Spectrographic trace visual support: impact on reliability of auditory-perceptual voice analysis by inexperienced evaluators

Apoio visual do traçado espectrográfico: impacto na confiabilidade da análise perceptivo-auditiva da voz por avaliadores inexperientes

Apoyo visual del trazado espectrográfico: impacto en la fiabilidad del análisis audio-perceptivo de la voz por evaluadores inexpertos

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Abstract

Introduction: clinical assessment is an effective tool for voice disorders analysis, due to it we can describe the vocal profile of an individual and identify the factors that trigger and maintain dysphonia. The types of evaluation that are used the most in speech therapy are the auditory-perceptual and acoustic analysis of voice. Objective: To verify if the simultaneous presentation of voices and spectrographic trace improves the reliability of auditory-perceptual analysis of the instability (I) and the general degree of vocal deviation (G) parameters carried out by inexperienced evaluators. Material and Methodology: This was a longitudinal study in which 14 Speech-Language Pathology undergraduate students evaluated in an auditory-perceptual form, at two different moments, 48 vocal samples with and without visual support of spectrographic trace. In order to analyze the inter- and intra-raters concordance, twenty

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percent of the voices were repeated randomly in two stages. In the analysis of the concordances, the Kappa statistical index was used. Results: there were differences between the inter- and intra-raters auditory-perceptual evaluations with and without visual support of spectrographic trace of the parameter instability (I). In relation to general degree of vocal deviation (G) parameter, there was statistical difference between the auditory-perceptual evaluations only in intra-rater agreement. Conclusion: the visual support of spectrographic trace increases the reliability of the auditory-perceptual evaluation of voice.

Keywords: voice; Speech Language Pathology and Audiology; voice disorders; instrumentation.

Resumo

Introdução: avaliação clínica é uma ferramenta eficaz para a análise de alterações vocais, devido ao fato de que podemos descrever o perfil vocal de um indivíduo e identificar os fatores que desencadeiam e mantêm a disfonia. Os tipos de avaliação que são mais usados na terapia fonoaudiológica são a análise perceptivo-auditiva e acústica da voz. Objetivo: verificar se a apresentação simultânea de vozes e traçado espectrográfico melhora a confiabilidade da análise perceptivo-auditiva da instabilidade (I) e o grau geral de desvio vocal (G) parâmetros realizados por avaliadores inexperientes. Material e Métodos: Este foi um estudo longitudinal no qual 14 estudantes de Fonoaudiologia avaliaram de forma perceptivo-auditiva, em dois momentos diferentes, 48 amostras vocais com e sem apoio visual de rastreamento espectrográfico. A fim de analisar a concordância inter e intra-avaliadores, vinte por cento das vozes foram repetidas aleatoriamente em dois estágios. Na análise das concordâncias, foi utilizado o índice Kappa estatística. Resultados: houve diferenças entre as avaliações perceptivo-auditivasinter e intra-avaliadores com e sem apoio visual de traçado espectrográfico do parâmetro da instabilidade (I). Em relação ao parâmetro de grau geral de desvio vocal (G), houve diferença estatística entre as avaliações perceptivo-auditivas apenas na concordância intra-avaliador. Conclusão: o apoio visual do traçado espectrográfico aumenta a confiabilidade da avaliação perceptivo-auditiva da voz..

Palavras-chave: *voz; Fonoaudiologia; distúrbios da voz;instrumentação*

Resumen

Introducción: *la evaluación fonoaudiológica es un instrumento eficaz para el análisis de trastornos vocales, puesto que permite elaborar el perfil vocal del individuo e identificar los factores desencadenantes que instalan y mantener la disfonía. Los dos tipos de evaluación frecuentemente utilizados en clínicas de fonoaudiología son el análisis audio-perceptivo y análisis acústico de la voz.* ***Objetivo****: verificar si la presentación simultánea de las voces, asociada al apoyo del trazado espectrográfico, aumenta la fiabilidad del análisis audio-perceptivo de los parámetros de inestabilidad (I) y del grado global de desviación vocal (G) realizada por evaluadores inexpertos. Material y método: Se trata de un estudio longitudinal ejecutado por 14 estudiantes del Licenciatura en Fonoaudiología. El análisis se realiza en dos diferentes etapas por medio de la evaluación audio-perceptiva de 48 muestras vocales con y sin el apoyo visual del espectrógrafo. Con el propósito de analizar las correlaciones inter e entra- evaluadores, el veinte por ciento de las voces fueron repetidas aleatoriamente en las dos etapas antes mencionadas. Para el análisis de las correlaciones se utilizó el índice estadístico Kappa.* ***Resultados:*** *Se ha observado diferencia entre las evaluaciones audio-perceptivas inter e entra-evaluadores con y sin el apoyo visual de la espectrografía en el parámetro inestabilidad (I). En el parámetro grado global de desviación vocal (G), se ha encontrado diferencia estadística apenas entre las evaluaciones audio-perceptivas en la correlación entra-evaluadores.* ***Conclusión:*** *el apoyo visual del trazado espectrográfico aumenta significativamente la fiabilidad de la evaluación audio-perceptiva de la voz..*

Palabras clave: *voz; Fonoaudiología; trastornos vocales; instrumentación.*

Introduction

The voice is used in oral communication, it offers information about physical and cultural aspects of a person and it works as a means of expressing personality and feelings. It is a manifestation with psychological foundation, but with a sophisticated and complex muscle processing. When there is muscle harmony, the voice is produced by the speaker with no discomfort or difficulty, and the listeners consider it a high quality sound. When voice emissions are noisy and produced with discomfort and difficulty,there is an impairment called dysphonia, characterized by a symptom caused by phonation disorders related to several aetiologies[1].

The speech-language pathology assessment is an efficient instrument to analyze voice disorders because it allows us to describe the vocal profile of a person and to identify the factors that are causing and maintaining the dysphonia1. Nowadays, there are several kinds of vocal assessments. Currently, the vocal assessments that are used the most in the speech-language pathology clinic are the auditory--perceptual analysis and the acoustic voice analysis.

Even with all its subjectivity, the auditory--perceptual assessment is traditional in the speech--language pathology clinic, being considered high standard to vocal quality analysis[2-3]. It offers us both anatomic and functional data and information about psychosocial and emotional aspects of the speaker's voice.

The acoustic analysis is an objective, effective instrument and it helps to complement the vocal assessment[4]. Spectrograph is one of its main tools. The spectrogram is a three dimensional graphic that registers characteristics both of frequency and intensity of the voice. It shows the acoustic characteristics of the voice emission visually; however, just like the auditory-perceptual analysis, these pieces of information demand an interpretation by the evaluators, who are under the influence of their experience[5].

The assessment of the spectrographic trace is made based on the visual analysis of parameters, such as: shape of the spectrographic trace; level of harmonic darkening; stability of the harmonic traces; presence of noise; presence of subharmonics and up to what frequency the harmonics are defined6. All of these parameters present correlations with auditory-perceptual data of vocal quality and with anatomic and functional data of the larynx, giving assistance in the multidimensional assessment of dysphonia.

Among the perceptual assessment of voice scales, the Grade, Roughness, Breathiness, Asthenia, Strain, Instability (GRBASI) scale is used and recognized throughout the world. This scale allows the analysis of several aspects in voice quality, among them, the parameter instability (I), which represents the fluctuation in vocal quality, that is, an abnormal variation of the voice. In the spectrogram, this parameter can be represented as: stable, unstable and absent trace. There is stability when the trace keeps on being continuous and constant, with low occurrences of waves; there is instability when the trace represents evident waves or snaps; and it is absent when it is not possible to assess the stability of the trace. All of the parameters of the scale, together, determine the general degree of dysphonia (G), which shows the global vocal deviation[1-8].

To understand how the assessor's experience affects the auditory-perceptual assessments is essential to clinical decision making, because pieces of information derived from different listeners affect the results measurement and the treatment decisions. Some studies found that the assessor's experience has a positive impact on the reliability of the auditory-perceptual assessment[9], and that the experienced listeners tend to judge dysphonic voices with more deviation than inexperienced listeners[10].

Studies also indicate that the visual support of spectrographic trace helpsauditory-perceptual analysis, when carried out by experienced evaluators, improving their reliability[3-10].

Theaim of this study was to verify if the simultaneous presentation of voices and the spectrographic trace improves the reliability of auditory--perceptual assessment of instability (I) andthe general degree of vocal deviation (G) parameters carried out by inexperienced evaluators.

Material and Methodology

This paper presents a longitudinal and prospective study, approved by the Research Ethics Committee of the Institution, by the technical report number ETIC 405/08 that used vocal samples of a tutorial for voice spectrogram analysis11. The voice material used in the research, part of the tutorial,

was the sustained emission of the vowel /a/ and this vowel was chosen because it presents more pieces of spectrographic information that are correlated to the vocal quality12.

Fourteen Speech-Language Pathology and Audiologyundergraduate students were invited to take part of this study and they evaluated in an auditory-perceptual form 40 voices with and without visual support of spectrographic trace. The evaluators were 21 years old on average – 12were females and two of them were males, all of them had no experience in auditory-perceptual assessment. The evaluators had theoretical knowledge about aspects in voice quality, and before the evaluation, they were trained and informed about the main spectrographic parameters and their correlation with the auditory-perceptual analysis.

The sample, composed by the number of evaluators and the analyzed voices, was defined from Kappa statistic index proposed by Fleiss, which has statistical power of 80% and a level of significance of 5%. Aiming to analyze the intra-rater agreement, 25% of the voices were repeated randomly, totaling 48 vocal samples and spectrograms. The selected 40 voices were made of dysphonic and neutralemissions bypeople between ages of 18 and 45, all of them female.

The individuals analyzed the instability (I) and the general degree of vocal deviation (G) parameters in an auditory-perceptual way. The assessments occurred in two moments – in the first one the participants evaluated the vocal samples that were presented in an auditory-perceptual way. In the second meeting, after 8 days, in order to reduce the possibility of memorization, the same voices were evaluated again in an auditory-perceptual way, but they were presented in a different order and simultaneously followed by a presentation of the spectrographic traces correspondent to their emission. The meetings took place in the university facilities and the evaluators did not have access to any information related to the voices that were evaluated.

The voices were simultaneously presented to all evaluators and emitted from a speaker in a silent room, with an environment noise of 47 dB SPL. The spectrograms were exhibited by a projector, using Microsoft® PowerPoint 97-2003. All of the vocal presentations, or the vocal presentations associated with a spectrogram projection, were repeated three time tops to the evaluators, according to their requirements.

To execute the evaluation, individually, each participant filled in a structured protocol containing the parameters used in the research: instability (I) and general degree of vocal deviation (G). The parameter I was classified as stable and unstable voice, 1 and 2, respectively, and the parameter G was classified in a deviation scale from 0 to 3; 0 meant no alteration; 1 slightly altered; 2 moderately altered and 3 intense alteration. To guarantee a higher uniformity among the evaluations, before the analyses were made, the evaluators were informed about how to fill in the protocol.

The inter- and intra-rater concordances of the auditory-perceptual analyses with and without visual support of spectrographic trace of I and G parameters were analyzed by the Kappa statistical method, which was classified according to the following criteria: almost perfect – Kappa between 0,80 and 1,00; good – Kappa between 0,60 and 0,80; moderate – Kappa between 0,40 and 0,60; regular – Kappa between 0,20 and 0,40; discrete – Kappa between zero and 0,20; poor – Kappa between -1 and zero13. All of the analyses were done using STATA Software, 9.0 version (Stata Corporation, College Station, United States).

Results

In the intra-rater concordance of the parameter instability (I) (Chart 1) and the general degree of vocal deviation (G) parameter (Chart 2), the results, both with and without visual support, presented almost perfect concordance, showing a higher concordance when the evaluator analyzes the instability of the voice and the general degree of vocal deviation with the visual support of spectrographic trace.

CHART 1: ANALYSIS OF THE INTRA-RATER CONCORDANCE IN THE AUDITORY-PERCEPTUAL ASSESSMENT OF PARAMETER INSTABILITY WITH AND WITHOUT VISUAL SUPPORT OF SPECTROGRAPHIC TRACE

			Answers Without Visual Support		Answers With Visual Support	
Evaluators	Concordance (%) With and Without Visual Support	Expected Concordance (%) With and Without Visual Support	Kappa	p Value	Kappa	p Value
1	62.50 - 50.00	23.44 - 21.88	0.5102	0.0021	0.3624	0.0173
2	50.00 - 50.00	31.25 - 21.88	0.2337	0.0843	0.3624	0.0173
3	87.50 - 50.00	29.69 - 26.56	0.8294	0.0031	0.3191	0.0207
4	75.00 - 75.00	40.63 - 23.44	0.5780	0.0347	0.1872	0.0023
5	62.50 - 50.00	28.13 - 23.44	0.2983	0.0065	0.3469	0.0319
6	62.50 - 62.50	32.81 - 29.69	1.0000*	0.0200*	0.4667	0.0891
7	62.50 - 62.50	25.00 - 39.06	0.5000	0.0030	0.2674	0.0230
8	37.50 - 62.50	25.00 - 32.81	0.1667	0.1695	0.4419	0.0040
9	62.50 - 62.50	32.81 - 25.00	0.4149	0.0175	0.5980	0.0037
10	62.50 - 75.00	35.94 - 28.13	0.4146	0.0248	0.6522	0.0010
11	25.00 - 50.00	12.50 - 21.88	0.1429	0.0512	0.3600	0.0173
12	87.50 - 100.00	26.56 - 28.13	0.8298	0.0000	1.0000*	0.0201*
13	50.00 - 50.00	28.13 - 21.88	0.3043	0.0593	0.3600	0.0224
14	62.50 - 75.00	26.56 - 34.38	0.5664	0.0030	0.6190	0.0079

*p-value<0,05 (statistical significance). Statistics: Kappa fleiss.

CHART 2: ANALYSIS OF INTRA-RATER CONCORDANCE IN THE AUDITORY-PERCEPTUAL ASSESSMENT OF THE GENERAL DEGREE OF VOCAL DEVIATION PARAMETER WITH AND WIHTOUT VISUAL SUPPORT OF SPECTROGRAPHIC TRACE

			Answers Without Visual Support		Answers With Visual Support	
Evaluators	Concordance (%) With and Without Visual Support	Expected Concordance (%) With and Without Visual Support	Kappa	p Value	Kappa	p Value
1	50.00 - 62.50	21.88 - 23.44	0.5102	0.0021	0.2600	0.0103
2	50.00 - 50.00	21.88 - 31.25	0.2727	0.0083	0.2600	0.0103
3	50.00 - 87.50	26.56 - 29.69	0.8292*	0.0001*	0.4667	0.0246
4	75.00 - 75.00	23.44 - 40.63	0.6189	0.0077	0.1902	0.0002
5	50.00 - 62.50	23.44 - 28.13	0.4782	0.0065	0.3999	0.0476
6	62.50 - 62.50	29.69 - 32.81	0.4419	0.0560	0.4027	0.0131
7	62.50 - 62.50	39.06 - 25.00	0.5970	0.0060	0.2594	0.0630
8	62.50 - 37.50	32.81 - 25.00	0.1667	0.1695	0.5413	0.0026
9	62.50 - 62.50	25.00 - 32.81	0.4419	0.0209	0.5000	0.0030
10	75.00 - 62.50	28.13 - 35.94	0.4419	0.0399	1.0000*	0.0000*
11	50.00 - 25.00	21.88 - 12.50	0.1429	0.0512	0.3600	0.0173
12	100.00 - 87.50	28.13 - 26.56	0.3043	0.0300	0.5034	0.0341
13	50.00 - 50.00	21.88 - 28.13	0.0179	0.0443	0.3600	0.0224
14	75.00 - 62.50	34.38 - 26.56	0.4894	0.0070	0.6070	0.0058

*p-value<0,05 (statistical significance). Statistics: Kappa fleiss.

The analysis of the inter-rater concordance of parameter I (Chart 3) pointed that visual support increases the concordance of auditory-perceptual assessment.

CHART 3: ANALYSIS OF INTER-RATER CONCORDANCE IN THE AUDITORY-PERCEPTUAL ASSESSMENT OF PARAMETER INSTABILITY WITH AND WITHOUT VISUAL SUPPORT OF SPECTROGRAPHIC TRACE

Answers WithoutVisual Support	Kappa	p Value
1	0.2628	0.0680
2	0.3187	0.0611
General	0.5812*	0.0010*
Respostas Com Apoio Visual	Kappa	Valor p
1	0.4202	0.0512
2	0.3240	0.0602
General	0.7442*	0.0000*

*p-value<0,05 (statistical significance). Statistics: Kappa fleiss.

In relation to parameter G (Chart 4), the values of the inter-rater concordance showsmall difference, when the auditory-perceptual analysis was done with the visual support of spectrographic trace.

CHART 4: ANALYSIS OF INTER-RATER CONCORDANCE IN THE AUDITORY-PERCEPTUAL ASSESSMENT OF THE GENERAL DEGREE OF VOCAL DEVIATION PARAMETER WITH AND WIHTOUT VISUAL SUPPORT OF SPECTROGRAPHIC TRACE

Answers Without Visual Support	Kappa	p Value
0	0.2672	0.0601
1	0.2016	0.0730
2	0.1015	0.0590
3	0.7274	0.9860
General	0.3474*	0.1460*
Answers With Visual Support	Kappa	Valor p
0	0.4202	0.0408
1	0.1499	0.0512
2	0.1629	0.0590
3	0.8005	0.0040
General	0.3912*	0.1036*

*p-value<0,05 (statistical significance). Statistics: Kappa fleiss

Discussion

Even though there is subjectivity in auditory--perceptual analysis, which can jeopardize the reliability of vocal assessment, it is known that, nowadays, this analysis is predominant and high standard to vocal assessment, specially because it shows, in a reliable way, the aspects related to vocal quality. Due to this subjectivity, complementary tools have been used increasingly in vocal assessments, like in acoustic analysis. Spectrography is one of the main tools of this kind of analysis and, although it is considered objective, a visual--perceptive assessment of spectrographic trace is made based on it through a graphic representation that translates sound signals into visual signals and that demands an interpretation by the evaluator[4-5].

An auditory-perceptual analysis can be influenced by several factors, among them there is the evaluator's audio training experience, speaking tasks and types of auditory-perceptual assessment

scale. The audio training of the listener, that is, the experience of the evaluator, has a positive impact on the reliability of the auditory-perceptual analysis. The most experienced evaluators are more reliable in auditory-perceptual analysis than inexperienced evaluators[14-15]. The type of speaking task, considering the sustained vowel and connected speech, may have an influence in auditory-perceptual analysis. Studies show that sustained vowel, unlike connected speech, is not under the influence of some aspects, like prosody, phonetic and phonologic context, that makes the listeners focus their attention to vocal alteration. Such circumstance explains the fact that the sustained vowel is analyzed more easily and it presents higher reliability in auditory-perceptual analysis than connected speech[16]. In relation to the scales used in auditory-perceptual assessment, GRBAS and CAPE-V scales are the most popular worldwide. Some studies show that both scales present high intra-rater concordance, when they are used individually and also when they are compared with each other[17].

Researches indicate that the general degree of vocal deviation (G) parameter is the most reliable among the variables that are part of the GRBASI scale because it offers a global perception of dysphonia and, therefore, it presents higher concordance18. Other studies report that some other parameters, like asthenia (A) and roughness (R), are frequently used and recommended as a basic perspective to characterize dysphonic voices, and they also present higher concordance4. However, in relation to other parameters, including theI, which was analyzed in this paper, researches that could explain high or low concordance from the assessment of such auditory-perceptual parameters were not found.

The results that were found in this research show that there was a significant statistic difference between inter- and intra-raterauditory-perceptual assessments with and without visual support of spectrographic trace of parameter I (Charts 1 and 3). Researches that analyze intra-rater[19] and inter-rater[4-19] concordance of parameter I with and without the visual support of spectrographic trace noticed an increase in the concordance; however, there was no statistic difference. Both researches[4-19] had evaluators with experience in auditory-perceptual analysis of voice. Studies in the field of Speech-LanguagePathology show that the evaluator's experience is a parameter that interferes in the reliability of auditory-perceptual assessment[20].

Therefore, it is possible to assume that, to evaluators with little experience, visual support of spectrographic trace brings a greater benefit to the assessment of parameter instability, since it is easier to be noticed in the spectrogram19. Another aspect that might also have positively influenced intra and inter-rater concordance in the auditory-perceptual assessment of parameter I was the fact that it was used a two-point scale in the assessments, characterized by stability or instability of the spectrographic trace. After considering that, it is valid to assume that a dichotomous analysis is easier to evaluate than a scale with a wider range.

In relation to parameter G, there was only a difference in the intra-rater concordance (Chart 2), and there was no statistic difference when an auditory-perceptual analysis with and without visual support of spectrographic trace in the inter--rater concordance was done (Chart 4). It is possible to assume that, to evaluators with little experience, the increase in the intra-rater concordance is due to the fact that the visual support of spectrographic trace helps the auditory-perceptual assessment of vocal quality. Some researches show that in the analysis of parameter G, the auditory-perceptual assessment carried out with the visual support of spectrographic trace increases or does not increase the inter-rater concordance[4-19]. It is also possible to assume that, probably, the size of the sample may have influenced the results, considering that some studies present greater or smaller amounts of vocal samples. Therefore, future studies will be necessary to understand the differences that were found.

As a high standard in vocal assessment, studies that analyze a concordance increase in the auditory-perceptual analysis show that this is an important tool to the development of Speech-Language Pathology assessment and that this kind of assessment is the most adequate, since objective assessments, despite being complementary to auditory-perceptual analysis, often do not include the subjective aspects of the voice.

Conclusion

In the auditory-perceptual assessment performed by inexperienced evaluators, the results showed that the intra-rater concordances of the auditory-perceptual analysis of parameter instability

(I) and the general degree of vocal deviation (G) increase when carried out with visual support of spectrographic trace. The inter-rater concordances of auditory-perceptual analysis of parameter I also increase when carried out with visual support of the spectrogram, however, in relation to parameter G, the inter-rater concordances do not increase, showing small statistic difference.

Based on these results, it is possible to conclude that the visual support of spectrographic trace increases significantly the reliability of auditory--perceptual assessment of voice, since it promotes the increase of inter- and intra-rater concordances of most of the analyzed parameters when performed by inexperienced evaluators.

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