The Effect of Music Training in Young Children

By Carolyn Foo

Author Bio

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Abstract

Music training, the active participation in learning music, can lead to changes in the brain's structure also known as brain plasticity. The impact of experiences that cause brain plasticity is especially strong during a child's developmental period. These changes in the brain due to music training can impact domains outside of music itself, suggesting a possible impact on a child's cognitive development. This literature review intends to determine whether there is evidence to support the idea that music training improves cognitive development. Through different literature, the effects of music training on the brain are shown from a measure of brain plasticity and near and far transfer effects. However, studies on this relationship do not consider external factors such as socioeconomic status, genetic predisposition, and reward value, that can impact the effect of music training in children. The findings reveal a possible positive correlation between music training in young children and improvement in cognitive development, but a causation relationship cannot be determined.

Keywords: Brain plasticity, critical periods, music and the brain, music training, genetic predisposition, cognitive development, transfer skills, education

Introduction

Learning skills are used in one's entire life. Whether it be in education, careers, or daily life, cognitive skills are important. Thus, when children are growing, cognitive skills (reasoning, logic, reading, etc.) are a critical set of milestones during that developmental period (Cognitive Development Domain, 2022). This developmental period where changes and influences of experience are strong, is known as the sensitive period (Miendlarewska & Trost, 2014; Harbin & Besson, 2009; Nelson et al., 2019).

Music training refers to the active participation in learning music. Music training is an experience that can lead to changes in brain structure (Herholz & Zatorre, 2012; Miendlarewska & Trost, 2014; Habib & Besson, 2009). These changes can impact domains outside of music itself, suggesting musical training has an impact on children's cognitive development and skills that will carry into their entire lives. (Hempenstall, 2019; Hyde et al., 2009; Miendlarewska & Trost, 2014).

Through a literature review, this paper explores the evidence supporting the idea that music training can improve cognitive development and lead to brain plasticity. First, the concept of brain plasticity is explored; second, the processing of music in the brain is identified; third, children who receive music training and those who do not receive music training are compared with the identification of factors not controlled for. Subsequently, music training in children on cognitive skills and development is reviewed.

Methodology

This literature review was conducted using Google Scholar, Jstor, and Google (for definitions). The restrictions for the search were no articles before the year 2000. The keywords used in these searches were "music and the brain", "brain plasticity", "effect of music training in young children", "musical training", and "critical periods". The analysis was performed through reading and studying the literature collectively to determine whether there was clear evidence for brain plasticity and cognitive effects due to music training in young children.

Discussion

Brain Plasticity

The nervous system, once thought of as static, changes as a result of experiences (Kolb et al., 2003). A major organ of the nervous system is the brain, which acts as a control system for the nervous system. Brain plasticity, also known as neural plasticity, is the ability of the brain and neurological system to change and reorganize in response to stimuli, which can either be internal or external factors.

The stimuli enact structural changes, reorganization of neural connections, and functions (Mateo-Aparicio & Rodriguez-Moreno, 2019). The two main mechanisms of brain plasticity are functional plasticity and structural plasticity (Puderbaugh, 2023). Structural plasticity is the physical structure of the brain changing due to stimuli, such as learning a musical instrument. Synaptic plasticity, for example, is the ability of neurons to change in strength and efficacy of neural connections in response to experience-dependent stimuli (Mateo-Aparicio & Rodriguez-Moreno, 2019). Functional plasticity occurs when the brain has functional changes, usually due to damaged areas in the brain (Puderbaugh, 2023). This typically arises in patients experiencing seizures resulting in long-term damage. Plasticity is important for the development and function of the brain (Mateo-Aparicio & Rodriguez-Moreno, 2019). In effect, brain plasticity affects learning, cognitive, and motor processes (Mateo-Aparicio & Rodriguez-Moreno, 2019). Thus, studying brain plasticity can show the effects of certain stimuli on the brain, how the brain develops, and how the brain is affected by damaged areas in the brain. This understanding aids the development of academic learning and therapies for patients recovering from brain injury, benefiting the education and healthcare systems (Mateo-Aparicio & Rodriguez-Moreno, 2019).

Music Processing in the Brain

The long-held view of music processing in the brain was that music is processed in one centralized area of the brain. However, the identification of neurological cases, such as brain damage caused by stroke, showed that a centralized location theory was not correct. This led to the development of the model of complex, interconnected

neural networks throughout the brain that process music. Thus, understanding how music is processed suggests that studying the effect of music training on young children is difficult.

Centralized Area for Music Processing

A popular view was that there was a single part of the brain just for music (Peretz, 2002; Warren, 2008). This idea was widely held because the isolation of musical abilities was evident in some pathological conditions (Peretz, 2002). However, many problems arose with this idea. Music is complex and multidimensional. It has dimensions of pitches, tempo (the speed), rhythm, and tone, making it unlikely that there is a center dedicated to music (Warren, 2008). Additionally, studies of clinical neurology reveal more evidence that this view is incorrect. One of these neurology studies is apperceptive music agnosia in the patient "JM" (Baird et al., 2014). Apperceptive music agnosia is a condition where selective music discrimination skills and the ability to identify familiar songs and environmental sounds are preserved (Warren, 2008; Baird et al., 2014). This disorder left a specific music function impaired while leaving other functions unaffected, suggesting that there is not a centralized music-processing area of the brain (Warren, 2008).

Complex and Whole Brain Music Processing

The improved model of music processing believes there are complex, interconnected neural networks throughout the brain involved in music processes (Warren, 2008; Peretz, 2002). Instead of one area of the brain dedicated to music, it is an entire brain experience. Different areas throughout the brain process different functions critical to music, like pitch, harmonies, tempo, and emotion (Warren, 2008). Processing music is modeled as a hierarchy organization with lower-status areas passing complex information up to higher-status areas (LaRivee, 2021). The organization makes the perception of music complex and interconnected.

Music Training in Young Children

Music training in early childhood has benefits in executive functions and brain plasticity. These benefits can be examined through studies comparing children who received musical training and education and children who have not. Due to the critical and sensitive periods, periods where training has strong and lasting effects, learning music in childhood is effective. While the studies reveal improvement in many areas, there are external and internal factors that are not controlled for. As a result, a causation relationship cannot be determined.

Musically Trained versus Untrained Children

Music training is correlated with the improvement of skills related to music. For example, musically trained children have better performance in working memory and attention, both considered executive functions (Kausel et al., 2020). In this study, the researchers tasked two groups of children aged ten to thirteen (with music training and without music training) with bimodal (auditory and visual) stimuli and asked the participants to focus on the stimuli, either auditory, visual, or both, while their brain activity was observed using a function MRI (Kausel et. al, 2020). After the assignment, they were tasked with a memory assessment of the stimuli (Kausel et al. 2020). The results revealed that musically trained children have better performance on memory retrieval tasks and increased activation of areas in the brain related to attention control during the initial learning of information (Kausel et al.).

Another study shows a similar improvement in cognition and non-verbal IQ in the group with musical training. In the study by Neville et al. (2008), the researchers separated children aged three to five into four groups, a small class (5:2 student-to-teacher ratio) with music education (creating music, listening to music, and singing), a small class with Head Start (typical preschool curriculum) curriculum, a large class (18:2 student to teacher ratio) with Head Start curriculum, and a small class with a curriculum focused on attention skills. The results of the study show that all groups except the large class size saw similar improvements in non-verbal IQ and spatial and numeracy cognition (Neville et al., 2008). While this study could suggest a correlation between music training and cognitive function and IQ, it is difficult to determine. Because all the small groups, including the music education group, show improvement in the same areas, it suggests that more attention to the children created this result. To determine a definitive effect of music training more research needs to be considered.

A final study shows a possible correlation between music training and motor and auditory functions. In the study by Hyde et al. (2009), a group of children with a mean age of 6.32 received instrumental music training for 15 months compared to the control group, children who did not receive the instrumental music training and received only a weekly forty-minute music class at school that consisted of singing and playing bells and drums. The results were obtained from magnetic resonance imaging (MRI) of the brains and behavioral assessments to test motor skills, listening skills, and music discrimination skills. It also tested five far-transfer skills (Hyde et al., 2009) which are skills related distantly to music, like skills in the verbal and visual domains. The results showed that the music training group had greater relative voxel size, a regional structural change, in areas of the brain related to motor and auditory functions similar to professional musicians (Hyde et al., 2009). This brain plasticity correlated with better performance on melodic and rhythmic tests (Hyde et al., 2009). Additionally, the experimental group showed more improvement in motor, listening, and music discrimination skills, but no significant improvements were made in far-transfer skills (Hyde et al., 2009).

These three studies show evidence that there is a possible correlation between music training and improvement of cognitive and executive skills, but there are limitations to these studies. Thus, a causation relationship cannot be determined.

Critical and Sensitive Periods

The effect of music training on younger children is often studied during critical and sensitive periods because these periods are important to brain plasticity and development. The critical period is a strict period where training alters performance and is essential for development, and the sensitive period is a time where training on the brain has strong effects (Miendlarewska & Trost, 2014; Harbin & Besson, 2009; Nelson et al., 2019).

While the critical and sensitive periods are similar in regards to the time music training has a strong impact on the brain, they differ in the time frame, flexibility, and changes made to the brain. The experiences during the critical period make permanent changes to brain function as the brain is still developing (Nelson et al., 2019; Miendlarewska & Trost, 2014). Moreover, different brain regions and domains have different critical periods. For example, the visual cortex has a critical period that ends after a few months after birth, while the auditory cortex myelination has a critical period that ends at age four to five (Miendlarewska & Trost, 2014). Generally, the critical period ends after age seven (Harbin & Besson, 2009). In contrast, the experiences during critical periods cause changes and shape the connectivity patterns because the basic structure of brain neural circuits is developed (Miendlarewska & Trost, 2014; Nelson et al., 2019). The time frame of the sensitive periods is not defined merely by age but also by experience and environment (Miendlarewska & Trost, 2014).

Due to the presence of these periods, earlier-trained musicians have a better overall performance of their instruments than later-trained musicians (Harbin & Besson, 2009). Thus, age and environment become important when studying the impact of music on the cognitive development of younger children.

Other Factors Not Controlled For

Although there is much evidence of a positive correlation between music on cognitive skills, there are many factors that have not been controlled for to determine a causation relationship. The main three factors are genetic predisposition, socioeconomic status, and reward value.

Genetic Predisposition

Children with certain brain structure differences are more predisposed to become musicians and motivated to learn music (Miendlarewska & Trost, 2014; Hyde et al., 2009). Studies have associated certain music abilities, like music perception and music discrimination, with loci on chromosomes in the body which carry the genetic information for humans (Tan, 2014). Many studies do not randomly assign the participants to the experimental or control groups (Miendlarewska & Trost, 2014). Thus, the improvement in cognitive skills may not be only due to music training, but also due to innate musical abilities and differences in motivation. The distinction between innate and developed differences in the brain is difficult.

Socioeconomic Status

Families with higher socioeconomic status and higher education have a higher probability that their children get access to music education (Miendlarewska & Trost, 2014; Francisco Reyes, 2019). In 2012, the Department of Education's research showed schools that had a higher percentage of poverty had fewer music resources, teachers, and music courses (Francisco Reyes, 2019). Additionally, low socioeconomic status areas in New York City and Chicago lack music instrument stores, suggesting less access to music education (Francisco Reyes, 2019). Thus, controlling for this factor could eliminate the possibility of the difference in access to music education contributing to the results of studying music training in young children.

Reward Value

The motivation and the reward of learning music can affect how music will impact an individual. Dopamine is a hormone that is released by the brain, which gives people a sense of pleasure and motivation (Dopamine, 2022). So, if music learning is pleasurable for the musician, dopamine will be released causing more motivation to continue practicing. Moreover, dopamine plays an important role in long-term memory formation (Miendlarewska & Trost, 2014). Thus, a positive and rewarding experience could promote more training leading to brain plasticity (Miendlarewska & Trost, 2014; Dopamine, 2022). However, a stressful and negative experience creates a memory that associates music training with stress. It has also been shown that negative reward harms learning and memory and impairs performance (Miendlarewska & Trost, 2014). While controlling the reward and pleasure of music is difficult, discriminating between a stressful and positive music experience is beneficial for determining the impact of music training.

Music Training on Cognitive Development

The effect of music training on cognitive development can be measured and observed through transfer effects and brain plasticity. This development is important for education and learning.

Transfer Effects

Transfer effects are effects that are from training that results in cognitive development that leads to the enhancement of skills in areas outside of music (Hempenstall, 2019; Hyde et al., 2009; Miendlarewska & Trost, 2014). There are two main categories of transfer effects, near and far transfer.

Near-Transfer

Near transfers are skills closely related to music training (Hempenstall, 2019; Hyde et al., 2009; Miendlarewska & Trost, 2014). For example, listening and fine motor skills are considered near-transfer skills in music (Miendlarewska & Trost, 2014). There is much evidence of near transfer in the literature because there is a close resemblance between music skills and other close domains (Hyde et al., 2009).

Near-transfer can be observed in the studies performed by Kausel et al. and Hyde et al. In the Kausel et al. (2009) study, the children with music training saw improvements in attention control, a near-transfer skill. Similarly, in Hyde et al. (2009), the children who received music training showed more improvement in motor, listening, and music discrimination skills.

Far-Transfer

Far transfer skills are transferring skills from a music context to a dissimilar context (Hempenstall, 2009). For example, verbal memory, social skills, IQ, and reading skills are considered far-transfer effects of music (Miendlarewska & Trost, 2014). There is limited evidence of far-transfer skills because it is difficult to determine a resemblance between music training and far-transfer skills (Hyde et al., 2009). Far-transfer can be observed in Neville et al. (2008), where children with music training improved in non-verbal IQ and spatial and numeracy cognition. However, due to the inclusiveness of the study, far-transfer effects in this study cannot be determined as all small groups saw this improvement.

Brain Plasticity

Music training in young children causes structural brain plasticity. The years of training and age of commencement correlated with brain plasticity (Herholz & Zatorre, 2012; Miendlarewska & Trost, 2014; Habib & Besson, 2009). This is due to the critical and sensitive periods, showing that earlier commencement of training has a greater effect on the neural systems (Miendlarewska & Trost, 2014; Habib & Besson, 2009). In the studies mentioned above there was increased activation of areas of the brain in the fronto-parietal which is related to attention control during the initial learning of information (Kausel et al., 2020). Moreover, after 15 months, the group that received training had a greater relative voxel size in motor areas similar to plastic changes in professional musicians. (Hyde et al., 2009).

This evidence suggests that music training can induce brain plasticity (changes in brain structure and neural circuits) which has transfer effects. Studying brain plasticity and how it affects behavior, like cognitive skills, allows researchers to see the impact of music training.

Effect on Education and Learning

Due to brain plasticity and music training having both near and far transfer effects, music training could enhance other learning domains. For instance, Moreno et al. (2008) observed improvement in sensitivity to pitch changes and reading abilities of complex words in children with music training. The improvements in this study highlight both near (sensitivity to pitch changes) and far transfer effects (reading abilities). Moreover, a study that examined the relationship between music involvement and academic achievement showed that academic achievement positively correlated with music involvement in and outside of school (Southgate & Roscigno, 2009). The positive correlation between music training and involvement, and education reveals that music could help improve cognitive skills important for learning.

Conclusion

Music training in young children has been shown to benefit children in many ways. It has been associated with structural brain plasticity that changes how the brain functions and organizes certain processes. The brain plasticity changes are permanent when occurring in the critical period and particularly strong in the sensitive period. Moreover, transfer effects, both far and near, were observed in children who received music training. This result suggests improvements in cognitive development. This type of music involvement has also been associated with improvement in academic achievement in education. While there are clear benefits for music training in young children, a causation relationship cannot be determined due to important aspects of the experiments not being controlled. Some main factors are genetic predisposition, socioeconomic status, and reward. While many studies, like Hyde et al. (2009), Kausel et al. (2020), and Neville et al. (2008), control for socioeconomic status, they do not control for other factors like genetic predisposition and reward values as they are difficult to isolate. Thus, research methods still have room for improvement. If more variables in the studies can be controlled for in the future, researchers can determine a causation relationship. This relationship can help children improve cognitive abilities that will benefit them for a life full of learning.

While there is no clear evidence of a causation relationship between music training and cognitive development, the literature shows a benefit for music training in young children. In the studies that were explored, there is a generally positive result when children receive music training. There is often brain plasticity and both near and far transfer effects. Therefore, music training for young children could be implemented in schools and education to improve student's learning experience. Additionally, music is associated with enjoyment and engages the entire brain. By adding a course or music experience in a child's during their education they could benefit from both the positive impacts of music itself and learning abilities.

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