The Effect of Music Education on Math Ability in Children

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Abstract

The decline of music education in schools has raised questions about potential cognitive benefits of music training, specifically in mathematical areas. Existing research suggests that music training may improve skills important for math, such as pattern recognition, and working memory. In this paper I review correlational and experimental studies linking music training with math performance. Correlational studies suggest that music training is related to math, but it's hard for them to prove a strong causal link because they struggle with potential confounding effects of outside variables. However, proving a causal connection through experimental studies remains a challenge due to the expense, ethics, and time needed for an effective study. Overall, studies find some evidence for a connection between music and math, but call for more research. To better understand this topic, future studies should focus on issues like finding long term effects, and isolating effects of musical training. Strengthening research designs and finding more evidence can lay the groundwork for evidence on the importance of musical training.

Introduction

According to the National Assessment of Educational Programs in the Arts, student exposure to arts education has steadily declined since 1997, with over 3.6 million students not having access to music education. Some research has found that kids exposed to music often perform better on pattern recognition and working memory (Schellenberg, 2005; Hyde et al., 2009). Musical abilities and the skills involved in musical training have become a topic of interest for many researchers. When looking into why music should be more valued in schools, the benefits need to first be investigated. Is it possible that the process of learning an instrument itself can help with seemingly unrelated skills like math? Music relies a lot on pattern recognition and recognizing the relationships between pitches and rhythms- skills that could be useful for math. Due to the skills used it's possible that improving one area could help the other.

Despite interest in the area, evidence for a causal link between math and science is sparse. Many studies depend heavily on correlation, and it is difficult to design a completely randomized and unbiased study. Any correlational outcomes are often influenced by many outside factors including socioeconomic status and prior abilities. Additionally, increased math ability is particularly challenging to assess. Math is a complicated topic with many subtopics that have varying skills required, this alone creates another set of problems for researchers. For these reasons, evidence supporting a causal connection between music and math is hard to prove, with some studies reporting varying results, and others finding no relationship between domains. This paper aims to provide a critical review and summarize existing literature on the effect of

musical training on mathematical abilities. It examines current issues with research methodology and explores new experimental designs aimed to provide more conclusive results. This research aims to provide reasoning as to why music education should be more prioritized in schools, and bring light to the decreasing attention to music education.

Near and Far Transfer

There are theories in the field of cognitive science suggesting that learning one thing might improve your ability to learn something else. One such theory called near and far transfer, can help ground available evidence on music training. Near and far transfer are the applications of learning from one area to another; these theories are critical to understanding how someone can apply knowledge beyond initial learning experiences. Near transfer is when learning a certain skill or ability influences it or a similar one whether positively or negatively. For example, someone who learns rhythmic rules in music writing might improve in their musical technique. In contrast, far transfer is when something from a seemingly unrelated domain has an effect on another, in this case music and math.

Results

Correlational studies

Many studies investigating the relationship between music training and mathematical ability are correlational. One study found preliminary evidence that music training could enhance musicianship which could be valuable in schools. This study included a group of 38 male students and 47 female students, in year 10 who were 15.5 years old on average (Bahr, 2012). Two tests were administered to the students, both designed by researchers. The Musicianship Rating scale measured musical ability based on pitch, tonality, keys, scales, time, rhythm, and terminology. The Mathematics Test was designed to measure the understanding of concepts learned in first semester year 10 math. This study found a positive correlation between musicianship and math skills. However, musicianship is not exactly the same thing as music training. Musicianship is more the ability to have artistic sensitivity when playing music, and it does not directly mean they are extremely skilled or technical; rather they have the ability to emotionally interpret music. Still musicianship is a quality that is often achieved through musical training, therefore this study provides preliminary evidence that increased music training might be beneficial in schools.

Building on this evidence, Foregeard (2008) provides a more direct test of a connection between music training and math. Forgeard (2008) compared 59 children aged 8-11 with at least 3 years of musical training (on average 4.6 years) to a control group of children who had never received musical training. The study similarly found a positive correlation with fine motor skills, vocabulary, and audio distinction. While these results suggest an association between music and math, factors like self-selection bias, and socioeconomic status make it hard to find solid

evidence. When the researcher is unable to control which children get musical training, there is a possibility that children who excel at academics are just more likely to play an instrument, whether because their parents are more likely to push them towards it, social influences, such as their friends participating in music, or just pure connected interest. Socioeconomic status can similarly skew results. Families who are more affluent have the resources to send their kids to music lessons, and also access to different resources designed to enrich academic performance. Therefore, a correlational study can be showing a link that is actually caused by outside factors.

While these studies are promising, several reviews find mixed evidence for a connection between music training and math. Sala et al (2017) reviewed studies on the effect of music training on cognitive and academic abilities in children aged 3-16. They found that most studies were correlational and not causal, and across all studies there was little to no effect observed. Vaughn (2000) conducted three meta analyses, which found that background music had a minimal effect on math performance. Some issues in the group of studies used were differences in control groups. Not all control groups were the same, so it was hard to replicate effects. The measurement tools used in the studies varied, which makes it hard to determine if the effect is caused by differences in the tests used. Both findings of these reviews are examples of why there is a need for more standardized measurement tools, and consistent study designs to provide more concrete evidence.

Hille et al (2011) introduce another issue with correlational studies. Hille et al. (2011) look at the role of extracurricular activities, including musical training. The study included 194 third grade boys from various schools. One group of children had previously received musical training and one group hadn't, based on a parental report. Students were tested on spelling ability and non-verbal intelligence using standardized tests. Their findings indicate that children who participate in music often come from families with a higher socioeconomic status, which could be the reason for a link to higher academic performance when having received music training. It's important to look at variables like these because they can often skew results and create a spurious correlation. Socioeconomic and cultural advantages often give people more academic advantages. This study highlights the importance of accounting for outside variables.

Correlational studies suggest a relationship between music training and math, but the evidence is mixed, and causality is difficult to determine. Despite these challenges, correlational studies are still a popular option. This could be due to many reasons. One of the most likely reasons is that it is challenging to execute an intervention study where the researcher assigns groups, to limit confounding variables. It's also expensive to conduct a long-term, randomized study on a large group. On the other hand it is easier and more efficient to find a large group for correlational studies. While correlational evidence is valuable, without a causative role tying

musical training to success in other subject areas, music training often falls low on the list of priorities for policy makers.

Experimental studies

Experimental studies are more of a gold standard for determining causality. The researcher is given control of which groups get which factors, this allows them to limit biases that happen with correlational studies, where participants aren't placed into groups by the researcher. There have been fewer experimental studies examining the link between music and math, but here we examine a few of them. Experimental studies are more reliable, however as discussed below they too come with their own set of issues.

One study (Sanders 2012) looked at how different types of music training and mindset affect math ability. There was no traditional control group, and instead six different groups, with half of them being explicitly told they were training music for the benefit of math and the other half just participating in the lessons. Each subgroup had one group learning melody, another rhythm, and the last one learning technique (ie. form while playing). The classes were taught over 9 months with 200 participants aged 7-8. Overall, all groups showed improvement in math abilities after the lessons, but the subgroup that was told about the math connection had the biggest improvement, and out of that subgroup, rhythm had the biggest change. These results are promising but are not solid proof into a relationship between music and math. Due to the lack of a true control group, one where there is an absence of music training, it's hard to even say that the improvement in math was a result of music training. It could just be the natural improvement of skills over time. This study also measures the effects of explicitly telling someone something versus not. This study did have several strengths as well, while it wasn't measuring exactly the effects of music, the design was consistent and thorough between groups, which allows for more accurate results. In order to measure music training the study could add a control group where they have no class and another group with some other sort of 40-minute extracurricular besides music training; that way, researchers can isolate whether it's just having an extracurricular present or specifically music training that improves math.

Two studies that have a more traditional control group focused on whether piano training affected academic performance, and self-esteem (Costa-Giomi, 1999; Costa-Giomi, 2004). Both studies looked at a group of 117 students before and after three years of piano training. The first study focused on the cognitive effects of piano training, specifically spatial-temporal reasoning, a skill that's important for both math and science. The study found that children who took piano lessons had a higher IQ, and spatial temporal reasoning after piano training, compared to the group which did not. After the study ended the students were tested again, and found that the gap between no training and training had started to lessen (Costa-Giomi, 1999). It called for more exploration involved in changing factors, such as method, duration, and intensity of music

training. The second study instead measured self-esteem before and after piano training (Costa-Giomi, 2004). Her reason for measuring self-esteem was because she hypothesized that emotional well-being and self-confidence are important for academic success, which could be confounding variables in the first study. Her second study was a follow-up study, providing more literature to look at and taking a different approach.This design allows her to establish a causal path between music training and academic performance. The combination of these two studies is compelling because she only changed a single factor each time, and is worth replicating with other factors. This strategy of only changing one factors is time consuming, but makes it easier to isolate factors by themselves and be more sure of what is causing the change.

Ribeiro et al. (2020) was an intervention study that explores how musical training could help children with developmental dyscalculia (DD), a learning disability similar to dyslexia. DD makes it harder to learn math. The study followed two groups of students with twenty-two in each group, one group with DD and one without, as they went through music training. This smaller sample size means reduced variability within each group, which could potentially skew the results. The researchers tested the children's math skills before, during, and after the training, and checked back 10 months later to see if the effects lasted. The results showed that children with DD improved in number comprehension, number production, and calculation. These improvements continued even after the music lessons ended, which suggests that music training does not have immediate temporary effects but more permanent benefits. The study found no major changes in abstract visual reasoning, meaning the benefits were most likely specific to math skills rather than general thinking ability.

Understanding the connection between music and math is important because it could lead to new educational approaches. If schools included music as part of their math curriculum, it could provide an alternative way to teach number concepts, and could help more students succeed. This study provides a unique look to music training, that it could actually help children with conditions like DD (Ribeiro et al., 2020). One limitation of the study is that it did not include a control group of children who did not receive music training, making it hard to say for certain if music was the main reason for the improvements. More research is needed to confirm these results and to determine if it really is music causing the change, or just the presence of an extracurricular activity.

Schellenberg (2004) was a study that explored effects of voice lessons and drama lessons, in addition to music lessons. It involved 144, six-year olds who were split into four different groups. One group in voice lessons, one group in drama lessons, one group in music who learned to play keyboard, and one control group who did not do an activity. IQ tests were performed on the kids before and after a year of lessons. The results found that students participating in keyboard lessons and voice lessons had more IQ improvement than drama and the control group. Children in the drama group had the biggest increase in social aspects, which was not true for

the music groups. Having good social skills can be important especially in children in learning environments. Being able to succeed academically does not depend solely on factors like IQ, making this study an interesting new way to approach a connection between music and math.

These findings suggest that music training might provide cognitive benefits that are broader and not necessarily specific to math. This study finds that it is most likely music training improving a variety of things, like memorization, attention, and coordination, all of which are a part of how effectively a child can learn something.

While these findings are promising, drawing conclusions from experimental studies can be problematic due to confounding factors. Being able to find a large enough group of children willing to participate in this study for as long as needed, is challenging. It is impossible to limit every single factor, especially in this case. Some parents may want to enroll their children in music, or kids might participate in it themselves despite being placed in a non-music group. It is also possible that parents who pull their kids out of a study share some common trait (income, work responsibilities, etc.) and this could skew results. Below I explore possible solutions to these issues.

Discussion

As music training is being underfunded in education, there is an important role for science to demonstrate the value of music for other more traditional subjects such as math. To better understand the connection between music training and math abilities there is a need for well controlled experimental studies. Many of the studies reviewed here provide preliminary evidence that learning music potentially causally improves math abilities. While these are compelling studies, each suffers from its own limitations. For example some studies did not have an assigned control group (Sanders, 2012). Some were not able to separate effects caused by music from other activities (Schellenberg, 2004). Others found effects but didn't follow up long term to see if these effects persisted (Sanders, 2012). Each of these limitations are important to address in future research.

Lacking a proper control group makes it difficult to determine causal effects. A control group creates a baseline to measure effects. In Sanders (2012) there was a lack of a control group that did no musical training. Instead he used different aspects of music training and compared them, which made it harder to determine if the effects observed were from the musical training they received, or just a natural academic progression. In future research there should be a randomized control group that is monitored exactly the same as the experimental group, to have a proper baseline.

Even with a control group determining if music specifically has an effect on math can be challenging. There needs to be evidence that music training specifically, as opposed to any

organized activity ie. sports clubs, is what causes the benefits. While one study found an increased IQ after music training, it also found similar effects after taking drama lessons (Schellenberg, 2004). This study provides evidence that just having any structured extracurricular activity may improve academic abilities. This possibility raises the question of if music itself has unique abilities or whether any engaging activity could produce similar benefits. As music training is increasingly undervalued in schools, it's important to provide evidence of the specific value of learning music. Thus future studies should investigate other activities in addition to music, using their same study model.

In addition, determining the long term effects of musical training should be a focus of future studies. For example some studies found that after music training standardized test scores were improved immediately, but these studies did not check back in for long term effects (Sanders, 2012). While a short term effect still has some effect, without a long term effect a lot of the importance of these studies is lost. If this were to provide evidence as to why there should be more support for musical programs in schools, there would need to be some sort of tangible long term effect. Studies should focus on checking in years later to solidify a long term effect.

Regardless of a connection between music and math, learning music itself may be inherently valuable. Music is one of the oldest ways humans have used to communicate. Music is intertwined with human social evolution, it is weaved into culture, emotional expression, and social connections (Schulkin & Raglin 2014). Music brings shared meaning and enriches social connections that just words often cannot do. Even if music training does not directly enhance mathematical abilities, its intrinsic value in fostering human connection and cultural continuity justifies its place in education.

Conclusion

Music education has been devalued in recent years, making it important to look at potential benefits of music education that we could be losing when pulling it from schools. Existing research suggests that music training may be connected to skills that are vital for success academically, specifically in math. Most of the literature available are correlational studies, due to them being more accessible to perform, but it is impossible to prove a causal claim off of purely correlational studies. However researchers do not always have the resources available to perform experimental studies, because of expenses, time needed, and ethics. To strengthen research design, future studies should focus on determining long term effects of music training, and they should reduce confounding factors to isolate the effects of musical training. Identifying a causal link between musical education and student success in other subject areas will highlight the importance of musical training for future generations.

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