journal of interdisciplinary music studies
spring/fall 2009, volume 3, issue 1&2, art. #0931203, pp. 45-55

Tonal hierarchies in *Sutartinės*

Rytis Ambrazevičius[1,2] and Irena Wiśniewska[2]

[1] Kaunas University of Technology
[2] Lithuanian Academy of Music and Theatre

Background in ethnomusicology and music cognition. *Sutartinės* are a Lithuanian type of *Schwebungsdiaphonie*. There are quite a few studies on *Sutartinės* and notated song collections (Slaviūnas, 1958, 1959, Račiūnaitė-Vyčinienė, 2002, etc.). However, they have only vaguely referred to the tonal structure of this music (e.g., Boiko, 1996). The study on tonal hierarchies was mostly concentrated on Western music cognition (Krumhansl's fundamental work (1990), etc.).
Background in psychoacoustics. Referred to as the *Schwebungsdiaphonie* in the Balkans and elsewhere, Brandl (1989) proposed that ideal sounding of this type of diaphony conforms to the maximum roughness. The same statement could be made regarding Lithuanian *Sutartinės* as well (Ambrazevičius, 2004, 2005a, etc). The most important issue is that the tonal structure is based on psychoacoustical (i.e., not pure musical) phenomenon and composed of approximately equidistant steps slightly less than 12ET-whole tone, i.e., it is non-diatonic.
Aims. We aim to reveal hierarchical scale structure in *Sutartinės* and to define its psychoacoustical correlates.
Main contribution. Pitch intervals in 8 recordings of *Sutartinės* were measured. Intonational zones in the performances were estimated. Two central pitches in the scale structure were found to be the most stable in many cases. Presumably this implies that the two scale steps are hierarchically the most important in the structure.
Several recordings were employed for the probe-tone experiment. A slightly modified version of Krumhansl's (1990) method was applied. The tonal hierarchies derived in the probe-tone experiment showed correlation with pitch stabilities, in general. They also show substantial divergence from Krumhansl's profiles.
Implications. Ethnomusicology courses considering *Sutartinės* (and probably *Schwebungsdiaphonie*, in general) could benefit from the new knowledge presented in this article: tonal hierarchies should be reconsidered, and notion of diatonic bitonality should be avoided. Folk singing practices should avoid exact reproduction of 12ET intervals in transcriptions but rather develop skills to master maximum roughness of dyads, especially when singing the central pitches.

Keywords: *Sutartinės*, *Schwebungsdiaphonie*, roughness, tonal profiles.

•*Correspondence:* Rytis Ambrazevičius, Faculty of the Humanities, Kaunas University of Technology, Kaunas, Lithuania; Tel.: +370-687-29384, e-mail: rytisam@delfi.lt

Introduction

Sutartinės constitute an important part of Lithuanian polyphonic song lore, first of all, because they present tonal thinking that is quite different from contemporary thought. Many *Sutartinės* can be regarded as a kind of *Schwebungsdiaphonie* ("beat diaphony") based on dissonant (from the viewpoint of the Western music theory) relations between voices. The continuous tradition of *Sutartinės* vanished in the middle of the 20th century, however, the reconstruction of this singing style is very popular nowadays among urban folk singers. Nevertheless, folk groups face difficulties because of the unusual intervals and singing manner.

The present study concentrates on the structure of the *Sutartinės* scale. It consists of two parts: the first one considers pitches and intervals in old *Sutartinės* recordings whereas the second one discusses the perception of the *Sutartinės* scale by contemporary listeners.

Preliminary acoustical measurements were done by Irena Wiśniewska. The remaining part of the study was done by Rytis Ambrazevičius.

Principles of *Sutartinės* performance

Fig. 1 shows a typical example of a *Sutartinė*. The transcription is intentionally presented on the peculiar staff to avoid associations with the diatonic scale. The intervals between the neighboring scale notes are similar, roughly 180 cents.

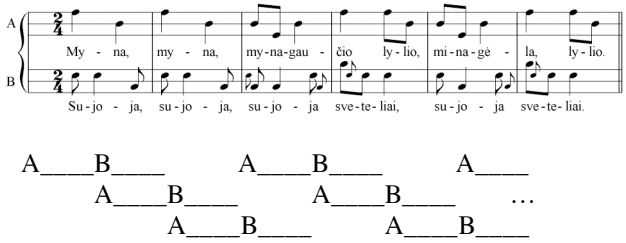

Figure 1. Simplified transcription of *Sutartinė* V4.[1] Top: A and B parts sounding simultaneously. Petit notes show the most characteristic variants. Bottom: canonical structure of the performance in three voices.

The *Sutartinė* is performed canonically by three singers, so that the two parts A and B sound simultaneously, except in the beginning when only one voice (part A) sounds. The lyrics are changed. Thus mostly intervals of the second occur continuously between the two voices. Fig. 2 shows the pattern of the succession of the seconds actually perceived by a listener (the variant versions are not shown).

This is a *Trejinė Sutartinė* ("Sutartinė in three voices"). There are also *Sutartinės* in two and four voices (performed by two and four singers) as well as some *Sutartinės* of

other peculiar types. All these types are reviewed by Slaviūnas (1958, 1959) and Račiūnaitė-Vyčinienė (2002). At any rate, most *Sutartinės* are based on the second interval relations between the voices. *Sutartinės* were performed mostly by groups of women having long experience of singing together.

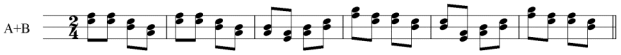

Figure 2. Perceived pattern of simultaneously sounding voices in *Sutartinė* V4.

Acoustical measurements

Samples

Heretofore a total of only 37 recordings of *Sutartinės* have been published (Četkauskaitė, 1998, Račiūnaitė-Vyčinienė, 1998, Nakienė & Žarskienė, 2004). This number includes 8 examples published repeatedly in the three mentioned collections and 3 examples not important for the present study (so-called modern *Sutartinės*, etc.). This does not include some single recordings published repeatedly in several collections. Also, the recordings of the contemporary urban *Sutartinės* singers are not taken into account. The contemporary singing of *Sutartinės* needs to be studied separately. It is clear that some characteristic traits of the old singing style have not been transferred and therefore this singing is not the subject of the present paper.

For this study, 8 recordings of *Sutartinės* were randomly selected from the remaining 26 samples that are of interest.[2] The selected samples are characteristic of the parallelism of second intervals discussed in the previous section.

Method

Software Praat was applied. Frequencies of the most prominent harmonics (and not obscured by the background noise) of the vocal dyads in the selected samples were measured. Mostly these were 2nd and 3rd harmonics, and sometimes 1st (fundamental) and 4th harmonics. The fundamental frequencies were calculated and, subsequently, the corresponding pitches and intervals were found.

Quasistationary segments of the dyads were considered (the voices often start with initial glides and reach "target" pitches). The average frequencies of the chosen harmonics in these quasistationary segments were measured. Several dyads were omitted from the consideration because of too low SPLs (of one or both voices) in comparison with the background noise. In the case of only one strong voice, only the single corresponding pitch was calculated. In the case of intervals other than seconds (thirds or fourths) both pitches were calculated, but the intervals were not considered. 494 dyads with the second interval in between, 31 single pitches, and 51 dyads with other intervals in between were considered.

Results

Stability of intonation. Fig. 3 shows results of our previous studies (Ambrazevičius, 2005a) where only one *Sutartinė* (V4) was considered.

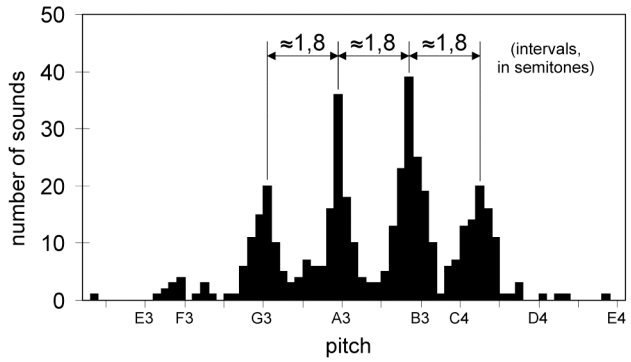

Figure 3. Histogram of pitches in Sample V4 (all pitches in all parts).

It is clearly seen that two pitches (around A3 and B3) are the most stable (their scatter is the least in the course of the performance) whereas the two others (around G3 and C4) are less stable, not to speak of the remaining marginal pitches (around F3 and D4) that appear episodically.

Standard deviations of the pitches and that of the second intervals occurring between the voices of dyads were calculated in all samples under investigation. Figs. 4 and 5 show the generalized results.[3]

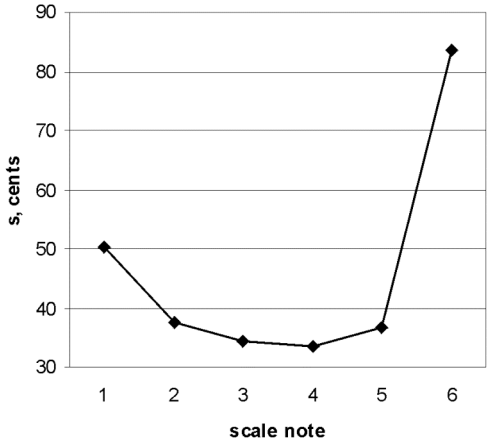

Figure 4. Standard deviations of the different scale notes averaged across all samples.

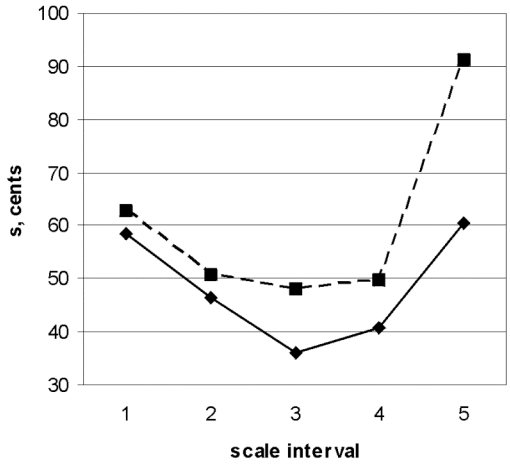

Figure 5. Bold line: standard deviations of the second intervals occurring between the voices of dyads averaged across all samples. Dashed line: the same, if tuning of the voices was absent.

Figs. 4 and 5 show that the regularities revealed in Sample V4 are generally found in all samples under investigation. That is, the most stable pitches are in the centre of the scales whereas the stability decreases by degrees when moving to the marginal pitches.

The dashed line in Fig. 5 is derived for the case if the voices were intoned independently, i.e., if they were performed as separate parts, regardless of how the other simultaneous voice sounds. Here the standard deviation of the interval (s_i) is evaluated as the outcome of the standard deviations of the two pitches (s_1 and s_2):

$$s_i = \sqrt{s_1^2 + s_2^2}$$

The higher values for the dashed line (compared to the bold one) mean that the voices are tuned one to other in the course of the performances. However, the stability of the absolute scale slightly prevails over the stability of the intervals: the mean standard deviation of the scale pitches is 39 cents whereas the mean standard deviation of the intervals is 43 cents.

It is also seen that the intervals between the higher pitches are tuned more consistently than those between the lowest ones.

Time considerations. It is natural to expect that the stability of intonation relates somehow with the durations of the notes. First, the prolonged notes tend to be intoned more precisely.[4] Second, a large number of occurrences of a certain scale note or large overall its duration in the piece probably is associated with its salience[5] and henceforth, perhaps, with its intonational stability. It is also worth mentioning that similar time (or composite) strategies are sometimes applied in ethnomusicological studies when the structure of musical scale is discussed, see, for instance, Nettl (1964, p. 145–147) or Alexeyev's "statistical tables" (1976, 153–161). In the simplest case,

the salience of scale notes is equated to their total durations (in percents) and depicted by different rhythmic values in the scheme of scale system (Ling and Jersild, 1965, p. 103–107).

Here we omit the ethnomusicological evaluation of the salience of scale notes, but we rather go straight to the evaluation of correlation between the stability of intonation and the time parameters (that are bound to the salience). To examine this, the occurrences of different scale notes and their total durations (expressed in rhythm values) in three samples (NŽ6, Č23, V4) were counted.

The results (Fig. 6) show that, indeed, the larger the time values, the more stable the intonation. The best correlation is found for T^2/N (product of the total duration T and mean duration T/N), T, and T/N (mean duration). One can expect that the correlations contribute to the results of the probe-tone experiment presented below.

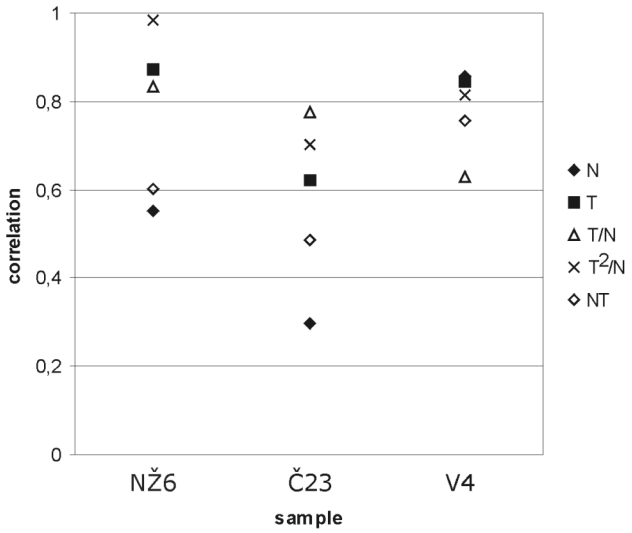

Figure 6. Correlation between the stability of intonation (evaluated as reciprocal to standard deviation) and the number of occurrences of the scale notes (N), their total durations (T), and the combinations of N and T. Three samples (NŽ6, Č23, V4) are considered.

Intervals of dyads. In our previous studies, several intervals in the central part of the *Sutartinės* scale were found to be approximately equal, roughly 180 cents on average (see Fig. 3).[6] This was shown for Sample V4. The size of the interval was collated with the outcomes of the study by Kameoka & Kuriyagawa (1969) on dissonance sensation. It was concluded that the size of the second interval corresponds quite well to the condition of the maximum dissonance when typical *Sutartinės* frequency and SPL values are applied. This means that the singing is based on the psychoacoustical phenomenon of "the best clash of voices".[7]

This conclusion was verified in the present study based on examination of more *Sutartinės*; Fig. 7 shows average sizes of the scale intervals.

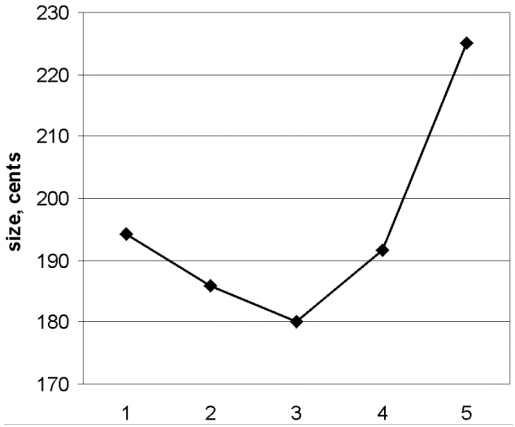

Figure 7. Sizes of the second intervals occurring between the voices of dyads averaged across all samples.

One can conclude that the narrowest second occurs between the most stable central pitches and the marginal pitches feature widest intervals. This issue needs further investigation; nevertheless, it is clear that generally the results correlate with the previous findings: the scale intervals are similar, mostly narrower than the tempered whole tone, and they conform to the principle of maximum dissonance.

Probe tone experiment

Method

Sample V4 was chosen for the probe tone test. Nine recordings were prepared. Each recording consisted of the polyphonic excerpt (length 10.5 s) cut from the original piece and the succeeding probe tone (length 1.2 s). The excerpt was faded in and out to avoid possible effects of the first and the last accords. It was separated from the succeeding probe tone by a gap of silence (1.6 s). The probe tones were made from the initial solo portion of the sample; two tones with the vowel *a* were used. The tones absent in this portion were made from the original ones by pitch change; software Cool Edit was applied. The 6 probe tones were tuned to the mean pitches of the 6 scale notes of the excerpt. Additionally, two tones were prepared (not present in the scale of the excerpt): one lower than the lowest note of the scale by 180 cents and the other higher than the highest note of the scale by the same interval. The 9th recording was simply a copy of the recording with the 3rd scale note of the excerpt (thus the 4th note in the whole scale). This was included to check the reliability of answers of the recipients.

The 9 sound recordings were presented to two groups of listeners. The listeners could freely choose the sequence of listening; the action buttons linked to the recordings

were randomly arranged on the computer screen. The listeners were asked to evaluate the degree of fitness of the probe tones in the context of the preceding excerpt. A 7 point scale was used (1 for no fitness and 7 for ideal fitness).

The folk group "Trys Keturiose" was chosen as the first group for the experiment. "Trys Keturiose" consists of 5 women having considerable experience in *Sutartinės* singing; this group is often regarded as the best contemporary group performing *Sutartinės* in Lithuania.

Group 2 was comprised of 20 listeners, mostly students from the Lithuanian Academy of Music and Theatre and the Kaunas University of Technology. All of them have some musicological background and knowledge of *Sutartinės*. However, they have no practical experience in *Sutartinės* singing.

Results

The results averaged across the listeners in Group 1 are presented in Fig. 8. As for the reliability of answers, the weights of the evaluations were introduced. The value of 1 was set for cases of equal evaluations of two identical recordings, and 0 was set for 6 point difference (1 and 7) between them. Two listeners noted no difference (weight 1), two of them noted a difference of 1 point (weight 5/6), and one listener noted a difference of 3 points (weight 0.5). Averaged individual estimation of the corresponding scale note (4th in Fig. 8) was considered. It is worth noting that not weighted and weighted results are quite similar.

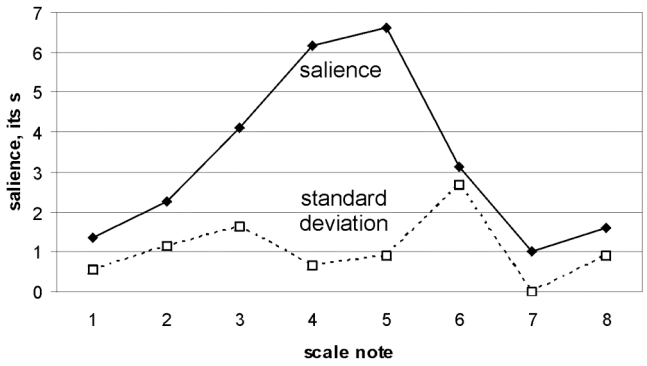

Figure 8. Tonal profile of Sample V4 (scale notes 2-7) derived from the probe tone test (Group 1). Additionally lower (1) and higher (8) notes absent in the scale of the sample are included.

Fig. 8 proves that there are hierarchical differences between the different scale notes in the Sutartinė. The two central pitches (4th and 5th in Fig. 8) are the most salient whereas the salience diminishes gradually when moving towards the marginal pitches. Quite interestingly, the central and marginal pitches show the least scatter of estimations while the scatter is considerably larger for the rest of the pitches. This means that cognitional categorizing is at work: the boundaries between the "fit" and "no fit" are estimated relatively indefinitely.

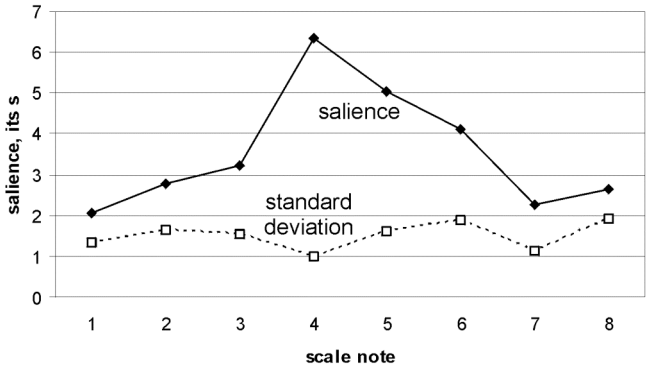

Figure 9. The same as in Fig. 8; for Group 2.

Fig. 9 shows the results averaged across the listeners in Group 2. The same method of weighting was applied as for Group 1. The results are similar to those of Group 1, in principle. However the discrimination of the notes as "fitting" and "not fitting" is less expressed.

Discussion

Collation of the results of acoustical measurements and the probe tone test leads to some conclusions. First, the evaluations of tonal salience negatively correlate with the standard deviations of intonation (Figs. 4, 8, and 9). This means that the cognitive tonal salience reflects in the stability of intonation. Second, the tonal profiles are approximately bell-shaped. This means that the tonal structure is comprised of the tonal centre and the scale steps with the salience gradually decreasing towards the margins of the scale. Or: it rests on the complex tonic "dissipated" in the tonal space.

Obviously, the cognitive basis of this structure is completely different from that of the major-minor system described by Krumhansl (1990, etc.) and others. Nevertheless, the tonal salience is in strong relation with the time parameters (total duration of the corresponding note in the piece, mean duration, etc.) as well.

The contemporary *Sutartinės* singers (Group 1) give approximately the same points for the salience of two central pitches (Fig. 8). One can say that they feel the "double tonic" constituted of the two most prominent pitches of the intertwining vocal parts. The other listeners (Group 2) distinguish one central pitch (Fig. 9). Possibly because they are more influenced by the usual scale with one tonic and because one of the two intertwining voices is stronger than other (this is, however, not the reason for the *Sutartinės* singers to distinguish one central pitch). Moreover, the *Sutartinės* singers make bigger differences between the salient and not salient pitches, whereas the other group shows a more flat tonal profile. Thus the hierarchical structure is more distinctly cognized by the *Sutartinės* singers.

Relatively large salience assigned to the high note not present in the original scale of the sample (note 8 in Figs. 8 and 9) is probably due to the specific interval relation: this note forms an almost exact minor trichord with the two other notes (4 and 6 in Figs. 8 and 9) in the excerpt of the piece presented for listening.

The results of the acoustical measurements of intervals confirm the earlier observations and assumptions on the psychoacoustical origin of the intervals: they roughly conform to the principle of maximum dissonance (see the evaluations of the intervals bearing the maximum dissonance, in Ambrazevičius, 2008).

Acknowledgments

We wish to thank the *Sutartinės* group "Trys Keturiose" and students of the Lithuanian Academy of Music and Theatre and the Kaunas University of Technology for their participation in the experiments.

References

Alexeyev, E. (1976). *Problemy formirovanija lada*. Moscow: Muzyka.

Ambrazevičius, R. (2004). Scales in traditional solo singing. In: S. D. Lipscomb, R. Ashley, R. O. Gjerdingen, and P. Webster (Eds.). *ICMPC8. Proceedings of the 8th International conference on music perception & cognition. August 3–7, 2004. Evanston, Illinois, USA* (CD). 105–108.

_____. (2005a). *Psychoacoustic and cognitive aspects of musical scales and their manifestation in Lithuanian traditional singing* (summary of PhD thesis). Vilnius: Lietuvos muzikos akademija. See in: http://www.rytisambrazevicius.hmf.ktu.lt/pdf/rytis-summary.pdf

_____. (2005b). The perception and transcription of the scale reconsidered: Several Lithuanian cases. *The World of Music*, 47(2): 31–53.

_____. (2008). Psychoacoustical and cognitive basis of *Sutartinės*. In: K. Miyazaki, Y. Hiraga, M. Adachi, Y. Nakajima, and M. Tsuzaki (Eds.). *ICMPC10. Proceedings of the 10th International conference on music perception & cognition. 25-29 August 2008. Sapporo, Japan* (CD). Adelaide: Causal Productions. 700–704.

Blacking, J. (1973). *How musical is man?* Seattle and London: University of Washington Press.

Boiko, M. (1996). *Die Litauischen Sutartinės. Eine Studie zur Baltischen Volksmusik.* Dissertation zur Erlangung der Würde des Doktors der Philosophie. Hamburg.

Brandl, R. M. (1989). Die Schwebungs-Diaphonie – aus musikethnologischer und systematisch-musikwissenschaftlicher Sicht. In: C. Eberhardt and G. Weiss, eds. *Südosteuropa-Studien. Bd. 40, Volks- und Kunstmusik in Südosteuropa*. Regensburg: Gustav Bosse Verlag. 51–67.

Četkauskaitė, G. (Ed.) (1998). *Lietuvių liaudies muzika II Aukštaičių dainos. Šiaurės rytų Lietuva / Lithuanian folk music II. Songs of Aukštaičiai. North-Eastern Lithuania.* Vilnius: Lietuvos muzikos akademija, Vilniaus plokštelių studija. (book with CDs)

Kameoka, A., & Kuriyagawa, M. (1969). Consonance theory, part I: Consonance of dyads. *Journal of the Acoustical Society of America*, 45(6): 1451–1459.

Krumhansl, C. L. (1990). *Cognitive foundations of musical pitch.* Oxford: Oxford University Press.

Ling, J., & and Jersild, M. (1965). *A method of cataloguing vocal folk music*. Stockholm: Svenskt Visarkiv.

Nakienė, A., & Žarskienė, R. (Eds.) (2004). *Aukštaitijos dainos, sutartinės ir instrumentinė muzika. 1935–1941 metų fonografo įrašai* / Songs, Sutartinės and instrumental music from Aukštaitija. Vilnius: Lietuvių literatūros ir tautosakos institutas. (book with CDs)

Nettl, B. (1964). *Theory and method in ethnomusicology*. London: Free Press of Glencoe.

Račiūnaitė-Vyčinienė, D. (1998). *Sutartinės. Polifoninės dainos. Lietuvių tradicinė muzika. 1935-1937 m. archyviniai įrašai / Sutartinės. Lithuanian Polyphonic Songs. Lithuanian traditional music*. Vilnius: Tautos namų santara, Vilniaus plokštelių studija.

_____. (2002). *Sutartinės. Lithuanian polyphonic songs*. Vilnius: Vaga.

Seashore, C. E. (1938). *Psychology of music*. New York: McGraw-Hill.

Slaviūnas, Z. (1958, 1959). *Sutartinės. Daugiabalsės lietuvių liaudies dainos*. I–III t. Vilnius: Valstybinė grožinės literatūros leidykla.

---

[1] See the footnote 2 for the abbreviations.

[2] NŽ3 (*Trys trys keturias brolalių klėtys*), NŽ6 (*Svirtis svira junt vartelių*), NŽ25 (*Titity tatatoj, kas ti gražė triūbijo?*), NŽ27 (*Tūto, jei tūto, jėjau rytelį, tūto*), NŽ30 (*Du dobiłėliai, trys dobiłėliai*), NŽ36 (*Šiaip sėjo linelį, teip sėjo linelį*): Nakienė & Žarskienė, 2004. Č23 (*Tumsumai tumsumai naktelių*): Četkauskaitė, 1998. V4 (*Myna, myna, mynagaučio lylio*): Račiūnaitė-Vyčinienė, 1998. The recordings are numbered according to their running numbers in the collections.

[3] These measurements were repeated with a larger sample of 25 *Sutartinės* (Ambrazevičius, 2008). The results differ slightly: the standard deviations of pitches and intervals are slightly less; they range mostly from 30 to 50 cents. However, the tendencies are the same (the standard deviations increase towards the marginal tones).

[4] For instance, Seashore (1938) noted that long notes correspond to the "theoretically exact ones".

[5] Cf. Krumhansl (1990), etc.

[6] By the way, the problems of equidistant scales in other types of Lithuanian folk music were discussed in Ambrazevičius 2005b and other studies of the author
(see http://www.rytisambrazevicius.hmf.ktu.lt/papers.html).

[7] Here is a good moment to mention Blacking (1973, p. 25): "…musical things are not always strictly musical, and the expression of tonal relationships in patterns of sound may be secondary to extramusical relationships which the tones represent".

Biographies

Rytis Ambrazevičius has graduated as physicist from Vilnius University and he received his PhD from the Lithuanian Academy of Music and Theatre. He is Assoc. Prof. at Kaunas University of Technology and Lithuanian Academy of Music and Theatre. His research interests include ethnomusicology, music and speech acoustics, and music cognition. He has authored or co-authored more than 45 papers and books, and ca 400 entries for Lithuanian Encyclopedia of Music. He collaborated in several projects of computerizing of folk music archives. He is also active as folk and folkrock musician.
e-mail: rytisam@delfi.lt. Homepage: www.rytisambrazevicius.hmf.ktu.lt

Irena Wiśniewska is master student at the Lithuanian Academy of Music and Theatre. Her research interests include ethnomusicology, especially traditional music of Polish minority in Lithuania and stylistic features of the traditional singing accessible with an aid of acoustical analysis. She is also active as folk singer.
e-mail: irena_vishnevska@yahoo.com