjects rate the buzziness of a number of stimuli. The stimuli are both natural and synthetic, belonging to one of six categories, as follows:
1. A recording of a singer (trained baritone sustaining the vowel [a] on C4),
2. The output of a synthetic vocal tract, spectrally matched to the singer in (1), and excited by the time derivative of the simultaneously recorded EGG signal.
3. A synthesized source pulse train with constant F0, used to excite the same synthetic vocal tract.
4. As in (3) but with random F0 flutter of 20 cents RMS.
5. As in (3) but with a sinusoidal vibrato matched to the real singer's vibrato (rate: 5.9 Hz, extent: 43 cent).
6. As in (3) but with both flutter (4) and vibrato (5) added.

For each category, filtered versions of the above stimulus tones were generated, with sound level in a frequency band around 6 kHz being varied in five steps. All stimuli were matched for equal equivalent level. In order to reduce listener boredom and fatigue, additional redundant stimuli, with different pitches and vowels, were interspersed amongst the test stimuli.

The results will show to what extent high-frequency content is a predictor of buzziness, and whether or not stationarity in the fundamental frequency exhibits a significant interaction effect. The responses to stimuli in categories 1 and 2 may serve to indicate the possible relevance to buzziness of other factors in addition to F0 stationarity.

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The Effect of Choir Spacing on Choral Singers' Perceptions of Efficient Vocal Production
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This presentation summarizes data from a series of studies that examined the effects of different spacings (close, lateral, circumambient) among and between choral singers (N=110) in three different choirs (high school and university) on singers' perceptions of vocal production and auditor (N=280) preferences for desirable choral sound. Choral singers reported significant differences in perceived efficiency of vocal production when in spread spacing, and auditors overall significantly preferred the choral sound of spread spacing. More vocally mature male singers reported a preference for lateral spacing, while female singers overall preferred circumambient spacing. Results will be discussed in terms of theories of self-to-other singer ratios in particular acoustic environments, parameters of healthy vocal production in choral ensembles, and the adequacy of traditional wisdom concerning choir formations typically found in choral methods and conducting preparation materials.

Developing Young Professional Female Singers in UK Cathedrals
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The numbers of cathedral girls' choirs
in England has steadily increased since their inception at Salisbury in 1991. At present, around one third of the cathedrals, minsters and major chapels that educate and train choristers for the singing of regular services include girls. This has been a break with a musical tradition that has celebrated the ‘uniqueness’ of the male chorister voice for over 1,500 years.

Over the past decade, a number of related studies have examined the assumption of ‘uniqueness’ to see if this has any basis in perceptual phenomena. The available data on child and adolescent vocal anatomy and physiology indicate considerable similarity between the sexes until the onset of puberty.

Nevertheless, perceptually, gender differences in untrained children’s singing voices become more evident as children progress through childhood. However, the perceptual data on trained singers is more equivocal (cf Welch & Howard, 2002), suggesting that there is considerable potential for female choristers to be confused as male, depending on the choir and the choice of repertoire. In part, this is believed to be a product of the particular traditions, expectations and cultural practices of the socio-musical environment to which choristers are inducted.

The presentation will focus on a year-long research project, funded by the UK Arts and Humanities Research Board (AHRB), that sought to clarify and understand better how the musical culture of a cathedral choir impacts on the musical development and performance of its female choristers with regard to an ‘appropriate’ sound.

The prime elements of the research methodology were both qualitative, through observation, semi-structured interviews, analysis of printed materials (such as music and service schedules) and quantitative, acoustic analyses of recordings of female chorister singing behaviours in practice rooms and rehearsal spaces (including the Cathedral Chancel and Nave) and services. Participants were aged eight to sixteen years. Across the research year, (i) 52 individual female chorister recordings were made, each following an established protocol; (ii) 23 hours were spent observing choristers singing in rehearsals, services and individually and (iii) an additional 15.5 hours was spent in interviews.

Preliminary analyses of the 15.5 hours of semi-structured interview data, related to 23 hours of observation, have generated four main classification categories (‘individual’, ‘group’, ‘environment’ and ‘relationships’) and fifteen sub-categories. The latter have been generated by a clustering of thirty-nine different elements that are identifiable as having a reported impact on chorister development. Although the data analyses are ongoing, a picture is beginning to emerge in which the female choristers may be seen both as part of an established tradition, but also as having a ‘transformational’ impact on it. The customary tripartite relationship in music (Small, 1999) between the physical setting, people (performers and listeners) and musical soundscape constrains the variety of possible musical outcomes, but this relationship has also changed to take account of the new female chorister membership. The changing gender make-up of the formerly all-male choir is bringing about a modification of cultural and musical expectations.

References:

Acoustical Description of Eight Common Singing Styles Produced by a Single Female Singer: Preliminary Results
Dr. Nathalie Henrich, Lisa Popiel
The purpose of our investigation is to explore various acoustical aspects of different common singing styles. What do they have in common; what are the differences? The results may give cues to people interested in learning to sing in different styles as well as expanding pedagogical possibilities for singing teachers.

We can imagine that these findings could even be integrated into future “voice coach” software aimed at helping people learn to sing and match vocal styles.

This presentation will show acoustical analysis of sound samples recorded by one subject, a skilled female singer (L. Popiel) demonstrating 8 different vocal styles: opera, musical theater “legit,” musical theater “belting,” pop, rock, jazz, country, and R&B (soul). These will be compared to a speech sample. Audio and EGG recordings were made using the song “Amazing Grace.”

Samples will be assessed from short samples extracted from the song and will measure the following acoustical parameters: pitch and vibrato, loudness, open quotient, spectral amplitude of the harmonics and harmonic-to-noise ratio.

Sound samples will be made available as an adjunct to the visual information presented.

Vocal Health in the Choral Rehearsal: Common Ground for Operatically Trained Singers, Studio Voice Teachers and Choral Conductors
John R. Weiss, D.M.A.
School of Music and Theatre Arts, Washington State University
Recent research and experimentation by Johan Sundberg, Ingo R. Titze, Mirano Hirano, William Vennard, and many others have contributed greatly to the understanding of voice physiology and function. Nevertheless, much anecdotal evidence reveals continuing problems experienced by operatically trained singers in the collegiate choral rehearsal. Previous studies have dealt with this topic in various specialized ways. The findings of Slusher (1991) showed that a conflict exists between studio voice teachers and choral directors relating to vocal pedagogy. The Cook-Koenig (1995) study extensively explored vocal fatigue in choral singing. A pilot study conducted at the University of Arizona (Weiss, 2000) corroborated Slusher’s findings.

Unfortunately, no study integrates contemporary voice research with vocal pedagogy and choral methodology. This presentation, therefore, will show how recent findings in voice physiology and function can be applied in the choral rehearsal so that operatically trained singers can participate without experiencing vocal fatigue, compromising vocal development, or risking vocal injury. Specifically, it will recommend two techniques that will help operatically trained singers meet the varying vocal demands of the collegiate choral rehearsal: physiologic Vocal Function Exercises as developed by Joseph C. Stemple (Sabol, Lee, and Stemple, 1995), and traditional messa di voce exercises. An empirical study at the University of Arizona (Weiss, 2001), successfully integrated these techniques into eleven 50-minute rehearsals of stylistically diverse repertoire requiring different sound ideals.

Comparative Study of Vocal Technique through Historical Recordings
William Carey and Donald Miller
A century of singers’ recordings presents a still largely neglected opportunity to examine historical developments in
voice production by means of acoustic analysis. This study looks closely at the recordings of Rosa Ponselle (1897-1970), focusing particularly on her use of registers. Her distinct treatment of three registers—chest, middle, and upper—is seen as typical of the earlier 20th century and is compared with the more recent trend of minimizing the differences between the registers. Recorded examples are presented, together with acoustic analysis. Implications for vocal pedagogy are considered.

The Tongue as Culprit: Increasing Vowel Clarity and Improving Legato through Releasing Unnecessary Tongue Tension
Ruth Rainero, MA
What in the world was God thinking when she designed the tongue? Why dedicate the delicate motor activity of articulation and vowel formation to a muscle primarily designed for the gross motor activity of pushing food down? Singers and other voice users have been suffering ever since.

Tongue tension will greatly impede the creation of a fully resonant sound and the ability to move smoothly and seamlessly from one pitch to another and from one vowel to another. Such tension will also cause consonants to separate—rather than connect—said vowels.

Unfortunately, such is the nature and location of the tongue that often neither student nor teacher are aware of this inhibiting tension. This workshop discusses the problems inherent in vowel and consonant formation, how to recognize aurally when the tongue is being used incorrectly, and how to achieve efficient tongue use. It offers clear and simple exercises for vowel formation and for vowel and vowel/consonant transitions. (Optional: discussion of sounds not found in English, e.g. Italian 'gl', French nasalized consonants, French and German 'ü', Dutch 'ij' and 'ui', and the tongue-specific problems they create for non-native speakers.)

The Control of Consonant Airflow During Singing
Martin Rothenberg
Professor Emeritus, Syracuse University, and President, Glottal Enterprises
The paper The Control Of Airflow During Loud Soprano Singing (COA), written with colleagues in the Syracuse University Speech Research Laboratory, Donald Miller, Richard Moltior and Dolores Leffingwell [Journal of Voice, Vol. 1 No. 3, 338-351 (1988)], can be seen as returning to the line of research of the monograph resulting from my doctoral dissertation, Breath Stream Dynamics of Simple Released Plosive Production (BSD) [Bibliotheca Phonetica VI, Karger, 1968]. The problem we considered in COA stemmed from the fact that the subglottal air pressure used by a professional soprano was known to reach values four or five times the pressures attained in normal speaking. A previous paper, Così Fan Tutte, explored one mechanism for conserving breath volume during vowel segments sung with air pressures this high. However, were there also mechanisms for conserving the breath volume during unvoiced consonants occurring between the vowels in the piece being sung? In many such consonants, as pronounced during speech, there is a period during which the vocal tract and glottis are both open and thus the airflow increases. Since the response times in the postural muscles controlling subglottal pressure are among the slowest in the body, it is not likely that the pressure could be reduced abruptly for the consonant and increased abruptly for a succeeding vowel. Therefore there are likely to be other compensatory mechanisms that must be learned by the professional singer. In COA we indeed found such mechanisms. In this paper I will review the mechanisms we found and show how the features of the physiologically based model for consonant production presented in BSD, in which a consonant is described in terms of a set of coordinated articulatory gestures, provide a better basis for explaining the consonant production patterns used in speech and singing than do acoustically based features such as voice onset time.

POSTER PAPER ABSTRACTS

Birth Control Pills and Voice
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The classic literature on voice disorders considers birth-control-pills as a risk factor. This view is based on reports of adverse androgenic effects (i.e., virilization) dated in the 1960's and 1970's. Since then, voice professionals often advise women, and especially professional voice-users, against the use of oral contraceptives. However, a series of recent studies (Amir et al. 2002, 2003a,b) has demonstrated that this traditional view should be re-evaluated. In these studies, modern low-dose monophasic birth control pills were shown to have no adverse effect on voice quality. In contrast, voice quality, as reflected by specific acoustic parameters, was found to improve among young women who use the pill.

The purpose of the present study was to extend our knowledge on the effect of oral contraceptives on voice, by comparing different categories of birth-control pills.

Three types of pills were included, arranged according to their progestin content: drospirenone (3mg), desogestrel (0.15mg) and gestodene (0.075mg). Accordingly, three groups of women, with no professional voice background, who use the pill, were compared: a) ten women who use Yasmin®; b) nine women who use Microdol® or Mercilon®, and c) ten women who use Gynera®, Harmonet®, Meliane® or Minolet®. In addition, a fourth group of nine women who do not use the pill was included, as a control group. All women in each of the three pill-groups were recorded twice. One recording was conducted after ten days of taking the pill, at the time hormones are at a steady state in the plasma ("On" condition). The other recording was conducted during the first three days of menses, when no pills are taken ("Off" condition). The control group was recorded once, in the "Off" condition, since the "On" condition was not applicable for them. Subjects were recorded while producing the vowels /a/, /i/ and /u/ repeated for five seconds. Computerized acoustic analyses evaluated fundamental frequency (F0), three frequency-perturbation measures (Jitter, PPQ and RAP), two amplitude-perturbation measures (Shimmer and APQ) and two noise-indexes (NHR and VTI).

Results revealed no significant differences in voice quality among the three groups of pill-users. Additionally, no differences were found between women
who do and do not use pills (P > 0.05). Marginal group differences (0.05 < P < 0.10), however, were observed between the women who use Yasmin® to the other two groups of pill-users.

Finally, no significant differences were observed between the “On” and “Off” conditions among the three pill-groups. The present findings do not reveal any adverse effect of birth control pills on voice quality, supporting recent research and contradicting the traditional view on oral contraceptives as a risk factor for voice. In addition, different categories of pills were found to affect voice quality similarly, with no observed advantage to a specific commercial brand. However, while our previous line of research suggested that modern birth control pills might improve vocal quality due to the elimination of the hormonal fluctuations along the menstrual cycle, the present study suggests differently.

This study, which included a significantly larger number of subjects, a wider and more systematic variety of oral contraceptives and a wider age distribution, suggests that modern birth control pills, indeed, have no adverse effect on voice, but neither do they have a favorable effect on voice quality.

The Three R’s of the Egoscue Method as applied to Vocal Production
Laura Bishop, M.M.

The goal of the Egoscue Method is “to bring about a state of muscular balance and internal homeostasis to the individual.” (1) This state of ‘muscular balance and internal homeostasis’ is the essential component of every outstanding singing artist. The primary objective of the Egoscue Method is to remove the person’s structural dysfunction, just as vocal pedagogues must first assist their students to eliminate any vocal dysfunction, before they may proceed with the formation of an exceptional singing musician. The human body is a highly integrated structure, as singing is a highly integrated artistry of body, soul, spirit, and voice.

The “three R’s of the Egoscue Method” (2) may be applied or specialized to the pursuit of superlative vocal pedagogy as follows: A) Rediscover Body’s Design: Rediscover the vocal benefits attainable through proper usage of the body’s design; B) Restore Function: Restore functional coordination (or optimum coordination) between voice and body through reanimation of intrinsic muscle functions to the extent that compensatory muscles have assumed their role; C) Return to Health: Return to joyous, spontaneous vocal expression.

There is an indivisible unity of sensible muscular coordination and vocal ease. “The Egoscue Method can reconnect individuals to their innate kinesthetic sense or muscle memory.” (3) The Egoscue ‘e-cises’ (physical exercises) provide a marvelous means for the attainment of many of our vocal studio goals, for instance: a) isolation/strengthening of a particular muscle/muscle group; b) relaxation of any compensatory muscle/muscle group; c) attainment of matchless muscular coordination; d) restoration of muscular functions following a convalescence. It is a wonderful system through which the following faults among singing students may be corrected, or, at least, improved: a) raised shoulders; b) chin jutting out; c) head pulling forward under effort; d) head angled off-lined to one side; e) inability to keep hips tucked under torso; f) inability to expand lower back for vocal support; g) eversion of feet.

Through the utilization of video recordings or, alternatively, slides together with audio recordings, the presentation will trace the improvement of half a dozen singers, each working on a chosen song or aria, during a two month period.

The repertoire used included dramatic, declamatory, floating, rhythmic, and sustained passages to demonstrate the facility and strength which the Egoscue Method can bestow to singers with both heavy and light voices in a broad span of musical expression. For the period of the study, each singer faithfully carried out his/her Egoscue ‘e-cises’ menu on a daily basis (approx. 30 minutes daily).

The menu itself was re-evaluated and correspondingly altered every ten days through examination of digital photographs. Additionally, the tendency to compensate, in a bodily way, to the technical difficulties of the musical work being studied was neutralized by rehearsing well-aimed ‘e-cises’ simultaneously with the repetition of the chosen work.

Since, in any case, the Egoscue method unconsciously alters the individual’s postural habits, this manner of exercising does not distract from productive vocal training….rather, the ‘e-cises’ may be used to enhance the learning process, since they promote a kinesthetic awareness on the part of the student, at the same time as he/she is training his/her voice. Among the some 400 Egoscue ‘e-cises’ are also many exercises that singing students could do on their own to strengthen their bodies and promote correct alignment for singing. These will be briefly discussed. The presentation will document the visible and audible improvement of the chosen musical works’ performance. Slides, taken at regular intervals during the study, will chart each singer’s improvement.

There is an obvious similarity in the objectives and observations of both the Egoscue Method and Alexander Technique. The overall purpose of the Egoscue ‘e-cises’ is to stimulate anew the ‘major’ muscles to carry the ‘vertical load’ of an upright well-aligned body, thereby neutralizing the ‘peripheral’ muscles which had inadvertently jumped in to compensate for the ‘atrophy’ of the above. Alexander referred to the necessity to maintain a lengthening of the stature while speaking at the same time. Alexander’s repeated admission that the vocal organs were influenced by the manner of using the whole torso, is, in the meantime, common knowledge among those working with their voices professionally.

The significant difference in the two techniques lies in the advantage of the closely monitored repetitive and regularly re-evaluated muscular training of the Egoscue Method. This training ultimately causes the appropriate muscles to automatically assume their intended task in its correct intensity, which subsequently involuntarily allows the ‘peripheral’ muscles to cease their misdirected effort. The repetitions enact the change or adjustment in the performer’s alignment; the danger of the misinterpretation or exaggeration of the verbal directives is thereby eliminated.

Alexander’s frustration over reliance on the spoken word was alluded to repeatedly in his book "The Use of the Self," in which he described the difficulty of enacting changes in a sensory experience simply through the written or spoken word. (1) “I must emphasize that my readers will not be following me unless they recognize: that knowledge concerned with sensory experience cannot be conveyed by the written or spoken word, so that it means to the recipient what it means to the person who is trying to convey it.” (2) “that they will need to depend upon new ‘means’ whereby for the gaining of their ends, and that they will ‘feel wrong’ at first in carrying out the procedures because these will be unfamiliar,” and (3) “that to ‘try and get it right’ by direct ‘doing’ is to try and reproduce what is known, and cannot lead to the ‘right’ the as yet ‘unknown!’” (4) Additionally, an admission from his vast teaching experience: “The belief is very generally held that if only we are

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told what to do in order to correct a wrong way of doing something, we can do it, and that if we feel we are doing it, all is well. All my experience, however, goes to show that this belief is a delusion." (5)

However, through the repetitions of the Egoscue 'e-cises', the somewhat dormant or neglected specific muscular utilization effortlessly becomes 'the known,' and therefore, logically, the habitual. Above and beyond this, Alexander was baffled by the absurdly high number of repetitive directives essential to finally completing the desired change in the participant's coordination. "Experience taught me that before attempting to 'do' even the first part of the new 'means whereby' which I had decided to employ in order to gain my end" (ie: vocal use), "I must give the directions preparatory to the doing of this first part very many times": (6)

With the Egoscue Method, through the repetitive execution of the 'e-cises', the body cultivates a 'new' coordination, solidifies it, and the margin for error is essentially eliminated. Thus, the singing artist has only to revel in his/her 'newly found' matchless integration of body, soul, spirit, and voice.

NOTES:
3. Ibid., p. 31.
5. Ibid., p. 33
6. Ibid., p. 41

Research on Breath Support
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Rationale. There is controversy in the musical field about breath support (S) and what muscles are being recruited to achieve it. We measured respiratory parameters and recorded sound (So) during professional flute playing in order to assess what physiological processes were associated with the term "breath support." Four standing young professional flautists played excerpts from the standard flute repertoire with S and without S (NS). Recordings included opto-electronic plethysmographic measurements of chest wall (cw) volume (Vcw) and its compartments: lung and diaphragm apposed ribcage, and the abdomen (Vrc.p, Vrc.a, Vab) using 6 infra-red video cameras filming 89 reflective markers on the thorax at 100Hz, surface electromyography (emg), at 1000Hz, scalene (Esca), transverse (Etra), rectus abdominus (Erec), parasternal (Epar) and sternocleido-mastoids (Este), mouth pressure (Pm), So during playing. Flow (V) was measured during quiet breathing and vital capacity and estimated by differentiating Vcw during playing. Diaphragm emg (Edi), esophageal (Pes) and gastric (Pga) pressures and cw distortion were measured in one subject. Emg signals were integrated, rectified and the area under the curve was compared within subjects.

Results. All subj. displaced cw compartments differently between S and NS.

For all subj., at least one of Vrc.p, Vrc.a, or Vab remained constant for a longer period during S than during NS. V was bigger and started more abruptly in NS than in S. Esca of 3 subj. and Etra of 4 subj. show distinct increased activity during playing S. In 3 subj., Pm shows finer variations during S than during NS. Este tended to be increased during S but varied more between subj. We believe that support entails finer control of Pm achieved by activation of inspiratory muscles, the scalenes, requiring greater recruitment of transverse expiratory muscles.

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An Alternative Hypothesis About How Human Bodies Stand, Sit and Move Within Earth's Gravitational Field
David Gorman, Babette Lightner, Leon Thurman, and Axel Theimer

Posture is the common label for upright whole body arrangements that can influence, for good or ill, the relative efficiency with which speaking and singing coordinations are produced. In pre-scientific speaking and singing pedagogies, a "focus-on-the-parts" and correctness tendency is exemplified by instructions about "arrangements" of the skeletal frame. The term posture has etymological roots in setting, fixing, or holding of one's body in a place [Latin: positura = formation; which is a stem of pono, poner, postum = to put, post, place, set, fix, or stake]. Common postural expressions reflect this static, positional semantic history, e.g., "Place your feet shoulder-width apart", "Keep your sternum up and your shoulders back and down," or "Hold your head up regally." Twentieth century advances in "body pedagogy" introduced methods by which speakers and singers can orient their bodies more advantageously. These advances are based on the hypothesis that facilitative body orientations during speaking and singing can be obtained by: (1) improving the relationship between the body's anatomical areas (e.g., head-neck relationship, spine-torso-pelvis are "lengthened"), (2) grounding those relationships in accurate knowledge of anatomical parts (e.g., body "maps"), and (3) "hands-on" facilitation by a teacher. These orientations are more advantageous to the state of the body than more traditional orientations because they optimize the internal space between vertically "stacked" body parts and result in greater degrees of freedom in body functions. They appear, however, to continue a tradition of consciously attending to isolated "body parts and their relationships" while the person is simultaneously supposed to be engaging in complex, global, goal-directed behaviors such as playing an instrument or moving while speaking or singing.

Typically, when singers and actors report "peak experiences" during rehearsal or performance, they describe experiences of wholeness, "flow", clarity, effortlessness, and "in-the-zone-outside-the-self" expressive connectedness with the music, text, and/or audience. They do not report that their body or vocal parts were performing correctly. With that in mind, this paper proposes an alternative hypothesis about what happens within whole human beings when they sit, stand, move, and perform complex behaviors (such as speaking and singing) within the support of Earth's gravitational field, the environmental terrain, and a social setting. The hypothesis is grounded in current micro-and macro findings in the anatomical, physiological, and evolutionary sciences, and the neuropsychobiological sciences. It proposes that evolutionarily designed human beings are endowed with a global, bodywide executive capability that enables (1) holistic navigation and action in Earth's gravity and in any encountered terrain, and (2) holistic execution of intended, goal-directed bodily coordinations (speaking and singing).

A metaphoric model for this human structural capability is: a lattice-work skeleton with moveable joints that are woven together in a suspended, counter-balanced, elastic web of muscle-connec-tive tissues, and the suspended elastic web is enacted automatically by the central nervous system's numerous interfacial neural networks of networks of networks, etc., to accomplish intended,
purposeful behavior. Human beings, therefore, are designed to function as a whole self, without needing to devote conscious attention to the body's physical, cognitive, and affective parts. Life experiences elicit neurophysiological adaptations in the body that, typically, produce compensatory alterations in the functioning of the suspended web, so that "unnecessary" neuromusculoskeletal "holdings" or neuropsychobiological constraints become instantiated in the body's neural networks and thus activate automatically (habitually). Helping people become sensitized to the state of their body when they act, and to the state of their body when their automatic, counterbalanced, suspended web is allowed to function according to its innate design, appears to facilitate optimum human performance.

Belters Pathology?

Three Case Presentations

Wendy DeLeo LeBorgne, Ph.D; Thomas J. Kereiakes, M.D.

The debate on the health of Broadway "belting" provides a source of heated discussion among many singing voice teachers, voice pathologists, voice scientists, and otolaryngologists. Specifically, it is belief detrimental to the laryngeal mechanism when it is trained in young voices or used robustly in eight performances per week? This session will provide three case studies of young belters (18-22 years old) who each present with an unusual, yet similar vocal anomaly. In each of these cases, one of the vocal folds presents as essentially non-vibratory, edematous, and erythematous; while the other vocal fold appears essentially normal in its mucosa and vibratory characteristics. Laryngeal videostroboscopic examinations will be provided on each of these singers. Perceptually, there was minimal hoarseness among these three performers. Two of the belters presented are professional (Actor's Equity Association) performers and one is in a pre-professional musical theater training program (currently earning Equity points). Audio examples will be provided. Demographic information, treatments attempted, and outcome results will be discussed. This session is designed to provide an open forum to discuss: (1) Possible explanation of this pathology and its relevance (or lack thereof) to belting; (2) Treatment recommendations from singing voice teachers, voice pathologists, and otolaryngologists.

Translating Imagery into the Language of Body Mapping

Melissa Malde, DMA

Many of us teach voice students using imagery. We ask them to "place the tone in the mask" or to "drink in the breath." These images are not based on anatomy and physiology. Some images work well for some students, but in others they can lead to misconceptions that compromise efficiency and inhibit ease of production.

All teachers know that what we say and what our students hear can be dramatically different things. Translating these images into factual descriptions of movement will help diminish this gap. We can guide students to visualize and refine the movement that leads to the desired sound. This is the power of Body Mapping: If we have a detailed map (of internal representation) of how we are built and how we function, we can bring our entire instrument (the body) into our awareness and learn to sense the difference between adequate, appropriate effort and excess, tension-causing effort.

Taking one of the examples above we can see the power of Body Mapping. When we instruct a student to "drink in" the breath, we might intend for the student to take in a flowing breath and feel the effects down to the abdominal region. Some students might understand this intuitively. However, some might equate breathing with the act of swallowing, which opposes the act of singing.

When we drink, the pharyngeal muscles contract in sequence from top to bottom, guiding the liquid into the esophagus, aided by contraction of the tongue. As the tongue contracts, it pulls up on the larynx. Muscles controlling the epiglottis contract, pulling the epiglottis over the larynx to prevent the liquid from entering the trachea. The esophagus, which is made of muscle, contracts and the liquid is pushed down past the diaphragm into the stomach.

Once this process is clearly described, it is obvious that it has nothing to do with singing. The muscles of the pharynx, tongue and esophagus are passive during a singing breath and release to provide maximum passage for the incoming air. The larynx remains low and the glottis opens wide. A vacuum is created in the thoracic cavity by the action of the diaphragm and intercostal muscles. Air rushes in through the trachea to the lungs in order to equalize the pressure. The trachea is made of cartilage and thus provides a clear passage for air without any effort. The lungs are organs, which effortlessly expand and contract to fill the thoracic cavity. The only movement involving the stomach is the downward pressure on all the organs exerted by the contracting diaphragm.

Using anatomical pictures and models, we may help a student to refine and deepen her body map of the structure and movement of breathing. Once correctly mapped, breathing may occur with appropriate effort, unhampered by misconceptions. This presentation will translate many of the prevalent images used in teaching voice into the language of Body Mapping, portraying the perils and profits that might arise.

Acoustic Differences in Voice Self-perception in Male and Female Singers

Scott McCoy, DMA

This study was prompted by a question recently raised by a student attending my class in voice acoustics, resonance and analysis, sponsored by the New York Singing Teachers Association: given the fact that sounds of short wavelength are more directional than those of longer wavelength, do men hear their own voices more accurately than women? The question posed, of course, relates only to that portion of sound heard through air conduction, ignoring the stronger component of bone/tissue conduction. To explore this issue, male and female singers will be recorded in the facilities of the Westminster Voice Laboratory, simultaneously taking samples 30cm directly in front of the mouth and at the side of the head, adjacent to the ear. Long term average spectra of the two signals will be compared. Preliminary testing shows significant gender-based differences.

Singing and voicework for those with Alzheimer's, Parkinson's and special needs as well as stroke patients and the carers for these groups: an on-going assessment of the benefits of working with voice to activate and improve muscular, aerobic and cardio-vascular exercise and overall well-being.

Liz McNaughton, M.A., LL.B

It is difficult to give quantitative data as these people are particularly vulnerable and the necessary methods for quantitative research would be invasive and therefore highly counter-productive, interfering with any improvement already manifesting in greater confidence and self-esteem. Qualitative feedback shows an overwhelming case for the ben-
effects of introducing this work into recovery and maintenance strategies in order to gain improved physical, mental, emotional and social communication skills.

A feeling of well-being dominates the comments in the feedback as well as an ability to focus on tasks, to co-ordinate, as in clapping and stamping while carrying out vocal tasks, and an improved memory and general state of mind at the time of the activity and afterwards.

Music has long been seen as a healer and the singing voice is particularly significant. However the enjoyment and benefit to many people of choral singing begs the question of why so many consider themselves unworthy of using their voices to sing.

The author has approached many groups to encourage voice work as a means of achieving better health and confidence for the whole person and although this was often regarded with some doubt, caution and not a little curiosity, when given the opportunity of holding workshops, the response has been overwhelmingly positive.

Any weakness in tone, pitch or rhythm was as nothing compared with the enormous joy of making sound more and more freely. Frequency of sessions also showed improvement in these areas along with good dynamic control.

This paper highlights the benefits of this work and urges others to help build up a body of information that will stand strongly in the stead of quantitative data providing a persuasive argument in favour of encouraging this opportunity for all by convincing doctors, health workers and everyone involved in caring for these people of the benefits.

With increasing numbers of frail and elderly people surviving longer, the social significance of providing voice training is clear as it is vitally important to improve the quality of that lifespan and allow more possibility of worthwhile and life-enriching activity.

The benefits to carers and cared for are many as are the rewards both professionally and personally to those privileged to work in these arenas.

Vowel Modification Revisited
John Nix, M.M., M.M.E.

In the last 40 years, many vocal pedagogy authors have written about the need for appropriate vowel modification. Modification involves shading vowels with respect to the location of vowel formants, so that the sung pitch or one of its harmonics receives an acoustical boost by being near a formant. The goals of such modification include a unified quality throughout the entire range, smoother transitions between registers, enhanced dynamic range and control and improved intelligibility. Elite singers, whether they consciously recognize they are modifying vowels or not, become experts at making subtle changes in vowels as they sing, or they do not have consistent careers. Modification concepts which have been widely accepted are summarized below:

1. Although there is a strong correlation between voice classification and formant frequencies, due to subtle articulation and anatomical differences, formant frequencies are unique to each individual.

2. The amount of modification needed varies with the size of the voice, the "weight" of the voice, the duration of the note being considered, the dynamic level, and how the note in question is approached. Sensitive singers report that the amount of modification they need may vary daily and also during the day, depending on how much they have warmed up.

3. Vowel formants are frequency bands, not one specific pitch.

4. Precise tuning of each note in a piece is not very practical nor is it acoustically beneficial. During a rapid passage, a singer may not have enough time to adjust for optimal resonance on each vowel on each note; moving on to the next note in the passage smoothly is a greater priority than exact tuning of each tone.

5. Males and females “tune” differently. In general, males seek to match harmonics above the fundamental to a formant, while females, especially in the upper voice, tend to reinforce the fundamental itself by matching it to the first or lowest formant.

6. Several general “rules” for modifying vowels exist (as summarized by Titze):
   (a) formant frequencies lower uniformly by lengthening the vocal tract (either by lowering the larynx or protruding the lips or some combination of both);
   (b) formant frequencies are lowered uniformly by lip rounding and raised by lip spreading;
   (c) fronting and arching the tongue lowers the first formant and raises the second formant, while backing and lowering the tongue raises the first formant and lowers the second formant; and
   (d) opening the jaw raises the first formant and lowers the second formant.

Other information now needs to be integrated into pedagogical approaches. Three areas of continuing study have particular significance for singing teachers.

1. The effect of subglottal resonances upon vocal fold vibration. Just as the vocal tract above the vocal folds has different formants, so too does the subglottal airway. The primary difference is that vocal tract resonances can be altered consciously by moving the tongue, lips, jaw, palate and larynx, while the subglottal airway remains basically the same for all vowels. So while the vocal tract formants vary from vowel to vowel, the subglottal formants are relatively “fixed,” with only a slight amount of variation possible due to changes in laryngeal height. The relationship between the sung pitch and the effect of these subglottal formants on vocal fold vibration should be incorporated into pedagogical approaches.

   The implication of subglottal resonances for singers is that at some pitches, particularly around D3 and D4, pressures due to subglottal resonances increase the amplitude of the vibration of the vocal folds, while at other pitches, especially around G3 and C5, subglottal resonance factors decrease the amplitude of vocal fold vibration. Titze suggests that this change in vocal fold vibration can be controlled by adjusting vocal fold adduction slightly. When subglottal driving pressures substantially increase vocal fold vibration amplitude, a slight increase in adduction may be warranted to prevent overdriving the system; when subglottal driving pressures substantially decrease vibration amplitude, a slight increase in adduction may be helpful. By doing so, the singer may avoid large changes in intensity from one pitch area to another.

2. Male singers shift from using the first formant for reinforcement to using higher formants. While in the lower voice they match a harmonic to the first formant of the vowel being sung, in the passaggio and above they lengthen the vocal tract by protruding the lips and/or adjusting the position of the larynx downward slightly to match a higher harmonic to a lowered second formant or to the singer’s formant. This is what is commonly described as “covering.” Brighter voiced singers like Luciano Pavarotti in his prime and Alfredo Kraus are good examples of male singers who use the second formant-dominant strategy in the high voice. Placido Domingo, on the other hand, tends to use the singer’s formant-dominant tuning strategy.

3. The importance of keeping the fundamental or its harmonics slightly below the resonance formant peak, in order to keep the vocal tract inertive (thus assisting in sustained vocal fold oscillation) and so that the pitch change due to vibra-
to remains in phase with the rise in amplitude as the formant is approached during each vibrato cycle (so that loudness rises and falls in sync with the vibrato).

How might singers and teachers apply this information to singing repertoire? The author’s poster will give a few examples. As always, each singer is unique. Fine adjustments for slight individual differences and how to best teach these concepts are left up to the teacher and the performer. Some singers prefer objective visual feedback about vowel tuning by using a spectrum analysis program like Voice Vista or Gram in the studio or the practice room; others respond best to verbal suggestions of target vowels to sing; some others thrive on kinesthetic commands like “adjust the space or lift of that vowel a bit more for the pitch and power of that note;” and still other singers find demonstration/imitation or imagery most effective. Chacun a son gout! And, as always, optimal sound output must constantly be weighed against the need for intelligibility. In almost every case, however, optimal acoustical tuning will both aid ease of production and improve intelligibility.

References:


Current Pedagogical Methods in Singing Voice Rehabilitation
Dr. Karen Wicklund
In the collaboration team of voice teacher, speech-language pathologist and physician, the voice teacher is perhaps the most critical collaborator due to the ongoing nature of the relationship with his/her student. The teacher and student who have built a relationship of trust and respect should be able to continue working together when and if vocal injury occurs, especially if the voice teacher is prepared with adequate rehabilitative pedagogical methods. Because rehabilitative techniques are not always a part of voice pedagogy courses in most university training, a teacher may seek out workshops, courses in speech pathology, and/or collaborative rehabilitative training internships to bolster his/her knowledge of therapeutic techniques.

The presenter of this presentation possesses a doctoral degree in voice and is also degreeed in speech pathology. She will describe her work with a University of Illinois at Chicago otolaryngologist in the rehabilitation of several professional singers. The singers had various disorders such as spasmodic dysphonia, vocal cord paresis from recurrent and superior nerve damage, vocal cord nodules, polyps, GERD, and muscular tension dysphonia. A single-subject study format will be used to present methods and results. Vocal recovery schedules and specific vocalizes for each type of disorder will be discussed and demonstrated.

In addition, specific therapeutic song repertoire choices and vocal hygiene recommendations for the injured singer will be discussed.

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