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ACOUSTICAL FEATURES OF COMMUNICATION IN LITHUANIAN «FIELD» SINGING

The purpose of this represented scientific article is to get acquainted with the research results of communication, based on acoustical features in Lithuanian «field» singing, which are well-known in the development of Lithuanian ethnomusicology. **The methods** of this specific investigation. For a detailed study of the chosen topic, an integrative methodology is used, which combines historical, theoretical, comparative research methods of scientific knowledge. **The scientific novelty** of the submitted particular research article lies in the fact that for the first time in Lithuanian ethnomusicology the phenomenon of just «field» singing research is considered, which is devoted to development of acoustical investigations of singing folklore. **Conclusions.** Formant tuning is applied clearly in the case of «singing outdoors», thus making the vocal technique more «economic» in terms of vocal efforts, whereas in the case of «singing indoors», the economy of vocal technique does not seem that important. In the analyzed examples of «outdoors» singing, intensification of the spectra in the singer's formant range is observed. This specialized phenomenon is stronger for the male singing and weaker for the female singing. Thus, the tendency is the same as for operatic voice. To generalize of this submitted exploration, multiple strategies (formant technique plus singer's formant) are employed to intensify and «project» the voices in «singing outdoors» mode. The professional prospects of this represented musically vocal investigation is implementation of contemporary research works, which dedicated to

questions about voice propagation over long distances, what is particularly sensitive in certain cases of traditional culture where individual singers or groups of singers who are far apart communicate.

The key words: acoustics, folk songs, melodic lines, «field» singing, sound propagation, formant technique, singer's formant.

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Акустичні особливості комунікації у литовському традиційному «польовому» співі

Метою статті є ознайомлення з результатами наукових досліджень слухових особливостей художнього спілкування у литовському «польовому» співі, які є перспективними у подальшому розвитку литовської етномузикології. **Методи дослідження.** Для детального вивчення обраної теми використовується інтегративна методика, що поєднує такі підходи як історичний, теоретичний, порівняльний методи дослідження наукового пізнання. **Наукова новизна** презентованої статті полягає в тому, що вперше у литовській етномузикології розглядається феномен саме «польової» народно-пісенної традиції, присвячений розвитку акустичних наукових досліджень пісенного фольклору. **Висновки.** Формантне налаштування звуковидобування народних співаків застосовується у випадку «співу на відкритому повітрі», що робить своєрідну вокальну техніку більш «економічною» з погляду вокальних зусиль, тоді як при «співі у приміщенні» економія вокальної техніки не здається настільки ж важливою. У проаналізованих зразках співу «на відкритому повітрі» спостерігається активне посилення спектрів у формантному діапазоні співака. Це явище більш сильніше виявлене у чоловічому співі, аніж у жіночому. Таким чином, тенденція звуковидобування народних співаків є такою ж, як і в оперних вокалістів. Узагальнюючи наукові результати відзначимо, що формантна техніка плюс форманта співака використовуються задля посилення та «проекування» голосів у режимі «співу на відкритому повітрі». Перспективами означеного наукового дослідження є максимальність спроби впровадження у практику сучасних науково-дослідницьких робіт, присвячених питанням поширення голосу на великі відстані, що є особливо

чутливим у певних випадках традиційної музичної культури, де, наголосимо, художньо спілкуються окремі музиканти-співачи чи групи співаків, що віддалені один від одного.

Ключові слова: акустика, народні пісні, мелодика, «польовий» спів, звуковидобування, формантна техніка, співоча форманта.

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Акустические особенности коммуникации в литовском традиционном «полевом» пении

Целью статьи является ознакомление с научными результатами исследований слуховых особенностей общения в литовском «полевом» пении, которые являются наиболее перспективными в дальнейшем развитии литовской этномузыкологии. **Методы исследования.** Для максимально детального изучения выбранной темы используется интегративная методика, сочетающая исторический, теоретический, а также сравнительный методы исследования научного познания. **Научная новизна** представленной исследовательской статьи заключается в том, что впервые в литовской этномузыкологии рассматривается музыкальный феномен именно «полевой» народно-песенной традиции, посвященный развитию акустических научных исследований певческого фольклора. **Выводы.** Формантная настройка извлечения звука народных певцов явно применяется в случае «пения на открытом воздухе», что делает вокальную технику более «экономичной» с точки зрения вокальных усилий, тогда как в случае «пения в помещении» экономия вокальной техники не кажется такой важной. В проанализированных примерах пения «на открытом воздухе» наблюдается активное усиление спектров в формантном диапазоне певца. Это явление значительно сильнее для мужского пения и слабее для женского. Таким образом, тенденция извлечения звука народных певцов является такой же, как и у оперных вокалистов. В целом отметим, что формантная техника плюс форманта певца используются для усиления и «проецирования» голосов в режиме «пения на открытом воздухе». Перспективы данного научного исследования включают в себя реализацию современных научно-исследовательских работ, посвященных многим вопросам

распространения голоса на большие расстояния, что, подчеркнём, особенно важно в некоторых случаях музыкальной традиционной культуры, когда общаются отдельные музыканты-певцы или группы певцов, находящихся далеко друг от друга.

Ключевые слова: акустика, народные песни, мелодика, «полевое» пение, извлечение звука, формантная техника, певческая форманта.

Statement of the problem. How to sing so that the voice propagates as far as possible? The simple answer would be – louder. From our experience, and especially from fieldwork, we know that traditional singers sometimes sang so loud that “the lamps were shattering”, whether it was indoors or outdoors. However, is just intense singing enough to make the voice heard far away?

The relevance of the study is presented in the analytic, acoustical, comparative, historical and typological studies of communication, based on acoustical features in Lithuanian “field” singing tradition.

Literature review. Among the works on the Lithuanian ethnomusicology we note the publications of sound recordings edited by G. Četkauskaitė [5; 6], A. Nakienė, and R. Žarskienė [15]. The research in the theoretical part of acoustic investigations was based on general knowledge about the physics of sound propagation (diffraction and absorption). A number of studies on formant tuning and singer’s formant in western operatic vocal, including those by L. Dmitriev, and A. Kiselev [9], H. K. Shutte, and R. Miller [20], T. Millhouse, F. Clermont, and P. J. Davis [14], (especially) J. Sundberg [21; 22; 23; 24; 25; 26; 27], and others, were reviewed. The academic writings in the field of acoustic analyses of non-western singing by G. Chrysochoidis, D. Delviniotis, G. Kouroupetroglou, and S. Theodoridis [7], R. Sengupta [18], N. A. Joshi, and M. A. Raju [12], R. Ambrazevičius [1; 2; 3; 4], R. Budrys [4], A. Johnson, J. Sundberg, and H. Wilbrand [11], G. Kovačić, P. Boersma, and H. Domitrović [13] have to be admitted here as well.

The purpose of the article is present the idea to consider the “indoors” voice to be a voice that has no intention of propagating over long distances, and the “outdoors” (or “field”) voice is to consider a voice that is formed to propagate over long distances.

The object of study there are the acoustical features in Lithuanian traditional “field” singing. **The subject** – particular traditional “field” singing.

Presenting main material. “Indoors” and “outdoors” (“field”) voice. The issue of voice propagation over long distances is particularly sensitive in certain cases of traditional culture where individual singers or groups of singers who are far apart communicate. Such are, for example, Lithuanian rye harvesting or mowing songs. By that I don’t mean that all the songs of these genres were performed in some special voice. Some of the songs (sub-genres) do not require long-distance communication. Moreover, with the disappearance of the traditional way of life and the singing situations caused by it, the singing styles of these genres have become faded (i.e. from ceremonial or directly related to the work action situation they became lyrical), and this can be felt from the examples of singing recorded in the last century. However, there are still a number of examples in which specific “field” voice quality has survived, to a greater or lesser degree. This paper is devoted to the investigation of such cases.

Let us agree that, within the framework of this article, we will consider the “indoors” voice to be a voice that has no intention of propagating over long distances, and the “outdoors” (or “field”) voice is to consider a voice that is formed to propagate over long distances. Again, it doesn’t just correspond to a weak and strong voice.

Sound propagation. The first question would be: what features facilitate vocal communication in long distances? Of course, this is a sufficient sound intensity. Obviously, the farther the sound source and sound receiver are, the weaker the sound. However, the efficiency of sound propagation also depends on the sound frequency: sounds of different frequencies are heard differently over long distances. There are two phenomena relevant in the context of this paper that determine sound propagation; namely absorption, and diffraction.

The attenuation of sound due to absorption in the air over short distances is small, but in the case of long distances it must be considered. High frequency components are highly absorbed; this is why high-frequency speakers are built away from the sound source in large arenas or stadiums to maintain frequency balance. This attenuation and dependence on frequency is quite complex and depends on air pressure, temperature, and humidity. To estimate this phenomenon, we will use an online calculator ⁴³ here.

Diffraction works in the opposite way: the low frequencies behind the slit (in this case the singer’s mouth) are spread more evenly in all directions,

⁴³ <http://www.csgnetwork.com/atmossndabsorbcalc.html>

while the high frequencies propagate more directionally (Fig. 1). Thus, due to diffraction, the high-frequency components of the voice in front of the voice source will be better heard on axis than the low-frequency components.

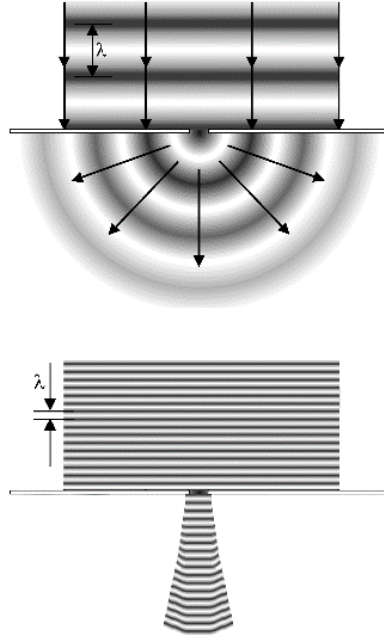


Figure 1. Diffraction of low frequency sounds (long wavelength; top) and high frequency sounds (short wavelength; bottom) through slit.

Fraunhofer diffraction by a circular aperture is described by the following simplified formula:

$$I = \left(\frac{A}{\lambda r_0} \right)^2;$$

here I stands for maximum relative intensity (i.e. compared to the intensity of the source) on axis, A is area of the aperture, λ is wavelength, and r_0 is distance from the source and receiver [19, p. 14]. Thus, the change in sound level from source to listener is as follows (here the wavelength λ is rewritten as the ratio of the sound speed v and frequency f):

$$\Delta L = 20 \lg \left(\frac{A f}{v r_0} \right).$$

Suppose one group of singers stands at a distance of 200 m from another, the air humidity is average (50%), the air pressure equals standard

atmosphere (101,325 Pa), mouth aperture(s) is 20 cm², and temperature is 20°C (i.e. sound speed is 343 m/s). Fig. 2 indicates a decrease in sound level.

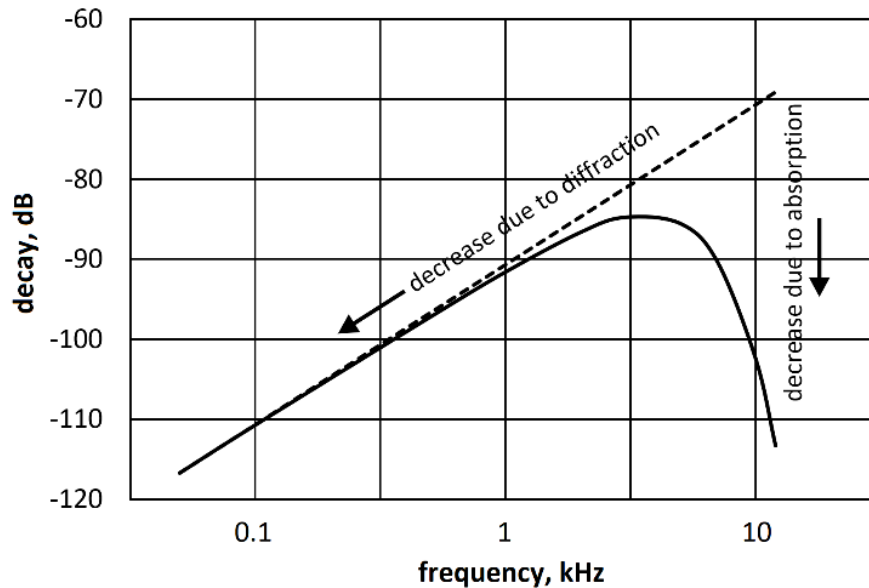


Figure 2. Dependence of sound level attenuation on frequency; for options, see the body text.

Fig. 2 shows that in the considered case, the components of about 2–5 kHz have the least intensity loss. Interestingly, this coincides with the frequency band to which human hearing is most sensitive. Thus, in order to enhance the propagation of voice over long distances under the conditions in question, it is necessary to intensify the voice components of this frequency band in some way. In the following sections of the paper, we will examine how this can be done.

Formant technique. One way to intensify the voice is formant technique (or formant tuning). This technique is widely studied for operatic voice (starting with “classical” studies, such as [23; 24; 25, p. 5–9; 26, p. 124–129], and continuing with the numerous studies in recent decades).

The formant technique can be briefly explained as follows. If no additional maneuvers are applied, when singing in a high voice (so this is especially true for sopranos), harmonics of the voice do not match the formants of vocal tract. So, the voice does not resonate, is not intense. To amplify the voice, the formants are “attracted”, tuned to the harmonics. This usually enhances the fundamental tone by matching the first or (if singing very high) second formant to it. This result is achieved with widening the jaw opening, either vertically or horizontally. Of course, this also changes the phonetic quality of the sung vowel.

There is a lack of research of formant technique for other (than operatic) vocal styles. One of the studies I would like to mention here is about the specific style of Swedish traditional singing, kulning [11]. It is the singing of women, mountain shepherds in a high voice, communicating over long distances. Among other things, the authors of the paper found that kulning differs from ordinary singing by intensely applied formant technique. Formant technique was also detected in Byzantine chant [7].

In previous papers (cf. [1–3]), I have examined how the formant technique is applied in Lithuanian traditional singing. Let's look at the example of one female singer. Two songs were considered, children's and rye harvesting (Fig. 3). The first five structural pitches of each song were analyzed, their fundamental frequencies (f_0), and frequencies of the first and second formants (F1, F2) were measured (Fig. 4). We can clearly see that in the rye harvesting song the formants correspond to the harmonics much more accurately than in the children's song.

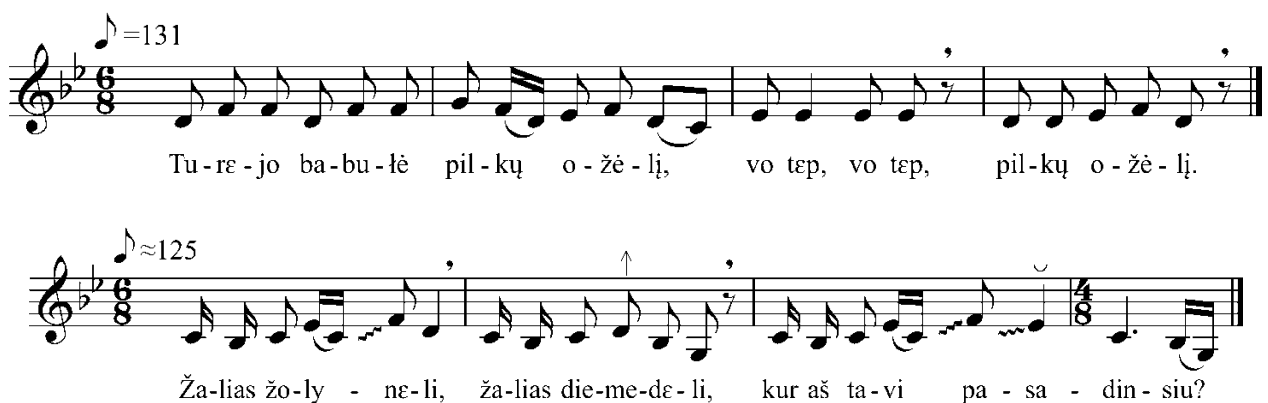


Figure 3. Transcriptions of two songs: *Turėjo babulė pilkų ožėlių*, children's song, and *Žalias žolynėlis, žalias diemedelis*, rye harvesting song (first melostrophes).⁴⁴

⁴⁴ The metrics: Agota Voldemarienė; Dysna, Švenčionys Dst., Vilnius Governorate, rec. 1908. [15, Nos 7 and 2].

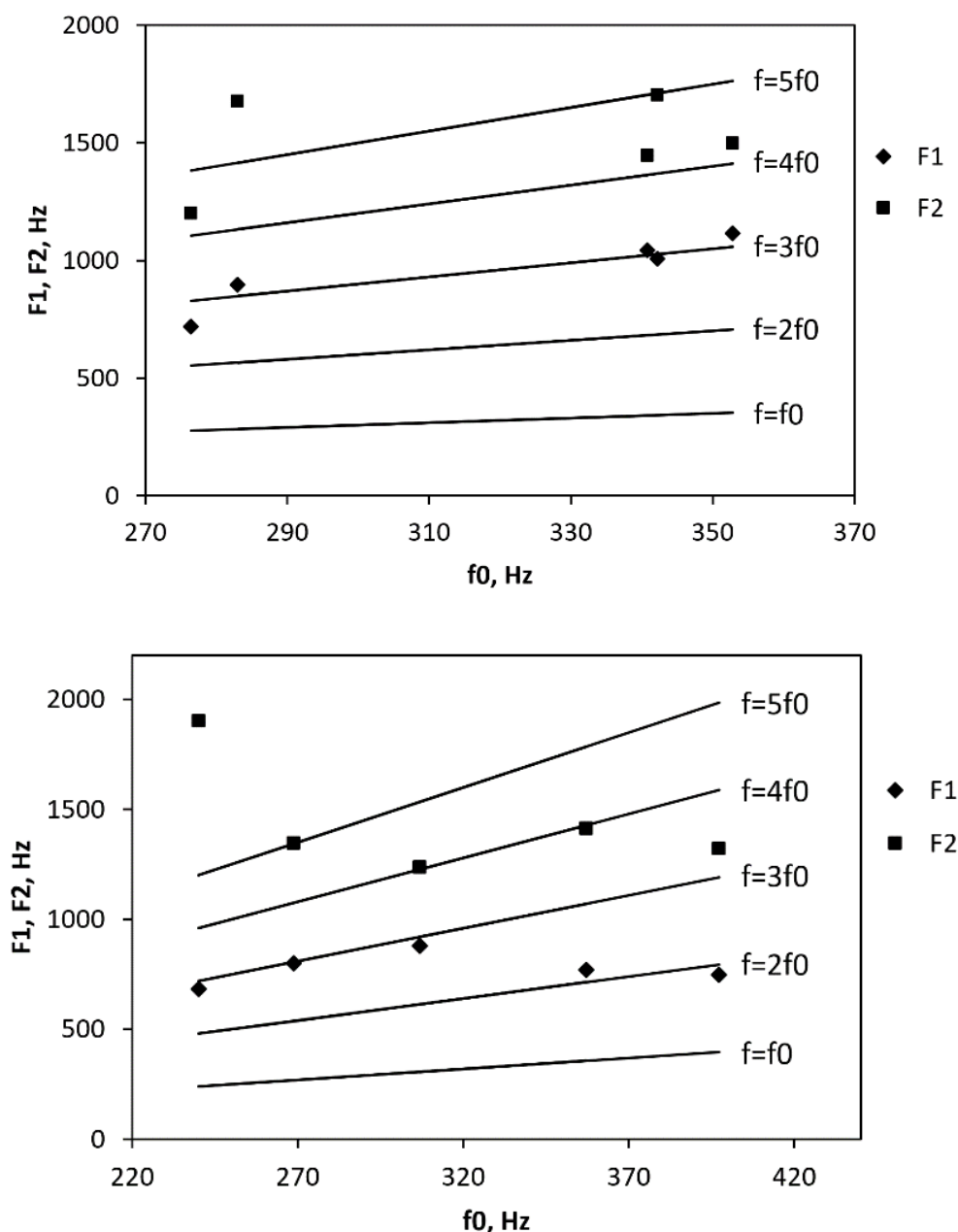


Figure 4. Fundamental frequencies and frequencies of the first and second formants. Five pitches from two songs each, *Turėjo babulė pilkų ožėlį* (top) and *Žalias žolynėli, žalias diemedėli* (bottom).

Analogous measurements of singing examples of nine other singers from various regions of Lithuania were performed. That is, in each case, two songs were taken – one regular (“indoors”), the other a “field” (“outdoors”) song (mostly rye harvesting or mowing). We can introduce a quantitative index that shows how much the frequency of the certain formant and the nearest harmonic do not match. If the formant and harmonic frequencies coincide perfectly, the value of the index is 0. If the frequency of the formant is exactly in the middle between the harmonics, the value of the index is 1. Thus, if the formant technique is not applied, the average value of the index should be 0.5.

The measurements showed the following average results: for “indoors” 0.32 (F1 mismatch) and 0.5 (F2 mismatch); for “outdoors” 0.19 (F1 mismatch) and 0.31 (F2 mismatch). Thus, it is obvious that in the case of “outdoors” the formant technique is applied much more intensively.

Singer’s formant. The singer’s formant, a specific formant occurring at approximately 2 kHz – 4 kHz frequencies (Fig. 5), is widely discussed, starting from the seminal studies published several decades ago (cf. [9; 20; 21; 22]) and continuing up to the present (cf. [10; 14; 16]). Presence of the singer’s formant is considered in fact an obligatory requirement for operatic male voices. In addition, more recent studies found possible manifestations of the singer’s formant in operatic female or castrato voices as well, though to a lesser extent (cf. [27]). Several techniques were proposed for evaluating intensity of the singer’s formant and for differentiation of the true formant from other phenomena responsible for some intensification of spectra in the 2 kHz – 4 kHz range.

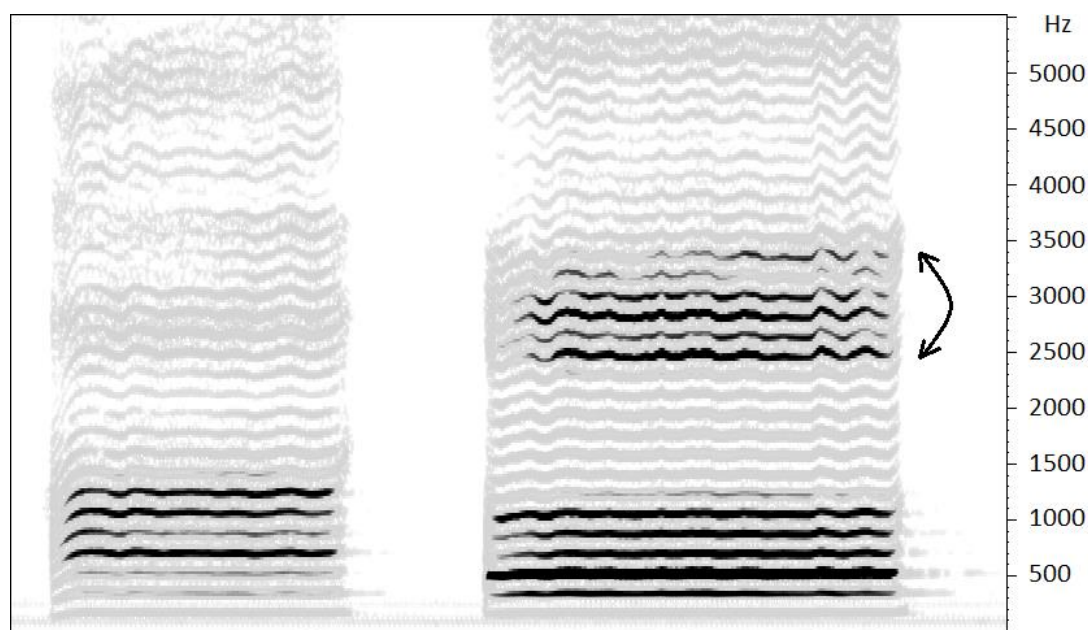


Figure 5. Spectrograms of voice without singer’s formant (left) and with singer’s formant (right). The range in which harmonics are enhanced by the singer’s formant is marked.

This peculiar voice quality is important, first of all, for large acoustical spaces without artificial sound reinforcement. Most probably, it is not that urgent for smaller chambers and for contemporary environments with sound reinforcement. Also, it is not clear whether the singer’s formant is relevant for other than operatic (or academic) vocal styles. For instance, traditional and generally non-Western singing is barely studied in terms of the singer’s formant (cf. [8; 12; 13; 18]). One could expect that, at least for certain

acoustical conditions and certain styles of traditional singing, the technique that is normally applied to operatic singing could be applied as well.

In the current paper, two typical traditional Lithuanian “outdoors” song performances are chosen for the investigation, a mowing song (male singing) and a rye harvesting song (female singing); see the transcriptions in Fig. 6.



Figure 6. Transcriptions of two songs: *Valioj pievų, pėvytalį*, mowing song, melostrophe 1; and *Vaikštinėjo tėvulis*, rye harvesting song, melostrophe 2.⁴⁵

The obtained results show more or less prominent intensification of the spectra in the 2–4 kHz range (Fig. 7). As expected, this quality is more distinct in the case of the male voice. Incidentally, the female example is characterized by two spectral peaks. The same tendency was observed by Seidner et al. [17]; they found that for female singers, two peaks can occur at frequency ranges of 2.5–3 kHz and 3–4 kHz. Aural impression suggests that both examples are characteristic of resonant voices and possibly singer’s formant is responsible for this. At any rate, intensification of the spectra in the discussed frequency range found for the examined vocal performances suggests that discussed vocal quality is somewhat specific and partly marks a certain quality of the resonant voice.

⁴⁵ The metrics: *Valioj pievų, pėvytalį*. Puponiai singers; Kupiškis Dst. [6, N 18]. *Vaikštinėjo tėvulis*. Ona Jauneikienė; Masališkės, Varėna Dst. [5, N 14].

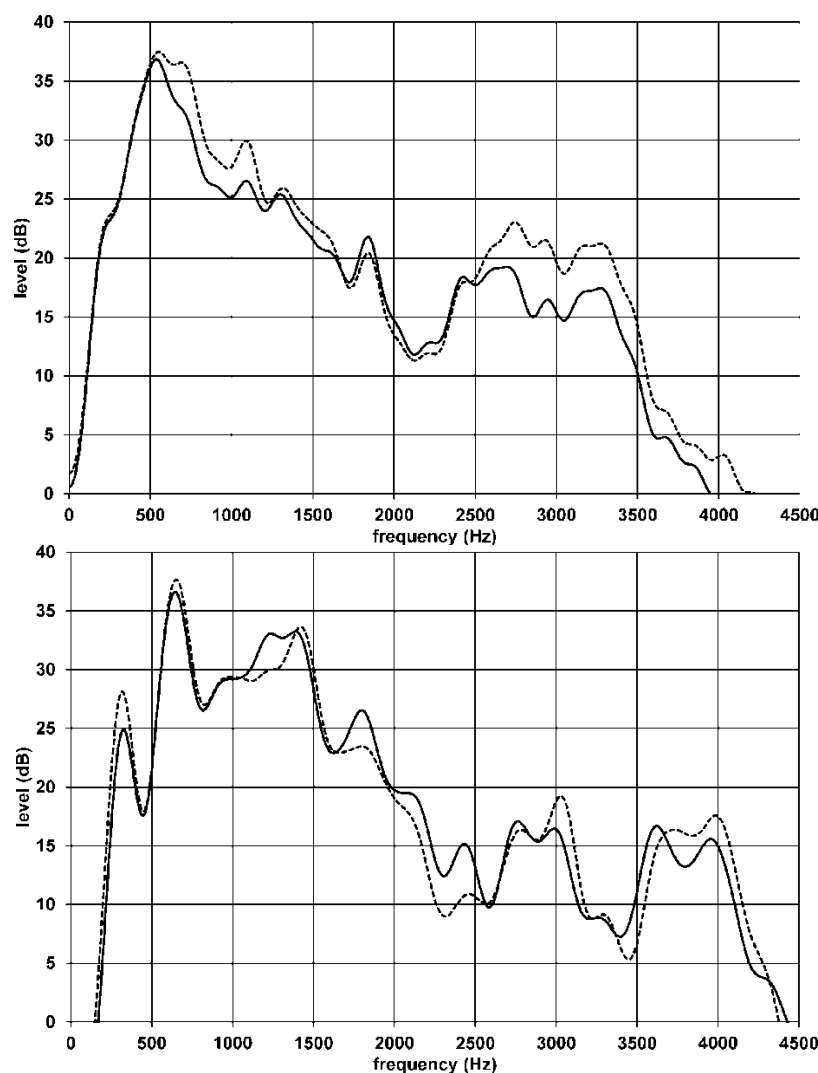


Figure 7. Smoothed LTAS spectra; the male song *Valioj pievū, pēvytalī*, melostrophes 2 and 4, and the female song *Vaikštinējo tēvulis*, melostrophes 2 and 5 [4].

Discussion and Conclusions. Formant tuning is applied clearly in the case of “singing outdoors”, thus making the vocal technique more “economic” in terms of vocal efforts, whereas in the case of “singing indoors”, the economy of vocal technique does not seem that important. In the analyzed examples of “outdoors” singing, intensification of the spectra in the singer’s formant range is observed. This phenomenon is stronger for the male singing and weaker for the female singing. Thus, the tendency is the same as for operatic voice.

For vocal communication over long distances, ways to enhance vocal transmission over long distances are particularly important. Several strategies can be used. First, intensification of voice can be achieved via vocal economy. That is, the formation of the voice does not increase vocal effort, but the vocal tract is modeled so that the voice becomes “flying”, resonating. This is exactly what the formant technique (formant tuning)

provides. Second, the propagation of voice can be facilitated by the enhancement of spectral components of a particular frequency band (roughly 2–5 kHz). This is exactly what the singer's formant provides. Although in the case of female singing the singer's formant effect is seemingly weaker, it is important that this case is characterized by a second maximum, about 3.5–4 kHz. And it is at these frequencies that the voice components propagate best (as shown by estimating the dependence of propagation on absorption and diffraction). In addition, it is to these frequencies that hearing is most sensitive. By the way, the formant technique should be mentioned here again. Although the range of the first two formants does not reach the maximum of “best long-range propagation”, it is still close to it.

To generalize, multiple strategies (formant technique plus singer's formant) are employed to intensify and “project” the voices in “singing outdoors” mode.

The prospects of this investigation is implementation of contemporary research works, which dedicated to questions about voice propagation over long distances, what is particularly sensitive in certain cases of traditional culture where individual singers or groups of singers who are far apart communicate.

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ПОВСТАНСЬКІ ПІСНІ СЕРЕДНЬОЇ ВОЛИНИ В КОНТЕКСТІ ПАТРІОТИЧНОГО СПРОТИВУ УКРАЇНЦІВ

Метою дослідження є виявлення особливостей побутування повстанських пісень на території середньої Волині⁴⁶, їхніх текстологічних і музичних характеристик, аналізу набутих за час існування трансформаційних змін. **Методологію** наукової розвідки обумовлено потребою всебічно і об'єктивно проаналізувати матеріали,

⁴⁶ Корецький, Гоцанський райони Рівненської області, Славутський район Хмельницької області та західні села Новоград-Волинського району Житомирської області.