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Treble Choral Acoustics

By Betty Jane Grimm

In the middle of the marvelous sixteenth century, the basic essentials of vocal skill and voice study as an art had been sought for, found and faithfully taught. The ability to sing smooth, flowing lines in long beautiful musical phrases, the value of pure and consistent vowel shapes and the necessity of distinct diction (initial and final consonants) — these phases of singing were all carefully studied. It is interesting to note that most of the basic principals set forth at this century were later incorporated into what is known today as the *Modern Italian Method.* This method deals with different kinds of voices; advocating a breakless continuity between the registers of the voice. The voice's head and chest registers were admissable. The proper emission of sound, the hygiene and deportment of the voice and body were set forth as being *essential.* Included also were many vocalises written for each voice on all the intervals.

As a result of these treatises, voice culture became so extremely prominent that individual singers actually began to dominate the very music itself. As a result of this change of emphasis, styles of writing were altered making different and more dramatic demands on the voices of this time.

In spite of the fact that Bach and Handel in later years depicted the "human passion of mankind" in their works for mixed choruses, we cannot omit probing into the earlier years where we find this: "The use of treble voices provoked an admission to an unusual phenomenon as tonal vibrations. An interesting description of treble voices that were used to perform the music of Palestrina, admits these voices capable of performing the music in such a way that it re-affirmed the composer's ideas of 'mystery and the idealizations of angels.' It is believed that this one factor was achieved by some particular arrangement of the voices."[1]

We believe these voices were placed in such a way as to effect what might be referred to as a "tone bank." The two prime tones, when sounded together, were placed in such a way that they produced enough of a *difference tone* to augment another voice that was singing the same pitch of the difference tone.

Laws governing the variation of stretched strings or vocal cords[2] were formulated by Pythagoras in 550 B.C. All things being equal, except the element of varying error in the human voice, the number of vibrations varies inversely as the length of a string; thus, half the note gives twice the vibrations, or an octave above the note. Two-thirds of the length gives three halves the number of vibrations, or a fifth above the original note. Thick or loose strings and vocal cords give an unclear tone. Varying degrees of thinner, lighter and longer strings produce a better sound. Violin strings already have a suspended tension set up between peg and tail piece. Vocal cords ae also attached to the voice box, front and back. The Larynx, which contains these vocal cords, initiates the pitch in much the same way as the lips start the tone in the mouthpiece of a brass instrument. The controlled stream of air is passed upward from the lungs with pressure from the diaphragm through these *vocal lips* which are held close together at varying tensions according to the mentally conceived pitch that is desired, setting the breath into motion and the lips into vibration. In singing, this resultant *pitch* becomes *tone,* being modified and strengthened by contact with all the inner surfaces of mouth, nose, throat, sinuses and lungs.

If the requisite depth of pitch were obtained by uncontrollably loose tension, the tone would be poor or weak. When strings or cords vibrate, they do not swing as a whole but subdivide into fractional parts. These fractional parts, being shorter than the whole string or cord, produce higher pitches and tones. These are called overtones, harmonics or upper partials and blend with the main or fundamental tone whenever it is sounded, and within thirds, augment a fifth.

The presence of these overtones in varying amounts is what causes the differentiation in tone color between different instruments and in different voices.

In musical acoustics when two loud tones are sounded simultaneously, the frequency is the difference of the sum of the two primary tones or of their multiples. If the two primary tones have the frequencies of 1200 and 700, the following *difference tones* (D) and *summation tones* (S) can be heard.

$D1 - 1200 - 700 = 500$
$D2 - 2 \times 1200 - 700 = 1700$
$D3 - 2 \times 700 - 1200 = 200$

$S1 - 1200 + 700 = 1900$
$S2 - 2 = 1200 + 700 = 3100$
$S3 - 2 \times 700 + 1200 = 2600$ [3]

Regarding combination tones and intonations, if one strikes two primary tones together in a major third and subtracts the tonic frequency from the frequency of the third, one hears the *difference* or *combination tone.*

In 1714 the existence of these *difference tones* was discovered by an Italian violinist, G. Tartini. He found that these difference tones were more easily recognized than other evidences of *summation* or *phantom tones.* The tone referred to as Tartini's tone is the same as the difference or combination tone.

During the "third tone era," there were various instruments such as the harmonium, organ and violin on which it was possible to distinguish the presence of Tartini's tone. Hence, the comparative reference to the violin and its likeness to the human voice. The violin

and voice have the ability of constant resonance, a string-like source of vibration and a control of support via the bow and the breath. Both are able to produce a portamento without fake fingering or clever pedaling.

The most significant discovery is the appearance of this third tone on the violin. Tartini, and other violin teachers of his day, believed this theory provided an excellent and foolproof means of controlling maximum intonation. Intonation embraced total tonal integrity, particularly in the playing of double stops (two tones together) on the various instruments. These elements common to violin and voice have led to the belief that Tartini's Tone will be useful in the proper juxtaposition of vibrant and pure voices. Consider that in voices, as well as the violin, the tension is already comparatively established. The body of the violin and the body of a singer are both consistent resonators. One can appreciate the comparable souces of energy. Even though the resonators are consistent, they can be manipulated to alter tone color.

To continue with the process of the use of an arrangement of voices and vocal frequencies, one can effectively observe the element of intonation flowering. Even when a first and second soprano are striking a major third together and evidence individual "intuneness," the incompatibility of their frequencies can cause the *difference tone* to be out of tonal character. The proper matching of different voices creates a better blend than the attempt to match like voices. In a treble choir of 100 voices, 40 voices singing the same note together in a section as first sopranos will definitely produce a distortion of pitch and of tone. This necessitates breaking up section singing. First sopranos distributed wisely beside proper second sopranos will, by singing together, produce the proper difference tone augmenting the first alto. Real first-alto voices are few and the augmentation by tonal influence of difference tones is most desirable. When voice parts are decentralized in this fashion, more effort is expended by the individual singer to listen to *all* the music and produce a more desirable overall vertical pitch relationship without vocal forcing. This gives a director better vocal production, and linear singing can be achieved without danger of vocal abuse.

Research has shown that well established musical sounds are *not* really heard. For example, the tones of the G string on the violin are virtually nonexistent. The G string tone is being produced aurally as the differential tones of their upper partials. It is the same in the specifically voiced treble choir (SSA, SSAA, SA). The singing of C by the first soprano (third space treble clef) and the singing of A by the second soprano (second space treble clef), correctly voiced, will produce the "phantom sound" of the first space F (treble clef), also practices aurally as the "difference tone" of the upper partials of C and the A below.[4]

The F difference tone reinforces a weak or light first also singing the F of the chord. This will result in a truer quality and will minimize the possible danger of forcing the voice in order to "sound like an alto." These difference tones, said by some to be nonexistent, are in fact an *inner-ear* experience and are possible to record on tape. It is this factor which makes Women's Glee Clubs sound distinctive. A full tone, a lush sound with maximum resonance is heard, free and not forced.

In Culver's *Book of Musical Acoustics* the author continues his probe of *Tartini Tones.* His comprehensive explanation goes deeper than that of some theoretical historians. For example, if one should sound a musical tone which contained, in addition to the fundamental, *only* the odd numbered partials, the listener might also be conscious of at least *some* of the even partials. Due to what Culver states is a non-

linear response of various components of the ear, various subjective *tones* are introduced into the final result.

The appearance of subjective tones appears dependent upon the intensity of the sound. (The frequency of subjective tones is not present in the original sound waves, but the ear may create new frequencies out of the incident disturbances.)

In considering the matter of pitch, it should be evident that the hearing apparatus may so respond to a determined objective stimulus that one may have the *sensation* of a frequency which is *not present* in the initial sound waves. One can also say that it is possible for the ear to create or recreate new and different frequencies.

Since the discovery of the *third tone* by Tartini, modern researchers have discovered that one may be aware of a complete sequence of these tones, some of which may *not* be present in either of the original sounds.

These exciting sounds may both be *pure* and entirely free from overtones, yet a listener may testify that he hears one or more such pseudo tones. We, then, are concerned with another materialization of the previously discussed *subjective tones.* The pitch ratio of the subjective tones to the energized tones can be put forth by presenting an illustration. Try amplifying the sounds produced by two tuning forks, say one F (300) and one F2 (500) cycles per second. Such experimentation will make manifest the fact that the listener may be aware of a sequence of subjective tones in the following ratio.

2 F 1 = 600
2 F 2 = 1000
F2 − F1 = 200
F1 + F2 = 800

The first two are the octaves or the *prime* overtones. The last two have an affiliation with the primary frequencies.

In the singing of any basic Italian vowel sound (ah, eh, ee, oh, ooh) the vowel sound is characterized by the presence of one or more definite groups of partials or overtones. The frequencies appearing in these characteristic groups are much the same regardless of the fundamental frequency. Also, in these characteristic groups the dynamic level does not increase or diminish with the dynamic fluxion of the two primary tones. If the prime tones arrive at a state of diminuendo, then the frequency of the difference tone appears to increase in volume, whereas it really maintains a dynamic constancy of its own.

The use of Tartini's tone was revealed almost by accident in attempting to acquire a distinctive choral tone with the Women's Glee Club of the Florida State University's School of Music. Working with this group of nonselect and unauditioned singers from various schools on our campus presented a wonderful opportunity to discover a way of voicing a treble choir so that it sounds as distinctive and becomes as listenable as that of a mixed choir.

Choral music usually consists of a balance of mixed voices: soprano, alto, tenor, and bass. To deviate would result in more limited scope such as an all male or an all female group of singers. The goal is to build a good female chorus that will meet the following requirements.

1. Be as distinctively satisfying to the listener as a fine mixed chorus.
2. Evidence good pitch and good quality, of intonation.
3. Suffer no vocal abuse by distortion through force.
4. Be voiced so as to augment the least opulent voices.
5. Respond to the proper balancing of "different" voices to produce like balance of choral tone, rather than the balancing of like voices.
6. Become skilled in the art of mentally, physically, musically and spiritually getting total appreciation and understanding of the music.
7. An omnicience of tone.
8. Producing not only pitch, but also good tone.
9. Destroy the audio-visual concept of singing in section which produces an angular and jagged choral framework.
10. Enhance good vertical pitch relationship without destroying linear phrase lines.
11. Avoid sectionalized seating where 30 sopranos will distort a feeling of unison pitch by competitive distortion.
12. Build reading independence and enhance the ability to hear all the music at once.

Listening to the first few rehearsals, one proved the presence of affections and impositions upon young voices in order to achieve a distinctively well-balanced and rich choral tone and tonal color.

Nearly all female voiced choirs at the high school and early college level find themselves to be lacking the presence of the true, natural alto voice. It is generally supposed that the choral director, without adequate time to develop the individual voice, will resort to the use of good readers in the inner and lower voice parts. This is actually ineffective as the quality is that of a soprano or an artificially conceived tone just to bring the part into choral balance. Also, no good tonal bulk is added to the structure of the chord. For the most part, unless some proper voicing is done, the true quality of *each* voice is often, if not always, slighted. Needless to say, the youthfulness of the voices will play a great part in our determination of quality. Sometimes we neglect to investigate the range of the individual voices, especially in an unauditioned or nonselect group. This procedure will oftentimes result in the presence of

"self-appointed altos" who, because of no training in voice, will choose to sing the alto part because the other parts are "too high" or because they can read music. The untrained voices will doubtless be more comfortable where they have always sung. An effective seating arrangement will augment these voices when properly received first and second soprano voices are placed in proper balance. The alto does not feel the need to push or distort, for she receives support from the difference tone set up by the two sopranos.

In addition to these factors we must also consider the individual mental concept of the desired tone quality for an alto voice or a "low" voice. This typical concept occasions "hybrid altos." This happens more often than not when a high school freshman becomes an alto for four choral years. Upon coming to college, she says that she cannot sing above second line G because she is an alto. She is surprised and sometimes dismayed to find that when she has to complete four years of voice, altos are nearly always expected to vocalize a high B flat or C. Thus, it sometimes happens that early choral classification limits the upper range. These voices have to be guided carefully in developing quality. This quality is sometimes found to be physically forced, thus departing severely from the natural voice timber. Such forcing can destroy true pitch and cause choral imbalance. This procedure of allowing vocal forcing is not desirable. Even though it might temporarily satisfy the ear in that all the parts are heard, the natural depth soon departs as this continued over-singing, over-producing, will strain the young voice giving the singer false maturity and an even more distorted idea of what a good tone should be.

One of the universal and eternal truths is that all sounds are the result of vibrations of some substance which produces vibrations of the air. Omniciently, we know that there are innumerable sounds in nature. The sounds contained in essential nature rise and fall at various pitch levels. Such characteristics do not necessarily mean that what we know to be MUSIC has been produced. This is due to the fact that each or all of these various tones do not possess any definite pitch. Nearly all so-called musical sounds are components of two or more simple tones. Their components, as we have previously stated, are called partial tones, the lowest of which, when determining pitch, is referred to as a fundamental tone. the others are partial (upper) tones, sometimes referred to as overtones. The function performed by these overtones serve to determine the quality of pitch. It might be more enlightening to say that the quality of pitch is enhanced by the overtones. The quality of pitch, in turn, serves to augment a basic tonal color or timber.

By experimenting with different choirs of treble voices, we hope these resulting pages have established this concept of a workable vocal tone bank for all treble choirs that will revivify the production of all the potential vocal sound available, that is whole and true in recreating the musical compositions of the Masters.

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TERMS

TONE — A term used to designate any given musical sound emitted by a sonorous body.

FUNDAMENTAL — The sound having the lowest frequency which a vibrating body is capable of emitting.

PARTIAL — Any component of a single complete tone.

UPPER PARTIAL — Any partial having a frequency that is higher than the fundamental.

OVERTONE — Synonymous with upper partial.

PURE TONE — A single musical sound which is devoid of overtones or upper partials.

TIMBRE — Innate tonal color of the vibrating source can either be bright or sombre.

SUMMATION TONE — A tone whose frequencies are the sum total of the original, also called the resultant tone.

DIFFERENCE TONE — The difference received by subtracting the two primary tones.