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Fado's Voice – Acoustic Features

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Fado is a popular Portuguese singing style acoustically characterized by reduced fundamental frequency, jitter as well as shimmer and perceptually by a low pitch, hoarse and strained voice. This study aims to scientifically contribute to the acoustic understanding of Fado singer's voice profile.

104 Fado singers participated on this study: 47 males, 57 females; 90 amateur and 14 professional, with ages from [18–67]. Fado singers produced spoken tasks consisting on sustained [a,i,u,s,z] plus reading aloud and sung tasks consisting on sustained [a,i,u] of the song "Nem ás paredes confesso". Acoustic voice parameters were compared between males vs. females, professionals vs. amateurs and young vs. older voices a two independent t-test with an α at .05.

Spoken voice samples of Fado singers presented: 1)higher values for F_0, jitter, shimmer and NHRcomparing to nonsingers; 2) lower F0 for maleprofessionals with age range [55–70] vs. amateurs ,formale amateurs with age range [18–55] vs. [55–70] yrold, and for female professionals vs. amateurs (exceptfor [a]); 3) older females had higher F0 than youngersingers, except for [a]; 4) professional male singershad higher jitter and shimmer than amateurs; and 5)professional female singers had lower jitter andhigher shimmer than amateurs.

Sung voice results revealed that males' and females' Fado voice were acoustically distinct in fundamental frequency and perturbation measures. Along with vibrato, these measures were similar for different age groups as for amateurs and professionals. Vibrato was present in most singers: vibrato rate ranged 5.49–6.82 Hz and extent 0.28–0.59 ST for males; and 5.23–5.99 Hz and 0.29–0.54 ST for females. Lastly, singers' formant was rarely present.

An important step was accomplished with this pioneer study in obtaining the Fado's singer voice profile. This knowledge can be generalized and applied on pedagogic, clinic and scientific level.

Keywords: Acoustic features, Sung voice, Fado.

Fado's voice – acoustic features

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Abstract

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Spoken voice samples of Fado singers presented: 1) higher values for F_0, jitter, shimmer and NHR comparing to nonsingers; 2) lower F_0 for male professionals with age range [55-70[vs. amateurs ,for male amateurs with age range [18-55[vs. [55-70[yr old, and for female professionals vs. amateurs (except for [a]); 3) older females had higher F_0 than younger singers, except for [a]; 4) professional male singers had higher jitter and shimmer than amateurs; and 5) professional female singers had lower jitter and higher shimmer than amateurs.

Sung voice results revealed that males' and females' Fado voice were acoustically distinct in fundamental frequency and perturbation measures. Along with vibrato, these measures were similar for different age groups as for amateurs and professionals. Vibrato was present in most singers: vibrato rate ranged 5.49-6.82 Hz and extent 0.28-0.59 ST for males; and 5.23-5.99 Hz and 0.29-0.54 ST for females. Lastly, singers' formant was rarely present.

An important step was accomplished with this pioneer study in obtaining the Fado's singer voice profile. This knowledge can be generalized and applied on pedagogic, clinic and scientific level.

Keywords: Acoustic features, sung voice, Fado.

1. Main text

Fado (latin *fatum* = fate) is a traditional Portuguese singing style. In 2011, it was added to United Nations Educational, Scientific, and Cultural Organization's (UNESCO, 2011) list of World's Intangible Cultural Heritage.

The voice of Fado is audioperceptually distinct from other vocal musical styles such as lyric, Pop Jazz, Soul, Country and Musical theater singers (Mendes, Rodrigues & Guerreiro, 2012). Although there is no scientific evidence that supports this perception or its acoustics underlying. This paper defines the acoustic and phonatory voice profile of the portuguese music genre Fado.

Temporal measures of maximum phonation time (MPT) and s/z ratio determine stability and efficiency of coordination between breathing and phonation (Mendes & Castro, 2005). MPT average of males is 20-29.9s and females 15-21.7s (Kent, Kent e Rosenbek, 1987; Toyoda, Ogawa, Oya & Kawai, 2004). A reduced MPT means an inefficient respiratory and phonatory system (Colton, Leonard & Casper, 2011). Normal s/z ratio value is 1 and a higher ratio means laryngeal abnormality (Eckel & Boone, 1981).

Fundamental frequency (F_0) changes across age: for children ranges 210-450 Hz; males ranges 100-150 Hz and females 170-230 Hz. At 65 years old F_0 of males and females start to approximate: M≈120-175 Hz; F≈150-225 Hz (Hollien, Hollien & Jong, 1997). Adult soprano singers' F_0 in reading aloud ranged 193-273 Hz (Drew & Sapir, 1995); 126-128 Hz in males and 201-207 Hz in females (Rothman, Brown, Sapienza & Morris, 2001).

Perturbation measures jitter, shimmer and NHR provide the acoustic signal fluctuation physiologically characterized by a variation in the vibration cycle pattern. Males' jitter in non-singers ranged 0.30-0.98% for [a], 0.26-0.72% for [i] and 0.29-0.49% for [u]; and for females 0.37-0.76% for [a], 0.32-1.14% for [i] and 0.31-0.82% for [u] (Araújo, Grellet, Pereira & Rosa, 2002; Brockman, Drinnan, Storck & Carding, 2009; Felippe, Grillo & Grechi, 2006; Morente et al., 2001). Males shimmer for non-singers

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ranged 0.57-0.65 and females 0.84-2.10% (Andrianopoulos, Darrow & Chen, 2001). Males' NHR in non-singers was 0.12 and females' NHR ranged 0.09-0.11 (Andrianopoulos, Darrow, & Chen, 2001). Normal NHR for nonsmokers was 0.02 and for smokers 0.05 (Pinto, Crespo e Mourão, 2014).

The singer's formant is an extra energy peak with frequency range 2.4-3.6 Hz produced by a clustering of F3-F5 (Sundberg, 2001). There are some parameters that may compromise the singer's formant: the lack of respiratory support, vocal fold tension and reduced sound wave (Sundberg, 1972; Sundberg, 1987; Sundberg, 2001; Gusmão, Campos & Maia, 2010).

Vibrato parameters rate and extent have significant differences in gender. Females have faster vibrato rate and greater extent than males (Sundberg, 1994; Guzman et al., 2012). Vocal training lead to higher vibrato rate regularity and stable extent however 4 semesters are not enough to develop a stable vibrato (Mitchell & Kenny, 2010; Mendes, Rothman, Sapienza & Brown, 2003). Vibrato rate has higher variability in males vs. females (Mitchell & Kenny, 2010). Lyric singers exhibit vibrate rate between 4-7 Hz (Benninger & Murry, 2008). Professional lyric singers exhibit a rate of vibrato range of 6.28-7.14 Hz and extent 0.38-3.26 ST (Dejonckere & Sundberg 1995; Howes, Callaghan, Davis, Kenny & Thorpe, 2004) and sertanejo singers (Brazilian music style) have vibrato rate of 5.00-6.56 Hz and extent 0.54-0.95 ST (Bezerra, Blaj, Duprat, Camargo & Granato, 2009).

The pertinence of this study stands on the requirement of scientific basis for therapeutic intervention (ENT specialists and voice pathologist) and singing training (singing teachers and voice coaches) of Fado singers. The objective of this research was to identify the Fado's speaking and singing voice acoustic profile and determine differences in gender, age and professional experience (amateur vs. professional).

Nomenclature

CSL	Computerized Speech Lab
ENT	Ear Nose and Throat
EP	European Portuguese
F_0	Fundamental frequency
Hz	Hertz
MDVP	Advanced Multi-Dimensional Voice Program
MPFR	Maximum Phonation Frequency Range
MPT	Maximum Phonatiom Time
NHR	Noise-to-harmonic ratio
ST	Semi- tone

2. Methods

Subjects

104 Fado singers participated of this observational research: 47 males, 57 females; ages from [18-67] which were divided into two age groups, 76% ranged [18-55[and 24% ranged [55-70[years; 90 amateur and 14 professional. 38% males had past musical and 45% had singing training, 24.5% females had past musical training and 37% singing training. Average daily hour singing practice was 15 for males and 12 hours/day females. The majority of subjects did not smoke or drink and reported a good physical condition (See Table 1).

Table 1. Subjects' characterizazion.

		Gender			
		M		F	
		N	Mean±SD	N	Mean±SD
Age		47	46±15	57	41±14
Musical training (mo)	Past	18	19±55	14	26±16
	Present	4	4±20	2	72±34
Singing training (mo)	Past	21	21±57	21	30±35
	Present	4	4±18	7	44±30
Singing practice (hr/day)		47	15±12	57	12±10
Singing Fado experience (yrs)		47	24±16	57	17±14
Smoking habits	No	28	-	44	-
	Yes	19	-	13	-
Drinking habits	No	25	-	47	-
	Yes	22	-	20	-
Physical condition	Poor	2	-	1	-
	Reasonable	14	-	15	-
	Good	22	-	35	-
	Excellent	9	-	6	-
Subtotal		47		57	
Total		104			

M = male; F = female A = amateur; P = professional; SD = standard deviation; mo = months; yrs = years.

Inclusion criteria were: (1) native European Portuguese (EP) speakers; (2) 18 years as minimum age; (3) no history of voice, speech, and/or language disorders; (4) no history of allergic and/or respiratory problems on recording day; (5) literacy abilities; and (6) no knowledge and/or participation on a similar study.

Subjects were classified by their professional experience using the following criteria: 1) reimbursement for the singing performances; 2) singing training; and 3) annual ENT assessment. If all four criteria were met the singer was classified as professional.

Before recording sessions subjects' received a written and verbal explanation of the procedures and signed an informed consent form. The consent form

was approved by the Ethics Committee for Research (ECR) of the Health Science School of Polytechnic Institute of Setúbal. A vocal health and background questionnaire was filled to ensure subjects' vocal health and to collect demographic data.

Phonatory tasks

All subjects performed spoken and sung tasks in a standing position. Spoken tasks included: sustaining [a, i, u] and [s, z] three times each and reading aloud the European Portuguese (EP) phonetically balanced text "O Sol" (*The Sun*) (Mendes, Costa, Martins, Fernandes, Vicente & Freitas, 2012). Sung tasks consisted of maximum phonation frequency range (MPFR) and sustaining vowels in three words: [a] of the word "afinal" (*after all*), [i] in the word "esqueci" (*forgot*) and [u] in the word "confesso" (*confess*) from the Fado song "Nem às paredes confesso" (*Not even to the walls I confess*). Subjects' were asked to sing *a cappella* at a comfortable pitch and vocal intensity as well as sustain target vowels for at least 6 seconds.

Spoken tasks provided the acoustic measures MPT, s/z ratio, F_0, jitter, shimmer and NHR. Sung tasks provided MPFR, F_0, jitter, shimmer, NHR, vibrato rate and extent and singers' formant. MPFR encompassed frequencies from the lowest modal register to the highest falsetto register (vocal fry not included). MPFR was obtained through the minimum and maximum frequencies range presented in Hertz (Hz) and semitones (ST). A digital keybord with discrete-step procedures were used to provide reference frequencies as well as audio feedback to the researcher and the subject.

Equipment

All phonatory tasks were recorded with noise environment less than 50 dB measured with a Mini Sound Level Meter INO 4453 Standard ST-805. Voice productions were obtained using a head-mounted microphone AKG C520L MicroMic placed from the right corner of the mouth and at 45º. An Agilent Technologies HP 8496A attenuator was activated to avoid peak clipping of loud phonations. Voice samples were recorded to a DR-680 Portable Multitrack Recorder TASCAM. For calibration purposes, a 500 Hz pure tone of 80 dB sound pressure level (SPL), at 3 cm distance from sound source to microphone, was recorded for 10 seconds. Samples were digitized at a rate of 48.0 kHz in mono sound and 24-bit resolution. Acoustic analyses were obtained using a Pentium IV with Computerized Speech Lab (CSL) model 4500 hardware and Advanced Multi-Dimensional Voice Program (MDVP) and MultiSpeech softwares of KayPENTAX. For the vibrato analysis of sustained sung Fado's vowels, Praat software was used to capture and select the needed sound sample. The SingingStudio from Seegnal Research was used to analyse the vibrato rate and extension. At least 3 cycles were used to obtain vibrato data with a maximum of 6 cycles.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) 22.0 was used for inferential statistics. A two independent t-test was used to determine differences between acoustic parameters on gender, age and professional experience. Alpha level was set at .05.

3. Results

Speaking voice

MPT mean values were higher in males comparing to females except for younger amateur singers. MPT was higher in younger vs. older and amateurs vs. professionals singers in both genders, but females reached significancy, ie. p=.01 and p=.05, respectively (See Table 2 and 3).

S/z ratio was higher in males comparing to females except for older amateurs. The mean values in male singers was higher in younger vs. older and professionals vs. amateurs. Female singers had higher s/z rate values in older vs. younger and amateurs vs. professionals (See Table 2).

Table 2. Mean values and standard deviations (Mean±SD) of MPT and s/z.

		M				F			
		A		P		A		P	
		N	Mean ±SD	N	Mean ±SD	N	Mean ±SD	N	Mean ±SD
MPT	[18-55[	26	18.82 ±6,44	5	18.44 ±10.72	39	20.07 ± 6.67	8	14.92 ±3.36
	[55-70]	15	17.78 ±6.09	0	-	10	14.29 ± 8.14	0	-
s/z	[18-55[	26	1.21 ±0.37	5	1.35 ±0.81	39	1.19 ± 0.33	8	1.16 ±0.17
	[55-70]	15	1.04 ±0.53	0	-	10	1.32 ± 0.37	0	-
Subtotal		46				57			
Total		103[1]							

M = male; F = female A = amateur; P = professional; SD = standard deviation; MPT= Maximum phonation time.
[1] One male amateur was not able to perform MPT and s/z tasks.

Table 3. Acoustic parameters significant p-values.

	Parameter	Variable			t	p-value
Speaking voice	MPT	Female	Age	A	2.53	0.02
		Female	A-P		2.69	0.01
	F_0 [a]	Sex			-8.74	0.00
	F_0 [i]				-8.16	0.00
	F_0 [u]				-8.38	0.00
	F_0 reading				-14.21	0.00
	jitter [a]	Female			-2.03	0.05
	Shimmer [a]	Male	Age	A	-2.57	0.01
		Female			-1.98	0.05
	NHR [a]	Gender			2.90	0.01
Singing vocie	MPFR	Female	Age	A	3.10	0.00
	F_0 [a]	Sex			-12.20	0.00
	F_0 [i]				-14.13	0.00
	F_0 [u]				-12.65	0.00
	F_0 chorus				-13.88	0.00
	Jitter [i]	Male	Age	A	-2.29	0.03
	Jitter [u]	Female	A-P		-2.07	0.04
	Shimmer [a]	Sex			2.39	0.02
		Male	Age	A	-3.20	0.00
	Shimmer [i]	Sex			2.77	0.01
		Male	Age	A	-2.73	0.03
	NHR [a]	Sex			2.90	0.01
		Female	A-P		2.23	0.03
	NHR [i]	Sex			3.34	0.00
		Male	Age	A	-2.05	0.05
	NHR [u]	Sex			4.70	0.00
					-2.54	0.02
	Vibrato extent [i]	Male	Age	A	-2.69	0.01

M=male, F=female, A=amateur, P=professional; MPT=Maximum phonation time; MPFR=Maximum phonation frequency range
$p<.05$

F_0 for sustained vowels was significantly higher in females than in male singers (p=.00), as it was expected (See Table 3). For the male group, F_0 had higher means in younger vs. older and amateurs vs. professionals. Female singers had higher mean F_0 values in older vs younger and amateurs vs. professionals, except for [a] (See Figure 1).

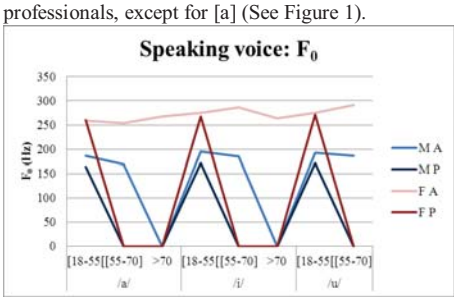

Figure 1 F_0 of sustained vowels in speaking voice, M=male, F=female, A=amateur, P=professional.

Mean jitter for sustained vowels was generally lower for male vs. female amateurs, and higher for male vs. female professionals (except [u]). Jitter in male singers was higher in older vs. younger (except for [i]) singers and professionals vs. amateurs (except for [u]). Female singers had higher mean jitter values in older vs. younger (except [i]) singers and professionals vs. amateurs (See Figure 2).

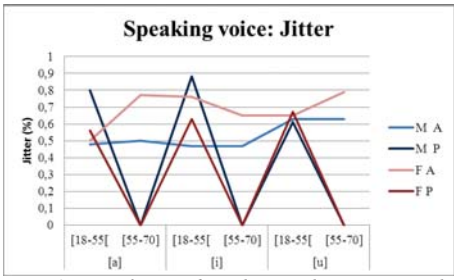

Figure 2. Jitter of sustained vowels in speaking voice, M=male, F=female, A=amateur, P=professional.

Mean shimmer in male amateurs for sustained [a,i] was lower (except older singers in [i]), and for sustained [u] was higher comparing to females. Mean shimmer was higher for male professionals comparing to females. Shimmer in male singers was higher in older vs. younger (except for [u]) and professionals vs. amateurs. Female singers' had higher mean shimmer values in younger vs older (except for [a]) and professional vs amateur (except for [i]) singers (See Figure 3).

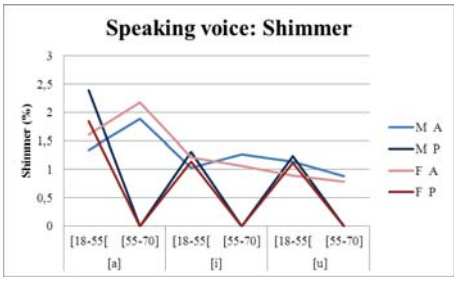

Figure 3. Shimmer of sustained vowels in speaking voice, M=male, F=female, A=amateur, P=professional.

NHR was significantly different between genders in [a] (p=.01) (See Table 3). NHR had higher mean values for males vs. females.

Mean F_0 of the reading aloud task revealed significant higher values for females vs. males (p=.00) (See Table 3). Mean F_0 was higher for older vs younger singers and male amateur vs. professional singers. Female singers had higher F_0 in younger vs. older and professional vs. amateur singers (See Table 4).

Table 4. Mean values and standard deviations of reading aloud task.

		M				F			
		A		P		A		P	
		N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
F_0 (Hz)	[18-55[	27	125.83 ±22.10	5	114.89± 18.04	37	200.80 ±29.95	8	215.41 ±18.70
	[55-70]	15	130.68 ±28.09	0	-	11	193.16 ±31.73	0	-
Subtotal		47				57			
Total		104							

M = male; F = female, A= amateur; P = professional; SD = standard deviation; F_0 = fundamental frequency.

Singing voice

MPFR was wider for males vs. females. It was wider for both genders in younger and professionals' voice. Younger female MPFR values were significant wider than older female singers (p=.00) (See Table 3). Male singers MPFR ranged 40-72 ST and female singers ranged 52-84 ST.

For the sung task F_0 exhibited significant differences between gender (p=.00) (See Table 3). As expected, females had higher F_0 than males. F_0 of sustained vowels was higher for male younger vs. older singers and amateurs vs. professionals. Mean F_0 was higher for female older vs. younger (except for [a]) singer and professionals vs. amateurs (See Figure 4).

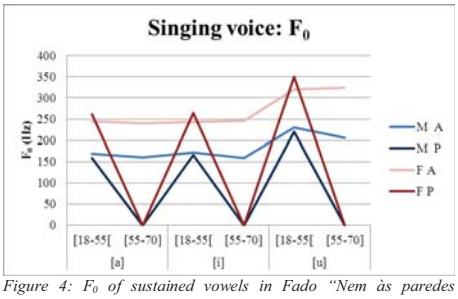

Figure 4: F_0 of sustained vowels in Fado "Nem às paredes confesso", M=male, F=female, A=amateur, P=professional.

Mean jitter of sung sustained vowels in singing was higher for male vs. female most of times (except professionals [i], younger amateurs and professionals [u]). Jitter was higher for older male vs. younger singers and professionals vs. amateurs (except for [a]). Mean jitter was higher for younger female vs. older (except for [a]) singers and professionals vs. amateurs (except for [a]) (See Figure 5).

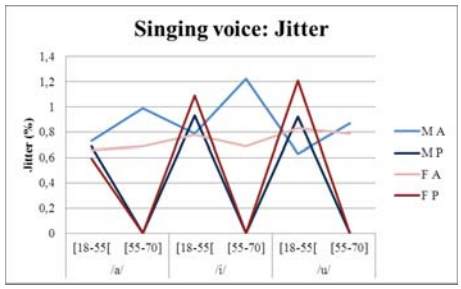

Figure 5. Jitter of sustained vowels in Fado "Nem às paredes confesso", M=male, F=female, A=amateur, P=professional.

Mean shimmer of sustained sung vowels was higher, significantly in males for [a] (p=.02), [i] (p=.01), and [u] (except younger amateurs). Shimmer was higher for male older vs. younger (significantly higher for [a,i], p<.05) (See Table 3) singers and professionals vs. amateurs. Mean shimmer was higher on older females vs younger (except for [u]) singers and amateurs vs professionals (except for [u]) (See Figure 6). Shimmer mean values were significantly lower on females on [a,i] (p<.05) (See Table 3).

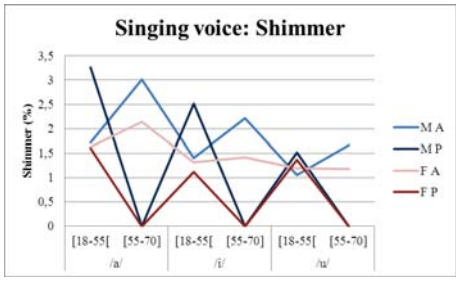

Figure 6. Shimmer of sustained vowels in Fado "Nem às paredes confesso", M=male, F=female, A=amateur, P=professional.

NHR was significantly different between genders (p<.05) (See Table 3) with higher mean values in males vs. females. Mean NHR was slightly higher on older males vs. younger (except for [a]) (See Table 3) singers and professionals vs. amateurs (except for [i]). NHR was higher on older females vs. younger and amateurs vs. professionals.

F_0 of the Fado sung task was significantly higher in females than in male singers (p=.00), as it was expected (See Table 3). Mean F_0 was higher for younger vs. older males and amateurs vs. professionals. For females, F_0 was higher in younger vs. older singers and professionals vs. amateurs (See Table 5).

Table 5. Mean values and standard deviations of F_0 of Fado sung task.

		M				F			
		A		P		A		P	
		N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Fado's chorus F_0 (Hz)	[18-55[	27	234.38 ±26.50	5	227.95± 22.02	37	328.52± 46.29	8	354.17± 26.97
	[55-70]	15	213.66 ±54.56	0	-	11	286.49± 65.31	0	-
Subtotal		47				57			
Total		104							

F_0 = fundamental frequency; SD = standard deviation; A = amateur; P = professional; M = male; F = female.

Vibrato frequency for male amateurs ranged 5.49 - 6.17 Hz and vibrato extension 0.28-0.59 ST; male professionals' vibrato frequency ranged 6.15-6.82 Hz and extension 0.30-0.36 ST. Vibrato frequency for female amateurs' ranged 5,66-6,13 Hz and extension ranged 0.29-0.46 ST; female professionals' frequency vibrato ranged 5.23-5.88 Hz and extension 0.44-0.54 ST.

In 104 subjects, 5 younger female singers produced peak amplitudes between 3 and 5 dB with the frequency range of 2800–3500 Hz in the chorus of the Fado. Formant frequencies centered 2969-3137 Hz with a peak amplitude between 3-7 dB.

4. Discussion

This study acoustically measured spoken and sung voice productions of male and female, amateur and professional, and younger and older Fado singers. Temporal, spectral, and perturbation measures were obtained from spoken and sung voice productions.

MPT mean values and s/z ratio were considered near the inefficient threshold. This might reveal inefficient coordination between respiratory and laryngeal systems of these singers. The lack of formal singing education may have affected on these acoustic measures.

In speaking voice both gender exhibited higher F_0 mean comparing to PE nonsingers and to vocal coalescent model (Guimarães & Abberton, 2005; Hollien, Hollien & Jong, 1997). It is important to bear in mind that SD values were high which indicate a high variability among subjects. Professional Fado singers' exhibited lower F_0 and therefore a deeper voice.

Perturbation measures jitter and shimmer of spoken voice were within normative values. Jitter was higher compared with nonsingers (Araújo, Grellet, Pereira & Rosa, 2002; Brockman, Drinnan, Storck & Carding, 2009; Deem et al., 1991; Felippe, Grillo & Grechi, 2006; Morente et al., 2001). Shimmer was generally higher for males and lower for females compared to nonsingers (Andrianopoulos, Darrow & Chen, 2001) however comparisons of the acoustic data across studies are limited due to the different speaking populations (portuguese vs. english) . Professional Fado singers exhibited higher jitter and shimmer which indicated aperiodicity of cycle-to-cycle F_0 and amplitude, possibly due to lack of control of air flow. NHR values were generally near nonsingers (Andrianopoulos, Darrow & Chen, 2001). Nevertheless NHR was higher for those considered to be within normal standards indicating noise on the vocal signal (Pinto, Crespo e Mourão, 2014). These perturbation measures values might be explained by the reduced singing education of Fado singers.

F_0 in reading task was lower in male Fado singers (Drew & Sapir, 1995), except for older singers. Female Fado singers had F_0 similar to lyric singers (Rothman, Brown, & Sapienza, 2001), lower in amateurs and higher in professionals during "Rainbow passage" reading (Drew & Sapir, 1995). Values were concordant with the vocal coalescent model (Hollien, Hollien & Jong, 1997). Professional male singers had lower F_0 (deeper voice) and professional female higher F_0 (acute voice).

MPFR was wider (max-min) on professional and younger Fado singers in both genders. Professional Fado singers were able to reach higher frequencies than amateurs which might reflect the professional experience and the singing training acquired. Older Fado singers had smaller ranges possibly due to anatomic and physiologic factors caused by age.

In singing voice, older males had lower F_0 than younger males and therefore a deeper voice. Older females generally had higher F_0 and therefore a more acute voice. This trend was observed on amateurs and professionals.

Singing voice perturbation measures were higher in professional male singers vs. amateurs. Jitter was higher for professional female singers vs. amateurs and shimmer lower. Male singers generally had significant higher shimmer and NHR than females. Males and professionals seem to have higher perturbation values. Once again, this pattern might be explained by the reduced formal singing education in Fado singers. Jitter, shimmer and NHR in singing voice were higher than those of lyric singers (Lundy, Roy, Casiano, Xue & Evans, 2000).

Vibrato was a voice feature often found in Fado singers' voice. Male amateurs' vibrato frequency ranged 5.49-6.17 Hz and extension 0.28-0.59 ST. Professional males' vibrato frequency ranged 6.15-6.82 Hz and extension 0.30-0.36 ST. Female amateurs' vibrato frequency ranged 5.63-6.13 Hz and extension 0.29-0.46 ST. Female professional frequency of vibrato ranged 5.23-5.88 Hz and extension 0.44-0.54 ST. Generally, males had higher vibrato than females; and professional males than amateur males. The higher vibrato in professional can be related to professional experience and singing training (Mitchell & Kenny, 2010; Guzman et al., 2012) that helps to develop laryngeal control.

Fado singers' frequency of vibrato was lower than professional lyrics (Dejonckere & Sundberg 1995; Howes, Callaghan, Davis, Kenny & Thorpe, 2004) except for professional male singers, however these values were within those found in lyric and sertanejo singers (Benninger & Murry, 2008; Bezerra, Blaj, Duprat, Camargo & Granato, 2009). Male and younger female singers had lower values of vibrato's extension comparing to professional lyrics (Dejonckere & Sundberg 1995; Howes, Callaghan, Davis, Kenny & Thorpe, 2004). In conclusion, Fado singers' have vibrato however less vibrato than lyrics singers.

Singers' formant was found in 5 female singers, amateurs and professionals, with age range [18-55[. This indicates that singers' formant is not a Fado singers' voice feature. Reduced MPT and coordination plus high vocal tension in Fado's voice are described as limiters of this specific formant (Sundberg, 1972; Sundberg, 2001; Gusmão, Campos & Maia, 2010). The singers' formant can be calculated if the area of the outlet of the larynx into the pharynx is less than a sixth of the area of the cross section of the pharynx (Sundberg, 1987). The lowering of larynx tends to expand the bottom part of the pharynx and it seems to explain the singing-formant peak. This physiologic event is incompatible with the lateral positioning of the head that Fado singers adopt during the performance. The head lateralization has a 45º angle with the shoulder and is slightly tilted back. With this head-neck posture, it is difficult to expand the laryngeal tube.

5. Conclusion

This study provided a new understanding of the characteristics of the Fado voice. Spoken voice samples of Fado singers presented: 1) higher values for F_0, jitter, shimmer and NHR comparing to nonsingers; 2) [55-70[yr old, professional, male, singers had lower F_0 than amateurs; 3) [18-55[yr old, amateur, male singers had lower F_0 than [55-70[yr old; 4) professional female had lower F_0 than amateurs; 5) older females had higher F_0 than younger singers; 6) professional male singers had higher jitter and shimmer than amateurs; and 8) professional female singers had lower jitter and higher shimmer than amateurs.

Singing voice samples of Fado singers presented: 1) professional male singers with lower F_0 than amateurs for both age group; 2) professional female singers had higher F_0 than amateurs; 3) older females had higher F_0 than younger singers; 4) perturbation measurement of Fado singers were higher than lyrics; 5) professional male singers generally had higher jitter and shimmer than amateurs; 6) female professional singers had higher jitter and lower shimmer than amateurs; 7) older males had higher jitter and shimmer than younger singers; 8) females had lower jitter and higher shimmer than younger singers; 9) vibrato was found in most Fado singers; and 10) singer's formant was rarely present.

This pioneer study, revealed the voice acoustic profile of FADO of 104 singers. This knowledge can be generalized and applied on pedagogic, clinic and scientific level.

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