International Journal of Music and Performing Arts
June 2017, Vol. 5, No. 1, pp. 11-22
ISSN: 2374-2690 (Print) 2374-2704 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/ijmpa.v5n1a2
URL: https://doi.org/10.15640/ijmpa.v5n1a2

Relationship between Sound Quality and Lip Muscle Density in French Horn Players

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Abstract

Much has been discussed among wind players about whether a sound whose timbre is considered good / valid is related to the degree of muscle strengthening of the lips. Assuming that the best sound is related to an increased number of lip muscle fibers, this study directly addresses this claim, for two tests were performed, one medical and one acoustic, both complementary. It was sampled from 16 horn students from Valencia; the acoustic test consisted of 3 recording sounds corresponding to harmonics # 2 (B ♭2), No. 4 and 8 , with two intensities: p and f , resulting in a total of 90 comparative sound samples. The results were subtle but concrete: All sound samples tested offered a surround sound with a similar profile. Comparing two sound samples (one considered lower-quality sound and the other as higher sound quality), it was observed that there are a higher amount of harmonics in those sounds that are considered of quality. With regard to the evaluation of ultrasound, the total volume of the upper lip 40-50% is occupied muscle. In conclusion, having more muscle fiber can help improve the sound of the horn player, but that is in combination with all other multiple technical factors.

Keywords: Englip density, ultrasound, sound spectral decomposition, sound quality, lip pursing, lip muscle fibres.

Introduction

1.1. What is Embouchure to Wind Players

Embouchure is the mechanism to form the lips in order to correctly insert the mouthpiece while playing a wind instrument. Fruncht defines this concept like " a well-organized collection of perioral and jaw muscles used to initiate and control the amplitude and intensity of the air column through the mouthpiece of the metal or wood wind instrument " According to Frunch's definition, 12 muscles are used to form the correct lip shape, the orbicular being the most important. Iltis y Givens[5], suggest a similar anatomy in embouchure of wind musicians; they include the next muscles to belong the shape embouchure: Orbicularis oris, Zygomaticus Major, Zygomaticus minor ,Levatorangulioris, Depressor angulioris, Levatorlabiisuperioris and Depressor labiiinferiores.

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[5]From: SOBOTTA: "Atlas de anatomía humana" , 19 ed, Madrid: edPanamericana; 1991.

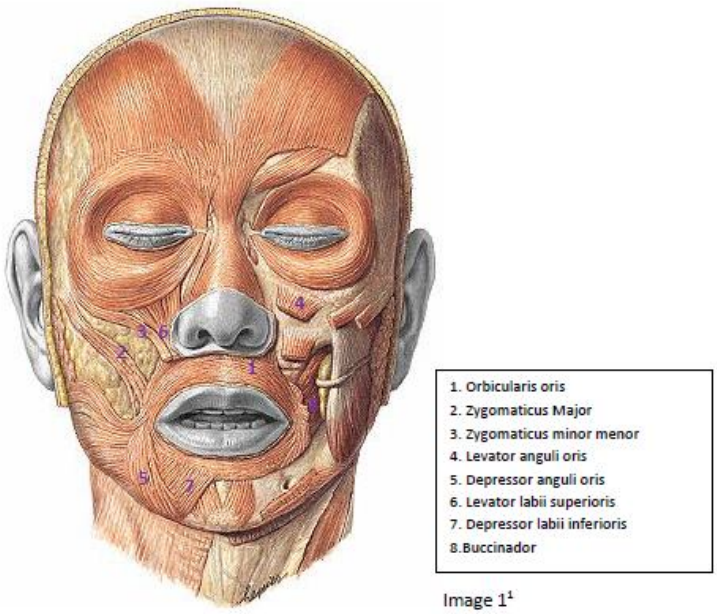


Image 1[1]

1.2 Area description: the lips.

The lips are the beginning of the digestive and respiratory systems and also the entrance to the mouth. The lips are composed of a central muscular part surrounded by interstitial tissue and skin.

Lip Density Muscle is defined as among / percentage of muscle in relation of totally lip area to study.

1.3. Ultrasound is a medical technology to evaluate in detail the structure of the muscle being the ideal method to diagnose different types of pathologies.

1.4. Acoustic behavior

Production of the sound in the horn: The vibration produced by the lips inside the mouthpiece comes into contact with the air that is contained the sonorous pipe (the horn), and activates it. The lips, make the air pressure in the mouth greater than on the outside. As the lips are flexible, they tend to bend or move (vibrating) thanks to the pressure difference. The opening of the passage of the air causes a reduction in the pressure inside the mouth and lips, thanks to their flexibility, they return to their initial shape and position. This process is repeated hundreds of times. A deep note, is a vibration at lower frequencies, and also results in a lesser tension of the mouth area (lips and muscles that surround the mouth). Normally, when a body vibrates, we don´t obtain a pure sound, but a sound composted of different frequencies. This is called harmonics. The frequency of the harmonics is a multiple of the lowest frequencies, called fundamental frequency or first harmonic.

The harmonics contribute to the acoustic perception of the quality of the sound and timbre. The French horn is prolific in harmonics, and this fact makes its singular and special timbre. It can produce between sixteen and twenty harmonics, considerably more than the nine to ten harmonics produced by the trumpet or trombone. The mouthpiece design with a longer stem and a slower decrease in diameter contribute to this fact. Musical sounds constitute a complex mix of vibrations that can be analyzed by means of their acoustic spectrum. The study of the instrument timbre in a scientific way is made through its particular spectrum that means the graphic harmonics representation that is produced in the tube of the instrument. In a review of the scientific literature we have found no evidence that deals with the relation of the sound quality and muscular properties of the lips. Although we did find several papers about discord and dental problems related to the mouthpiece, like those presented by Porter, Telfer o Landeck.

2. Working Hypothesis.

The Sound Quality In French Horn Players Is Related To The Quantity Of Muscle Fibers In The Lips, Especially The Part Of The Lips Which Are Inserted Into The Mouthpiece

3. Main Objectives

1. To Know the Proportion of the Muscle Which Vibrates
2. To Know The Composition Of The Sound Spectrum And To Define The Spectral Elements Related With Subjective Perception.
3. Relation between Both.

4. Methodology: Population, Procedures.

4.1 Design of Study

Two trials were conducted, one medical and another acoustic, both complementary, using different methods and materials. Population: The study was conducted on 16 adult horn students' players. In the few references to similar studies, the sample size varies between 4 and 42 to analyze the strategy in 15 different instruments. For this reason it is estimated that for a single instrument (horn) it is sufficient to have a sample size of 15 musicians. All subjects are familiar with the protocol and have signed the related consent form. The acquisition conditions of the different tests were Standardized and the musicians played the instrument in a natural and artistic way, playing the usual positions of interpretation.

4**.2 Technics of study: Procedures.**
4.2.2 Recording and Decomposition Sound Sessions.

Day 1: Recording of sound in the LEA CSMV:

This consisted of recording 3 sounds corresponding to harmonics # 2 (B b2), No. 4 (B b3) and No. 8 (B b4), with an intensity of piano forte, resulting in a total of 90 comparative sound samples. All sounds were obtained with the same instrument (an Alexander Bb 103 gold messing material) using each individual the mouthpiece. The recording of sound samples was performed in the recording studio at the Conservatory of Music "Joaquín Rodrigo" of Valencia by Professor G. Jiménez and frequency spectral analysis has been carried out by Horn Teacher ,Juan Jose Llimerá Dus.

Notice: Note Fa is in horn in F. The real sound is Bb when is heard in C tone.

Sampling

The spectrum was recorded with a sampling frequency of 44100 Hz (32 bits), and it was obtained by analyzing samples with Audacity 2.0.3 program. For the analysis, Fourier Transform "Hamming" function was used with a size of 1024 logarithmic frequency which was visually be the most practical.

Computer equipment that has been used:

- Chain recording and analysis of sound samples:

Microphones-Preamplifier.-Converter AD-Computer and Software:
Microphones: Newman U87: very flat response microphone so the spectrum
Engraved harmonic which is similar to the actual sound.
Preamplifier: Universal Audio LA 610 model.
AD converter: Digidesign 192 I / O
Audio Interface Pro HD system tolos

- Computer: Intel Xeon Quad Core Mac

A 2.26 GHz, 8 MB RAM and two 24-inch screens. System hard disk recording Pro Tools HD2.
Images obtained:

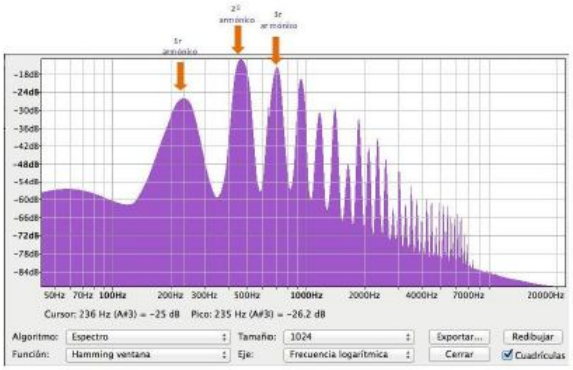


Image 3

2. Making the Labial Ultrasound.

High definition ultrasound was performed with high frequency linear probe in the radiology department of the Consortium General Hospital Universitario de Valencia, using standard radiation safety requirements. The ultrasound system used was the LOGIQ S7 Expert model, with the head: ML-6-15 brand both GE Healthcare.

Data of Procedure:

For each patient several samples were taken at the following levels:

1. Sagittal plane, with vertical head:

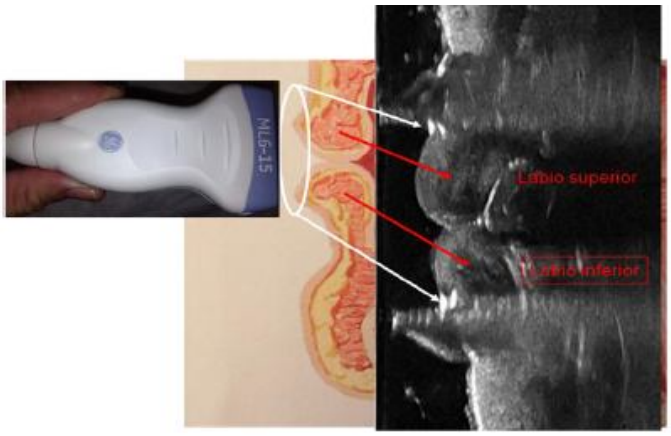


Image 4

Image 5

It has been used for this type of section to:

It has been used for this type of section to:
a) Compare quantity lip sup/inf inside the mouthpiece.
b) Areas
2. Transverse plane with head horizontally:
It has been used for this type of section to:
a) Compare lip strain for records
b) Areas

Image 6

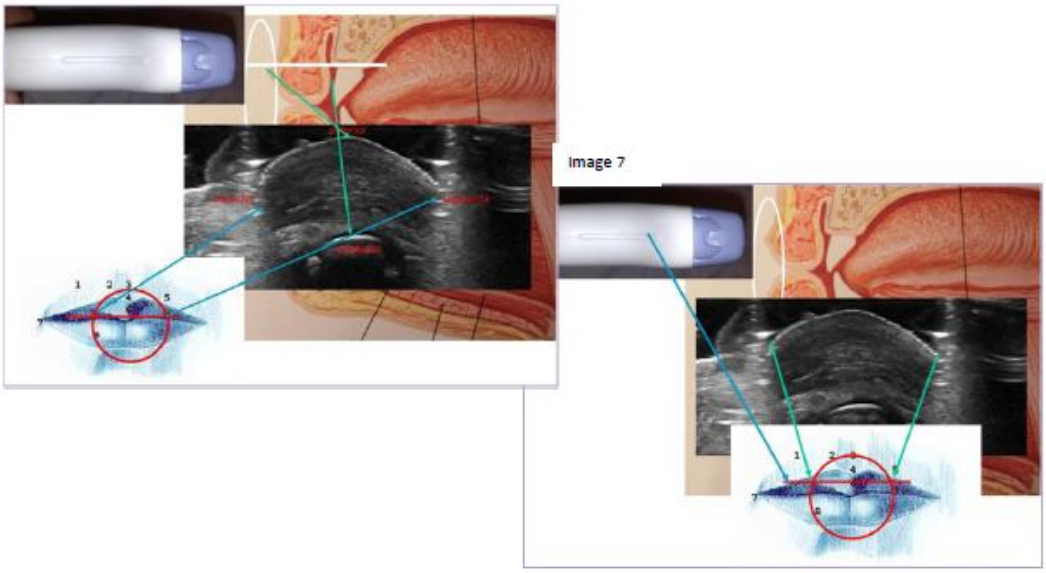


Image 7

5. Results and Discussion

1. of ultrasounds
2. The spectral decomposition of sound

5.1. Ultrasounds

5.1.1. Comparison amount greater / lower lip is inside the mouthpiece.

Various types of sections were used to relate what / how much of upper and lower lip is in the inside of the mouthpiece. It is known by horn players that it is usual is to occupy, inside the mouthpiece, approximately 2/3 the upper lip, whereas the remaining third corresponds to the lower lip.

However From The Following Images We Can See That:

1. In a sagittal section, the upper lip covers the largest area (as you would expect, as I said before) for the bottom.

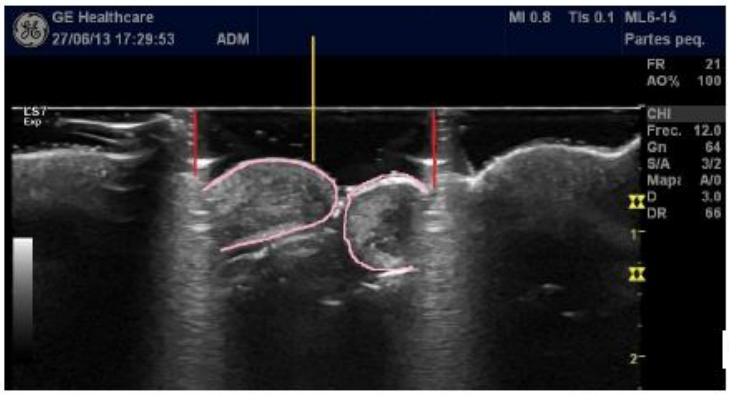


Image 8

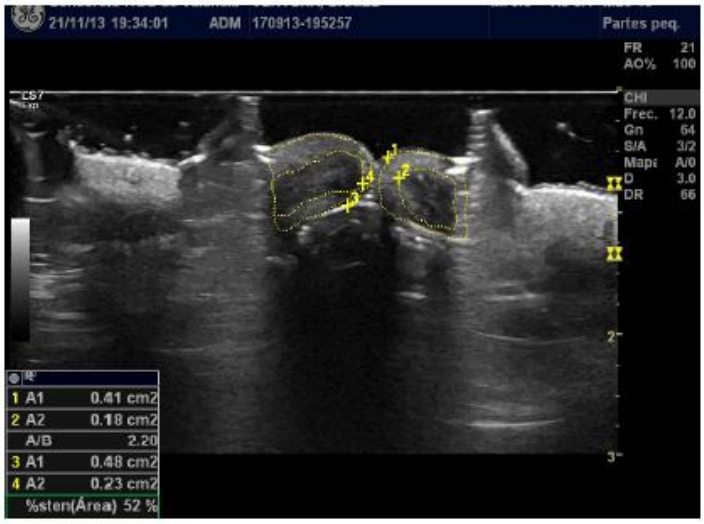


Image 9

2. In the coronal plane, although we place 1/3 lower lip within the mouthpiece, you can occupy almost the same area or even more as the lower lip tends to be thicker.

Image 10

Image 11

To make an opportune education reflection, we could suggest that horn players should pay more attention to the lower lip, as it is shown that the vibration level is less than the upper lip, It occupies an important space in the whole set.

5.1.2 Relationship Amount of Muscle / Total Amount of Lip Is In Each Lip

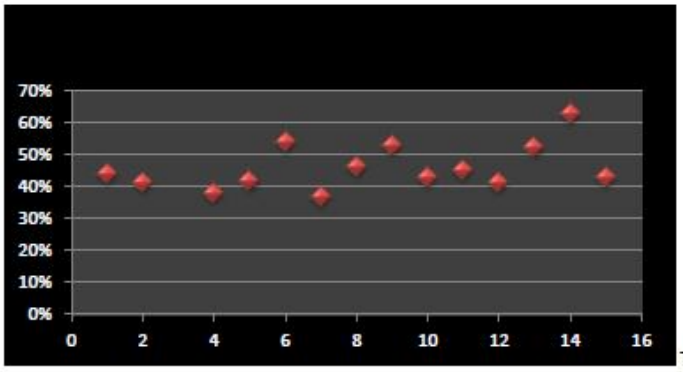
To determine which proportion of muscle in total are measured in amount relative to the lip, the volume measurements were taken, separating the upper lip of the bottom.

Image measurement of the total volumen of the upper lip

Image 12

Volume= a×b×c×0,52

Upper lip: This graph shows the proportion of muscle regarding to the total volume of lip between the samples taken.

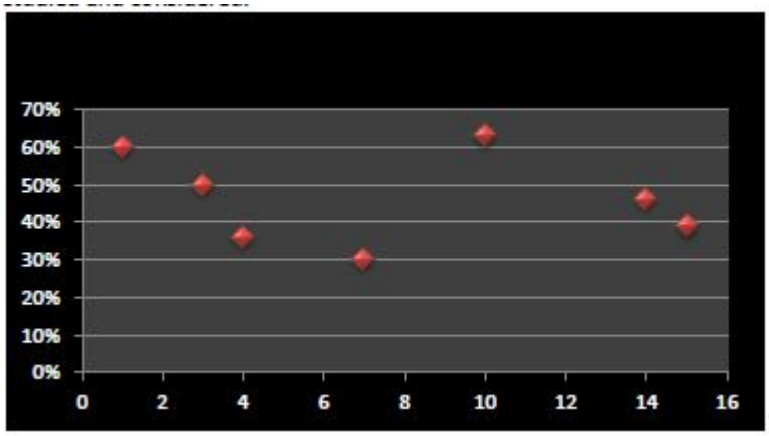


T.1

As we can see, most of the participants are between 40 and 50%, that is, the total volume of the upper lip is between 40-50% of occupied muscle. There is no evidence that participants with a higher proportion of muscle have significant differences (more power, better quality, etc.) in the sound. Even though you have more muscle strength it seems it is the same, however this is still a factor to consider.

Lower lip

Regarding the lower lip, the results are more dispersed, but most are between 40 and 60%. It should be noted that the two students with the least amount of muscle, shown in relation to the total, are students whose sound is considered of a lower quality. However, we cannot say with this small sample that the sound quality could be considered improvable. This may be due to less muscle ratio, and given that other multiple anatomical and technical factors should be studied and considered.



T.2

5.1.3. Comparison for Registers.

Where:

- 1 and 2 are linear lip cm inside the mouthpiece.
- 3 is t is the thickness of the lip, or the amount Sagittal lip
- 4 the amount of muscle in the sagittal plane
- 3 and 4 are the part of the lip that it isn't muscle

Image 14

For the comparison of registers this type sections were chosen:

Analysis on the upper lip focused, since by definition is the one that changes with the change of register. Attempts have been quantified by measuring the degree of lip strain with the shift register, defining lip strain as degree of muscular contraction, and therefore related to the space occupied by the muscle: the higher lip strain less space will occupy.

The main conclusions were:

1. In some participants, the position of lip is inclined respect the medium line: there isn't the same proportion in right part to left upper lip part, without any prejudice evident to the horn player.
2. Lip thickness without vibration and in low register is too similar.
3. The degree of lip strain varies with the shift register: Muscle is much more tense (occupies less space) in the high register.

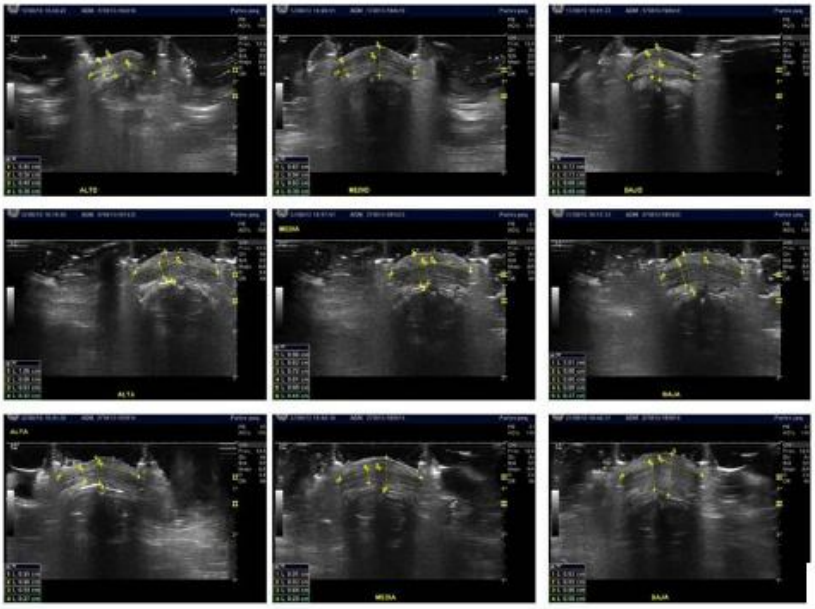


Image 15

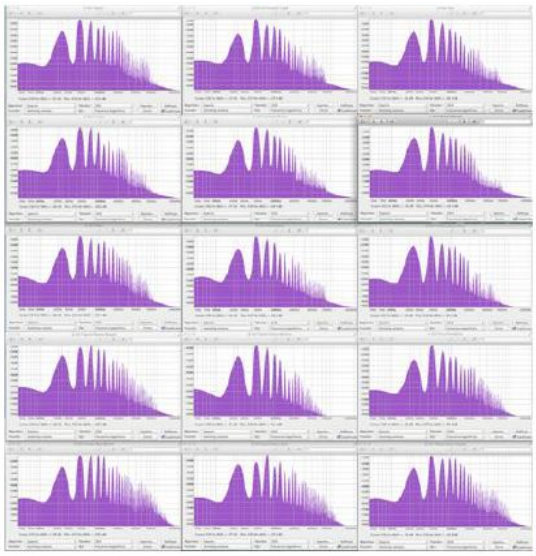
2. **About Spectral Decomposition of Sound**

a. General characteristics of harmonics:

The fundamental sound (considered here as first harmonic), has an intensity that is usually higher than the other harmonics and determines the height of the complex sounds that it integrates. The second harmonic reinforces the key, giving the sensation of high precision when it is deep. If we look at the harmonic spectrum of the Horn in F, we can see that, unlike the spectrum of other instruments, the harmonic dominates the second, which explains the difficulty in obtaining the first harmonic or pedal on the same.

Harmonics 3, 6 and 12. - The third connects to the complex a nasal timbre; the sixth and twelfth accentuate this effect.
Harmonics 4, 8 and 16.-intensify the qualities provided by the second.
Harmonics 5 and 10.-the fifth is very important, because it gives the sound complexities, comprising of a warm and round chime; It forms one major along with the third and the first perfect chord. The tenth harmonic intensifies the qualities provided by the first.
Harmonics 11, 13 y 15. Are dissonant and they contribute roughness, especially the two firsts ones.

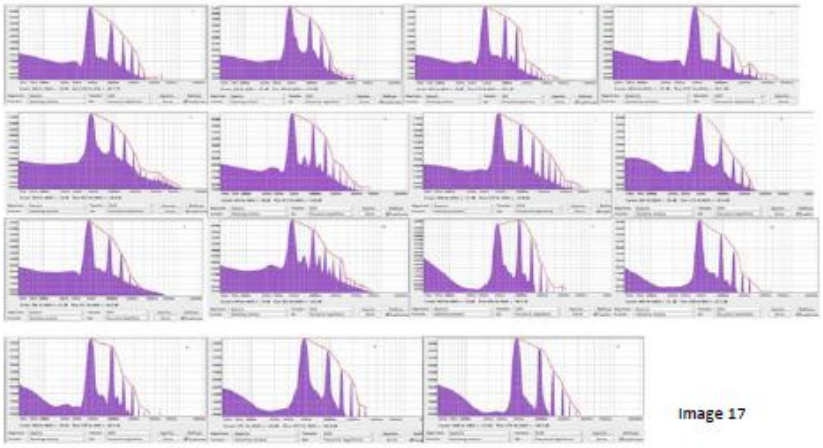
b. Pattern of surround sound: On the general outline showing all the harmonics, it is worth noting that all sound samples tested offered a surround with a similar profile that decays and fades almost entirely around 22000 Hz.



c. Analysis:

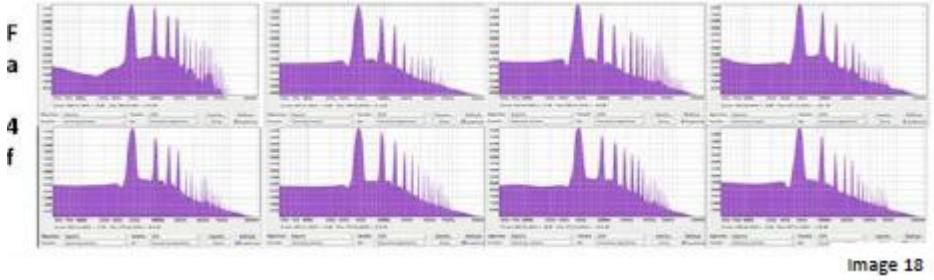
We have taken as an example notes Fa 4 f and p, where the correct air pressure and position of the lip are essential.

Note spectrum analysis Fa 4 p:



If we focus on the comparison of the Harmonics 3.5 and 11:
Harmonic 3: to -42dB arrive: pictures 1,2,3 , 6. The remaining do not reach that limit.
Harmonic 5: -72dB arrive; pictures 1, 3, 4,5,6,7 and 10 (surpassing in great way), 12.
Harmonic 11: only present in 1 and 5.

- Spectrum Analysis of the note F 4 f: spectrum fairly evenly among the participants:



As there were no great differences between them, was chosen the Ns.1 and 5, as examples of better / improvable sound, to see if some difference is observed.

- Comparison of samples:

Thus, taking the sample No. 1 as sound quality, and the sample No. 5 as sound of lesser quality, we see that there is more number of harmonics (greater presence) in those sounds which are considered to be of quality.

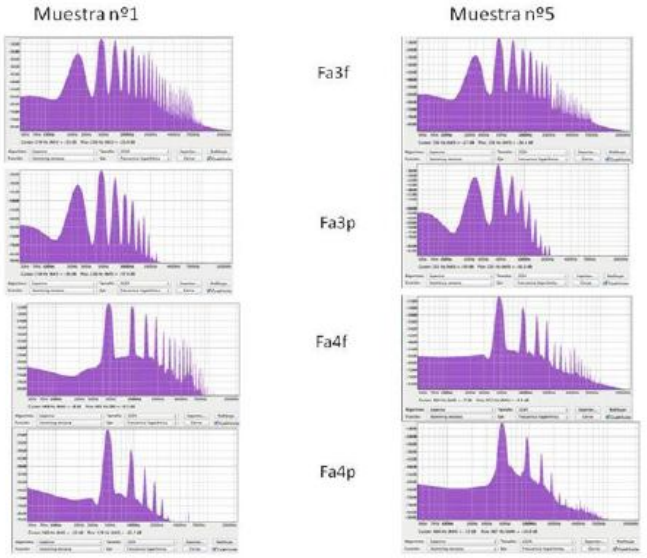


Image 19

We could notice that, although the picture of surround is similar, in sample nº1 there are more presence of harmonics. To continue comparing, we took samples 4 and 14, considering that sample nº4 is apoor quality sound, and sample nº14 is a good quality sound.

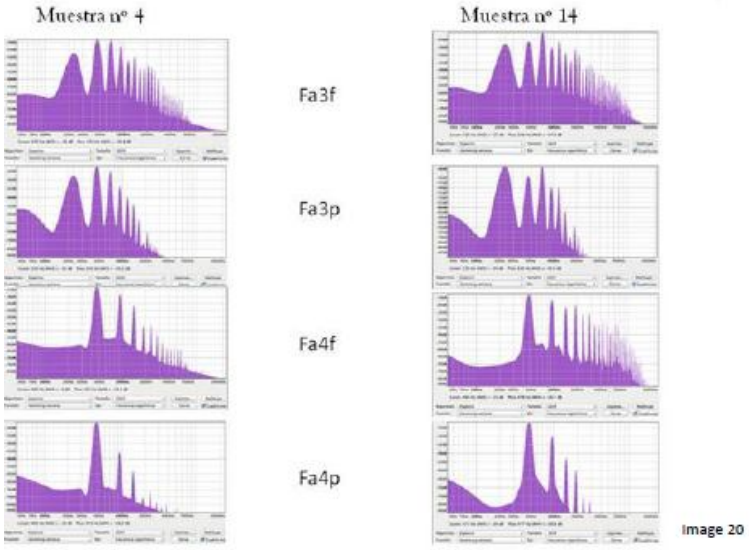


Image 20

There is a coincidence that the samples nos. 4 and 5 received a lower percentage muscle in the analysis using ultrasound. Therefore, as CONCLUSIONS in both analysis, we can say that:

1. Most of the students are placed in a standard regarding the spectral decomposition (no huge differences between them), and ultrasound analysis, subtle differences are found in both test results among those students whose sound is considered to be improved, and those whose sound is considered of a higher quality.
2. Given the narrow margin between some horn players and others, we can consider that the number of muscle fibers (and therefore degree of muscle strength) is sufficient in both groups; exercises carried out in some schools about lip muscle strengthening, might have some effectiveness, which is well directed to the prevention of fatigue or addressing the perspective of sound enhancement, even in this light, we must not disentangle aspects of general techniques: the proper use of the upper airway, the study of lip vibration control in the breathing process, etc.
3. Having more muscle fibers can help improve the sound in the horn player, but in combination with all other multiple technical factors affecting wind instrumentalist.
4. Sound quality certainly is an abstract and subjective concept of the listener, however, you can define certain acoustic parameters.
5. The use of ultrasound from the medical field can help the listening area, and by extension in musical education and practice.
6. It is essential to maintain good hygiene and muscle stretching.
7. They must use all available resources to improve the sound in an instrumentalist, including the study of the acoustic spectrum and improving technical and artist.

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