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Voice quality analysis from a phonetic perspective: Voice Profile Analysis Scheme Profile for Brazilian Portuguese (BP-VPAS)

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Abstract

The present study aims at presenting the instructional material developed in the Brazilian Portuguese context to apply the Voice Profile Analysis Scheme-VPAS (PB-VPAS) for the perceptual evaluation of voice quality and at reporting preliminary data analyzed from a group of nine judges who attended a workshop on VPAS. The adaptation of the VPAS into Brazilian Portuguese was accomplished and the corpus to be used in the training of judges was built up. Furthermore, the voice quality database necessary for the application of the protocol was recorded, evaluated by two expert subjects and integrated into the instructive material of the BP-VPAS. Preliminary data from nine judges (linguists and speech therapists) who attended a PB-VPAS workshop using the material described (in 2 stages: before and after a 20-hour workshop on VPAS) are presented. The relevance of the application of PB-VPAS to the analysis of voice disorders and expressiveness uses of voice quality is pointed out.

1. Introduction

The present study aims at presenting the instructional material developed in the Brazilian Portuguese context to apply the Voice Profile Analysis Scheme-VPAS (Figure 1) for the perceptual evaluation of linguistic, paralinguistic and extralinguistic uses of voice quality settings such as marking utterance boundaries, conveying attitudes and emotions and indicating physical and pathological conditions. Preliminary data on the analysis of two evaluation tasks performed by a group of nine judges who attended a workshop on VPAS are also presented.

The phonetically-grounded investigation of voice quality has advanced recently as regards close inspection of its production and perception mechanisms, in a continuum which encompasses from the investigation of correlations between sound and meaning, in the field of speech expressivity, to those caused by disturbances in the system of production and perception of sounds in the field of dysphonia[2-5].

The adoption of theoretical models allows the deviation from the classically assumed dichotomy between normality and voice disorder. Voice quality under a phonetic perspective shows us the possibility to approach its study from a basic notion: the plasticity of the vocal apparatus.

The *Vocal Profile Analysis Scheme*- VPAS profile[1;6-8], which is based on a phonetically grounded description of voice quality[9], is the result of the continuous work of a team of researchers from *Queen Margareth University College* (*QMUC- Edinburgh*). In the history of this long-standing project, they kept the tendency of a clear and user-friendly presentation of the profile, with all the components rated in accordance with the neutral setting.

The application of the *Voice Profile Analysis Scheme* (VPAS) in the Brazilian context led a group of researchers at LIAAC- PUCSP (Integrated Acoustic Analysis and Cognition Laboratory of the Catholic University of São Paulo) to systematize and improve the material aimed at instructional purposes. Experience in applying the model emerged in the following processes: investigating linguistic, paralinguistic and extralinguistic uses of vocal quality; investigating acoustic and physiological (eletroglottography, laryngoestroboscopy and videokimography) correlates of settings of voice quality[10-11]; structuring a voice quality database; introducing the model in workshops and answering questions posed by learners about voice data collection procedures and application procedures in these workshops.

The phonetic description of voice quality model[10] analyzes voice quality in terms of an analytic unit: the setting, from now on defined as long-term muscular tendency. The possible voice quality settings include those of phonatory (basically defined in terms of vocal folds modes of vibration), vocal tract (supralaryngeal or articulatory) and tension (laryngeal and vocal tract) dimensions. The aforementioned group of settings is defined as variations from the reference condition (neutral setting) in which: the vocal folds mode of vibration is balanced (both in terms of adduction forces and longitudinal tension) without audible whispering or other noises.; the supralaryngeal vocal tract cavities are not characterized by any degree of constriction or expansion; the total distance between vocal cords and lips is kept intermediate without shortening or lengthening effects, and finally laryngeal and supralaryngeal tension is moderate[6-8].

The adoption of the neutral setting as reference can be considered a landmark in the investigation of voice qualities since it does not introduce a rupture between normality and voice disorder.

This paper introduces the version of the phonetically-grounded protocol for the evaluation of vocal qualities [1] adapted to the Brazilian context (PB-VPAS) and presents instructional material on how to collect data for the purpose of describing vocal quality.

2. Methodological procedures

2.1. Instructional workshop material and corpus design

The adaptation of the VPAS to the Brazilian Portuguese context (Figure 2) followed a comprehensive theoretical critical review of the bases of the model profile [1; 6-9]. The version presented in this paper derives from the 2002 [10] and 2007 (Figure 1) versions of the profile [1].

In adapting the originally English design for BP applications, we introduced some modifications, considering more recent advances in speech science research related to

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studies on the physiology and speech signal research [5;10;12-13]. The main changes introduced in the adaptation of the protocol to Brazilian reality concerned the phonatory (laryngeal) settings related to air escape and laryngeal irregularity.

The building of the corpus to be recorded and retrieved in the voice data took into account the principle of susceptibility proposed by Laver[9] and made use of the key speech segments as proposed by Mackenzie-Beck[8].

Audio and video recordings of a group of 14 speakers without voice complaints concerning speech production or perception were collected in studio conditions at the Radio Laboratory facilities at PUCSP, so that most of the settings described in the phonetically-grounded evaluation protocol were included. As the VPAS poses that the same setting, depending on the degree, can be thought as normal or deviant, the recordings of voice qualities to constitute the database for the training were intended to illustrate the variety of voice quality settings and not differences between normal and deviant voice qualities.

A head-set microphone was placed at 10cm distance from the speakers' mouth. Speech signals were monitored by means of the Soundforge software. Intensity calibration procedures were introduced. A 1 kHz, 80 dB tone (measured with a Radio-Shack Digital-Display sound-level meter) was played in an acoustic amplifier, at a 10cm distance from the microphone. Following the capture and recording of this tone the sound board was configured according to the speaker-specific monitoring features [14].

Two recordings of pharyngeal constriction contrasting pharyngeal expansion settings can be listened from the audio files pharyngeal_constriction_setting.wav and pharyngeal_expansion_setting.wav.

2.2. Preliminary report on the analysis of voice quality evaluation tasks

The recorded material was evaluated by two experts in the use of the protocol (one linguist and one speech therapist). It comprised a great variety of voice quality settings representing those most commonly found in normal conditions, such as lip spreading, modal voice and creaky voice and in pathological conditions, such as harsh voice, hyperfunction and nasal air escape. The recordings which presented the most representative examples of the settings were included in the instructive material meant to be applied to the training of judges in the use of the adapted voice analysis protocol, the BP-VPAS.

A nine-judge group, composed by speech therapists and linguists was trained to apply BP-VPAS. The aforementioned instructional material was applied at a five session twenty-hour workshop.

At the first session (Stage 1), judges did not have any experience in using the VPAS. At the beginning of the first session of the workshop they were requested to listen individually (by headphones) and judge a corpus of 20 samples of settings of voice quality produced by 11 speakers available in the database (each student had a computer to perform the activity). They were requested to fill a printed version of BP-VPAS (Figure 2).

Most of BP-VPAS settings were included in the recording. Some samples were presented twice (or three times) so that intra-judge agreement scores in performing voice quality analysis could be evaluated.

At the last session of the workshop (Stage 2), they judged the same samples presented in the first session so that their level of ratings of voice quality could be compared. The same application procedures were used in the first and last sessions. The results were compared to those of the experts in order to elaborate the confusion matrices. The total number of judgments varied in function of the occurrence or co-occurrence of specific settings in the samples.

3. Results and Discussion

3.1. Instructional workshop material and corpus design

The VPAS in its 2007 version and the BP-VPAS are presented in Figures 1 and 2 respectively.

The sentences that integrate the corpus built up to evaluate vocal qualities in Brazilian Portuguese are presented in Figure 3. The key segments chosen for the sake of making identification of settings easier according to the principle of susceptibility are underlined [9]. The group of settings potentially best identified by the sentence is also referred to. Although some speech segments are repeated in the sentences of the corpus, the sentences are easy to pronounce as demonstrated by production tasks carried out by speakers of diverse sociolinguistic backgrounds. These sentences are not tongue twisters.

	FIRST PASS		SECOND PASS						
	Neutral	Non-neutral	SETTING	moderate			extreme		
				1	2	3	4	5	6
A. VOCAL TRACT FEATURES									
1.Labial			Lip rounding/protrusion						
			Lip spreading						
			Labiodentalization						
			Minimised range						
			Extensive range						
2. Mandibular			Close jaw						
			Open jaw						
			Protruded jaw						
			Extensive range						
			Minimised range						
3.Lingual tip/blade			Advanced tip/blade						
			Retracted tip/blade						
4. Lingual body			Fronted tongue body						
			Backed tongue body						
			Raised tongue body						
			Lowered tongue body						
			Extensive range						
			Minimised range						
5.Pharyngeal			Pharyngeal constriction						
			Pharyngeal expansion						
6.Velopharyngeal			Audible nasal escape						
			Nasal						
			Denasal						
7. Larynx height			Raised Larynx						
			Lowered Larynx						
B. OVERALL MUSCULAR TENSION									
8. Vocal tract tension			Tense vocal tract						
9. Laryngeal tension			Tense larynx						
			Lax larynx						
C. PHONATION FEATURES									
	SETTING		**Present**			**Scalar Degree**			
			Neutral	Non-neutral		Moderate			Extreme
					1	2	3	4	5	6
10. Voicing type	Voice									
	Falsetto									
	Creak									
	Creaky									
11. Laryngeal frication	Whisper									
	Whispery									
12.Laryngeal irregularity	Harsh									
	Tremor									

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		Neutral	SETTING	moderate			extreme		
				1	2	3	4	5	6
D. PROSODIC FEATURES									
13.Pitch	**Mean**		High						
			Low						
	Range		Minimised range						
			Extensive range						
	Variability		High						
			Low						
14. Loudness	**Mean**		High						
			Low						
	Range		Extensive range						
			Minimised range						
	Variability		High						
			Low						
E. TEMPORAL ORGANIZATION									
15. Continuity			Interrupted						
16. Rate			Fast						
			Slow						
F. OTHER FEATURES									
17. Respiratory support			Adequate						
			Inadequate						
18. Dyplophonia			Absent						
			Present						

Figure 1: *Vocal Profile Analysis Scheme – VPAS (2007)*

QUALIDADE VOCAL	PRIMEIRA PASSADA		SEGUNDA PASSADA						
	Neutro	Não neutro	AJUSTE	Moderado			Extremo		
				1	2	3	4	5	6
A. ELEMENTOS DO TRATO VOCAL									
1.Labial			Arredondamento/protrusão						
			Estiramento						
			Labiodentalização						
			Extensão diminuída						
			Extensão aumentada						
2. Mandibular			Mandíbula fechada						
			Mandíbula aberta						
			Mandíbula protraída						
			Extensão diminuída						
			Extensão aumentada						
3.Lingual ponta/lâmina			Avançada						
			Recuada						
4. Corpo de língua			Avançada						
			Recuada						
			Elevada						
			Abaixada						
			Extensão diminuída						
			Extensão aumentada						
5.Faringe			Constrição						
			Expansão						
6.Velofaringe			Escape nasal audível						
			Nasal						
			Denasal						
7. Altura de laringe			Elevada						
			Abaixada						
B. TENSÃO MUSCULAR GERAL									
8. Tensão do trato vocal			Hiperfunção						
9. Tensão laríngea			Hiperfunção						
			Hipofunção						
C. ELEMENTOS FONATÓRIOS									
	AJUSTE		Presente						
			Neutro	Não Neutro	Graus de escala				
					Moderado			Extremo	
					1	2	3	4	5	6
10. Modo de fonação	Voz Modal								
	Falsete								
	Creakiness/ (creak)								
	Voz creakiness (creaky voice)								
11. Fricção laríngea	Escape de ar								
	Voz sussurosa								
12.Irregularidade laríngea	Voz áspera								

Ocorrências em curto termo ( )quebras ( ) instabilidades ( ) diplofonia ( ) tremor
Para ajustes de ocorrência intermitente assinalar (i)

DINÂMICA VOCAL	Neutro	AJUSTE	Moderado			Extremo		
			1	2	3	4	5	6
D. ELEMENTOS PROSÓDICOS								
13.*Pitch* Médio		Elevado						
		Abaixado						
13.*Pitch* Extensão		Extensão diminuída						
		Extensão aumentada						
13.*Pitch* Variabilidade		Alta						
		Abaixada						
14. *Loudness* Médio		Aumentado						
		Diminuído						
14. *Loudness* Extensão		Extensão diminuída						
		Extensão aumentada						
14. *Loudness* Variabidade		Alta						
		Baixa						
15. Tempo								
Continuidade		Interrompida						
Taxa de elocução		Rápida						
		Lenta						
16.OUTROS ELEMENTOS								
Suporte respiratório		Adequado						
		Inadequado						
		Presente						

Figure 2: *Brazilian Portuguese version of Vocal Profile Analysis Scheme – PB-VPAS (2007)*

General evaluation of voice quality	*O objeto de estudo da Fonética é essa complexa, variável e poderosa face sonora da linguagem: a fala.*	
	Na cidade de São Paulo a contribuição que cada grupo étnico ou regional deu à cidade é vista em cada esquina. Italianos, japoneses, árabes, judeus, portugueses, coreanos e pessoas de todo o país ajudaram e muito a construir esta metrópole. São Paulo é hoje uma metrópole cosmopolita um lugar onde todos se sentem em casa.	
	A Roberta gosta muito de comprar livros de fotos de pássaros. Ela também costuma ir ao jardim zoológico para ver suas aves preferidas: a arara, a garça, o sabiá, o periquito, o tico-tico, a coruja e o tucano.	
Specific settings	**Key-sentences**	**Key-segments**
Phonatory and lingual body settings	*A Lara guarda figuras de pássaros em uma caixa e suas preferidas são a da arara, da patativa, da garça, do canário e do sabiá amarelo*	low central and mid-high vowels
	Liliane diverte-se imitando os trinidos do periquito, do bicudo, do bem-te-vi e do tico-tico.	high front vowels
	O garoto tirou muitas fotografias do tucano, da coruja, do pombo e do jaburu.	high back vowels
Labial, lingual (tip, blade and body) and velopharyngeal (nasal and audible nasal escape)	*Soube que a Casa dos Bispos é visitada por turistas todos os dias e que o roteiro de visita dura cerca de duas horas para ser percorrido*	Oral, posterior and mid-high and high vowels Alveolar fricative consonants
	Detesto ir à casa dele, pois fica do outro lado da cidade e o acesso é difícil.	Alveolar fricative consonants
lingual (tip, blade and body) and velopharyngeal (denasal)	*Não mencionei anteriormente, mas minha mãe morou muitos anos em Santos, numa mansão à beira mar.*	Nasal vowels Alveolar fricative consonants

Figure 3: *Corpus designed to evaluate vocal qualities in Brazilian Portuguese - PB-VPAS*

3.2. Preliminary report on the analysis of voice quality evaluation tasks

Preliminary analysis of data obtained in the first and last training session showed that judges were able to identify phonatory and vocal tract settings better at the last session, specially the first group. For the sake of space, the confusion matrices related to supralaryngeal settings displays only lips, tongue (tip and body), pharynx and nasal cavity settings in Figures 4 and 5, respectively to Stages 1 and 2. The phonatory settings were represented by a group of long-term adjustments, including vertical position of the larynx, displayed in Figures 6 and 7.

	LR	Spr	LTA	LTRe	FTB	BTB	PCon	PExp
LR (N=18)	**6**	0	0	0	0	2	0	6
Spr (N=18)	0	**4**	0	1	1	1	0	0

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LTA (N=18)	1	2	**3**	1	3	0	1	1
LTRe (N=09)	0	1	0	**0**	0	0	3	0
FTB (N=18)	1	2	3	0	**4**	3	1	0
BTB (N=09)	0	1	0	0	0	**1**	1	1
Pcon (N=18)	0	4	0	1	1	1	**4**	1
PExp (N=27)	4	0	2	3	3	1	5	**4**

Legend: LR: Lip Rounding; Spr: Lip Spreading; LTA: Lingual tip advanced; LTRe: Lingual tip retracted; FTB: Fronted tongue body; BTB: Backed tongue body; PCon: Pharyngeal constriction; PExp: Pharyngeal expansion

Figure 4: *Confusion matrix of vocal tract settings (lips, tongue and pharynx) related to voice quality judgment in Stage 1*

	LR	Spr	LTA	LTRe	FTB	BTB	PCon	PExp
LR (N=18)	**7**	0	0	0	1	0	0	4
Spr (N=18)	1	**3**	0	0	0	0	0	0
LTA (N=18)	1	0	**6**	0	0	0	0	1
LTRe (N=09)	1	0	0	**1**	0	0	0	0
FTB (N=18)	0	1	3	1	**1**	1	1	1
BTB (N=09)	0	1	0	0	0	**0**	1	0
PCon (N=18)	1	3	0	0	0	0	**3**	2
PExp (N=27)	1	0	0	0	0	0	4	**0**

Legend: LR: Lip Rounding; Spr: Lip Spreading; LTA; Lingual tip advanced; LTRe: Lingual tip retracted; FTB: fronted tongue body; BTB: Backed tongue body; PCon: Pharyngeal constriction; PExp: Pharyngeal expansion

Figure 5:*Confusion matrix of vocal tract settings (lips, tongue and pharynx) related to voice quality judgment in Stage 2*

	RLar	LLar	LHip	LHyp	Mod	Cvoi	BVoi
RLar (N=18)	**3**	0	1	0	4	0	1
LLar (N=18)	0	**5**	1	0	5	0	1
LHip (N=18)	0	3	**0**	0	4	0	4
LHyp (N=18)	2	3	0	**0**	10	1	3
Mod (N=09)	1	2	0	0	**6**	0	0
Cvoi (N=27)	0	0	1	1	7	**2**	3
BVoi (N=18)	0	5	1	0	5	0	**1**

Legend: RLar: Raised larynx; LLar: Lowered larynx; LHip Laryngeal hipofunction; Lhyp: Laryngeal hyperfunction; Mod: Modal Voice; CVoi: Creaky Voice; BVoi: Breathy voice

Figure 6: *Confusion matrix of vocal tract (larynx,) and some laryngeal (pnonatory) settings related to voice quality judgment in Stage 1*

	RLar	LLar	LHip	LHyp	Mod	Cvoi	BVoi
RLar (N=18)	**2**	0	0	2	0	0	3
LLar (N=18)	1	**5**	4	0	7	0	0
LHip (N=18)	2	0	**7**	0	7	0	3
LHyp (N=18)	3	0	0	**5**	12	3	0
Mod (N=09)	0	1	1	0	**6**	2	0
Cvoi (N=27)	0	3	9	2	7	**3**	6
BVoi (N=18)	0	0	0	0	7	0	**4**

Legend: RLar: Raised larynx; LLar: Lowered larynx; LHip: Laryngeal hipofunction; Lhyp: Laryngeal hyperfunction; Mod: Modal Voice; CVoi: Creaky Voice; BVoi: Breathy voice

Figure 7: *Confusion matrix of vocal tract (larynx) and some laryngeal (pnonatory) settings related to voice quality judgment in Stage 2*

Trainees had better results at the last session, but still had difficulties in evaluating specific settings such as BTB (backed tongue body) and PExp (pharyngeal expansion). As the terminology of supralaryngeal settings is based on segmental phonetic description, linguists were found to have a better performance than speech therapists who were used to evaluating voice qualities in clinical settings with labels restricted to laryngeal activity. Otherwise, speech therapists did better in evaluating laryngeal settings. The functional aspects of laryngeal activity (especially the vibratory pattern of vocal folds) are much emphasized on speech therapy studies. That could explain the higher agreement between speech therapists and experts' labeling of laryngeal settings. Another difficulty faced by the trainees was labelling complex settings. As settings co-occur, they tended to describe only the setting they judged more salient and failed in pointing out related settings such as hyperfunction associated to raised larynx. Some additional strategies for the identification of the settings could be introduced in an extension of the course to improve trainees' performance.

4. Conclusions

The adaptation of the VPAS into Brazilian Portuguese was accomplished and the corpus to be used in the training of judges was built up. Furthermore, the voice quality database necessary for the application of the protocol was recorded, evaluated by expert subjects and integrated into an instructive material. The material was used to train judges and their performance was evaluated. Preliminary data on the analysis of the judges' performance indicate their progress in evaluating settings of voice quality .

As future perspective, the implementation of a continuous numeric scale of settings instead of scalar degrees (from 0 to 6) and a longer period of training are intended.

The relevance of the application of the protocol to the analysis of voice disorders and expressive uses of voice quality may be appreciated considering its usefulness for investigating compensatory mechanisms used by individuals in cases of voice disorders and its suitability for describing the combination of laryngeal and vocal tract settings used to express attitudes and emotion as well as to consider uses of sound symbolism and sound metaphors.

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