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Variation in singing voice quality. A case-study from traditional music of southern Marche

In this paper a recording of two traditional *stornellos* performed by two non professional singers from southern Marche (Italy) has been analyzed. Three acoustic measures related to harsh voice quality – jitter, shimmer and harmonics-to-noise ratio (HNR) – have been examined in order to describe by means of quantitative descriptors the difference between the voices of the two singers and to investigate some prospective factors that can be related to the variability of their voice quality in the recorded performance.

Key words: voice quality, singing voice, harsh voices, Central Italy traditional singers, ethnomusicology.

1. *Introduction: voice quality in singing*

In vocal music, one of the main issue regarding score notation is that music symbols can express only the skeleton of a melody, whereas all the subtleties present in the real act of singing are hidden in the partiture (Stockmann, 1989; Ellington, 1992). The movements between and inside the notes may be of greater importance than the basic structure of a melody, but cannot be adequately described by standard musical notation. In particular, the so-called 'timbre' dimension – in the widest sense of the term – of the voice is not included in the score and depends almost completely on the specific characteristics and choices of the singer. One of the essential parts defining the timbral dimension of singing is voice quality, that has a major importance both as part of a musical style and as a crucial trait of a singer's performative art. At the so called *estesic* level (Nattiez, 1987), this aspect has been left for centuries to the impressionistic evaluation of the listeners and singing expert. Nowadays, instrumental analysis allows one to observe and analyze this aspect of vocal performance in detail and in an objective way.

In this paper I will examine one particular characteristic of voice quality that is referred to with different adjectives (the most frequent of which are *harsh*, *rough* and *raspy*) by specialists approaching the voice from different perspectives. In fact, no agreement is nowadays shared on the terminology to be used to describe those voices that, according to the common sense and use of the language, may be said to have a harsh sound quality.

In the field of phonetics, as John Laver observes, "small cycle-to-cycle variations in fundamental frequency are associated with voice judged to be *harsh*" (Laver, 1980: 127, italic mine). In particular, in fact, *jitter*, *shimmer* and *harmonicity* (or HNR: Harmonics-to-Noise Ratio) are acoustic features correlated with the perception of harshness. The first two are measures of the vocal perturbation: *jitter* refers to small variations in the fundamental frequency; *shimmer* refers to perturbation in the amplitude of cycles. *Harmonicity* refers to the amount of spectral noise in the signal and is measured as the ratio between the energy in the harmonics and in the noise[1].

In the field of logopedics and phoniatrics, anomalies of this kind relevant to the laryngeal activities are usually considered under the term *roughness*. Both GRBAS (Isshiki *et al.*, 1969; Hirano, 1981) and CAPE-V (ASHA, 2006), two scales commonly used by voice pathologists, consider "roughness" as one of the crucial parameters in the diagnosis of voice dysfunctions.

In the field of ethnomusicology, one of the parameters used in Alan Lomax's *cantometrics* to describe the vocal features of singing is defined by the word *raspiness*, but the same author remarks that the words "throatiness" or "harshness" could also have been used (Lomax, Grauer, 1968: 73-74).

This paper aims at examining the effects of factors that may be supposed to be involved in the variation of voice quality that occurs while singing. In particular, it is analyzed how acoustic features related to harsh voice quality (jitter, shimmer and HNR) vary in relation to some prospective factors of change – tone level and movement, duration, vowel type, phonetic context, intensity, metrical position and stress – in a sung performance of two traditional and non professional singers from the southern part of the Marche region (central Italy). A crucial difference between linguistic and musicological analysis that has to be taken into consideration is that vocal harshness may be, in the case of singing, more a matter of stylistic choice (either individual or genre-dependent) rather than a 'mechanical' outcome bound to phonetic, prosodic or metrical factors.

2. *Case-study: Defiantly stornellos from Corridonia (Marche Region – Italy)*

In 1998, the folk revival group "La Macina"[2] published a CD comprising, in addiction to its musical elaboration of traditional songs from the region of Marche (Italy), some recordings of old, non-professional singers of this region (La Macina, 1998). Having been made in a studio, these high-quality recordings are valuable documents of the voices of these traditional singers. Of particular interest are the recordings of the "stornelli a dispetto" (defiantly *stornellos*), a genre of singing typical of this area (Arcangeli, 1982). The

[1] It has to be noted that variations in these acoustic correlates may refer not only to harsh voices, but also to creaky ones. In articulatory terms, the two registers are distinguished by a major constriction of the ventricular folds in harsh voice. According to Edmondson and Esling (2006: 169): "[c]reaky vocal register […] generally occurs at low pitch, with constricted Valve 3 ['sphincteric compression of the arytenoids and aryepiglottic folds forwards and upwards by means of the thyroarytenoid muscle complex'], but with a loose enough glottis that vibrations are slow and undulating. Harsh vocal register at high pitch […], when viewed laryngoscopically, shows Valves 1 ['glottal vocal fold adduction and abduction'] and 2 ['partial covering and damping of the adducted glottal vocal fold vibration by the ventricular folds'] engaged, with clear Valve 3 engagement. Noticeable are the ventricular folds, which cover a substantial portion of the vocal folds […], compressing them and damping oscillation".

[2] La Macina is a folk music revival group devoted – as expressed by the complete name of the group – to the "research and singing" of traditional music of Marche. The group was founded by its current leader, Gastone Pietrucci, some forty years ago and is still active today (La Macina, 2016).

stornellos (track 9 of the CD) were recorded in 1995 and were performed by two singers of traditional songs, both from the village of Corridonia, in the province of Macerata - Marche (Italy): Nazzareno Saldari (hereafter NS), male (1912-2004), and Lina Marinozzi Lattanzi (hereafter LML), female (1925-2010)[3]. The two voices documented in the recording, though clearly different from one another, share some basic characteristics of the traditional singing voices of the Centre and South of Italy. Those voices have been described as "strozzate" (throttled) and "forzate" (forced) by Diego Carpitella and Tullia Magrini, two well-known Italian ethnomusicologists of the recent past (see Carpitella, 1955: 23; Magrini, 1990: 23).

Figure 1 - *The two singers of traditional songs from Marche Lina Marinozzi Lattanzi (left) and Nazzareno Saldari (right)*

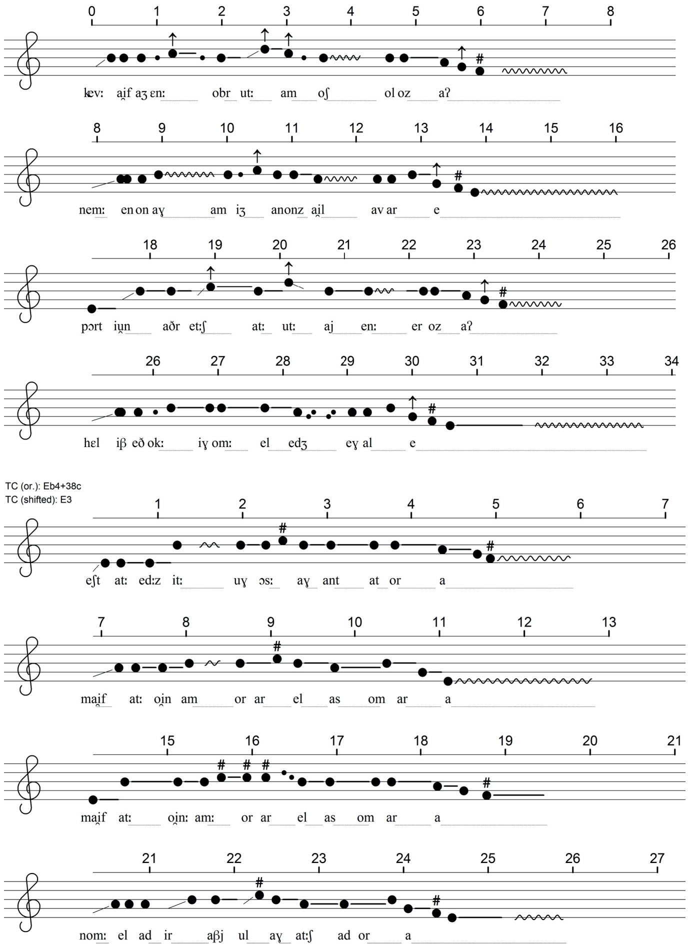
A musical analysis of the recording is out of the scope of the present work. However, a basic description of the free rhythm melodies through staff notation, together with a broad phonetic transcription of the texts, is given in Figure 2[4]. The two musical transcriptions have been reported to the same tonal centre (E4) to facilitate their

[3] Little information is available on the two non professional singers. The booklet that accompanies the CD recording reports that Lina Marinozzi Lattanzi was a farmer and later worked in a shoe factory (La Macina 1998: 13). Nazzareno Saldari was also a farmer (direct information). Further information and a short biography of Lina Marinozzi Lattanzi are in Arcangeli, Pietrucci & Bravi, 2016.

[4] The verbal texts of the *stornellos* and their translation as reported in the booklet are the following: "[NS] Che vai facendo brutta mosciolosa / nemmeno unà camigia non sai lavare / porti una treccia tutta jennerosa / e li pedocchi comme le cicale [What are you doing, filthy woman / You are not able to wash even a shirt / Your hair is so much dirty / That the lice are big as cicades] [LML] E statte zittu co' ssa cantatora / m'hai fatto innamorare la ssomara / m'hai fatto innamorare la ssomara / non me la tira più la cacciatore [Shout up, with this song / You delight my sheass / You delighted my sheass / So that she doesn't pull the hand-cart anymore]" (La Macina, 1998: 13).

comparison, but in fact they have different ranges, being LML's performance one perfect fourth higher than NS's one[5].

Figure 2 - *Musical transcriptions of the stornellos sung by NS (top) and LML (bottom)*

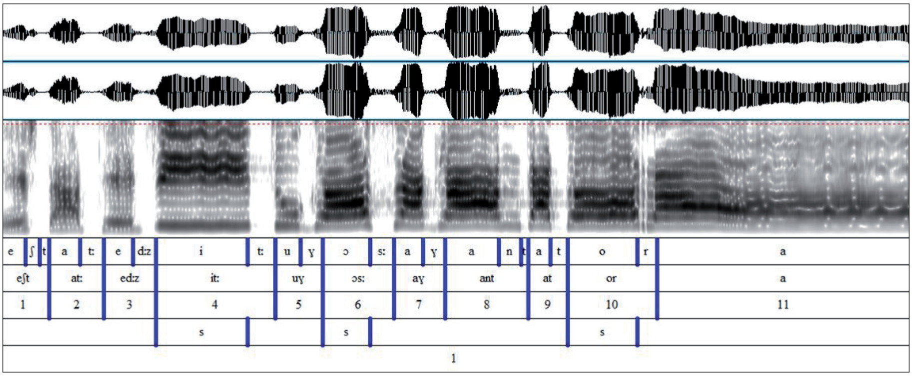


In order to analyze the acoustic features of the two voices, a manual multilevel segmentation of the recording was carried out by means of the software Praat (Boersma, Weenink, 2016). Segmentation tiers were relevant both to phonetic (phono, V-to-V interval) and metrical (line, position, stress[6]) aspects (Figure 2).

[5] *Tonus finalis* – i.e. the tone at the end of a melodic phrase or section, also referred to some times as 'cadential tone' (Agamennone, 1991: 158-163) – has a mean value of 240 Hz for NS and 320 Hz for LML.

[6] The three words referring to metrical notions may require to be clarified and referenced. 'Line' is a basic concept in poetry and in metrical analysis: "[w]hat distinguishes all poetry from prose is that poetry is made up of lines (verses). [...] In metrical poetry [...] lines must satisfy requirements on length and on the location in the lines of marked syllables, and different conditions are met by different kinds of non-metrical poetry" (Fabb, Hall, 2008: 1). The "metrical position" is assumed to be the basic unit of the line in some modern approaches

Figure 3 - *An example of multilevel segmentation performed through Praat TextGrid*



3. *Analysis*

Based on an impressionistic evaluation, the two voices have different voice qualities: while LML's voice has a strong harsh quality, NS's one may be defined – using a term that is often used in the field of singing voice analysis – as "pressed"[7]. The first part of the analysis has aimed to better define this course-grained evaluation through an instrumental analysis of the three acoustic features – jitter, shimmer and HNR – that are considered to be associated with the perception of harshness in voice quality. Measurements of the values of these three features in the 96 vowels sung in the *stornellos* by the two singers (see Table 1) have been carried out via Praat[8].

to metrical analysis, particularly those referring to the generative approach. As observed by Morris Halle and Samuel J. Keyser, "[a]position is normally occupied by a single syllable, but under certain conditions it may be occupied by more than one syllable or by none. [...] Two vowels may constitute a single position provided that they adjoin, or are separated by a liquid or nasal or by a word boundary which may be followed by *h*-, and provided that one of them is a weakly stressed or unstressed vowel. [...] An unstressed or weakly stressed monosyllabic word may constitute a single metrical position with a preceding stressed or unstressed syllable" (Halle, Keyser, 1966: 197; for the concept of metrical position used with reference to the Italian metrical tradition, Di Girolamo, 1983: 22-24, and Beltrami, 1991: 39-40). 'Stress' is here considered not as referring to the prominent syllable in a word (lexical stress), but as a concept related to the metrical/musical structure of the sung line (Beltrami, 1991: 27-29; Fraisse, 1979 [1974]: 65-68).

[7] As observed by Johann Sundberg, "[p]ressed phonation is characterized by a high subglottic pressure combined with a strong adduction force" (Sundberg, 1987: 80; Fussi, Magnani, 2010: 200). Closing quotient of the vocal folds, subglottal pressure, sound level and glottal area are the main objective features related to it: "[w]hen the adduction force is high as in pressed phonation, the glottogram amplitude becomes small, the closed phase long, subglottic pressure is high, sound level is low, and the glottal area is small" (Sundberg, 1987: 83-84).

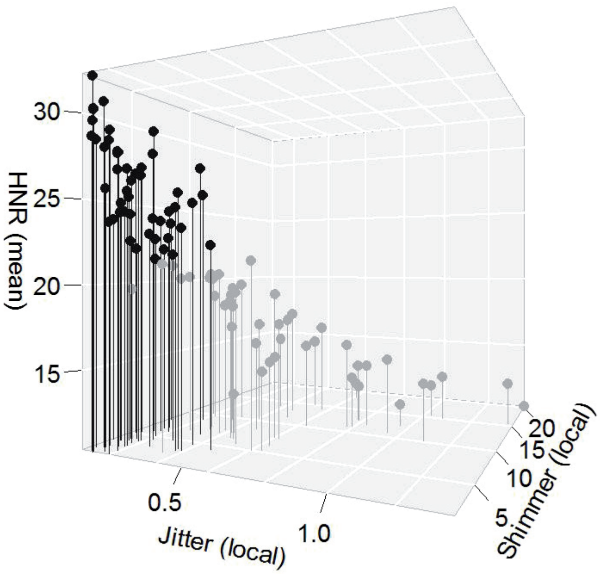
[8] Different types of measurement of jitter and shimmer are used to assess voice quality. Here the most common types of measure – local jitter and shimmer – have been utilized (see "Voice" section in the Praat manual for details).

Table 1 - *Table of counts of vowels in the two stornellos sung by singers LML and NS*

		Vowel type							
Singer		*i*	*e*	*ɛ*	*a*	*ɔ*	*o*	*u*	
	LML	6	5	0	25	1	9	2	48
	NS	6	12	2	15	1	9	3	48
		12	17	2	40	2	18	5	96

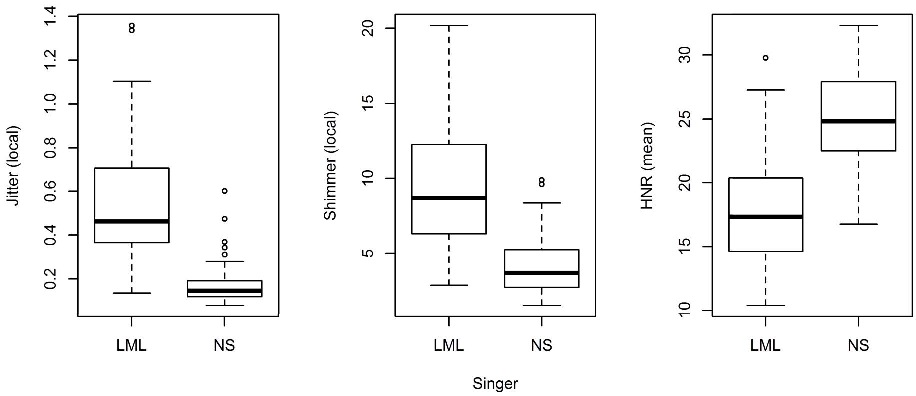
The distribution of the values of the three acoustic features confirms the subjective evaluation of a clear distinction of the quality of the two singing voices. The 3D plot in Figure 4 shows that the area of distribution of the points relevant to the three features in the vowels sung by LML is clearly set apart from that of NS. A closer inspection of the value distributions for each acoustic feature proves that a significant difference between the two singers is present (see Figure 5 for a graphical representation)[9]. While jitter and shimmer levels are higher in LML sung vowels, HNR is lower. In particular, the values of shimmer are extremely high in LML's voice, compared with the threshold value considered for the assessment of pathology[10].

Figure 4 - *3D plot of the values of jitter, shimmer and HNR values in the sung vowels of the stornellos sung by LML (light grey) and NS (dark grey)*



[9] Wilcoxon tests with continuity correction have been carried out with the following results: W = 2140, p-value < 0.001 (jitter); W = 2032, p-value < 0.001 (shimmer); W = 286, p-value < 0.001 (HNR).
[10] This threshold, as reported in the Praat manual, is 3.810% according to the program Multidimensional Voice Program – MDVP (see http://www.fon.hum.uva.nl/praat/manual/Voice_3__Shimmer.html).

Figure 5 - *Boxplots showing the distribution of jitter, shimmer and HNR for the two singers*



As far as the relation among the three features is concerned, in 5 out of 6 cases values are significantly but rather weakly correlated to one another in each singer[11].

The second part of the analysis has aimed to explore what factors may be associated to the variability of voice quality in the two *stornellos*. This part, in turn, is divided in two sections: the first one aims at investigating if the variability of jitter, shimmer and HNR may be explained by continuous variables relevant to duration, fundamental frequency (mean and range) and intensity; the second one aims at verifying if factors vowel type, phonetic context, metrical position and stress have a significant effect in the variation of the three acoustic features.

As far as continuous variable are concerned, a series of correlation tests have been performed. A number of statistically significant correlations (see results in Table 2[12]) have been found, particularly as far as duration and intensity are concerned. However, the effects are usually rather week, being the variance shared by the two variables within the range 11%-45%. Two plots based on data that exhibit statistically significant correlations (shimmer / duration and HNR / intensity) are shown, as example cases, in Figure 6.

[11] Correlation tests (Pearson method) give the results that follow. Singer LML: jitter / shimmer [$r = 0.68$, $df = 46$, $p < 0.001$], jitter / HNR [$r = -0.78$, $df = 46$, $p < 0.001$], shimmer / HNR [$r = -0.74$, $df = 46$, $p < 0.001$]; singer NS: jitter / shimmer [$r = 0.16$, $df = 46$, $p = 0.28$], jitter / HNR [$r = -0.45$, $df = 46$, $p = 0.001$], shimmer / HNR [$r = -0.73$, $df = 46$, $p < 0.001$].

[12] Measures are relative to the vowels sung in the two *stornellos*.

Table 2 - *Correlation tests between numeric variables*

statistic_t	*df*	*p-value*		*r-squared*	*variable1*	*variable2*	*Singer*
-3.285	42	0,0021	**	0,2044		Jitter	LML
-0,5686	40	0,5728		0,008		*(local)*	NS
-24.014	42	0,0208	*	0,1207	Duration	Shimmer	LML
-49.175	40	0	***	0,3768		*(local)*	NS
23.311	42	0,0246	*	0,1146		HNR	LML
58.256	40	0	***	0,459		*(mean)*	NS
-31.319	46	0,003	**	0,1758		Jitter	LML
-30.093	46	0,0042	**	0,1645		*(local)*	NS
-19.635	46	0,0557		0,0773	f_0	Shimmer	LML
10.133	46	0,3162		0,0218	*(mean)*	*(local)*	NS
0,9068	46	0,3692		0,0176		HNR	LML
-0,1275	46	0,8991		4,00E-04		*(mean)*	NS
-0,2344	46	0,8157		0,0012		Jitter	LML
36.671	46	6,00E-04	***	0,2262		*(local)*	NS
-0,0394	46	0,9687		0	f_0	Shimmer	LML
-23.697	46	0,0221	*	0,1088	*(range)*	*(local)*	NS
13.297	46	0,1902		0,037		HNR	L
0,6587	46	0,5133		0,0093		*(mean)*	NS
-61.805	46	0	***	0,4537		Jitter	LML
-14.994	46	0,1406		0,0466		*(local)*	NS
-39.457	46	3,00E-04	***	0,2529	Intensity	Shimmer	LML
-25.687	46	0,0135	*	0,1254	*(mean)*	*(local)*	NS
27.231	46	0,0091	**	0,1388		HNR	LML
45.291	46	0	***	0,3084		*(mean)*	N

Figure 6 - *Correlation between acoustic features and continuous variable: shimmer / duration (left); HNR / intensity (right)*

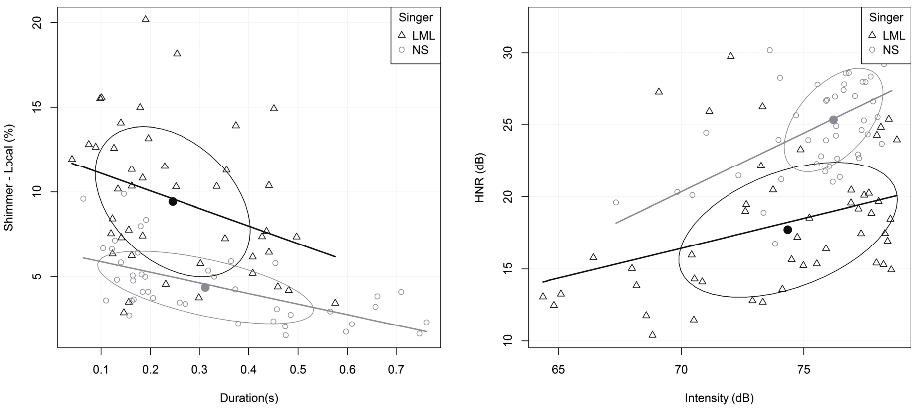


Table 3 - *Mean values of jitter, shimmer and HNR for levels relevant to the factors vowel, phonetic context (pre), phonetic context (post), metrical position, stress*

		factor: *vowel*						
		i	*e*	*ɛ*	*a*	*ɔ*	*o*	*u*
Jitter	LML	0.62	0.50	0.77	0.36	/	0.58	0.23
(local)	NS	0.21	0.14	0.16	0.60	0.31	0.12	0.19
Shimmer	LML	9.39	9.54	12.51	3.76	/	8.58	6.01
(local)	NS	5.68	4.05	3.10	4.99	3.50	4.14	6.93
HNR	LML	17.64	17.84	13.23	25.38	/	18.29	28.50
(mean)	NS	20.61	26.05	26.10	21.36	25.06	26.56	21.07

		factor: *phonetic context (pre)*					
		plosive	nasal	fricative	trill/tap	vowel	others
Jitter	LML	0.52	0.51	0.47	0.51	0.85	1.08
(local)	NS	0.26	0.12	0.15	0.15	0.21	/
Shimmer	LML	8.50	9.95	8.00	9.96	12.18	14.97
(local)	NS	4.64	3.77	3.57	4.03	9.28	/
HNR	LML	19.29	17.21	19.28	17.32	14.36	13.26
(mean)	NS	23.49	25.24	26.20	26.62	18.59	/

		factor: *phonetic context (post)*					
		plosive	nasal	fricative	trill/tap	vowel	others
Jitter	LML	0.53	0.61	0.58	0.41	0.67	0.46
(local)	NS	0.14	0.15	0.18	0.26	0.19	0.16
Shimmer	LML	9.24	8.96	9.75	9.24	10.79	8.15
(local)	NS	3.74	4.72	4.55	3.85	3.55	1.61
HNR	LML	18.76	17.30	17.65	18.13	16.41	20.40
(mean)	NS	25.89	24.93	24.49	24.73	23.92	29.22

		factor: *metrical position*										
		1	2	3	4	5	6	7	8	9	10	11
Jit	LML	0.84	0.67	0.60	0.29	0.44	0.37	0.61	0.36	0.77	0.38	0.46
loc	NS	0.42	0.19	0.13	0.15	0.15	0.15	0.12	0.13	0.17	0.12	0.15
Sh	LML	12.48	10.65	8.37	5.33	8.87	7.40	12.50	8.29	10.79	9.34	8.15
loc	NS	4.03	5.63	4.99	2.92	5.29	3.70	4.57	3.83	5.45	2.84	2.36
HNR	LML	15.82	15.27	17.60	21.60	20.08	21.46	14.47	18.74	15.13	18.92	20.40
mn	NS	22.77	20.79	23.81	27.63	23.91	24.85	26.34	27.06	22.04	29.12	28.29

		factor: *stress*	
		unstressed	stressed
Jitter	LML	0.61	0.35
(local)	NS	0.17	0.17
Shimmer	LML	10.02	7.48
(local)	NS	4.51	3.48
HNR	LML	17.14	20.65
(mean)	NS	24.43	26.48

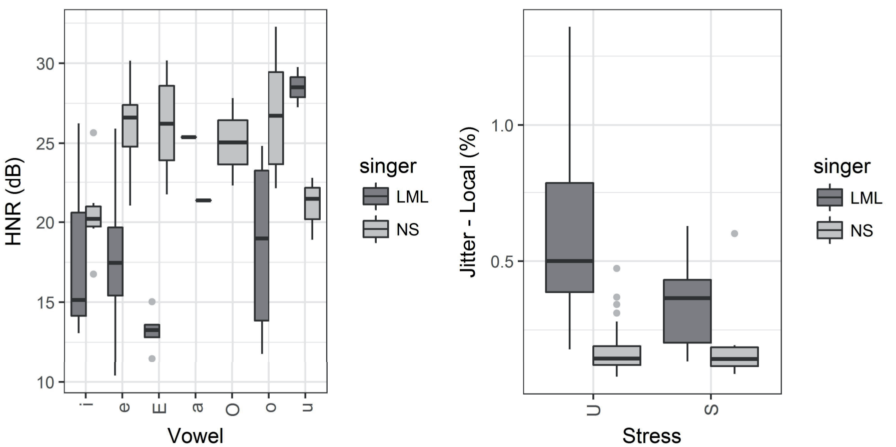
Table 4 - *Kruskal-Wallis tests for factor vowel type, phonetic context (pre and post), metrical position and stress*

chi-sq	*df*	*p-value*		*factor*	*response*	*singer*
82.967	5	0,1406		Vowel	Jitter *(local)*	LML
122.835	6	0,0559				NS
67.463	5	0,2402			Shimmer *(local)*	LML
95.473	6	0,1451				NS
146.951	5	0,0117	*		HNR *(mean)*	LML
174.312	6	0,0078	**			NS
73.818	5	0,1938		Phonetic context *(PRE)*	Jitter *(local)*	LML
103.252	4	0,0353	*			NS
75.239	5	0,1845			Shimmer *(local)*	LML
111.825	4	0,0246	*			NS
65.788	5	0,2539			HNR *(mean)*	LML
124.331	4	0,0144	*			NS
3.132	5	0,6796		Phonetic context *(POST)*	Jitter *(local)*	LML
0,8794	5	0,9717				NS
12.968	5	0,9353			Shimmer *(local)*	LML
58.591	5	0,3202				NS
38.907	5	0,5653			HNR *(mean)*	LML
50.191	5	0,4136				NS
165.123	10	0,0859		Metrical Position	Jitter *(local)*	LML
151.962	10	0,1251				NS
138.848	10	0,1783			Shimmer *(local)*	LML
155.361	10	0,1137				NS
144.953	10	0,1516			HNR *(mean)*	LML
277.778	10	0,002	**			NS

73.673	1	0,0066	**	Stress	Jitter *(local)*	LML
0,0082	1	0,9277				NS
3.449	1	0,0633			Shimmer *(local)*	LML
17.307	1	0,1883				NS
46.944	1	0,0303	*		HNR *(mean)*	LML
28.174	1	0,0932				NS

As far as factor analysis is concerned, a series of Kruskal-Wallis tests have been performed. Results are presented in Table 3 and Table 4. In the case of vowel type, a significant effect occurs on HNR (but not in the other two features); in the case of phonetic context[13], significant effects occur in the case of one singer (NS), but not in the other (LML), and only as far as left context is concerned; in the case of metrical effects, stress has a significant effect in singer LML as regards the features jitter and HNR. Two series of boxplots relevant to factors that exhibit statistically significant effects (HNR by vowel type and jitter by stress) are shown, as example cases, in Figure 7.

Figure 7 - *Vowel type and matrical stress effects. Left: HNR by vowel, SAMPA Symbols; right: jitter by stress, [U]nstressed vs. [S]tressed*



4. *Discussion*

The analysis of voice quality in the sung *stornellos* performed by two traditional singers of the Marche has shown that, despite both singers can be regarded as valuable expressions of the vocal style that characterizes traditional song of central and

[13] The phonetic context – either "pre" or "post" vowel – have been evaluated grouping the phones that precede/follow the vowel into five main categories (plosive, nasal, fricative, trill/tap, vowel), plus a residual group comprising a little number of other different types of phonos. Grouping phonos into a small number of phonetic categories is due to the limitation of the available corpus of sung vowels.

southern Italy, their voices are significantly different from one another. The strong harshness that characterizes Lina Marinozzi Lattanzi's voice is absent in Nazzareno Saldari's one. All three features here examined – and particularly jitter and shimmer – show that sung vowels of the first singer have a different quality with respect to those of the second.

Less conspicuous are the results of the analysis of factors and variables that may be related to the change in voice quality. Short vowel duration – that implies vicinity to consonants and rapid articulatory change – is correlated with increase of jitter and shimmer (and decrease of HNR), but from one side the variance explained is rather low, from the other there is no clear evidence of a specific effect of the phonetic context on the three features. Intensity is correlated with all features (with the exception of jitter in NS), but from one side – again – the variance explained is low, from the other the factor "stress" (which in its turn might have been expected to be associated to intensity) is a significant factor only for LML.

As a whole, the analysis of factors and correlations confirms that the voices of the two singers differ not only in their intrisic characteristics, but also in their response to prospective factors of variability. Tone movement within vowels (here measured in terms of f_0 range within the phono), is significantly correlated with jitter and shimmer in NS, but not in LML. Left phonetic context has a significant effect on all features in NS, but not in LML. Metrical stress, as noted beforehand, has a significant effects in LML's voice, but not in NS's one.

The analysis of the factors that may explain the variability of the voice quality in this recording certainly suffers from the scarsity of available data. This is an obvious but inescapable side-effect of the exceptionality of the recording that we have considered. Further studies, based on a larger corpus of recordings, are likely to be able to shed more light on the issue of the variability of voice quality in this type of traditional singing.

In a wider perspective, two main points have to be highlighted. The first one is that when one deals with singing, criteria and benchmarks that are commonly used for assessing voice quality with regard to speech cannot be mechanically applied. In the case of singing, harshness cannot be regarded as a form of voice disorder or a pathology, but instead has to be seen as a distinctive and remarkable characteristic of particular singing styles, or as an expressive trait of particular vocal passages. Within the traditional song of the Marche region, this is the case of the extra-harsh voice of Lina Marinozzi Lattanzi. Her typical vocal quality is considered a gift of a talented singer, and not a blemish or an unpleasant sign of pathology[14]. Observed under this perspective, the characteristic harshness of her voice might be evaluated, at least in part, as a matter of specific stylistic choice, more (or rather) than an effect – perhaps indesirable and/or unaivodable – of particular factors related to the metrical, prosodic and phonetic settings and conditions.

[14] This is also the case of many renowned rock and flamenco singers, to name just a couple of well known musical genres.

This observation leads to the second aspect that is worth of proper consideration. Differently from what both a romantic view of folk art and an old-fashioned practice of field research in the field of ethnomusicology might lead us to think, usually there is no such things as 'anonymous' voices in traditional music. Or, at least, one cannot find 'impersonal' voices here more than in the field of lyrical song or in other singing styles which are duly based on a formal training. Traditional music is in most cases a practice which involves identifiable performers, each of whom – included the late Nazzareno Saldari and Lina Marinozzi Lattanzi taken into examination here – has his/her own style and imprints a particular 'vocal signature' on his/her singing performances.

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