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USAGE OF COMPUTERISED MEANS IN VOCAL ASSESSMENT

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SUMMARY. This study investigates implementation of new technologies in vocal assessment pertaining to university degree artistic education. One of our objectives represents the collection of information regarding changes occurring in singing voice as a result of professional training. This approach fully validates recent research in the field, proving that vocal training has a significant effect on human voice, and close follow-up of the subsequent development brings numerous benefits for both young singers and teachers.

A relevant advantage of ICT use is represented by the precision in following-up of the vocal development process, creating also the possibility of organizing custom diagrams regarding the progress of vocal parameters. So, computerized means open up new perspectives and opportunities, becoming a way of objectifying musical and artistic performance. Another important factor is the possibility of early tracing of a possible wrong development of the voice and thus, preventing it in time. This study presents a comparative table based tracking of vocal evolution on some voice students from singing department of 'G. Dima' Music Academy from Cluj-Napoca. Data presented here was processed through ICT[2] means.

Keywords: computer software, sound, spectrogram, formants, pitch, intensity, vocal parameters, acoustic analysis.

Research done by audiologists and phoniatrics physicians show that vocal training leads to changes in vocal physiologic level, as well in the acoustic and perceptive level. Estimation of these changes was done by various ways along the last decades, but last generation technologies and investigation types proved to be most efficient, more flexible to use and most easy to employ. In this respect, results got worldwide in creating and exploring new technical equipment for analysing vocal parameters, represent an important argument in favour of their integration into the learning process.

The object of this endeavour is represented by the vocal evolution of young singers, students from the singing department. There were ten students participating in this project aged from 18 to 23, who were recorded while singing, following a two semester time lap. Recordings were done about every 3 or 4 weeks, meaning once a month, for ten months in a row.

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[2] ICT is an acronym that stands for **Information Communications Technology**

In order to ensure maximum relevant data, we took in account factors that are influencing vocal development. Among these we count age, sex, vocal hygiene habits, as well as the music style they sing in. In this context we need to mention that students were trained according to the Italian Bel canto vocal art principles, which are based on educating flexibility and smooth voice emission, on the capacity of singing in refined gradations, accomplishing *messa di voce* on controlled breathing. None of the selected students were smokers or being on medication. We have ignored possible physiological differences (which were too much emphasized in the past) as well as vocal cords length, form and volume of resonating cavities, space between vocal cords etc. Also, there was no physiologic examination of vocal apparatus of singers.

Recordings were done by professional means, maintaining a 30 cm distance from mouth to microphone. Students were asked to adopt a comfortable singing position. Body movements were restricted as much as possible, without preventing freedom of expression while performing. The purpose explained to students was to reach an ideal stage performance regarding vocal dynamic and quality. Fragment recording was made up of vocalizations, arias and songs which were part of mandatory repertoire.

Recordings have taken place usually at the end of classes (becoming in a way a standard procedure), but mostly during recitals or examinations done in public. Although in the latter case it was impossible to follow all the rules of recording live performances compared to studio ones, the superposition of results indicated changes regarding the 'quality' of performance (not always in the positive way). All these facts confirm that emotional involvement is influencing the quality of singing. 'Projection' of sound is thus a cognitive activity, the human voice being also a conveyor of sensitive feelings.

Alongside the emotional involvement while performing, the purpose of vocal training is represented by achieving control of sound producing mechanism, meaning acquiring muscular coordination in conjunction with appropriate breathing.

The examples of computerized analysis hereby included are only those that were done in the recording studio, because about 70% of the amplitude values observed at different points in a reverberant room lie within a band that is about 11 dB wide[3].

To follow the vocal evolution of a singer means to observe modifications that occur in four characteristics of sound: intensity, pitch and timbre. Computer software made for visualizing, playing, annotating and analyzing *sound* from

[3] Sundberg, Johan, *My research on the singing voice from a rear-view-mirror perspective* http://www.med.rug.nl/pas/Conf_contrib/Sundberg/Sundberg_bio_touch-Groningen+figures.pdf

the acoustic point of view, allows measuring objectively the acoustic spectre, namely realizing a spectrogram or a sonogram. The spectrogram made through Praat program, which was used to process recorded data, allows simultaneous viewing of pitch and intensity parameters. A spectrogram reflects an analysis of voice quality in terms of its piercing and vibrato. Singers need to be heard when on stage over an orchestra (whose sonority can reach 120 dB). The western classical opera style develops the ability for the voice to produce powerful sounds, due to achieving a high density of acoustic energy, which enables the voice to be heard from the stage without amplification. It is about the S*inging Formant* or the *Singer's Formant* which can be found only on educated voices. This concept, discovered in 1934 by Wilmer T. Bartholomew, who's research were continued by Fritz Winckel (1956), William Vennard (1964) and Johan Sundberg (1970) is marked by a concentration of harmonics around 3000 Hz. Thus, the evolution of singing voice has its own reflection in the formant table.

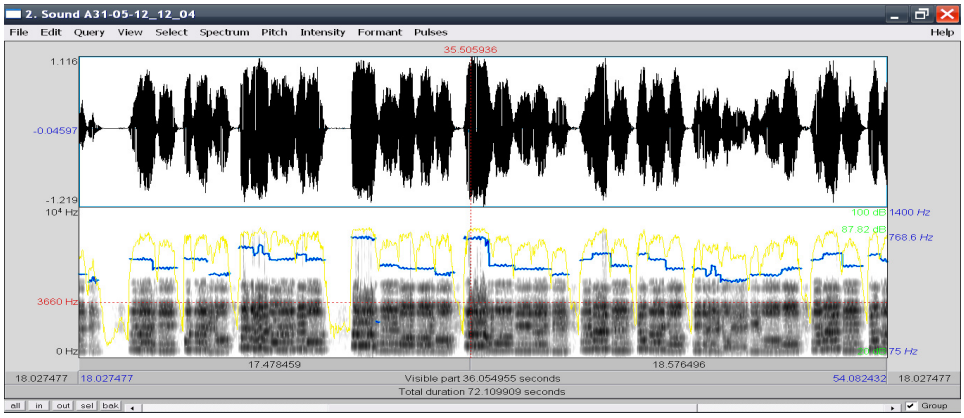
Johan Sundberg associates 'the singer's formant' with lowering the larynx while singing. Studies made referring to the physiology of vocal apparatus show that by lowering the larynx the length of vocal tract is increasing. Changes in its configuration would contribute to subtle modifications of voice quality, as well in increasing the singer's formant. Articulation can lead, also, to variation of formant frequency, namely the higher the pitch the wider the jaw opening, especially on sopranos. Enrichment of voice at the formant level can be achieved also by modifying the resonators in shape and volume. Formants are defined as the spectral peaks of the sound spectrum of the voice or the acoustic resonance of the human vocal tract. Thus, the beauty of voice lies in correct usage of resonators, demonstrating the presence of formants.

The first important step in analysing vocal evolution of a singer it is considered to be the carrying out of comparative spectrograms, of the same musical fragment, done at a certain time interval. Analysis of recordings, through computer software, accomplished every 6 singing lessons, has directed us, with great precision, to the areas which needed help. Knowing that the vocal apparatus is a live instrument, we have tried to keep its natural developing rhythm. Progress achieved was slow, especially for first-year students.

We are going to show the spectrogram of a fragment from *Ridente la calma* by W. A. Mozart, performed by a first-year soprano student. The analysed recording was made at the end of the first semester, namely after 22-24 lessons.

Knowing that we were analysing the human voice, we have recorded it without accompaniment and this also was a condition of the software used.

Fig. 1



Spectrogram from the first semester

This spectrogram shows several parameters. The yellow line represents intensity or volume of sound. The pitch or melodic line is a blue line, and the grey mess in the background is the spectrogram which is basically what we call timbre. The fragment shown here is from the first stanza of the *Ridente la calma* song by Mozart and has a 37 seconds duration. The shorter the fragment to analyse the more details can be emphasized. We have chosen to analyse the middle part of the first stanza considering it more relevant.

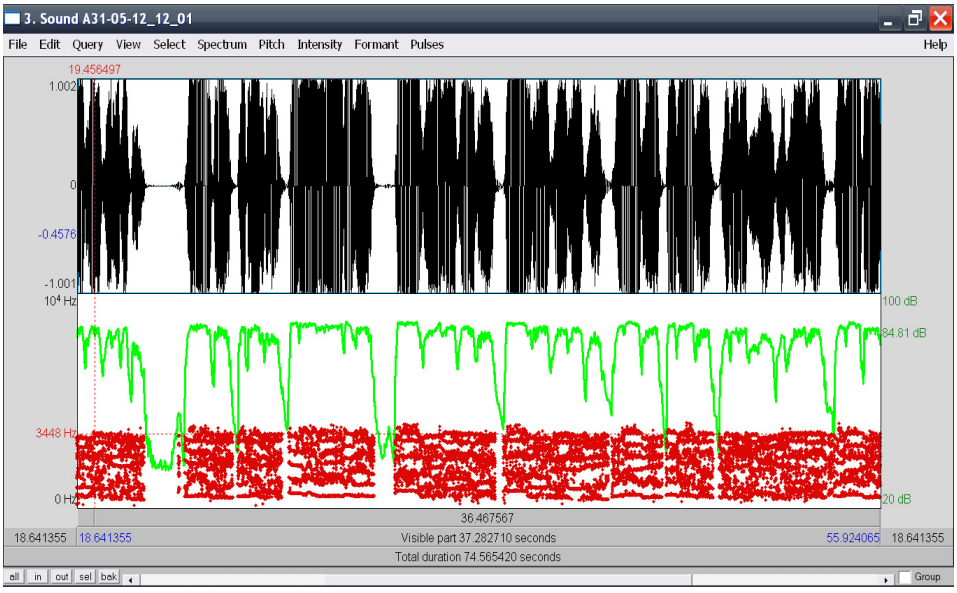
As we see from the lower graphic, the intensity boundaries of the sound are between 27 and 88 dB. The upper limit, being 87,82 dB shows us that concerning this parameter the young soprano has a satisfactory level. Professional trained sopranos can reach 90 dB and over. Thus, our further suggestions will be more from an aesthetic point. Thereby, our objective represents the education of smoothness and elasticity in singing, and concerning the high pitch area careful dispensing of vocal cords pressure is necessary. Ideal singing should include the capacity of singing *legato* numerous musical notes, without interruption, in a smooth flow, with breathing support, on all pitches and intensities. Only then the process of coordination of technical vocal elements will prove to be efficient. The technique of singing *legato* represents the essence of vocal exercises, especially in the beginning of singing lessons.

The index of pitch in the spectrogram notifies a certain incertitude relating the pitch. Singing without accompaniment signifies ‘the lack’ of harmonic support which is necessary to beginners and often shows problems in this area. Thus, instead of 783 Hz, which is G in the second octave, we have 773,1 Hz, meaning under the tone.

Undoubtedly, precise intonation reflects accurate musical hearing, and improving it needs much solmization, vocalizations and vocal exercises. All these need to be correlated with the complex mechanism of the larynx muscles, meaning the correct projection of the tone, precise attack of every note, tone emission and leave of note. Precision of tone emission is in direct correlation with the functioning of phonatory mechanism, any cause of instability would not necessarily mean a lack of musical hearing, but often is the consequence of the voice not being properly projected. The education according to Bel canto principles offers efficient methods of fixing such problems, and following them would suppress bad singing, allowing beautiful singing even in high *tessitura* and before informed public.

Regarding the spectrogram, we see that only the lower part has intense gray. The average of frequency intensity is concentrated around 3660 Hz. In the upper part of the graphic, where this figure in surpassed, we see a decrease in the density of acoustic energy and even total lack of it. The table with formants agrees with the spectrogram:

Fig. 2



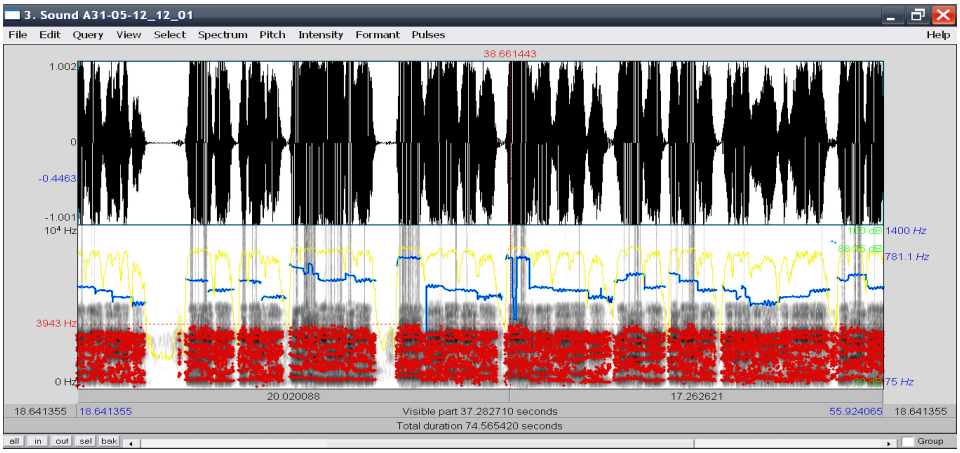
Graphic of intensity and formants

The acoustic average of the segment is concentrated around 3448 Hz. This is the peak. We see a concordance between the increase of sound intensity and formant density. Where intensity values are around 30 dB, red lines are disappearing. From these graphic results also the young singer is associating intensity increase with pitch gain, which is frequent with beginners.

Truly, the melodic climax is represented by G 5 (in the second octave), and the accent of the syllable on this tone is on the ‘e’ vowel. To get an increase on the ‘e’ vowel, it is necessary to reduce the tongue bulging.

Can we obtain good results in a relatively short time regarding the development of vocal proficiency? The answer to this question will be given by analysing subsequent recordings. We will look at the spectrogram of the same musical fragment, recorded approximately after four months, namely after 20 hours of singing classes, at the end of the second semester:

Fig. 3



Spectrogram of second semester

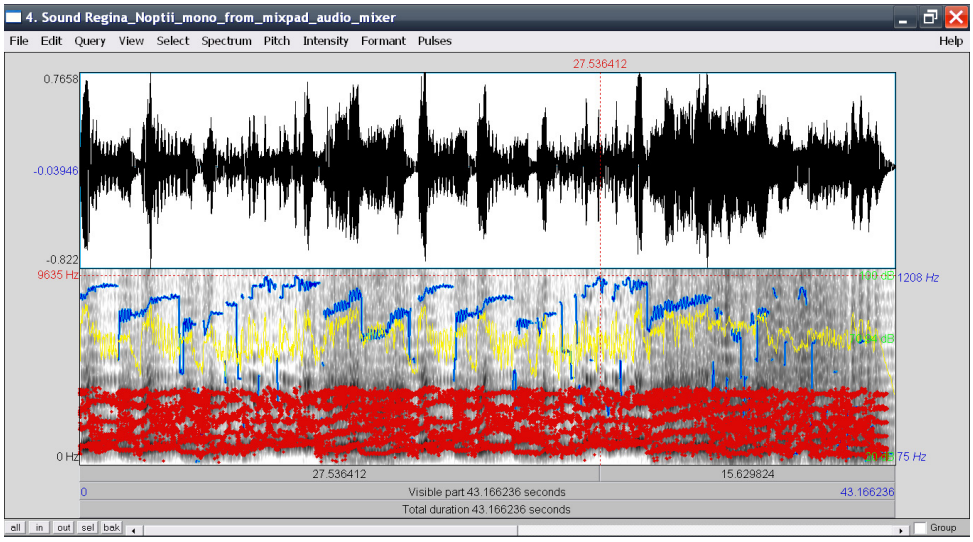
As we see, values of the second spectrogram do not show a spectacular change in vocal parameters. Still, there is a small increase of maximum intensity level, from 87,82 dB to 88,15 dB on high pitches. We also notice that G 5 has 781,1 Hz, being much closer to the standard 783 Hz than the previous note attained four months ago. Density of acoustic energy, marked in grey, is over 3900 Hz, level not reached in the first semester. Maximum value for formants is 3943 Hz. All these values demonstrates an evident increase of sound quality and by consequence it means that voice development follows a correct path, as a result of reaching study objectives. One of these objectives is represented by the obtainment of homogenous voice registers and smoothness of singing. The declared purpose was the homogenous passage from a vowel to another, on all intensities and on the whole tonal range. Reaching this objective allows one to get a perfect legato in singing.

Undeniably, voice education must be undertaken individually, following the same purposes: to sing on breathing, with a warm tone, homogenous and flexible, reaching gradually technical prowess, which will allow smooth passage

from one tone to another on all intensities and vocal range. Regarding the vocal range, we observe that it has improved a little, being richer with several high notes as compared with the first recording, Some changes were noticeable also concerning tessitura, which describes the most musically acceptable and comfortable range for a given singer. All these features, being easy to implement to the music repertoire, have been worked out through vocalizations. Computer analysis of the chosen vocal exercises recorded along the entire semester which were discussed with each student separately, have become the backbone of their vocal evolution. Superposition of sonograms extracted from the middle part of vocalizations has shown us the direction to follow in improving singing.

We have considered necessary to show another sonogram, recorded by a soprano, a student in second year of master degree. It shows us a possible path to follow:

Fig. 4



Sonogram including all vocal parameters

The analyzed fragment is extracted from *Queen of the Night* aria (*Der Hölle Rache kocht in meinem Herzen*), second act, *The Magic Flute* by W.A. Mozart. The pitch (blue line) shows us the predominance of high notes, several times being reached the 1208 Hz value. Intensity is calculated at 71 dB, ranging from 60,52 and 83,72 dB. This average is acquired in a high pitch range of soprano voice, where vocal penetrance is due mainly to the capacity of the singer to focus the sound. From this point of view, the analysis of formants is crucial, which represents probably the best way to assess acoustic vocal qualities.

This spectral analysis highlights the presence of formants which is characteristic to the 'a' vowel, sang alone for several bars. The acoustic density of the frequency is concentrated around 4862 Hz. We see that this time the grey mess is all over the graphic, although it is diminishing a little on the upper part of the spectrogram. Consequently, the spectrogram exemplifies the existence of harmonic structures or formants of high intensity, unveiling the rich qualities of the vocal sound in the higher range of soprano voice.

Using the Praat program we got the formant graphic, which displays a wide range of formants, proving the special voice quality of the soprano, offering thus a model to be followed by young singers eager to become good singers. Accordingly, technological equipment offers voice teachers and students with the possibility to have a better control over the voice. Exploring ICT resources brings changes in the learning process and also a more active and flexible education. Students have the opportunity to learn, to acquire knowledge by exercising critical thinking, and using ICT means represents a basis which ensures continuity in practice for life.

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