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Original

MULTIDIMENSIONAL ASSESSMENT OF VOICE QUALITY FOR FUTURE ELITE VOCAL PERFORMERS

Evaluación multidimensional de la calidad de voz de los futuros intérpretes vocales de élite

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SUMMARY

Introduction and objective: This study correlates the Singing Voice Handicap Index (SVHI) scores with videostrobolaryngoscopy and acoustic analysis in healthy professional singers, as a measure of self-perceived vocal health, versus actual pathology diagnosed during examination by stroboscopy, or by modification at the acoustic voice evaluation. The objectives of the study were to measure the strength of self-assessment among professional singers and to determine whether there is a benefit of combining SVHI, acoustic analysis and videostrobolaryngoscopy for the routine assessment of singers who have no obvious singing voice problem. Method: Prospective cross-sectional study. The voice quality of 40 students of the Music Academy, Cluj-Napoca, was assessed by means of a multidimensional test battery containing a singing voice handicap index (SVHI), as well as SVHI-10, videolaryngostroboscopy, maximum phonation time on vowel /a/, S/Z ratio, Jitter, Shimmer and NHR (Harmonic Noise Ratio, at lowest, highest and conversational frequency). Additionally, in a questionnaire on daily habits has been recorded for the participants, covering the prevalence of smoking, eating habits, and vocal abuse. The correlation between SVHI scores, acoustic analysis and pathologic findings seen on videostrobolaryngoscopy was analyzed using linear regression and serial t tests to draw the conclusions of this study. Results: Both SVHI and SVHI-10 scores showed, as previously expected, normal values for healthy singers (SVHI-10 being the singers preferred metric). However, although all participants self-identified as healthy, laryngeal abnormalities were relatively common. Acoustic analysis of students voices identified relative instability of pitches, problems with F0 variation, TMF (Maximum Phonation Time) and S/Z ratio. No Significant correlation (P = 0.9501) between SVHI scores, acoustic analysis and videostrobolaryngoscopy findings were shown by the linear regression analysis. Conclusions: Multidimensional assessment of voice quality for the routine evaluation of singers without obvious singing voice problems is an important tool for the early detection of voice

problems, despite appearances of a healthy voice. A trained singer has the possibility to compensate minor laryngeal modifications using singing techniques and, thus, is at risk of overlooking or ignoring an existing pathology. In conclusion, acoustic evaluation of the performers' voices through the methods outlined above could assist in early detection and treatment of vocal pathology.

KEYWORDS professional voice; acoustic analyses; SVHI; voice

RESUMEN Introducción y objetivo: Este estudio correlaciona el índice de deficiencia de voz de canto (SVHI) con videolaringoestroboscopia y análisis acústico en cantantes profesionales sanos, como una medida de la salud vocal subjetiva, contra la patología actual diagnosticada durante el examen por estroboscopia, o por la modificación en la evaluación acústica de la voz. Los objetivos del estudio eran medir la fuerza de autovaloración entre cantantes profesionales y determinar si hay una ventaja de combinar SVHI, el análisis acústico y videolaringoestroboscopia para la evaluación rutinaria de cantantes que no tienen ningún problema de voz de canto evidente. Método: Estudio prospectivo. La calidad de voz de 40 estudiantes de la Academia de Música Cluj-Napoca, fue evaluada mediante una batería multidimensional de pruebas que contiene un índice de deficiencia de voz de canto (SVHI), así como SVHI-10, videolaringoestroboscopia, tiempo de fonación máximo en vocal /a/, proporción de S/Z, Jitter, Shimmer y NHR (Harmonic Noise Ratio, en la frecuencia más baja, más alta y conversacional). Además, los participantes anotaron en un custionario sus hábitos diarios, como hábito tabáquico, hábitos de comida y abuso vocal. La correlación entre os datos de SVHI, análisis acústico y halllazgos patológicos en videolaringoestroboscopia fue analizada usando la regresión lineal y t-test. Resultados: Tanto el SVHI como los datos de SVHI-10 mostraron valores de referencia para cantantes sanos (SVHI-10 fue la evaluación preferida). Sin embargo, aunque todos los participantes se identificaron como sanos, las anomalías laríngeas fueron relativamente comunes. El análisis acústico de las voces de los estudiantes identificó inestabilidad relativa de entonación, problemas con la variación F0, el TMF (Tiempo de Fonación Máximo) y la proporción S/Z. No se halló correlación significativa en el análisis de regresión lineal entre las medidas de SVHI, análisis acústico y los hallazgos de la videolaringoestroboscopia (p= 0,9501). Conclusiones: la evaluación multidimensional de la calidad de voz para la evaluación rutinaria de cantantes sin problemas de voz de canto obvios es un instrumento importante para el descubrimiento temprano de problemas de voz, a pesar de tener una voz aparentemente sana. Un cantante entrenado tiene la posibilidad de compensar una patología laríngea menor mediante técnicas de canto con el peligro de pasar por alto o no detectar una patología existente. Para concluir, la evaluación acústica de la voz puede descubrir patología de voz precozmente y permitir el tratamiento de la patología vocal.

PALABRAS CLAVE voz profesional; análisis acústico; SVHI; voz

INTRODUCTION

As emphasized by Sataloff [1], professional singers, especially at the onset of their careers, have greater vocal demands and require special attention for the early detection of vocal problems. Assessing the vocal health of professional singers requires comprehensive methods of evaluation tailored to their needs. Because of these high vocal demands, singers are more vulnerable to developing vocal problems than ordinary people, whilst being faced with the ongoing need to maintain good vocal health and consistently perform in their field. For this reason, it is a challenge to find methods for the early detection of voice problems. Today, voice researchers, clinicians, and singers have identified the need for immediate voice assessments to increase awareness.

Prevention of vocal problems should be the driving goal of all specialists involved in the care of professional singers. Voice quality is an important indicator of the vocal health of a singer. Paradoxically, there are few investigations into the voice quality of professional singers [1-3].

The acoustic analysis of trained singers has advanced dramatically in recent years. Previous studies have shown correlation between Singing Voice Handicap Index (SVHI) and videostrobolaryngoscopy in healthy professional singers, whilst other studies focus on comparative acoustic analyses between trained and untrained singers [2, 3].

A systematic review, made by Roy [4], provided evidence that selected acoustic, laryngeal imaging–based, auditory–perceptual, functional, and aerodynamic measures have the potential to be used as effective components in a clinical voice evaluation, but it did not analyze professional voices.

In this study, we have proposed a multidimensional assessment of voice quality for the routine evaluation of professional singers, to

detect voice problems as early as possible and apply the insights from the literature for the benefit of professional singers.

The objectives of this study are to measure the strength of self-assessment among professional singers and to evaluate the accuracy of the Singing Voice Handicap Index (SVHI) as well as the Singing Voice Handicap Index - 10 (SVHI-10) in predicting vocal health and identifying vocal problems in professional singers. This study also aims to determine whether there is a benefit of combining SVHI, acoustic analysis and videostrobolaryngoscopy for routine assessment of singers without an obvious singing voice problem, as a measure of self-perceived vocal health versus actual pathology seen on examination or modifications at the acoustic evaluation of voice.

Research in the field of these correlations would be of utmost importance in developing a more comprehensive method of evaluating vocal health in singers, and finding an accurate and useful tool to check the quality of the voice and for early detection of vocal problems.

METHOD

A prospective cross-sectional study has been applied for this objective. The voice quality of 40 students who study Classical Canto at the Music Academy, Cluj-Napoca, was assessed by means of a multidimensional test battery containing: SVHI, SVHI-10, videolaryngostroboscopy, maximum phonation time (MPT) on /a/, S/Z ratio, jitter, shimmer, harmonic to noise ratio (NH at lowest, highest and conversational frequency). All subjects are considered future elite vocal performers at different stages of their vocal training, most of them in the initial stages of their careers.

The subjects (16 males and 24 females) were between 19-24 years old (mean: 20). Because all subjects are trained musicians, it was deemed important for them to be classified as per their voice type (Table1).

Table 1. Classification according to voice types.

Subjects	Number	Mean age
Soprano	15	20
Mezzo-Soprano	7	19
Tenor	5	21
Baritone	8	20
Bass	5	22
Total	40	20.4

In a questionnaire on daily habits, the following parameters were recorded: the health history (acid reflux, allergies), prevalence of smoking and drinking, vocal abuse and singing experience which might affect vocal health. All participants had no history of chronic vocal pathology, no previous voice therapy, no history of drug or alcohol abuse, no history of smoking nor any allergies or voice problems, at the time of testing. Two subjects declared that they smoked occasionally.

The correlation between SVHI scores, acoustic analysis and pathological findings (seen on videostrobolaryngoscopy) were analyzed by using linear regression and serial t tests.

RESULTS

Voice evaluation protocol

The psychosocial impact of the voice, as perceived by the subject, was measured by means of SVHI (translated and adapted in Romanian language) and SVHI-10. The Singing Voice Handicap Index (SVHI) is a questionnaire recently developed and validated as a tool to assess voice function and quality specifically for singers [5, 6]. We also used SVHI-10, a shorter version of the SVHI, and compared the results between these two subjective tests. SVHI include a series of 36 items referring to singing voice quality and how it affects the singer's life. Singers had to express their opinion and rate each item on a scale of 0 to 4 (0= never, 4= always). A total SVHI score was generated based on these results. SVHI-10 was also administrated to the subjects, and the subjects in the study group preferred it, as they found this easier to use and more significant for their needs.

We have found a very high correlation between the values of SVHI and SVHI-10 (Pearson r = 0.87) and for this reason we have introduced the latter in our everyday practice, since it is easier to complete and understand (Figure 1).

Videolaryngostroboscopy was carried out by using a 90° Storz rigid telescope and a stroboscopic light source, with the purpose of detecting the diseases of the vocal fold epithelium, as well as the modification of vibratory characteristics. The vibratory characteristics of the vocal folds were measured by the

parameters laid out in the European Laryngological Society protocol (ELS): the degree of glottal closure (GC), the type of GC, the quality of the mucosal wave (MW), the regularity (R) and the symmetry of the movement of the vocal folds. Each scale was rated as 0 (normal), 1 (slight), 2 (moderate) or 3 (severe) [7]. Spoken and sung pitches were used as method to assess vocal cord appearance and function.

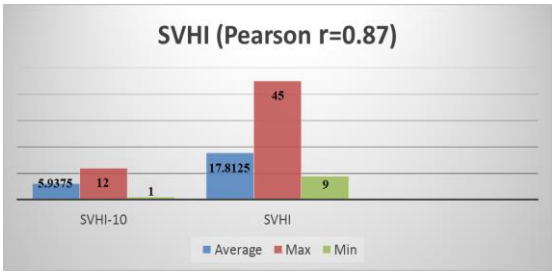

Figure 1. SVHI versus SVHI-10 (Pearson r = 0.87).

The laryngoscopy findings have revealed that 65% of the student singers have normal laryngeal aspect, without any pathological modification, 30% have slight modifications, as different forms of altered laryngeal muscle tension, 5% have moderate pathological modifications. No singer with severe modification of the vocal folds has been found (figure 2).

Although all singers identified themselves as being healthy, we have found relatively frequent laryngeal abnormalities. However, we have not encountered cases of severe pathology, with the only observed pathologies being: one case with vocal nodules, one case with fusiform edema on the right vocal fold and 12 cases with slight vocal fold insufficiency.

There is no correlation between SVHI-10 and laryngeal modification (p=0.35).

The voice assessment protocol was achieved through acoustic analyses, including evaluation of Fundamental Frequency (F0 habitual), vocal range profile (minimum and maximum frequency F0 min, F0 max), and perturbation measurements: pitch instability (jitter), amplitude instability (shimmer), Harmonics-to-Noise Ratio (HNR), as well as aerodynamic analyses, including Maximum Phonation Time (MPT) on vowel /a/ and S/Z ratio [8].

The voice samples were recorded on a PC and analyzed with the use of specialized software for acoustic analysis (Vocalab 4) [9]. As we had expected from vocal performers, the vocal range in the study group was very large, between 87 Hz - 988 Hz. This result reflected the vocal potential of the students and corresponded to their self-evaluation (Figure 3).

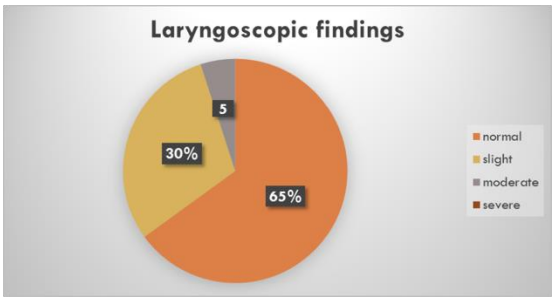

Figure 2. Laryngoscopic findings.

This study was an initial assessment for the voice of singing professionals in early stages of their careers, and can constitute a foundation for more granular explorations into areas such as gender differences and voice classifications.

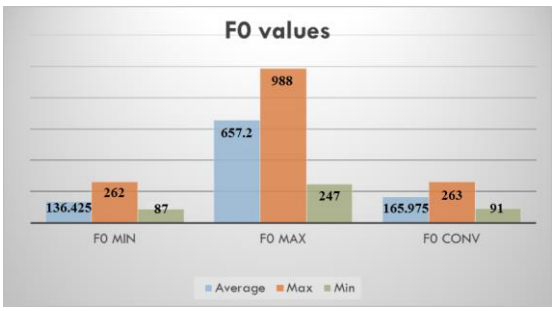

Figure 3. Fundamental frequency.

For perturbation analyses the participants were asked to produce sustained phonation with a comfortable pitch and loudness on the vowel /a/ for at least five seconds. Mouth to microphone distance was set at 10 cm.

MPT had lower values than we had expected for professional singers. During the examination we noticed that some of them had problems with breathing control.

There was a minor inverse correlation between S/Z ratio and SVHI-10 (r=-0.56), and no correlation between MPT and SVHI-10 (r=0.34) (Table 2).

Acoustic analyses of students 'voices showed relative instability of pitches (Table 3). Considering normal values for Vocalab [9] (normal voice vs. pathological voice around 1.0 for all indicators) theoretically, all our acoustic data were indicative for the pathology (Figure 4).

Table 2. Aerodynamic parameters.

	Average	Max	Min
S/Z ratio	1.2	1.9	0.5
MPT	14.77	22.8	7.6

Table 3. Acoustic parameters.

Acoustic voice parameter	Mean (SD)
F0 (Hz)	166.86 (48.37)
F0 min (Hz)	136.40 (51,10)
F0 max (Hz)	656.80 (223.24)
Jitter (%)	1.58 (1.2)
Shimmer (%)	2.64 (0.57)
HNR	1.44 (0.71)

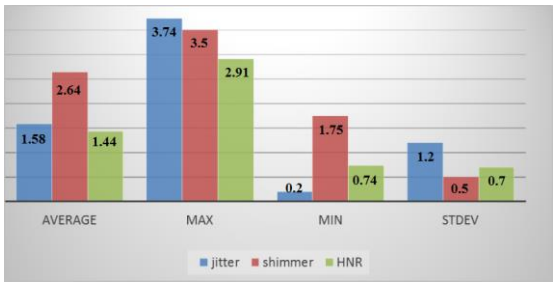

Figure 4. Acoustic analyses.

There was no real explanation for these findings, but they show similar outcomes to those published by Butte [10]. He compared perturbation analyses of different singing styles and found that the opera style had normal jitter (0.52%) and significantly high median shimmer values (P ¼ 0.001) of 7.07%. He concludes that 'opera singing is probably more irregular than other singing styles; this is a previously unknown quality of opera singing' [10].
Because of the high values of perturbation analyses in the study group we decided to separate subjects with normal laryngoscopic findings (Group1) from subjects with pathological laryngoscopic findings (Group 2) and a comparison of these two groups was performed (Figure 5).
We found a statistically significant difference for jitter (t=0.028 p?) and for shimmer (t=0.003) but not for HNR (t=0.26), in these groups (Figure 6). Based on this observation we considered that acoustic evaluation could help us to make a screening for voice problems among singers.

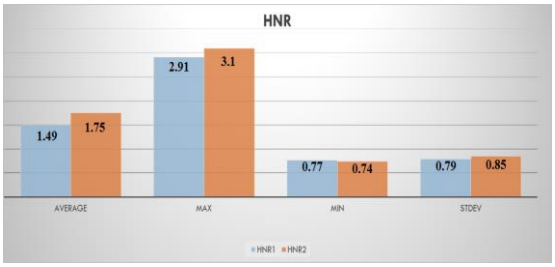

Figure 5. Harmonics to Noise Ratio.

These findings correspond with the studies of Buder [11] and Eadie [12] who found that perturbation analysis of the injured voice have much higher parameters than the normal voice, suggesting that vocal differences that cannot be heard by the human ear could be detected via perturbation analysis. Future research into this area is required for validation of the findings.

Statistics
The main purpose of the investigation was to find an accurate and useful tool to evaluate voice quality and for the earlier detection of vocal problems. The data was analyzed with the Analysis Tool Pak in Excel, focusing on paired t-tests, Pearson correlation and linear regression.

SVHI scores proved to be as previously expected for healthy singers. Singers preferred SVHI-10 and the results were similar between these two tests. However, although all singers were self-identified as healthy, laryngeal abnormalities were relatively common. We found no significant correlation between SVHI-10, SVHI and laryngeal modification.
Acoustic analysis of students' voices showed relative instability of pitches, problems with F0 variation, TMF and S/Z. Linear regression found no significant correlation (P = 0.9501) between SVHI scores, acoustic analysis and

videostrobolaryngoscopy findings but despite this fact, acoustic evaluation might help us make a screening for voice problems among singers. This fact was sustained by the statistically significant differentiation between the group of students without vocal dysfunctions and the group with vocal problems. Based on this observation we considered that acoustic evaluation could support the process of screening for voice problems among singers.

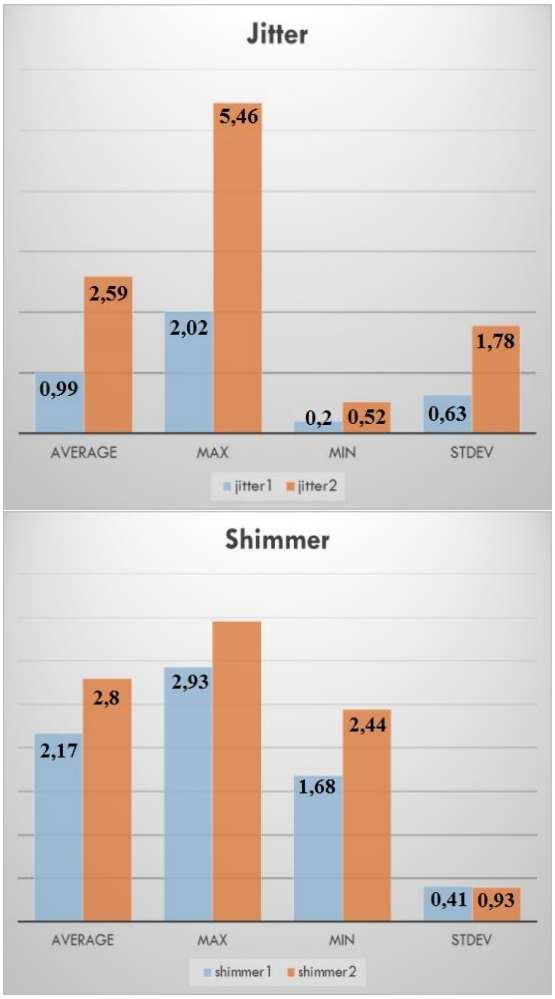

Figure 6. Jitter and Shimmer.

DISCUSSION

We found more pathology than expected among singers who had identified themselves as being healthy. These findings correspond with the results published by Castelblanco [13] who concluded that laryngeal appearance does not correlate with the quality of the singer's voice. As aforementioned, the results indicate more laryngeal abnormalities than expected, but no severe pathology. Perhaps these pathologies do not affect the subjects' singing or they have learned to work around them. What may be 'normal' for one singer may be 'abnormal' for another.

Professional singers do not appear to have a strong ability to predict their vocal health as defined by the total number of pathological findings, despite the results of SVHI-10 and SVHI. This may be due to a difference in sensitivity in self-assessing vocal changes.

Acoustic analyses of singers 'voices were more perturbed than we had expected. The high shimmer values may be explained by the fact that professional opera singers have the tendency to phonate too loudly, and that they employ techniques to support their voice. The perturbation may be due, also, to the singers' formant and vibrato, thus any evaluation should be adapted to the singers' particularities [14].

Vocalab 4 might not be the most adequate program for acoustic analyses in professional singers. An avenue to explore would be a comparison of the evaluation with Vocalab 4 with evaluations made with other vocal analyses programs, to observe which program is the most relevant for acoustic analyses in professional singers.

CONCLUSION

Multidimensional assessment of voice quality for routine assessment of singers without an obvious singing voice problem is an important tool to detect early voice problems despite the apparent normal appearance. A trained singer has the possibility to compensate minor laryngeal modifications by using a proper singing technique and, thus, to ignore existing pathology. It is difficult even for a professional singer, who is supposedly more aware of their vocal health, to objectively assess the presence of a minor vocal problem. There is no significant correlation between the SVHI, videostrobolaryngoscopy, acoustic and aerodynamics findings in healthy professional singers. The SVHI does not accurately predict vocal health as defined by strict pathological findings upon videostroboscopy examination. It is of great importance to develop a method with increased sensitivity for detecting early vocal pathologies that may cause a problem in the future, particularly for professional singers.

In conclusion, acoustic evaluation of the performers' voices could detect early signs of vocal pathology and should be introduced in the routine assessment of singers' voices.

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