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Performance activities of vocalists, choir singers and conductors in the light of the neurocognitive paradigm and digital technologies

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The article highlights the problem of updating methodological approaches to understanding solo and choral vocal performance in the context of the digitalization of arts education and professional communication. The main topic of the study is the neurocognitive paradigm as an interdisciplinary artefact, within which the effectiveness of performance is considered through the prism of the integration of auditory and emotional perceptions, motor actions and bodily sensations, supported by mechanisms of attention, self-control and reflection.

The purpose of the article is to justify the expediency of referring to the ideas of the neurocognitive paradigm for conceptualizing vocal performance as a system of interaction between cognitive, emotional, and bodily processes in a culturally and communicatively conditioned context, as well as to identify appropriate forms of digital technology implementation to improve the quality of performance by singers and choir conductors. Particular attention is focused on related types of performance – solo and choral – the commonality between which is determined by the task of simultaneously solving phonation-technical, interpretative-artistic, ensemble-communicative and stage-suggestive tasks and the need to self-regulate the psychophysiological state in stage conditions, the solution of which causes increased cognitive, artistic-creative and emotional-volitional stress.

The neurocognitive paradigm allows us to consider vocal performance not only through artistic-interpretative, stylistic and methodological factors, but also through the mechanisms of the brain and body, in particular multimodal-sensory-motor integration, neuroplasticity, interoceptive-auditory sensitivity, developed attention, memory, reflection, and emotional self-regulation. Digitalization is interpreted as a factor in the restructuring of cognitive strategies of self-control, self-analysis, and improvement of the quality of vocal performance and conducting, as well as the mastery of solo and choral repertoire. An interdisciplinary approach contributes to the integration of the neurocognitive concept and digital technologies and, thus, to improving the quality of stage and performance activities of solo vocalists and choir singers. Examples are given of technology-based self-analysis of the quality of a singer's phonation and mechanisms for using digital music notation programs, which help choristers to learn complex choral works, in particular in terms of intonation properties and polyphonic texture.

Keywords: *vocal, choral performance; choral conductor, neurocognitive paradigm, digitalization, reflection, emotional-volitional self-regulation, interdisciplinary approach, stage and performance activities.*

Introduction. The neurocognitive paradigm of musical performance in the era of digitalization emerges as a response to two interrelated trends in contemporary arts education: the intensification of interdisciplinary integration of knowledge about humans and the rapid expansion of the digital environment of professional communication.

Traditionally, musical performance has been understood through the prism of artistic interpretation, stylistic and methodological factors. However,

there is now a growing need to explain its essence and effectiveness in terms of neurocognitive mechanisms that manifest themselves in the characteristics of multimodal-sensory-motor integration, artistic-emotional self-regulation, interoceptive-auditory sensitivity, and neuroplasticity (Z. Piao, G. Xia, 2022). It is in this perspective that the development of memory, musical thinking, artistic-associative representations and reflection is actualised, and the concentration of attention and the ability to distribute it between auditory representations and the actual performance process are enhanced (Cox, 2016).

In this context, digital technologies should be interpreted not as an external "addition" to traditional performance practice, but as a factor that reorganizes cognitive strategies of self-control, self-analysis and planning of one's own performance self-improvement, as well as facilitating the process of mastering the musical repertoire through the use of analytical and digital feedback methods, music notation software, electronic instruments and AI capabilities to enrich and update corrective performance procedures (Ashikhmina, Melnichenko 2025; Nikolai, Linenko, Koehn et al., 2019) and the implementation of the provisions of an interdisciplinary approach and the organisation of the educational process on the basis of interdisciplinary coordination.

Literature review. The methodological basis of the article is the neurocognitive paradigm, which emerges as an interdisciplinary approach within which human activity and behavior are explained through the interaction of cognitive processes that provide perception, attention, memory, thinking and imagination, as well as the mechanisms of prediction and decision-making through their neural mechanisms (Dehaene & Naccache, 2001).

In the context of musical performance, its essence lies in the fact that musical and psychological processes are analyzed not as abstract 'internal states,' but as dynamic modes of brain functioning that are realized through the interaction of functional networks that integrate sensory information, motor actions, emotional responses, and mechanisms of control and self-improvement (Gilman, 2014).

Central to this view is the idea of neuroplasticity as the basis for achieving a high level of mastery through the brain's ability to restructure neural connections through training and purposeful practice. Unlike purely psychological approaches, the neurocognitive perspective emphasizes the bodily nature of cognition, allowing us to consider thinking, imagination and emotions in close connection with sensorimotor organization, proprioception and interception, thereby ensuring the integration of external motor-auditory reactions and coordinating them with internal body signals (muscular, respiratory, vibrational, visceral). As scientists note, it is these processes that form the subjective self-awareness of singers and choir conductors, influencing their physical and psychological state, in particular, muscle tone, the quality of phonatory breathing, the expressiveness of facial expressions and gestures, as well as the degree of anxiety before a stage performance, thereby regulating affective processes and the quality of the realization of performance intentions.

In vocal performance practice, these influences manifest themselves through the sensation of breath support, awareness of the bodily "map" of resonant and articulatory settings, and the kinesthesia of phonatory, facial, and gestural actions, etc. These provisions are embodied in the concept of "body mapping", which is based on rhythmic-playful physical activity and exercises for the development of cognitive, motor, and communication skills, improvement of motor coordination, attention, memory, and communicative-empathic properties (Gilman, 2014).

The involvement of singers in body training correlates with the principle of embodied cognition (Craig, 2002) and is significant as a way of improving the sense of bodily resonance, strengthening singing skills on support, and improving motor coordination by combining the sensory, emotional, and cognitive components of singing. In addition, the role of sensory intelligence is emphasized, which scientists associate with the importance of trusting one's feelings while singing and relying on them as a source of information about phonation-vocal coordination and the basis of artistic intuition in the process of performing an artistic-interpretative idea (Cox, 2016).

Thus, in the artistic sphere, the neurocognitive paradigm allows us to consider performance processes as holistic systems formed by the combination of auditory apperceptive representations and motor actions aimed at the musician's emotional and expressive embodiment of the performance and interpretative concept of a musical work.

An important component of the neurocognitive paradigm is its socio-communicative vector: musical-cognitive processes do not unfold in isolation, but in interaction with other subjects of activity in specific socio-cultural conditions. Hence, the mechanisms of reflection and self-regulation are naturally actualized, in particular, conscious control of vocal microtechnique, performance and expressive actions, external means of embodying artistic and performance intentions, and emotional and volitional self-control during preparation and in the process of public performance.

Purpose of the article is to justify the expediency of referring to the ideas of the neurocognitive paradigm, which allow conceptualizing musical performance activity as a system of interaction between cognitive, emotional and bodily processes mediated by cultural context and artistic tasks, as well as to identify appropriate forms of digital technology implementation to improve the quality of soloists' and choir singers' performance.

Research methodology. The achievement of this goal is based on the principles of the neurocognitive paradigm, the implementation of which is ensured by a complex of scientific approaches, in particular, interdisciplinary, integrative, etc., as well as a complex of modern ICT technologies, the synergy of which lays the foundation for improving the effectiveness of the performing and performing skills of vocalists and choir singers.

Results and discussion. A synthesis of literature and practical experience shows that the possibilities for solving these tasks at the present stage are significantly expanding thanks to the enrichment of established methods for singers and choir conductors to improve their performance skills by taking into account the guiding principles of the neurocognitive paradigm. The use of somatic and suggestive trends, VR (virtual reality) technologies to acquire stable performing attention, emotional and volitional self-regulation skills, and self-correction in conditions of stage stress (Pengfei Yang, 2024) plays an effective role in their implementation, as well as the use of AI support tools and digital means of automated analysis of vocal manifestations and feedback (Koehn, 2024; Pettersen, Westgaard, 2005; Yu Funk, M. Hu & Q. Wang et al., 2018).

The latter include digital devices, programs and resources that work with digitized sound, musical notation and audio data. The use of these capabilities in the process of information exchange through networking, sharing, remote interaction and content transfer transforms these tools into a type of musical information and communication technology (Varnavska, 2012). In our opinion, the most relevant digital tools that provide new opportunities for improving performance skills include: notation tools and working with digital scores; analytical tools for audio recording and visualization of performance parameters; media technologies for processing audio and video materials for the purpose of self-control, self-analysis and self-correction.

The least “costly” in terms of resources and relative complexity for future specialists in digital technologies to master in performance practice is the implementation of digital notation of musical works. For this purpose, music notation editors are used, in particular Sibelius, Finale, MuseScore, etc. The latter, in our opinion, is the most accessible and at the same time sufficient in terms of functionality to solve a significant part of professional tasks for both soloists and choir singers and conductors.

MuseScore is used to typeset and lay out musical texts, transpose works, and enable various forms of work with scores, including creative tasks (Ship, Melnichenko, 2022). In addition, music notation editors have tools that facilitate the study of vocal or choral parts, including the mastery of new rhythmic patterns, complex intonation turns, and phrasing features in melodies with asymmetrical structures, etc.

The interactive format of the MuseScore mobile app allows you to follow the score as it is played, change the tempo, and, if necessary, loop a short segment of the musical text for continuous repetition. This allows musicians to listen to complex episodes in more detail and repeatedly, to better memorize them, and to interact with their electronic reproduction, gradually automating the necessary skills.

Another valuable feature is the ability to listen to a selected accompaniment part in order to focus on the harmonic language and elements of polyphony in the accompaniment.

We should also note the possibility of isolating and listening to (singing along with) both a specific choral part and various options for combining it with other voices, textural elements, or the score of the work as a whole, which is a significant aid in mastering complex polyphonic works for both singers and choral conductors.

A wonderful addition is the perception of the audio recording of the work in combination with the simultaneous visual representation of the musical text of the score. The interactive format of the MuseScore mobile application allows you to follow the score while it is being played, change the tempo as needed to pay detailed attention to complex episodes, etc.

It should be noted that there are a significant number of online scores available in the MuseScore library. Although the sound quality does not fully correspond to the natural timbre and the dynamics of the musical material, this example is useful for practicing rhythmic accuracy and understanding the overall structure of the piece, its texture and the dynamics of the musical material.

From this point of view, it is advisable to refer to video recordings in the Music with score animation format, an example of which is the recording of Zoltán Kolai’s work “Adventi ének”, posted on YouTube (https://www.youtube.com/watch?v=4Kmga1zqwGU).

If the required example is not available in the public domain or it is necessary to create a score animation for a piece from your own repertoire, i.e. an animated display of the musical text synchronized with the sound of the piece, you can create it yourself using video editors (e.g., CapCut, OpenShot, etc.), using them as a tool for visualization and self-analysis.

It is advisable to use programs that allow you to record your voice (Dykun, 2018) and analyze the sound quality according to objective parameters. One example of such analysis is the ability to rely on the construction of a spectrogram of the fundamental tone (F0 / pitch) and the visualization of the melody performed by the singer according to the parameters of pitch-intonation movement in combination with its unfolding in time. Programs such as Vocal Pitch Monitor, Sonic Visualiser and others can be used as tools. Their capabilities allow you to visualize the fundamental frequency of sound (F0), measured in hertz (Hz),

which corresponds to musical perceptions of pitch. On the graph, the change in F0 is represented as a line that unfolds in an upward/downward movement, reflecting the change in pitch; the waveform (change in line thickness) also characterizes the articulatory homogeneity of the sound and the quality of the vibrato. If there are visual "drops" in the graph, this most often indicates the presence of unvoiced fragments, which can be explained by overly long pronunciation of consonants, significant pauses between inhalation and sound attack, insufficient mastery of singing on support, etc.

It is important to note that F0 is not an indicator of loudness (loudness is described by intensity, usually in decibels) and does not characterize timbre: timbre is formed by the ratio of harmonics and formant zones, while F0 forms the basis of the harmonic series. In addition, it should be noted that for the correct determination of F0, it is advisable to set the pitch search range according to the type of voice: male – 50–300/400 Hz; female – 100–500/600 Hz; child – 150–700/800 Hz (sometimes higher).

A rough algorithm for self-analysis can be presented as a sequence of the following steps: recording a fragment in a quiet room while maintaining a stable distance from the microphone; construct a spectrogram and enable F0 tracking with the range adjusted to the voice type; interpret the results based on the following characteristics: F0 accuracy and stability; presence of "approaches"/glissando; attack characteristics; vibrato parameters; absence/presence of "drops".

Mastering digital self-analysis tools is particularly important for singers given the phenomenon of "vocal confrontation", i.e. the incomplete coincidence of the internal perception of one's own voice with the actual external sound, which complicates adequate self-assessment and self-correction. Therefore, visualization of F0 and spectrograms shifts self-assessment from the level of general impressions ("good/bad") to the level of controllable parameters that characterize the quality of performance according to certain criteria – intonational stability, the nature of the sound attack, the presence/absence of "approaches", the quality of vibrato, etc.

At the same time, it is important to realize that obtaining such information is only the first step towards improving the quality of singing: vocal technique relies on subtle muscle sensations and coordination of micro-movements, so further improvement requires intensifying search activities and their proprioceptive and auditory self-assessment, i.e. combining neurocognitive principles of unity of thought, reflection on polymodal and sensory-motor actions with digital ICT as a practical tool. On this basis, effective techniques for correcting identified deficiencies should be selected and means of high-quality phonation should be identified, with their subsequent algorithmic reinforcement and automation.

It is also useful to perform a comparative analysis of the obtained analytical graphs of one's own performance "before" and "after" to determine the degree of success/failure of the self-improvement techniques used. Thus, the objective identification of performance and technical problems enables more targeted correction of actions related to specific elements of phonation technology: vocal position, articulation, breathing quality, sound attack, sound control, etc.

Therefore, mastering these technologies increases the singer's ability to self-regulate and self-correct on the path to success in the process of stage and performance activity, and allows the choir conductor, if necessary, to identify individual problems specific to choir performers and provide them with specific advice on self-improvement of singing skills.

This gives reason to assert that digital technologies are not only an auxiliary resource, but also a factor that reshapes the cognitive strategies of planning, conscious control, and self-improvement by future specialists in the field of vocal and choral artistry and performing skills.

Conclusions and prospects for further scientific research. Turning to the neurocognitive paradigm allows us to more accurately understand the essence and mechanisms of performing activities in the field of vocal and choral art as a holistic interaction of cognitive, emotional, and bodily processes. Digitalization tools, in turn, provide a practical combination of data from neuroscience and music psychology with the real conditions for improving professional skills in rehearsal and stage performance activities.

From this perspective, the application of neuropedagogical principles and digital music technologies and their integration enhance the controllability of the creative process, expand the possibilities for self-control, search and self-improvement activities, and stimulate the use of innovative and effective means of eliminating identified shortcomings with subsequent verification of the effectiveness of one's actions.

Thus, taking into account the principles of the neurocognitive paradigm and applying the capabilities of ICT lay the foundation for improving the quality of vocal and performing activities of vocalists and choir members in the context of the ongoing process of digitization of modern arts education. Further prospects lie in turning to the ideas of the somatic approach and improving the emotional intelligence of performing musicians through the use of modern innovative technologies.

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Нейрокогнітивна парадигма виконавської діяльності вокалістів і хорових співаків у епоху цифровізації

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У статті висвітлено проблему оновлення методологічних підходів до осмислення сольної і хорової вокально-виконавської діяльності в умовах цифровізації мистецької освіти та професійної комунікації. Основною темою дослідження є нейрокогнітивна парадигма як міждисциплінарний артефакт, у межах якого ефективність виконавства розглядається через призму інтеграції слухових, емоційних уявлень, рухово-моторних дій і тілесних відчуттів, що підтримуються механізмами уваги, самоконтролю й рефлексії.

Мета статті полягає в обґрунтуванні доцільності звернення до ідей нейрокогнітивної парадигми для концептуалізації вокально-виконавської діяльності як системи взаємодії когнітивних, емоційних та тілесних процесів у культурному й комунікативно зумовленому контексті, а також у визначенні доцільних форм упровадження цифрових технологій задля підвищення якості виконавської діяльності співаків. Особливу увагу зосереджено на споріднених видах виконавства – сольному та хоровому, спільність між якими визначається завданням одночасного розв'язання фонаційно-технічних, інтерпретаційно-художніх, ансамблево-комунікативних і сценічно-сугестивних задач та потребою здійснювати саморегуляцію психофізіологічного стану у сценічних умовах, вирішення яких викликає підвищене когнітивне, художньо-творче та емоційно-вольове навантаження.

Нейрокогнітивна парадигма дає змогу розглядати вокальне виконавство не лише через художньо-інтерпретаційні, стилістичні та методичні чинники, але й через механізми роботи мозку й тіла, зокрема мультимодально-сенсомоторну інтеграцію, нейропластичність, інтероцептивно-аудіальну чутливість, розвинені увагу, пам'ять, рефлексію та емоційну саморегуляцію. Цифровізація трактується як чинник перебудови когнітивних стратегій самоконтролю, самоаналізу й удосконалення якості вокально-виконавської діяльності та опанування співаками сольного і хорового репертуару. Міждисциплінарний підхід сприяє інтеграції нейрокогнітивного концепту і цифрових технологій і тим самими – підвищенню якості сценічно-перформативної діяльності солістів-вокалістів і хорових співаків. Наведено приклади технологізованого самоаналізу якості фонаційних дій співака та механізмів використання цифрових нотно-графічних програм, звернення до яких сприяє вивченню хористами складних хорових творів, зокрема за інтонаційними властивостями і поліфонічною фактурою.

Ключові слова: *вокальне, хорове виконавство, нейрокогнітивна парадигма, цифровізація, рефлексія, емоційно-вольова саморегуляція. міждисциплінарний підхід, сценічно-перформативна діяльність.*