The Impact of Classical Music on Neuroanatomy & Brain Functions

Vani Sharma

Abstract

The human brain is responsible for a variety of functions that govern daily life, adaptation, and survival. Characteristics such as memory consolidation, mood states, and neural plasticity give rise to brain biodiversity and higher-order intelligence. There are many external stimuli that evoke such characteristics, from a car horn to the latest Marvel movie, and classical music is no exception. This genre of music is a means to stimulate neural chemistry and cerebral circuits. This paper focuses on the nervous system as well as the neuroanatomy that can be impacted by engagement with such music. Classical music increases memory consolidation, relaxes the nervous system, can amplify emotional mood states, and can increase neural plasticity to slow down age-related cognitive decline. Furthermore, it can be used as a therapy for memory-related brain-based conditions such as Alzheimer's disease and dementia.

Introduction

Humans, at our fundamental cores, are complex beings. We possess introspection, reasoning and language skills, and high levels of emotional intelligence. These traits, along with an innate ability to respond to music and dance, help to distinguish Homo sapiens from any other animal species (Moeller, 2017; Trimble and Hesdorffer, 2017). The human brain consists of cortices, connections, and structures that respond to sound and rhythmic inputs (Trimble and Hesdorffer, 2017). From the rhythmic beating of human hearts to the hand clapping motions of ancient hominids (Trimble and Hesdorffer, 2017), many aspects of human biology and behavior have evolutionarily been tied to music, and neuroanatomy and brain function play a key role in that connection.

When humans listen to music or play a musical instrument, the music activates the brain, ignites emotion, and can impact brain-behavior associations, memory, and even psychopathology (Trimble and Hesdorffer, 2017). These neural effects are much more amplified when looking at classical music. Classical music is significant because it has greater harmonic resources and rhythm variety than modern music, which leads some to consider it as more expressive (Young, 2016). As per Cleveland Clinic, a non-profit academic medical center at the forefront of neurological research, this type of music stands out as a therapy and has been shown to assist with the treatment of neurodegenerative diseases ("Music Therapy," 2020). The techniques and variations within classical music also greatly bolster neural functionality (Young, 2016). This article will discuss how classical music increases memory consolidation, relaxes the nervous system, amplifies mood states, and slows down age-related cognitive decline. It also dives into the rising methods of music therapy and clinical applications for Alzheimer's disease as well as dementia.

Classical Music Affects Memory Consolidation

Classical music affects the neurochemistry of the brain in relation to memory consolidation.

Memory consolidation refers to forming and retrieving memories to adapt to the demands of a changing environment through the steps of encoding, consolidation, and retrieval (Rasch and Born, 2013). In this process, a new memory trace is first formed. Next, during the consolidation stage, the memory trace is stabilized and integrated into pre-existing knowledge networks in the brain. Lastly, during the retrieval, the stored memory is accessed and recalled. The most critical player in the memory consolidation process is sleep. The sleeping brain is what provides the ideal conditions for the encoded memory to go into long term memory.

Recent neurological studies have shown that classical music can reactivate memories during sleep, assisting with consolidation and especially benefiting patients that have poor sleep patterns (Gao et al., 2020). A recent study published in the National Library of Medicine played classical music consisting of Chopin, Beethoven, and Vivaldi to sleep-deprived undergraduate microeconomics students. These students were then asked to take a college-level exam that included problems they were trained to solve and new questions that require knowledge application. The students that listened to classical music showed a 20% increase in knowledge transfer, concept integration, and memory consolidation (Figure 1).

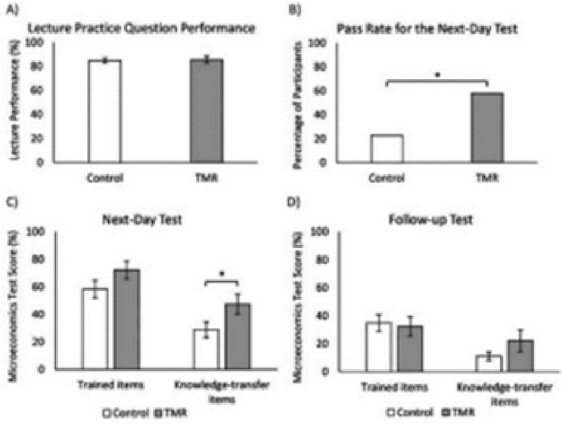

Fig. 1. Gao et al., 2020.

Studies such as this suggest that classical music can be leveraged in preparing for academic tests, test performance, and tasks that require day-to-day memory consolidation.

Classical Music Induces Relaxation States

Classical music affects functional neuroanatomy by inducing relaxation states. Physiological change in the nervous system has long been associated with music perception (Siragusa et al., 2020). These changes include heart rate and blood pressure fluctuations. Research shows that exciting or fast tempo music tends to increase heart rate and blood pressure, while relaxing or slow-tempo music has the opposite effect (Siragusa et al., 2020). Additionally, there is evidence that cerebral blood flow increases in the brain arteries when subjects are exposed to music with a faster tempo (Siragusa et al., 2020).

In recent years, neurological studies have further proposed that music influences cognition and emotion. Specifically, a 2020 study done by the Clinical Investigation Center of the Hospital of France took healthy individuals ages 18 to 45 and exposed them to Stravinsky and Rossini's classical music compositions. The brain's pulsatile movement, which is the measure of brain volume changes in relation to cerebral blood flow and elastic tissue properties, was tracked. The results showed a decrease in amplitude. Studies such as this suggest that classical music can relax the nervous system and induce physiological and emotional changes within the brain and body.

Classical Music Induces Relaxation States

Similarly, research has shown that emotional states can be induced by happy, sad, and neutral classical music. Evidence shows that emotional states produced by music are strong, long-lasting, and more pervasive (Mitterschiffthaler et al., 2007). One brain region that is particularly responsive to pleasant music is the ventral striatum, which is involved in reward, attention, and motivation (Mitterschiffthaler et al., 2007). Conversely, another brain region known as the amygdala is engaged in response to fearful and sad stimuli. Evidence has shown that there is decreased cerebral blood in the amygdala in relation to "chills" that are produced from pleasurable classical music. There is also greater amygdala activity with unpleasant musical excerpts (Mitterschiffthaler et al., 2007).

A study from the Institute of Psychiatry at King's College in London played its participants' sad, neutral, and happy classical music compositions (Mitterschiffthaler et al., 2007). When compared to neutral music, it was found that listening to happy classical music induced an increase in activation in various gyral regions (temporal, front, parahippocampal, etc.) and the ventral striatum (Figure 2). Likewise, brain activity increased in areas such as the hippocampus, amygdala, and cerebellum after listening to sad classical music (Figure 3). This evidence demonstrates that classical music can induce and even amplify happy or sad states while activating the emotional neural pathways.

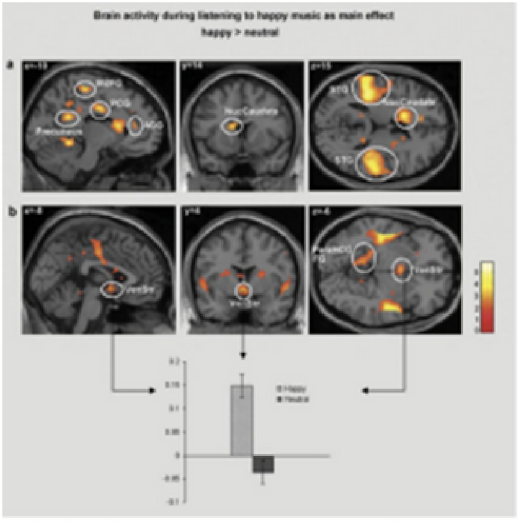

Fig. 2. Mitterschiffthaler et al., 2007

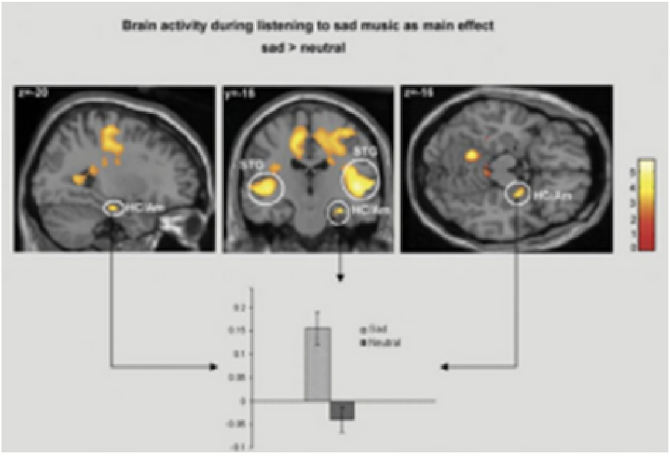

Fig. 3. Mitterschiffthaler et al., 2007

Classical Music Induces Relaxation States

Classical music has also been frequently associated with preventing cognitive decline. As humans age, it is normal to see cognitive regression (James et al., 2020). This means that there is a reduction in gray matter, loss of structural connections within the brain, and the information flow dynamics between regions . The elderly commonly experiences a deterioration in terms of hippocampal function and memory. Specifically, there tends to be a lapse in long-term memory and a decrease in abstract thinking. This puts the elderly at a greater risk for cognitive conditions such as dementia. This is where classical music has been applied as a potential intervention to slow down and prevent such decline.

A study published in BMC Geriatrics, an open access journal publishing peer-reviewed articles, trained the elderly in playing classical music on the piano over an extended period. Participants trained on piano saw improvements in executive function, working memory, and general well-being, which were measured through behavioral observation and physiological testing. Tracking these patients also highlighted the functional and structural plasticity in the hippocampus, which can counteract age-related decay leading to neural decline in this region (James et al., 2020). This is especially clear in the case of older adults, as learning a new skill, such as playing the piano, can increase and engage neural plasticity (James et al., 2020).

Engaging geriatric populations with classical music in this way opens a new medicinal and therapeutic outlet that can promote neural plasticity and slow down age-related cognitive decline.

Clinical Applications of Classical Music with Alzheimer's Disease & Dementia

Classical music has been proposed as a form of therapy for elderly patients with Alzheimer's disease and dementia. In both cases, memory is impaired, which can cause confusion and agitation (Gerdner, 2005). Since classical music has not only been shown to prevent cognitive decline but also promote relaxed and positive mood states, studies have been conducted to test its effects in alleviating these symptoms and helping patients cope with the disease.

A study published in the International Psychogeriatric journal by Cambridge University describes conducting classical music interventions for thirty minutes twice a week. Thus, for a total of six weeks, elderly men and women with severe cognitive impairment were monitored in long-term care facilities. The research showed that there was a significant reduction in agitation following individualized classical music therapy (Gerdner, 2005). Due to the prevalence of such memory-based conditions in elderly populations, classical music is being further researched and utilized as a therapeutic treatment option ("Music Therapy," 2020). With more research studies at bay and innovation, classical music is promising in its potential to serve as an alternative medicine treatment option to patients.

Conclusion

Classical music is much more than a pleasant sound. It can help boost cognitive performance, amplify emotional states, and promote relaxation. It can have positive effects on multiple aspects of health, including one's physical, mental, and emotional well-being. This genre of music serves as one of the most essential sub-components of music therapy due to the bolstering effects it can have on neuroanatomy and brain function. However, as music therapy is becoming a more mainstream treatment method, it requires evaluation of its clinical applications and limitations. Music therapy is accessible, economical, and widely culturally accepted, making it a promising for a large patient population across a diverse globe. While classical music therapy is only one application of music therapy, its neural impacts serve as a testament to the powerful bond between the human brain and its complex sensory inputs from the environment.

References

1. Gao, C., Fillmore, P., & Scullin, M. (2022, May 17). Classical music, educational learning, and slow wave sleep: A targeted memory reactivation experiment. Neurobiology of learning and memory.
2. Gerdner, L. A. (2005, January 10). Effects of individualized versus classical "relaxation" music on the frequency of agitation in elderly persons with alzheimer's disease and related disorders: International psychogeriatrics. Cambridge Core.
3. Ibswit. (2017, May 12). How are humans different from other animals? Human Animal Differences | Ask A Biologist.
4. James, C. E., Altenmüller, E., Kliegel, M., Krüger, T. H. C., Van De Ville, D., Worschech, F., Abdili, L., Scholz, D. S., Jünemann, K., Hering, A., Grouiller, F., Sinke, C., & Marie, D. (2020, October 21). Train the brain with music (TBM): Brain plasticity and cognitive benefits induced by musical training in elderly people in Germany and Switzerland, a study protocol for an RCT comparing musical instrumental practice to sensitization to music - BMC geriatrics. BioMed Central.
5. Mitterschiffthaler, M., Fu, C., Dalton, J., Andrew, C., & Williams, S. (2007, February 8). A functional MRI study of happy and sad ... - wiley online library. Human Brain Mapping.
6. Moeller, K. (2017, May 12). How are humans different from other animals? Human Animal Differences | Ask A Biologist.
7. Music therapy: What is it, types & treatment. Cleveland Clinic. (2020, November 24).
8. Rasch, B., & Born, J. (2013, April). About sleep's role in memory. Physiological Reviews.
9. Siragusa, M. A., Brizard, B., Dujardin, P.-A., Réméniéras, J.-P., Patat, F., Gissot, V., Camus, V., Belzung, C., El-Hage, W., Wosch, T., & Desmidt, T. (2020, January 24). When classical music relaxes the brain: An experimental study using ultrasound brain tissue pulsatility imaging. International Journal of Psychophysiology.
10. Trimble, M., & Hesdorffer, D. (2017, May). Music and the brain: the neuroscience of music and musical appreciation. BJPSYCH International.
11. Young, J. (2016, August 30). How classical music is better than popular music: Philosophy. Cambridge Core.