SUMMARY

From Natural Tunings to Ethno-Scale Systems: Theoretical vs. Creative Perspectives

Introduction

The content of this book reveals a new and so far little-studied scientific-creative phenomenon: the study of the interval relations of Lithuanian folk *sutartinės* (multipart chants), monodies and instrumental music in search of microtonality and tunings that are close to the natural harmonic series, and also the creative integration of the obtained results, namely the interval structures of these archaic songs formed by unequal interval distances, into compositional practice. Another important aspect of this work is the comparison of the world's main tuning systems and the resulting temperaments, which determine the variety and variability of the scale construction of musical works and their sonority in different historical periods, with an analysis of the extended just intonation in the 20th century and the search for natural intervals in the division systems of equal temperament, and the realisation of these systems in the works of contemporary composers.

The musical thinking of world societies is closely related to the diversity of auditory perception and the distinctiveness of sound systems. This leads to different approaches to harmony and timbre and to the search for new ways of tuning musical instruments. In different historical periods, pitch perception and temperament systems have changed human thinking, while cultural or historical events have influenced the further development of tuning systems; therefore, a newly formed system often reflected the old one, or else the old tuning system evolved into a new one over time and through performance practice. In addition, each tuning system was shaped by cultural and historical factors that determined different pitches and their characteristics.

In European music, the last millennium has seen an important change in the tuning systems themselves: the natural tuning (just intonation) and its temperaments (meantone, well-temperaments, and extended just intonation in the 20th century) and the divisions of equal temperament. The variety of interval relations is revealed in the context of these tuning principles, influencing the perception of the human ear, the sonority of composers' scores, and the spread of new tuning systems and new theories of sound. Finally, the twentieth-century trend towards the conceptualisation of sonic space logically developed long-standing theoretical approaches and defined models for the interpretation of pitch – concepts of pure interval relations or equal interval distances between tones – which manifested themselves in musical creativity, especially in the practice of expanding the sonic space.

In this context of natural and tempered interval tunings, I discuss the issue of ratio and distance interval relations as a way of interpreting sound organisation that focuses on the quality of the sound itself on the one hand and on perfectly tuned distance intervals, as of precise (pure) and relative interval models, on the other. To this end, paragraphs 1.1-1.3 distinguish between three ratio- and distance-based temperament models corresponding to the main tuning systems.

The first chapter of the book aims to classify and compare the most influential Western and Eastern tuning theories and structural similarities from ancient civilisations to the twenty-first century on the basis of two tuning systems, with their derived temperaments and scale divisions. It proposes a new classification model based on the conceptual differentiation of the two main tuning concepts (the first based on the natural harmonic series, and the second on the equal division of the octave). According to the new model, the tunings of the natural harmonic series are divided into two categories, one on the lower harmonics and another one on the higher harmonics, while the equal temperament tuning 12-TET is divided into series of equal micro-intervals.

We should not exclude the premise that these two tuning systems – the natural harmonic series and 12-TET – had a significant influence on the interval structure and tuning in the Lithuanian vocal and instrumental folk music tradition. Folk instruments that produce overtones are used in many cultures around the world, including neighbouring European countries.

It was therefore **hypothesised** that by comparing the intervals of these two systems it would be possible to explain the tunings of Lithuanian traditional music. This led to a new research project: the study of the interval relations of Lithuanian folk songs, analysed using *Melodyne* software. This analysis identified approximately 100 pieces of vocal and instrumental music (vocal monodies and *sutartinės*, instrumental *kanklės* – an instrument in the zither family, wooden trumpet and *skudučiai* – panpipe ensembles) from over 140 recordings from the 1930s that contained micro-interval relations. The research questions were: What interval distances and tunings are characteristic of Lithuanian folk songs of the early 20th century, which were based on tradition, although the gradually changing tuning system at the turn of the century was supposed to have undergone the transformation to 12-TET equal temperament? Did they retain examples of natural tuning? Are natural intervals and micro-intervals common in Lithuanian folk music scales? It is important to note that while earlier researchers of Lithuanian folklore were satisfied with notes in written songs about the inconsistency of some sounds with the original harmonies (19th century transcriptions), later these observations began to be marked with approximate signs of micro-alteration (J. Čiurlionytė, G. Četkauskaitė). For example, Stasys Paliulis published numerous examples of instrumental music (*daudytės*, wooden trumpets, *skudučiai* ensembles), but the intervals of the scales presented do not have any indication of the microalteration marks or tuning system, except for the *daudytės*, the tuning of which was determined by the author himself by distinguishing the original numbers of the overtone series but without indicating the exact interval distances in the scales.

Julius Juzeliūnas was the first to study the probe tones of the *sutartinės*, the intonation-melodic and interval structures of the scales, and the functional relations of the *sutartinė* intervals. However, he relied on the 12-tone equal temperament system. Rytis Ambrazevičius carried out further research in this field, using computer music software to identify Lithuanian folk music scales by means of acoustic-statistical analysis methods in order to study and calculate the aspects of psychoacoustics and tonal hierarchy in Lithuanian folk music scales. The results of his research allowed him to justify the assumption of the diatonic and equitonal construction of the scales found in Lithuanian folk songs and s*utartinė* polyphony.

Thus, the broad historical context of the research does not suggest other methods of analysing interval distances in traditional scales, i.e. identifying the distances between tones by comparing two tuning systems – natural harmonic series and 12-TET – with audio recordings of vocal and instrumental music. This study of micro-intervals and tuning systems revealed the prevalence of microtonal structures and examples of natural tuning in the scales of the Lithuanian performance tradition, from which an archaic code was derived as the typical interval structure of Lithuanian folk songs.

How the author has applied the results of this research to his own creative system is described in Chapter 3. Here, various techniques for integrating archaic interval structures into the scales are presented: harmonic transformations and/or reconstructions combining archaic scale degrees or microtones of the natural harmonic series with a tempered sequence of sounds, integrating the archaic interval structures of the *sutartinė* and wooden trumpet ensembles into the 12-TET system, or forming new scales, on the basis of the archaic scales, that would become part of the general compositional system. The aim is to show in practice how the generated interval structures function in concrete examples of music composition, whether the transformation of the interval structures leads to the disappearance of the distinctiveness of the archaic structure or to the transformation of the interval structure into a new sonic quality of the scale.

TUNING SYSTEMS OF NATURAL HARMONIC SERIES: STRUCTURAL ASPECTS

The musical cultures of the world are characterised by a variety of closely related tuning systems that simultaneously belong to different traditions. Tuning systems may be restricted to one particular region or have certain commonalities even in geographically distant cultures. Therefore, in the twentieth century, the variety of historical tunings was grouped into categories characterising the sound of musical works through different tunings of instruments. This was done by taking into account how each interval of the natural harmonic series, based on the ratio of prime numbers, generates a new interval and sound. Tunings based on the prime number system can be divided into two tuning categories: those of lower harmonics (1, 3, 5) and higher harmonics (7, 11, 13, ... 23, ... 31, ... 53, ...). These two groups of tuning, given the historical tuning connotations, separate the systems of natural harmonic tunings and temperaments of previous eras and the twentieth through twenty-first century, and become the starting point for the first part of the present research paper. It addresses the variety of temperaments of the natural harmonic series and considers how the interval ratio of the natural harmonic series interacts with the equal temperament division principles; in other words, the starting point of the study was the discrepancies in tone distances when comparing 12-TET and natural harmonic series systems.

In Chapter 1, three tuning models based on the interval ratio and distances are commented upon in additional detail. They correspond to the principal tuning systems and help to categorise the variety of different tunings:

1) principles of natural tuning based on exact *ratios*/unequal *distances*;

2) natural tuning systems characterised by relative *ratios*/unequal *distances*;

3) equal temperament based on equal *distances*/relative *ratios* (for example, 12-TET, other structures of equal intervals, or structures composed of equal micro-intervals).

Tuning systems based on the principles of lower harmonic *ratios* (1, 3, 5)

The issues discussed in this subchapter are divided into two smaller subsections: 1.1.1. Tuning systems based on the perfect fifths progression and string division; 1.1.2. Tuning systems based on the theory of the Pythagorean cycle of perfect fifths.

When discussing these tunings, two essential subgroups emerge:

1. Perfect fifths progression and string division systems, including the ancient tunings of Europe and Asia: those of Ancient Greece, India, China, Japan, and Korea. It should be mentioned that these different tunings were related by common systems based on the progression of the circle of fifths and the principles of string division.

2. Tuning systems based on the theory of the Pythagorean cycle of perfect fifths, including European (from the Middle Ages to the twentieth century), Arab, and Persian tunings.

All these tunings are based on two temperament models of natural harmonic series: 1) tuning of natural harmonic series based on exact ratios/unequal distances, and 2) temperament systems of natural harmonic series based on relative ratios/unequal distances.

In these examples of tunings (subsection 1.1.1) presented from different world cultures, the interval distances and the reference tone tuning standards were not the same. However, despite the diversity of the interval *ratio* structure, these different tunings were characterised by unifying conceptual factors: they shared common principles of the formation of tuning systems and identical numbers of sounds in the scales. Tuning systems based on the theory of the Pythagorean circle of fifths (subsection 1.1.2) developed from 12 to 31 tones per octave in the Renaissance and Baroque eras. In these systems, micro-intervals were often approximated depending on the system-defined interval distance *ratio* in one octave, yet efforts were made to maintain "pure" *ratios* of natural intervals: pure fifths or natural thirds. All temperament systems, by combining tones of natural harmonic series (pure consonants) with tempered sounds (dissonances), aimed to obtain a harmonic balance of consonant and dissonant to create perfect harmony.

Characteristics of temperaments of the higher harmonic ratio (7, 11, 13, ...)

This subchapter deals with the tuning cases of natural harmonic series, the structure of which is characterised by the higher harmonic *ratio* (7, 11, 13, ... 23, ... 31, ...) or a *ratio* of intervals greater than the five-limit tuning of the prime numbers. These twentieth-century tunings have expanded the scale of interval *ratio* of the natural harmonic series: such are the tuning systems Harry Partch, Ben Johnston, La Monte Young, and James Tenney incorporated into their compositions. In this group of tunings, one can identify the model of the temperaments of natural harmonic series based on exact *ratios*/unequal *distances*. The higher harmonic *ratio* systems are characterised by particularly pure-sounding tones of the natural harmonic series, and interval modulations are possible up to an infinite number of pitch centres; this opens up the possibility for composers of creating new timbral nuances and an unlimited variety of new intervals and chords. In the diversity of tuning contexts of the current century, the interpretation of intervals no longer depends solely on the sound of an individual interval. Instead, it can be deduced from the overall sonic context. This listening alternative demonstrates the fundamental difference between equal-tempered and natural tuning, perceiving music primarily as tone temperament or as natural tuning.

Natural interval relations in the equal temperament system

This subchapter discusses the most popular equal temperament systems used in music composition of the twentieth through twenty-first century and how links with the natural interval *ratio* proportions and sonorities arise in the principles of equal temperament systems. When addressing the experiments undertaken by various composers into the artificial division of the tone series in the scale into equal parts, two groups can be identified: 1) pitch-adding techniques characterised by the 12-TET interval division system and 2) various cases of octave division into equal parts (more or less than 12), collectively called EDO (equal division octave) tunings.

The so-called 12-TET pitch-adding technique was developed as early as musical works by Béla Bartók, Alban Berg, Charles Ives, Julián Carrillo, Alois Hába and Ivan Wyschnegradsky; further, the adaptation of equal temperament (12-TET, EDO) systems in the works of Easley Blackwood, Ezra Sims, and Claude Vivier is discussed, as well as how the tuning systems used by these composers approximate the natural interval *ratio* and sonorities of the natural harmonic series.

INTERVAL STRUCTURES OF LITHUANIAN ARCHAIC SCALES

This chapter focuses on the characteristics of interval relations in Lithuanian folk melodies, identified during studies of archival audio recordings of Lithuanian folk songs and their instrumental versions. By comparing the interval distances of the two tuning systems with the natural harmonic series and the equal temperament (12-TET) and considering a possible deviation, the study identified typical/frequently repeated micro-intervals, the tones corresponding to harmonics and microtonal harmonics of the 31 natural harmonic series.

At the beginning of Chapter 2, the historical context of previously conducted studies of Lithuanian folk songs is presented to show the importance of the present research. The studies of Lithuanian folk songs were divided into three stages:

In the first stage of the research project, the research question was posed whether the tuning of Lithuanian folk instruments was based on the interval relations of the natural **harmonic series.** An attempt was made to answer it by identifying the interval distances based on the reference tone. This was followed by calculating tone deviations compared to the interval distances of the natural harmonic series.

Using the results of the comparisons of scale structures with natural harmonic series, **the second stage** aimed to compute the interval distances between tones in the scale and to highlight the characteristics of the distances in songs, to derive formulas for scale distances in vocal and instrumental music, and to establish common codes for scale distances throughout all songs.

In the third stage, the number of the recurrent/most typical tones and intervals in the scales was identified. The most stable, most frequently recurring tones were singled out and calculated to derive a common interval code of vocal and instrumental music.

These stages of the research made it possible to reveal the dominance of certain microtonal structures in the tradition of vocal *sutartinės*, and especially monodies, and to identify similarities in the tuning of musical instruments compared to the interval distances of natural harmonic series and equal twelve-tone temperament. Based on the obtained results, it was possible to reconsider the perception of traditional scale interval structures, performance practices, and the application of the results to music composition.

Retrospective research into Lithuanian folk songs

The broad historical context of research presented in this subchapter does not refer to any other methods of interval distance analysis in traditional scales, that is, identification of distances in relation to the reference tone and distances between tones by comparing two tuning systems – the intervals of the natural harmonic series and twelve-tone equal temperament (12-TET) – with samples of vocal and instrumental music recordings.

Technological aspects of analysing song recordings

Melodyne software (versions 4 and 5) was used for the analysis of the recordings, which aimed to:

1) identify the typical/frequently recurring microtonal scale degrees based on the 12-TET equal temperament, and

2) identify the harmonics of the scale degrees based on the interval distances of the natural harmonic series, and evaluate the possible deviation.

In the analysis carried out using the *Melodyne* software, from over 140 pieces of vocal and instrumental music recordings from the 1930s, about 100 were identified as containing micro-interval relations. A total of 44 (39) samples of sutartinės, 47 (34) monodies, 16 melodies for horns, 7 for skudučiai, and 13 (4) for kanklės were analysed (the number of recordings selected after the analysis is in parentheses). The recordings that could refer to natural tuning were also selected: 17 sutartinės, 20 monodies, 16 melodies for horns, 4 for skudučiai, and 4 for kanklės.

Using melodic and polyphonic algorithms, the sound deviation analysis function used in the computer programme helped identify the tone deviation in the scale. The programme automatically identified the algorithm of the vocal or instrumental audio recording (polyphonic or melodic) and then displayed the tones/scale degrees, the distances of the tones in cents in the 12-TET system (calculated from the reference tone), instrument tuning standards (for example, when A = 440 Hz), interval *ratio*, and the names of the scales. The results obtained were also compared acoustically using a keyboard musical instrument. Since the algorithms of the software in most cases created a heptatonic scale, in my research the non-played or non-sung sounds were not eliminated but placed in parentheses. In most vocal samples, the programme identified the general tone distance or approximated tones in the scale, since the same tone could be lowered/raised (microtone) while simultaneously singing both a tempered tone or a regularly repeated microtone. Moreover, when singing several stanzas in a row in vocal samples, differences or similarities in interval distances were observed in each stanza; however, in such cases, the software expressed and displayed only the general interval distances in the scale. Furthermore, when searching for microtones, it was necessary to define certain limits of interval distances, referring to such practices in the studies of other scholars. The decision was taken that a tone shall be considered a microtone when, calculating from the fundamental tone of the scale, it showed a deviation of 20–80 cents compared to the equal temperament system, and overtones could be defined in cases of characteristic deviation of up to 10–25 cents compared to the interval relations of the natural harmonic series.

Microtonal harmonics in recordings of Lithuanian folk songs

When selecting songs for this research, preference was given to recordings with certain intonational "deviations": clear, audible micro-intervals in monodies and micro-sonorities in vocal and instrumental music. This made it possible to reveal and categorise the characteristics of micro-intervals of archaic musical scales and to name specific microtones and microtonal harmonics.

The identification of specific harmonics in the present study was significant in order to confirm the argument that the scale structure of Lithuanian folk melodies was close to the principles of sound organisation of the natural harmonic series. When analysing and categorising the data obtained from the song recordings, I found from 1 to 3 harmonics in the sutartinės, from 1 to 5 harmonics in the monodies, from 3 to 4 in the horn ensembles, and from 3 to 4 in the recordings of skudučiai and kanklės (given the aforementioned deviation up to 10–25 cents), compared to the interval relations of natural harmonics.

Upon analysing 17 vocal ***sutartinės***, 20 monodies, 4 ***skudučiai*** ensembles, 4 ***kanklės,*** and 16 horn ensembles, I found that the vocal music samples (based on 37 recordings) can be characterised by the sequence of prime numbers of the 3rd, 5th, 9th, and 11th harmonics of the natural harmonic series that match the tuning of the horn ensembles, while in the tuning of the skudučiai ensembles, the 9th harmonic or a natural second is replaced by the 7th harmonic or by the interval of a natural seventh, and it was the 5th harmonic or a natural third, absent in the tuning of kanklės, that was replaced by the 13th harmonic, or the interval of a natural sixth.

Identification of interval structures and tones

In addition to the study of interval relations compared to the natural harmonic series, a new study was conducted with equal temperament (12-TET) to determine tone distances in the scale. The goal of this research was to identify the similarities and regularity of interval distances in the scales between samples of vocal and instrumental music and different groups of instruments. This was done by deriving a common interval cell of distance as a symbol of archaic interval structure, based on which all the scales might have been constructed. Furthermore, I sought to identify the codes of the categorised scales of the songs and their distances, which could be further integrated into new compositional systems by preserving or transforming the sonority of archaic structures. By compiling typical sequences of interval structures, I sought to demonstrate recurrent formulas of distances, and therefore I decided to limit the smallest distance to 1/4; distances were rounded off based on 200 cents = 1 tone; 100 cents = 1/2 tone; 125–175 cents = 3/4 tone; and 25–75 cents = 1/4 tone.

Models of interval structures

Upon comparing interval distances in vocal and instrumental polyphony, all scale structures were divided into two groups.

Group 1 structures were characterised by sequences of a tone, three quartertones, and a semitone. In this group, six subgroup divisions (a, b, c, d, e, f) were identified, which include the scales of interval distances in monodies, skudučiai, and kanklės, and were categorised following the similarities of interval distances. The first subgroup (a) represents the characteristic of 1st group interval distances found in the recordings of horn ensembles; it was observed that these distances correspond to sequences of the same interval distances in the sutartinės and monodies (arranged differently, however).

Group 2 structures were characterised by identical microtone and tone sequences. They were found in all the samples of vocal and instrumental music. The interval distances of this group represent the characteristics of the 2nd and 3rd group distances for the horn ensembles.

Characteristics of the number of tones in the scales

In the next study, all the songs (vocal and instrumental) were divided by the number of tones in the scale: 3, 4, 5, 6, and 7 tones.

In the tetrachord group of interval distances, identical structures were identified in the *sutartinės*, monodies, and skudučiai ensembles; in the pentachord group, all the samples had identical structures except for the *kanklės*, and in the mixed group, in most cases, in the *sutartinės*, the horn ensembles and *skudučiai* ensembles; in the hexachord group, the distance structures fell into separate subgroups of the monodies, *kanklės*, and *skudučiai*. All the interval distance groups in vocal and instrumental music were united by interval cells ¾ 1 1 and 1 ¾ ½, realised through various interval rearrangements. Mixed structures included an additional ¼ distance (1¼), and in the hexachord distance structures in the recordings of the *kanklės*, *sutartinės*, and *skudučiai*, narrow ¼ ¾ ½ + 1¼, 1½ interval distances were identified.

The most popular distances in interval structures are:
Group 1/subgroup a – the general distance formula is 1 ¾ ½,
/ subgroup e – the general distance formula is ¾ 1¼ 1,
Group 2 – the general distance formula is ¾ 1.

Identification of the most characteristic recurrent tones

This study aimed to identify recurrent tones in the scales and to derive the common interval structure of recurrent tones that could correspond to the probe-tone structures which form the basis of the vocal and instrumental music scales. Moreover, the scales were systematised and compiled into graphics which present the spectrum of all the analysed scales of the vocal and instrumental songs (from the lowest to the highest pitch) with the fixed marking of the microtones, indicating a certain tuning deviation and the identified interval distances (compared to 12-TET). The interval relations of these folk music scales could be interconnected when composing tone sequences using preferred graphic sections or by creating a common compositional system.

Thus, the most popular intervals in Lithuanian vocal and instrumental music were derived in terms of the number of recurrent tones in the scale and based on the results obtained by studying the *sutartinės*, monodies, and all the songs. A common interval structure for vocal and instrumental music is C F# F.

1. *Sutartinės*: C F# (17), C F# – C# C# (16)
2. Monodies: C F B♭ (14)
3. All songs: C F# (29), C F# F (28)

The recurrence of the tones of the *sutartinė*, monody, and vocal-instrumental music was generated in an octave, resulting in three common scales of 17, 31 and 19 tones.

THE CREATIVE ADAPTATION OF IDENTIFIED MICROTONAL STRUCTURES IN NEW COMPOSITIONS BY VYTAUTAS GERMANAVIČIUS

In this part of the artistic research paper, I present my compositions written during my artistic doctorate project. In these pieces, I used different techniques to integrate micro-interval structures and microtones in newly built scales. Here I present the following techniques:

1) integration of microtones of archaic degrees in the chromatic 12-TET scale;
2) integration of archaic degrees in the tetrachord-pentachord diatonic scale;
3) projections of models of overtone structures;
4) implementation of the interval structure of *sutartinės*;
5) integration of the three-interval scales of *sutartinės*;
6) transformation of the scale of wooden trumpet ensembles by the interval structures of sutartinės.

Timbre and harmony relations

Timbre, previously ignored in musical composition, becomes an autonomous phenomenon, a separate parameter that encompasses the whole discourse of musical language, e.g. sound fluctuations (vibrato, glissando, shifts in the harmonic spectrum, tremolo) which are not ornamentation, but an independent musical text. The harmonic-timbral relations are presented in the following compositions as a transformation of interval structures or the entire episodes into timbral textures.

Use of quartertone strategies in the composition "Rote Bäume" for flute (piccolo), cello, and organ (2018)

In this composition I employed the technique of combining individual microtones with tempered sounds, realising it in the form of a composed 20-tone scale. However, a huge "cluster" of interval structures does not appear simultaneously. It was broken up into four episodes of the composition, although in some places one can hear huge masses of tones. For the composition, I used selected rearrangements of tones of the interval structures consisting of a maximum of 14 sounds, while retaining dynamic balance and the timbral-rhythmical spectrum of contrasting episodes.

The integration of archaic scale degrees in the composition "I Was Killed by a Banana Tree" for tenor recorder (2019)

In this composition, a tetrachord-pentachord harmonic structure was constructed based on a seven-degree diatonic scale, which integrated a series of 18 microtones and extended the scale up to 30 tones. The implementation of archaic degrees into a seven-degree diatonic scale occurs when the sound zone of each tone is entered from 2 to 6 microtones, which enables the timbral nuances of one pitch to change using the instrument's technical capabilities in the form of multiphonic chords, microtonal shifts, and amplitude changes.

Projections of overtone structures in the composition "Blooming Ice" for string orchestra (2020)

In this project I identified the frequently repeated microtonal scale degrees of traditional scales, comparing the interval distances of a natural harmonic series with fixed tone deviations of up to 10–15 cents. In the composition, I used 12 microtonal harmonics (approximated in quartertones) which correspond to the interval relations of two natural harmonic series of C and G. These two harmonic series were the primary models on which the microtonal series were based. Thus, the microtonal harmonics and the tempered tone scale were combined to form interval structures. The trichordal microtonal structure was taken as a basic structure, adding more structures or replacing them with another structure to expand the scale limits.

Models of *sutartinė* in the composition "L'Astéroïde B-612" for two violins (2021)

Based on the study of the scales, a modified four-tone micro-interval structure of one *sutartinė* was integrated into the scale of this composition, clearly highlighting the "archaic" micro-sonority of its episodes. The concept of the composition is the timbral colouring of tone d, which is the projection of one harmonic chord wrapped in micro-interval relations which form the soundscape of the piece.

Tone row structuring based on three *sutartinės* in the composition "No Titre" (2021) for the shakuhachi flute and string quartet

The scale of three *sutartinės* was selected with identical tone progressions (F G A B C) but varying interval relations. Thus, the scale of the composition was formed by integrating the sonic codes of the *sutartinės* into the 12-TET system; I integrated the three original sonic codes of three *sutartinės* to form one scale. The result is a 21-tone scale which consists of a 9-tone scale of three *sutartinės*, combined with a 7-semitone progression that conforms with the interval distances of folk songs (from another study I conducted) and by a progression of 5 quartertones.

Transformation of the intervallic structure of horn and *sutartinės* in the composition "Avalanche"(2022) for orchestra

The selected scale of the natural tuning of horn ensembles was expanded with microtones and tempered sounds, incorporating fourteen scales of vocal *sutartinės* and several separate tones of fragments from traditional scales. The initial structure underwent a certain transformation in the subsequent stages as its intervals were modified with interweavings from other *sutartinės*. In the piece, new interval structures were formed using the techniques of interpolation, transformation, and disintegration. Some fragments of the harmonic spectrum are formed in a few places of the composition, for example, from reference tone A, representing the 5th harmonic or the natural third in the strings section. As the scale transformation is achieved, the recognisable aspect of the archaic sonority disappears or transforms into fragments of reconstructed archaic interval structures.

CONCLUSIONS

It is evident from the abundance of tunings in a natural harmonic series that different cultures use unequal interval distances within the same interval ratio. The seemingly stable interval ratio of a fifth to a third, for example, is found to have unequal distances. For this reason, in the present artistic research paper a differential model of tuning systems was developed which separated the tuning systems of lower and higher harmonics of the natural harmonic series; moreover, the intervals of the natural harmonic series and the 12-TET systems, based on the principles of distances and ratio models, were compared by identifying natural intervals in the temperaments of equal tone division of the octave in the latter and supplementing the material with analyses of musical works by Western composers. It is relevant to note that, when discussing the practical and creative aspects of the dissemination of natural tuning systems, the use of natural harmonic series or the use of natural intervals in 12-TET systems are not typical of Lithuanian composers' works. In addition, in a short survey of composers who use microtonality in their compositional system, all of them without exception refuted the fact that they ever used natural tuning or natural intervals in their works. Natural tuning or natural intervals could be one of the purposes of forming a compositional system.

In contrast to spectral music theory, in which overtones are equated to their nearest pitches, the harmonic spectrum is perceived as constantly changing approximations of a tone frequency. However, in natural tuning, the series of harmonics of a natural harmonic series is defined by the exact interval relations of whole numbers (integers) between the reference tone and its components (harmonics). In this way, the natural harmonic series in compositional systems becomes not a spectrum of a single sound, but a scale or a chosen series of tones according to the tuning of musical instruments. Therefore, regarding the above-mentioned arguments, only the tuning system of natural harmonic series was chosen for the realisation of this research project, while the theory of frequencies of the harmonic spectrum was not studied in greater detail.

Based on the historical and theoretical classification and comparison of tuning systems in Chapter 1, I can conclude that tuning systems around the world share certain interval-related similarities, but general principals of temperament systems are different and produce different distances between tones. Therefore, it does not make sense to look for the similarity of intervals or the interval distances in Lithuanian traditional scales; on the contrary, it is appropriate to compare the interval distances identified in Lithuanian traditional melodies with the natural harmonic series, which makes it possible to identify and specify the tuning characteristics of traditional scales, or, compared to the 12-TET, the proportions of micro-interval relations in the compiled groups of the scales of vocal and instrumental music.

In the analyses of Lithuanian vocal and instrumental music recordings from the 1930s, a three-stage analysis led to the following observations:

1. Based on the equal temperament system, frequently repeated microtones and micro-intervals were identified, and, based on the interval relations of the natural harmonic series and estimating a possible deviation of tones, the specific number of harmonics was identified: in vocal music the exact number of harmonics is 7 and in instrumental music 2. As established, 5 harmonics (Nos 3, 5, 9, 11, 21) were mostly used in vocal music, of which 2 harmonics (Nos. 11, 21)

were microtonal, and in instrumental music, 4 harmonics (Nos 3, 5, 9, 11), of which 1 harmonic (No. 11) was microtonal. These harmonics were also fixed in vocal music. It is worth mentioning that J. Juzeliūnas in his theory book "On the Structure of the Chord", at the end of Chapter III, juxtaposes two *sutartinės* in which he distinguishes augmented and diminished fourth intervals among the probe tones of thirds, which may correspond to harmonics Nos 11 and 21.

2. Upon comparing the interval structures of the scales of analysed songs, the general tendency of interval distances was determined, and the two most specific groups of distances were distinguished: the group of microtone and tone variants (¾ 1), which was especially common in sutartinės and wooden trumpets, and the group of a semitone, tone, and microtone (½ 1 ¾), most common in the melodies of wooden trumpets, monodies, and sutartinės. The study was based on the comparison of the interval structures of the songs in terms of the number of tones in the scale. The **general interval distance codes** were concluded: ¾ 1 ½ (C, -D, E, F), which is particularly characteristic of the *sutartinės* and wooden trumpets, and ¾ 1 1 (C, -D, E, F#), which is most common in the melodies of the wooden trumpets, the monodies and the *sutartinės*.
3. Upon calculating the number of recurrent sounds and intervals in the scales when comparing sutartinės (vocal and instrumental), monodies, and samples of all the analysed songs, a **common interval structure** was deduced for vocal and instrumental music C F# F: the interval structure of the fourth/fifth and the tritone corresponds to the same structure of **general interval distance codes** (C-F and C-F#). Thus, the intervals C-F-F# may represent the **archaic interval code**, which forms the initial framework for the construction of the scale in Lithuanian folk music.
4. Upon examining the samples of instrumental music, it can be concluded that the tuning of wooden trumpet instruments is based on interval relations of the natural harmonic series and refers to the most frequently performed harmonics Nos. 3, 5, 9, and 11, which can also be found in other Lithuanian folk instruments and vocal music, namely in sutartinės and monodies. The origin of folk instrument tuning is likely derived from the natural harmonic series, which is related to the vocal music singing tradition. It is noteworthy that, in early recorded samples of Lithuanian folk music, the microtonal and non-microtonal models of certain scale degrees are close to the scale intervals of the natural harmonic series. Thus, based on the results of the three-stage study, it is possible to draw conclusions regarding the prevalence and use of microtonal interval structures in the scales of musical instruments and in the tradition of performing vocal music (*sutartinės*, and especially monodies).

The main goal of the integration of archaic interval structures into a compositional system was to preserve or transform the original sonority of interval structures. Consequently, a variety of integration techniques were used to develop the scale for each music composition: integrating separate tones, interval structures, or *sutartinė* scales into the 12-TET system or using material from archaic structures combined with the 12-TET intervals for the formation of the scale: using fragments of the scale of the *sutartinė* for inclusion, transformation, disintegration, and reduction due to the new interval sonority. In summarising the techniques of integration of archaic structures into the compositional system and the transformation of authentic or modified microstructures, the third chapter of the thesis discusses five of my compositions, which can be divided into two categories:

1) The first three compositions use different microtone-adding techniques to build a scale: in "Rote Bäume", a progression of 8 quartertones was combined to a chromatic twelve-semitone scale; in the piece "I was Killed by a Banana Tree", a progression of 18th microtones and additional five EDO tones were combined to form a seven-tone diatonic scale; the scale of the piece "Blooming Ice" was formed from the initial trichord microstructure by adding other microstructures, composed of 12 approximated quartertones of natural harmonic series and 12 tempered tones.

2) In the last three compositions, the integration and transformation of archaic interval structures were achieved by implementing scales, intervals, or single microtones of sutartinės: the 19-tone scale of the composition "L'Astéroïde B-612" (for two violins) was composed of five components (a modified interval microstructure of a vocal sutartinė, a scale of a *sutartinė* approximated in the 12-TET, microtonal harmonics identified with the *Melodyne* software, additional 12-TET tones, and a 3rd-degree specific microtone of folk music tunes); the transformation of the archaic microstructure in a piece appears as an integrated four-tone scale, but with no more than two simultaneously produced tones or one interval of a *sutartinė*. The composition "No Titre" (for shakuhachi flute and string quartet) is built on 5-tone scales of three sutartinės but with different micro-intervals set up with a semitone-tone progression and additional quartertones. In this composition, a microstructure of 9 tones (4 tempered and 5 microtones) of three sutartinės was integrated into a 21-tone scale, which manifests itself through different arrangements of microtones for the sonority of micro-intervals in different sections of the composition. A model of natural harmonics was chosen for the formation of the scale for the piece "Avalanche" (for orchestra): a progression of 5 harmonics of the horn ensemble to which the tempered harmonic of the interval

of a fourth and the high harmonics of the *sutartinės* was added, and the microtones of these songs were compared to the 12-TET and tempered ones. A 24-tone scale was constructed by shifting micro-sonority based on vocal and instrumental *sutartinės*, where the original interval structure was transformed by integrating fragments of scales of other structures.

In my compositions, I employ a number of different technical models which, in my view, demonstrate the general idea that archaic interval structures are likely to both preserve and change traditional sonorities, especially if one applies extended sound-producing techniques or different tunings which alter pitch and timbre, or if one additionally incorporates rhythm for timbral recolouring of harmonic structures. On the other hand, by using scale formation techniques for the integration of traditional intervals, we can achieve the archaic aspects of sonority, even when changing intervals within traditional scales, while still retaining the originality of the interval *ratios* of a few interval structures.