

# From Ancient Practices to Algorithmic Listening: The Evolution of Ideas About Music as a Means of Emotional Impact in the Context of the Development of Modern Music Computer Technologies

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**Abstract**— Music has historically been employed for targeted emotional influence; however, systematic experimental verification of these notions based on controlled sound synthesis commenced only in the second half of the 20th century and continues in contemporary generative models. The aim of this work is to trace the evolution of concepts from ancient practices to algorithmic listening, utilizing a historical-genetic approach and two empirical studies (analysis of 54 compositions and an experiment involving 64 participants). Stable correlations were established between emotions and parameters such as tempo, frequency balance, and dynamics, confirming the effectiveness of psychoacoustically designed sound design. A dependence of perception on individual listener characteristics and situational context was discovered, including cognitive dissonance arising from a mismatch between sound and video. The study demonstrates the continuity of the "analysis-by-synthesis" approach in modern generative models and underscores the necessity of their adaptation to account for subjective and contextual factors of perception.

**Keywords**— Algorithmic listening, generative models, analysis-by-synthesis, emotional impact of music, music computer technologies (MCT), psychoacoustics, sound design), subjectivity of perception, Variational Autoencoder (VAE).

## I. INTRODUCTION

Historically, music has been viewed as a means of purposeful emotional impact, from Pythagorean "musical medicine" to the Baroque theory of affects. However, systematic experimental verification of these concepts has become possible only in modern times. The purpose of this article is to trace the evolution of ideas about music as a means of emotional impact from ancient practices to modern algorithmic environments, to identify a meaningful continuity between intuitive knowledge of the past, experimental research of the 20th century and technological capabilities of the 21st century. The methodological basis of the research is the historical-genetic approach and experimental-psychological analysis based on research, the results of which are described in [1], as well as in the works of prominent scientists who laid the foundation and made a significant contribution to the

development of such fields of scientific knowledge as the psychology of technical creativity, psychoacoustics, cognitive science, and the theory of artificial intelligence. The essential limitations of universal acoustic-emotional correlations related to the subjectivity of perception are revealed in the work of V.V. Suntsova [2], devoted to the testing of L. Ferrara's phenomenological method, these limitations are fundamental for understanding why even a strictly calibrated sound design can have a different emotional effect on different listeners. The empirical basis of the work consists of two original studies conducted by the author of the article. In the first [3], the basic acoustic-emotional correlations were empirically verified on the basis of 54 film musical fragments. In the second [4], a sample of 64 people experimentally confirmed the high efficiency of musical accompaniment designed on the basis of psychoacoustic principles. Special attention is paid to the transition to algorithmic listening, the practice of human interaction with computational models that generate sound content in real time, which is directly related to the topic of the authors dissertation research.

## II. THE MAIN CONTENT OF THE STUDY

Since ancient times, music has been recognized as a tool for influencing the psyche. The Pythagorean tradition discovered the mathematical relations of tones (octave, fifth, quarter) and developed the idea of "musical medicine" – the use of frets and rhythms to correct emotions [5]. Hippocrates, in his treatise *On Diet*, also noted the healing potential of sound, linking the correct intervals with normal development. In parallel, music served as a direct psychotherapeutic tool in shamanic rituals: the three-part structure of *kamlaniya* (slow-fast - slow) provided emotional release, which today is interpreted as bioresonance [5]. During the Reformation, Martin Luther, who experienced the purifying effects of music, asserted its moral and educational function: "Music was created to serve a holy purpose... to awaken devotion and gratitude to God in the human soul" [6]. This juxtaposition of the "noble" and "ignoble" uses of music anticipated the Baroque theory of affects, according to which certain musical means naturally evoke specific emotions. Luther's ideas were embodied in the Protestant chorale, and the pinnacle of this trend was the work of I.S. Bach, who combined theological reflection with musical

Manuscript received May 11, 2026.

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art [6]. At the beginning of the 20th century, composers continued to intuitively comprehend the connection between music, science and space. As noted by M.R. Arpentieva, A.N. Scriabin, like J.S. Bach in the Baroque era, combined theoretical knowledge about the higher world order with musical creativity, striving to express the universal laws of existence through sound [6]. Later, this tendency led to a synthesis of scientific and artistic thinking (see, for example, in the works of I.B. Gorbunova and M.S. Zalivadny [7-12], as well as a number of employees of the Research and Methods Laboratory *Music Computer Technologies* of the Herzen State Pedagogical University of Russian named) was embodied in algorithmic approaches to understanding the concept of "musical sound" and the methods of its artistic, technological and structural-semantic analysis, methods and technologies for its creation using modern dynamically developing music computer technologies (MCT) and related software and hardware. All these ideas remained mostly intuitive. The mechanisms of music's influence have been described in philosophical or theological categories, but have not been experimentally verified. The transition to scientific verification required new methodological tools. The key method of the 20th century is the approach based on the principle of "analysis through synthesis" – the creation of sound objects with controlled parameters. In the Soviet psychological school, this approach was implemented by A.A. Volodin, who developed the concept of statics, kinematics and dynamics of sound [1, pp. 12-13]. The experimental base was the ANS photooptical synthesizer, which made it possible to graphically control the sound spectrum [13]. The transition from empirical studies of musical perception to modern algorithmic environments marks a qualitative shift: the listener ceases to be a passive recipient of acoustic information and becomes a participant in the interactive process. If empirical studies have revealed stable correlations between acoustic parameters and emotions, then an algorithmic approach allows us to implement these correlations in interactive systems. Algorithmic listening is the practice of human interaction with computational models that generate, modify, or select audio content in real time. The key technological basis is variational autoencoders (VAE), proposed by D.P. Kingma and M. Welling [14]: they map audio data into a continuous latent space, where interpolation generates new variations, and the reparametrization mechanism [14] allows models to be trained by end-to-end stochastic gradient descent. Specialized audio architectures that solve specific practical tasks have become a further development of this approach: DDSP (Distinguishable Digital Signal Processing) integrates classical signal processing elements (filters, oscillators) into differentiable neural network layers, providing high-quality timbre imitation, while RAVE (Realtime Audio Variational autoEncoder) effectively compresses audio into latent space. possible real-time sound generation and morphing. These technologies, along with GAN, form the toolkit of modern "algorithmic listening", focused on interactivity and personalization of the sound experience [15; 16]. In addition to generating new content,

algorithmic listening allows you to restore the lost emotional expressiveness of existing recordings. For example, in the field of restoration of historical phonograms, E. Moliner and V. Välimäki proposed the BEHM-GAN method to expand the frequency band of gramophone recordings [17]. This approach allows algorithmically restoring the lost high-frequency components, returning the recordings to their original timbral saturation and, as a result, the emotional expressiveness inherent in the original performance. Technologically, algorithmic listening is implemented not only in generative models (VAE, RAVE), but also in selective sound extraction systems (for example, SpeakerBeam, SoundBeam [18]), which allow the user to selectively focus on the necessary elements of the sound stage. This selectivity opens the way to fine-tuning the emotional background: the listener gets the opportunity to enhance the soothing or, conversely, stimulating components of the acoustic environment without changing the recording itself. Such systems demonstrate the transition from passive perception of a fixed recording to interactive interaction with the sound environment. Empirical data obtained in previous works by the author of this article [3] and [4] indicate the presence of stable correlations between acoustic parameters and emotional states. As shown in the study [3], the obtained quantitative characteristics are consistently consistent with intuitive ideas about the connection between musical instruments and emotions, known since the Baroque era. These results are consistent with the idea that basic acoustic parameters have a universal emotional impact, which is confirmed by both psychoacoustic studies [19] and data on the ability of listeners to differentiate emotional shades of musical sounds without special training [20]. Despite the differences in tools, there is a substantial continuity in the ideological plan linking the approach of A.A. Volodin [1] with the logic of modern generative models. If Volodin formulated the concept of a three-level analysis of the perception of musical sounds - statics, kinematics and dynamics, and implemented it through manual spectrum control on the Equodin instrument [1] and through graphical control in the ANS photo-optical synthesizer [13], then today's neural network architectures (VAE, GAN) implement a similar principle of "analysis through synthesis" at a high-quality level. at a different mathematical level, automatically learning latent concepts of musical (and non-musical) sound [21]. Regardless of the laboratory synthesis methods described above, modern empirical research, including the work of the author of this article [3; 4], focuses on verifying acoustic-emotional correlations on finished musical material and in a multimedia context. The data obtained in them confirm the existence of stable connections, but shift the focus from the physical construction of sound to the study of the influence of contextual and subjective factors. The data of V.V. Suntsova [2] are consistent with this conclusion, demonstrating that even L. Ferrara's phenomenological method, designed to analyze atonal music, largely functions as a projective test: its results depend on the listener's individual experience, and not only on the objective properties of the sound material. Thus, along with universal acoustic correlations, it is necessary to

take into account personal and contextual modulators of perception, which is especially important when developing adaptive algorithmic systems. The experiment conducted earlier by the author of this article [4] demonstrates both the strength and limitations of this approach. It has been empirically confirmed that sound design based on psychoacoustic principles is able to evoke an emotional response comparable to recognized standards of disturbing music, but sharply decreases with contextual misalignment. At the same time, the case of S. Joplin's ragtime ("The Entertainer") revealed the phenomenon of cognitive dissonance: music that did not correspond to the visual context not only reduced emotional engagement, but also caused rejection. This result indicates the importance of situational and cultural context, factors that cannot always be formalized in purely acoustic terms (see also articles [22; 23]). In the context of algorithmic listening, the problem of subjectivity [2] takes on a new dimension. If in the traditional paradigm the listener interprets a fixed sound object, then in interactive algorithmic environments the listening process itself becomes distributed between the person and the model. This raises the question of the representativeness of the data on which the model is trained: empirically identified correlations between acoustic parameters and emotions, while clearly expressed in large samples, may not work for individuals or cultural groups.

Empirical data obtained in studies [3] and [4] support the fundamental possibility of predictable emotional impact through the control of acoustic parameters of sound, but indicate the need to take into account at least three classes of factors: universal psychoacoustic patterns (tempo, frequency balance, dynamics); contextual and cultural modulators of perception; individual differences of listeners. Further development of generative AI models for creating variable sound effects should take into account these limitations. In particular, it is necessary to introduce mechanisms for personalization and adaptation to the context, which can be implemented through conditional generative models and user feedback. The technological shifts described above lead us to a broader view of algorithmic listening – not only as a technological tool, but also as a new form of human interaction with the sound environment. Whereas in the analog era, synthesis involved manual spectrum construction [1; 7], modern neural network architectures (VAE, DDSP) offer a fundamentally different path: the model itself identifies patterns in the data and generates sound without explicitly specifying physical parameters. Thus, the idea of synthesizing sound with specified perceptual properties has evolved from manual spectrum construction to automatic data learning. Integrating into everyday auditory experience (streaming services [24; 25], noise reduction systems), these technologies form a distributed subjectivity in which the perception of sound (and musical sound in particular) becomes the result of joint human and algorithm activity [26; 27]. It is in this context that the question of what data the model is trained on and whose auditory experience it reproduces becomes of particular importance for further research.

### III. CONCLUSION

The conducted research traces the evolution of ideas about music as a means of emotional influence from ancient practices (Pythagoreanism, shamanism, theory of affects) to modern algorithmic environments. The empirically identified acoustic-emotional correlations are modified by contextual and individual factors, which must be taken into account when developing generative systems.

Thus, the continuity of the methodology of "analysis through synthesis" from Volodin's tools to modern neural networks is obvious, but the key challenge is not so much the accuracy of sound generation as the consideration of subjective and contextual perception factors. Algorithmic listening generates distributed, interactive subjectivity.

The authors further work will be aimed at creating a software module based on RAVE, in which the user feedback mechanism will allow adapting the generation to the individual and contextual perception features identified in this study.

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Prof. Dr. Gorbunova has developed first ever course in higher music education in Russia *Music Computer Technologies*, which has been offered under the Bachelors of Arts and Sciences (BASc), which in 2004 carried out student recruitment in different regions and educational institutions of Russia and she also leads post-graduate courses *Music Computer Technologies in Education* available under the MA in Music Education, since 2006; then, under the leadership of I. B. Gorbunova, the Bachelor's degree program in *Information Technology in Music and Sound Design* (2023) and the Master's degree program in *Digital Technology in Music and Sound Design* (2022) were developed and implemented in the educational process of the Russian Federation.

Prof. Dr. Irina B. Gorbunova has more than 550 scientific publications. There are more than 15 monographs among them: *Music Computer Technologies: Historical-Theoretical, The Concept of Music Computer Pedagogical Education, Musical Instruments of the Digital Age, Voice and Computer and the Practical Aspects* and *Music Computer Technologies: The Problem of Modeling the Process of Musical Creativity*; a lot of course books: *Information Technology in Music*, vol. 1 – 4; vol. 1: *Architectonics of Musical Sound*, vol. 2: *Musical Synthesizers*, vol. 3: *Musical Computer*, vol. 4: *Music, Mathematics and Computer Science* (compiled with participation of Mikhail S. Zalivadny); *Musical Sound Engineering* and many others, as well as a variety of educational resources and programs (more than 100) developed for educational purposes, including those hosted in specialized distance education systems such as Moodle, Coursera.

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MCT as a means of rehabilitation of people with disabilities;

MCT as the new direction in preparation of specialists of humanitarian and technological profile;

MCT in the field of digital arts;

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Professor Dr. Gorbunova directs a number of doctoral and postdoctoral studies (more than 30) and lectures on music computer technology and information technology in music. She directs research in various fields, including: Theory and history of culture, Musical art, Information systems and processes (in music), Theory and methodology of vocational education, Mathematical modeling in music, Numerical methods and software systems, Theory and methods of teaching and educational work (in music, computer science). The research results of Prof. Gorbunova has published more than 550 peer-reviewed publications, including more than 50 books and more than 300 articles in various scientific journals.

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