THOUGHTS ON THE TREND OF SCIENCE AND TECHNOLOGY IN THE XXIST CENTURY

Fulvia Anca **Constantin**[1], Doru **Ursuțiu**[2]

Abstract. *The greatness of the XXIst century is that of technological development and scientific discoveries that are changing the human condition. This period is characterized by the combination of digital system with the biological and physical ones, seeing a transition from the analogue age to a society where data is the most important in innovation. The integration of AI leads to rapid progresses in all fields, from engineering and medicine to psychology and music*

Keywords: artificial intelligence, science, technology, music, psychology, music therapy.

DOI : 10.56082/annalsarsciphyschem.2026.1.118

1. Introduction

The XXIst century's technological progress, the connection between technology and innovation represents evidence highlighting humankind's creativity and apprehension while maintaining emotional intelligence. Machine learning and neural networks has permitted computers to complete tasks demanding human-like cognition (image and language processing recognition, writing samples, so on) based on complex mathematical algorithms. Artificial intelligence passed man-machinery tandem taking into consideration achievements that once believed to be impossible, for example, precise ways to compose or diagnose, modern and adapted to individuals medicine, customized treatments, programming through advanced techniques, directed therapies, so on. [1] The learning use of AI powered tools prove the adaptability of the individuals, their advanced thinking of the integration of technologies into everyday life, suggesting that the progression is fast and continuously intensifies. As significant ethical questions are being discussed in academic and policy circles, there is need for an ethical framework to manage the risks associated with all these rapid advancement. [1] As an example, we remember Jennifer Doudna and her collaborators discovery of the tool that could edit DNA (CRISPR) that is of great help in medicine, used afterword to create vaccines for coronavirus that hastened the transition to other innovations but, in the same time, was raising numerous moral questions. [2] AI is considered maybe the most

[1] Doctorand at "Gheorghe Dima" National Academy of Music, Cluj-Napoca, Romania, fulvia.constantin@gmail.com
[2] Professor dr. at *Transilvania* University of Brașov, Romania, full member of Academy of Romanian Scientists, ursutiu@unitbv.ro

important technological development, assisting to a transition from „symbolic logic to deep learning." One note in here specifies that it is easier to solve engineering or mathematical problems than psychological, intuitive ones. [3] The conclusion remains clear: „The XXIst century has witnessed a paradigm shift in scientific and technological capability, characterized by the convergence of information." [1] [3]

2. The intersection of science and other disciplines

2.1. Science and music

The connection of science and music is characterized by digitalization of sound, the application of psychoacoustics, and the use of algorithmic composition. [4] Music is not entirely physical, but a data-driven experience, the mathematical properties of sound waves being manipulated through sophisticated digital signal processing (DSP). On top of it, the multiple existent devices allow the accessibility of high-fidelity recording and synthesis. [4]

A trend in music is nowadays, the use of algorithmic composition and artificial intelligence to musical structures. A management of timbre and pitch is allowed by software that utilizes Fourier transforms to break up complex sound waves into frequencies. In acoustic of sounds we find the relation between fundamental frequency f of a sound wave and its period T given by the equation (1):

$$f = \frac{1}{T} \tag{1}$$

Moreover, in the XXIst century, the new 'generative' music permits the systems' use of stochastic processes in order to discover musical patterns in real-time. [5] In the last years, the study of psycho-musicology and neuro-musicology has improved by utilizing medical imaging techniques such as Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (fMRI) to map how the human brain processes harmony, rhythm, and melody. The scientists got to the conclusion that music perception is fixed in the brain's predictive coding mechanisms, where the auditory cortex constantly generates expectations about upcoming notes. [6] The integration of these scientific insights into music production has led to the development of 'intelligent' instruments and adaptive audio environments that respond to the listener's physiological state, leaving from the static recordings of the XXth century.[4] The central focus of neuro-musicology is represented by the emotional response to musical scales. It states that reaction to music is not only cultural and preferential, but embedded in the auditory system. The predilection for intervals that are consonant (e.g. the perfect fifth) is determined by the harmonic series with a simple frequency ratio between two notes of 3:2. When the brain processes these simple ratios, the neural patterns in the auditory cortex are more synchronized, which the brain interprets as 'nice', 'stable', or 'pleasant'. [4] On the

other hand, dissonant intervals with complex ratios (e.g. minor second 16:15) generate 'beating' patterns in the basilar membrane of the inner ear, which the brain perceives not only as dissonance but as 'tension'.[7]

Also, it could be seen a shift from physical sound production to mathematical modeling to only remember the development of Frequency Modulation synthesis (by J. Chowning) from the end of the XXth century that transformed the sounding by permitting complex timbres to be generated from simple waves. Also, with the increase of computing power there were developed physical modeling syntheses, meaning that differential equations were used to simulate the vibration of physical objects (e.g. strings, so on) in real time. [8] These innovations have permitted contemporary musicians to link the emotional resonance of outmoded scales to the limitless sonic possibilities of AI and digital computation. [9]

2.2. Science and psychology

The process of human change is recognized in psychological literature as a complex, constant progression. Therefore, the psychology of XXIst century is showing a profound scientific transformation, especially towards highly collaborative, trans-disciplinary research. [10] This development is part of the philosophy of science, where knowledge is the relational process between researchers, communities (people) and various organizations. [11]

The modern psychology is a link between precise science and the human necessity of ‚meaning' and its understanding. [12] Thus, traditional psychology mostly relies on empiricist foundationalism, the present approach see scientific and humanistic interdisciplinary ‚concordance.' We could discuss the Unified Theory of Knowledge addressing philosophical problems, such as the relationship between the ‚knower and the known,' ‚matter and mind,' and the discrepancy between facts and values, [13] or Prochaska's Transtheoretical Model, suggesting that change is a spiral process not a linear path. [14] The role of 'narrative' became a central focus in modern psychological research, as well. For a more comprehensive understanding of themselves and their relationships, human beings are ‚narrating constantly' using simple words or stories „to interpret the past, navigate the present, and prepare for the future." [12] The knowledge, application-oriented becomes scientific, more contextualized by cultural, political, and economic realities, [11] while, psychology develops as an integrative and trans-disciplinary field that emphasizes modern science towards complex global challenges.

2.3. Towards scientific music therapy

Music therapy has experienced a deep transformation itself. From a simple tool for changing the mood it became a sophisticated, scientifically evidence-based clinical discipline. [15] In the contemporary background, the field has moved beyond

simple ‘listening sessions’ toward highly structured, neuro-scientifically grounded interventions. Modern music therapy now integrates advanced knowledge of brain plasticity, cognitive psychology, and physiological monitoring to offer treatment to a whole spectrum of conditions from neurodegenerative diseases to psychiatric ones like depression, stress and post-traumatic stress disorder and chronic pain management. [16]

A significant change in music therapy practice is the Neurologic Music Therapy (NMT) that focuses on the scientific understanding of how the brain processes music and how it can be used to retrain neural ways instead of just concentrate on the emotional or psychodynamic aspects of music. [17] For example, rhythm is considered to have a significant tool in physical rehabilitation to facilitate motor control in various diseases (e.g. Parkinson’s disease) or stroke-related impairments. By using the brain's harmonization to rhythmic auditory stimuli, therapists can help patients improve their movement patterns, a process that relies on the synchronization of motor systems with external auditory signals. [15]

There are numerous examples of how the integration of technology has helped the music therapy area: digital interfaces, biofeedback sensors, and specialized software to get in real-time person’s physiological responses (heart rate variability, temperature and cortisol levels). [18] This data-driven method permits personalized interventions music stimuli perfectly adjusted to the person's neurological state, a trend in healthcare towards precision medicine, where the ‘dosage’ and ‘type’ of music are created on objective clinical outcomes rather than only subjective preference. [16] The music therapist has than an expanded role based on his interdisciplinary training.

Modern practice emphasizes the three-way relationship model, where music is used as a balancing intervention alongside the neuro-psychological and medical methods. Music-based interventions are validated by the specialized researchers in music therapy arguing that, based on the therapeutic effects observed in clinical situations, these can moderate the release of neurotransmitters (dopamine and oxytocin), essential for social relationship and emotional connections. [17]

2.4. The integration of artificial intelligence

Artificial intelligence (AI) has fundamentally transformed the scientific research entirely towards a predictive, data-driven discipline. AI algorithms analyze electronic records and multiple data to identify new, evolved electronic music, therapeutic targets, health treatments or drug development through time optimization, virtual simulations, and large diversity. Thus, large discussions concerning ethical challenges, fairness, empathy, fundamental right of people to maintain control over their decisions, writings and compositions, sensitive information, involved all categories of people worldwide. Privacy concerns are

intensified by the risk of plagiarism and re-identification, behind sophisticated AI algorithms (although benefic) been hidden various risks. To diminish these risks, researchers argue for 'algorithmic accountability' - an obligation for AI systems to be obvious and understandable. [9] From a historical point of view, scientific progress was restricted by the cognitive limits of human intuition and the time-intensive nature of trial-and-error experimentation, AI has the ability to predict results, to operate huge datasets, to identify of patterns that remain invisible to the human eye, basically to minimize years of traditional research into hours of computational simulation. [9]

Conclusions

(1) The trend of science and technology in the XXIst shifts from the model of 'techno-science' to market profitability and complex worldwide multinational industrial trusts. [19]

(2) In the XXIst century could be seen an evolution in the relationship between science and society: on one hand, globalized economy encourages international cooperation; on the other one, it threatens the free exchange of ideas due to competitive pressures. [20]

(3) The integration of computer and AI in scientific practice alongside theory and experiment bring valuable power to theoretical understanding.

(4) There is a strong movement of involving science and technology in fields like music, psychology and medicine.

R E F E R E N C E S

[1] K. Schwab, *The Fourth Industrial Revolution*, Crown Currency Publishing. (2017)

[2] W. Isaacson*, The Code Breaker: Jennifer Doudna, Gene Editing and the Future of the Human Mankind Race*, Simon & Schuster Publishing. (2021)

[3] I. Goodfellow, Y. Bengio, A, Courville*, Deep Learning*, MIT Press. (200?)

[4] D.J .Levitin, *This is Your Brain on Music:The Science of a Human Obsession*, Dutton(2006)

[5] C. Roads*, Composing Electronic Music: A New Aesthetic*, Oxford University Press. (2015)

[6] D. Huron, *Sweet Anticipation: Music and the Psychology of Expectation,* MIT Press. (2006)

[7] H. von Helmholtz, J.A. Ellis, *On the Sensations of Tone as a Physiological Basis for the Theory of Music*, London, New York: Longmans. (1895) Internet Archives, accessed 22.05.2026.

[8] C.Dodge, T.A. Jerse*, Computer Music: Synthesis, Composition and Performance*, New York, Schirmer Books. (1985). Internet Archives accessed 21.05.2026.

[9] S. Fruch, *How AI is Shaping Scientific Discovery*. National Academies. (2023)

[10] S.F. Davies, W. Buskist, 21st Century Psychology: A Reference Handbook, Sage Publication. (2008)

[11] J.K.Tebes, *Twenty-First Century science as a Relational Process from Eureka to Team Science and a Place for Community Psychology*, American Journal of Community Psychology 53 (3-4) pp.215-231. (2014)

[12] T.L. Brink, V. Karalun, *Narratives: the Focus of 21st Century Psychology*, Nova Science Publishers. (2022)

[13] G, Henriques, *A New Metapsychology for the 21st Century.* Psychology Today. **(2020)**

[14] J.O. Prochaska, J. Norcross, C. DiClemente, *Changing for Good: A Revolutionary Six-Stage Program for Overcoming Bad Habits and Moving Your Life Positively Forward*, Harper Collins Publishers. (1994)

[15] M. Thaut, H. Volker, *Handbook of Neurological Music Therapy,* Oxford Univ. Press. (2014)

[16] K.E. Bruscia*, Defining Music Therapy*, Barcelona Publishers. (2014)

[17] O.Sacks, *Musicophilia: Tales of Music and the Brain*, Alfred A. Knopf. (2007)

[18] T. Wigram at al., *A Comprehensive Guide to Music Therapy, Theory, Clinical Practice, Research and Training*, Jessica Kingsley Publisher. (2002)

[19] T. S. Kuhn, *The Structure of Scientific Revolutions*, University of Chicago Press. (1996)

[20] P.Hoyningen-Huene, M. Weber, E. Oberheim. *Science for the Twenty-First Century: A New Commitment*, Nature Spring Conference Paper. (1999)