Using Digital Technology in a Voice Lesson

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Deep rooted teaching traditions and practices are slow to alter to newer more advanced ways that use technology. For decades, the tradition of voice teaching was the teacher at the piano and the student standing facing the teacher awaiting instruction; only the eye and the ear, along with the teacher's good musical taste (tradition), guided students through their vocal development. Technology such as tape recorders, video cameras, computer sound analysis programs, and other such electronic devices were unknown. Today, they are gaining in importance in vocal pedagogy.

The large modern orchestras and performing areas place ever greater demands on vocal production. Vocal loudness alone cannot be sustained nor is it sufficient to rise above a harmonically rich background accompaniment in today's performing arenas. These demands require an increasing need for digital technology in order to redefine and refine the acoustical properties of the human voice. Only through an understanding of vocal energy and all of its components and how they relate to physiology and acoustical laws can voice be given the necessary power (projection) to meet the acoustical demands of our future concert halls and opera houses.

To combine visual and audial observation brings a new consciousness to the act of singing. It also establishes documentation for later usage which might significantly shorten the normal development time of student's studies, an important financial consideration in today's world. For example, questions pertaining to posture and how to apply breath to tone become clearer through technology's ability to quantify vocal output. Postural alignment during phonation is made significantly clear through the use of video cameras.

The data acquired during voice teaching can be of immense value to the pedagogue as well. A quiet time to review one's teaching practices throw into relief areas of weakness and suggests where more detailed information could be given to the student. Out of this can evolve new approaches to the disciplines of breath, onset, and resonance.

Using new technology requires the pedagogue to research the areas of physiology and acoustics that pertain to phonation. Many articles and books on the subject grace our libraries today. They form a data base which covers the multitude of dysfunctions found in students seeking vocal instruction. A few of the prominent voice researchers are: Minoru Hirano, Seishi Hibi, Richard Miller, Thomas Hixon, Diane Bless, and Johan Sundberg. Their work deals with the basic functions of voice production and the voice's acoustical properties and production.

It is beneficial to read vocal research which can result in a deeper understanding of vocal pedagogy. Questions as to how the physical and the acoustical relate, how resonance and breath are related, and how alterations unnatural to speech affect the vocal tract and its output remain unanswered when little or no reference is made to scientific studies.

The technology of vocal amplification through sound systems becomes clearer to the user when an analysis defines the results and shows that microphones do not correct vocal faults - they merely amplify them. Some sound systems synthetically add in harmonics. In such cases, the singer is noted as a better recording studio singer than performing artist. Experience tells us that it is better to bring all the tools a voice requires - a full range of harmonics and a pleasing vibrato - with us, rather than rely on recording technology to supply the missing elements. The following sections demonstrate some applications of digital technology to vocal analysis and pedagogy.

The Instrumentation

The instrumentation used to record the voices was a Sony ECM 155 Electret Condenser Microphone IMP High held up to 24 inches away from the singer; the software program was "Dr. Speech" made by Tiger Electronics Inc.; the computer was a Toshiba Satellite Pro 400 CS laptop. All of this instrumentation is portable and within the financial boundaries of most singing teachers.

The Singers

There were five singers involved in this paper. The youngest was 20 and the eldest 62. All had some experience performing either as a choral singer or soloist. All sang the vowels (i), a front vowel; (uh), a neutral vowel; and (aw), a back vowel

The Motor or the Breath

It is common for the pedagogue to ask for more breath support, or "support the voice.". The term "support" metaphorically refers to a multitude of physical actions whose exact interpretation depends on the singing school the teacher represents. What is demanded is a greater vocal intensity which in turn improves the formant energy and narrows the vibrato's amplitude.

In figure #1 below, the lower left hand windows show vibrato and breath intensity of a soprano singing on the pitches C5 and F5 respectively. On the right are two windows which show the formant structure (the undulating lines), while the peaked red lines show the various harmonics involved in the sample taken from the left hand window's gridlines. Height of harmonics is given at the bottom stating frequency up to 5.0 kHz; intensity is indicated on the left showing values from -20 to +100 dB.

The top left hand picture shows that the pitch does not always begin in the same location while the rising endings of the utterance indicate glottal tension. The lower illustration shows that the singer cannot break off and re-begin the utterance on the higher pitch, indicating a breath renewal problem. These observations open up the lesson to areas where problems may exist - mainly breath and posture in this instance, with additional tongue retraction, indicated through the low formants.

The right hand pictures show that the energy of the formants is high on the lower pitch (C5 upper right hand picture), and is low on the higher pitch (F5). To say the voice would not carry, is not true, but the timbre, of the sound is seriously altered, making vowel identification difficult. The high dB assures loudness and audibility. Figure #1 below depicts Soprano #1 singing (i), (uh), and (aw) on C5 and F5.

Fig.#1
C5
F5

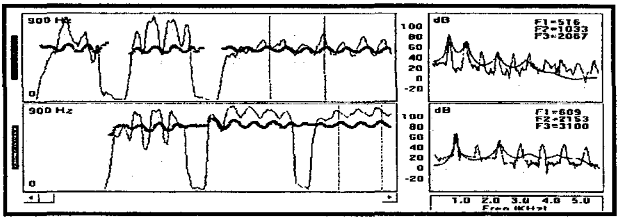
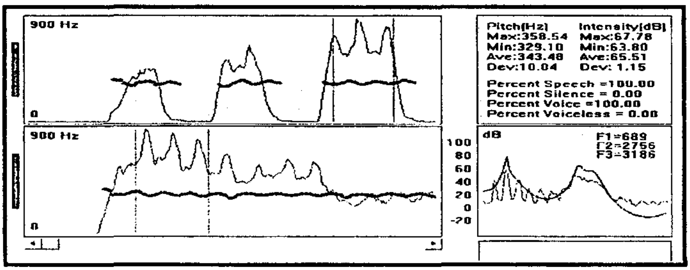


Figure #2, a tenor, repeats the pitches but exemplifies different vocal problems. His formants appear to be stronger, and his vibrato is less wide, but there is tension at the beginning of the utterance, as shown in the lower left hand frame through a skip in the line. Within the gridlines, his formants are strong and reflect a balanced sound. However, the tension in the breath and neck would remove some of the vocal beauty.

Noteworthy is the richer harmonic structure compared with the soprano voice in Figure #1. This is characteristic of the male voice. As one speaks or sings lower, the harmonics increase.

Fig. #2
C 4

F4



The automatic analysis portion of the chart provided in the upper right hand corner shows no breathiness within the selected part of the utterance (100 per cent voice with no voicelessness); it also shows that the singer's vibrato (represented as Deviation of 10.04 Hz) is within acceptable norms, which range from 8 to 15 Hz, depending on pitch level.

Given the results of the digital analysis, a check of the singer's breath application would be in order. Obviously, the above mentioned skip comes from laryngeal malfunction. The presence of the pitch skip proves how delicate the balance is between breath and vocal function.

The singing world is filled with different schools of breathing. Thomas Hixon (1973:85[1] says that "It is possible to move air in and out of the lungs using a number of relative displacements of the thoracic cage and diaphragm." If this is the case, then the

[1] Hixon, T., 1973, Respiratory Function in Speech, in Normal Aspects of Speech, Hearing and Language. Engelwood Cliffs, N. J.: Prentice Hall Inc.

choice ought to centre on a displacement of air resulting in a steady flow of air to the larynx, resulting in turn in an agreeable vibrato and a rich harmonic structure. Overall, the breath would not create tension posturally nor in the throat or the vocal tract. This is important as any perturbations which might originate are corrected through the breath.[2]

Hixon's approach does not emphasize the singer's posture. A postural approach, such as that of the famous American pedagogue Richard Miller, claims that "... The axial body (head, neck, and torso) must be well aligned, there should be no elevation or lowering of the chin, a relatively high sternal position is essential to such alignment." R. Miller (1993:20)[3]

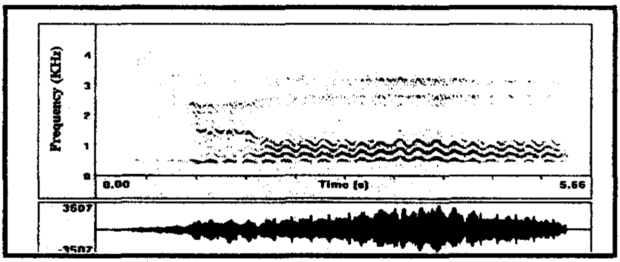
If one accepts Miller's suggested postural alignment, then the relative number of choices of displacement mentioned by Hixon would be greatly reduced. As already mentioned, tonal quality and vibrato are seriously affected by how the breath is applied and under what postural alignment.

The Resonator or the Vocal Tract

The human quality of the human voice results from postural alignment, breath, laryngeal function and vocal tract configurations. Vocal energy results from a combination of actions between the lips, tongue, jaw, soft palate. The removal of tension creates a coordinated flow of action-coarticulation-releasing a greater energized sound: coarticulation which means "The overlapping of articulatory adjustments for a sound of speech with the preparatory adjustments for a subsequent sound."[4]. This action gives flow to speaking and singing.

The tongue can give tremendous clarity to speech when retraction is avoided and the main body remains relaxed in the proper vowel position throughout, i.e. filling the mouth along the sides as well as in the front. Also, when lip rounding is required for the back vowels, if it occurs without stiffening and pulling down of the cheeks, then a resonance is maintained.

Fig. #3



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[2] Dejonkere, P. H., Minoru, Hirano, Sundberg, Johan, 1995, Vibrato. San Diego, London. Singular Publishing Group, Inc.

[3] Miller, Richard, 1993, Training Tenor Voices. New York, Oxford, Singapore and Sydney: Schirmer Books, Maxwell Mac Millan International.

[4] Perkins, William H., Kent, Raymond D., Functional Anatomy of speech, Language, and Hearing. Austin, Texas; Proed.

Figure #3. Baritone singing (i), (uh), and (aw) on A3. Note the formants as they change for the vowels. This is brought about through the necessary tongue postures and the lip rounding for the schwa (uh) and the back vowel (aw). Both utterances are the same pattern and pitch, but have differing F1 and F2 formant locations.

Formants

A formant is a vocal tract resonance shown as intensity peaks in the frequency curve. They are calculated using three dimensional geometry of the entire vocal tract. The most important formants for the singer are F1, F2, and F3. (I exclude here FO which is the basic pitch.) F1, the first formant, is the first area of resonance found above the fundamental, FO; F2, the second formant, is the second resonance above FO. Although there are other measurable formants above these, F1, and F2 are essential for vowel identification. A third area of resonance not usually found in daily speech but essential to the carrying power of the singing voice is F3, or the "Singer's Formant." This energy peak carries the voice through and over orchestral accompaniments. It is sometimes called the "ring," or the "ping" in a voice. (It is also found in actors' voices.) This energy peak lies in varying areas depending upon voice category: 2700 - 3400 Hz for baritones and tenors, and 3400 - 3900 for mezzos and sopranos. These numbers are arbitrary according to vocal production and size of the instrument, e. g. mezzo versus a light soprano, or a spinto tenor and a bass.

Formant location within the vocal tract is dependent upon three major factors: "the place of the major constriction within the vocal tract, the degree of constriction at that point, and the area and length of lip constriction" (Minifie 1973:248)[5] Other factors such as age and sex play an equally important role in determining vocal formants. It is essential for reasons of projection and vocal beauty that a voice contain all formants at all times. Lack of these energies is quite often the difference between an amateur and professional voice user. No untrained voice contains all of these energies in all of the vowels or their combinations. It is the role of the pedagogue to re-shape the various parts of the singer's instrument, thereby enabling formant creation. Shaping includes such regimens as posture, watching for and correcting unnecessary physical movements, tensions, etc. All of the technical instrumentation mentioned to date is of enormous potential in this working through of vocal production.

Vowels

These are the energy bearers of the vocal sound. Phonetic science has classified them according to tongue position: front, back, high, and low. However, long before this occurred, the Italians simply observed them as chiaro or oscuro elements - light or dark. They were wise enough to realise every vowel contained elements of both.

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[5] Minifie, Fred D., 1973, Phonation. In Normal Aspects of Speech, Hearing, and Language. Englewood Cliffs, New Jersey: Prentice Hall, Inc.

The formants F1 and F2 appear at different Hz values (see Figure 3) due to the altering constrictions within the vocal tract and the varying lip positions - width and distance apart. Kent in an important study has this to say:

> Front vowels are associated with fairly wide F2 -F1 separation, back vowels with fairly narrow F2-F1 separation. Therefore, F2 -F2 (sic) correlates with advancement or retraction of the tongue. High vowels are associated with a low F1, low vowels with a high F1. Therefore F1 frequency correlates with tongue height (or jaw opening). The effect of lip rounding is to lower all formant frequencies. In English, only the back vowels and the r-colored vowels are rounded. Kent, R.D. 1993[6]

Following these basics is essential to healthy vocal production in singing.

Registers

Registers "make a profound difference in quality, pitch range, and loudness." (Perkins & Kent, 1986, p. 101[7] It is important for voice teachers to recognize where certain physical alterations take place in the vocal range (e.g. the passaggio) in order to equalize the vowel sounds. It is the evening out of this area which is vital for upper voice singing. Not to equate the harmonic structure of the sounds through adjusting mouth opening would result in uneven timbres.

Finding the registers is most simply explained by a clinician. "If you start singing as low a pitch as you can and gradually ascend to the highest possible pitch , there will be two points within the range at which the transition to the next highest pitch cannot be made smoothly. These are transitions between voice registers."[8]

Changing Registers

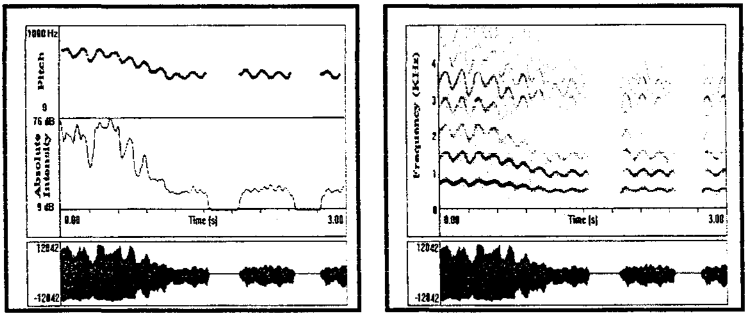
The register change becomes obvious to the listener because of the dramatic change in sound (timbre) which is quite often accompanied by a sudden lifting of the head in amateurs. It is these sudden changes which a pedagogue must smooth over if the voice is to be even. In figure #4 below, the soprano offers a relatively smooth transition downwards from F5 to bB4. However, the vibrato is too wide and the formants show irregular changes in the in the resonance balancing; nonetheless, the pitch, despite these shortcomings, was carried out without striking timbre changes. This occurred because the

[6] Kent, R. D., 1993: 97-117. Vocal Tract Acoustics, J. of Voice, Vol. 7, No. 2

[7] Perkins, William H., Kent, Raymond D., Functional Anatomy of speech, Language, and Hearing. Austin, Texas; Proed.

[8] Broade, David J., 1973, Phonation, p. 153. In Normal Aspects of Speech, Hearing and language. Engelwood Cliffs, New Jersey: Prentice Hall, Inc.

Figure #4. Soprano #2 singing (aw) from F5 to bB4-5 note series.



mouth aperture as she sang downward was correctly adjusted.

This altering of the mouth opening in the passaggio range of the voice agrees with a famous pedagogue's statement: "Gradual opening of the mouth alters relationships among harmonic partials of the spectrum but the same posture of the tongue, lips, and zygomatic (area of the cheekbone) muscles are retained while defining the vowel." (Miller: 39&49[9]) The reverse is applicable when descending.

Vibrato

This is probably the most contentious area of vocal production. For that reason alone it is better dealt with scientifically. One of the main reasons for cultivating an even and non-wobbly vibrato is described in a statement by Sundberg. " ...vibrato tones are produced with a lesser degree of glottal adduction than nonvibrato tones."[10] This lesser degree of glottal adduction in desirable. Greater glottal adduction requires greater laryngeal tension, resulting in "pressed" phonation. Sundberg goes on to state that "It is certainly a basic condition for creating an esthetically and artistically satisfactory result that difficult tasks are solved without apparent difficulty."[11]

In the past, great care was taken to ensure a pleasing vibrato to ensure beauty and vocal energy which would allow the singer to perform strenuous tasks without unduly taxing their reserves. Today, the microphone supplies the energy. Masters such as Giovanni Battista Lamperti's comments recorded in William Brown's diary of his teachings, Vocal Wisdom, make us aware of how the old Italian masters considered vibrato and its qualities.

[9] Miller, Richard, 1993, Training Tenor Voices. New York: Schirmer Books, Inc.
[10] Sundberg, Johan 1993. Acoustic and Psychoacoustic Aspects of Vocal Vibrato. In San Diego, London, Singular Publishing Group, Inc.
[11] Ibid.

> It is not difficult to sing from one tone to another, if there is a common quality of vibration in the two tones, tho' the resonance changes. Resonance always changes. Vibration never. (Lamperti, 1891-93: p.98)[12]

> The energy in regular vibrato is constructive. The violence in irregular (vibrato) energy is destructive. (Lamperti, 1891: p. 49)[13]

In figure #5 below, Singer #5, a young baritone, sings (aw) and (yaw) on A3 without vibrato. Note the high breath pressure (subglottal) as indicated on the Absolute Intensity graph below the unwavering vibrato line. It is interesting to see that the small indications of vibrato showing the stiffness in the laryngeal area are partially overcome by the instrument's natural inclination to vibrato.

Fig. #5

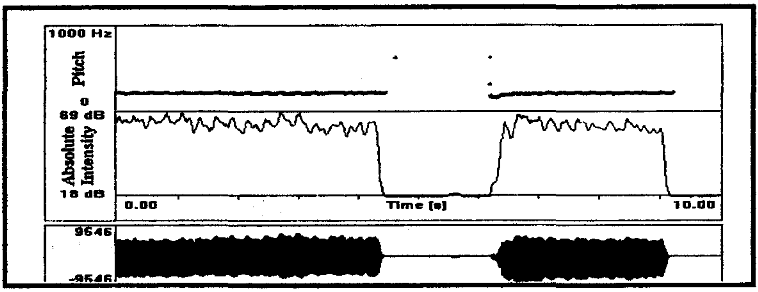
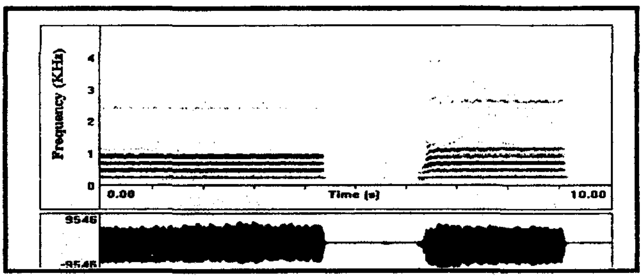


Figure #6 displays the harmonic structure of the same vocal utterance as Figure #5.

Fig. #6



Note that in the second sound the formants are stronger due to the presence of the consonant (y) making the utterance into (yaw). The glide tends to make the vocal tract more relaxed and positively influence the vowel.

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[12]Brown, William, Vocal Wisdom, p.98. Axioms from Giovanni Battista Lamperti's Teachings. New York: A Crescendo Book, 1933.
[13]Ibid

In the figures below, singer # 6 sings (i),(uh), and (aw) and goes from A3 to C#4 and back at the end of the utterance. Note the regularity of the vibrato, the maintained energy and the lower Absolute Intensity (reflecting lower subglottal breath pressure) than in the vibratoless singing of the previous figures.

Figure #7

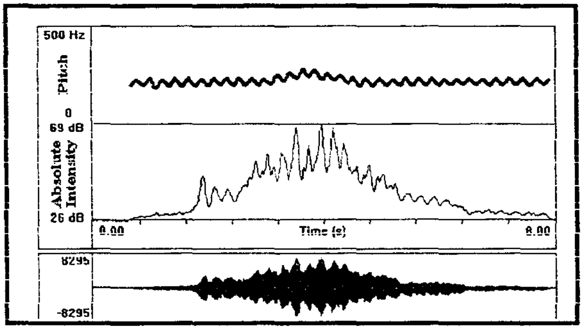
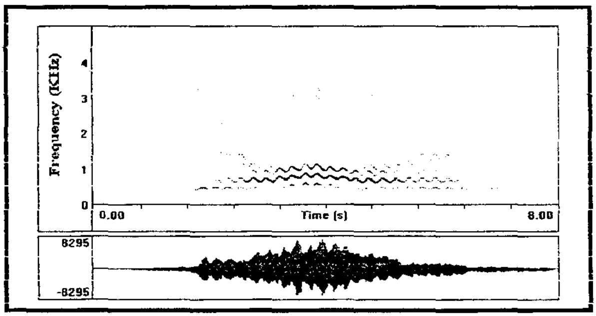


Figure #8, a harmonic analysis of the same vowels as sung above.



Note the changing formant formations, the regularity of the vibrato and the height of the strongest formant F3 at around 3,000 Hz. Also noteworthy is the manner in which the pitches are changed, which directly relates to Sundberg's statement pertaining to difficult tasks being solved without apparent difficulty. Here Sundberg's statement pertaining to regular vibrato is applicable.

Summary

The goal of this paper has been to show that technology confirms and sometimes points out details which go unobserved during the evaluation of a vocal utterance. These elements are important as they often point the way to an improved pedagogical approach, or to the acquisition of a valuable vocal energy or more a aware physical stance. In any case, technology with its objective quantification can improve one's approach to vocal energy which in turn, increases the impact of interpretation. Both vocal energy and interpretation are inextricably linked. Without vocal energy, the meaning of the moment is lost.

Although using digital technology makes arduous learning demands on the pedagogue, it is time well spent. New pedagogical approaches and a greater insight into the student's vocal dilemmas come through the new knowledge. Connections between the physical and the acoustical are less remote. For this reason, technologic instrumentation is a boon to anyone who can coordinate its usage into their concept of a 21 Century voice studio.