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LONG-TERM AVERAGE SPECTRA IN PROFESSIONAL FOLK SINGING VOICES: A COMPARISON OF THE *KLAPA* AND *DOZIVAČKI* STYLES

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Abstract

In Croatia different folk singing styles have been inherited over long periods of time. To examine the differences between the *klapa* and *dozivački* styles of singing, singing voices of 12 professional male singers were digitally recorded and analysed for long-term average spectrum (LTAS) in the Praat program. All the singers were members of the *LADO Folk Dance Ensemble of Croatia*, which practises songs and dances from all regions of the country. Each singer performed a song representing the *klapa* style as well as a song representing the *dozivački* style. The LTAS contours of both the *klapa* and the *dozivački* styles showed no evidence of a singer's formant. Actually, the averaged LTAS curve for the *dozivački* style showed a broad spectral peak in the frequency range between 3000 and 3800 Hz (these are the –10 dB points), while the *klapa* style showed two peaks in an even broader frequency region. The more pronounced peak in the *dozivački* style may be the effect of the louder singing production typically employed in the vocal production of this style (a *shouter's formant*), rather than evidence of a singer's formant. The results seem to be in agreement with very few previous studies about folk singing styles.

1 Introduction

The first voice "investigators" were voice pedagogues such as teachers of singing, drama and rhetoric. Their data relied on subjective methods of investigation – intuition, empirical observations and feelings about how the voice functions. Therefore, many terms were (and some still are) defined figuratively through description of physical sensations related to certain aspects of vocal production. Thanks to the dramatic development of modern technologies throughout the last century, scientific explanations and (re)definitions of the old subjective interpretations became possible.

The earliest modern scientific information on the singing voice was based on studies of classically trained voices. It was shown that the acoustic parameters of the singing voice are different from those of speaking. Figure 1 shows wide-band spectrograms (Figure 1a) and LTAS (Figure 1b) for speaking and singing voice samples where some of the differences can be seen. The essential difference refers to the *singer's formant*. This resonance phenomenon has been observed in male operatic

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singing voices, but also in female altos. It is usually the name of Wilmer T. Bartholomew that is mentioned as the first who described it: "…a high formant, usually lying for male voices between approximately 2400 and 3200 cycles. … Speaking generally, the better the voice, or the louder the tone, the more prominent this formant becomes." (Bartholomew, 1934: 27–28).

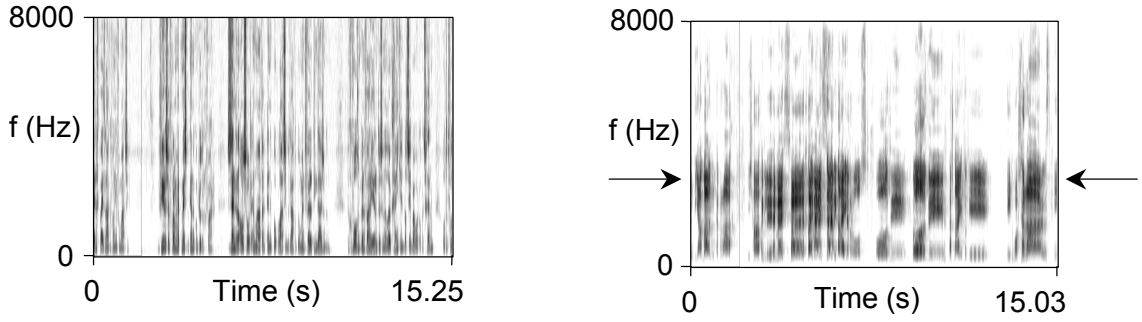

Figure 1a. Wide-band spectrograms of the speech of a male speaker (left) and the singing of a male professional singer (right), showing the prominent difference at around 2.7 kHz – the singer's formant.

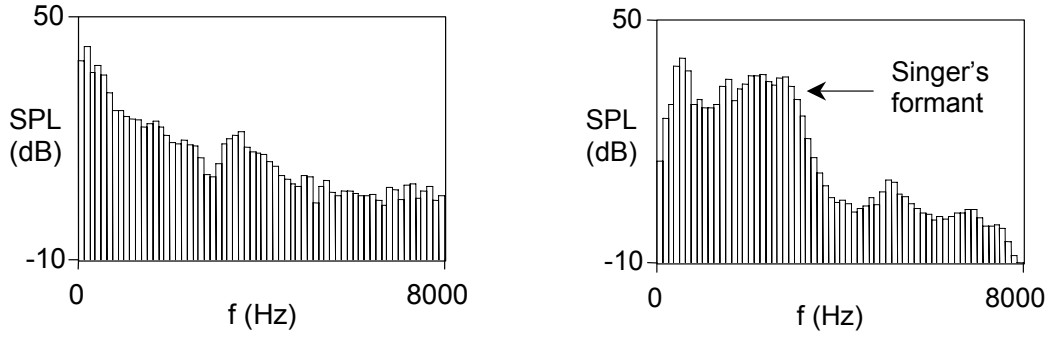

Figure 1b. LTAS of the speech of a male speaker (left) and the singing of a male professional singer (right), showing the singer's formant.

The term *singer's formant* was introduced by Johan Sundberg (1973; 1974) who studied it in detail. Soon, when the findings of other independent acoustic studies on the singing voice (Hollien, 1983; Seidner, Schutte, Wendler & Rauhut, 1983; Schutte & Miller, 1985; Bloothooft & Plomp, 1986; Burns, 1986) have shown similar results, the term has been accepted and used widely by the international scientific community. The singer's formant indicates prominent sound energy near 3 kHz and is the result of a clustering of the third, fourth, and fifth formants. It also makes the voice heard in the presence of a loud orchestra (Sundberg, 2001).

Despite numerous investigations of the singing voice little is known about non-classical (non-operatic) singing. If singing voice research is to be used for the purpose of singing pedagogy or training or for e.g. voice therapy for singers, then research on non-classical singing seems to be at least as important as research on classical singing, because there exist many more non-classical than classical singers. The only problem is that non-classical singing comprises a wide range of different styles such as jazz, blues, rock, pop, musical, heavy metal, and so on, with folk singing being particularly tricky because of the various substyles that emerge from differences among the

existing world cultures, e.g. differences in aesthetic orientation. However, non-classical singing caught the attention of some scientists who gave their contributions to the acoustics of the non-classical singing voice (Burns, 1986; Sengupta, 1990; Bloothooft, Bringmann, Van Cappellen, Van Luipen & Thomassen, 1992; Ross, 1992; Klingholz, 1993; Schutte & Miller, 1993; Sundberg, Gramming & Lovetri, 1993; Doskov, Ivanov & Boyanov, 1995; Rachele, 1996; Sundberg, Cleveland, Stone & Iwarsson, 1999; Stone, Cleveland & Sundberg, 1999; Feijó, Moschetti & Steffen, 1999; Cleveland, Sundberg & Stone, 2001; Thalén & Sundberg, 2001; Lindestad, Sodersten, Merker & Granqvist, 2001; Borch & Sundberg, 2002; Van Tongeren, 2002; DeLeo LeBorgne, 2002, Van Lankeren, Van Luin, Miller & Schutte, 2002; Stone, Cleveland, Sundberg & Prokop, 2003; Grawunder, 2003). So far, the data are too limited and too scattered to give generalizations. Therefore, more studies on particular non-classical styles are needed, and in the recent years there seems to be a slow trend for doing so.

The aim of the present investigation is to investigate the inter-style differences between the *klapa* and *dozivački* styles of singing, both of which belong to the Croatian folk tradition. *Klapa* is a unique Croatian form of musical expression of love. It originated in Dalmatia, a Mediterranean part of Croatia. It is typically performed *a cappella*. The word *klapa* denotes a crowd, a bunch of friends. The *dozivački* style[1] of singing is distinctive for the Dinaric region and the Dalmatian Hinterland. The inhabitants of these regions are not familiar with the term *music* in the Western sense of that word. Usually, they sing very loud in a high register (male singing), and to a Western ear this singing may not be perceived as singing at all, but as shouting (Ćaleta, 1999). The reader of this paper is suggested to visit www.fon.hum.uva.nl/paul/CroatianFolkSinging/ to listen to authentic samples of each style as performed by local singers and by the LADO Ensemble, whose members took part in the present study.

We will describe the two styles by means of long-term average spectrum (LTAS) analysis. We will examine whether there is a singer's formant in the LTAS of each singing style and whether it is consistent in terms of its level and central frequency. This study is based on an analysis of professional folk voices. The advantage of taking professional folk singers into investigation is the opportunity to reveal stylistic variation by investigating the intra-subject differences between the performances of the two styles. This methodological approach is thought to provide significant results because it will directly reflect the changes in phonatory behaviour that the singer makes in order to tune into the desired mode of singing. This makes it possible to measure the vocal quality typical for each style of singing while using the same morphological basis, i.e. the same vocal organ.

Because all singers belong to the leading and single professional ensemble of Croatian folk song and dance in Croatia, we can consider their voices as fine representatives of the respective styles, and we can also consider the subjects homogeneous in terms of working hours per day, singing practice/training hours, working conditions, etc.

This is the first acoustic study on Croatian folk singing, on which the only data has previously been given from an ethnomusicological point of view. Therefore, the current investigation is explorative.

[1] We call it a *style* here, although it may actually be better described as an interpretation that is present in several vocal forms. We have selected here only one of them, from a single region, namely around the town of Vrlika.

2 Method

2.1 Subjects

A total of 12 male professional folk singers voluntarily took part in the investigation. All were members of *LADO Folk Dance Ensemble of Croatia* (www.lado.hr), which practises song and dance from all regions of the country. The singers had been performing Croatian folk music as *LADO* members for an average period of 10 years (for details on subjects see Table 1). Their average age was 33 years. None of the subjects had formally studied singing before joining the *LADO* ensemble. During the time of participation in the study, all singers reported to be in good vocal and physical condition.

Table 1. Data on the age and professional singing experience of the subjects (N=12).

Variable	Mean	Standard deviation	Minimum	Maximum
Age (years)	32.66	6.12	24	45
Professional experience (years)	10.08	4.99	4	20

2.2 Data collection

The recording was performed in an anechoic chamber of the Department of Electroacoustics of the Faculty of EE and Computing of the University of Zagreb (Figure 2). Since the sound field in the anechoic chamber consists only of direct sound (i.e. the reflections are absorbed in the walls), the possible environmental influence on recording is negligible. The background noise level measured inside the chamber was 19 dB(A).

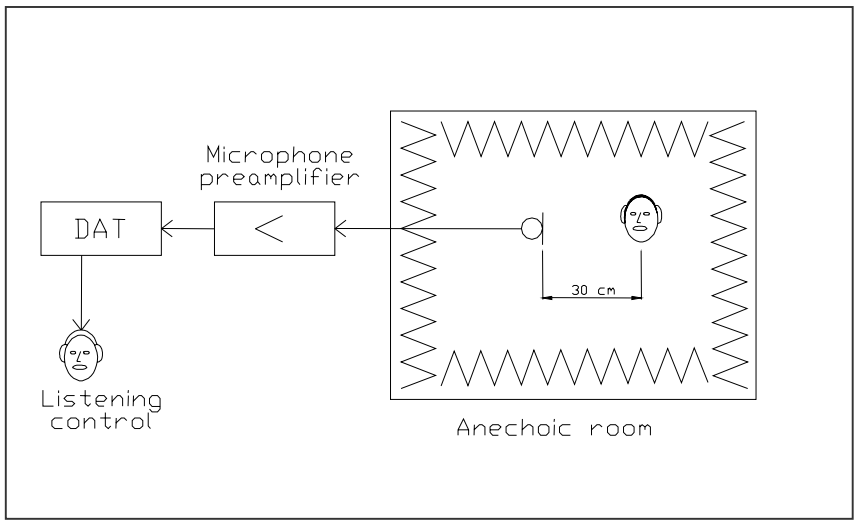

Figure 2. Schematic illustration of the voice recording setting.

The subjects were recorded one by one. Each was asked to perform one traditional song from Dalmatia representing the *klapa* style, and one traditional song from the Dalmatian Hinterland representing the *dozivački* style. The songs were selected by the artistic director of the LADO Ensemble, who also chose the key for each song: the Dalmatian song *Zaspalo je siroče* was performed in G-major, while the song *Mi smo rekli zapivati ode* from the Dalmatian Hinterland was sung in c-minor by all singers.

The songs were performed three times each. One take of each song, namely the one that was judged as the best both by the singer himself and by the first author of this paper, was selected for acoustical analysis. The criteria were authenticity, stable vocal quality (no voice breaks or other undesirable qualities), and the singer's overall satisfaction with his performance.

Prior to the recording procedure, special attention was given to minimizing the influence of the equipment being used. Since unidirectional microphones may add coloration to the recordings (depending on their off-axis frequency response), the *Behringer ECM 8000* omnidirectional microphone was used.

Each singer performed in standing position and the mouth-to-microphone distance was 30 cm. The microphone signal was fed to a *TOA D-4* microphone preamplifier. During the test recording, the gain of the preamplifier was set to the optimal level for each singer. The recording was performed on an *AIWA HD-S200* DAT-recorder with a sample rate of 44.1 kHz and later digitally transferred to CD. For each individual singer, the recording gain was equal for the two styles (except for singer 2, who turned out to be unexpectedly loud in the second style recorded, i.e. the *dozivački* style). This made sure that the loudness levels of the two styles could be compared for each singer (although the recordings were not calibrated for absolute sound pressure level). The signal was monitored with headphones by an assistant.

2.3 Acoustic analysis

The LTAS analysis was performed by the computer program *PRAAT, version 4.1.2*. developed by Paul Boersma and David Weenink from the Institute of Phonetic Sciences of the University of Amsterdam. The analysis was performed with a filter bandwidth of 125 Hz and a frequency range from 0 to 5 kHz. The average lengths of the songs were 57.16 seconds for *Zaspalo je siroče* (*klapa*) and 50.75 seconds for *Mi smo rekli zapivati ode* (*dozivački*) (for the lyrics, see the Appendix; for samples of the audio recordings, visit www.fon.hum.uva.nl/paul/CroatianFolkSinging/).

To compare the two styles, we will compute a *trend line* for the LTAS of each singer and each style, namely a linear least-squares fit between 0.6 and 4 kHz. The difference between the original LTAS curve and the trend line (in dB) will give a better view of possible inter-style differences. Furthermore, the relationship of the spectral peaks and particularly the power of the singer's formant, if it exists, will be recognized.

3 Results

The results of the spectral analyses for the *klapa* and *dozivački* styles are displayed in Figures 3 and 4, respectively. Although the results vary between subjects within each style, we can see some general trends and speak about inter-style differences in spectral envelopes (LTAS) and corresponding trend lines. The most obvious differences are related to spectral slopes and to sound levels. The trend lines clearly show that the slope of *klapa* singing is steeper than that of the *dozivački* mode. This is

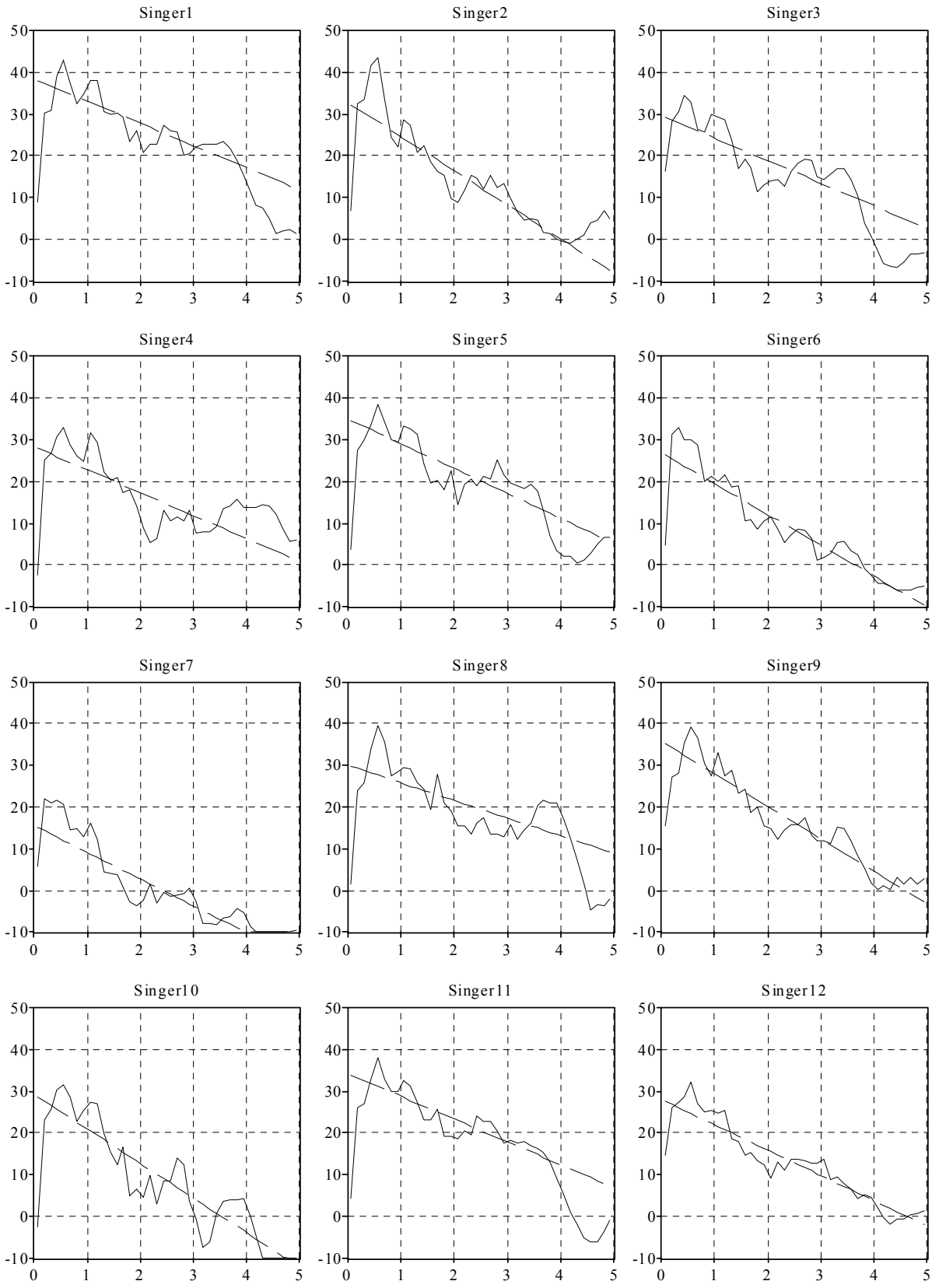

Figure 3. Spectral envelopes and trend lines for the *klapa* style for 12 singers.

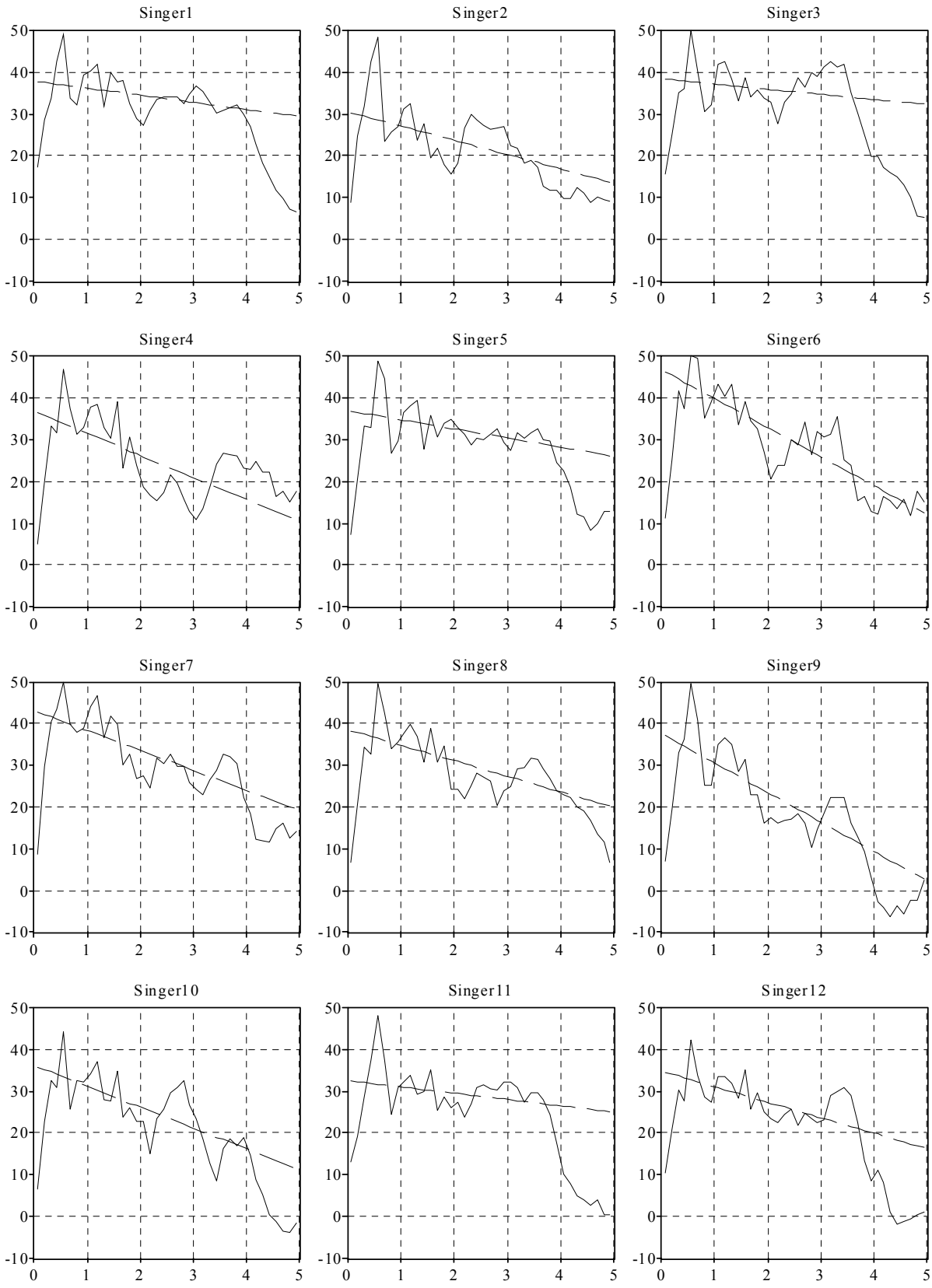

Figure 4. Spectral envelopes and trend lines for the *dozivački* style for 12 singers.

so for practically all singers. Knowing that the spectral slope is related to the speed of glottal closure, the abovementioned differences suggest that there is a difference in the voice source characteristics employed in each singing style. The steeper slope for *klapa* may also be seen as a result of softer vocal loudness of this style as compared to *dozivački*. This feature is noticeable through the differences between the amplitudes of the strongest spectral peaks of each style at around 0.6 kHz, which approximates an amplitude difference of 10 dB. Actually it ranges from 5 to 16 dB with the single exception of singer 7 where this difference reaches 28 dB. It is clear that great loudness is an important feature of the *dozivački* style and is shared by all singers.

Apart from differences in vocal loudness, the two styles differ in regularity of the spectral peaks. For the *klapa* style there seems to be a regular pattern of peaks appearing particularly around 2.5 and 3.5 kHz reflecting the third and fourth formants (F3 and F4). This is the spectral region where one may expect and/or look for the singer's formant. For most of the singers and their spectra, the peak amplitudes in this frequency range between 2.5 and 3.5 kHz are rather low and the amplitude difference between the strongest spectral peak and the one at around 3.5 kHz is about 20 dB. In other words, it is apparent that there is no singer's formant in *klapa* singing. Actually, the *klapa* spectra resemble those of speech. No evidence of a singer's formant in other folk singing voice qualities were found by Burns (1986) for American *country-and-western* folk singing, by Ross (1992) for Estonian folk singing, and by Cleveland et al. (2001) for country singing.

The spectra for the *dozivački* mode of singing are different. As said earlier, it shows louder vocal production. Therefore the spectral slope is not as steep as in *klapa*. The pattern of peaks in the upper part of the spectrum for *dozivački* is not as clear or regular as for *klapa*, and this also may be seen as the result of different vocal loudness the singers employed in *dozivački* singing. The LTAS contours show broader spectral peaks distributed along the frequency range between 2.2 and 3.8 kHz. In quite a few spectra those peaks are prominent, suggesting the existence of a singer's formant. The peaks make envelopes that look like grouping of the higher formants, and it is known that clustering of the third, fourth and fifth formants is one of the characteristics of the singer's formant (Sundberg, 1974). While for most singers this peak is broad, in some cases it is possible to easily differentiate the higher formants such as in the spectra of singers 7, 8 and 10. Although such a broad peak is noticeable in most other spectra, there are two factors that do not support labelling it as a singer's formant. First, its frequency is higher and in most such spectra reaches or surpasses 3.0 kHz (spectra of singers 1, 3, 5, 6, 9, 11, 12), whereas the central frequency of the singer's formant is known to be lower – at around 2.5 kHz or higher up to 3 kHz, depending on voice classification (bass, baritone or tenor). The fact about the higher location of the upper broad formant in *dozivački* singing may again be seen as a result of the greater loudness typical for this mode of singing. The second factor that does not support the existence of a singer's formant in *dozivački* singing is the amplitude difference between the strongest spectral peak at 0.6 kHz and the broad peak in the upper part of the spectrum. In most of the spectra it exceeds 10 dB. Thus, only the spectra of singers 1, 3 and 11 seem to have the features of a singer's formant. Such differences in spectra of 12 singers and particularly the information in the upper part of the spectrum are probably the results of inter-individual differences in singing skills and musical talent of the singers as well as a different professional singing experience.

Figure 5 shows LTAS for the *klapa* and *dozivački* styles pooled over all 12 singers. Again, the inter-style differences between the spectral envelopes are quite obvious. The LTAS for *klapa* looks similar to the LTAS of speech, while *dozivački* is characterized by a large loudness, as shown by a prominent first spectral peak. The effect of loudness is reflected in the overall LTAS contour and its slope. The relative

amplitude difference between the strongest spectral peak and the broad strong peak located between 3.0 and 3.5 kHz is about 17 dB, thus there is no support for labelling this peak as a singer's formant.

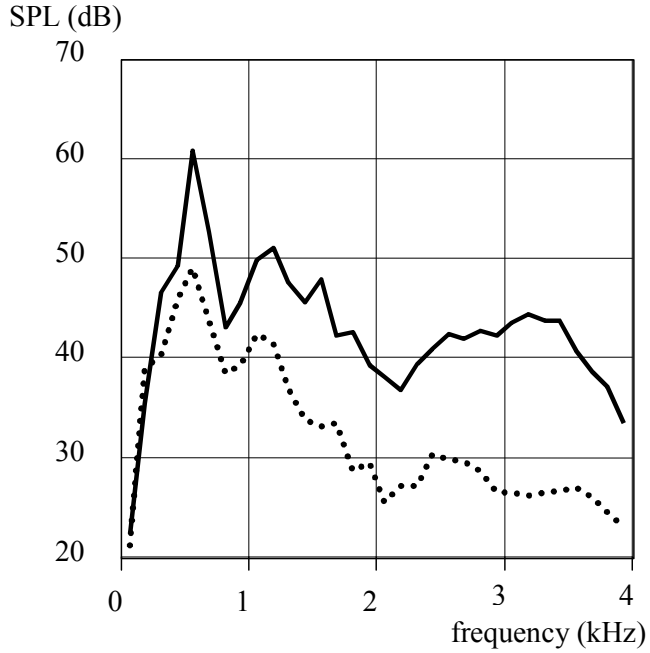

Figure 5. Spectra for the *klapa* style (dotted line) and the *dozivački* style (solid line) pooled over all 12 singers.[1]

4 Discussion and conclusion

The results of an LTAS analysis of the *klapa* and *dozivački* styles of singing indicated differences between these styles. The spectral slope is a factor that distinguishes the two styles, and the energy concentration along the spectra is another obvious difference. The *klapa* style turned out to be rather similar to speaking in terms of LTAS characteristics such as the regularity of the spectral peaks or the locations of these peaks. The *dozivački* style appears to be different in that respect, and it may be assumed that this difference is the result of the large vocal loudness that is characteristic of this mode of singing.

Actually, if translated to English, the term "dozivački" itself stands for the act of calling over a distance and that may include even shouting-like vocal production (as may be heard on www.fon.hum.uva.nl/paul/CroatianFolkSinging/). The greater loudness in *dozivački* is indicated in Figure 5 by a generally higher level of intensity (remember that the microphone gain was not changed between the two styles), but is also reflected in the upper part of the spectrum where the broad spectral peak gives the impression of a singer's formant. Nevertheless, this peak is not likely to actually be a singer's formant, because of its low amplitude level and its high location in the spectrum; this strongly suggests another resonance phenomenon known as *actor's* or *speaker's formant (ring)*. This formant has not been studied in such depth as the

[1] Pooling means that the voices have been added to each other, as in a choir; this is why the levels are higher here than for any of the singers in Figures 3 and 4.

singer's formant, but it was observed (Leino, 1994; Nawka, Anders, Cebulla & Zurakowski, 1997) that it can be detected in spectra of trained speakers in the same way that a singer's formant is detected in trained singers (this analogy to singing has given the speaker's formant its name). The speaker's formant refers to a strong spectral peak between 3.0 and 3.7 kHz, that is, in the region of the fourth formant, resulting in sonorous voice quality (Nawka et al, 1997). There are also assumptions that this formant represents an effective transition of the singer's formant into a resonance of the speaking voice (Barrichelo, Heuer, Dean & Sataloff, 2001; Thunberg, 2003). According to data by Leino (1994), speaking voices of good quality contain a speaker's formant that is comparable to a singer's formant, but its frequency is about 1000 Hz higher and its amplitude level is weaker. Such findings were established in the current study as well where a broad formant was detected at around 3.0-3.5 kHz, and its amplitude is about 17 dB lower as compared to the strongest peak of the spectrum (according to Leino 1994, the difference of 15-25 dB is already considered a criterion of good voice quality). Although this data supports the presence of a speaker's formant in the *dozivački* voice quality, one has to be very careful with this label. The main problem is that the speaker's formant, as suggested by its name, is related to the speaking voice, not to the singing voice, so it deserves a different label in our study. The presence of a speaker's formant was also found in the study by Cleveland et al. (2001) where the spectra of country singers were analysed. Therefore, if future independent studies on folk singing voices will show similar results, then it will be clear that this resonance phenomenon will have to be relabelled by another appropriate name. Cleveland et al. (2001) agreed to simplify this problem by talking about a more prominent fourth formant.

As has already been stated, the strong spectral peak in the speaker's formant region found for *dozivački* singing may also be seen as a result of the louder singing and nearly shouting-like vocal production typically employed in this mode of singing. Therefore, it seems that the appropriate label for the discussed formant could be *shouter's ring* or *shouter's formant*. The data provided by Sundberg (2001) have shown that the 10 dB increase of the overall sound level resulted in an average increase of 16.3 dB in the spectral energy above 2 kHz. Similar findings were reported by Bloothooft & Plomp (1986). This analogy may explain the prominence of a high formant labelled *shouter's ring* in *dozivački* singing. It may be speculated that softer singing would result in a somewhat decreased level of this formant, but then the *dozivački* style would lose its most distinctive attribute, making itself even less functional because the essence of this style is to be heard over long distances. For that reason, the employment of the shouter's formant is understandable and required. At the other hand, it may be hypothesized that this formant may be even more prominent in the voices of local singers who sing even louder; but this topic is left for further research.

The results of the current study are in agreement with the few previous studies conducted by other investigators that also showed that folk singing does not rely on a singer's formant (Burns, 1986; Ross, 1992; Cleveland et al., 2001). However, the presence of another resonance phenomenon was observed. It refers to a prominent spectral peak located at higher frequencies (between 3.0 and 3.8 kHz) sometimes called the speaker's formant, the fourth formant or, as in the present study, the shouter's formant. This fact alone shows that more studies on folk singing are needed.

Acknowledgments

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Appendix

The lyrics to the Dalmatian folk song *Zaspalo je siroče* sung in *klapa* style, and to the folk song *Mi smo rekli zapivati ode* from the Dalmatian Hinterland performed in *dozivački* style.

Zaspalo je siroče

Zaspalo je siroče isprid tuđih dvora,
Ručicama doziva priko sinjeg mora,
Ručicama doziva priko sinjeg mora.

Dođi, dođi, oče moj, mrkla noć se sprema,
Naše mile majčice još nam doma nema,
Naše mile majčice još nam doma nema.

Mi smo rekli zapivati ode

Mi smo rekli zapivati ode,
Mi smo rekli zapivati ode,
Mi smo rekli zapivati ode,
Zapivati ode.

Bilo veče, bilo usrid podne,
Bilo veče, bilo usrid podne,
Bilo veče, bilo usrid podne,
Bilo usrid podne.