ISSN: 1997-0854 (Print), 2587-6341 (Online) DOI: 10.17674/1997-0854.2019.3.104-111
UDC/УДК 78.072.2

IRINA B. GORBUNOVA, MIKHAIL S. ZALIVADNY
Herzen State Pedagogical University of Russia
Saint-Petersburg Rimsky-Korsakov State Conservatory
St. Petersburg, Russia
ORCID: 0000-0003-4389-6719, gorbunovaib@herzen.spb.ru
ORCID: 0000-0001-9599-5925, trifonov_e_d@mail.ru

Leonhard Euler's Theory of Music: Its Present-Day Significance and Influence on Certain Fields of Musical Thought

The article examines the musical research works of Leonhard Euler (1707–1783) in which the scholar forestalls the theoretical and informational aspects of musical knowledge and presents an original interpretation of issues of harmony, as well as of the relations between pitch and rhythm organization within the framework of the general processes of periodicity. Notwithstanding the historically explainable bounds of these outlooks, they have proven to be significant due to the numerous features of great heuristic significance which remains relevant up to the present day. The greatest value in Euler's theory is determined by posing a number of fundamental musicological issues, the emergence of which was stipulated by the condition of musicology and other disciplines during Euler's time. It may be asserted with full substantiation that a more active application of these ideas would bring new fruitful theoretical and practical results in the sphere of musical education and upbringing, as well. Thereby, Leonhard Euler's theoretical views on music create the necessary conditions for the continuity between traditional musical education and informational technologies in the contemporary educational process.

Keywords: Leonhard Euler, music theory, harmony, rhythm, theory of information.

For citation: Gorbunova Irina B., Zalivadny Mikhail S. Leonhard Euler's Theory of Music: Its Present-Day Significance and Influence on Certain Fields of Musical Thought. *Problemy muzykal'noj nauki/Music Scholarship.* 2019. No. 3, pp. 104–111. DOI: 10.17674/1997-0854.2019.3.104-111.

И. Б. ГОРБУНОВА, М. С. ЗАЛИВАДНЫЙ
Российский государственный педагогический университет
имени А. И. Герцена
Санкт-Петербургская государственная консерватория
имени Н. А. Римского-Корсакова
г. Санкт-Петербург, Россия
ORCID: 0000-0003-4389-6719, gorbunovaib@herzen.spb.ru
ORCID: 0000-0001-9599-5925, trifonov_e_d@mail.ru

Теория музыки Леонарда Эйлера: современное значение и влияние на некоторые области музыкального знания

В статье рассматриваются музыкально-теоретические исследования Леонарда Эйлера (1707–1783), где учёный предвосхищает теоретико-информационные аспекты музыкальной логики и выдвигает оригинальную трактовку проблем гармонии, а также

связи звуковысотной и ритмической организации в рамках общих периодических процессов. Несмотря на исторически объяснимые границы этих воззрений, они оказались примечательными благодаря многочисленным особенностям большой эвристической значимости, которые остаются актуальными до настоящего времени. Основная ценность теории Эйлера определяется постановкой ряда фундаментальных музыковедческих проблем, появление которых было обусловлено состоянием музыкознания и других наук во времена Эйлера. Можно с полным основанием утверждать, что более активное применение этих идей может привести к новым плодотворным теоретическим и практическим результатам также в сфере музыкального образования и воспитания. Таким образом, теоретические взгляды Леонарда Эйлера на музыку создают необходимые условия для преемственности между традиционным музыкальным образованием и информационными технологиями в современном образовательном процессе.

Ключевые слова: Леонард Эйлер, теория музыки, гармония, ритм, теория информации.

Для цитирования: Gorbunova Irina B., Zalivadny Mikhail S. Leonhard Euler's Theory of Music: Its Present-Day Significance and Influence on Certain Fields of Musical Thought // Проблемы музыкальной науки. 2019. № 3. С. 104–111. DOI: 17674/1997-0854.2019.3.104-111.

INTRODUCTION

The systematic republication of classical works belonging to different historical epochs in music theory constitutes a remarkable phenomenon in musicology of the recent decades, in particular, the following examples (published in the original languages and in Russian translation) may be given: Aristoxenus. *Elements of Harmonics* (Moscow, 1998); Aristoxenus. *Elements of Rhythm* (St. Petersburg, 2015); Ptolemy. *Harmonica* (Moscow, 2013); Boethius. Institutio musica (Moscow, 2012); Johannes Tinctoris. *Treatises on Music* (Moscow, 2007); Descartes. *Compendium musicae* (Moscow, 2001), etc. Besides their contribution to the process of realizing the whole panorama of music theory in its historical development, such republications render an effective assistance in clearing out certain characteristic features in republished works which could not be discerned during their initial publication, but which become much more evident at present, owing to new achievements and possibilities of research.

The main validity of this book (and other works by Euler works devoted to music and related fields of research [8]) is determined, first and foremost, not by concrete proposals concerning various parameters of musical system, but by raising a number of fundamental musicological issues which had stimulated the appearance of these proposals in Euler's times. Such attitudes present in Euler's works towards music are distinctly expressed by a number of authors who analyze this section of the scholar's heritage[1].

EULER'S CATEGORY OF 'PLEASANTNESS'

The problem of importance of Euler's theory is evidently displayed in his attempt to systematize the interrelations of sounds and their combinations based on the category of 'pleasantness' (or 'euphony,' *suavitas*) [8]. Despite the historically explainable incoherency of Euler's abstract mathematical approach to the essence of this category (pertaining to the sphere of social psychology in its nature [6]) and its individual manifestations in music, his

attempt is undoubtedly remarkable as it bears the more general idea of the integrative index of complexity (respectively – of the regularity of order) concerning the logical organization in music and given in the respect of perceiving this organization by an individual subject. This idea stands close to the later notion of information that is essential for aesthetic evaluation of various phenomena [4] and the significance of that (as well as of the Eulerian category of 'pleasantness') is not limited to purely logical sphere, it is much broader in its meaning and richer in its content.

Besides this notion – which is philosophical in its general essence – the aesthetical aspects of music were proved very soon after it had been suggested [1; 10]. It included the theoretical thought on music proposed (mainly – in the 20th century) a number of similar integrative characteristics, though more 'local' in their meaning, such as 'density', 'tension', 'sound temperature' of musical structures and so on[2]. Some of these propositions (e. g. 'tension' of pitch combinations and their systems) played an important role in comprehending the new logical regularities in 20th century music, thereby assisting the process of 'contributing clearness and proportionality' (according to the well-known words of Sergey Taneyev[3]) to their practical application. It is evident that the structural principles of such generalizations (not being equal in their individual contents) demonstrate the features of similarity to Euler's analogous attempt, which gives the grounds for evaluating the latter as containing a perspective of outstanding historical scale and importance. The main direction of this perspective does not totally coincide with some of initial premises of Euler's theory, guided by the notion of simplicity (and not of interrelations between simplicity and complexity) as expression of 'euphony' and 'perfection' of pitch combinations [8]; but the tendency to coordinate the theoretical calculations with the data of practical experience leads Euler logically to the conclusion of optimal euphony as occupying a certain middle place between the minimum and the maximum of complexity of that kind of phenomena accessible for human perception [Ibid.].

HORIZONTAL AND VERTICAL IDENTITY IN PITCH

Similar worthwhile possibilities may be found in some other ideas of Euler concerning the logical organization of music (resp. the functions of the category of 'pleasantness'). In particular, this group includes the idea of horizontal and vertical identity in pitch [Ibid.] which supposes a relative independence of the indices of 'pleasantness' from the factor of time. The meaning of this idea proposed by Euler has two different aspects which embrace both the field of logics and that of psychology of musical perception. First of all, this proposition corresponds to a veritably observed psychological phenomenon of simultaneous integrating (simultanizing) musical structures ([3]; it must be noted that in this case the final result, according to Euler, is not a sound but an abstract numerical index of 'pleasantness'). Secondly, this point of Euler's theory constitutes a kind of parallel with certain historical processes which took place (though mainly in a 'peripheral' form remote from the focus of observation) in 17th and 18th century music before having been advanced to the forefront in the 20th century. The main results of these processes were the poly-chord settings in harmony[4] and the developed forms of 'free' counterpoint, which assume – in correspondence with the peculiarities of individual artistic concepts – any necessary number of voices and any necessary simultaneous combinations (respective

interrelation in pitch). In this connection, Euler's use of thoroughbass figures, which have no strict differences between the so-called 'chordal' (self-dependent) and 'non-chordal' (bound up) voice combinations, and, thus, logically suppose the possibility (translated into reality in later history of music) of transforming the latter into a self-dependent entity – is very symptomatic. This characteristic feature of Euler's theory is in conformity with another idea proposed by the theorist – that of correspondence between the opposition between consonance and dissonance and the degrees of complexity of pitch combinations (measured by frequency ratios). In its essence, this latter proposition forms the basis for the idea of the relativity of consonance and dissonance which became important for 20th century music[5]. It is also remarkable that some of the combinations of the kind possessing a relatively high index of complexity ('decreasing euphony', according to the initial premises of Euler's theory) analyzed by Euler are very similar to the acciaccaturas used in musical practice of his times (e. g. in the clavier sonatas by Domenico Scarlatti). At the same time, it is quite clear that Euler's index of simultaneous 'pleasantness' must be supplemented by the corresponding index characterizing the peculiarities of transition between the structure elements and, thus, belonging to the sphere of 'musical time' that is different from the 'spatial' aspect of music manifestations.

MODULATION MATRIX, TEMPERAMENT AND BINARY LOGARITHMS

The necessity of such indices becomes realized by Euler himself when studying the processes of modulation and formation of general composition structures which presuppose the interaction of complex pitch systems [8]. It is noteworthy that, while characterizing logical and psychological details of transition (modulation) from one key to another, Euler uses a matrix form [Ibid., p. 262] known from later history of music theory in connection with studying different levels of logical organization in music – from transitions between individual sounds to interactions of vast multi-dimensional sound complexes[6] – as well as in connection with studying musical synesthesia [2]. One of the most remarkable features of Euler's modulation matrix is an element of game theory (evaluation of modulations as 'easy', 'difficult' or 'unattainable') that is interesting not only as a historical fact of musicology but also as that of mathematics (in which the period of active formation of game theory falls on the 20th century).

Euler's propositions concerning the musical pitch system are based on non-tempered tuning, and this feature of his theoretical views on music that could seem to be archaic in the times of the past reveals its worthwhile possibilities in light of the microtonal aspects of contemporary music (attainable, in particular, with the assistance of electronic and computer music devices). Moreover, Euler also proposed the system of measuring intervals in binary logarithms of frequencies – in other words, in parts of the octave [8] – which, in essence, is of the same kind as the principles of equal temperament. Thereby, Euler in fact was taking into consideration both of the principles of forming the pitch systems which played an important role in music history (being reflected correspondingly in the history of music theory) – namely, those of addition and division in relations to the systemic elements. The specific form of relation between these principles themselves, according to Euler, characterizes the researcher's individual position on this issue. In this connection, a version of the 24-degree temperament which uses the 'natural minor seventh' (frequency ratio 7:4) as one of the basic intervals[7] must

also be noted among Euler's contributions to this field of music theory. Nowadays, all of Euler's proposals in this direction may be tested acoustically and psychologically and estimated aesthetically owing to the assistance of electronic and computer technologies.

PITCH-RHYTHM AND SOUND-LIGHT CORRESPONDENCES

In contrast to Euler's attempt of studying pitch organization in music, his works on musical rhythm, as well as on the issue of correlation between light and sound, have never formed a subject for actual discussion. Euler's theoretical remarks on the issues of rhythm expressed by the researcher in some of his early (unpublished) works, remained unknown to broader categories of readers. And, as to Euler's analogies between light and sound (partly – also smell), authors of musicological research works have noted his (also characteristic historically) purely physical approach to the problem ('an ear, an eye, even a nose, as certain highly perfect devices of research in a physicist's laboratory')[8]. Probably, these features of Euler's works formed the reason for having been left beyond the famous 18th-century discussion of the nature of sight-and-hearing synesthesia (in connection with the issue of the synthesis of colour and music) inspired by the researcher's contemporary Louis-Bertrand Castel, although Euler himself showed some interest to Castel's ideas [2]. Nevertheless, the idea of the similarity in the structure of pitch and rhythmical systems deduced by Euler from of both phenomena pertaining to the category of periodicity processes (expressed in a general way in his main treatise on music theory [8]) stimulated later (though not directly) a considerable number of studies and theoretical systematizations of musical rhythm that have resulted in essential enlarging of this field of musical expression (e.g. the theoretical concepts by Henry Cowell, Karlheinz Stockhausen, Ludwig Bielawski a. o.[9]). For example, Bielawski's theory constitutes an attempt of constructing the universal scale of periodical processes (and embracing also analogies to sound adhered by Euler) going far beyond the musical field in the proper sense [7], but, despite the evident marks of simplification in its content (as well as in the analogous scale of systematizing spatial measuring units) it is remarkable as a kind of 'musicological breakthrough' to the spheres of other disciplines of research, presenting worthwhile ideas in the other fields of artistic (and human in general) activities. Initial premises for that breakthrough, however, are available in Euler's theoretical works on music, as expressed by the researcher himself: *Praeterea quoque in omnibus aliis rebus, in quibus decorum et ordo inesse debet, haec tractatio magnam habebit utilitatem, si quidem ea quae ordinem constituunt, ad quantitates reduci numerisque exprimi possunt; sicut in Architectura, in qua decori gratia requiritur, ut omnes aedificii partes ordine, qui percipi possit, sint dispositae* [8, p. 43]. (Besides that, also in all other spheres, where there is a need for order and beauty, this approach may be very useful – certainly, if matter put in order may be reduced to quantity and expressed in number; for example, in architecture, where the beauty requires for all the parts of the building to be disposed in order accessible for recognizing [Lat.]).

CONCLUSION

The peculiarities of musical theory suggested by Euler give the grounds for speaking about its high heuristic significance essentially confirmed by posterior development both in theory and practice of

music. In the general picture of historical development of theoretical thought on music Euler's innovative ideas occupy an important place. Some of the remarkable perspectives for development of these ideas are connected with the relatively new branches of mathematics such as set theory, relation algebra, theory of fuzzy sets etc. (among them, the aforementioned game theory – see above the paragraph *Modulation Matrix*). There is no doubt that results of research work in these directions may be organically included into a more complex and fundamental integrative model of musical system (at more length see: [5; 9]), as well as their application to other research disciplines (e.g. general system theory). And it may be said with good reason that a more active approach to these ideas would also bring new fruitful theoretical and practical results in the sphere of musical education and upbringing[10], including the connection between traditional forms of music education and information technologies in the educational process.

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About the authors:

Irina B. Gorbunova, Dr.Sci. (Pedagogical), Chief Researcher of the Educational and Methodical Laboratory of Music Computer Technologies, Professor at the Department of Informatization of Education, Herzen State Pedagogical University of Russia (191186, St. Petersburg, Russia), **ORCID: 0000-0003-4389-6719**, gorbunovaib@herzen.spb.ru

Mikhail S. Zalivadny, Ph.D. (Arts), Senior Researcher, Saint-Petersburg Rimsky-Korsakov State Conservatory (190000, St. Petersburg, Russia),
ORCID: 0000-0001-9599-5925, trifonov_e_d@mail.ru

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Об авторах:

Горбунова Ирина Борисовна, доктор педагогических наук, главный научный сотрудник учебно-методической Лаборатории музыкально-компьютерных технологий, профессор кафедры информатизации образования, Российский государственный педагогический университет имени А. И. Герцена (191186, г. Санкт-Петербург, Россия), **ORCID: 0000-0003-4389-6719**, gorbunovaib@herzen.spb.ru

Заливадный Михаил Сергеевич, кандидат искусствоведения, старший научный сотрудник, Санкт-Петербургская государственная консерватория имени Н. А. Римского-Корсакова (190000, г. Санкт-Петербург, Россия),
ORCID: 0000-0001-9599-5925, trifonov_e_d@mail.ru