

# Immediate effects of the semi-occluded vocal tract exercise with LaxVox<sup>®</sup> tube in singers

## *Efeitos imediatos do exercício de trato vocal semiocluido com Tubo LaxVox<sup>®</sup> em cantores*

Original Article

Artigo Original

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### ABSTRACT

**Purpose:** The purpose of this study was to analyze the immediate effects of the semi-occluded vocal tract exercise (SOVTE) using the LaxVox<sup>®</sup> tube in singers. **Methods:** Participants were 23 singers, classical singing students, aged 18 to 47 years (mean age = 27.2 years). First, data was collected through the application of a demographic questionnaire and the recording of sustained emission - vowel /ε/, counting 1-10, and a music section from the participants' current repertoire. After that, the participants were instructed and performed the SOVTE using the LaxVox<sup>®</sup> tube for three minutes. Finally, the same vocal samples were collected immediately after SOVTE performance and the singers responded to a questionnaire on their perception regarding vocal changes after the exercise. The vocal samples were analyzed by referees (speech-language pathologists and singing teachers) and by means of acoustic analysis. **Results:** Most of the singers reported improved voice post-exercise in both tasks - speech and singing. Regarding the perceptual assessment (sustained vowel, speech, and singing), the referees found no difference between pre- and post-exercise emissions. The acoustic analysis of the sustained vowel showed increased Fundamental Frequency (F<sub>0</sub>) and reduction of the Glottal to Noise Excitation (GNE) ratio post-exercise. **Conclusion:** The semi-occluded vocal tract exercise with LaxVox<sup>®</sup> tube promotes immediate positive effects on the self-assessment and acoustic analysis of voice in professional singers without vocal complaints. No immediate significant changes were observed with respect to auditory-perceptual evaluation of speech and singing.

### RESUMO

**Objetivo:** O objetivo deste estudo foi analisar os efeitos imediatos do exercício de trato vocal semiocluido (ETVSO) com tubo LaxVox<sup>®</sup> em cantores. **Método:** Participaram 23 cantores, estudantes de canto lírico, com idades entre 18 e 47 anos (média de 27,2 anos). Inicialmente, a coleta de dados envolveu a aplicação de um questionário contendo os dados de identificação e a gravação da vogal "ε", contagem de números de um a dez e trecho de música do repertório atual. Na sequência, os participantes receberam orientações e realizaram o ETVSO com tubo LaxVox<sup>®</sup> por três minutos. Finalmente, as mesmas amostras vocais foram coletadas imediatamente após a execução e os cantores responderam a um questionário sobre sua autopercepção em relação às possíveis modificações vocais geradas pelo exercício. As amostras vocais foram analisadas por juizes fonoaudiólogos e professores de canto e por meio de análise acústica. **Resultados:** A maior parte dos cantores referiu melhor emissão pós-exercício, tanto na fala quanto no canto. Na opinião dos juizes, não houve diferenças entre emissões pré e pós-exercício nas provas da avaliação perceptivo-auditiva (emissão sustentada, fala e canto). A análise acústica da vogal indicou aumento da Frequência Fundamental (F<sub>0</sub>) e redução da Proporção *Glottal to Noise Excitation* (GNE) pós-exercício. **Conclusão:** O exercício de trato vocal semiocluido com tubo LaxVox<sup>®</sup> promove efeitos imediatos positivos quanto à autoavaliação e análise acústica da voz do cantor profissional sem queixas. Quanto à avaliação perceptivo-auditiva da fala e do canto, parece não haver modificações imediatas significativas.

### Keywords

Voice  
 Voice Disorders  
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 Voice Training

### Descritores

Voz  
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## INTRODUCTION

Dysphonia cases are characterized by changes in the voice production mechanism that impair communication<sup>(1)</sup>. Currently, the voice clinic counts on a large number of methods, techniques, and exercises for the benefit of dysphonic patients<sup>(2)</sup> and, due to scientific and technological advancement, new therapeutic possibilities are periodically presented.

Exercises involving resonance tubes have been described for many years as a therapeutic option for cases of voice disorders<sup>(3)</sup>. In 2006, a fundamental research on this theme showed that the semi-occluded vocal tract promoted by phonation into a tube can provide improved adjustment in the source-filter model<sup>(4)</sup>. The authors also reported that, for reasons related to inertance, coaptation of the vocal folds occurs more smoothly and, consequently, more efficiently, with better mobility of the free edge of vocal folds owing to increased activity of the thyroarytenoid muscle to replace activity of the cricoarytenoid lateralis muscle<sup>(4)</sup>.

Based on the results of the aforementioned study, research on the use of different types of resonance tubes and their application possibilities in different populations were intensified in several countries. The current specific literature provides reports on their effectiveness in the treatment of vocal disorders involving phonation into straws of low and high resistance<sup>(5-7)</sup>, as well as phonation into rigid and flexible resonance tubes immersed in water<sup>(8,9)</sup>.

The LaxVox® tube was developed by a Finnish company and it proposes to combine the semi-occluded vocal tract exercise (SOVTE) with water resistance. It is a silicone tube (LaxVox®) thoroughly tested according to its specifications, diameter, application possibilities, etc.<sup>(10)</sup>. The authors presented it as a technique used for voice conditioning that allows the development of better voice control and the decrease of excessive tension during phonation; it is believed that resistance in the water enhances the effects of the SOVTE. Some studies conducted with different populations have demonstrated the positive results of this technique<sup>(11,12)</sup>.

Classical singers have a very specific vocal demand, and any deviation in voice quality can result in a negative impact on their professional activity. Presently, there are vocal warm-up programs, specifically aimed at conditioning the singer's voice before a performance/concert, showing very positive results<sup>(13,14)</sup>. However, such training programs are often time-consuming and detailed. In our professional practice, we commonly find singers who report having been unable to complete such program in a disciplined and rigorous manner before a performance.

Considering that the application of the SOVTE using the LaxVox® tube was designed to improve vocal training and reduce excessive strain during phonation, in this study, we raised the possibility of obtaining positive effects using this technique with singers - even if they present healthy spoken voices - in training/warm up for professional demand. Because positive effects have been observed, such exercise could streamline the voice warm-up process of singers, allowing

them to conduct the program with greater discipline and rigor, thus preventing the development of laryngeal lesions due to vocal abuse or excessive voice demand.

The purpose of this study was to analyze the immediate effects of the semi-occluded vocal tract exercise (SOVTE) with the LaxVox® tube in singers with regard to their self-assessment and the auditory-perceptual and acoustic aspects of the voice.

## METHODS

This observational, analytical study was approved by the Research Ethics Committee of the "Hospital da Clínicas", Federal University of Parana - UFPR, under number 360689. Participants were 23 singers, 13 women and 10 men, aged 18 to 47 years (mean age = 27.2 years), who were previously invited to participate in the survey and signed an Informed Consent Form (ICF).

Inclusion criteria comprised being regularly enrolled at the undergraduate Singing Course of the "Escola de Música e Belas Artes do Paraná" - EMBAP, University of the State of Parana - UNESPAR and age  $\geq 18$ . The following exclusion criteria were adopted: speaking voice complaint; history of diagnosis of laryngeal lesions and/or vocal disorder (past or present); infection of the upper airways at the time of data collection; history of any health problems/changes (past or present) that could negatively influence phonation; being under speech-language pathology therapy or training.

Data were collected individually at EMBAP according to the following protocol:

1. Application of a demographic questionnaire for identification and data collection regarding gender, age, time of singing practice, weekly singing practice hours, and type of degree in singing.
2. Initial recording of voice samples: the material for analysis was composed of sustained emission - vowel /ε/, counting 1-10, and a music section from the participant's current repertoire at EMBAP (tonality recollected to the participant using a piano). Although the singers have selected different songs, in general, they had a similar level of difficulty, considering that all individuals were undergoing the same type of training and all songs belonged to the repertoire proposed by the university. The samples were recorded directly using a unidirectional microphone headset positioned at 45° and 3 cm away from the corner of the mouth and connected to an adequate notebook computer sound card.
3. Performance of the SOVTE using the LaxVox® tube: recording was made with participants comfortably seated. They were instructed with respect to the correct performance of the exercise and could also observe a mock execution by one of the researchers. All doubts were cleared before the beginning of the exercise. In addition, the singers could perform a 20-second pre-training in order to make any possible adjustments or recapitulate important information. The exercise was conducted for three minutes as follows:

- a. First minute: vocalization of the vowel /u/ into the tube immersed in 2 cm of water at the bottom of the 500 ml mineral water bottle (half the bottle filled with water). Emission occurred at the habitual pitch and loudness of the singers;
  - b. Second minute: vocalization of the vowel /u/ into the tube using the same type of immersion as in the first minute, but with performance of ascending and descending gliding from the lowest to the highest pitch, keeping pitch range at a comfortable level so that no laryngeal and/or vocal tract tension would occur;
  - c. Third minute: vocalization of the vowel /u/ into the tube using the same type of immersion as in the first and second minutes, but with performance of ascending and descending scales from the lowest to the highest pitch, keeping pitch range at a comfortable level so that no laryngeal and/or vocal tract tension would occur.
4. Final recording of voice samples: it included the same material of the initial recording, following the same criteria and care.
  5. Application of the self-assessment questionnaire: singers responded whether they had observed changes in their vocal characteristics (sustained vowel, numbers, and singing) before and after performing the exercise in a closed question with the following choices: “improved”, “worsened”, or “no change”. In the case of positive or negative changes, they responded to the following open question: “Which aspects have been improved or worsened?”

Data analysis comprised the following steps:

1. Vocal self-assessment: singers’ responses to the questions regarding possible changes in the voice observed after the exercise were classified. For the open question, two categories of analysis were created based on their answers: “features related to the glottal source” - corresponding to references such as “cleaner voice”, “more stable voice”, “less tense voice”, “improvement in the recording”, “higher voice”, “easier vibrato”, etc.; “features related to the vocal filter/tract” – corresponding to references such as “more projected voice”, “brighter voice”, “better positioned resonance”, “more embedded sound”, among others; and “features related to phonatory comfort” – corresponding to references such as “more relaxed larynx”, “easier voice”, “lighter voice”, “looser musculature”, “more comfortable emission”, etc. The singer could report whether there were changes in the voice and what were they for each of the three samples collected (sustained vowel, numbers, and singing).
2. Edition of the material: The samples collected pre- and post-exercise were edited. As for the sustained vowel, the beginning and the end of the emission were excluded, keeping average 10-second sections. As for the counting of numbers and singing, the samples were not edited with respect to exclusion. Due to the small differences in signal intensity during voice collection, the samples (sustained vowel, numbers, and singing) were standardized by manual calibration using the software program Audacity® 2.0.3.
3. Auditory-perceptual evaluation of voice: the samples were saved in individual folders for each participant and identified with the numbers 1 and 2 (the two assessment moments). However, the pre- and post-exercise periods were randomly arranged as to such numbers, and only the researchers had access to this information.
  - a. The speech samples (sustained vowel and numbers) were sent to three speech-language pathologists with expertise in voice and at least 10 years of experience in the profession, who listened to them and marked on a specific protocol which of the two emissions was better according to the auditory-perceptual standpoint or whether they were the same regarding the main features (vocal quality, resonance, pitch, loudness, articulation, stability, etc.).
  - b. The singing samples were sent to three classical singing instructors of similar professional education and extensive experience in singing teaching. The referees noted which of the two emissions was better or whether they were the same according to the auditory-perceptual standpoint, considering the main features (pitch, stability, projection (filter), etc.).
  - c. Classification of the data provided by all of the referees (speech-language pathologists and singing teachers) to perform the Kappa test (intra- and inter-class agreement): As for the speech-language pathologists, data from the three referees showed good intra-class agreement (Kappa, 0.6 - 0.8) with respect to grouping of the two speech samples (sustained vowel and numbers). For the inter-class agreement between the speech-language pathologists, we selected the referee whose assessments showed moderate general agreement (Kappa > 0.5) between sustained vowel and counting of numbers compared with the assessments by at least one of the other referees. As for the singing teachers, all of them presented excellent inter-rater agreement (Kappa > 0.8). Based on this analysis, we selected the referee whose assessments showed moderate general agreement (Kappa > 0.5) between the variables compared with those by at least one of the other referees. Selection of one referee per assessment category (one speech-language pathologist and one singing teacher) was needed because, although all referees had similar professional formation, the other two referees did not show at least moderate inter-rater agreement.
4. Acoustic analysis of voice: The software program VOXMETRIA® 2.5 (CTS Informática) was used to provide measures on mean fundamental frequency ( $F_0$ ), jitter, shimmer, and glottal to noise excitation (GNE) ratio, keeping the same recording conditions at the pre- and post-exercise moments.

5. Statistical analysis: After collection and classification, the data were statistically analyzed. It is worth mentioning that for the statistical analysis of auditory-perceptual assessment, the referee whose evaluation showed the highest agreement with those of the others was chosen, for both speech (speech-language pathologists) and singing (singing teachers) tasks. In addition to the previously mentioned Kappa test, utilized in the intra- and inter-rater analyses, the following tests were used: Test of equality of two proportions – which analyzes the possible statistical differences between responses by pair of samples; Student's t-test – for comparison of continuous variables whose data presented normal distribution (mean); Mann-Whitney test – for comparison of continuous variables with irregular distribution (median); and Fisher's Two-tailed exact test - for comparison of data distribution in absolute numbers (n) and percentages (%) in a 2x2 contingency table. Significance level of 95% ( $p < 0.05$ ) was adopted for all statistical analyses.

## RESULTS

The results were divided into two main aspects according to pre- and post-exercise moments: singers' vocal self-assessment and auditory-perceptual evaluation of speech and singing; acoustic analysis of the sustained vowel /ε/.

Regarding vocal self-assessment, most of the singers reported better emission post-exercise, for both speech and singing (Table 1). Whereas in the speech tasks main improvement was perceived with respect to the glottal source compared with improvement in phonation filter and comfort, all of the singers reported similar perceptions for all categories in the singing task (Table 2). When singers' positive perceptions were compared with respect to the type of task performed, changes in phonation comfort were more frequently observed post-exercise (Table 3).

As for the auditory-perceptual evaluation of speech (sustained vowel) and singing, the referees found no difference between pre- and post-exercise emissions. Nevertheless, such response options were more frequently selected by the referees than the option "no difference", which was different from that of the reference sample (post-exercise, due to its greater number of occurrences). The opposite occurred in the speech task of "counting numbers 1-10", in which the option "no difference" predominated in relation to other possible answers, that is, most of the samples did not show a change between the pre- and post-exercise moments (Table 4).

Acoustic analysis of the sustained vowel /ε/ showed an increase in the fundamental frequency value for women and a decrease in the glottal to noise excitation (GNE) ratio post-exercise. The other measures (jitter and shimmer) were similar at both assessment moments (Table 5).

**Table 1.** Singers' vocal self-assessment pre- and post-SOVTE with LaxVox® tube

Self-assessment	Speech (vowel/numbers)*			Singing		
	n	%	p	n	%	p
No difference	1	4.30%	<0.001	2	8.70%	<0.001
Improved at post-exercise	21	91.30%	Ref.	21	91.30%	Ref.
Improved at pre-exercise	1	4.30%	<0.001	0	0.00%	<0.001

$p < 0.05$  - Test of equality of two proportions; Ref.: reference value for comparison with the others; SOVTE: semi-occluded vocal tract exercise. \*same result for both, although the singer was able to evaluate each task individually

**Table 2.** Positive changes observed by singers post-SOVTE with LaxVox® tube

Self-assessment	Speech (vowel/numbers)* (n=21)			Singing (n=21)		
	n**	%	p	n**	%	p
Glottal source	18	85.7%	Ref.	12	57.1%	Ref.
Filter / vocal tract	6	28.6%	0.02	9	42.9%	0.29
Phonation comfort	1	4.8%	<0.001	7	33.3%	0.10

$p < 0.05$  - Test of equality of two proportions; Ref.: reference value for comparison with the others; SOVTE: semi-occluded vocal tract exercise. \*same result for both, although the singer was able to evaluate each task individually; \*\*the singer could report more than one aspect

**Table 3.** Comparison between positive changes observed by singers post-SOVTE with LaxVox® tube in the speech and singing tasks

Self-assessment*	Glottal source		Filter		Phonation comfort	
	yes	no	yes	no	yes	no
Speech**	18(85.7%)	3(14.3%)	6(28.6%)	15(71.4%)	1(4.8%)	20(95.2%)
Singing	12(57.1%)	9(42.9%)	9(42.9%)	12(57.1%)	7(33.3%)	14(66.7%)
p	0.08		0.52		0.04	

$p < 0.05$  - Fisher's Two-tailed exact test; SOVTE: semi-occluded vocal tract exercise. \*the singer could report more than one aspect; \*\*vowel and numbers, same result for both, although the singer was able to evaluate each task individually

**Table 4.** Auditory-perceptual evaluation pre- and post-SOVTE with LaxVox® tube

Auditory-perceptual evaluation	Sustained vowel			Numbers			Singing		
	n	%	p	n	%	p	n	%	p
Improved at post-exercise	7	30.40%	0.134	3	13.00%	<0.001	8	34.80%	0.234
Improved at pre-exercise	12	52.20%	Ref	3	13.00%	<0.001	12	52.20%	Ref
No difference	4	17.40%	<0.001	17	73.90%	Ref	3	13.00%	0.005

p<0.05 - Test of equality of two proportions; Ref.: reference value for comparison with the others; SOVTE: semi-occluded vocal tract exercise

**Table 5.** Acoustic analysis of sustained vowel emission pre- and post-SOVTE with LaxVox® tube

Measure	Moment	Mean	Median	SD	n	p
F <sub>0</sub> women	Pre	219.79	227.35	26.83	13	0.001
	Post	237.35	245.76	29.17	13	
F <sub>0</sub> men	Pre	131.74	131.32	30.53	10	0.153
	Post	136.7	131.28	35.92	10	
Jitter	Pre	0.19	0.17	0.1	23	0.651
	Post	0.19	0.16	0.09	23	
Shimmer	Pre	3.06	2.87	1.34	23	0.066
	Post	2.71	2.42	1.11	23	
GNE ratio	Pre	0.9	0.94	0.1	23	0.012
	Post	0.84	0.88	0.12	23	

p<0.05 - Mann-Whitney test; F<sub>0</sub>: fundamental frequency; GNE: Glottal to Noise Excitation ratio; SD: standard deviation

## DISCUSSION

The singers investigated reported the benefits brought by the exercise with the LaxVox® tube in their vocal self-assessment. In the speech tasks, a greater perception of this population was observed for changes related to the glottal source, which were reported by them as “vocal stability” and “decreased tension during phonation”. Studies have described a sensation of easier and more comfortable phonation after the exercise with resonance tubes even for short training periods<sup>(9,15,16)</sup>. These effects may have resulted from the decreased phonation effort promoted by change in the vocal tract impedance during the exercise. Semi-occluded phonation implies increased vocal tract impedance, which directly affects the self-maintenance of vocal fold vibration by reducing the phonation threshold pressure<sup>(17,18)</sup>.

With respect to self-assessment of the singing task, in addition to the benefits perceived in the glottal source, the singers reported positive changes in voice brightness and projection (filter) and phonation comfort with similar frequencies. It is believed that the similarity between types of perception may have resulted from differences in the musical repertoire interpreted by the singers. Thus these improvements may be related to individual performance demands, according to certain interpretation characteristics and/or requirements peculiar to the song chosen. In contrast, this is a population of classical singing students under academic improvement undergoing weekly vocal and auditory training, which favors proprioceptive control. Moreover, it is known that the SOVTE enhances proprioception, accentuating some vibratory sensations during and after the exercise<sup>(4,5,19)</sup>.

According to the specific literature, such vibratory sensations in resonant voice could be originated from a conversion process of the glottal energy that, when effective, would distribute such

vibrations throughout the face and head, resulting in brighter and more projected voice quality<sup>(20)</sup>. This sound effect has been observed in studies on phonation into rigid and semi-rigid resonance tubes, which describe an increase in spectral prominence in the singer’s formant region (resulting from the grouping of the third, fourth, and fifth formants) due to adjustments of the vocal tract after the exercise<sup>(5,19,21)</sup>. This fact could explain the changes in filter reported by the participants of this research.

The findings of the auditory-perceptual evaluation did not meet the results of the vocal self-assessment. In general, the literature shows improved results in vocal quality after performance of the SOVTE for this type of assessment<sup>(9,22)</sup>. However, a similar outcome for the task of vowel sustained emission was found in a study that investigated the immediate effects of exercise in high resistance resonance tube in individuals with and without vocal fold injury. The authors suggest that the result may be related to the short running time of the exercise<sup>(16)</sup>. It is worth mentioning that, in the present survey, the population of singers investigated did not present vocal alterations. This factor may hinder the auditory perception of small differences in vocal quality when comparing pre- and post-emissions of a single exercise.

A study using a similar SOVTE technique - glass tube with end immersed in water, also with a population of singers - showed that the best results for post-exercise vocal quality were obtained by less experienced singers. This way, daily vocal training would provide better habitual phonation, which would not be prone to improvement with a short and simple exercise<sup>(15)</sup>, justifying the findings of this research.

Regarding acoustic analysis, the results showed that the new adjustments generated by phonation into the resonance tube favored displacement of the F<sub>0</sub> towards high pitched sounds, as well as reduction in the GNE ratio. A recently published

literature review<sup>(22)</sup> addressing different types of semi-occluded vocal tract exercises found that interference in the  $F_0$  (increase or decrease) and reduction of glottal noise were among the positive effects of these exercises. Concerning the specific literature on phonation into resonance tubes, studies which addressed rigid and semi-rigid tubes in their methodologies showed a discrete change<sup>(16,23)</sup> and/or a significant reduction in the  $F_0$  after the performance of the technique<sup>(6,9)</sup>. A study using the LaxVox® tube on the changes in vocal standard during phonation described a discrete increase in the  $F_0$ , as well as a significant fluctuation of this parameter. Such increase in the  $F_0$  was attributed to a possible raise in subglottal pressure owing to the need to overcome a second constriction point added to the vocal tract<sup>(7)</sup>.

In the present study, one noteworthy aspect that would justify the increased  $F_0$  observed in women after performance of the SOVTE would be the range of vocalized tones during the execution of the adopted technique. In the LaxVox® technique<sup>(11)</sup>, after the initial minute with phonation in the usual tone, the next few minutes (second and third) explored the acute vocal tract by means of gliding and ascending scales, unlike the techniques used in the aforementioned studies<sup>(6,7,9,16,23)</sup>, which utilized only emissions in normal speech frequencies in their methodologies. A study on the immediate effects of the SOVTE in high pitched sound found a significant increase in the  $F_0$  post-exercise. The authors suggested that this increase originated from the activation of the cricothyroid muscle during the exercise performance in acute tone, which is responsible for controlling the fundamental frequency<sup>(24)</sup>.

As for the non-alteration of the other acoustic parameters pre- and post-exercise, it should be emphasized that none of the participants presented vocal complaint. Thus, even at the pre-exercise emission, the mean values for jitter and shimmer were already within the normal standards adopted by the VOXMETRIA software.

Regarding the GNE ratio acoustic parameter, its modification can be explained by previous studies which showed more relaxed voice production<sup>(25)</sup> and modification in vocal fold coaptation<sup>(15)</sup> after the exercise. This coaptation change may have been caused, according to the same study, by increased blood flow in the glottis resulting from the massage effect provided by phonation into the tube. Another recent study<sup>(7)</sup> demonstrated that the massage effect on the laryngeal region, provided by phonation into the LaxVox® tube, would originate from the increased intraoral pressure during the exercise, resulting in a significant fluctuation of the contact coefficient of the vocal folds; this means the incidence of greater variability of the open and closed phases. However, it is worth noting that, just like the other acoustic measurements, the mean values of GNE ratio were already within the normal standards at the pre-exercise moment, which allows us to infer that the statistical difference herein obtained may not have any clinical impact.

Regarding the limitations of the present study, it is important to investigate the immediate effects with other exercise duration (five minutes, for instance) and, mainly, evaluate the effects of

this technique in a longitudinal research, in which the individuals have the opportunity to perform the exercise more than once and for a pre-established period of time. This may contribute to the outcome of auditory-perceptual and acoustic analyses. Another possibility is to increase the number of participants and use a homogeneous group regarding gender.

## CONCLUSION

The semi-occluded vocal tract exercise (SOVTE) using the LaxVox® tube promotes immediate positive effects with regard to the vocal self-assessment of professional singers without voice complaints. The acoustic analysis, except for the increased value of  $F_0$  for women, shows similar and normal pre- and post-SOVTE results. No immediate significant changes are observed with respect to the auditory-perceptual evaluation of speech and singing, which deserves to be better investigated in further studies.

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#### Author contributions

*CBXF and APDL contributed to all phases of the study, including data collection; RSS, CGSJ, CASD and DJS were responsible for the study design, analysis of data, and writing of the manuscript.*