ACOUSTIC FEEDBACK IN A PROFESSIONAL VOICE (PART I)

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Abstract: - The vocal abuse is a generating cause of illness the voice. To prevent this phenomenon we suggest to educate the spoken voice and to place it in areas of resonance of the vocal apparatus so that, between spoken voice and singing voice to not exist dissociation. With an acoustic feedback in a professional voice we have determined the existence of formants and share formants in speech and in singing to achieve a healthy and a longeval voice.

Key-Words: - professional voice, spoken voice, sung voice, vocal technique, formants, spectrogram, vocal health

1 Introduction
A modern research to include an interdisciplinary complex phenomenon called voice becomes mandatory for us, the voice professionals and to all others, the users of the sung and spoken voice. In our acceptation we will rely on existing studies, on the scientific discoveries in the field of professional voice, trying over a large study, which will include several parts of which this article is only the beginning, to develop a theory related to undisassociated sung voice by the spoken voice, which will provide a healthy and a longeval voice.

Because we could induce a labyrinthine nature of this research through an adventurous discrepancy of the everyday reality we communicate that, it is about our attempts, our experiments in the description and the sensory representation of a sensorial reality that could not result in any a result but, to fire a warning of shortfalls on physiologic-acoustic aspects of the development of professional voices, spoken or sung.

To such dangerous “experiments”, daring we could say, will add some hearing and visual pictures about the acoustic feedback that which speaks for, of a professional voice which not dissociated the spoken voice from that used in singing. But we try not to generalize the results of our research and to build dream factories of an absolute vocal technique that can solve any problem but, we can show some characteristics of a good vocal techniques that certainly will not lead to illness the sung or spoken voice.

2 Anatomic and physiological minimum requirement [1]
Vocal sound [2] is produced by vibration of vocal cords during the crossing the airflow origin of pulmonary. The vocal cords [3] are two folds of muscle, which opened in inspiration and expiration stick. One end of these vocal cords is attached to a pair of movable cartilage called arytenoid cartilage, while the second end is firmly anchored to the thyroid cartilage, known as Adam's apple. Phonation and voice sound development occurs when narrowing the gap between the vocal cords, that stick above the vocal cords, on previous, posterior, or median parts of the vocal cords and air from the lungs is expelled through the space, in the larynx. Voice amplitude – the number of harmonics that is enriched the primary sound emitted by the vocal cords and amplified by the larynx, is determined by the force with which air from the lungs is expelled through resonance cavities, through mouth and then out. Height voice sounds is determined by the length and degree of tension of the vocal cords. I mean, if the vocal cords issued a lower sound they become thicken and compress, vibrating at the bottom of their length. Medium sound is produced by bonding and stretching the medium part of the vocal muscles. The high voice sounds produce the most vocal cords tension. During the high notes emitted by the vocal cords, those become thin and tightened, stick and unstick it so many times per second how many cycles per second is the height of the sound. Depth and natural timbre of voice are determined by shape and size of
the pharynx and larynx, nose and mouth; this is why men, generally, have longer vocal cords and freer movement, having also deeper voices than women, who's larynx and vocal tract are less than men and with shorter and thinner cords.

By successive sticking and detachment of vocal cords when the air flow of pulmonary origin passage through, it produce singing voice or spoken voice. But not all spoken voice sounds come only from vocal cords vibration. In general, vowels and consonant sounds are issued mainly by vibrating the vocal cords.

The speech involves the use of larynx as the primary resonator, the mouth and the skull as principal resonators, the emitted of the very low sound involving the resonance of the cervical vertebrae. Also actively participate in spoken voice the tongue, some facial muscles and passively: the teeth and soft palate. The mouth cavity has, generally, six walls: a wall above formed by lip and gingival dental arches, two side walls corresponding to cheek, an upper wall corresponding to the hard palate, a lower wall corresponding to the sublingual region and tongue and posterior wall formed by soft palate and isthmus oro-pharyngeal.

The mouth cavity is totally involved in speaking, but also in singing, because it helps to shape the sound emitted by the larynx phonation cavity. Pronunciation of consonants such as k or t, for example, requires that the air passing through larynx to be greatly diminished by the tongue and soft palate, while the vowels a and e do not require this, but only a certain positioning of the tongue and teeth. Each sound is determined by a slightly different movement of the lips, tongue and teeth.

The ability of the deaf people to read lips due to the role that the mouth plays in speech production. In a previous study, we've presented the speech defects and how to remove those with a non-medical therapy. The specialized staff, as the speech voice therapist are quite rare in Romania, but with a very extensive concern in Germany, Austria are those who know how to make a medical therapy under control and working with doctors O. R. L. This study concerns only an acoustic feedback in a professional voice, through which we have determined the existence of formants and share formants in speech and in singing to achieve a healthy and a longevity voice.

2.1 Phonation process [5]

As we said, to make primary emitted sounds by the vocal cords into the intelligible words, actively participate the larynx, the pharynx, the oro-farongian isthmus, the lips, the tongue, the soft palate and all the cavities that give voice resonance. In the professionally singing, a singing of high power, where the voice is not artificial amplified by the microphone, we are seeking the placement of the voice into the superior resonators cavities, using skull as a resonator and the sound direction in areas of maximum impedance. Years of seeking the route guidance voice stream so that, through a good vocal technique to be able to obtain voice quality, accuracy, amplitude, vocal agility, while maintaining the voice device health, and longevity of the vocal cords in use. The control of the muscles and bone structures involved in phonation and resonance phenomenology is achieved by hundreds of muscles and nerves, which works with incredible speed and create the miracle called the voice.

Thus, the primary sound complex consisting of a range of tones, have not a perfect sine curve, but very close to this shape. The lowest sounds is called the fundamental tone and the following frequencies, which are integer multiples of the fundamental sound are called harmonics. The fundamental sound with harmonics forms the partial sounds. The harmonics amplified through the resonant cavities by the resonance phenomenon are called formants. So, the formant it is defined as the frequency domain in which is concentrated most of the acoustic energy of a vowel. [6]

After J. Perelló, formant (the latin translation specifying the form or constitution of a sound) is "a frequency or a frequency group that is above the fundamental sound that matters in defining vowel timbre".[7]

Ernest Robson [8] discovered since 1938 the formants of the musical sounds, referring to the frequency band of vowels or diphthong, as their energy level resonator. According to the researcher, each vowel has defined three formats, but most of the vowels can contain 4 formants. The most visible
formants are the first and the second, which have the lowest frequencies. The formants, after Ernest Robson saying, have been identified by the spectrogram in 1920 and are as we can see:

![Spectrograms of the formants - F1, F2, F3, F4 belonging to the vowels (i, o, u) and to the diphthongs (ei, oi, iu) [9]](image)

Fig. 2 – Spectrograms of the formants - F1, F2, F3, F4 belonging to the vowels (i, o, u) and to the diphthongs (ei, oi, iu) [9]

From the figure above could be observed:
- The darkest areas are due to the intensity level of the vowels or of the diphthongs emission;
- The formants 1 and 2 are close as frequencies for vowels and remove for the diphthongs;
- The absence of the forth formant in the emission of some vowels or some diphthongs and the predominant presence of the 1 and 2 formants indicate a starting point in recognizing the vowels and their formants during the issue of spoken or sung sounds.[10]

The formants are indistinguishable isolated, or been standing alone when listening to broadcast of a vowel or a diphthong. The formants structure allows us to distinguish one vowel from another and a vocal timbre from another vocal timbre. A melodic line can be read after the formants' structure of which it is made, by placing each vowel as is in the frequencial structure of the 1 and 2 formants. It was discovered that a close emission of vowels and diphthongs so the 2 formants is almost common - a phenomenon known as share formant[11] reveals a more accurate vocal emission, from a professional point of view.

According to the experts the vocal tract have 4, 5 formants, the lowest being the most relevant. To characterize the posterior vowels (o, u) are sufficient the first and second formants and for the previous vowels (i, e) is necessary the third formant.

Anatomical shape of the vocal tract can cause the emitted frequency of the vowels or diphthongs formants, and the vowel quality depends ultimately, by the sound management issue into the resonance cavities. Illustrating how the vocal tract length affects the quality of vowels we found in several studies the following:
- by pronunciation the vowel i, as is in the word *villa* with lips in a normal position, the larynx is high, thus shortening the vocal tract, the sound being short articulated;
- in the moment we decide to pronounce the french word *tu* (you), pronounced *tü*, lowering the larynx leads to lengthening the vocal tract and extending the articulation for the diphthong *iu* (new);
- the soft palate rises in the moment of swallowing as well as during the emission of the oral vowels and consonants. Come down during respiration and nasal consonant articulation.

Thus, as the conclusions we can deduce:
1. The frequencies of the formants are directly influenced by vocal tract length in this way: as the vocal tract is longer, the formants frequencies are lower, and as the vocal tract is shorter, the formants frequencies are higher.
2. Any movements of the articulator affect the formants frequencies in this way:
   - the formants frequencies all come down in the articulation of the vowels *u, o* and also the articulation of the diphthongs *eo, iu, io, eu, oi*;
   - the first formant frequency, F1 is affected by movements of the jaw in this way: the movement towards of the lowered mandible increases the first formant frequency. We’re talking about pronunciation of the vowels: *i, e*, which leads to ‘sharpen’ of their timbre;
   - the second formant, F2 is influenced in particular by the form of the tongue, because to a very
complex structure that contains 17 muscle performs a large and varied range of movements that change the spectre of the second formant: - compressing the tongue in the front part of the vocal tract when it is articulate the palatal vowels (i, e, a, o), the frequency of the second formant rise to maximum.
- compressing the tongue in the velar region, while the lips are rounded, as it is for the pronunciation of the vocal u, the second formant reaches the lowest frequency.

![Fig. 3 – Amplitude and frequency changes according to the first formant according to the jaw position [13]](image)

3 Experimental results

We propose an experiment to see the similarities and the differences at the professional voice (soprano) between the spoken and sung voice. We used programs as: Sing&See™ (for recording), Adobe Audition 3.0 (for sound timing) and Praat software (for the analyse sound) with which we made graphs and spectrograms of vowels and consonants during the voice emission (spoken or sung). Research to which we referred have shown that the properties of the sound spectrum - the number of harmonics, the nature of frequency, the intensity and the energy of the sound - are not the only factors that define the timbre of the voice, but have to be aware of the temporal variations, of the types of vocal attack, of the dynamic evolution, of the spectral envelope changed in time, etc.

3.1 Sung voice

Our test is based on three vocalizes on a third melodic structure - (starting with d⁴ in the central octave) sung on several vowels: i – a – u in a slow tempo (M.M. ≈ 50).

![Fig. 5 – The vocalizes using the vowels i, a, u](image)

These vowels were selected to represent the brightness vowel (i) and the darkness vowel (u), the extremes in the placement of the voice sung or spoken, as well as the central vowel (a) of the vowels spectrum, using as a reference the phonetic segments triangle described by Hellwag.

![Fig. 6 – The Helwag's articulator triangle [16]](image)

With Sing&See™ software we have recorded several options for each vocalize, and we choose the variants which had similarities in the frequency band is around 500 Hz, while the high frequency band is between 2500 and 3000 Hz.
and amplitude, knowing that the voice is an instrument untempered.

![Spectrogram](image)

Fig. 7 – Spectrogram on i, a, u vocalize

The obtained images shown that to each sound corresponds to a harmonic spectrum consists of the natural setting of its harmonic frequency levels. We were able to view precisely the frequencies of the first 5 formants.

Observations:
- The vowel i is characterized by the presence of 3 frequencies bands (F1-F2,F3-F4,F5);
- In the vowel a spectrogram we identified 2 frequencies bands: F1,F2 and F3,F4,F5;
- At the vowel u appears only one frequency band (F1,F2) the formants F3,F4,F5 appearing in an irregular shape.

![Spectrogram](image)

Fig. 8 – Comparative frequency progression of vowels formants

For the soprano voice, we emphasized the placing of the formants in a manner typical of the production of belcanto.

**Belcanto** is "a particular vocal type resulting from a technical mastery, to which is added the purity of the sounds' attack, the colour equalization in the transition from one to another vocal registry".[17] The main requirements imposed by the belcanto concerns the ambitus, the intensity, the timbre of voice and the physical strength. [18]

### 3.2 Spoken voice

To a professional voice it required an undissociated sung voice by the spoken voice, which will provide a healthy and a longevive voice. The most representative example to obtain the undissociated sung voice by the spoken voice is a particular type of musical declamation called *Sprechgesang* – a manner of interpretation in which speech and singing are in a relationship of mutual assimilation, as we found in the serial and postserial music (the technique discovered by Schönberg and his followers). We used for our test a part belonging to the Ana Szilagy's lied *Geistliche Dämmerung: Stille begegnet am Saum des Waldes.*

![Spectrogram](image)

Fig. 9 – The spectrogram where is represented:
- the pitch line – blue; the formants – red;
- the intensity (the volume) – yellow

Observations:
- the spectral image of the analysed fragment shows the differences that occur between vowels and consonants, "the difference between vowels and consonants is based on the placement of the sound: the vowel is formed in the larynx and the consonant is placed into the oral cavity. From acoustic point of view, the vowel is a truce and the consonant is an exchange" [19], in the form of vertical blocks from left to right';
- *b.z (bilabial zone), ld.z (labio-dental zone), sd.z (superior dental zone), pp.z. (pre-palatal zone), p.z. (palatal zone), v.z (velar zone)
- the consonants considered noise has a punctiform spectral representation;
- the vowels (i, e, a, u) keeps, as in the sung voice the harmonic spectral content (5 formants), but also we can see the tendency to compress the
spectrum from light to the dark vowels. - the intensity measured in decibels is much higher in the areas of the harmonics partials (corresponding to the vowels) than non-harmonic partials (corresponding to the consonants)

![Fig. 10 – The Frequency/Intensity Spectrogram](image)

To analyze the vocal sound we had in view both the vocal formants (which we are not interpreted as the single frequencial line, but as a "strip" or "frequency areas [20]) and noise-the consonant sounds; the proportion of consonants-vowels thought this time as a succession (and not as an overlay) is important for defining the manner Sprechgesang.

4 Conclusion

The sound is a complex sonor consisting of a fundamental tone with its harmonics, whose main characteristic is the constancy of the vibration. In the vibration pattern exists, however, the fluctuations caused by the presence of noise components. In the spectral structure of the spoken or sung vocal part can be found both harmonic and non-harmonic partials. "The harmonic partials are consecutive multiples integer of the fundamental frequency, unlike by the non-harmonic partials - some multiple of the fundamental frequency." [21] Keeping in view that the vocal sound trained in the belcanto’s technique has a harmonic spectrum of the constantly 5 formants, we recommend for avoiding the illness of the voice by placing the spoken voice in the same resonance area as is placed the sung voice.

References:
[9] Idem.
[16] Helwag’s triangle at http://paginapersonales.deusto.es/airibar/Fonetica/Apuntes/05.html