Popular and Classical Female Singers: Acoustic Comparison of Voice Use in the Song *Melodia Sentimental* (*Sentimental Melody*) by Heitor Villa-Lobos

Natalia Eugenia Sanchez Escamez, Ana Paula Guimarães Silva, and Marta Assumpção de Andrada e Silva,
São Paulo, Brazil

Summary: Objective. This study aims to compare acoustic characteristics of classical and popular female singers' vocal performances in Heitor Villa-Lobos' *Melodia Sentimental* (Sentimental Melody).
Method. Long-term average spectrum acoustic analysis and long-term voice onset time (VOT) were performed for two consonants /d/ in the first six verses of *Melodia Sentimental* sang by 10 professional singers: five classical (GC) and five popular (GP).
Results. Classical singers presented prominence in the region of the frequencies between 2.5 and 3.5 kHz, not observed in the majority of the popular singers' group. The GC group showed lighter spectral decline curves and the numerical value of decline was also lower. Classical singers presented lower long-term voice onset time values, which indicates a longer period of glottic closure.
Conclusion. Acoustic analysis revealed that classical singers have more energy in glottic closure associated with a shorter duration of glottic coaptation.
Key Words: Music–Voice–Song–Brazilian Portuguese singing–Acoustic analysis.

INTRODUCTION

Regardless of musical style, there are considerable differences between classical and popular music genres. Classical singing requires more extensive vocal *tessitura*, higher intensity, and refined voice adjustments,[1] whereas in popular singing, the key is adaptable, also incorporating characteristics of the speaking voice.[2]

Heitor Villa-Lobos (1887–1959), Brazilian composer and maestro, considered the greatest composer of the Americas,[3] was well known for stylistically oscillating between classical and popular genres. His works include aspects of European music fused with Brazilian national musicality and elements of Brazilian folkloric, popular, and indigenous songs.[4] *Melodia Sentimental* (1958) stands out as one of his most acclaimed works. It was first debuted and recorded in 1959 in New York, with musical direction of the author himself and interpretation by Bidu Sayão. Its success transcended the classical realm for which it was firstly written and spread as a popular song in various arrangements and renditions, being recorded by Elizeth Cardoso (1967), Ney Matogrosso (1997), and Maria Bethânia (2003), among others.

Classical singing favors vocal virtuosity more than textual matters, semantics, intelligibility, and phonetic precision.[5] Expressive intentions, such as dynamics and duration of the notes, may not be executed even if noted. The classical singer may convey meaning, recognize, and execute nuances not explicit in the sheet music.[6,7]

In popular singing, on the contrary, the core of the musical experience is the recording or performance and not its notation.[8,9] The popular singer is able to experiment with different voice sonorities, without compromising regularity in vocal *tessitura*.[10] The presence of a microphone exempts voice projection[11] and privileges voice timbre contrasts.[12] The incorporation of "defects"—an altered, airy or hoarse voice, for example—is used as a personal trait characteristic of popular singing[2,11] in opposition to the classical genre.[12,13] For the popular singer, words are performance instruments, which make text intelligibility essential as well as the rhythmic and sound exploration of every word, but not the quality of the issuance.[2,11–13] The popular interpreter is free to create his or her own oral gestuality.[1]

The nonobservance of certain melodic, rhythmic, or harmonic patterns defines the interpretation of a song. In that sense, it also depends on how the singing is interpreted for it to be considered classical or popular.[14] Although in popular songs the change of key, rhythm, and even melody are accepted, in classical singing, the interpretative traits are far subtler. The possibility of transposition[10] exists, but without changing the distance and duration of melodic intervals—for example, a melody starting with two notes of a set time duration a major third apart (such as the notes Do-Mi) should keep that duration and start with a major third even when transposed. Temporal rhythmic aspects are modified, but in less perceptible levels.[15]

Phono-articulatory organs have specific adjustments for singing, being subject to anatomical and physiological individual conditions, to an interpretation style and to the demands of each music genre.[16] Zampieri et al[17] performed a research with 26 popular singers, 10 men and 16 women, observing laryngeal adjustments. The research found supraglottic adjustments closer to the speaking voice—a characteristic of such music genre.

Titze[18] understood that, in classical singing, the singer's vocal tract configuration interferences with phonation stability and drastic changes could result in phonation oscillation and involuntary register breaks. Nevertheless, if the singer is able to keep a uniform acoustic energy distribution, the register changes can be delayed or even avoided. Sundberg[19] argued that for voice

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From the Pontifical Catholic University of São Paulo, São Paulo, Brazil.
Address correspondence and reprint requests to Ana Paula Guimarães Silva, Pontifícia Universidade Católica de São Paulo PUC-SP, Rua Ministro Godoi, 969—4° andar—sala 4E-13, Perdizes, São Paulo CEP 05015-901, Brazil. E-mail: paulimana@uol.com.br
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projection, lowering the larynx helps to expand the pharynx cavity and widen the resonance space. Keeping a lower larynx during high frequencies is a trained classical vocal technique as it is not natural.[20]

The purpose of Hollien et al's[21] study was to observe if changes in fundamental frequency (f0) could really interfere with the correct understanding of vowels. A total of 18 professional singers, 13 women and 5 men, recorded three isolated vowels in low and high frequencies recurring to *piano* and *forte* dynamics. Fifty listeners were asked to identify the vowels and distinguish between male and female voices. The researchers concluded that intelligibility is dependent on context, and vowels are harder to distinguish when f0 exceeds the usual first vowel formant. In higher frequencies, vowels in female voices were less recognized compared with male ones.

Barlow and LoVetri[22] studied closed quotient and spectral measures of female adolescent singers considering different singing styles using long-term average spectrum (LTAS). Twenty singers between the ages 12 and 17 years, classical singing and musical theater singing (belting) students, recorded "Happy Birthday to You" in key of C major (C) in three different octaves (C2, C3, and C4) applying a mezzo-forte dynamic. The authors observed that the spectral decline was similar in the lower notes, but become more pronounced for classical voice after 350 Hz, suggesting that it had a higher closed quotient and a higher amplitude peak. This observation reveals an alternative use for resonances of the vocal tract characterizing, in classical voice, a "round" sound and, in belting, a "bright" and "sharp" one.

Sundberg and Romedahl[23] investigated intelligibility for opera singers and musical theater singers. Four professional singers, two opera singers and two musical theater singers, recorded a musical sentence using a *legit* voice, and a syllable was changed for each of three repetitions. Six levels of noise were added in total, the highest being equivalent to an orchestra playing forte. LTAS analysis showed a 3k spectral peak for classical singers against 1k for *legit* musical theater singers. LTAS noise analysis was also performed. Considering a total of 192 different stimuli (4 singers × 8 phrases × 6 levels of noise), listeners were asked to list the syllables they were hearing.

The syllables sang by musical theater singers were recognized a higher number of times than those sang by opera singers, showing that the vocal articulation of the first is closer to the speaking voice. Additionally, singers' formant in opera singers' voices were more continuous than those of musical theater singers, which, on the contrary, seemed intermittent, shadowed by the background noise.

Loiola-Barreiro and Andrada e Silva[13] studied vocal characteristics and vocal tract configuration in the singing practice of 20 professional singers:10 classical and 10 popular. LTAS analysis revealed that only classical singers presented spectral peaks in the singer's formant area ranging from 3k to 4k. Additionally, in comparison with the speaking voice, there was an increase in singing intensity, which indicated a more comfortable singing issuance. Intensity was more noticeable in classical singers, who perform with greater volume, projection, no external amplification, and above the orchestra's sound. They also showed lighter decline curves, meaning a stronger level of closure in glottic adduction.

During the production of obstruction sounds, the voice onset time (VOT) refers to the time interval between occlusion release and the beginning of the voicing happening before, after, or at the same time of this release. VOT values vary according to the place of articulation, and the difference between voiced and voiceless plosives marks the presence of prevoicing. Thus, the VOT is negative for voiced plosives.[24,25]

According to Lisker and Abramson,[26] this parameter gives a consistent evaluation of synchronization. Ladefoged and Maddieson[27] understood that the characteristics of sound and aspiration influence the vocal quality and, according to Lofredo Bonatto,[25] the plosive consonants bring a singular quality through laryngeal activity as a result of the approximation of the vocal chords and its relation to oral articulation.

McCrea and Morri's[28] hypothesis was that since trained singers learn how to perform a variety of phonatory and articulatory adjustments, their VOT would be higher than that of nontrained singers regardless of the task whether sung or spoken. They also observed if the VOT was different between singing and speaking. Thirty men were divided into two groups: 15 vocally trained and 15 untrained. The participants were given two sentences containing the bilabial occlusive consonants /p/ and /b/ in starting position. The sentences were spoken and sung in the determined rhythm. VOT measurement did not reveal significant difference between the two consonants in singing and speaking. Trained singers had a lower VOT during the singing task and a higher VOT in the spoken task for /p/. In relation to /b/, trained singers tended to voice the interval before the beginning of the word, producing a negative VOT.

The purpose of the present research is to compare issuance's acoustic characteristics in classical and popular singers during the execution of an excerpt from *Melodia Sentimental*, a song by Brazilian composer Heitor Villa-Lobos.

METHOD

For convenience purposes, the sample was finalized with 10 professional Brazilian Portuguese speaker or singers: five classical sopranos, establishing a classical singer group (GC), and five popular singers (GP).

The eligibility criteria of the singers included being aged between 25 and 45 years, period understood to be of greater vocal efficiency[29]; knowing the song chosen for the study; not showing self-referred vocal complaint; not showing signs of vocal alteration noticed during the recordings; having at least one year of professional singing experience; singing professionally in only one of the music genres determined by the research; when it comes to classical singers, being vocally classified as *soprano*, considering the original key of the song; knowing the song chosen for the study; being in overall good health condition on the day of the voice recording for data collection.

All the 10 singers filled in a specific form with their name initials, music genre and, regarding popular singers, the key chosen for the recording. For classical singers, the recording or sheet music of the musical accompaniment for *Melodia Sentimental* followed the original key of Villa Lobos's composition, A Minor

(Am). Considering that one of characteristics of popular singing is the possibility of changing the key for better suitability to the singer's voice, popular singers were allowed to change the song's key.

Two weeks before the scheduled recording date, the singers received by *e-mail* the musical accompaniment to be used as reference (MP3 file), as well as the lyrics and the sheet music. The musical accompaniment was written in the music software *FINALE* (2011 version, made by MakeMusic in the United States), recommended for writing, editing, and reviewing sheet music. A piano and voice version of the original song—in the key of A Minor (Am)—was transcribed and used as a model for the file sent to the classical singers. The file for the popular singers was transposed for the respective key appointed by each participant when filling the identification form. Two files were produced: an instrumental version of the same song accompanied by piano and guide melody, and another file without the guide melody to be used on the day of the recording. All singers received both tracks.

Melodia Sentimental (Sentimental Melody)—Heitor Villa-Lobos, 1958.
Acorda, vem ver a lua
Que dorme na noite escura,
Que surge tão bela e branca
Derramando doçura,
Clara chama silente
Ardendo meu sonhar.
Wake up, come see the moon
That sleeps in the dark night
Appearing so beautiful and white
Shedding sweetness
Bright silent flame
burning my dreams.
Bold italic: Excerpt used for acoustic ELT analysis.
Bold italic underlined: Consonants /d/ observed in VOT analysis.

Before starting the phonographic recording, the subjects were asked to use an in-ear monitor and listen to the reference song as a parameter for music speed and key. The recorded verses refer to the first part of the song and were performed twice, being the first time so that the subjects could get familiar with the environment and the equipment, and the second time to be used as material for the analysis.

The pedestal microphone was set for all singers in a 30° angle in relation to the sagittal axis of the body changing exclusively the height when needed. The distance between microphone and mouth was 15 cm for the classical singers and 6 cm for the popular singers. The difference in the distance to the microphone between classical and popular singers is justified by the fact that the classical singers show higher vocal intensity while singing than the popular ones. Audio input volume control in the sound board was set in position 8 and kept all through the GE recordings. When it comes to the GP, it was set at position 9, in a scale from 0 to 10. All procedures were defined after a pilot study.

The audio recordings were captured with a *Le Son Beyerdynamic Opus* 39 microphone connected to a *TASCAM US-144 MKII* audio interface for the computer (made by TEAC America in the United States). The software used for the audio recordings was *SoundForge* 10.0. The sampling rate was established at 44 kHz.

For the acoustic analysis, they used *PRAAT* 5.3.56, a free software distributed for acoustic phonetics research (made by Softonic International S.A. in Spain). LTAS and VOT were measured over the recorded material. LTAS consists of the representation of intensity in different frequency bands, being equivalent to the average of a series of independent short-term spectra applied to a sufficient duration issuance.[30] The LTAS acoustic analysis was performed over an excerpt of the first verses of the second recording lasting approximately 40 seconds (Figure 1).

The extraction of the excerpt was performed manually considering the sound wave form together with the broadband spectrum. *LTAS pitch-corrected* was used to calculate the spectral envelope of the sound parts correcting the influence of the fundamental frequency (f0).[31] The pitch range was adjusted between 75 and kHz and the maximum frequency to 5 Hz. For the ELT graphic, the values for the frequency range were established between 0 and 5 kHz and *sound pressure level* between −20 and 80 dB.

To obtain the average spectral decline (in dB), an interval was determined between 0 and 1 kHz for the low-pass filter and

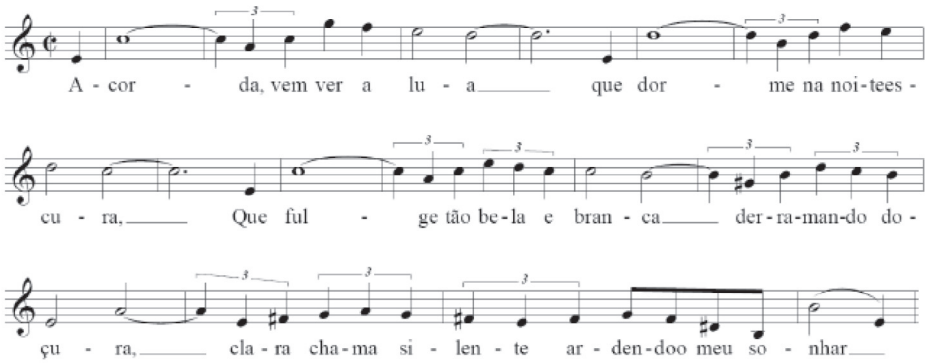


FIGURE 1. Music sheet including the first stanza of *Melodia sentimental*. VOT measurement considered the plosive voice consonant /d/ for the words *acorda* and *dorme*.

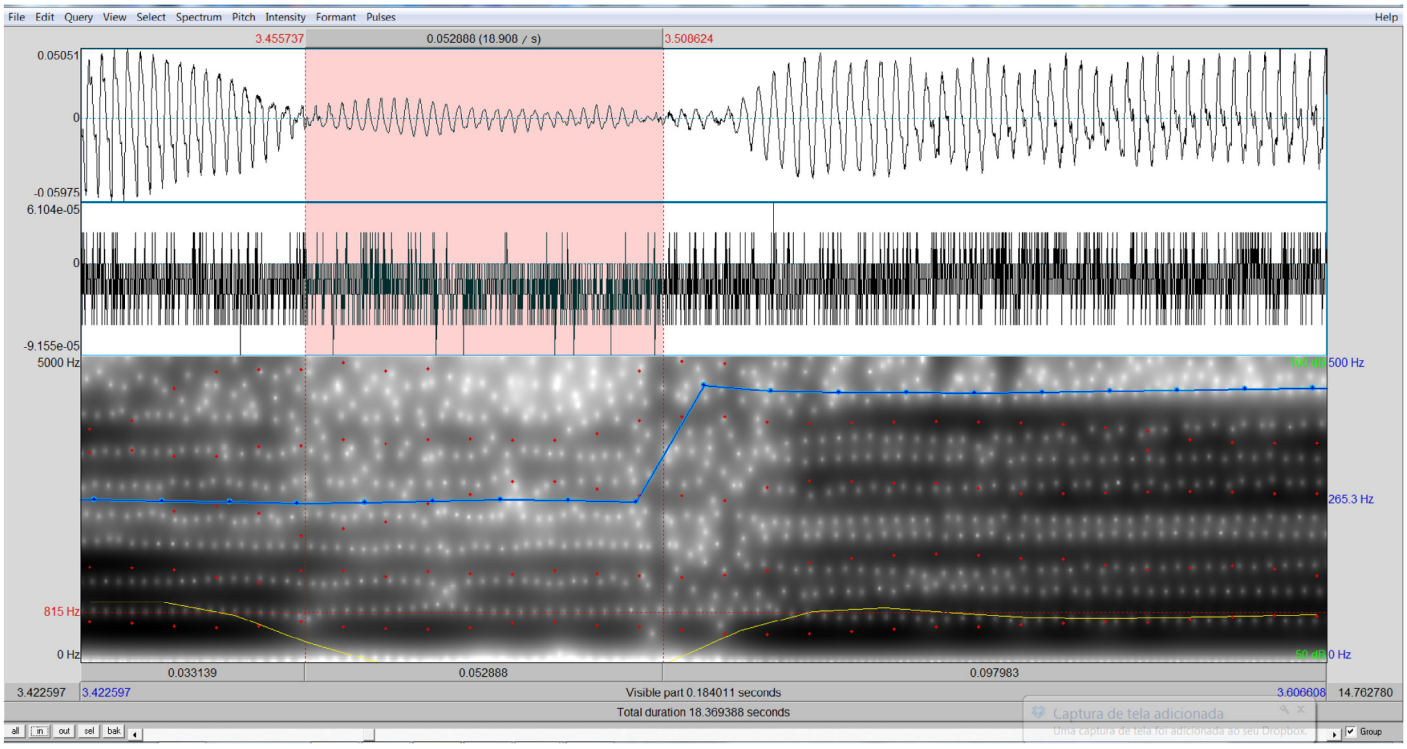


FIGURE 2. VOT extraction example for the consonant /d/ for the word *acor**d**a*.

1–5 kHz for the high-pass filter. The average spectral decline is considered an important verified stimulus larynx tension level measurement.[32]

During the analysis of the VOT, we measured the time of voicing attack. Verifying the VOT characteristics of the voiced alveolar plosive /d/ in both of the given words, the inspection of the acoustic signal was performed in the shape of wave and in the broadband spectrogram. The beginning of the voicing preceding the burst was considered in the obstruction interval between articulators, whenever the voicing was present and, when it was not, the entirety of the sound bar was taken into consideration until the beginning of the subsequent vowel (Figures 2, 3).

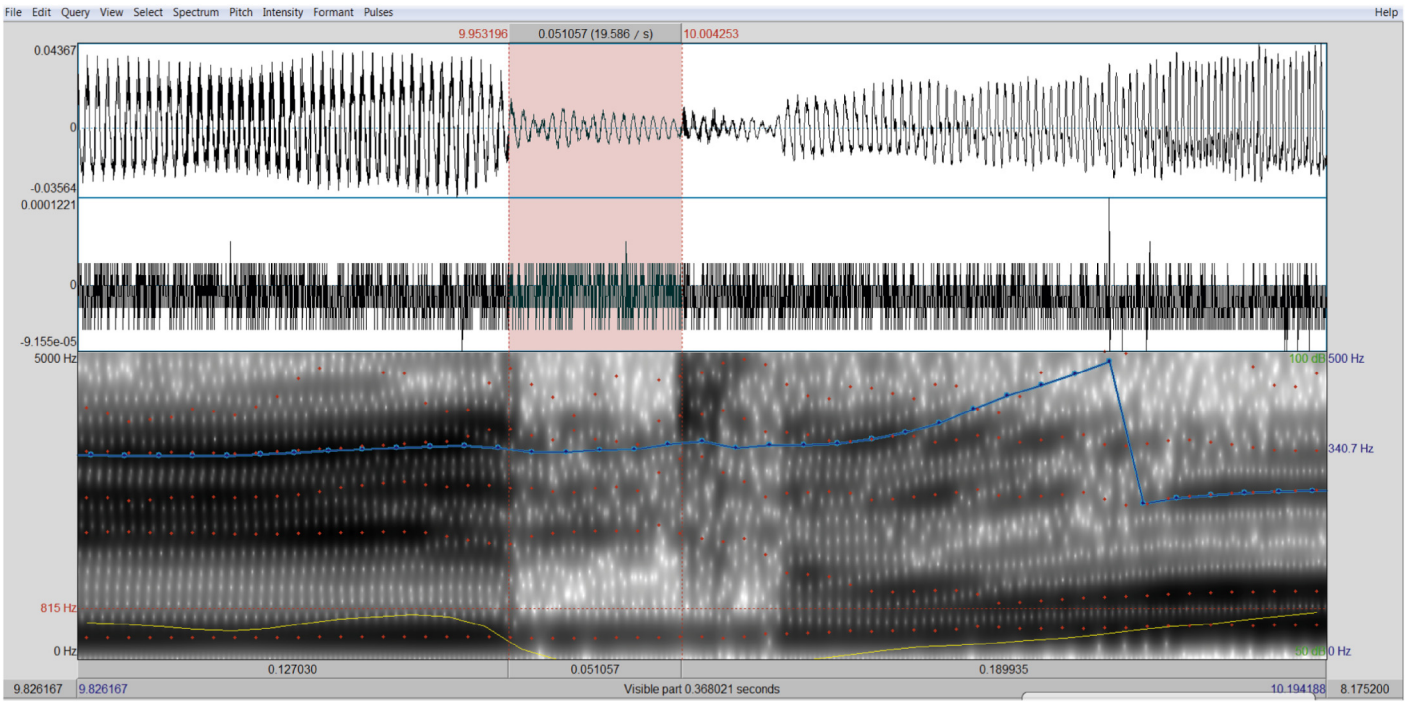


FIGURE 3. VOT extraction example for the consonant /d/ for the word ***d**orme*.

TABLE 1.
Average Spectral Decline for Classical and Popular Singers

	Spectral Decline Measure (dB)
Classical singers	
E1	–17.65
E2	–10.79
E3	–18.51
E4	–9.67
E5	–12.38
Popular singers	
P1	–11.48
P2	–20.43
P3	–22.49
P4	–18.73
P5	–20.71

RESULTS

Pictures 2 and 3 show the LTAS graphics and the spectral decline curves for each singer. The corresponding value for the average spectral decline is found on the bottom of the graphics. The values for the spectral decline (in dB) of both groups are represented in Table 1. Table 2 shows the VOT measurement (in ms) for the alveolar plosive consonant /d/ in the words *acor**d**a* (wake up) and ***d**orme* (sleep) for both groups, as well as the VOT average by word and group.

DISCUSSION

Picture 1 shows that the average age for the classical singers' group (GC) was 33.2 years old; 12.6 years for time spent with education and 10.2 years working professionally. Moreover, the popular singers' group (GP) had an average age of 32.4 years old, close to the GCs, although the time spent with education (9.4 years) and working professionally (7 years) were lower. The average time spent with education was higher (3.2 years) in the GC, as well as the average time for professional experience, although the time of spent with education and professional experience between the groups was the same. Classical singers had the need for a longer ongoing training. It is worth noting that at the event of the research, all GC singers were attending singing lessons, whereas only three singers in the GP were taking private singing lessons.

TABLE 2.
VOT Measures (ms) for the Plosive Consonant /d/ of Classical and Popular Singers in the Words *Acorda* and *Dorme*

	VOT (in ms)			
	acor/**d**/a	Average	/**d**/orme	Average GC
Classical singers				
E1	–53	–54.2	–51	–68
E2	–44		–85	
E3	–75		–63	
E4	–50		–60	
E5	–49		–81	
Popular singers				
P1	–81	–84.8	–114	–116.2
P2	–104		–121	
P3	–92		–134	
P4	–91		–105	
P5	–56		–107	

Music genre	Subjects	AGC	Length of education (years)	Professional experience (years)	Song key
Classical GC	E1	37	14	12	Am
	E2	32	14	10	Am
	E3	42	20	20	Am
	E4	26	5	2	Am
	E5	29	10	7	Am
Popular GP	P1	30	11	7	Dm*
	P2	25	6	2	Dm*
	P3	29	2	1	Dm*
	P4	37	13	10	Am**
	P5	41	15	15	Dm*

* Dm (D minor), 5ª below the original key.
** Am (A minor), 8ª below/lower the original key.

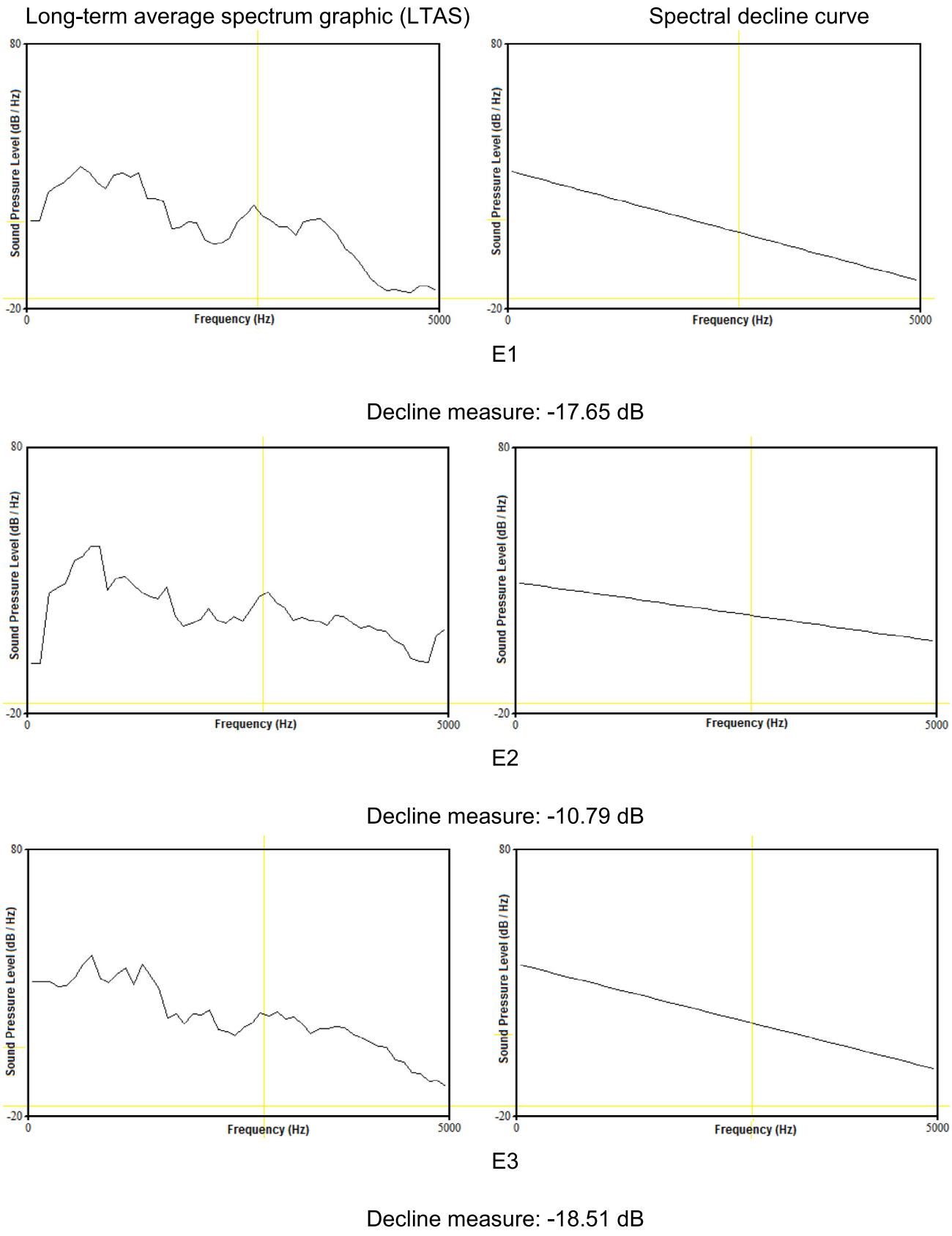
PICTURE 1. Classical singers (GE: E1, E2, E3, E4, E5) and popular singers (GP: P1, P2, P3, P4, P5) sample description according to age, length of education, and song key.

The GC sang the song in the original key, A Minor (Am), whereas four singers within the GP—P1, P2, P4, and P5—performed it a fifth below, in the key of D Minor (Dm). One singer within the GP—P3—sang in A Minor (Am), but one octave lower. The ELT graphics in Picture 2 show that the GC presented higher sound intensity and projection than GP as shown in Pictu re 3, except for P1, who had a result similar to the GC. This GC result arise because, during their performance, classical singers usually increase the subglottic pressure, extend the vocal tract, and decrease the buccofacial musculature tension to modify resonances, what provides the necessary loudness in this music genre, as it exempts external amplification.

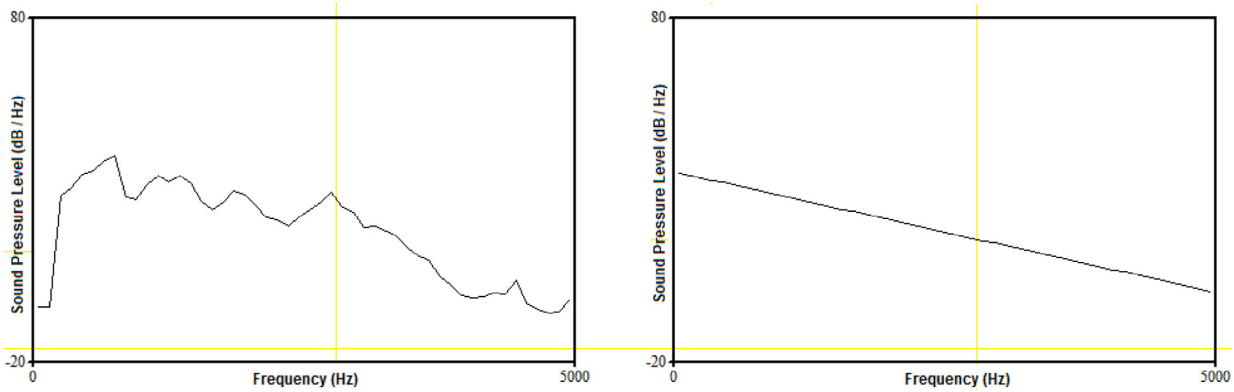
Music genre is one of the aspects affecting vocal matters related to the singing activity.[13] Our starting point was then to associate the genre with the singer's type of issuance and her way of singing, comparing acoustic characteristics of classical and popular singing voices.

Classical singing offers better breath control, lowered larynx for an extended resonance cavity leading to a consequently higher voice intensity.[19,20] Taking into account a wide range of voice textures usually present in classical vocal works,[1] a wider jaw opening, especially in the higher notes, helps to keep a more homogeneous vocal texture.[18] Nevertheless, uniformity in all registers may influence the intelligibility of the text mainly in higher frequencies.[33]

The popular singer, however, aims at singular vocal signature,[2] varying larynx position, and adjustment are closer to the speaking voice[17] and leading to a better intelligibility of the text.[23] The

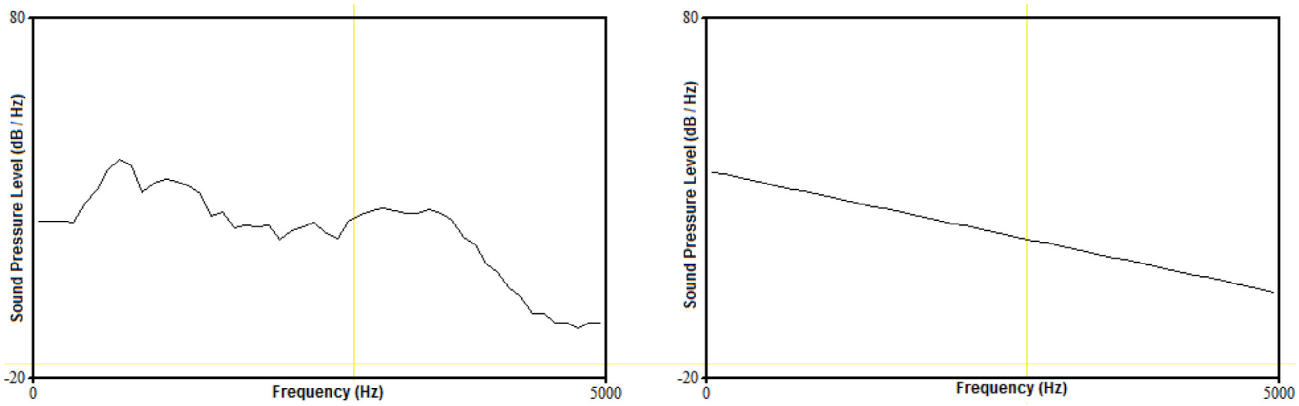


PICTURE 2. ELT graphics and spectral decline curve for classical singers.



E4

Decline measure: -9.67 dB



E5

Decline measure: -12.38 dB

PICTURE 2. (***Continued***)

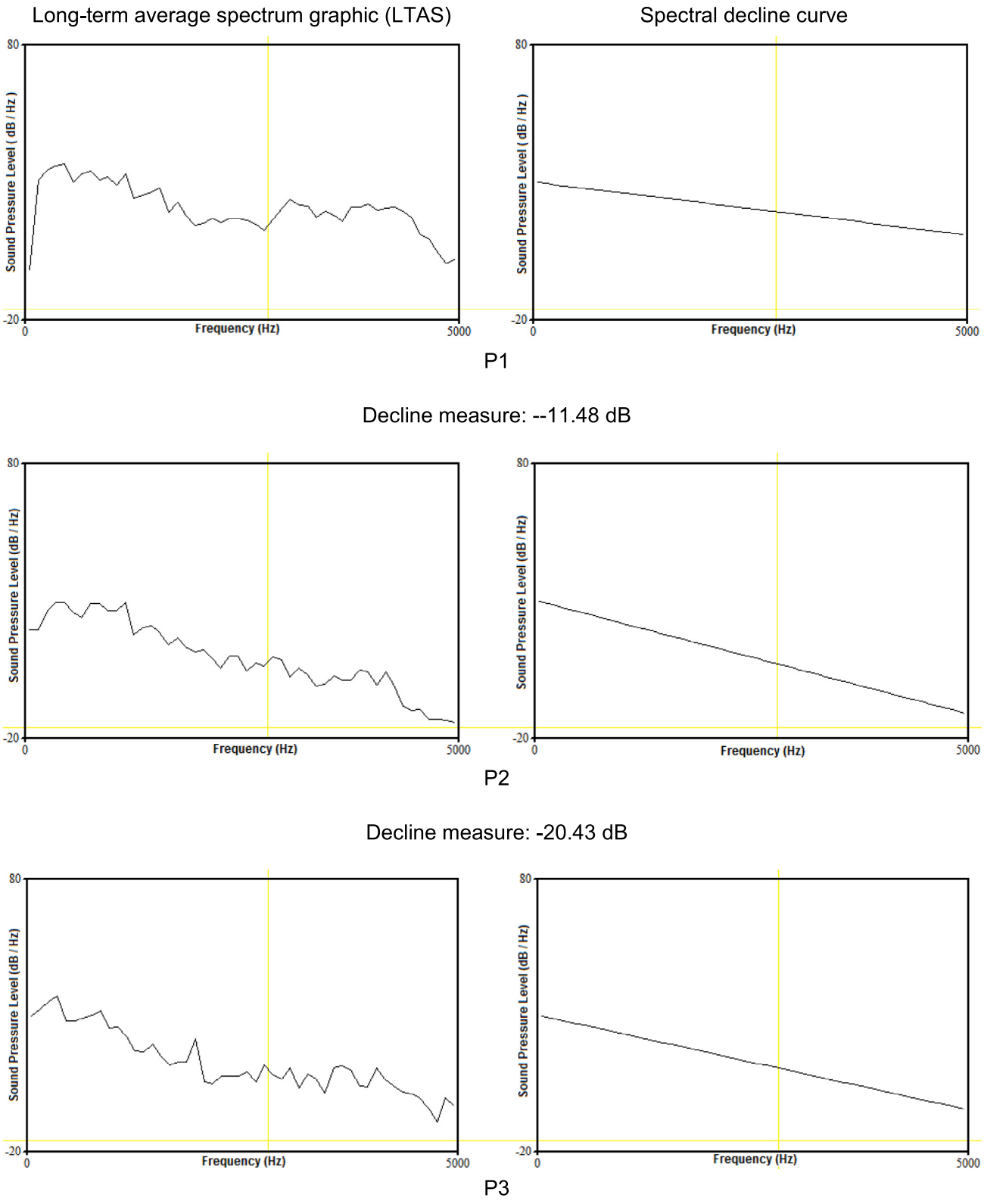
understanding of the text is imperative in popular singing and, thus, the melodic extension of the songs can be adapted and adjust to vocal texture. The popular singer's freedom of choice regarding the key was considered, in this research, as a strong characteristic of the genre. Voice amplification is performed with the use of a microphone and, although desirable, a big opening of the mouth is not indispensable.

According to Loiola-Barreiro and Andrada e Silva,[13] different music genres may show different forms of interpretation and that is what identifies the genre. Classical vocal works are understood as being more formal, with rules and with rare opportunity to freely change the notes in the melody. However, classical interpretation brings small rhythmic variation in the exact point where the consonants start and end and even in the way words are pronounced[14,15] besides what is written in the sheet music. In popular singing, vocal singularities that help artists to stand out are welcomed, and there is autonomy for the interpretation.

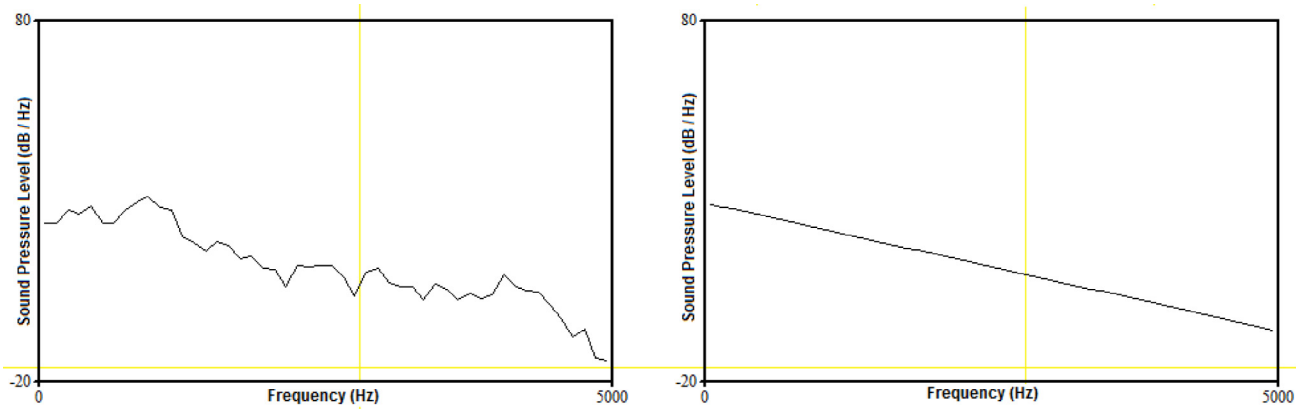
Comparing both GC and GP, we were able to observe that classical singers had higher peaks of energy at the range between 2.75 and 4 kHz. That was not observed in four of the five singers in the GP, who had less visible curves in high frequency regions. The results are in conformity with Loiola-Barreiro and Andrada e Silva,[13] for where classical singers had higher energy in the same region, but not the popular ones. P1 had peaks in the region between 3 and 4.25 kHz.

The LTAS analysis offers another meaningful data: the spectral decline curve. Barlow and LoVetri[22] suggested that the spectral decline is associated with the closed quotient in glottic coaptation. Sundberg et al[34] argued that a low intensity voice has a higher decline compared with one of higher intensity. That happens because flat spectral curves suggest a longer closed phase in the glottic cycle, indicating higher subglottic pressure, which can also be understood as tension.

We highlight Picture 2 and Table 1, facing the spectral decline of GC and GP, noticing that the GC singers' curves are more horizontal than the GPs, except again for singer P1, who had the lowest decline in the GP group, setting her apart from the other singers. According to Scherer,[33] this result could suggest a strong power of coaptation and consequently higher tension.

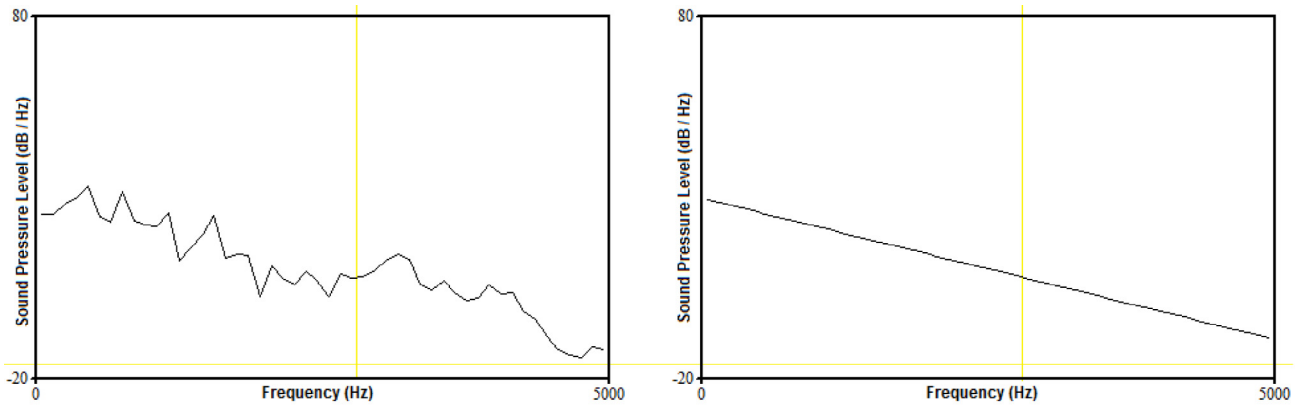


PICTURE 3. LTAS graphics and spectral decline curve for popular singers.



P4

Decline measure: -18.73 dB



P5

Decline measure: -20.71

PICTURE 3. (***Continued***)

However, it is known that the classical singer works to keep the facial and neck musculature less tense and that the surplus tension in that area could make voice projection difficult. We believe that classical singers use resonance elements in many different ways and that there is a stronger power of glottic coaptation in comparison to popular singers, although with a smaller and more efficient occlusion phase.

Still examining Table 1, we highlight the LTAS results and P1's decline. From GP, P1 had the higher voice volume, the long-term average spectrum had higher peaks in the higher frequencies as GE, and the lighter curve in her decline, close to the ones analyzed in GE, distinguishing her from the other GP singers. She obtained a value of −11.48 dB when the average of the other 4 GP singers was −20.59. That result is in conformity with Scherer,[33] who states the increase in vocal tension increases the power of the harmonics and diminishes the spectral wave tilt. Same results were also found in another study comparing classical and musical theater teenager singers. The authors suggest that more than increasing vocal tension, the belting singer uses a resonance strategy different from the one used by classical singer.[26] That was probably the reason for the similarities in the results between the GC singers and P1, even though she was not using the same resonance strategies than classical singers. We also point to the fact that P3, with a shorter period of education and professional work (Picture 1), was the only one to sing an octave lower and had the highest spectral decline in GP (−22.49 dB).

When comparing the VOT of the consonant /d/ in the word "*acorda*" (Table 2), the GC values were lower than the GP, except for P5, who presented values similar to GC's. The average VOT of /d/ in "*acorda*" was −54.2 for GC and −68 for GP. Considering the word "*dorme*," the VOT was lower in all 5 GC singer, compared with GP, with an average −84.8 for GC against −116.2 for GP. Those results allow us to infer that classical singers had less voicing than the popular ones, meaning a shorter period of glottic coaptation. It is worth highlighting that the sampling for the VOT analysis used excerpts of the song that were taken from the complete musical performance so that it would be closest possible to a personal interpretation. We highlight that measurements were made seeking to be as close as possible to real singing situation, generating more reliable results.

The comparison between the two groups revealed that the VOT values for P1 were considered average for GP, in contrast with the LTAS analysis results and the average decline. We also highlight the highest VOT value for the word "*dorme*" in the GP, which is related to P3, who also had the highest decline value in the abovementioned analysis.

According to our findings, the classical singers showed lower VOT values compared with the popular ones, evidence that the period of glottic coaptation for classical singers was shorter than for popular singers. McCrea & Morris[28] also found lower VOT values for classical singers, but in comparison with amateur ones.

The singer's attempt to reach the ideal performance for the specific music genre depends not only on technical training and understanding of the work or song but also on the artists' emotional state and on the connection established with the given music. Some singers get nervous and put the performance in second place. There are also those that, although not very vocally skillful, are able to express what the music means to them and convey those emotions to others.

The expressive singer—regardless of the specific genre—is able to convey what is expected[35] and singers working in only one music genre only show a closer relationship with the genre itself as much as they stay identified with it.[13]

Based on the results of this research, it is possible to conclude that the lower VOT value showed by the classical group does not necessarily indicate higher tension in the glottic production. The lower spectral decline and a lighter curve would be the response to the energy kept during the singing. Popular singers, who do not use a homogeneous vocal texture, can work with a lower level of air flux support control and lower energy level in comparison to classical singers, without that necessarily being a negative aspect of their singing, although it interferes with the conception and interpretation of the popular genre.

There are different vocal characteristics between classic and popular singers and the comparison between the groups of singers reveal specific aesthetical choices that both music genres and can be a result of many factors such as education type, education duration, personal dedication, professional experience, and also the music genre itself. Music genre specificities should be noticed and respected without being compared or understood as either superior or inferior.

It must be considered as a limitation the fact that each singer has his or her own personal characteristic and specific interpretative mark, matters which are difficult to be measured, regardless of the music genre.

A scientific analysis of singing voices should be performed to bring not only the necessary technical knowledge but also practical applications for singing professionals. The possibility of communicating and working together with different voice professionals, such as speech therapist, pathologists, singers, and researchers in the artistic and clinical contexts can be very valuable for advancements in the singing voice field.

CONCLUSION

When comparing the acoustic characteristics of the singing issuance of classical and popular singers in Heitor Villa-Lobos' *Melodia Sentimental*, we were able to conclude that the spectral decline was lower and with a lighter curve for classical singers. The VOT in the studied consonants was also lower for the classical singers.

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