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Review of the Literature: Can Music Training Improve Memory?

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Abstract

Music training typically starts at an early age when the brain is most receptive to plastic changes. Musicians practice countless hours in an extended amount of time to master their music-making abilities, making them an excellent model to study brain plasticity. Yet, the specific mechanisms that bring about changes following music training are unclear. Though the "Mozart effect" myth has been rejected by numerous researchers, the myth that music training will increase intelligence is still embraced by many teachers, parents and even policy-makers in the education system. In addition, an increasing number of studies now suggest that music training is likely associated with improvements in other areas that are not related to the training itself, such as visual memory. In this review, I evaluate the merits of three studies that drew competing conclusions on the effects of music training on memory to obtain a comprehensive view of the underlying challenges in this field of research. I argue that the extent to which music training extends to other realms outside of the musically relevant skills remains subject to question. Therefore, policy-makers, educators and parents must be prudent when introducing children to music training in hopes of improving their far-transfer skills such as linguistic abilities, social skills and general intelligence.

Music Training

Skill learning during sensitive periods is difficult to measure due to the lack of extensive practice and low sample sizes to make a conclusive claim about brain plasticity. Musicians, however, are an excellent model for studying brain plasticity and their long-term effects. Music education and training typically start at an early age when the brain is most receptive to plastic changes and musicians practice countless hours in an extended amount of time to master their music-making abilities (Wan & Schlaug, 2010). In 1993, researchers found that participants who listened to music composed by Mozart performed better on a spatial reasoning task than those who listened to the relaxation tape (McLachlan, 1993). The media misinterpreted this finding and concluded that classical music makes people smarter, famously known as the "Mozart effect." As a result, people radically bought Mozart CDs and enrolled their children in classical music lessons. Numerous researchers later provided evidence that Mozart's music cannot make children smarter and soon debunked the "Mozart effect" myth (Thompson, Schellenberg, & Husain, 2001).

Researchers instead reported that the changes in mood and arousal from the music may have a significant effect on task performance (Thompson et al., 2001). Since the last few decades, the effects of music on cognition has been increasingly studied. Music education and music training has been found to have positive effects on brain development as well as lasting benefits that extend beyond the skills that are directly relevant to musical training (Schellenberg & Weiss, 2013). Much has been written on the purported long-term effects that could potentially improve one's linguistic, spatial and mathematical skills when children receive music training at an early age in life. There are also bold claims that early music training could improve general IQ and academic achievement (Miendlarzewska & Trost, 2014). Music training seems to have a sensitive period for which multiple brain areas such as the auditory, motor and sensorimotor cortices are susceptible to changes that extend to adulthood (Merrett, Peretz, & Wilson, 2013). Yet, music therapy has been shown to elicit brain plasticity effects long past the sensitive period in adulthood. This emerging field is especially important for the development of interventions and treatments in restoring lost brain functions (Thaut et al., 2015). Other studies have shown that older patients suffering from Parkinson's Disease, Alzheimer's disease, dementia, autism and ADHD are the target population for music therapy (Aldridge, 1993).

Near and Far Transfer Effects of Learning

The transfer of learning from one domain to another depends on the similarities between the processes involved. Transfer effects can be near or far and are stronger and more likely to occur if it is near (Hallam, 2015). For example, near transfer effects of music training include improved listening and fine motor skills as opposed to far transfer effects such as social skills and general IQ. Near transfer effects of music training are not surprising, as the skills are directly engaged through music education. However, the possibility that effects of music training could extend to improved language skills could be explained by the overlap of neural resources for music and language (Slevc et al., 2009). Though many studies support the theory that the benefits of early music training could be long-term and transferable to non-music related tasks, an equal amount of literature has argued otherwise. For example, Costa-Giomi's research found that children receiving piano lessons improved more than their matched controls in visual-spatial skills. Additional analyses showed that although the experimental group obtained higher spatial abilities scores in the Developing Cognitive Abilities Test after one and two years of instruction than did the control group, the groups did not differ in general or specific cognitive abilities after three years of instruction (Costa-Giomi, 1999). Another study that investigated working memory in adult musicians compared to non-musicians found no significant difference in the WAIS-III Digit Span and WMS-III Spatial Span test (Hansen, Wallentin, & Vuust, 2013). Likewise, numerous studies have shown that there is no correlation between musical training and IQ (Miendlarzewska & Trost, 2014). This paper will discuss three articles that specifically investigate the extent of verbal memory and visual memory, near and far transferable skills, respectively. The analysis of the three studies will provide insight into the ongoing debate of the extent to which the effects music training transfers to unrelated skills.

Anatomical Effects of Music Training

Researchers compare the brain structures of musicians and non-musicians in hopes of explaining the behavioural differences between the two groups. A largely cited empirical study denotes musicians' increased gray matter volume in specified areas involved with movement, hearing and sight (Gaser & Schlaug, 2003). The researchers applied an optimized method of voxel-based morphometry (VBM) to determine whether structural differences exist between three matched groups of participants: professional musicians, amateur musicians and non-musicians that differ in practice intensity ranked from high intensity, low intensity and no instrument training, respectively. The results suggest a positive correlation between musician status (non-musician to professional musician) and gray matter volume in the primary motor and somatosensory areas, premotor areas, anterior superior parietal areas, as well as the inferior temporal gyrus. In addition, the left cerebellum, the left Heschel's gyrus and left inferior frontal gyrus volumes increased with increasing musicianship. Gaser and Schlaug noted that the high volumes in the motor, auditory and visual regions may play a crucial role in planning, preparation, execution and control of "bimanual sequential finger movements," a necessary skill that is mastered by professional musicians (Gaser & Schlaug, 2003). Though Gaser and Schlaug recorded significant gray matter differences between participants with differing musician status, no differences in white matter volume were observed.

This study was strictly empirical and did not examine behavioural differences correlated with structural differences in the brain other than musician status. The belief that musical training may impose structural changes in the brain remains inconclusive, as one could argue that the patterns of normal anatomical variability cultivate the development of the musician's technical mastery. Moreover, structural differences in the brain may be attributed to innate predispositions, in which people with these predispositions are more likely to become musicians. This study made no conclusions about whether or not the effects of musical training are exclusively confined to the domain of musical abilities. Nonetheless, this study produced compelling evidence that musician status certainly correlates with increased gray matter volume in specified areas involved with movement, hearing and sight. This pivotal finding extended to many behavioural studies that investigated the transfer effects in musicians compared to non-musicians.

Music Training Improves Verbal Memory, but not Visual Memory

Cohen et al. (2011) investigated whether musical training improves an individual's ability to remember not only music but also nonmusical sounds. The study compared auditory and visual memory in musicians and non-musicians. First, the study measured whether musicians have superior auditory memory abilities compared to non-musicians for both musical and non-musical stimuli. Musicians and non-musicians were given 258 well-known pop songs, nursery rhymes and theme songs as control. To measure auditory memory, all participants were given unfamiliar music coming from a variety of musical styles, excluding jazz and classical music, as well as speech clips and environmental sounds. To measure visual memory, all participants were given visual stimuli comprised of 258 images on white backgrounds and abstract art. Each participant was then asked to complete a recognition memory task and a semantic classification task. The recognition memory tasks consist of a study phase where 60 to172 stimuli were presented sequentially in 5s or 12s intervals, depending on condition. After the study phase, participants were given another set of 60 to 172 stimuli with half of the stimuli being drawn from the study phase stimuli. Participants were then asked to identify whether the stimuli were "old" or "new." The two types of classification tasks consist of free-recall and multi-alternative forced tasks. The free recall task requires that the participant listen to or look at a series of stimuli and name them one-by-one. The multi-alternative forced-choice tasks require that participants listen or look at each stimulus sequentially and choose a name that described that stimulus from a list of options. Results showed that musicians' auditory memory was significantly better than non-musicians in that they remembered more familiar music, unfamiliar music, speech clips and environmental sounds. Results showed that the musician's superior auditory memory was not confined to the musical domain and extended to the non-musical sounds such as speech and environmental sounds (Cohen et al., 2011). However, for both musicians and non-musicians, memory for auditory stimuli was inferior to memory for the visual objects. This result suggests that considerable musical training is associated with better musical and nonmusical auditory memory, but musical training does not increase the ability to remember sounds to the levels found with visual stimuli. Thus, this study also suggests that musical training does not improve general memory.

The Effects of Music are Confined to the Realm of Musical Ability

Contrasting to Cohen et al.'s study, evidence that the effects of music training do not transfer to other auditory realms have been shown by Peretz and Coltheart. Peretz and Coltheart analyzed the literature that studied patients with impaired music recognition abilities and patients with impaired spoken word recognition abilities, termed amusia and agnosia, respectively. The striking finding is that amusia individuals who suffer lifelong difficulties with music can recognize the lyrics within a song, even though they cannot name the tune paired to the song. Similarly, patients with brain damage causing the impaired ability to recognize spoken words could still recognize music. These cases seem to suggest that no single system is responsible for processing music, speech and environmental sounds. Peretz and Coltheart predict that there are at least two exclusive auditory processing modules, one for music and one for speech. The study has made clear that the processing of music and speech engage different neural systems. The researchers suggest that the effects of musical training may be limited to the realm of musical ability.

Music Training Improves Both Verbal and Visual Memory

Unlike Cohen et al. and Peretz and Coltheart's study, Jakobson et al. concluded that music training indeed possesses far transfer effects to visual memory, and they also found that musicians had higher IQ compared to non-musicians. Jakobson et al. compared highly trained pianists with matched individuals with no formal music training. All participants were asked to study multiple, eight-item lists consisting of four numbers presented visually (either 1, 2, 3, or 4) or four piano notes presented aurally and were then asked to recall their given stimuli using numbers. In the case of visual stimuli, the numbers were recalled in the modality it was presented and for auditory stimuli, the notes were also presented by numbers where the lowest played note equals 1 and the highest played note equals 4. The study revealed that musicians recalled more items in both experimental groups, allowing the researchers to conclude that music training correlates to superior verbal recall abilities compared to non-musicians.

Besides investigating the verbal memory of musicians compared to non-musicians, Jakobson et al. also tested the visual memories between the two groups, using the RVDLT. The RVDLT consisted of a series of images that were presented to the participants and after a delayed period of 15 minutes, each participant was asked to draw all the figures they could recall, in no particular order. The results demonstrated that musicians scored significantly higher on the RVDLT compared to matched non-musicians. In addition, the researchers found a stronger correlation between CVLT-II scores, which measured verbal memory and RVDLT scores in musicians compared to non-musicians. Lastly, this study also found that musicians had significantly higher estimated Full-Scale IQ compared to non-musicians.

This study found significant differences in IQ, verbal memory and visual memory of musicians compared to non-musicians. The researcher suggests that verbal memory advantage demonstrated by musicians does not simply reflect on rote memorization skill (Jakobson et al., 2008), but it is associated with superior abilities to extract higher-order, semantic information during encoding, as shown as likewise high visual memory abilities. However, what is problematic is that the researchers did not show whether higher IQ in the musician group was preexisting or due to musical training. Thus, the researchers cannot separate the individual differences in IQ, verbal and visual memory from the effects of music training.

Discussion

All three studies referenced Gaser and Schlaug's imaging study to discuss the different neural structures of musicians compared to non-musicians. They extended the study to investigate whether there are behavioural differences in musicians as well. Cohen et al. used familiar music, non-familiar music, speech sounds and environmental sounds to determine whether or not musicians' superior auditory memory extended to non-musical auditory stimuli. The study concluded that musicians' superior verbal memory extended to non-musical stimuli, such as speech and environmental sounds. Peretz and Coltheart reviewed existing literature on amusia and agnosia patients. They noted that amusia patients were still capable of recognizing spoken words, and agnosia patients were still capable of recognizing musical melodies. They concluded that the effects of music are confined to the realm of musical ability. Jakobson et. al conducted the CVLT-II and RVDLT tests on the musician and non-musician group to investigate whether the superior verbal memory in musicians extended to visual memory as well. They concluded that music training improves both verbal and visual memory.

Research on the effects of music training raises a major concern because studies are rarely done using randomized controlled trials (RCTs). All studies discussed in this paper recruited participants from pre-existing groups: musicians and non-musicians. However, confounding factors such as IQ scores, socio-economic status (SES) and cultural backgrounds could compromise the validity of the effects as the researchers did not separate the individual differences in these variables with verbal and visual memory performance from the music training effects. As such, it is still unclear whether superior performance in verbal and visual memory in the musician group was preexisting or due to musical training.

Perhaps, using randomized controlled trials (RCTs) could minimize the confounding variables by randomly assigning participants to the music intervention group and the matched control group. This method, however, poses a significant challenge. Though extrinsic factors such as SES could be controlled, intrinsic factors such as motivation can still pose a significant challenge to the validity of the experiment. Children in the music training group who are more motivated may enroll in the program for the entire length of the study, while those who are unmotivated may withdraw from the study, causing the results to be skewed to the children who are motivated to receive music training. Additionally, unmotivated children may not invest equal time to practicing compared to those who are motivated, thereby introducing a major confounding variable. Moreover, forcing the children in the music training group to practice their instrument every day despite their potential lack of motivation and interest could raise significant ethic concerns. Furthermore, prohibiting children who are randomly assigned to the control group from taking music lessons during the study may raise ethical concerns as well.

Future directions

Gaser and Schlaug's study examined solely gray matter volume using the MRI, whereas the other three studies discussed in this paper only used behavioural measured to investigate the effects of music training on auditory and visual memory. Perhaps in future studies, large-scale trivariate methods using fMRI, EEG and behavioural tests could be used to provide a more holistic perspective of the specific cognitive processes that are affected following music intervention (Turner et al., 2016). fMRI studies provide excellent spatial resolution while EEG studies provide excellent temporal resolution. Many neuroscientists have combined these two imaging techniques to gather fine-grained details of a higher-order neural process where many brain regions interact to perform a given task provided by EEG imaging and also the spatial information provided by fMRI imaging. Furthermore, the imaging techniques could be paired with behavioural tests to examine how neural processes in different areas of the brain translates to measurable behavioural differences.

The three studies investigated whether music training extends to other near or far realms with different approaches. However, the complexity of the brain poses challenges in designing a valid and reliable method as well as interpreting the results. Across the three studies, the designs and methods varied widely as do the sizes of the samples of participants. Though the three studies have made comparisons between groups identified as musicians or non-musicians, a more comprehensive study could recruit professional or young musicians with varying levels of expertise to isolate confounding variables such as age and amount of training, rather than using a binary method to divide the two groups. Moreover, each study varied in the length of the intervention, the range of measures adopted to measure outcomes and the ages of the participants, thereby producing conflicting evidence. Future studies could use qualitative research methods including interviews, focus groups, ethnographic and case studies to grasp a more holistic and representative view of the music training experience. These qualitative research methods may be used to explore the contexts within which music may have a wider impact.

Conclusion

The specific mechanisms that bring about changes following music training are unclear. However, an increasing number of studies have suggested that music training is likely associated with improvements in other areas that are not related to the training itself, such as visual memory. When synthesizing the literature, it is important to analyze each study in its context as different factors such as gender, age, surveys and even p-values may yield different conclusions. In my opinion, one study cannot generalize to entire populations. Likewise, scientists cannot make broad conclusions that music training directly improves other skills outside of its realm of training. As such, parents, educators and policy-makers must have a broad perspective of the current literature and be mindful of other important factors that are often associated with music education.

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