



Category: Psychological Acoustics

Audio-Perceptual Features of the Singing Voice Classified by 4 Judges' Groups: Development of an Appreciation Scale

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Audio-perceptual voice analysis is common in clinical practice. Eventhough acoustic analysis provides objective and useful data, audioperception is irreplaceable. The main purpose of this observational research was to develop a singing voice rating scale (*Escala de Apreciação da Voz Cantada – EAVOZC*) and second to identify the Fado's singing voice audio-perceptual profile. EAVOZC has a continuous visual analogue scale with a 50mm line to grade the accentuation level on 13 audio-perceptual voice parameters: 1) pitch, 2) loudness, 3) resonance, 4) phonatory and respiratory coordination, 5) precise articulation, 6) voice quality (roughness, breathiness, strain and asthenia), 7) vibrato, 8) voice projection, 9) voice emotional expression, 10) timbre, 11) brilliance, 12) tuning and 13) global voice appreciation.

This paper reports the audio-perceptual classifications of singing voice using the EAVOZC. 40 judges participated in this study: 10 singing teachers (ST), 10 speech-language pathologists (SLP), 10 Fado singers (FS) and 10 naive listeners (NL). Age ranged from [19–73] yrs. Judges listened to 20 voice samples of the Fado Chorus “Nem ás paredes confesso”. These samples were produced by 10 males, 10 females; 10 amateur, 10 professional singers divided in two age groups [18–55] and [55–70]. Judges filled in the EAVOZC. One-way ANOVA and t-test were used with a α at .05.

Results revealed ST and SLP significantly judged singing voice samples in a similar manner in terms of the audio-parameters above listed. The same happened in the groups FS and NL except for timbre and brilliance. Therefore, from now on the results were presented based on 2 groups instead of 4.

EAVOZC parameters showed that male and female voices' were distinct in roughness, pitch, tuning and global voice appreciation. Professional Fado singers had higher scores in tuning, emotional expression, precise articulation and had less tension when compared to amateurs. Timbre was classified as dark on male voices and light on female voices. Brilliance was absent in males and present in female voices.

Keywords: Audio-perceptual parameters, Singing voice scale, Fado, Judges.



Audio-perceptual features of the singing voice classified by 4 judges' groups: development of an appreciation scale

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Abstract

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1. Main text

Voice is produced through a complex mechanism of neuromuscular coordination involving the respiratory, laryngeal, and supralaryngeal systems (Mendes, Guerreiro, Simões & Moreira, 2013). However many factors may influence voice production: environment, speech context (eg. cheerful, sad), professional singing voice experience, etc. (Behlau, 2001; Ishii, Arashiro & Pereira, 2006). Voice production may entail: spoken voice and sung voice; both share the same physiologic mechanism however with distinct acoustic and audio-perceptual features (Bradley, 2010).

Audio-perceptual voice analysis is common and irreplaceable in clinical practice. Eventhough much software and equipment are available for acoustic analysis (Orlikoff et al., 1999). Audio-perceptual intra- and inter-judge reliability often present higher variability due to its subjectivity. Listeners frequently agree on perceptual classification of normal vs. pathologic voices and disagree in mild and/or moderate deviant voices (Kreiman, Gerrat, Kempster, Erman & Berke, 1993). Naive listeners differ more in the classification of pathologic voices and expert listeners in normal voices classification (Kreiman, Gerrat, Precoda & Berke, 1992; Dedivitis et al., 2004).

There are several scales for the spoken voice but few for the singing voice. The singing scales published in scientific works were mainly designed for specific studies (Oliveira, 2007; LeBorgne, Lee, Stemple & Bush, 2010; Ekholm, Papagiannis & Chagnon, 1998).

Audio-perceptual scales were designed to assess the singers' voice entailing: phonatory and respiratory coordination, pitch, loudness, vocal onset, resonance/ring, focus, nasality, and registration breaks vocal register, brilliance, projection, vibrato,

timbre and vocal quality. The scale types were categorical, equal appearing interval (EAI) and visual analog (VA). (Oliveira, 2007; LeBorgne, Lee, Stemple & Bush, 2010; Ekholm, Papagiannis & Chagnon, 1998; Oates, Bain, Davis, Chapman & Kenny, 2006).

In order to develop a scale it is essential to assess the scales' validity and reliability (Kenneth, Shipley & MacAfee, 2015). There was an acceptable intra and inter rater reliability (ICC>.75) for EAI and VA scales (Oates, Bain, Davis, Chapman & Kenny, 2006). Intra-judge reliability was studied in the VA scale CAPE-V and ordinal scale GRBAS. The conclusions were that CAPE-V was less reliable (Zraick et al., 2011).

EAVOZC was developed in order to allow an objective, qualitative as well as quantitative audio-perceptual rate of the singing voice. Nonetheless there might be an association among audio-perceptual parameters, an altered parameter can have an impact on others but not necessarily. For instance, phonatory and respiratory coordination, voice projection, resonance, precise articulation and also loudness are associated (Penteado, Soares e Camacho, 2006).

Fado singers' voice is audio-perceptually distinct from other vocal musical styles, such as lyric, Country, Musical theater, Soul, Jazz, and Pop singers (Mendes, Rodrigues & Guerreiro, 2012). However there is no scientific evidence that supports this perception or its acoustic correlation (Castelo-Branco, 2004; Gouveia, 2010; Nery, 2004). Therefore it is relevant to characterize quantitatively and qualitatively this voice genre.

Fado is a traditional Portuguese music genre added to United Nations Educational, Scientific, and Cultural Organization's (UNESCO) list of World's Intangible Cultural Heritage in 2011. The singer usually is solo, instrumentally accompanied by viola, classic guitar and Portuguese guitar (Carvalho, 2003; Cook, 2003). Fado songs are melancholic and reflect feelings of sadness, fate and love sorrow (Carvalho, 2003).

The main purpose of this observational research was to develop a singing voice rating scale (EAVOZC) and secondly to identify the Fado's singing voice audio-perceptual profile.

This study will develop teaching, clinical and scientific knowledge of the Fado singing voice. Also it will allow an understanding on Fado's singing vocal features and developing an evidence based practice.

Nomenclature	
ST	Singing teachers
SLP	Speech and language pathologists
FS	Fado singers
NL	Naive listeners
EAVOZC	Singing voice rating scale
EAI	Equal appearing interval
VA	Visual analog

2. Methods

This paper reports the audio-perceptual classifications of singing voice using the EAVOZC. 40 judges participated in this study: 10 singing teachers (ST), 10 speech and language pathologists (SLP), 10 Fado singers (FS) and 10 naive listeners (NL) age ranged from [19-73]; 12 males and 28 females (See Table 1). ST and SLP were chosen because they work with singers, represent the pedagogic and health care areas, in singing and speaking voice respectively; FS are singing voice performers and auditory skilled listeners; and NL are consumers of the singers' production.

Table 1: Judges' characterization.

Judge	Gender	N	Age			Experience (yr)		
			Mean	Min	Max	Mean	Min	Max
ST	M	4	38	35	42	17	10	25
	F	6	53	37	73	30	6	50
SLP	M	2	33	27	39	9	7	10
	F	8	41	26	61	15	5	30
FS	M	3	39	22	61	24	10	40
	F	7	37	21	65	13	5	40
NL	M	3	30	24	37	0	0	0
	F	7	42	19	59	0	0	0
Total		40						

Min = minimum; Max = maximum; ST = singing teachers; SLP = speech and language pathologists, FS = Fado singers; NL = naive listeners; M = male; F = Female.

Judges listened to 20 voice samples of the Fado chorus "Nem às paredes confesso" (*Not even to the walls I confess*) plus four repeated samples (20%) to assess intra-judge reliability. These singing voice samples were produced by 20 Fado singers: 10 males, 10 females; 10 amateur, 10 professional singers divided in two age groups [18-55] and [55-70].

Each judge heard 24 voice stimuli for a total of 800 voice appreciations.

Inclusion criteria for judges' selection were: 1) Five years of voice experience, 2) Hearing within normal limits, 3) Literate and 4) European portuguese as native language.

Judges were chosen by convenience using the "snowball method". In "snowball method" the initial subjects provide names of potential subjects (Ribeiro, 2007).

Procedures

All judges had an auditory screening performed to guarantee that their auditory acuity was within normal limits for speech production purposes. Pure-tone frequencies of 1000, 2000, and 4000 Hz at 25 dB were given using a GSI 17 Audiometer (Asha, 1997-2015).

Voice samples were given three times each in free field at 70 dB. Noise environment was always less than 50dB, measured with a Mini Sound Level Meter INO 4453 Standard ST-805. Judges filled in the EAVOZC.

20 voice samples were divided in 2 subsections with 10 voice samples each and a 3rd subsection with the 4 repeated samples. There were five minutes interval between each subsection to avoid fatigue.

Scale

EAVOZC is a continuous visual analogue scale with a 50mm line to grade the accentuation level (the greater accentuation the higher the score). Zero means adequate and ± 100 means altered. The rationale for this decision was based on the higher sensitivity of visual analog scales (Nemr et al., 2012; Oates, Bain, Davis, Chapman & Kenny, 2006). This scale also includes six dicotomic items: gender, age, timbre, brilliance, professional experience classification (amateur vs. professional), and a yes/no question about the desire to continue to hear the same singer.

EAVOZC has five categories with audio-perceptual parameters: (A) pitch and loudness, (B) Resonance (nasal, oral and laryngopharyngeal), (C) Phonatory and respiratory coordination and precise articulation, (D) Voice quality (roughness, breathiness, strain and asthenia), (E) Vibrato, voice projection, voice emotional expression, timbre, brilliance, tuning and global voice appreciation.

The scale also entails four parameters related with gender, age, professional experience classification (amateur vs. professional), and if the judge would like to hear the given voice sample.

EAVOZC content validity was assessed by 12 judges: 3 ST, 3 SLP 3 FS and 3 NL. A thematic analysis was performed in order to improve the

content and form. Intra-judge reliability was assessed repeated judgments of voice samples and inter-rater reliability was assessed by comparing the 4 groups judgments.

Statistical analysis

Intra-judge reliability analysis was based on the repeated voice samples using Pearson Correlation (Pestana e Gageiro, 2003). Inter-judge reliability was determined with one way ANOVA ($\alpha < .05$).

Audio-perceptual parameter differences according to gender, age group and professional experience were determined with t-test.

3. Results

Intra judge reliability was performed by 38 judges on 4 repeated voice samples (20%).

Reliability was high in roughness ($r_{ST+SLP} = .79$; $r_{FS+NL} = .75$), asthenia ($r_{ST+SLP} = .71$; $r_{FS+NL} = .72$), gender classification ($r_{ST+SLP} = .98$; $r_{FS+NL} = .97$) and in loudness ($r_{ST+SLP} = .86$). Reliability was low in vibrato presence ($r_{ST+SLP} = .38$; $r_{FS+NL} = .06$), nasal ($r_{FS+NL} = .30$) and oral ($r_{ST+SLP} = .39$) resonance, precise articulation ($r_{FS+NL} = .37$) and professional classification ($r_{FS+NL} = .35$).

Inter judge reliability

One way ANOVA was performed to determine inter judge reliability among the 4 groups of judges. The groups ST and SLP had similar responses as well as groups FS and NL. The 4 groups were clustered into 2 groups for analysis of audio-perceptual parameters, except for timbre and brilliance. The same trend was found in judgments however with higher scores given by FS+NL comparing to ST+SLP.

EAVOZC Judgments

For gender classification, male Fado singer voices correctly identified as males (100%) by ST and FS judges These scores decreased for SLP and NL, 97% and 99% respectively. Female Fado singers voice samples were correctly identified as females by all judges except for NL (99%). All voices were mainly identified as amateurs and belonging to the age group [18-55] by the 4 groups of judges (See Table 2).

Table 2. Audio-perceptual parameters judgments of gender, age group and professional experience.

		ST	SLP	FS	NL	
		% (right answers)				
Gender	Male	100	100	97	100	99
	Female	100	100	100	100	99
Age range	<18	0	-	-	-	-
	[18-55]	180	70	72	78	53
	[55-70]	20	70	60	55	50
	>70	0	-	-	-	-
Professional experience	Amateur	100	59	70	80	70
	Professional	100	52	46	37	30

ST = singing teachers, SLP = speech and language pathologists, FS = fado singers; NL = naive listeners.

Roughness in male voices' was significantly ($p=.00$) higher comparing with females. Amateurs and older Fado singers also exhibited high scores for both genders (See Figure 1).

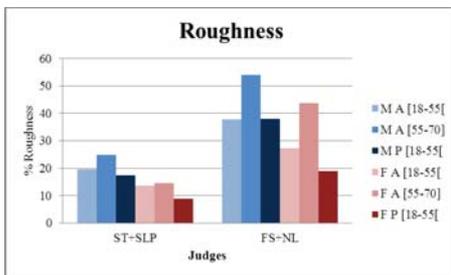


Figure 1. Judges' classifications of roughness.

Breathiness generally had higher scores in males compared with females, amateurs compared with professionals and older compared with younger Fado singers (See Figure 2).

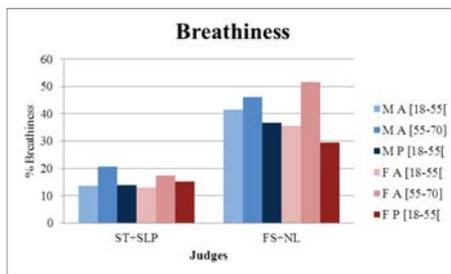


Figure 2. Judges' classifications of breathiness.

Tension was generally significant higher for males ($p_{ST+SLP}=.02$; $p_{FS+NL}=.03$) compared with females. Amateurs were classified with higher scores compared with professionals and older compared with younger Fado singers. Older female Fado

singers had the higher scores, meaning a more tense voice (See Figure 3).

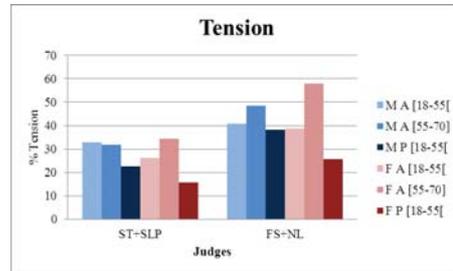


Figure 3. Judges' classifications of tension.

Asthenia had the higher scores in male amateurs. Older Fado singers were scored higher indicating a more asthenic voice (See Figure 4).

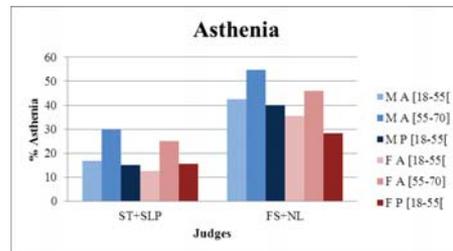


Figure 4. Judges' classifications of asthenia.

Negative loudness indicated a weak loudness of Fado singers (41.5%) (See Figure 5). 29% of scores indicated an adequate loudness. Loudness was scored with negative values by most judges. Loudness had higher scores in males compared with females, amateurs compared with professionals and younger compared with older singers.

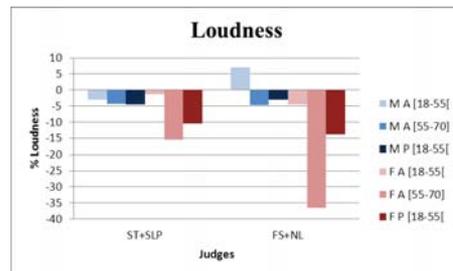


Figure 5. Judges' classifications of loudness.

Voice projection was classified with lower scores indicating better voice projection for males compared with females, professionals compared with amateurs

and younger compared with older singers (See Figure 6).

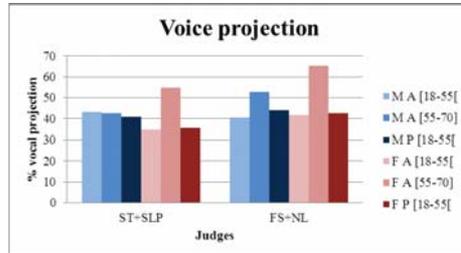


Figure 6. Judges' classifications of voice projection.

Pitch was classified as lower for males and higher for females by all judges. Pitch was scored as deep for males and acute for females. Professional Fado singers were usually scored with deeper voices than amateurs as well as older comparing to younger singers (See Figure 7).

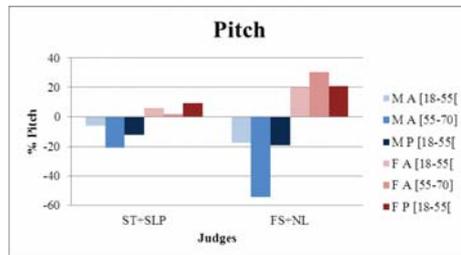


Figure 7. Judges' classifications of pitch.

Vibrato was identified most of the times in these voices (70-89%). It was classified as exaggerated in males and weak in females (see Figure 8).

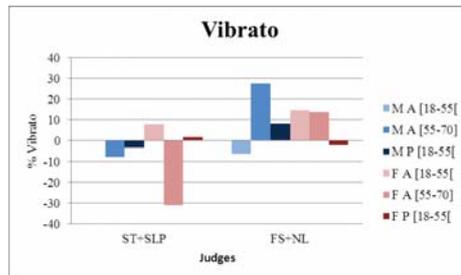


Figure 8. Judges' classifications of vibrato.

Fado singers were mostly in tune considering a cut-off point at 50%. Older females were scored with less tuning voice. Professionals were more in tune according to judges (See Figure 9).

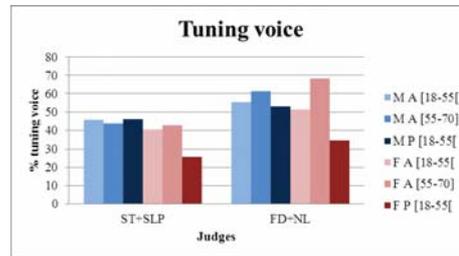


Figure 9. Judges' classifications of tuning voice.

Resonance was scored with higher values in laryngo-pharyngeal resonance (See Figure 10).

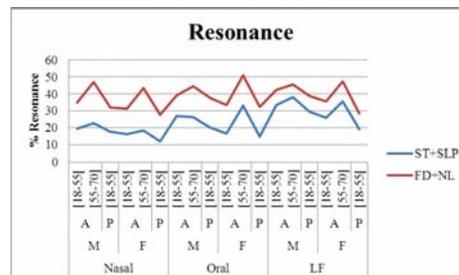


Figure 10. Judges' classifications of resonance.

Voice emotional expression was classified with higher scores indicating less emotional expression on males compared with females, amateurs compared with professionals and older compared with younger Fado singers. Amateur older females were an exception, they had the higher scores and therefore less emotional expression (See Figure 11).

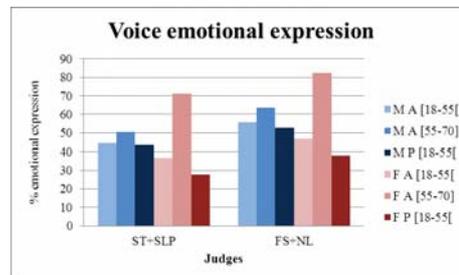


Figure 11. Judges' classifications of emotional expression.

Phonatory and respiratory coordination was scored high indicating less breathing and speaking coordination in amateur older Fado singers. Professionals and younger Fado singers were low

scored indicating higher breathing and speaking coordination (See Figure 12).

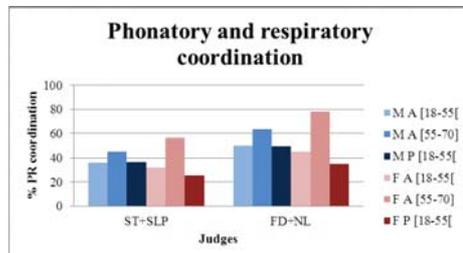


Figure 12. Judges' classifications of Phonatory and respiratory coordination.

Precise articulation had higher scores for amateurs compared with professionals and older compared with younger Fado singers therefore less articulation precision. The cut-off point at 50% indicates a good articulation precision. This parameter was scored with similar trend except for male professionals and female younger amateurs: ST+SLP scored male professionals with lower values (higher verbal precision) than female younger amateur. (See Figure 13).

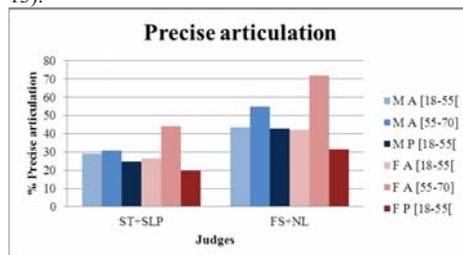


Figure 13. Judges' classifications of precise articulation.

Global voice appreciation was classified with higher scores on amateurs compared with professionals and older compared with younger Fado singers. This means they were considered to have the most unpleasant voices.

Female older amateurs had the higher scores and female professionals the lowest scores (See Figure 14).

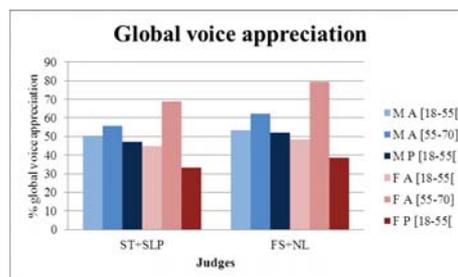


Figure 14. Judges' classifications of global voice appreciation.

For timbre, male voices were classified as "dark" and females as "light". SLP were the judges who scored timbre as 'Don't know' more times (See Figure 15).

Brilliance was classified as absent in male and amateur voices and present in females and professional voices. Brilliance was usually absent in younger female amateur singers' and present in professionals' voice.

4. Discussion

This study audio-perceptually measured sung voice productions of Fado singers.

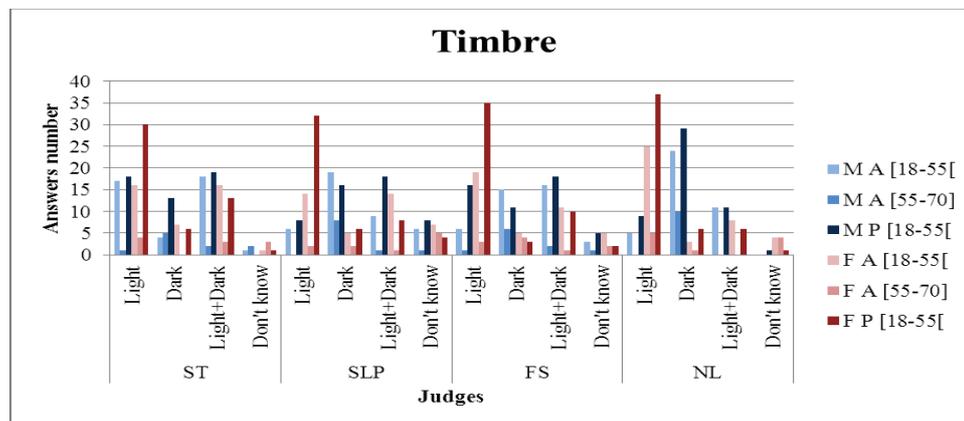


Figure 15. Judges' classifications of timbre.

A singing voice rating scale was developed, its validity and reliability were tested.

Validity was tested with 12 judges to improve content and form.

Intra-judge reliability of this VA scale was high in roughness, asthenia, gender classification and loudness. Intra-judge reliability was low for EAVOZC as for CAPE-V comparing to GRBAS (Zraick et al., 2011). Possibly because a VA scale has a wider range of possible values comparing to a categorical scale.

Inter-judge reliability was tested and the 4 groups were clustered into 2 groups: ST+SLP and FS+NL. t-test showed no significant differences between these groups scores ($p > .05$). ST and SLP gave lower scores comparing to FS and NL however the trends were usually the same but with different scores. This inter-judge reliability makes sense since ST and SLP have a structured background on voice, singing and/or spoken. FS and NL had similar scores which mean they share a common knowledge on singing voice in the light of consumers.

There is a high variability intra and inter judges due to its subjectivity which are usual in perceptual studies. Fado singers presented some high scores which may be mild or moderate deviant described as having lower reliability (Kreiman et al., 1992; Kreiman et al., 1993; Dedivitis et al., 2004).

Fado singers' voice had parameters that may be pointed as detectors: roughness and pitch for gender; tension, tuning, emotional expression, coordination of breathing-speaking and precise articulation for professional experience; loudness, emotional expression and coordination of breathing-speaking for age range ($p < .05$). Global appreciation had significant different scores for gender, age group and professional experience.

Professional Fado singers exhibited lower scores in roughness, breathiness, tension and asthenia than amateurs. These results might indicate that singing training has an effect in these voice quality parameters possibly through acquisition of vocal technique.

As expected male Fado singers had lower F_0 and females higher F_0 therefore a deeper pitch for males and an acute pitch for females. This acoustic measure is audio-perceptually related to pitch. A sadder environment displays deeper sounds (Behlau, 2001) and Fado is a music style that reflects sad and melancholic feelings (Carvalho, 2003). Therefore it would be expected a deeper voice however Fado evolved. This evolution implied changes in lyrics and music, these days it's possible to find happier Fado songs and consequently acute sounds. Another aspect

to be considered is personal style that implicates changes in pitch which adds singer's variability.

The significant differences ($p < .05$) found between professional experience (amateur vs professional) in tuning can be explained by the "trained ear" that professionals develop (Ishii, Arashiro & Pereira, 2006) and that can be acquired with singing training.

Unbalanced resonance system affect voice projection as it will not allow to shape and project the sound; and in emotional expression as a balanced resonance system allows muscular mobility that provides different emotions (Behlau, 2001). Fado singers had deviated scores in resonance, voice projection and emotional expression.

Phonatory and respiratory coordination and precise articulation had more deviant scores in amateurs vs professionals. Once again, sets the singing training along with the vocal technique developed in professional Fado singers. Difficulty in coordination of breathing during phonation implies deviant voice projection which is related to resonance, articulation and loudness (Penteado, Soares e Camacho, 2006). All these parameters were highly scored in Fado singers and may have contributed to the incoordination scores of breathing and speaking.

5. Conclusion

EAVOZC validity and reliability were tested. As a VA scale there are some low reliability parameters. There was a clear tendency for ST and SLT and for FS and NL to have similar classifications. This might be due to their academic and professional backgrounds or lack of formal education, respectively.

The 4 judge groups unanimously classified Fado male singers' voice as low and female as high pitch.

Fado singers' loudness was generally classified as weak.

For roughness and breathiness, all 4 judges groups presented a similar pattern of classifications but with different accentuation levels.

Timbre was classified as dark for male voices and light for females. Brilliance was absent in males and present in female voices.

Vibrato classifications were similar for all judges, generally exaggerated. Females were generally classified with higher values.

This study developed a reliable scale and revealed the audio-perceptual profile of Fado singers. This knowledge can be generalized on pedagogic, clinic and scientific level.

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