

Music Therapy and Cognitive Function: Exploring the Mechanisms and Potential for Enhanced Care

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Author Bio

Inchara Hosanagar is a junior at Newark Academy in Livingston, New Jersey. She has been Captain of the Women's Varsity Fencing Team, president of the Pop-Up Book Club, vice president of the Cancer Awareness Club, and the grade appointed member of the Equity & Inclusion Team as well as the Community Service Council at Newark Academy. Apart from school, Inchara has a deep passion and interest in the STEM field where she spends time on ongoing research projects and internships. This specific research project was under the mentorship of Dr. Roger Worthington, chair of the editorial board (recused from the review of this article). She focused on the cognitive impacts of music therapy as she is deeply interested in the relatively new subject.

Abstract

In a clinical setting, music therapy has been shown to improve cognitive function and improve mental health in some patients who are suffering from psychiatric symptoms. It is one of the non-pharmacological approaches to treating a range of disorders. With a long history of use, music therapy has been shown to improve cognitive function by interacting with a variety of different brain functional networks and cognitive domains. This paper will discuss the various mechanisms of music therapy, the advantages of music therapy's influence on neural plasticity, and some studies that are currently being done about music therapy and cognition in this paper, with an emphasis on an improvement in cognition. Numerous studies have shown that music therapy can slow cognitive deterioration, particularly in the areas of global cognition, psychomotor speed, executive function domains, and autobiographical and episodic memories. A promising intervention for the treatment of various illnesses and disorders is music therapy. However, additional data from prospective, randomized, blinded, consistent, and methodologically focused investigations are required.

Keywords: music therapy; mental health; brain functional networks; cognitive domains; cognition.

Introduction

Music is often considered a form of entertainment; however, there is another angle to approach this subject: that music is used as expressive therapy. Music therapy is essentially an application of music in a clinical environment, where the use of music intervention methods is used to accomplish individualized results. Music therapy is generally administered by a credentialed professional as part of an approved program. Music therapy is used to influence cognition, which can improve language skills. Researching this relatively new therapy, it was clear that music therapy has a strong influence on the brain, which ends up boosting many aspects of the mind and body. It was particularly interesting to see how music therapy does not just change the brain but also lets parts of behavior and function adapt. Because music therapy affects the brain in many different ways, its relevance includes that it can non-invasively enhance cognitive function in a variety of disorders and diseases. In addition to this, it is also able to help alleviate psychiatric symptoms in some patients and improve mental well-being.

Some of the objectives of this paper include describing different aspects of music therapy as well as the distinct functional networks and structural components that are affected. It will also detail how the functional networks translate into positive effects. Furthermore, it introduces future and current research on music therapy by detailing specific case studies that are trying to make the therapy more specialized and individualized. There is a need for therapeutic interventions to provide adaptive strategies to sustain the quality of life, decrease neurologic impairment, and maintain or slow cognitive decline and function due to degenerative neurologic diseases (Mahoney 2013). Musical interventions with adults with cognitive impairments have received increased attention over the past few years, with music being used to decrease agitation and anxiety and aid in certain cognitive functions by forcing neurons to create new pathways for themselves (Cortes, Bartel 2018). These approaches indicate the expanding scope and efficacy of music therapy and the potential mechanisms involved (Cortes, Bartel 2018).

Music therapy is used for many individuals with various disorders and diseases because it has

shown significant results in boosting cognition and improving executive functions. This is done by affecting several distinct areas of the brain as it strengthens neural connections and increases brain plasticity. Certain studies are being conducted on how to create a more specialized and individualized music therapy experience. The idea of sound as a healing influence for health and behavior has been prevalent since the twentieth century, during the World Wars, for veterans suffering from physical and emotional trauma. However, music therapy is a relatively new discipline, as it is stemmed from the historically prevalent sound therapy. The earliest known reference for sound therapy was in 1789 when it was used in institutions to alter sleep and wake cycles as a form of psychotherapy (Peng 2013). As it is known to be one of the oldest treatment methods and is used to treat diseases in many different cultures, it regulates physiological functions such as blood pressure and respiratory rhythm and regulates brain oxygenation and blood supply by positively affecting hormones such as serotonin, dopamine, adrenaline, and testosterone (Peng 2013).

Music therapy allows for the objectives of this paper to connect music therapy's impact on cognitive function with how this effect can translate into improved and advanced care for many different disorders and diseases.

Cognition and Music Therapy

Music therapy is regarded as an “expressive therapy,” which is when the use of creative arts is implemented as a form of therapy, and unlike some traditional arts, the process of creation is more emphasized than the final product. Music therapy is used in a variety of different places and by different people. It is being used for a multitude of disorders and diseases, so it is used in some medical hospitals, cancer centers, schools, drug rehab programs, psychiatric hospitals, and correctional facilities. Music therapists often use music and its physical, emotional, mental, social, and spiritual facets to help patients improve and maintain their health. Music therapy provides a non-invasive and cost-effective technique that has contributed to improving cognitive function through its cultural role in facilitating social learning and emotional well-being (Fang et al. 2017). As previously stated, music affects many different parts of the brain, which explains why it has so many different benefits (such as improved

memory, motor function, and mood) that cover our entire human experience mentally, physically, and socially. Some of the fallbacks of music therapy include overstimulation, false memories, and anxiety. Music therapy consists of many different factors, such as volume, acoustics, and many instruments, which can sometimes provide overstimulation, causing neurological stress. In addition to this, it can create false memories and anxiety in patients suffering from disorders and diseases like post-traumatic stress disorder (PTSD) and Alzheimer's, which can cause distress (Fang et al. 2017).

Methodology

This project included a literature review and analysis, using search engines like Google Scholar, PubMed, and the National Library of Medicine. When searching for sources, there was a ten-year restriction on the research because new research findings about music therapy and cognitive performance are always surfacing, as it is a relatively new topic of research. While many case studies fell within this timeframe, no sources were excluded that were close to the period because they would still provide new information and insights that would help to add to my analysis. Keywords that were used to locate possible sources include cognitive performance in music therapy, music therapy, cognitive function, music cognition, binaural beats, and music cognition. To categorize this research, multiple case studies were observed and qualitatively analyzed in many resources to notice certain variations and similarities between the sources, which guided the conclusions.

What Is Music Therapy?

While there may be some drawbacks to music therapy being used, its boost in cognitive function over time outweighs the negative aspects, as it is proven to improve multiple domains of cognition, including attention, memory, psychomotor speed, orientation, and executive functions. In addition to this, music therapy can benefit patients by evoking a wide range of feelings that can enhance one's psychological well-being, stress reduction, and quality of life. Also, in terms of perceptions of pain, music can stimulate the release of endorphins, thus improving overall pain management.

For example, in a study by Särkämö, 89

elderly patients with mild dementia, mostly of them were diagnosed with Alzheimer's disease, were randomized to a singing group, a music-listening group, and a usual care group for 10 weeks (Swayne 2014). Compared to usual care, both music listening and the singing group improved orientation, attention, executive function, and general cognition, as proven by an increase in Mini-Mental State Examination (MMSE) scores, a test that is used extensively in clinical and research settings to measure cognitive impairment (Swayne 2014).

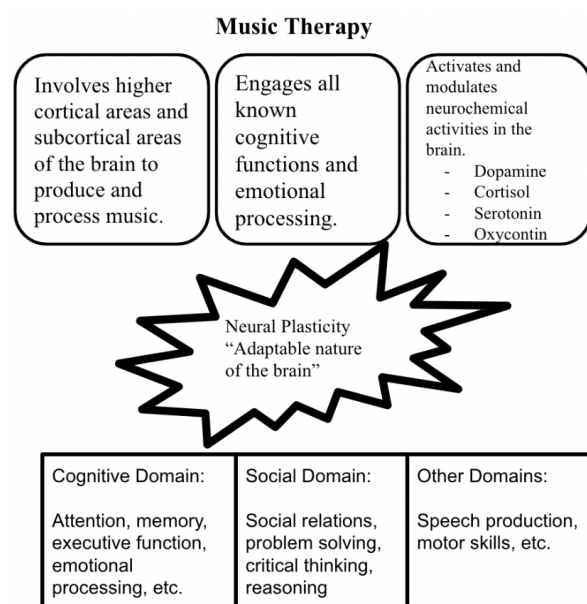


Figure 1: Factors Contributing to Neural Plasticity and Its Effect on Cognitive Domains (Hosanagar 2022)

Functional Networks and Structural Components

Many of the positive effects that music therapy has on these structural components have to do with something called brain plasticity, also known as cognitive plasticity, conveying how the different functional networks and structural components are utilized by music therapy (López-Caballero, Escera 2017). This is the ability of the brain to adapt to certain experiences and interactions by building new neural pathways. Early exposure to music therapy allows for a greater difference in the gray matter, effectively boosting brain plasticity (López-Caballero, Escera, 2017). As shown in Figure 1, music therapy causes

structural and functional changes in the brain through an increase in brain plasticity, which can lead to improved cognition but also growth and changes in brain circuitry and connectivity. Some of the different parts of the brain that are affected are the temporal lobe, which includes specific gyri that help process tone and pitch; the cerebellum, which helps to process and regulate rhythm, timing, and physical movement in music therapy; the amygdala and hippocampus, which regulate and evoke emotions and memories; and the brain's reward system. Cognitive improvement by listening to music has been linked to the relationship between the orbitofrontal cortex and the dopaminergic mesocorticolimbic circuit (Sharma et al. 2018). These parts of the brain vary in function, which conveys how music therapy reaches different audiences and can help with many diseases and disorders because of its extensive reach to different parts of the brain, as well as what all these different parts entail. For example, its effect on the amygdala and regulating emotion has been studied, and there have been clinical studies with patients with depression feeling happier because of music therapy (Sharma et al. 2018).

Comparing two case studies: one was being performed by a research team at UCLA, and the second one was being performed in an elderly home by a team of researchers. And in the first one, an elderly population was only subjected to short-term music therapy, while the second one had two groups that were subjected to short-term and long-term, respectively; generally, the short-term effects of music therapy do not contribute to a boost in cognitive function; it is the long-term exposure that initiates improved cognitive function (Lyu et al. 2018). Short-term exposure to music therapy does not cause growth in cognition, and it can only be done when there is long-term exposure. While we may not be able to revive atrophied tissue from strokes, or developmental, or neurodegenerative diseases, we can activate, or modulate, the signaling in certain areas of the brain involved in emotional processing, cognitive flexibility (or abstract thinking), attention, reward, and motivation (Lyu et al. 2018). Over time, if the brain continues to fire in new ways, it can create new neural pathways.

Translation into Positive Effects

Three factors of how music therapy affects

cognition are that it involves higher cortical and subcortical areas to produce and process music, it engages all known cognitive and emotional processing, and it activates certain neurochemical activities in the brain (Stegemöller 2014). These factors contribute to “neural plasticity,” where the cognitive, social, and executive domains of the human body are greatly increased. People who are exposed to long-term music therapy are proven to have an increase in brain plasticity as the neural pathways in their brains change as neurons learn how to fire in different ways or strengthen previous connections (Stegemöller 2014). This can be extremely helpful for patients that suffer from neurological diseases like Alzheimer's, Parkinson's, strokes, etc. due to an increase in the gray matter, which leads to improved cognition.

A newer aspect of music therapy and sound therapy includes “binaural beats,” which are a part of auditory beat stimulation. Binaural beat therapy makes use of the fact that the right and left ear each receive a slightly different frequency, yet the brain perceives these as a single tone (Kayaaslan, Lok 2019). Auditory beat stimulation, a significant aspect of music therapy, allows for certain cognitive functions to be significantly boosted. For example, Wahbeh tested verbal memory performance using the Rey Auditory Verbal Learning Test, where 92 psychiatric and neurological patients, in which 45 of the patients were classified as memory-impaired and the other 47 were classified as non-memory-impaired, are asked to repeat a list of 15 unrelated words over several trials (Smith 2019). They reported that binaural-beat stimulation at 5 Hz, for fifteen-minute sessions, resulted in a significant increase in the number of words recalled post-stimulation, as measured in the Wechsler III Memory Scale (Smith 2019). These results may suggest that prolonged exposure to auditory beat stimulation may affect verbal memory performance and recall (Smith 2019). Due to a lack of research, because it is a relatively new therapy, there are not many studies on how it can boost cognitive function. However, it is more individualized and specialized compared to some of the more traditional aspects of music therapy, like singing and playing instruments. There are five categories of brain waves (delta, theta, alpha, beta, and gamma), in which each brain wave is associated with a different activity (Wilbrecht, Shohamy 2010). For example, gamma waves show promise for helping with increased cognitive flexibility and divergent thinking (Wilbrecht, Shohamy 2010).

By focusing on certain brain waves, different cognitive abilities can be boosted depending on one's needs.

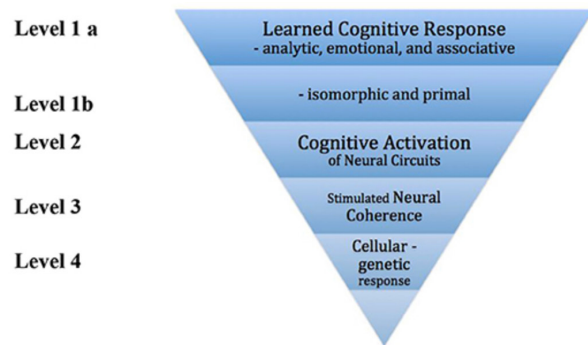


Figure 2: A model of response mechanisms to music (Bartel, Clements-Cortes 2018)

Music is implicated in many different types of interventions relating to health and well-being. It looks at treating the whole person and is broader than music medicine, which can be considered to be more of a prescribed approach to music applications. Some mechanisms are responsible for and involved in the effectiveness of music therapy (Zhang et al., 2019). The cognitive response is oftentimes connected with how one can associate an emotional response with the music they are listening to. As seen in Figure 2, Level 2 in the model involves mechanisms of neural circuitry activated by cognitive processes (Flo et al. 2022). For example, when a person loses the use of language due to a stroke, music with language activates a different circuit in the brain and can thereby rehabilitate language function. This circuit-based approach can focus on movement, speech, language, and other cognitive processes such as memory and critical thinking (Flo et al. 2022). The practice of NMT is based on neural mechanisms for cognitive processes. Levels 3 and 4 are more speculative as they are the responses to music therapy at a vibrational, rhythmic level. Listening to and participating in music therapy allows for these mechanisms to come into play (Flo et al. 2022). As they are being utilized, several different neurons and pathways in the brain are being activated, causing a boost in cognitive and executive functioning as it allows for reinforced responses.

Brain plasticity allows us to be more adaptable and ready to experience new environments, which also causes brain plasticity. This is because music therapy allows for more verbal and emotional

fluency. After all, music therapy is interpreted as a new language by the brain. There is research being done on whether certain music types or certain aspects of music therapy can be used to control which areas of the brain can be changed. In addition to this, music therapy can be used to help normalize brain function in states of disease or optimize brain function in states of wellness (Kayaaslan, Lok 2019). This is done because music therapy is shown to better regulate the executive control sections of the prefrontal cortex even in a non-music-related task, and this, along with the altered activation of sensory and motor regions of the brain, translates into an improved cognitive function (Kayaaslan, Lok 2019).

Future and Current Research

Music therapy and its research have mainly been conducted using Western compositions and many classical styles, like Mozart and Bach. While music is oftentimes considered a universal language, it is important to highlight the need to recognize the importance of musical diversity and that musical preferences vary by culture, although there has been little research undertaken into multicultural music therapy. However, researcher Laksmidewi performed a study that involved the Balinese elderly in a retirement home by randomly separating two groups and having Western classical music therapy for one, and instrumental Balinese flute music therapy for the other (Schlaug 2010). As music is linked to one's identity, it can help to connect with a past sense of self. Because of the immeasurable results, it was quite difficult to see if there was a difference in cognition between the two groups.

Some research is being done on whether certain parts of the brain and cerebral circuits can be specifically accessed through music therapy to provide more individualized care. For example, Thaut and Altenmüller developed a new brain circuit named Neurologic Music Therapy (NMT). NMT uses the perception of auditory structures and patterns in music as specific circuit activators to retrain brain function, which is organized into three main areas: sensorimotor training, speech/language training, and cognitive training (Zhang et al. 2019). A specific example of this is when Poeppel proposed the right hemisphere of the brain is potentially more advanced at handling slowly modulated signals in individuals with expressive aphasia, so the sensorimotor network will be more

easily activated with music therapy, which is exposed to the left side of the body (Schlaug 2010). This is research that has been going on for many years to see if we can optimize what type of music to select to invoke a certain cognitive, motor, or emotional response in a patient by activating certain circuits. This can then allow us to use music to help normalize brain function in states of disease or optimize brain function in states of wellness. For example, in an epilepsy case study conducted by Dr. Ovary (2009), he discovered more about music therapy and its effect on epilepsy specifically. Because patients with epilepsy have different cerebral rhythms and limbic activity, there is more research being done on music therapy and its specific effects on many disorders and diseases, and how to adapt music therapy accordingly.

Conclusion

Music therapy can be considered a non-pharmacological intervention that has the potential effects of reducing cognitive decline and improving neuropsychiatric symptoms. Research has demonstrated that music therapy, while it naturally has some fallbacks, clearly boosts cognitive function. Also, certain mechanisms of music therapy allow for different facets of cognition to be conveyed, especially through an increase in neural plasticity and gray matter. As music therapy is a relatively newer therapy, it is crucial to keep up with current and future research as it aims to provide more specialized and individualized care for individuals, especially those with neurological disorders and diseases. Certain mechanisms and aspects of music therapy can also translate into different effects, as it positively affects individuals and their executive functions. Music therapy causes cognitive function to be increased as it affects different functional networks and structural components of the brain, which relay positive effects on the different domains of cognition. While I was researching for this paper, one particularly interesting aspect of music therapy is that it is constantly changing due to new studies being conducted. It also adapts to each condition that it treats, and while it is crucial to see the benefits that music therapy provides, such as a boost in cognition, it is imperative to modify music therapy as these new studies bring more insight and perspective into how to create more advanced, specialized, and focused care for patients with disorders and diseases.

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