ACOUSTICS IN SOLFEGGIO – EFFECT AND OUTCOMES IN EDUCATIONAL PRACTICE[1]

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Abstract: In the tradition of Western European music, the musical process of tuning tones has undergone various stages. Although fixed and confirmed as such, the pitch oscillates due to natural inertia. The Herz – determined tuning of the reference tone is the most applied in both instrumental and vocal-instrumental music. In these cases we witness the strong relationship between acoustics and solfeggio in auditory and performing domain.

Key words: acoustics; standard pitch; solfeggio; working procedures.

The paper is aimed to pointing out to the standard facts in the field of acoustics related to the narrow field of musical sound[2], and emphasizes the mutual relationship between acoustic factors and ways of their perceiving and reproducing offered by solfeggio. It is a result of initial stage of interest in the selected matter. Among others, the following issues were singled out: an overview of thoughts on acoustics over history: the process of determining standard pitch[3] a[1]; perception of the role of tone tuning in vocal performance and auditory perception – given that solfeggio typically uses voice as the means of expression; in what way authors of some of selected solfeggio textbooks approach the awareness, perception and performance of elements which are, of course, related to the phenomenon of sound and pertain to educational practice of tonality[4]

[1] The choice of the topic is a result of interest and research the results of which will, among other things, be incorporated in the author's doctoral dissertation. The proposed theme of doctoral dissertation is Musical and musically in solfeggio: between acoustics, graphics and creative, at the Academy of Music, University of Sarajevo.

[2] The term "sound" encompasses everything we hear. Sound is defined as elastic oscillations in solid bodies, fluids and gases, i.e. sound is a change in pressure, tension, shift or speed of particles which expand in elastic environment (Kovačević, 1971, 20).

[3] B/S/C: Kamerni ton, kamerton; Italian: diapason, French: diapason; English: standard/ normal pitch; German: Kammerton, Stimmton (Peričić, 2008).

[4] "The sense of major and minor, i.e. tonality, is experienced as a sound complex; interwoven with interaction of functional relations, and based on tonic triad. In this sense, education in the sense of tonality depends on the ability to master these relations. (…) Work on gaining the understanding of atonal music should start from an entirely different platform and education should develop other habits, other senses and other sound-related accustoming. Both new and different senses compared to listening to the tonal, and ways of reproduction serve to another purpose and lead to another goal. One should not ignore the fact that atonal music lacks the

solfeggio.[5]

Acoustics[6] is a science of sound[7], i.e. – of what we perceive with the sense of hearing. The phenomenon of sound has always drawn scientists' attention. Significant discoveries and views in the area of acoustics, nature of tone and relations among tones can be traced to the time of Pythagoras[8] (ca. 582 to ca. 496 B.C.), Aristotle (384–322 B.C.), Boethius (480–524)[9]. Vincenzo Galilei[10] (1520–1591) advocated the view that vocal music should make a compromise between Pythagorean and Ptolemaic[11] tuning, i.e. the implementation of a more flexible tuning system (Palisca, 2009). Marin Mersenn[12] (1588–1648), whose work *Harmonicorum Libri* (1636) is considered the basis of modern acoustics, has defined tone and sound as air oscillation, and concluded that pitch depends on the number of oscillations in a unit of time. He is considered the first to point out to partial tones of a tone. He has contributed to the improvement of theory of tuning and the nature of tone by synthesizing previous knowledge. He advocated the uniform tone tuning, which would be easier to apply in the practice of building

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gravitation centre, as well as the characteristic mutual relations between functions, which primarily distinguishes it from tonal music." (Krajtmajer, 2002, 4)

5 The topic certainly requires approach from the aspect of music psychology, psychoacoustics, sociology, aesthetics of music as well. Such topics would certainly require a separate paper.

6 Akoustos (gr. ἀκούω – I hear). There are many area of human activities where acoustics and sound play essential roles: electrical engineering and technology, mechanical engineering, architecture, visual arts, psychology, physiology, medicine, soil physics, atmosphere physics, oceanography, etc.

7 Essential characteristics of musical sound, tone, are as follows: the basic frequency that determines its pitch, spectral composition that timbre depends on, loudness, time flow of intensity which includes growth or initial transient, stationary state and decline or final transient. The continuous transition from a tone of one frequency to a tone of another frequency is called portamento, while tremolo or vibrato is an amplitude or frequency-based modulation of a given tone (Kovačević, 1971, 24).

8 He investigated the relations between string lengths on the monochord and thus defined intervals (Pythagorean tuning – a^1 = 432Hz). Many people who studied the nature of tone and pitch, from the 15th to late 18th century used the monochord to define intervals, relations among tones and systems of tone tuning. Results were presented graphically, in the form of drawings or engravings, or as number relations (Rasch, 2008, 195).

9 The recommended elementary literature on tuning and the nature of tone includes James Murray Barbour, *Tuning and Temperament*: *A Historical Survey*, as well as: Dupont, *Geschichte der musikalischen Temperatur* Jorgensen, *Tuning the Historical Temperaments by Ear*; *and Tuning*; Lindley, *Stimmung und Temperatur*; Devie, *Le tempérament musical*; Ratte, *Die Temperatur der Clavierinstrumente*; Lindley and Turner-Smith, *Mathematical Models* (Rasch, 2008, 194).

10 Italian composer, lutist, music theoretician.

11 On the process of tuning, from Pythagoras on, from the viewpoint of mathematics and Suzuki teaching method, see: York, 2012; Staples, 2014.

12 French mathematician, philosopher, music theoretician and scientist.

musical instruments (Elvers, 2009). In the early 18th century, Joseph Sauveur[13] (1653–1716) advocated the development of a science of sound, which would be called acoustics (Boyden and Walls, 2009; Sigalia and Campbell, 2009). Ernest Chladni[14] (1756–1827) repeated Hook's[15] experiments and visually proved the different forms of sound vibrations on the corresponding surface – board, known as Chladni's figures. He was also interested in pitch tuning (Kovačević, 1971, 323; Sigalia and Campbell, 2009). Hermann Helmholtz's[16] (1821–1894) work *Lehre von den Tonempfindungen als physiologishe Grundlage für die Theorie der Music* (1863) established laws which determine, which is believed to be of the utmost importance for music theory, acoustics and psychoacoustics, with experiments and based on treatises by Jean Philippe Rameau (1683–1764), Giuseppe Tartini (1692–1770) and others, have established laws that define timbre in various instruments and human voice, and natural limits of the acoustic sensitivity of human hearing and it also derives conclusions pertaining to overtones, etc. (Kovačević, 1974). Helmholtz also gave a significant contribution and impetus to studies of listening, auditory perception and psychophysical effect of sound and music. He drew attention to the sense of hearing. Alexander Ellis[17] (1814–1890) built upon Helmholtz's work. He published a number of significant studies, particularly on the history of determining pitch. His work *On the History of Musical Pitch* (1880) is considered the obligatory reading (Thistlethwaite, 2009).

From the viewpoint of solfeggio, which typically uses voice as a means of expression, an interesting process is that of developing awareness of tone pitch, tone tuning[18]. In other words, can it – and how, be reflected in the perception and way of expression in solfeggio?

In the tradition of Western European music, the process of tone tuning and determining their established pitch has undergone different stages over a long period of time. The need to uniform the tuning became particularly prominent

[13] French physicist.

[14] German acoustician.

[15] Robert Hook (1635–1702) studied the effect of vibrations on a corresponding surface and established and studied "sound knots".

[16] German physiologist and physicist.

[17] English philologist, acoustician, mathematician and musicologist. He translated Helmholtz's work *On the Sensation of Tone* and, with Helmholtz's permission, added his own work to it.

[18] A special quality of a sound (e.g. an individual musical tone) which fixes the position of tone in a scale, contrary to absolute tuning, hearing that implies recognition of pitch without a given contextual relationship with other tones, e.g. in a scale. Tuning is expressed by combining frequency values (such as 440Hz) with the tone name, e.g. a^1=440Hz. Frequency, tone pitch are natural phenomena. It is only when they are related with the standardized tuning that they take over musical dimension. The tuning standard is a convention on uniform tuning, which is prescribed and which is generally used by musicians in a given point in time and at a given location (Haynes, 2009).

when the vocal-instrumental music practice began. *A capella* pieces were tuned according to natural tuning, taking into account characteristics of a piece of music voice ranges. Until the second half of the 16th century, organ was the only music instrument in the church. Development of instrumental music and the increasing usage of secular instruments in the church affected the uniforming of instrument tuning. The well-established tuning standard present in the Western European art music was not always the same, nor was it the same everywhere. Different parameters of pitch tuning were applied at the same time. Tuning was different for *a capella*, and for instrumental music; different in different countries, towns within the same country, even in churches of a single town. Attempts to uniform different instruments, or voices and instruments, frequently resulted in the transposition of a given instrument's part. The organ part was usually transposed *a vista* in order to adjust to the tuning of another instrument of voice range. Transposition was a usual though exacerbating process. Thus, in the 16th and 17th century, distinct terms were used for the kind of tone tuning: in Italy, the terms used included *mezzo punto* (a^1=464Hz), *tutto punto* (a^1=440Hz), and *tuono corista* tuning for church choirs, which was the lowest. In around 1740, organ builder Pietro Nachini (1694–1769) began to use the tuning a^1=440H, known as *corista veneto*. Until the end of the 18th century, the tuning was adopted by almost whole Europe and therefore it can be claimed that, ultimately, it was as early as then that the 20th century tuning was known. Similar was true of other European countries. In France, actual tunings were lower than the Italian ones. After 1740, tuning was adjusted to the Italian one. In Germany, tuning was higher. Terminological dilemmas were also evident and resulted in a lack of understanding of terms *Kammer Ton* and *Cammer ton*. In England, Quire-pitch, a^1 of around 473Hz was in use. Eventually, they also adopted to the Italian tuning. By the end of the 18th century, church organs across Europe had tuning that differed from orchestral instruments. They were tuned like in the previous century, which made them too highly tuned in Germany, and too low in France and England (Sigalia and Campbell, 2009; Haynes, 2009).

In the course of history, tuning moved upwards and downwards. All tunings were similar to each other, so it seems that the final tuning was actually a logical compromise. The production of musical instruments has also standardized, which also contributed to the uniforming of reference tuning. In 1939, International Organization for Standardization[19] fixed the standard pitch a^1 at 440Hz[20], which was confirmed in 1953.

[19] ISO (gr. Isos = equal)

[20] On the ISO's official website, the standard pitch was last revised and confirmed in 2017, a^1=440Hz (Iso, 2017). Although confirmed, the chamber tone a^1 still has a tendency to change. Thus, renowned philharmonic or opera houses have set their standard chamber tone a^1, and even certain conductors require a certain tuning of the chamber a^1. See: New York Philharmonic, 2017; Abdella, 1989.

However, the question arises as to whether these studies and facts on the process and determination of standard pitch find their place in the area of solfeggio. Considered as a natural phenomenon, fixed and referential in music, tuning is the most properly applicable in instrumental and even in vocal-instrumental music. It begs the question about tuning voice. How to tune voice? Voice in the *a capella* context does not have to insist; one could even say that it cannot insist on tuning in such a context. Voice in intonation responds to external factors; psychological, and physical ones.

Solfeggio classes are often delivered in groups, as well as singing together or as a choir. A parallel could be drawn with choral *a capella* singing. For good performance, any choir singer relies upon joint music-making, listens to neighbouring voices and harmonic motions, striving for the correct, enviable performance and creation of unified choral tuning and timbre. Conductors have the task to balance voices – dynamically, numerically, using the singers' positions in space, so that they direct choral singers toward unified, homogenous performance. The ultimate result is a conscious, engaged performance of a piece, opening the possibility for indulging in the momentary auditory perception of the performed piece and having a chance for momentary, creative, joint, musical expression.

Solfeggio is mostly focused on voice and its natural tuning. The effect of acoustics on the educational practice of solfeggio is inevitable. Solfeggio develops its working procedures relying upon acoustics, not exclusively as determined, given, Herz-fixed tone pitch (except in case of some specific demands). Determination of tone pitch and tuning now suggests the feature of tone to have a unique quality which fixes its position compared to other tones in the scale, chord, compared to other instruments or singing voices.[21] On the other hand, the defined tone pitch would identify the tone regardless of its contextual relations with other tones – absolute pitch, tempered system of 12 equal tones. In solfeggio, sound phenomena are observed, and reproduced (sung), which is followed, if necessary, by a kind of graphic recording.

[21] For a graphic presentation, see: Kazić, 2004.

Through literature[22]

By grasping authors' methodical approach, kind of tasks offered by authors, the way in which they administer them and interpret the essence and goal of tasks, one can realize how acoustic phenomena are perceived in solfeggio classes. Table 1 provides an overview of some observations.

Scales are processed gradually according to the layout of the whole and the half-step, indicating their characteristics by listening and singing.
Tonal exercises are performed with guitar accompaniment.
Exercises for intonation are performed with piano accompaniment with prominent markings for tempo, dynamics, agogic.
Exercises are at the C level without insisting that they are intonatively at C level and performed at C level.
The relationship between the tones is highlighted, the absolute pitch of the tone is not emphasized.
The importance of training good and proper singing is emphasized.
Improving tonalities by singing together in various voices, using D7 chord in the major and minor tonality by emphasizing the moment of release.
Adjectives melancholic, sad, happy, bright, clarify the sound differences between major and minor tonalities.
Relations between tones are established with the use of solmization.
Perception of major and minor pentachord is associated with playing on the piano.
It points to qualitative, and not only to quantitative characteristics of the interval, referring to inevitable interval singing.
Perceiving major/minor tonalities by listening to sound clips.
A connection with harmony is created by singing the tones of chords and sequence of chords.
Improvisation is encouraged.
Examples are played and sung simultaneously.
It is suggested to choose a melodic patern that is being trained, and for which the intonation is taken arbitrarily.
It is suggested that the student does not rely entirely on instinct and natural talent, but should develop the possibility of logical thinking and to use capacity to combine the adopted elements.
Training aural skills include the ability to distinguish different types of musical sound.
It emphasizes the character of each tone, degree in the scale as a specification that by its position and relation to other tones creates a certain mental effect by which it can be recognized in any tonality . . .

Table 1.

[22] The literature used for the analysis includes a few textbooks by international authors, with different years of publishing, selected from a broader range: Batiste (n.d.), Carulli (n.d.), Cleland and Dobrea-Grindahl (2010), Crescentini (1885), Cringan (1889), Curwen (1900), Dannhäuser (1891), Hegy (1987), Hindemith (1949), Holmes (2009).

Acoustics affects solfeggio and practice in solfeggio education. It allows solfeggio to strengthen its position in other musical areas as a medium offering the space for elementary notions of acoustics – observation of a musical sound with the sense of hearing and its reproduction. In its working procedure, solfeggio allows experiencing and understanding tendencies of sound phenomena, and their efficient translation into performance. Moreover, this opens the possibility to integrate auditory and performing abilities and the way of perceiving acoustic phenomena developed and acquired in solfeggio classes into other areas of music education.

Working procedures in solfeggio classes do rest upon the acoustics. Acoustics, solfeggio and educational practice are in a causal relationship; mutually complementing and being directed toward each other. This does not exclusively imply the sphere of fixed tone pitch. With unique working procedures, solfeggio opens the possibility for auditory perception and reproduction of acoustic phenomena, perception in both physical and educational and performing terms. Solfeggio thus plays the role of a medium that provides a possibility for multifaceted approach in music education. It becomes a space of activity which affects the formation of a complete music theoretician, pedagogue, artist or scientist. It drives consideration of relations between acoustic phenomena, and ultimately results in a conscious, engaged, musical perception and their performance.

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