INSTITUTE OF ART STUDIES, BAS

IVAN KOSTADINOV YANAKIEV

THE CONCERT PITCH A^1 = 432 Hz AND THE OPEN FIFTHS: AN ATTEMPT FOR INTEGRAL ACCOUSTIC, PSYCHOPHISIOLOGICAL, COGNITIVE AND PRACTICAL RESEARCH

AUTHOR'S SUMMERY

OF THE THESIS FOR THE AWARD OF EDUCATIONAL AND SCIENTIFIC DEGREE *DOCTOR*

SOFIA

2020

INSTITUTE OF ART STUDIES, BAS

IVAN KOSTADINOV YANAKIEV

THE CONCERT PITCH A^1 = 432 Hz AND THE OPEN FIFTHS: AN ATTEMPT FOR INTEGRAL ACCOUSTIC, PSYCHOPHISIOLOGICAL, COGNITIVE AND PRACTICAL RESEARCH

AUTHOR'S SUMMERY

OF THE THESIS

FOR THE AWARD OF

EDUCATIONAL AND SCIENTIFIC DEGREE *DOCTOR*

IN SCIENTIFIC STUDIES

MUSICOLOGY AND MUSIC ART, *8.3.*

SCIENTIFIC SUPERVISOR
PROF. MILENA BOZHIKOVA, DSc
SCIENTIFIC CONSULTANT
PROF. PhD VASIL KOLEV, INB-BAS

REVIEWERS::
PROF. MARIANA BULEVA, DSc
ASSOC. PROF. MIGLENA TSENOVA, PhD

SOFIA, 2020

The dissertation was discussed and directed for public defense at a meeting of the Research Group Musical Contemporary, held on 17.02.2020.

The dissertation consists of 314 pages, preface, 9 chapters and 18 titles bibliography in Cyrillic and 113 titles in Latin.

The public defense will be held on 00.00.2020 from 11:00 am in Hall 1 of the Institute of Art Studies at a meeting of a scientific jury composed of: Prof. Dr. Georgi Venkov, TU; Prof. Dr. Mariana Buleva, VTU; Assoc. Prof. Dr. Miglena Tsenova-Nusheva, IAS; Assoc. Prof. Dr. Stefka Venkova, IAS; Prof. Dr. Assoc. Philip Pavlov, SWU; Prof. Dr. Natasha Yapova, NAM, reserve member; Assoc. Prof. Dr. Yavor Genov, IAS, reserve member.

The materials on the defense are available to those interested at the Administrative Services Department of the Institute of Art Studies at 21 Krakra Street.

Съдържание

I. Introduction

Goals

This text summarizes an attempt to reflect on the matter of the relationship between the frequency of the concert pitch (i.e. the frequency of the first octave tone as fundamental to the whole pitch system) and the effect its change has on the perception of music. The work has the following goals:

- Study of the historical context that led to the establishment of a unified concert system and the current state of concert and composition practice in the concert system a^1 = 432 Hz.
- Research on the theoretical formulations on the issue of the systems for organization of the tonal space – variants of temperaments and intonations and research of the temperament with open fifths.
- Study of the possibility for different perception of music and in general – of the presence of different cognitive-associative results depending on the concert pitch (a^1 = 432 Hz or a^1 = 440 Hz) in which music sounds.
- Study of the presence of a concert system a^1 = 432 Hz in non-concert sound practices - speech intonation and chants and declamation intonation during Orthodox service.
- Development of a neurophysiological hypothesis for objective study of the perception of music in the context of the concert pitches a^1 = 432 Hz or a^1 = 440 Hz and temperament with "open fifths".

Methods

The methods by which the goals of the dissertation will be achieved are research of literary sources, preparation of mathematical models of temperaments and intonations, conducting and analysis of surveys with musicians and non-musicians, conducting and analysis of sound recordings in kindergartens, schools and Orthodox churches during services, and synthesizing the results of research. This is presented in eight chapters.

II. The concert A – History of the Standardization and Contemporary Interpretations

“Концертен строй“ [“Kontzerten stroj”] is the Bulgarian translation of the term "concert pitch", with which the English-language literature names the reference frequency to which the tone **a** of the first octave should be tuned. Historically, this concept has been defined in the field of application of Western European musical practice and Western European musical thinking.

STANDARDIZATION

First Attempts at Standardization

The first attempts to adopt a single reference value for the concert pitch took place in Germany in 1830 at a conference in Frankfurt. The conference was convened by physicists. There ia value for the concert pitch in Germany was adopted – a^1 = 440 Hz.

The next country to introduce standardization relatively successfully was **France**. In 1859, the Lissajous-Halévy Commission was formed, headed by the physicist Jules Antoine Lissajous[1]. The Commission chose an average value between the lowest and highest value of the available tuning forks **– 435 Hz** (French *"diapason normal"*).

Italy attempted its standardization in 1884. A decree was issued obliging all brass bands to tune their la from the first octave to 432 Hz (Haynes, 2002).

First Attempt at International Standardization

The next step towards common standardization took place in 1885 at a conference in Vienna (November 16-19) (Weinstein, 1952), where Germany (Prussia, Saxony, Württemberg), Italy, Russia, Sweden and France decided to adopt a common concert style. with a reference frequency for a ton of second octave - 870 Hz. (from Guido Adler's commentary on Ellis's monograph Ellis, 1986). This remained the norm for the old continent until May 1939, when a conference on the same subject was held in London.

Great Britain and the New Philharmonic Pitch

In 1896, at a meeting of the Royal Philharmonic Society, agreement was reached on the value of the **new philharmonic pitch**. Not a good enough translation from French of the term "*diapason normal*", by which term the French refer both to the standard and the tuning fork itself, leads to the misconception that the concert pitch should sound with an absolute value of 435 oscillations per second when the ambient temperature is 15° C (59° F). In fact, it is the temperature at which the tuning fork instrument itself should be calibrated (Lloyd, 1949). Unaware of this inaccuracy in the translation, the Royal Philharmonic Society recalculated the value of the standard relative to the higher average temperature (20° C/68° F) in the concert

[1] Jules Antoine Lissajous (1822 – 1880) – French physicist known for his contribution to acoustics with graphical representations of complex oscillation functions – Lissajous curves – the invention of a device bearing his name (tuning fork with lenses attached to its horns https://www.youtube.com/watch?v = xPjNPb8h8Ok, as well as the Lissajous pendulum, which draws these same complex linear functions).

halls on the British island. And so, the **new philharmonic pitch** in Britain was calculated at 439 Hz.

USA During 20th Century

There was no standardization in the United States until the mid-1920s. John Calhoun Deagan[2] (Deagan, 1918) is the scientist who, based on the same translation error of the British scientists, recalculated the frequency of the concert pitch in the United States. His calculations aim to justify the identification of the value of 440 Hz at an average temperature of 21,1 ° - 24,4 ° C (70 ° - 76 ° F) with the value of 435 Hz at the colder European temperature.

The Conferences of 1939 and 1949

The conferences of 1939 and 1949 had an identical object of discussion – the final unification of the concert pitch, but in two different periods – pre-war and post-war. The second conference was called to confirm the decisions of the first. As Lloyd writes, (Lloyd, 1949.) The conference declared the following: "(i) That the international standard of concert pitch be based on a frequency of 440 cycles per second for the note A in the treble clef; (ii) That this value be maintained within the closest limits possible by soloists, orchestras, choirs, etc., throughout all musical performances and also in recorded music ; and (iii) That with a view to reducing the necessary tolerances to acceptable values, a set of technical recommendations be drawn up, preferably on the basis of international co-operation.", (ibid., p. 75).

The Creation of the ISO Organization and the ISO 16 Standard

In 1955, a formal ISO 16 Committee was set up to standardize the the frequency of the concert pitch. Unfortunately, all documents from the 1955 meeting, including documents for possible discussions, are missing. This necessitated a revision of the standard in 1975. It has since been recorded as ISO 16: 1975.

Standardization in Bulgaria

In "Musical Acoustics" by Stoyan Dzhudzhev we can see clearly that until about 1958, when the book was published, the idea of the concert pitch 435 Hz still existed in Bulgaria. This is evident from the tables in which Dzhudzhev gives reference values for the frequencies of equal temperament and just intonation. He also speaks of an accepted standard of 440 Hz in the USSR.

[2] John Calhoun Deagan (1853–1934) – clarinetist and instrument builder, born in Hector, New York. He studied music at the University of London while serving in the US Navy and his ship "Brooklyn" is in English waters. Attends lectures by Hermann Helmholtz on acoustics. He is known for the company he founded J.C. Deagan, Inc., which manufactured percussion instruments and tuning forks.

The Bulgarian state standard for the frequency of a^1 is BDS 4610: 1974, and it is 440 Hz, at least because of the principle of ISO membership: each country is a member through its state institute for standardization, thus making common international decisions an imperative norm in each member state.

Modern Practice and Non-compliance with the Standard for the Value of the Concert Pitch

Modern practice shows that the standard is not always observed and implemented. Non-compliance with the standard is not an isolated phenomenon in the practice of the 20th and 21st century. Ellis gave values for tuning forks at that time in Berlin in the range of 448 to 451 Hz. Until the adoption of *"diapason normal"*, the situation was similar in Vienna, where the concert line at the beginning of the 19th century reached 458 Hz.

Nowadays, the standard for tone frequency a^1 is also not observed and this can be easily confirmed. It is sufficient to look for an answer by asking every professional musician the question – "At what frequency do you tune 'a^1'?". Practice shows that the answer is a value usually higher than 440 Hz for "classical" musicians; some of the baroque music specialists would answer either 415 – 430, or 466; others would prefer a concert arrangement that corresponds to the era and place where the work was created[3].

Perspectives

The prospect of maintaining the **status quo** seems most realistic. This is also stated in the protocols from the periodic revisions of ISO 16 and especially the result for its approval.

Commentary

The modern dimensions of the fragmentation of society do not presuppose the sustainable existence of external standards in musical expression. We are witnessing non-compliance with the standard, but not as a choice that came in response to a conscious search for functional or categorical features of musical expression, but most often as a blind transfer of individual

[3] The values of the concert pitch during the Baroque era and before varied widely. Ellis (Ellis, 1969) and Haynes (Haynes, 2002) provide detailed tables in which they record the information they receive about specific values. Haynes talks about the values in different countries during different eras, citing different sources: in Italy, the frequencies for tuning the a1 range from 378-380 Hz (Rome, 1670) to 452 Hz (Milan, 1856) (Haynes, 2002); in France as early as the period 1730-1770 the frequencies of a^1 varied between 385 - 442 Hz (ibid.), while in the 19th century a *"diapason normal"* was established; in Germany, Pretorius also writes of a high value of a^1, which is calculated to be 521 Hz (ibid.), and the lowest and highest value of a^1 in organs is given by Haynes as follows - 408 Hz (Michaelkirche, Hamburg, 1843) and 489 (Jacobikirche, Hamburg, 1721) (ibid.). A clear tendency for a gradual increase in the value of the concert procession cannot be deduced from the historical data. The many parallel setting values are examples of "local consensus".

solutions from one geographical location to another. All desires to change the standard would have had more weight if they had been substantiated.

The real perspective is to pay conscious attention to the issue of choosing a particular concert pitch in practice and stimulate one to make a conscious assessment of the role of the concert style in the interpretation **after the one has experienced the sound.**

In this sense, the concert system could be considered as a means of expression through which certain authors, performers, ensembles or orchestras would like to show specifics in their sound.

A list titled **"432Hz Artists & Labels List"** created by Yves Thomassin (Thomassin, 2014) **includes 258 names** of artists or artistic groups that create or perform music in a 432 Hz concert style. Here we will list as examples ensembles in which the use of the 432 Hz concert system is established as the main way of working, playing classical repertoire and using acoustic instruments.

1. **Camerata Geminiani**[4], London – chamber string ensemble founded in London by violinist and conductor Gian Marco Sana.[5]
2. **"Quartet 432"**[6] – established in St. Petersburg at the end of December 2011. The quartet is part of a larger project - „Project «432»"[7]. There are realized recordings that are available for listening here: http://www.string-people.com/records.html;
3. **432 Chamber Orchestra** is an innovative Bulgarian chamber string orchestra. It consists of 13 instrumentalists and 1 conductor. It was founded in November 2013 in Sofia as an experimental ensemble by conductor Ivan K. Yanakiev.[8][9][10].

All three professional ensembles, which we gave as an example, are string ensembles. This specificity is due to the flexibility of string instruments in terms of intonation. The least effort is required to tune a string instrument to another concert pitch.

The origin of the use of the concert system a^1 = 432 Hz can be found as historically derived from the idea of the "Philosophical" musical pitch. In his monograph, Alexander Ellis (Ellis,

[4] http://www.geminianiproject.com/#!camerata-/c1ulm
[5] http://www.geminianiproject.com/#!academy/crc0
[6] http://www.string-people.com/quartet.html
[7] http://www.string-people.com/project.html
[8] https://youtu.be/b06-CCNlYRs
[9] Review of the concert of the 432 Chamber Orchestra – "Contemporary Bulgarian music was presented with a concert in the Great Hall of BAS" Duma newspaper149/02.08.2017:, https://duma.bg/savremenna-balgarska-muzika-be-predstavena-s-kontsert-v-golemiya-salon-na-ban-n150173?go=news&p=list&categoryId=45
[10] https://youtu.be/1Co8_24qnG0

1986) provides information on a concert ensemble of this value, citing Charles Merens.[11]. In his monograph "Il diapason (corista)", (Meerens, 1776) Merens cites the mathematician Joseph Sauveur[12] as an author who talks about the value of c = 128 Hz or its double-octave repetition c^2 = 512 Hz. In Merens' case, the initial tone ***c*** (the lowest string of the viola) has a value of 128 oscillations per second. The resulting a^1, 3 pure fifths higher, has a value of: $128 * \frac{27}{8} = 432\ Hz$.

III. Temperament and Intonation

a. General Positions and Historical Review

Intonation and temperament - definitions and review of practice

The terms **intonation** and **temperament** describe two different ways to reach a solution to the problem of generating the frequencies of the elements of the tonal space (i.e. the tones themselves).

Historically, the term **intonation** always refers to pure intonation or just intonation (JI). This is a system for organizing the tonal space, which uses just intervals – the relationships between the frequencies of two tones, which can be found in the overtone series, emitted by bodies with harmonious-sounding aliquot tones.

Just intonation in practice in Western European music after Zarlino[13] and before Fokker[14] has a prime limit of 5. The expansion of the boundaries of the system, i.e. adding a new interval as a generator also adds a new dimension to the system. In this sense, the system with prime limit (p-limit) of 3 (the so-called Pythagorean intonation) is an one-dimensional linear system, a system with p-limit of 5 is a two-dimensional planar system, a system with p-limit 7 is a three-dimensional volumetric system, with p-limit 11 is four-dimensional, and so on. Very quickly - just by expanding the system to p-limits of 7 and 11 – one reaches outer the realm of the three-dimensional systems.

---

[11] Charles Meerens (1830-1903) was born in Bruges, Belgium. Initially known as a cellist, he continued his career as a musicologist and researcher of musical acoustics and psychology.

[12] Joseph Sauveur (1653 – 1716) is a French mathematician who also works in the field of acoustics. Sovereign introduced his own nomenclature for studying octave intervals. méride: 1/43 octave; ptaméride (or heptaméride): 1/301 part of an octave, or 1/7 part of a méride; this term is also known as savart; demi-heptaméride: 1/602 octave; 1/2 eptaméride; decaméride: 1/3010 part of an octave; 1/10 eptaméride; also 1/55 part of the octave is called " Sauveur's comma".

[13] Gioseffo Zarlino (1517 – 1590). Italian composer and music theorist. He was the first to advocate the use of the small and large pure terce 5: 4 and 6: 5. He thus realized the idea of Pythagorean diatonics by adding a new simple boundary to the linear system, making it two-dimensional. He is also known for his dispute with Vincenzo Galilei over his ideas for equal temperament in polyphonic string instruments such as the viola da gamba.

[14] Adriaan Daniël Fokker (1887 – 1972) is a Dutch mathematician and music theorist. As a student he worked under the direction of Albert Einstein, Ernst Rutherford and Max Planck. He is the creator of the Fokker organ, which is tuned to an equal temperament of 31 tons per octave. This temperament approximates well intervals with a p-limit of 7.

Temperaments

In the general case, a temperament or tempering is a method of generating a system for pitch organization in the octave by changing the width of a given generator (usually the fifth) in order to eliminate a given comma. The result is that in this way the system has the ability to present a good approximation of the just intonation, while, in the most general case, presents an uniform or relatively uniform system of intervals.

The Problem of The Fifths and the Octaves

The problem of the mismatch of the fifths and octaves is mathematical and is described by the inequality: $\left(\frac{3}{2}\right)^{12} > \left(\frac{2}{1}\right)^{7}$; $\frac{531441}{4096} > 128$; $129{,}7463 > 128$

The interval that occurs between the fundamental tone and the final tone, 7 octaves lower, is called a Pythagorean or diatonic comma. It has a numeric value:

$$\frac{\left(\frac{3}{2}\right)^{12}}{\left(\frac{2}{1}\right)^{7}} = \frac{\frac{531441}{4096}}{128} = \frac{531441}{524288} = 1{,}01364 = 23{,}460\ c$$

But $1{,}01364 \neq 1.$ This means that 12 consecutive pure fifths with width of 3:1 cannot be included in 7 consecutive pure octaves with width of 2: 1.

In the light of these considerations we are obliged to mention also for another kind of comma – Syntonic comma. It is obtained when we compare the just large third (with p-limit of 5) - with 4 consecutive pure fifths, down 2 octaves (Pythagorean large third with p-limit of 3).

$$\frac{\frac{5}{4}}{\frac{\left(\frac{3}{2}\right)^{4}}{\left(\frac{2}{1}\right)^{2}}} = \frac{\frac{5}{4}}{\frac{\frac{3^4}{2^4}}{2^2}} = \frac{\frac{5}{4}}{\frac{3^4}{2^6}} = \frac{5}{2^2}\,.\frac{2^6}{3^4} = \frac{80}{81} = 0{,}98765432 = 21{,}506\ c$$

The most convenient solution is to narrow some or all of them with some part of the comma (or to extend the period by losing the octave equivalence of tones) by dividing any comma between 12 or fewer fifths[15]. Narrowing the fifth or a certain number of fifths leads to a

[15] We must clarify that if we work with the Pythagorean comma, we are working in a linear system for organizing the tonal space, and the pure large third must be understood as an interval which numerator and denominator have the greatest prime factor 3 (81/64). If we choose to work with the syntonic comma, we work in a two-dimensional system in which the pure large third has a width of 80/64 or 5/4. Working in two-dimensional and multi-dimensional systems creates new problems. In the two-dimensional system, we have two widths for each interval, because systems with a higher p-limit contain systems with lower p-limits (including intervals from lower-level systems). For example: the whole tone in a two-dimensional system with a p-limit of 5 has two widths: 9/8 and 10/9. A compromise must now be sought not only for the width of the fifths, but also for the width of other tones.

number of other consequences. The remaining intervals in the octave also gain different widths according to the narrowing of the fifth.

Equal Temperament With 12 Tones per Octave

Mathematically, the perfect method for tempering fifths is called equal temperament. Basically, the method is based on the distribution of the diatonic comma between the 12 fifths. Each of them is narrowed by the same part of the diatonic comma. In this way, the difference is evenly distributed between all fifths. This is the most common temperament in the modern music world.

b. Unequal Temperaments After Maria Renold

In her book „Intervals, Scales, Tones and the Concert Pitch C = 128 Hz" (Renold, 2004) the author Maria Renold describes two piano temperaments (from 1962 and 1985). The first temperament is called "Twelve True Fifths". It is based on the model described by Henricus Grammateus[16].

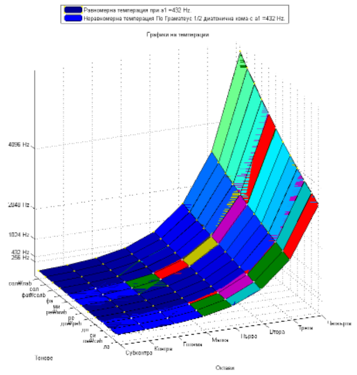
диезни	Maria Renold	бемолни
cis	delis	des
dis	elis	es
fis	gelis	ges
gis	alis	as
ais	belis	b

Фигура 1 – New nomenclatures for the names of the chromatic semitones, introduced by Maria Renold (Renold, 2004).

Maria Renold builds her entire "Twelve True Fifths" temperament on this principle - each chromatic semitone is the geometric mean of its two adjacent diatonic tones. Renold introduces new nomenclatures for tone names. The "Twelve True Fifths" temperament allows the piano to have 10 absolutely pure fifths and two so-called by Renold herself "formed fifths". The formed fifths are not adjusted. They are located between the intervals h:gelis and f:belis. To make it clear how they are obtained, we will look at the setup methodology.

The "Twelve True Fifths" temperament differs from the equal temperament. Graphically presented, the same information looks like this:

[16] Henricus Grammateus (1495 – 1525 или 1526) – известен и като Henricus Scriptor, Heinrich Schreyber или Heinrich Schreiber е теоретик от XV век, автор на идеята за изчисляване на средно геометрична стойност между дължините на две органови тръби с цел да се получи тон, който е на еднакво отстояние от всеки един от изходните тонове.



Фигура 2 – Graphical representation of the difference in cents of the temperament "Twelve True Fifths" from the equal temperament, at a^1 = 432Hz, top view.

The main reason why this temperament has more aesthetic merits than other temperaments with narrowed fifths is a phenomenon described by Hugo Riemann in Chapter II, §9 of his "Handbuch der Akkustik" (Riemann, 1921). This is the tone of the difference. The tuning methodology it offers is tailored to this specific sonority – the ten pure fifths are tuned acoustically, looking for the sonority of the difference tone.

Conclusion

Maria Renold's first temperament - "Twelve True Fifths" is a good unequal temperament[17]. It is characterized by 10 pure Pythagorean fifths and two formed, narrower by ½ DC. In temperament, the same quantitatively different intervals have a different qualitative ratio. This helps the different tonalities sound in a characteristic way. The specific tuning method that Renold offers is more valuable than the relationships between the intervals themselves, due to the higher level of artistic suggestion. It preserves the acoustic tone of the difference in each pure Pythagorean fifth, which gives the piano a new sounding look – a new timbre.

Maria Renold's Second Temperament from 1985

The structure of Maria Renold's second temperament is organized in a very different way, which she calls simply "A New Method for Tuning the Scale of Twelve Fifths." In order to be able to dissect it, we must first clarify what an open fifth is.

Open Fifth

Maria Renold empirically finds the values of the three fifth widths at which a stable oscillogram is observed. These three stable values will be referred to hereinafter as stases of the fifth or only stases. On these new empirical studies, she based a "New Method for Adjusting the Twelve Quint Scale," henceforth called the "Open fifths" temperament.

The "Open fifths" Temperament

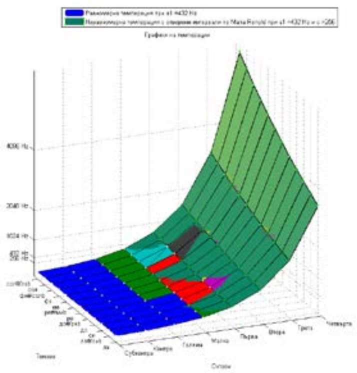
As we already know, the "Open fifths" temperament is a continuation of the ideas set in the "Twelve True Fifths" temperament, only the width of the fifths has changed. The quantitative

[17] Good unequal temperament is such a system that allows the use of all tonalities.

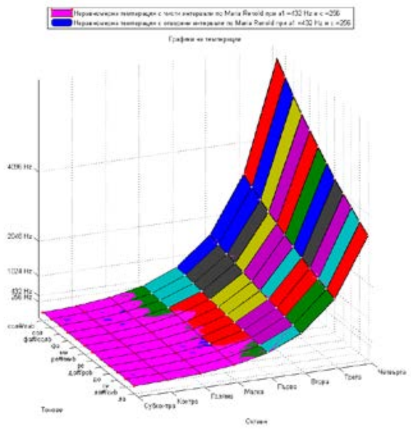
relations, the distribution of the comma (if we can talk about a comma at all), as well as the division of the octave into two equal parts by means of the geometric mean value of gelis^1 (relative to c^1 and c^2), are also preserved. The tuning methodology is also preserved – only in fifths and quarts, but this time they are wider. The output tones are also preserved – c^1 = 256 Hz; a^1 = 432 Hz; gelis^1 = 362.4 Hz[18]

For the width of the open fifths in the current temperament, we will use the data given by the piano tuner Lothar Matthias in Chapter 24 of the same book by Maria Renold. These are 703,45 c for an open fifth and 499,9 c for an open fourth.

Compared to the equal temperament and the Twelve True Fifths temperament, the graphs look like this:



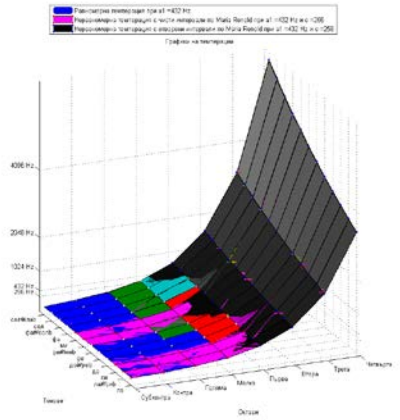
Фигура 3 – Comparison between equal temperament and "Open fifths" temperament top view.



Фигура 4 – Comparison of the "Twelve True Fifths" temperament with the "Open Fifths" temperament - top view.

[18] The number of oscillations for gelis^1, as a geometric mean, is equal to 362,389 Hz. For practical convenience, Maria Renold gives its value as 362,4 Hz. The difference of 11 thousandths of a Hertz is negligible for the human ear, but also for most measuring instruments. However, the values for the temperament with open fifths will be calculated with the true number of oscillations - from 362,389 Hz for the geometric mean value of gelis^1.

The graphs in Figure 3 clearly show that the “Open Fifths” temperament is significantly lower and higher than the equal temperament from the “Twelve True Fifths” temperament in its final registers. And from Figure 4 it is clear that the temperament “Open Fifths” is respectively higher and lower than the temperament “Twelve True Fifths” in the lower and upper case.The superimposed graphs of the three temperaments - uniform temperament, “Twelve True Fifths” temperament and “Open Fifths” temperament – are presented graphically as follows:



Фигура 5 – Graphic comparison of even temperament, "Twelve True Fifths" and "Open Fifths" - top view.

It is clear from this graph that the tone values for the final registers of the Open Fifths temperament are the furthest from the values of the other two temperaments in the same registers. The "Open fifths" temperament envelops the other two temperaments. The only common tone for the three temperaments is $a^1 = 432$ Hz.

Conclusion

Maria Renold's "Open Fifths Temperament" is an innovative unequal temperament. The innovation is in the method of tuning – only by open fifths and fourths. At this temperament there is a variety in the widths of the same intervals in the different octaves. This is precisely due to the innovative tuning methodology, which leads to three separate rows of tones that are related to each by with a Pythagorean interval (a large Pythagorean sixth with ratio $\frac{27}{16}$). This interval is not targeted anywhere else in the setting, but affects the temperament’s structure. The difference in the width of the intervals is caused exclusively by the relationship between the three rows of tones. The "Open Fifths" temperament is the widest of the three temperaments presented in this text. It encompasses both the "Twelve True Fifths" temperament and the even temperament at $a^1 = 432$ Hz.

IV. Experiments

a. Previous practice – review

Maria Renold conducted several experiments through a survey in connection with the perceptions that certain frequencies (ethos of the tone itself) arouse in listeners. The experiments were conducted in front of more than 2,000 people with different professions and at different ages in the United States, Italy, Germany and Switzerland.

The survey unequivocally shows that the tones associated with a^1 = 432 Hz and c^1 = 256 Hz are well received among the majority of respondents. Tones belonging to the equal temperament and imposed with ISO 16 standard of a^1 = 440 Hz is evaluated at the other extreme. Some opinions describe quite extreme, even strange impressions. In any case, we cannot ignore these results, but it is not fair to trust them blindly. These, however, are verbal descriptions of psycho-physiological cognitive processes. Other observations described in the previous pages are practical-acoustic – the free tone, the stases of the fifths and fourths. The described case with the antisocial atmosphere felt during the application of the "Twelve True Fifths" temperament, together with the a^1 = 440 Hz concert pitch and the disappearance of this atmosphere, in turn of this application, requires a complex interdisciplinary approach to its interpretation.

Another study on the role of the concert system a^1 = 432 Hz on human emotions is described in "Influences of 432 Hz Music on the Perception of Anxiety during Endodontic Treatment: A Randomized Controlled Clinical Trial" (Di Nasso, 2016) – The music they choose , is a five-part album composed by Stefano Crespan Shantam. The album sounds in the style of World Music, and most parts include characteristic melodic intonations for Indian ragas.[19]. The specific is that all tracks are in concert pitch a^1 = 432 Hz.

100 people aged between 13 and 83 years, 46 men and 54 women were studied, and the groups were considered homogeneous. During the procedure, the tracks of the composer Stefano Crespan were played to ½ of the subjects. The other ½ did not listen to anything. The result of the study was that in patients who listened to music during the procedure, there was a significant change in systolic and diastolic blood pressure, as well as heart rate (compared to the group who did not listen to anything). The team concluded that listening to music at 432 Hz during dental canal treatment reduced systolic and diastolic blood pressure as well as patients' heart rate.

[19] YouTube playlist with the compositions of Crespan, used in the study: https://www.youtube.com/watch?v=e7AWBTjo2QU&list=PLPvYwnklD68M_d7aX4bNJDud7VKKvR4KV&index=8

Based on these studies from foreign practice, our own experimental studies were conducted, which aimed to compare the concert system a^1 = 440 Hz and the concert system a^1 = 432 Hz, as well as the equal temperament and the "Open Fifths" temperament.

b. Experiment with the Choir of Medics "Rodina" - November 2015

On November 25, 2015, an experiment was conducted with medics - "Rodina" in the building of the Ministry of Health (MH). The aim was to find out whether amateur singers, with musical experience as choristers, feel the difference between:

1) the sound of the equal temperament with a^1 of 432 Hz, compared to the sound of the same temperament with a^1 of 440 Hz;
2) the sound of equal temperament at a^1 = 432 Hz and a "Open Fifths" temperament, again at a^1 = 432 Hz.

To achieve this goal, a questionnaire with 10 questions was developed – 5 questions for each of the two sub-cases studied, and general questions related to gender, level of education, age group of respondents, type of voice and the profession they practice. Each of the two main groups of questions included a special question related to the localization of the sensation of sound in the body. Most questions were divided into two parts - a "yes" and "no" answer, and a free answer to the question. Exceptions were the questions for free association of the sensation of sound, in which the "yes" and "no" answer was missing and have only sections for open answers in both parts of the survey.

For the purpose of the survey, a new concept was introduced **– the sensation of a localization of the sound on the body**. The concept of a **sensation of localization of sound on the body** describes a subjective perception of the focal point of sound on a part of the body or non-locally (on the whole body). One of the purposes of the survey was to determine whether this subjective phenomenon can be observed among more people.

Results analysis

The general analysis of the results shows that over 90% of the respondents recognize that there is a difference between the sound of the concert pitch at a^1 = 432 Hz and at a^1 = 440 Hz. Almost 90% say that different sounds evoke different sensations. Over 70% answer positively to the question whether there is a difference in the perception of the localization of sound on the body. Over 50% of those surveyed say they prefer the concert pitch a^1 = 432 Hz, while only 14.29% share a preference for the current 440 Hz standard.

In the second section, questions related to the comparison of temperaments, we have the following answers: over 70% of the participants recognize the temperament with open fifths as different from the uniform one. When asked if there is a different localization of sound on the body, only 42% answered in the affirmative, and almost as many - 39% - did not answer the question. Only 18% did not find a different localization of the sound. The majority of respondents prefer “Open fifths” temperament – almost 54%, while only 21% prefer equal temperament.

Practical conclusions from the translation of the study: The “Rodina” Choir assisted in conducting the survey related to the concert pitch. However, in the course of the study itself, two main problems clearly crystallized:

1. The lack of professional musical education on the one hand guarantees the lack of prejudice on the question of the concert pitch, but on the other hand directly raises the problem of awareness of intonation and the question of intonation as a function of mastery of one's own vocal apparatus. The lack of professional music education was clearly recognizable in the conceptual apparatus with which the respondents described their experiences in the various concert pitches. This, to some extent, limited the more precise formulation of the answers.

2. There is also a tendency for less confident respondents to leave more than one question unanswered when in doubt.

- As a result of the mentioned issues, it is unequivocally concluded that experiments with the concert pitch and temperament should be conducted with professionally educated musicians who have already acquired a certain degree of mastery of their instrument (voice).
- However, the answers show the preference of non-professional singers for the "Open Fifths" temperament, which is preferred because of the wider sound and the feeling of freedom. Despite the statistically higher percentage expressing preferences for the concert pitch a^1 = 432 Hz, the written answers did not show a clear trend, but rather equality of preferences. It often happens that both concert pitches, which are examined by the survey, are named with the same qualities.
- **The only indicator for which we can be categorical in our assessment is the clearly outlined tendency for the sensation of localization of sound on the body to move from top to bottom with the change of the concert pitch from a^1 = 440 Hz to a^1 = 432 Hz.**

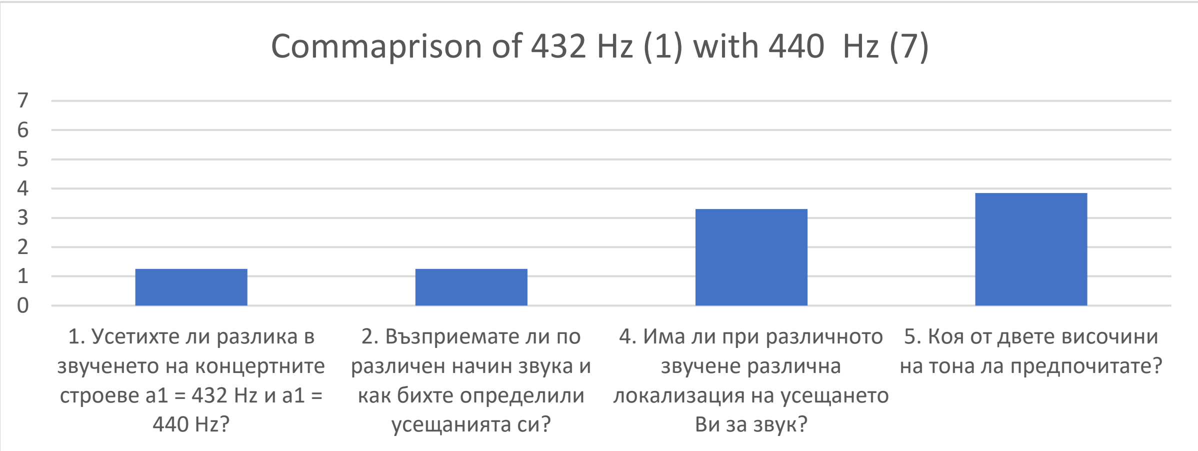
c. Experiment with Recordings of Instrumentalists: August 2016 – May 2017

Result of the Surveys of 18 Instrumentalists

In the period August 2016 - May 2017, the second survey was conducted to study the concert pitch and temperaments. The survey was conducted as a practical experiment with instrumentalists who play string instruments - violin, viola, cello, double bass, guitar and harp. The survey was attended by 20 musicians - 8 of them pupils at NMU "Lyubomir Pipkov", the rest - students at the National Academy of Music, Sofia and graduate professional instrumentalists.

A questionnaire was prepared with three sections: **1)** 10 questions - 8 of which with sub-questions for grading preference using a 7-point Likerd scale; **2)** 9 questions with sociological metrics (age, gender, musical experience); **3)** a title based on the translation of TIPI (Gosling, 2003) to capture the five main psychological categories.[20]

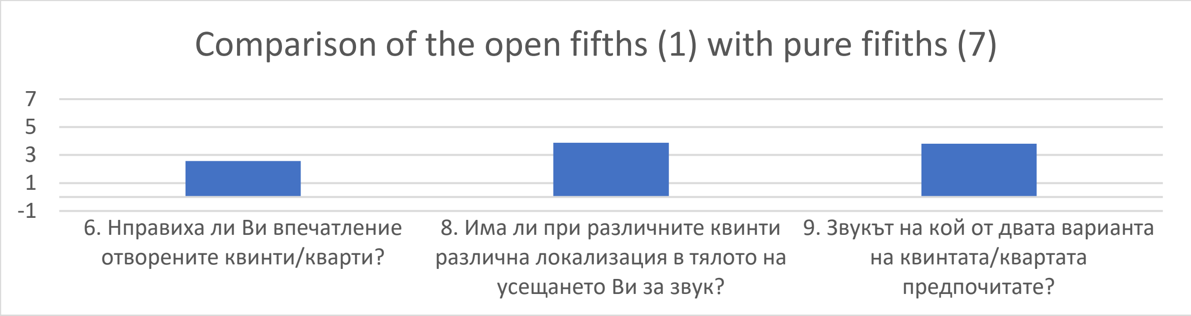
You can see the average value of the answers to the first five questions in Figure 6.



Фигура 6

The lower values are in favor of the frequency of the concert pitch a^1 = 432 Hz (0), and the higher values are in favor of the sound of the concert pitch a^1 = 440 Hz (7).

[20] The categories are evaluated: extroversion, empathy, conscientiousness, emotional and openness to experiences.



Фигура 7

The general impression from the survey shows that the respondents prefer the 432 Hz concert system and the 440 Hz concert system equally.

Interim summary

From the analysis so far, we have learned that all the instrumentalists who participated in the survey recognize the concert pitch a^1 = 432 Hz as a completely different sound reality and give verbal examples of this. In most of them, there is also a change in the localization of the sensation of sound (a term introduced here to describe the point or area where the focus of sound is felt on the body while playing or listening to music). Both frequencies and concert pitches are equal according to instrumentalists. It can be said that we find a general tendency in most of the respondents to associate the frequency 432 Hz and its derivative system (with pure fifths / fourths) with calm and warmth, while the frequency 440 Hz and its derivative concert pitch (also with pure fifths / fourths) with a feeling of tension, sharpness and coldness. From the verbal answers about the preference of one or the other system, two groups of answers were formed - with internal and external motivation. It turns out that the preference for frequency / concert pitch in the answers falling into the category of intrinsic motivation dominates the choice of frequency / concert pitch 432 Hz; the preference for frequency / concert pitch in the answers falling into the category with external motivation is always only the frequency / concert pitch 440 Hz. The **second part** of the survey compares the setting with pure fifths with the setting with open fifths.

General Conclusions

- There is a clear tendency to distinguish the 432 Hz concert pitch from the 440 Hz concert pitch. This is done by many indicators, but most of the respondents believe that the difference is in the internal state that the two concert pitches carry. The concert pitch a^1 = 432 Hz is most often associated with a state of calmness and warmth, and the concert pitch a^1 = 440 Hz - with a feeling of tension and coldness.

- A change in the localization of the sensation of the sound occurs in some of the respondents. Verbal responses form two tendencies - moving from top to bottom and moving from local to non-local (super-local - feeling the sound with the whole body).
- A relatively equal number of instrumentalists prefer each of the concert pitches – i.e. both concert pitches are equal in the minds of the interviewed instrumentalists.
- Most of those who filled in the questionnaires in the second part find a difference between open and pure fifths, mostly characterizing the sound created by open fifths as related to the feeling of freedom, and the sound of pure fifths - with a sense of stability or accuracy, or limitation.

d. Online Survey - October 2016 - June 2017

An online survey was also developed to give an idea of the general preferences of website visitors. The survey is structured in 3 large sections. The first section collects general statistical information as well as specific questions related to how to listen to the examples.

The second part offers to complete TIPI (Gosling, 2003) a standardized psychological test that looks at the 5 major psychological categories (extroversion, compliance, conscientiousness, emotional stability (neuroticism), openness to experiences) (ibid.), offering a quicker test.

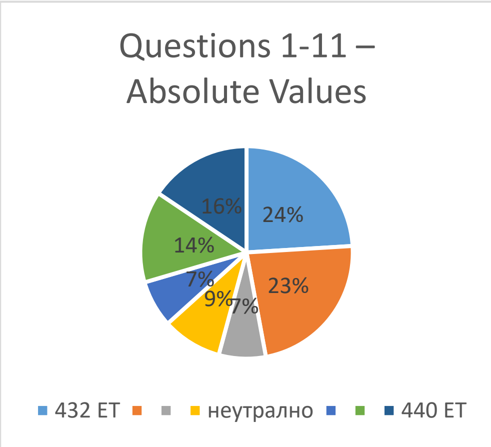
The third part of the survey contains the actual musical examples for comparison and is conditionally divided into two large sections. Each section contains 11 pairs of examples, and in both sections (Part 3 and Part 4) the musical pieces are the same. Part 3 compares the degree of liking of the works in the concert pitch a^1 = 432 Hz with the same examples in the concert pitch a^1 = 440 Hz, in the conditions of 12-tone equal temperament. Part 4 compares the degree of liking of the 12-tone equal temperament compared to Maria Renold’s second proposal – the temperament with “Open fifths”, as both files are in the conditions of a concert pitch a^1 = 432 Hz.

Analysis of the Survey Results

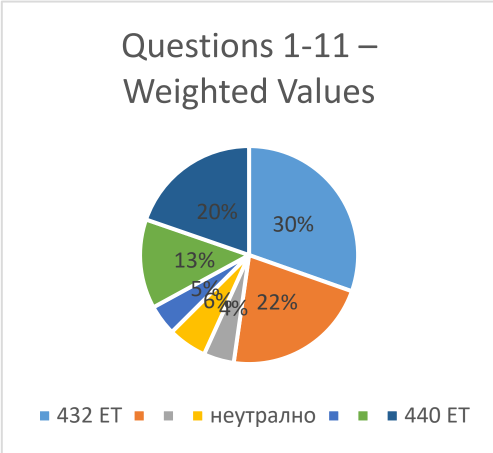
General Analysis

Most participants – 39,3% are aged 31 to 50 years (39,29% are aged between 41 and 50 years and 25% are aged between 31 and 40 years), with the next group being young people aged 19 to – 30 years – a total of 21,5% (3,6% from 19 – 25 and 17,9% from 26 – 30), followed by the group of 51 – 60-year-old with 10,7%; in last place are students with 3,6%.

Summary - Questions 1 – 11



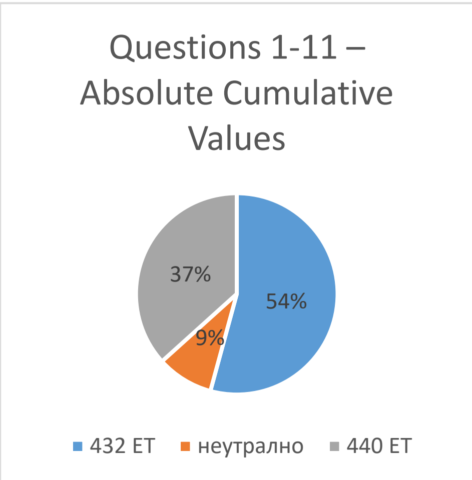
Фигура 9



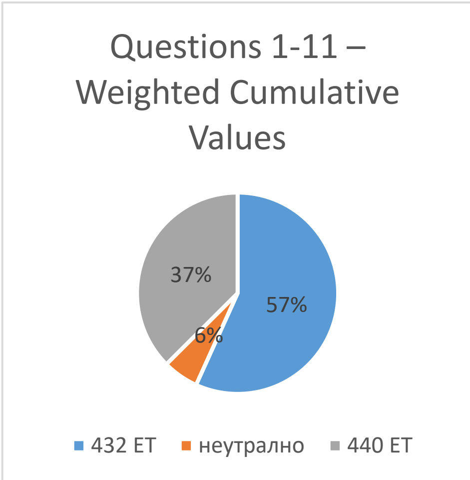
Фигура 8

The general trend that can be deduced from the answers to the survey for questions 1 to 11 is that the respondents prefer the sound of the concert pitch a^1 = 432 Hz. The average absolute values of the definite final answers show that 24,03% of the respondents definitely prefer the concert pitch a^1 = 432 Hz, while the concert pitch a^1 = 440 Hz is the preferred sound modality for only 15,58%. At the weighted values these percentages increase to 30,39% against 19,71% for the concert pitches a^1 = 432 Hz and a^1 = 440 Hz respectively.

Cumulatively, this trend is expressed in absolute values such as 54,22% for the concert line a^1 = 432 Hz, 9,09% neutral preference and 36,69% for the concert pitch a^1 = 440 Hz. With aggravation, these values acquire an even clearer tendency to prefer the concert pitch a^1 = 432 Hz: 56,78% choose this sound modality, 5,57% remain neutral and 37,47% prefer the standardized sound of the concert pitch a^1 = 440 Hz .

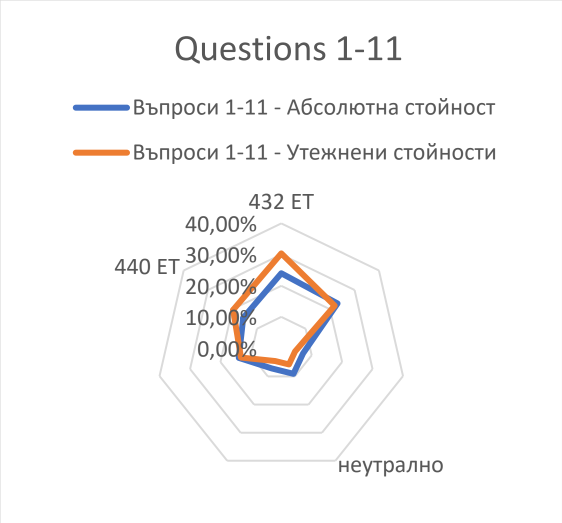


Фигура 11



Фигура 10

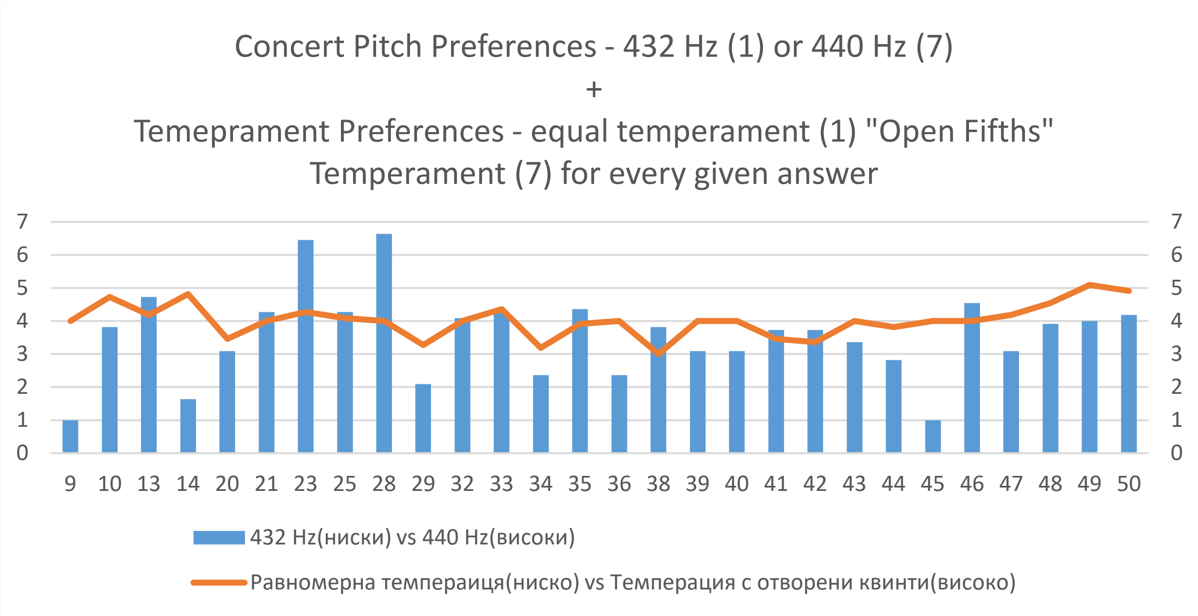
An interesting point in the survey response is the tendency to balance preferences, when the example of comparison is part of the musical heritage of the twentieth century. In questions №№, 1, 8 and 9 (works by Schoenberg, Prokofiev and Hindemith) no clear tendency can be drawn for the preference of the concert system. However, the neutral answers remain within the established limits of the other questions (10% – 12%) – i.e. for the respondents, it is not only in which concert pitch piece sounds, but there is no consensus on the preferred sound of this example.



Фигура 12

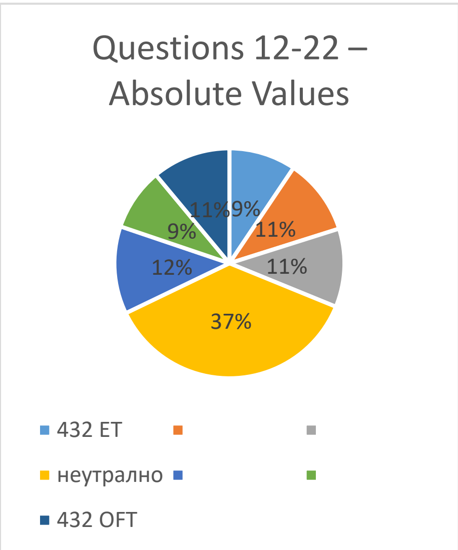
Also, in a detailed analysis of the relationship between the five personal instruments, there is no correlation between the degree of extroversion, openness to new experiences or emotional stability and preferences for concert style.

The general preference for the concert line a^1 = 432 Hz for the respondents is not bound by a certain local affiliation. The participants in the survey are from different countries, as it is filled in on the Internet, on the project’s website.



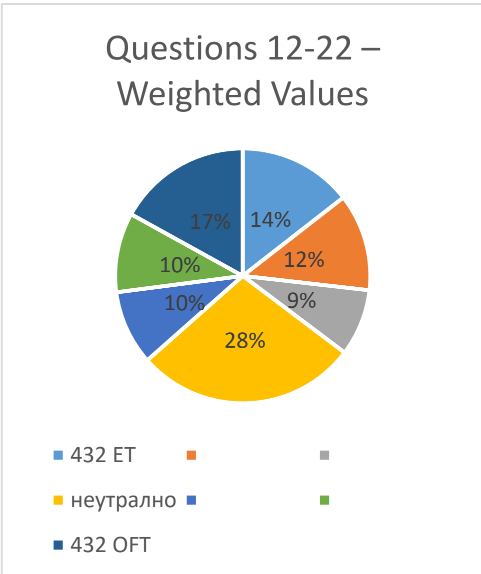
Фигура 13

The second part of the online survey aims to track the variations in the opinion of the respondents regarding the issue of temperament. For comparison, two temperaments in concert pitch a[1] = 432 Hz were proposed - equal temperament and temperament with open fifths. However, unlike the part related to the question about the preference of a concert pitch, the values vary within very narrow limits and around the neutral answer, "I like example A and example B equally". The pieces proposed for comparison in this section are the same as in the previous 11 questions.



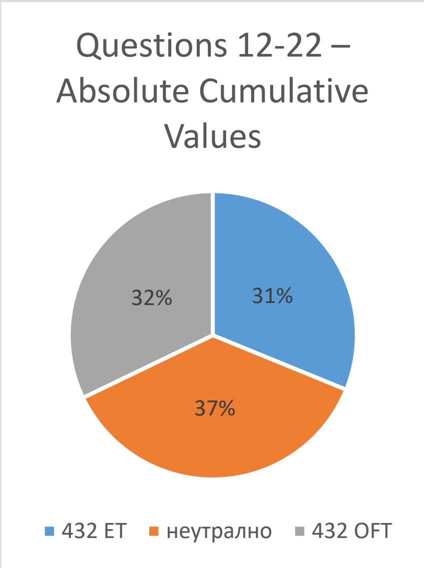
Фигура 14

Summary – Questions 12 – 22

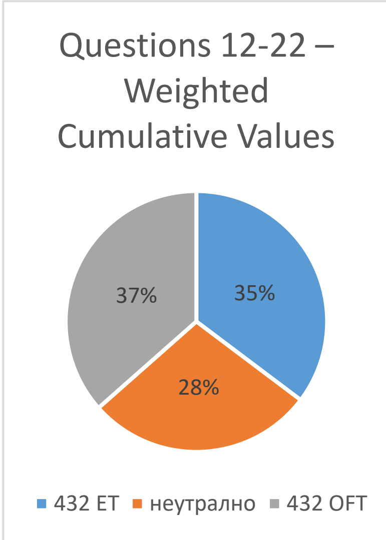


Фигура 15

The general impression of the average values of the answers to the second part of the survey is that



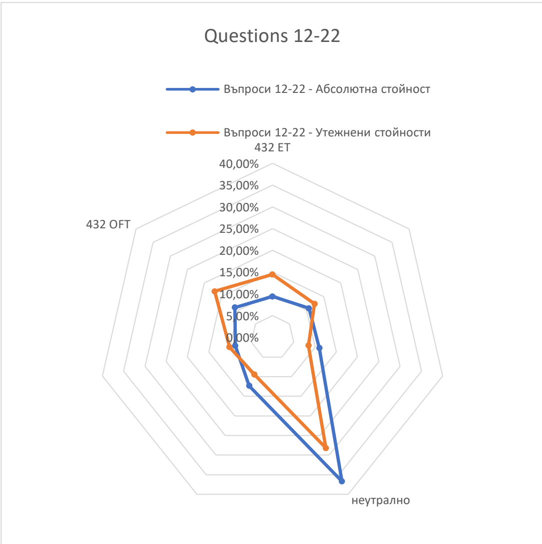
Фигура 17



Фигура 16

the neutral opinion prevails. In addition, the relatively balanced values of the other questions indicate an even distribution of opinion between the equal temperament and the "Open Fifths" temperament.

This hypothesis is also confirmed by the cumulative graphs. The almost uniform percentage distribution of responses in the three segments suggests a general impression of equality of temperament preferences. In contrast to the results in the comparison of the concert system, where there are more preferences for a^1 = 432 Hz, the respondents find it equally permissible for music to sound in the two temperaments proposed for comparison.



The tendency for the neutral response to prevail is also preserved in the radar graph. The distribution of the answers of the remaining questions is even.

We can conclude that the change of the temperament from equal to good unequal is not a determining factor for the degree of liking, but on the contrary - the temperament with open fifths is accepted equally by the respondents compared to the equal temperament.

V. The Connection Between Speech Intonation and Music

a. General Positions

Common Elements

The most common description of overlapping functions is the idea of common or shared resources between language and music. According to Stefan Koelsch (2012), tonal center extraction is one of the main mechanisms by which Western European music corresponds to language. In language, a similar process occurs in semantic extraction. Koelsch gives an example of the sentence "The man accepted the prize was not going to him" – there is a semantic ambiguity - i.e. it can be understood as "The man accepted the price did not go to him," but also as "The man accepted the price did not go to him."

Koelsch is a proponent of the Shared Syntactic Integration Resource Hypothesis (SSIRH) (Koelsch, 2013). Anirudh Patel also supports the shared resources hypothesis in language and music processing. Patel also considers the structural correspondence of the syntax of the language with the tonal harmony by comparing the syntactic specificity of the language with the harmonic moves (Patel, 2012).

Observations on Speech Intonation

Speech intonation is an important factor when it comes to transmitting nonverbal information. In support of this are some of the publications of music psychologist Prof. Diana Deutsch [21]. We will focus on her ideas for musical illusions, the triton paradox, as well as the auditory illusion that speech can be perceived as a melody.

The Speech Intonation and the Concert Pitch - a Hypothesis

In a parallel study of speech intonation in two neighboring Chinese villages (Deutsch, 2009) in which Mandarin is spoken, Deutsch noticed a difference in the tonal area of their speech intonation.

The main hypothesis that we will try to explore in this text is that the tone a^1 = 432 Hz is related to the speech intonation of the Bulgarian language. This is most evident in the speech of young children. The author's preliminary observations show that very often children who sing or speak melodiously intone harmoniously to the tone a^1 = 432 Hz. The hypothesis associated with this observation is that children are not exposed to the modeling influence of the standardized concert style, but intone freely, in the closest way to their body.

[21] Diana Deutsch is a professor of psychology at the University of California, San Diego. Her research includes primarily issues related to the perception of sound and sound memory. Deutsch was elected a Fellow of the Acoustic Society of America, the American Association for the Advancement of Science, the Society for Audio Engineering, the Society of Experimental Psychologists, the American Psychological Society, and the American Psychological Association. She is the founder of the Society for Perception and Cognition of Music and the founder of the magazine "Musical Perception". She has served as president of the Society of Sound Engineers, as president of the psychology department of the American Association for the Advancement of Science, as president of the Tenth Division of the American Psychological Association, and as president of the Society of Experimental Psychologists. In 2004 she was awarded the Rudolf Arnheim Prize for Outstanding Achievement in Psychology and the Arts by the American Psychological Association and the Gustav Theodor Fechner Prize for Outstanding Contributions to Empirical Aesthetics by the International Association for Empirical Aesthetics in 2008.

b. Analysis of sound Recordings in a Kindergarten in Sofia

In November 2016, a recording was made in kindergarten № 69 - "Firebird", thanks to the assistance of Mrs. Magdalena Vodenicharova-Stamboliyska, music teacher at the institution. The recordings were made during a music class. The lessons are conducted to the accompaniment of a piano, which is set in a concert setting a^1 = 440 Hz. The the session recorded the whole lesson in which the children sing accompanied by the piano. For the analysis of the speech intonation, only those parts from the whole recording were used, in which the children speak and the piano does not play.

Conclusion

The predominant intonation sound modality belongs to the frequency 432 Hz. This is taken into account in the analysis of the sound recording of the five groups. An exception to this trend is the fifth group - in it all speech intonations belong to the frequency 440 Hz.

c. Analysis of Sound Recordings in a High School in Sofia

It was performed in 15 Middle School "Adam Mickiewicz" on May 23, 2017. Sound was recorded in the yard, in the classrooms and hallways of the school.

Conclusion

The dominant sound modality for the speech intonation in the recordings from 15 Middle school "Adam Mickiewicz" in Sofia are tones that belong to the frequency 432 Hz. In contrast to the recordings from the kindergarten, chromatic tones (so-called geometric mean values) are much more common here. Also, the general contour of the intonation is much richer and more diverse.

Observations on Orthodox Chants

In the singing intonation in the Orthodox churches in Bulgaria and in the recordings of Orthodox chants from psalms (especially in the earliest available recordings) the construction of 432 Hz is extremely common. There are documentary sound recordings in the Church Archives of the IAS, in which the predominant presence of the concert pitch a^1 = 432 Hz is clearly heard. In the recordings: АИИИзкI.2.ET15_1.1 [AIIIzkI.2.ET15_1.1], АИИИзкI.2.ET15_1.2 [AIIIzkI.2.ET15_1.2] и АИИИзкI.2.ET16 [AIIIzkI.2.ET16], (Stavropigial Patriarchal Cathedral-Monument "St. Alexander Nevski ”: May 11, 1979 - visit of His Holiness Elijah II - Patriarch of Georgia), made by Elena Toncheva.

The oldest tape recordings of church chants are by Nikolai Kaufman from 1956. There are recordings of two protopsalts – Ivan Kaikov and Peter Pop Dimitrov. All chants sound on tones inherent to a^1 = 432 Hz.

d. Analysis of Sound Recordings[22] in Orthodox Churches in Sofia

In connection with Diana Deutsch's hypotheses for centering the speech intonation around a tone center, recording sessions were held in Orthodox churches in Sofia.

General Conclusion

The analysis of the recordings in Sofia's Orthodox churches confirms the hypothesis that the intonation during singing can be understood to have Pythagorean relations with the frequency 432 Hz – i.e. we can say that we find many examples of the fact that in a large part of the time in which the priests serve, they intone in a 432 Hz concert pitch. The observations from the records found in the sound archive of the Institute of Economics of the Bulgarian Academy of Sciences were also confirmed, namely that in the "St. Alexander Nevsky" Cathedral and at the moment the priests are singing into a 432 Hz concert pitch. From the considered records we can say that the frequency 432 Hz and the frequencies belonging to it through pure Pythagorean relations and geometric mean values of the tones are a living part of the service.

VI. An Attempt to Hypothesize a Neurophysiological Correlation Between the Frequencies of the Concert Pitch and the Temperaments, and the Answers, Described in the Surveys.

a. Categorical Perception and Attempt to Hypothesize a Neurophysiological Correlation Between the Frequencies of the Concert Pitch and the Temperaments, and the Answers, Described in the Surveys.

Categorical Perception of the Intervals

The auditory system is very well adapted to perceive complex tones (tones with more than one frequency in its composition or more simply: tones with timbre). And while virtually every tone of an acoustic instrument (excluding the sound of a siren) is a complex tone with (most often) a maximum intensity of the fundamental tone (F0), this adaptation has a more important function. It is used more often in communication - in recognizing the phonemes of language. Phonemes, like timbres, are complexes of superimposed sine frequencies that the human

[22] We clarify that we are not looking for a concert pitch in the church chants. The subject of the research in this case is to consider objectively whether the spontaneous choice of focal frequency in the declamatory utterance of prayers (reading) can be related to the tone a^1 = 432 Hz or to the tone a^1 = 440 Hz.

auditory system recognizes as vowels and consonants. Similar phenomena of vowel recognition in music are pitch recognition of complex tones; noise corresponds to consonants.

The categorical perception of phonemes is one of the most common proofs that motivate the common intersections between language and music. In phonemes we can talk about the invariance of categorical perception. The case is similar with the studies of Locke and Kellar (Locke and Kellar, 1973) quoted by Yanakiev (2018), in which professional musicians confirm the presence of insufficiently developed ability to categorize at intervals other than the widths established by the uniform twelve tones. Yanakiev concludes that categorization is not a consequence of the inability of hearing to physically recognize these stimuli as different, and the reason is insufficiently well-defined new category and a stable definition of the width of the intervals of uniform twelve-tone temperament (Yanakiev, 2018).

Categoricalness as a principle can also be found in a study by Stephen Van Hedger (2013), published in the article "Absolute Pitch May Not Be So Absolute". In it, Hedger proves experimentally that the perception of a group with absolute hearing can be modeled according to the context.

The experiment shows how the context determines the categorical perception of the accuracy of the reference values in subjects with absolute hearing. This case can also be seen as an adaptation of categorical perception so as to serve in a new context.

In addition, it is also important to note that a concert pitch lower by 33% than the halftone of the ISO 16: 1975 standard is a concert pitch with a^1 = 431,6923. This study practically shows that placed in the context of a concert pitch a^1 = 432 Hz for more than 40 minutes, absolutists, with their acquired definitions of the limits of the categories for absolute pitch, de facto tune their entire categorical system to the new concert pitch.

Neurophysiological Hypothesis

The hypothesis derived from the above review of neurophysiological practice in the neurophysiological study of music is that we can find correlations between the brain activity of certain subcortical areas and the type of auditory stimulus. The test of this hypothesis consists of two steps.

1. Study of the change in activity in some of the subcortical areas as follows:

a) To study the neurophysiological correlates, a questionnaire should be prepared to record the subjective response of the subject to his preferences for concert style or temperament. The subject marks these preferences while listening to sound stimuli.

b) When looking for subjective (emotional / affective) indications in favor of a particular concert style, activity in the hippocampus and amygdala, and perhaps the entire hippocampal system, parahippocampal gyrus, and temporal fields, should be considered (BA38).

c) When examining the sensations that a certain temperament brings to the subject, a change in the activity of the parahippocampal gyrus should be sought.

d) When examining the displacement of the sensation of sound focus on the body, a change in the activity of the insular cortex and gyrus cinguli or in the subcallosal gyrus should be sought.

2. Each subject should receive a confirmed clearly distinguishable value of FFR, which coincides with the studied stimulus, which will confirm the objectivity of the perceived stimulus by the person.

This research methodology is prepared on the basis of the experience gained with the surveys conducted during the dissertation period, as well as on the basis of the theoretical and practical research discussed in this chapter. Confirmation of the correlation between a change in activity in the subcortical areas and a change in auditory stimuli will become the initial point of a broader series of specific neurophysiological experiments.

VII. Composers' Solutions

In the composers' practice the question of the concert system occupies a peripheral place. The presence of playing pitch requirements is a relatively new phenomenon. Already in Chapter II we gave the list of Yves Thomassen[23] as examples of musicians working in the concert pitch a^1 = 432 Hz. From the authors who appear there, we will focus on Coreene Morsink [24]. She is a contemporary composer who requires her works to be played in concert form a^1 = 432 Hz. In the next section we will focus on Morsink's latest work "There was a time".

The Concert Pitch

[23] 432 Hz Artists & Labels List. 2014. Accessed at: https://www.facebook.com/groups/326302077904109/

[24] Coreen Emily Morsink is a Canadian composer who lives and works in Athens, Greece.

Morsink's explicit request, recorded in the score, reads: „*The piece must be performed in A = 432 Hz, because the songs of the birds I quoted sound in A = 432 Hz, which is their natural frequency. If played at a higher frequency, the overall effect will be lost (which is the sound of nature)"*.

In the work we find a synthesis between the ancient Greek music system, the sounds of nature and the idea of recreating the natural sound of birdsong through the use of the concert pitch a^1 = 432 Hz speaks of a conscious intention to sacralize the very action of making music. Morsink believes that in this way she recreates the unification of man with nature[25].

The Stylistics

Morsink's piece is built using a collage technique of juxtaposition of artifacts – ancient Greek scales and the sound of natural phenomena – bio music. In essence, the idea behind the sound is to unite in a synthetic construct the symbiosis between the natural order and human cultural activity, presenting the pursuit of spiritual unity through their merging. The whole work is built on the principle of heterophonic superimposition of individual themes on each other and/or their heterophonic imitation through literal repetitions. With regard to the technical requirements for performers, Morsink boldly uses triads in monophonic flutes (bars 4-8), glissandos (bars 21, 27-28), timbre games (whispering tones, full sound, hollow sound, bright sound, air sound), including specific instructions for changing the intensity of the air flow.

The Form

The work is divided by the author herself into two parts, which define the dramatic development. Their descriptive function is directly related to the verses quoted by the author by the ancient Greek poet Corinna.

But if we focus only on the musical text, we can make another proposal for the structure of the work. In its overall sound there is a clear three-part structure and the third part being a synthetic part with a character of a reprise.

In the first part, the author focuses mainly on conducting the songs of birds. The second big section begins with a downward presentation of the range of "la", this time extended. She introduces a synthetic melody designed by her to depict the song of the poet Corinna. The third part literally returns the structure of the first (with only one measure added), and the order of the birds' appearance from the beginning is preserved in four of the six flutes.

The vertical synthesis between the invariably sounding nature in the first part and the poet's melody created by Morsink is complemented by a horizontal synthesis in the parts of the alto

---

[25] The dominance of the concert system a^1 = 432 Hz, as a spontaneous choice for the sound modality in the sacred rites, is confirmed by the author's field research on the intonation of Orthodox priests during service (see Chapter V).

flutes with double quotes and birds (the sharp-tailed sparrow and sparrow of Le Conte). The whole work ends with burdon tones, against which a hoopoe sings his final song – he has the last word and his song as a frame opens and closes the door to the world of birds.

Morsink's self-identification with the image of the young poetess who defeated Pindar in a competition, which has been transferred to this day, is obvious. Moreover, the story of the female poetese with her victory over the male poet/creator, the emanation of the status quo, directly raises the question of the increasingly significant role of women composers in contemporary musical life.

VIII. Results and Conclusions

The following results were obtained for the set goal for research of the historical context, which led to the establishment of a unified concert system and the current state of the concert and composers' practice in the concert pitch a^1 = 432 Hz.:

The concert pitch a^1 = 432 Hz is a continuation of the idea of the "Philosophical" pitch, in which a value of down to the fourth infraoctave (4 octaves below the subcontract octave) equals to 1 Hz is used as a reference frequency. The tone a^1 = 432 Hz is reached by applying to the "Philosophical" pitch a linear system for the organization of the tonal space of the type of just intonation with a p-limit of 3.

There are recordings stored in the library of the University of California at Santa Barbara from the beginning of the XX century in the USA, during the playing of which a concert pitch a^1 = 432 Hz is recognized.

The professional ensemble practice from the beginning of the XXI century shows several ensembles in which the tuning takes place in relation to a^1 = 432 Hz. They are string ensembles: "Quartet 432" – Moscow, "Camerata Geminiani" – London and "432 Chamber Orchestra" – Sofia.

In the modern composers' practice, the presence of requirements for playing at a specific concert pitch is a relatively new phenomenon. Chapter VII provides a brief overview of the creative pursuits of composer Coreen Morsink. Chapter IV examined examples from the work of composer Stefano Crespan Shantam, which were used in the study "Influences of 432 Hz Music on the Perception of Anxiety during endodontic treatment: A Randomized Controlled Clinical Trial" (Di Nasso, 2016).

The results of the study conducted within this goal showed that the use of the concert pitch a^1 = 432 Hz in the practice of composers and performers is more episodic compared to the general professional practice in the standardized concert pitch. However, the professional use of the concert pitch is not homogeneous (currently in concert halls and orchestras in Europe and the United States are used about 8 concert systems - a^1 = 415 Hz, 430 Hz, 440 Hz, 441 Hz, 442 Hz, 443 Hz, 444 Hz, 445 Hz). In this sense, the concert pitch a^1 = 432 Hz is recognizable as a form of individual preference for expression.

The following results were obtained for the set goal for the study of the theoretical formulations on the issue of the systems for the organization of the tonal space (variants of temperaments and intonations and the study of the temperaments with open fifths):

In the present work, the question of the open fifth – an interval described by Maria Renold in her monograph, and her proposed temperament based on this interval was also considered. The "Open fifths" temperament is an innovative unequal temperament with which Renold places the effect of the sonority of the tone of difference before equality of the system. The innovation is in the tuning method.

In this temperament there is a variety in the widths of the same intervals in the different octaves. The purpose of the many compromises that are made with the width of the intervals is to some extent justified - to inspire the keyboard instrument timbre, closer to the live sound of the string instruments, motivated by the tone of the difference.

The two proposed unequal temperaments prepared by Maria Renold were modeled mathematically, which allowed a comparative perspective with the equal temperament. Based on these temperaments, music examples were prepared and included in subsequent practical studies.

According to the set goal for studying the presence of a concert pitch a^1 = 432 Hz in extra-concert sound practices – speech intonation and declamatory-speech forms of vocalization during Orthodox service, the following results were obtained:

If we exclude the results of the historical review of the process of standardization in the music theory and practice of Western European music[26] and we review the recordings cited in Chapter

[26] We exclude the listed results due to the fact that the way of reaching them is different from the objects of study – speech intonation in children and students and declamatory-speech forms of vocalization in Orthodox priests during service. The results of Chapters II, III and IV are in the first place a consequence of purposeful search and investment of a rational resource to achieve a single result (the desire for standardization). Speech intonation is a spontaneous phenomenon, which is a consequence of the influence of a certain psychological affect, emotion or, more generally, of a certain inner state (especially in the case of the state of prayer in priests). This spontaneity is not subject to regulation, unlike the concert style and temperaments. The research proposed in Chapter V shows that in many cases the spontaneous choice

V (recordings of children's speech intonation and the vocalization of priests during Orthodox service), we can conclude that they often contain tones that coincide with the tones of pure intonation with a border 3 (Pythagorean intonation), calculated from a^1 = 432 Hz.

Important examples of the connection between music and language are the neurophysiological experiments cited by Stefan Koelsch. There the contours of the waveform of phonemes in Mandarin (tonal language) are found represented literally in EEG graph of FFR potentials. When these waveforms are played, the EEG representations of the phonemes sound like tones. In this sense, the many coincidences of the close correspondences found in the speech intonation with the tones belonging to the pure intonation with a p-limit 3, calculated by a concert pitch a^1 = 432 Hz, is a confirmation for the following: the “Philosophical” pitch has grounds to exist and recognized in speech intonation (tone a^1 = 432 Hz at c = 128 Hz); the tone a^1 = 432 Hz occurs spontaneously and therefore we can assume that it is natural.

In the analysis of the sound recording of the five groups in kindergarten, it was concluded that the predominant intonation sound modality belongs to the frequency 432 Hz. An exception to this trend is the fifth group - in it all speech intonations belong to the frequency 440 Hz. The dominant sound modality for the speech intonation in the recordings from 15 Middle School “Adam Mickiewicz” in Sofia are tones that belong to the frequency 432 Hz. In contrast to the record in kindergarten, chromatic tones (calculated as geometric mean values) are much more common here. Also, the general contour of the intonation is much richer and more diverse.

The analysis of the recordings in Sofia’s Orthodox churches confirms the hypothesis that the intonation during the vocalization of the priests can be understood as related with Pythagorean intervals to the frequency 432 Hz. I.e. we can say that we find many examples of the fact that in a large part of the time in which priests serve, they intone, vocalize or recite on tones, in Pythagorean relations to a^1 = 432 Hz. From the recordings considered in the text, we can say that the frequency 432 Hz and the tones belonging to it through pure Pythagorean relations and geometric mean values are a living part of the Orthodox service.

In the objective to research the possibility of a different perception of the music and the general case of the presence of various cognitive and associative results, related to the

coincides with the value of a scale that corresponds close to pure intonation with a simple limit of 3 (Pythagorean intonation) at a^1 = 432 Hz. And, although in these cases it is not a concert procession, the very existence of these phenomena should be taken into account.
The examples set out in Chapter V set more questions than they give answer to so far. In this sense, the author envisages a further deepening of his research into the relationship between the perception and expression of internal states with sound, systems for the organization of tonal space and the neurophysiological correlates of musical processes in his subsequent works.

concert pitch (a^1 = 432 Hz or a^1 = 440 Hz), in which the sounds of music, the following results were obtained:

The experiments conducted during the dissertation terms showed that the majority of respondents recognize the difference between the concert pitch a^1 = 432 Hz and the standardized pitch of ISO 16:1975. Most of the respondents even give associative characteristics, which leads to the idea: the concert pitch a^1 = 432 Hz differs from ISO 16:1975 not only in the absolute values of the tones in the system, but also in the suggestion that the lower frequencies of the whole system carry.

Another important conclusion is the establishment of a general tendency in the localization of the sensation of sound on the body. A general trend was found in all surveys - the localization of the sensation of sound on the body shifts from top to bottom with the change of the concert pitch from higher to lower. The change in localization was less pronounced when the temperament changed from evenly tempered to “Open fifths” – from localized to non-localized sensation.

It was found that the change of the temperament from equal to good unequal is not a determining factor for the degree of liking, but on the contrary - the temperament with open fifths is accepted by the respondents in the same way as the equal temperament.

In the objective to build a neurophysiological hypothesis for an objective study of the perception of music in the context of concert pitch a^1 = 432 Hz or a^1 = 440 Hz and temperament with "open fifths", the following hypothesis was prepared:

The hypothesis derived from the above review of neurophysiological practice in the neurophysiological study of music is that we can find correlations between the brain activity of certain subcortical areas and the type of auditory stimulus. The test of this hypothesis consists of 2 steps.

Confirmation of the correlation between a change in activity in the subcortical areas and a change in auditory stimuli will become the starting point for starting a larger series of specific neurophysiological experiments.

Conclusions

1. The concert pitch a^1 = 432 Hz should be recognized as another valid element of musical expression. It is possibel to consider it as an emancipated form of musical expression, because the concert pitch a^1 = 432 Hz is already recognized as such by many

musicians: various ensembles in Bulgaria and Europe, composers and authors of musical products.

2. The concert pitch a^1 = 432 Hz occurs not only as a result of the abstract theoretical or practical thought of Western European musical culture - related to the "Philosophical" pitch and the "Philosophical" C through the system of just intonation with a p-limit of 3. Tone reference a^1 = 432 Hz occurs spontaneously in speech intonation and during Orthodox service.

3. The open fifth is an interval that has a synthetic character and at the piano temperament "Open fifths" (proposed by Maria Renold) creates a different aesthetic perception.

4. The perception of music changes subjectively with the change of the concert style and temperament, as confirmed by the surveys conducted during the research in the dissertation.

5. A general tendency was observed and confirmed in the study of the localization of the sensation of sound in the body: when the concert pitch changes from a^1 = 440 Hz to a^1 = 432 Hz, a general tendency to move the focal point from top to bottom is observed; when the temperament changes from equal to one with open fifths (with the same concert pitch) there is a tendency (but weaker than when changing the concert pitch) for a transition of the sensation from localized to non-localized.

6. It follows from conclusions 4 and 5 that subjective judgments must be examined objectively. This test should be based on the collected studies to seek proof of the neurophysiological hypothesis using the methodology described in Chapter VI.

IX. Bibliography

1. **Джуджев, Стоян.** Музикална акустика. Въведение в науката за звука. София. 1958 **[Dzhudzhev, Stoyan.** Muzikalna akustika. Vavedenie v naukata za zvuka. Sofia. 1958**]**
2. **Deutsch, Diana. Le, Jinghong. Shen, Jing. Henthorn, Trevor.** The pitch levels of female speech in two Chinese villages. In: Journal of the Acoustical Society of America, 2009, DOI: 10.1121/1.3113892
3. **Di Nasso, Luca et al.** Influences of 432 Hz Music on the Perception of Anxiety during Endodontic Treatment: A Randomized Controlled Clinical Trial. In: Journal of Endodontics, Volume 42, Issue 9, 1338 – 1343, September 2016. Accessed at: 10.1016/j.joen.2016.05.015
4. **Ellis, Alexander John. Mendel, Arthur.** Studies in History of Musical Pitch, Amsterdam. 1986. Frits Kunf
5. **Fokker, Adriaan Daniël**. Equal Temperament and the Thirty-one-keyed organ. 1955. http://www.huygens-fokker.org/docs/fokkerorg.html
6. **Gosling, Samuel D.. Rentfrow, Peter J.. Swann, William B., Jr..** A Very Brief Measure of the Big Five Personality Domains. In: Journal of Research in Personality, Volume 37. 2003. pp. 504-528. Accesed at: https://doi.org/10.1016/S0092-6566(03)00046-1
7. **Haynes, Bruce.** History of Performing Pitch: The Story of "A". Maryland and Oxford. 2002

8. **Koelsch, Stefan.** Response to target article "Language, music, and the brain: a resource-sharing framework". In P. Rebuschat, M. Rohrmeier, J. A. Hawkins, & I. Cross (Eds.), *Language and music as cognitive systems* (pp. 224-234.). New York. 2012
9. **Koelsch, Stefan.** Brain and Music, New Jersey, 2013.
10. **Lendvai, Ernö.** "Béla Bartók: An Analysis of His Music". Kahn & Averill. London. 1979
11. **Lloyd, Llewellyn Southworth. Fould, Achille.** International Standard Musical Pitch. Journal of the Royal Society of Arts, 98(4810), 74–89. 1949**.** Accessed at: http://www.jstor.org/stable/41364475
12. **Locke, Simon & Kellar, Lucia.** Categorical perception in a non-linguistic mode. In: Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, Volume 9. Issue 4. pp. 355–369. Elsevier. 1973 https://doi.org/10.1016/S0010-9452(73)80035-8
13. **Meerens, Charles.** Il diapason (corista). Versione con l'aggiunta di alcune note di Gioacchino Muzzi. Roma. 1876
14. **Patel, Aniruddh D.** Language, music, and the brain: a resource-sharing framework. In: P. Rebuschat, M. Rohrmeier, J. A. Hawkins, & I. Cross (Eds.), *Language and music as cognitive systems*. pp. 139-155. New York, 2012 Oxford University Press
15. **Renold**, **Maria**. translated Bevis, Stevens, Ed. by Meuss, Anna R.. Intervals, Scales, Tones and the Concert Pitch c=128 Hz. East Sussex, 2004.
16. **Riemann, Hugo**. **Handbuch der Akustik (Musikwissenschaft).** Dritte Auflage. Berlin. 1921
17. **Thomassin, Yves.** 432Hz Artists & Labels List. 2014 Accessed at: https://www.facebook.com/groups/326302077904109/
18. **Van Hedger, Stephen & Heald, Shannon & Nusbaum, Howard.** Absolute Pitch May Not Be So Absolute. In: Psychological science. 2013 August. No. 24(8). pp. 1496–1502. Accessed at: https://doi.org/10.1177/0956797612473310
19. **Weinstein, Jerry L.** Musical Pitch and International Agreement. In: The American Journal of International Law 46. No. 2. 1952. pp. 341-43. Accessed at: www.jstor.org/stable/2194075.
20. **Yanakiev, Ivan.** Equal division of the octave (EDO) with more than twelve tones - concept, authors, results. In: ArtReadings 2018. Art In Europe: Models And Identities. pp. 565-574
21. **Yankiev, Ivan K.** The Categorical Perception of the Music Scale: A Challenge Before the Microtonal Music. In: Accelerando Belgrade Journal of Music and Dance 3:3. 2018. accessed at: https://accelerandobjmd.weebly.com/issue3/the-categorical-perception-of-the-music-scale, on 31.08.2018.

I. Publications and Papers on the Dissertation Topic

Studies:

1. **Yanakiev, Ivan.** Mathematical devices in aid of musical theory composition and performance. In: Music between Ontology and Ideology (Ed. Milena Bozhikova). Cambridge Scholars Publishing. 2020. pp.36-60. ISBN (13): 978-1-5275-4531-1
2. **Янакиев, Иван.** Връзката между езика и новата музика – опит за интердисциплинарен дискурс.. В: Съвременно музикално мислене: Композиция, медиация, посоки в XXI век. София. 2019. сс. 141 – 163 [Vrazkata mezhdu ezika i novata muzika – opit za interdistsiplinaren diskurs. V: Savremenno muzikalno mislene: Kompozitsiya, mediatsiya, posoki v XXI vek. Sofiya. 2019. ss. 141 – 163]

Articles:

1. **Yankiev, Ivan K.** The Categorical Perception of the Music Scale: A Challenge Before the Microtonal Music. In: Accelerando Belgrade Journal of Music and Dance 3:3. 2018 https://accelerandobjmd.weebly.com/issue3/the-categorical-perception-of-the-music-scale

2. **Yanakiev, Ivan.** Equal division of the octave (EDO) with more than twelve tones - concept, authors, results. In: ArtReadings 2018. Art In Europe: Models And Identities. pp. 565-574
3. **Янакиев, Иван.** Употреба на обогатена реалност (Augmented Reality) в полза на музикалната теория – поглед върху диамантите на Хари Парч. В: Докторантски четения 2018. Сборник с материали от научна среща на докторанти в НМА „проф. Панчо Владигеров“. София. 2019. сс. 119-129. [Upotreba na obogatena realnost (Augmented Reality) v polza na muzikalnata teoriya – pogled varhu diamantite na Hari Parch. V: Doktorantski cheteniya 2018. Sbornik s materiali ot nauchna sreshta na doktoranti v NMA „prof. Pancho Vladigerov“. Sofiya. 2019. ss. 119-129.]
4. **Yanakiev, Ivan.** Role of the Golden Ratio in Perceiving Humanness by Random Generated Tones. An Empirical Study. In: Art Readings 2017: Crossing Borders in Arts. Beyond Modern & Postmodern. Sofia, 2018. Institute of Art Studies. BAS. pp. 151-161 [Yanakiev, Ivan. Zvukovi transferi. Pesnite na ptitsite i „There was a time“ (“Edno vreme”) ot Koriyn Morsink“. V: Dinamika na kulturnite protsesi. Sofiya 2017, ss. 123-131]
5. **Янакиев, Иван.** Звукови трансфери. Песните на птиците и „There was a time“ (“Едно време”) от Корийн Морсинк“. В: Динамика на културните процеси. София 2017, сс. 123-131 [Yanakiev, Ivan. Zvukovi transferi. Pesnite na ptitsite i „There was a time“ (“Edno vreme”) ot Koriyn Morsink“. V: Dinamika na kulturnite protsesi. Sofiya 2017, ss. 123-131]
6. **Янакиев, Иван.** Въпросът за концертния строй през XX век – генезис и история на проблематиката. В: „Изкуствоведски четения 2016. Автори. Течения. Взаимодействия.“ София. Институт за изследване на изкуствата – БАН. 2017. сс. 244-252. [Yanakiev, Ivan. Vaprosat za kontsertniya stroy prez XX vek – genezis i istoriya na problematikata. V: „Izkustvovedski cheteniya 2016. Avtori. Techeniya. Vzaimodeystviya.“ Sofiya. Institut za izsledvane na izkustvata – BAN. 2017. ss. 244-252.]
7. **Янакиев, Иван**. Втори конгрес на Обществото за теория на музиката, В: „Българско музикознание“, 2015, №4, сс.106-110. ISSN: 0204-823X [Yanakiev, Ivan. Vtori kongres na Obshtestvoto za teoriya na muzikata, V: „Balgarsko muzikoznanie“, 2015, №4, ss.106-110. ISSN: 0204-823X]
8. **Янакиев, Иван. Какво чува този, който (не) чува. Компаративно осмисляне на темперациите.** В: „Изкуствоведски четения 2015. Изкуствата в Новото време: смесване на езиците“ София, Институт за изследване на изкуствата – БАН 2016, сс. 296-308, ISSN 1313-2342 [Yanakiev, Ivan. Kakvo chuva tozi, koyto (ne) chuva. Komparativno osmislyane na temperatsiite. V: „Izkustvovedski cheteniya 2015. Izkustvata v Novoto vreme: smesvane na ezitsite“ Sofiya, Institut za izsledvane na izkustvata – BAN 2016, ss. 296-308, ISSN 1313-2342]
9. **Янакиев, Иван.** „Чия е тази песен? – наблюденията на музиканта.” – В: Прилози. Балкански идентитет/и. Скопје, Македонска академија на науките и уметностите 2015, XL 1-2, сс. 212-219. ISSN 0350-1914 [Yanakiev, Ivan. „Chiya e tazi pesen? – nablyudeniyata na muzikanta.” – V: Prilozi. Balkanski

identitet/i. Skopje, Makedonska akademija na naukite i umetnostite 2015, XL 1-2, ss. 212-219. ISSN 0350-1914]

Popular Science Publication

1. **Янакиев, Иван** – „Човешкият глас на виолите на Краля слънце", http://artstudies.bg/platforma/?p=765 [Yanakiev, Ivan – „Choveshkiyat glas na violite na Kralya slantse", http://artstudies.bg/platforma/?p=765]

Head of two research projects under the Program for Support of Young Scientists at BAS:

1. **"Intonation and concert pitch a^1 = 432 Hz: Bulgarian and world practice, variability, impacts and results" (2016-2017)**
2. **"Temperament and intonation systems in the XX century" (2017-2019)**
   During the project ends and remote course in MatLab Stanford University, which helped to refine program codes included in the dissertation.

Participant in two research projects with reports in national and international conferences and publications: **"Cultural Integration and Identity"** project between BAS and MANU and **"Contemporary Music Composition, Theory and Philosophy"** at the Research Fund - MES (2017-2020).

Participation with reports at the conferences:

1. **Fourth Congress of the Society for Music Theory - Kazan 2019 –** The terms Temperametn and Intonation in the Context of the Microtonal Music in the Late 20th and 21st Century. Theory and Practice
2. **International Theoretical Symposium within the Varna Summer Festival - June 25, 2019** with the report: *"Die Theorie der Affekte – ein Überblick aus dem Standpunkt der zeitgenössischen Microtonal Theorie"*
3. **International Conference "Art Readings" Sofia 2019 (08 - 10 April 2019)** с доклад *„Tuning to timbre. Revisiting Consonances and Dissonances in Microtonal Context"*
4. **"Doctoral readings", Sofia 2018 (April 16-17, 2018)** with a report *"Using Augmented Reality in favor of music theory - a look at the diamonds of Harry Parch"*
5. **International Conference "Art Readings" Sofia 2018 (28 - 30 March 2018)** with the paper *„Equal division of the octave (EDO) with more than twelve notes – concepts, authors, results"*
6. **Third Congress of the Socitey of Music Theory – Moscow (25-29 September 2017) Moscow 2017** with the paper *„The Tacid Revolution. Pitch Standardization Effect on Musical Interpretation and Perception"*
7. **International Conference "Art Readings" Sofia 2017 (02 - 05 April 2017)** with the paper *„Role of the Golden Ratio in Perceiving Humanness by Random Generated Tones. An Empirical Study "*
8. **International Conference between BAS and MANU "Cultural Integration, Transfers, Signs of Memory" (October 27-28, 2016)** with the paper *"Sound transfers. The Songs of the Birds and "There Was a Time" by Corinne Morsink"*
9. **III International Festival Review of Folklore Ensembles Established in Secondary Vocational and Higher Education "Universal Wreath" and V International Scientific and Practical Conference for Pupils, Students and**

Doctoral Students "Ethnomusicology: History, Theory, Practice" with a report *"Bulgarian folk music, Orthodox chants and other examples and the role of the*

10. *concert pitch as an inherent attribute of the sound."* – May 16-19, 2016;

11. **"Art Studies Readings 2016"** with the paper"The concert system in the XX century - the genesis and history of the issue" (April 2016);

12. **"Art Studies Readings 2015"** with a report on Maria Renold's first piano temperament proposal "Twelve True Fifths" (May, 2015);

13. **Second Congress of the Society for Music Theory** in Moscow (September 25-29, 2015) with a report on Maria Renold's second proposal for piano tempo "A new method for tuning the scale of twelve quintes";

14. **"Balkan Identities"** in Skopje as part of a project between BAS and MANU with a report "Whose song is this? The musician's observations. "(November, 2014).

Lectures:

1. **"Microchromatic music in the XX and XXI century"**, presented to students majoring in Music at FNPP at Sofia University "St. Kliment Ohridski "April 23, 2019.
2. **"432vs440"** presented on March 19, 2016. In Ruse within the International Music Festival "March Music Days": http://www.ustream.tv/recorded/84634664
3. **"432vs440 frequencies in shape and sound. scientific and musical empirics "**, presented on 09.05.2016 in the hall of the Institute of Art Studies, Sofia 09.05.2016: https://www.youtube.com/watch?v=6lFHcBLpaq4

Contributions of the Dissertation

The dissertation has the following contributions:

1. Revises and refines the definition of the terms concert pitch, temperament and intonation, making a clear distinction between them. (Chapter II, III).

2. 2. Defines new concepts - infra octave (Chapter II) and localization of the sensation of sound (Chapter IV).

3. Develops mathematical models of temperaments and applies in practice the model in the graphical visualization of the temperaments and in the generation and modeling of sound representations of the temperaments reviewed in the work (Chapter IV), (Chapter III).

4. Collects and analyzes information from the conducted surveys (Chapter V).

5. Collects audio and video recordings of instrumentalists during the conducted surveys (Chapter V).

6. Collects and analyzes sound material from speech intonation in kindergartens and schools, as well as from Orthodox priests during orthodox service (Chapter VI).

7. Proposes a neurophysiological hypothesis based on the results of surveys. The purpose of the hypothesis is to provide an option for an objective analysis of the subjective impressions from the comparison of the concert pitches a^1 = 432 Hz and a^1 = 440 Hz and the equal temperament and the temperament "Open fifths".

8. It offers developed software for checking the feeling of synchronization and potential connection with the number φ.