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Neuromusic Education in Cognition and Quality-of-Life Promotion. An Outline

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Abstract. The new cognitive field of neuromusical education and research combines neuroscience and music. This article reviews recent research literature and discusses the application of neuroscience to music education, highlighting the positive effects of music education on the cognitive functions of the brain and the enhancement of an individual’s quality of life. Consequently, the purpose of this study was to examine the value of music education in enhancing brain function and promoting quality of life, as well as its continued application in the contemporary educational environment.

Keywords. Neuroscience, Neuromusic, Music Education, Cognitive Functions, Quality of Life

1. Introduction

Utilizing neuroscience to enhance the educational process is a topic that frequently concerns scientists. Neuroscientists have recently begun evaluating how to incorporate brain-based research into the classroom in collaboration with educators (Antonopoulou et al., 2019; 2020; 2021a; 2021b; 2021c; 2021d; 2022; Giannoulis et al., 2022; Watagodakumbura, 2015; Weinberger, 2014). Frequent research focuses on the utility of neuroscience in comprehending learning processes, enhancing educational practices, and enhancing student outcomes (Farmakopoulou et al., 2023; Gkintoni et al., 2021c; Gkintoni & Dimakos, 2022; Gkintoni et al., 2022a, b; Gkintoni et al., 2023a, 2023b; Pincham et al., 2014). As young professionals who are more ‘creative,’ young teachers should be able to propose novel solutions to the challenges they face in their efforts to improve education. Neuroscientists have been fascinated with how the brain processes music for the past two decades (Anderson & Della Sala, 2012; Geake & Cooper, 2003). Neuroscientists have a better understanding of the structures and functions of the human brain thanks to new technologies (Halkiopoulos & Boutsinas, 2009; Halkiopoulos & Boutsinas, 2012; Halkiopoulos et al., 2022; Stamatiou et al., 2022; Stewart & Williamon, 2008). They have proposed additional models to explain how the brain processes music. Although these models shed light on how the brain functions, they have yet to have an impact on the field of music education, where music processing skills are central. This literature review was conducted in response to the following research questions:

▪ [RQ1] Can neuroscience provide music education with evidence-based support?
▪ [RQ2] Can neuroscience contribute to effective music education pedagogical practice?
[RQ3] What is the connection between neuroscience, music, and quality of life?

2. Literature Review

Brain Facts and Music

When humans perform or listen to music, multiple regions of the brain cooperate to create a single, complicated action known as a hierarchically structured sequence. The following brain functions are implicated in the neuroscience of music: The right hemisphere is responsible for [a] prosody - poetic rhythm and emotional tone of speech, [b] melody recognition, and [c] linkages between harmonic sounds. Consequently, the left hemisphere is implicated [a] in rhythm and [b] in sensorimotor integration, a component of an auditory-motor integration circuit that may play a crucial role in the development of speaking and musical talent. Moreover, it can enhance verbal working memory. The forebrain participates in [a] models associated with music listening and performance, [b] information redistribution, [c] movement initiation, [d] rhythm reading, [e] in the coordination of touch, sight, and hearing, [f] in reading melody, and [g] in the coordination of movement sequences. Lastly, the cerebellum contributes to the physical equilibrium between ballistic movements. The emphasis placed on the right hemisphere of the brain is a constant conclusion from research on music listening.

A musical melody can generate a variety of feelings, including joy. Depending on the context, the degree of attention paid to listening to it ranges from simple to attentive listening. Recent neuroimaging research have studied the network connection and activation of certain brain regions when listening to music, specifically between the auditory cortex, the brain’s reward enhancement system, and the activated brain regions. The music of Alexander Scriabin, in which instances of surprise are observed, can be described as “polyphony and aesthetic experience” because it employs an innovative use of chord structure and sequence and creates a chord based on fourths as opposed to the conventional thirds proposed as a starting point for insight.

Multiple elements of brain development are positively affected by music education, according to recent neuroscience studies. For instance, it has been observed that musicians’ brains have thicker gray matter and faster memory storage and retrieval processes. Utilizing fmri-like neuroimaging techniques to monitor brain architecture and function in real-time, neuroscientists noticed that using music as a stimulus provided significant insights into understanding the brain. For instance, as the individuals listened to and processed the music, their brains utilized multiple areas concurrently as opposed to the original dominant area.

In addition, similar results have not been observed in previous research that used foreign language learning as a stimulus. This prompted neuroscientists to examine the brain architecture of participants with musical instruction, particularly those who could play a musical instrument, versus those without musical training. Researchers discovered remarkable differences between the brains of musicians and non-musicians. These results revealed that music instruction had positive effects on human behavior and learning (Brattico, 2006).

It has been identified that music training improves visual and verbal memory by boosting higher cognitive skills, such as immediate and delayed recall of visual and linguistic information. Researchers (Collins, 2013) revealed that the way the brain responds to, and processes emotion is related to cognitive memory function and music. The study demonstrated that emotion improves memory. Therefore, the capacity of music to elicit responses contributes to the enhancement of numerous types of brain memory, including sensory and working memory. Jancke addressed the possibilities: “If music has such a strong influence on emotions
and the human cognitive system, it begs the issue of whether strengthening memory through emotional music might also be utilized to improve cognitive function.”

Gruzelier and Egner (2004) suggested that musical training positively improves brain networks associated with focus and tranquility. Posner, Rothbard, Sheese, and Kieras (2008) discovered that training in conflict resolution and music enhanced cognitive functioning. Bialystok and DePape (2009) showed that musicians’ brains perform similarly to those of bilingual speakers on non-verbal spatial awareness tasks that assess executive function levels. Hanna-Pladdy and MacKay (2011) found, among many other tests, that musicians perform better on executive processing than non-musicians. This study and a 2009 study by Wan and Schlaug related music instruction to the preservation of cognitive function in old age.

Additionally, the connection between language and music has been extensively studied. Numerous studies, inspired by the complexity of their relationship, have found separate, simultaneous activities in shared, parallel, and distinct brain regions (Hodges, 2009). The relationship between musical syntax and speech syntax is a vital field of study.

Dammann (2009) proposed that music could aid youngsters in deciphering the grammar of everyday language. Wandell et al. (2009) found substantial functional linkages between the brains of musicians and their heightened phonological awareness. In musicians’ brains, the communications system is more diffuse, and as a result, messages are sent to the temporal lobes, which are responsible for identification and swift categorization. This enables musicians to edit, absorb, and assimilate new information more effectively than non-musicians, particularly in speech recognition and development. The topic of neuroscience and music is relatively new, with research beginning to be published in the mid-1990s. These are only a few of the findings that have been provided.

Cognitive Enhancement and Music Education

Learning music has beneficial consequences and cognitive benefits. It has been demonstrated that participation in school music ensembles increases cognitive ability and growth in students. In addition, it has been demonstrated that performing/playing a musical composition on an instrument reduces the chance of acquiring dementia and continuously activates the cognitive region of the brain responsible for playing a musical instrument. In addition, performing/playing a piece of music activates numerous senses in the brain, which improves cognitive abilities, including social and emotional awareness, resulting in enhanced interpersonal communication (Granot, 2005). Additionally, reading music can increase general reading comprehension skills. When we play and listen to music, it is processed by numerous brain regions. Neuroscientists observed numerous brain regions being active concurrently, processing diverse information in complex, linked, and astonishingly rapid sequences. For instance, playing a musical instrument concurrently utilizes nearly every region of the brain, including the visual, auditory, and motor cortices. Additionally, music connects several frontal regions of the brain, hence strengthening executive functions (Theodoratou et al., 2023), practical decision-making skills and creativity.

There has been a remarkable quantity of research on musicians and the good impacts of playing and practicing music. Studies indicate that learning music enhances general growth and performance (Peterson, 2011). Music education is especially good for elementary school children. Specifically, music aids in the development of fine motor abilities, leading to emotional and behavioral development. Children who take music lessons typically have larger vocabularies and more advanced reading skills than their peers who do not study music. When music education begins in early life, the benefits to auditory and motor function are greater.
Several studies have shown, however, that musical practice affects the auditory system even when it begins in adolescence, suggesting that moderate practice beginning later in life can impact brain function. Children who acquire a musical instrument are more likely to excel in all of their academic subjects, perform better in groups, possess enhanced critical thinking abilities, remain in school and pursue additional education. Students of all socioeconomic backgrounds who participate in high-quality music programs (Kragness, 2014) achieve greater scores on reading and spelling tests. Young children who take music lessons exhibit different brain growth and enhanced memory over the course of a year compared to those who do not. Moreover, mathematics and music are strongly intertwined. By comprehending rhythm, pace, and scales, children learn how to divide, produce fractions, and identify patterns. Musical instrument playing improves hand-eye coordination and fine motor skills. Children who study an instrument learn a great deal about discipline, commitment, and the benefits of a difficult task. In addition, the benefits of music increase when children join school and are faced with new personal and interpersonal obstacles. Among others, major emphasis is placed on learning collaboration, sharing, compromise, creativity, and attention.

Quality of Life and Music

The World Health Organization has also highlighted life skills and, in particular, music education and its connection to enhancing the quality of life of persons, particularly children and adolescents (WHO). More precisely, WHO guidelines for the social and educational integration of children and adolescents advocate the development of life skills as a protective factor in various life cycle stages. In practice, a variety of artistic activities, including music instruction, are proposed. The analysis of the literature demonstrates the use of musical activities to promote life skills, including social and school skills, which should be used as protective factors for satisfactory development in childhood, because music education can contribute to both the evaluation and promotion of these skills, thereby improving the students' and other special groups (for instance people with special needs like spinal cord injury overall quality of life (Gkintoni et al., 2019a,b; Tzanos et al., 2019). Musical training is essential for the neurodevelopment and cognitive functions of the brain, interfering with its plasticity, favoring the connection between neurons in the frontal region, which is related to the processes of memory and attention, and stimulating communication between the two hemispheres of the brain, which may explain its relationship to logic and mathematics (Halkiopoulos et al., 2023).

In addition, music stimulates several regions of the brain, including those engaged in other types of cognition, making this a difficult subject of study. However, it permits understanding of its function, from the acquisition of motor skills or language to the origin of emotions. Additionally, music perception is primarily centered in the right hemisphere of the brain. Recent research has demonstrated, however, that music learning requires both hemispheres due to its interdependence with other brain functions such as memory, verbal language, problem-solving, and analysis. Music education is among the main techniques of musical intervention. It is a knowledge-building process that aims to stimulate and develop musical taste, while also promoting the development of sensitivity, creativity, rhythmic sense, the pleasure of listening to music, imagination, memory, concentration, attention, self-discipline, respect for others, socialization, and affection, and contributing to effective body awareness and movement. The goal of this study was to evaluate the value of music instruction in improving brain function and enhancing quality of life currently. Considering this, several study findings from the latest research literature review are listed.
3. Methodology

This bibliography consists of academic studies published in scientific publications. These academic databases were utilized to locate and analyze related articles: ScienceDirect, Wiley SagePub, JSTOR, and SCOPUS. The critical literature were searched using keywords including "neuromusic", "quality of life and neuromusic", and "neuroeducation and music". In addition, for the collection of data, an analysis and application of the papers cited by the authors were conducted. For such a crucial topic as neuromusical training in the improvement of quality of life, it is vital to take a holistic approach to the study and not simply reproduce the findings of previous researchers.

4. Results

"Can neuroscience provide evidence-based support for music education as a key topic?" was the first inquiry [RQ1]. Researchers are already aware of numerous benefits of music education, the two most prominent being conceptual benefits - referring to perception through the senses - and practical benefits (e.g., Elliot, 2012) - which develop social skills and character, activate multiple brain mechanisms simultaneously, and strengthen neural networks that facilitate the learning of all other academic subjects. In addition, there is evidence that music instruction contributes to greater accomplishment scores, academic performance, and enhanced social skills, all of which are advantageous to society. The benefits of music education for learning and establishing social skills have been the subject of extensive research. However, basic research is the foundation for verifying this discipline, as it can provide scientific data to understand how music produces these effects.

The second research question [RQ2] is "can neuroscience help to good music education pedagogical practice?" Since neuroscience provides study into brain processing and learning, this may also give educators with the means to teach more effectively, so multiplying the advantages. The research (Collins, 2014) revealed that all groups demonstrated a statistically significant increase in the importance they assigned to music education following the intervention session. In addition, the experimental group shown greater confidence in teaching music than other creative disciplines. There were also significant breakthroughs about the advantages of music education, the usefulness of learning a musical instrument, and the significance of music education. In general, the participants maintained their view that music education enhances children's creative and social-emotional development. These results indicate that the neuromusical research intervention had a beneficial effect on the participants. However, the replies of the control group suggested that the most emphasis should be placed on the social-emotional benefits of music education. However, they also mentioned other advantages of merging neuroscience with music education.

Regarding the third research question [RQ3], a recent example of a meta-analysis relating to music and quality-of-life outcomes is Pietschnig, Voracek, and Formann's (2010) study of forty separate studies on the "Mozart Effect." The researchers determined that no data supported this impact. This result had ramifications for both the general public and politicians, such as the extensive marketing of CDs and DVDs based on this phenomenon and the distribution of Mozart CDs by the Georgia government to new mothers. Before reaching a judgment based on a single study, this example demonstrates that researchers must investigate the whole spectrum of studies on a topic. Among addition to the aforementioned meta-analyses, Catterall (2009) and Catterall, Dumais, and Hampden-Thompson (2012) explored the association between intense arts involvement and academic success, civic engagement, and labor market outcomes in U.S. at-risk children. The results of these research, which
demonstrated a substantial correlation between arts involvement and specific outcome indicators, centered on arts engagement in general and not only music. Unknown at this time is whether or to what extent music might buffer these interactions (Dileo, 2006; Pietchnig et al., 2010).

5. Discussion & Conclusion

Neuroscience can provide evidence-based support for music education as a core subject through enhanced academic performance and social development and as a synergistic enhancer of other academic disciplines such as mathematics, science, and language arts. Three studies (citation) evaluated the impact of music on academic performance. Their combined findings revealed insignificant effects, and there was moderate heterogeneity between studies. Individually analyzing these trials revealed major effects of music listening on academic skills/performance, while another study revealed significant, moderate-to-large effects of music involvement (instrument playing/singing) on a language decoding test. In a single study, listening to music had no influence on reading comprehension. Another study examining the influence of music on academic skills indicated that music listening has a considerable effect on mathematics but a little effect on reading comprehension (Peretz & Zatorre, 2003).

Five research explored the influence of music on several cognitive processing characteristics; the pooled results were diverse and lacked statistical significance. There were no statistically significant effects of music on visual processing, processing speed, or spatial visualization. In each of these analyses, there was heterogeneity among researches. In addition, one study found that music listening had no influence on the manipulation of mental imagery. Only one study that directly evaluated quality of life as an outcome was included. Physiological, psychological, behavioral, social, and cognitive domains were among the different outcome categories that the researchers found significant to quality of life. One could argue that the outcomes examined in these fields have no significant affect on life quality. Thus, music and quality of life research must become more focused.

It is important to recall that the risk of bias was determined to be significant in all the research included in this review. Therefore, these data must be evaluated with the utmost caution. These encompass psychological, cognitive, and social aspects. For instance, music exposure may improve our disposition, boost our morale, help us relax, raise our sociability, and boost our focus and memory. Across two or more studies, no physiological results were found to be statistically significant. Future study on the relationship between music and quality of life must be performed with greater precision. Future studies will likely apply and publish suitable protocols for randomization, allocation concealment, blinding, attrition, and selective reporting, as well as other potential biases, in order to increase their quality. In addition, future research should contain adequate data reporting, as a lack of data may prevent a study from being included in a future meta-analysis on the issue. In addition, future research should employ power estimates to guarantee that sufficient sample sizes are used. In addition to listening and background music, additional study is required on quality-of-life variables and many forms of music interaction. To identify if there is an optimal strategy to use music to improve the quality of life, comparative studies of different types of music engagement are recommended.

Findings from the field of neuroscience indicate that music can be used to create neural pathways that enhance the learning of other academic disciplines. Collaboration amongst all academics should be incorporated into a single integrated curriculum, and these practices can and should inform policy. The contributions of neuroscience research to music education include altering brain plasticity and strengthening attention, memory, spatial reasoning, reading,
and language skills, as well as increasing IQ and self-esteem and appearing to greatly increase the quality of life. Numerous neuroscientific studies support music education as an indispensable tool for the individual and society.

**References**


