

The Effect of Music Intervention on Children's Cognitive Development: A Review Study

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Abstract. This review study investigates the effect of music intervention on children's cognitive development, focusing on general cognitive skills, academic skills, and executive functions. The aim of this study is to synthesize the main findings from empirical research into the role of music in enhancing children's cognitive competencies. The review encompasses a range of studies that utilized experimental and correlational designs, involving children from preschool to adolescence. The main findings pointed out that music intervention favorably influences IQ and verbal memory, with some pieces of evidence suggesting its contribution to improved academic performance and even executive functions, such as working memory and cognitive flexibility. However, across methodologies, age groups, and the nature of the music intervention, the strength of effects does vary; thus, the benefits possibly appear more pronounced in private music tuition or specific populations. It thus concludes that while music education holds promise for improving cognitive skills, further longitudinal research is necessary to understand long-term effects and to develop focused music education programs that maximize cognitive benefits across diverse groups of children.

Keywords: Music Therapy; Working Memory; Executive Functions.

1. Introduction

The study reviews the key literature regarding to the effect of music intervention on children's cognitive development. Numerous scholars have conducted empirical research examining the role of music in children's cognitive development (Ho et al., 2003; Kaviani et al., 2013; Schellenberg, 2004). Studies have predominantly focused on the impact of music intervention on children's visual, auditory and voice awareness. More importantly, music intervention has positive effects on cognitive skills and academic skills (Bhide et al., 2013; Kaviani et al., 2013; Moreira et al., 2013; Schellenberg, 2004).

At present, the specific protocols of music interventions and their impacts on cognitive development have been underexplored in China. To enhance the public attention and recognition of the role of music intervention in children's cognitive development, and to expand the application of music intervention. This paper aims to study the interventional effect on three major areas, which are general cognitive skills IQ, academic skills, executive functions. This study begins with the music intervention's effect on children's general cognitive skills, followed by the music intervention's effect on children's academic skills, for example, math and reading. Finally, the paper delves into the effect of music intervention on children's executive functions such as working memory, cognitive flexibility. The study intends to provide evidence-based insights into the applied applications of music in educational contexts. A more nuanced understanding of music's contribution to various cognitive domains can help inform more effective programs directed towards optimizing children's intrinsic capacity for learning.

2. Review of Literature

2.1 Impact on General Cognitive Skills IQ

2.1.1 Summary

Collectively, the five studies provided some mixed findings regarding the effect of music intervention on general cognitive abilities, such as IQ, in children (Ho, Cheung, & Chan, 2003; Jaschke, Honing, & Scherder, 2018; Kaviani, Mirbaha, Pournaseh & Sagan, 2013; Portowitz,

Lichtenstein, Egorova & Brand, 2009; Schellenberg, 2004). Schellenberg (2004) found that lessons in music, compared with lessons in drama or no lessons, produced an increase in full-scale IQ in children, thus supporting that the education of music enhances general cognitive skills in addition to musical abilities. Similarly, Ho et al. (2003) reported that music training enhanced verbal memory (as a critical component of IQ) but not visual memory among children, which indicated that the influence of music on cognitive functions is salient. Kaviani et al. (2013) reported significant increases in IQ among preschool children who underwent music lessons through enhanced verbal reasoning and short-term memory. Portowitz et al. (2009) examined the effects of a music program on high-risk children and reported enhanced cognitive skills along with enhanced social esteem. Strikingly, Rickard et al. (2012) failed to observe broad cognitive or psychosocial benefits of school-based music instruction in 10–13-year-olds, which contrasts with the benefits described for private music training.

2.1.2 Synthesis

The studies all highlighted the benefits of music education, specifically on general cognitive development (e.g. IQ). The designs were both experimental and correlational, with participants ranging from preschool to adolescent students. Schellenberg (2004) and Kaviani et al. (2013) used the experimental-control group approach, assigning children to music or non-music activities and measuring changes in IQ, whereas Ho et al. (2003) used a cross-sectional and longitudinal approach to examine the longitudinal effects of music training on verbal memory.

With regard to the results, both Schellenberg (2004) and Kaviani et al. (2013) produced positive effects on IQ scores after the implementation of music intervention and therefore supported the hypothesis that music education improves general cognitive abilities. Ho et al. (2003) furthered this by demonstrating that music had a specific effect on verbal memory, which is a crucial component of IQ. Portowitz et al. (2009) further incorporated social esteem by adding another dimension to the cognitive benefits that music education are able to solve problems that required such skills like general learning skills may serve as mechanisms that link music education and cognitive modifiability

However, Rickard et al. (2012) contradicted these findings and added that the benefits perhaps are limited to private music tuition or specific populations, for example, students in socio-economically disadvantaged schools. The differences in results may be due to differences in methodologies used, age of participants, and the nature of music intervention. The positive findings in Schellenberg (2004) and Kaviani et al. (2013) may have resulted from the more structured and focused nature of the music lessons themselves, while the null findings of Rickard et al. (2012) may reflect the more general and possibly less intensive nature of the school-based music programs. Students in socio-economically disadvantaged schools may be more responsive to the intervention because of their lack of early exposure to music. Therefore, the initial direct effect of intervention would be pronounced. Moreover, both duration and intensity of music training may also be important factors affecting its influence on cognitive skills. Longitudinal duration and high-frequent intensity are ideal for the development.

2.1.3 Research Gaps and Directions

These studies no doubt provided useful insights into the effects of music intervention on children's cognitive skills; however, a number of gaps still remain. Most of the research has focused on the immediate cognitive benefits, with less attention given to long-term effects and the sustainability of these skills beyond the music intervention period. For example, it is underexplored whether the cognitive enhancements observed are temporary or engender long-lasting changes in cognitive abilities.

In addition, the methodologies and populations of these studies vary considerably, casting serious doubt on generalizing that music indeed facilitates IQ and cognitive skills uniformly. There is an urgent need for more standardized and randomized controlled trial (RCT) studies to tease out what elements in music education make for cognitive enhancement. Further, some longitudinal studies have explored the role of individual differences in age, socioeconomic status, and pre-existing cognitive abilities to determine how this influences the potential impact of music education on

cognitive development. These studies have a profound significance for the in-depth exploration of music education for the development of cognitive ability.

Furthermore, future research should address the limitations by conducting longitudinal studies that trace the development of cognitive abilities for extended periods beyond the time of the music intervention. More research is also needed regarding the specific aspects of music education to which cognitive enhancement can be attributed and individual differences as potential moderating factors. Further investigation into the neural bases of these observed cognitive benefits might provide a better understanding of how music education leads to changes in the developing and developed brain. Such research may lead to the development of targeted music education programs that maximize cognitive benefits for diverse groups of children.

Additionally, considering that most of the reviewed studies indicated the role of music education in the development of social skills and emotional well-being, further exploration is warranted. Appreciating the more holistic impact of music in child development could inform consolidating the place of music education in mainstream curricula, beyond limited academic and cognitive gains.

With that in mind, while the research to date has gone a long way toward understanding the relationship between music education and cognitive development, there is certainly a need for further studies that are comprehensive, longitudinal, and nuanced. These would not only provide clarification of the specific benefits of music education but would be guides to educational policy and practice with the aim of unlocking the powers of music in child cognitive and socio-emotional skill enhancement.

2.2 Impact on Academic Skills

2.2.1 Summary

The impact of music intervention on children's academic skills has been a subject of interest within educational and psychological research. This literature review synthesizes findings from five studies that explored the effects of music education on the academic performance of children across different age groups, including preschoolers, elementary school students, and adolescents (Tierney & Kraus, 2013; Bhide, Power & Goswami, 2013; Costa-Giomi, 2004; Cogo-Moreira, Avila, Ploubidis & Mari, 2013; Hogenes, Oers, Diekstra & Sklad, 2015). The studies focused on a range of academic skills, with a particular emphasis on reading, language, and mathematical abilities. Bhide et al. (2013) conducted a comparative study of rhythmic musical intervention versus a letter-based intervention for poor readers, finding both approaches beneficial for literacy development. Giomi (2004) assessed the effects of piano instruction on academic achievement and self-esteem in fourth-graders, reporting enhancements in self-esteem but not in math or language achievements. Moreira et al. (2013) conducted a pragmatic cluster-randomized trial to evaluate the impact of music education on reading skills and academic achievement in young poor readers, yielding positive results, especially when considering compliance with the intervention or not. Tierney & Kraus (2013) provided a comprehensive review linking musical training to enhanced reading ability through various subskills. Hogenes et al. (2015) explored the effects of music composition in the classroom on engagement and academic achievement, noting increased engagement but no significant changes in academic or music achievement.

2.2.2 Synthesis

Despite their shared focus on the academic benefits of music intervention, these studies differ in several key aspects. Methodologically, they ranged from randomized controlled trials to quasi-experimental and review studies, reflecting a diversity of research designs. Participant demographics also varied, including preschoolers, elementary-age students, and adolescents, which influences the generalizability of findings.

Bhide et al. (2013) and Moreira et al. (2013) both focused on struggling readers, yet their methodologies and outcomes differ. Bhide et al. (2013) compared two distinct interventions, while Moreira et al. (2013) implemented music education as a whole-school intervention. Giomi (2004)

provided a control group with no music instruction, offering a contrast to the other studies that incorporate music into the curriculum. Tierney and Kraus (2013) suggested a biological basis for the link between music and reading skills. Hogenes et al. (2015) administered a classroom-based intervention, focusing on music composition as an active learning strategy.

With regard to the results, there is a consensus that music intervention can positively influence academic skills, particularly in reading. For example, Bhide et al. (2013) and Moreira et al. (2013) found that music intervention can improve reading fluency and phonological awareness in children with reading difficulties, while Giomi (2004) observed no significant impact on academic achievement from piano instruction. However, the specific nature of these benefits varies. Bhide et al. (2013) and Moreira et al. (2013) reported improvements in reading skills, supporting the hypothesis that music education can enhance literacy skills. Tierney and Kraus (2013) reinforced this by linking music training to improved neural processing relevant to reading. In contrast, Giomi (2004) found no significant impact on academic achievement, suggesting that music's benefits may not translate directly to standardized measures of math and language skills. Hogenes et al. (2015) identified increased engagement but no improvement in academic scores, indicating that the impact of music on academic performance might be indirect or require a different metric for assessment.

2.2.3 Research Gaps and Directions

While the studies conducted thus far have established a foundation for understanding the potential links between music intervention and academic skills, significant gaps still remain. The variability in methodologies and outcomes across studies suggests a need for more standardized approaches to assess the impact of music education. This standardization would allow for more direct comparisons between studies and could help pinpoint the specific elements of music intervention that are most beneficial for academic skills.

Secondly, while some studies indicate improvements in reading skills, the effect on other academic areas, such as math and science, remains understudied. Future research should explore the impact of music intervention on a broader range of academic subjects to provide a more comprehensive understanding of its potential benefits.

Longitudinal studies are also needed to determine the long-term effects of music intervention on academic achievement. Many of the current studies only assessed outcomes immediately following the intervention, leaving questions about the durability of any gains made. Additionally, there is a lack of consensus on the specific components of music education that contribute most effectively to academic gains. Future research should explore the differential effects of various music interventions, such as rhythm training versus music composition, and how they relate to academic skills across different age groups. In addition, more research is needed to understand how music intervention interacts with other educational strategies and how it can be integrated into standard curricula to maximize its potential benefits. By addressing these research gaps, the educational community can better leverage the power of music to support academic development and achievement in children.

Lastly, more research is needed on the underlying mechanisms that link music training to academic improvement. Understanding these mechanisms could inform more targeted educational strategies and potentially enhance the effectiveness of music interventions in academic settings. In conclusion, while the current body of research suggests that music intervention can have a positive impact on children's academic skills, further investigation is needed to fully understand and maximize these effects.

2.3 Impact on Executive Functions

2.3.1 Summary

The ten synthesized studies provided a comprehensive look into the impact of music intervention on children's executive functions (EF), a set of cognitive processes that include inhibitory control, working memory, and cognitive flexibility. (Bayanova, Chichinina, Veraksa, Almazova & Dolgikh,

2021; Bowmer, Masion, Knight & Weich, 2018; Chen, Scheller, Wu, Hu, Peng, Liu, Liu, Zhu & Chen, 2021; Frischen, Schwarzer & Deg'e, 2021; Holochwost, Propper, Wolf, Willoughby, Fisher, Kolacz & Jaffee, 2017; Jaschke, Honing, Scherder, 2018; Moreno, Bialystok, Barac, Schellenberg, Cepeda & Chau, 2019; Roden, Grube, Bongard & Kreutz, 2014).

The first study by Jaschke et al. (2018) investigated the longitudinal effects of music education on primary school children's EF, tracking improvements in inhibition, planning, and verbal intelligence over a 2.5-year period. The second, by Bowmer et al. (2018), used a two-phase experimental design to assess the impact of musicianship training on 3-to-4-year-olds, showing improvements in planning and inhibition skills. The third study, a cross-sectional study by Jaschke et al. (2018), explored the relationship between a musically-enriched environment and cognitive functions in primary school children, revealing no significant relationship with executive sub-functions but a trend with verbal IQ. Roden et al. (2014) examined the influence of instrumental music training on working memory performance in primary school children, reporting superior developmental courses in children with music training. The fifth study, Holochwost et al. (2017), examined the association between music education and academic achievement, along with EF, in a diverse sample of children. The study by Moreno et al. (2011) explored the effects of short-term music training on verbal intelligence and executive function, finding enhancements after just 20 days of training. The seventh study by Frischen et al. (2021) explored the effects of instrumental music lessons on EF in 6- to 7-year-old children, finding improvements in some components of EF, particularly inhibition, after an 8-month training program. The next study by Moreno et al. (2011) reported that short-term music training enhances verbal intelligence and executive function in preschool children. Shen et al. (2019) examined the sustained effect of music training on EF in preschool children, showing that music training can enhance EF and that these effects persist 12 weeks after the training ends. Lastly, Chen et al. (2021) investigated the relationship between early musical training and EF, suggesting that early childhood may be a sensitive period for the influence of music training on EF.

2.3.2 Synthesis

The studies shared a common interest in how music intervention affects children's EF. They diverged, however, in their methodologies, participant demographics, and findings. The methodologies ranged from randomized controlled trials to longitudinal studies, and the participants varied from preschoolers to elementary school children. This diversity in methodology and participant age provided a more holistic understanding of how music training affects EF at different developmental stages.

Jaschke et al. (2018) and Bowmer et al. (2018) employed with preschool and primary school children. Both used structured music education programs, but Bowmer et al. (2018) focused on a younger age group. Jaschke et al. (2018) examined a musically-enriched environment's impact on primary school children, using questionnaires and neuropsychological tests. Roden et al. (2014) and Moreno et al. (2011) also investigated the effects of music training but through a quasi-experimental study and a training program, respectively, with different age groups. Holochwost et al. (2017) focused on a diverse sample, linking music education to both academic achievement and EF through a lottery-based music program.

In addition to the difference in participant group, the studies differed in the duration and intensity of the music interventions. Moreno et al. (2011) and Shen et al. (2019) reported immediate effects post-intervention, whereas Chen et al. (2021) highlighted the long-term benefits of early music training on EF. Methodologically, Jaschke et al. (2018) and Bowmer et al. (2018) employed longitudinal and experimental designs only rather than Roden et al. (2014) and Moreno et al. (2011) investigated through a quasi-experimental longitudinal study and a short-term training program, respectively. Jaschke et al. (2018) examined cross-sectionally only while Holochwost et al. (2017) stood out with its focus on a diverse sample. Frischen et al. (2021) used a randomized controlled design, while Moreno et al. (2011) and Shen et al. (2019) employed interactive computerized training

programs. Chen et al. (2021) validated the effects of music training by comparing early and late training onset, providing evidence for a sensitive period hypothesis in EF development.

With regard to results, positive effects of music training on EF were identified (i.e. Chen et al, 2021, Moreno et al, 2011, Aschke et al, 2018, Roden et al, 2014). Chen et al. (2021) showed that early music training has a more significant impact on EF than late training, suggesting a critical period for music's influence on cognitive development. The positive effects on inhibitory control were found in Frischen et al. (2021) and Shen et al. (2019). The positive effects on working memory were found in Shen et al. (2019), Aschke et al. (2018) and Roden et al. (2014). Moreno et al. (2011) demonstrated rapid enhancements in verbal intelligence and executive function following short-term music training while Moreno et al. (2011) reported enhancements in verbal intelligence. Bowmer et al. (2018) found initial evidence of cognitive benefits from musicianship training in preschoolers. However, Jaschke et al. (2018) found no significant impact on executive sub-functions but a positive trend with verbal IQ, suggesting different aspects of cognition may be affected. These studies collectively suggested that music intervention can positively influence children's EF, yet the specific mechanisms and sustainability of these effects require further exploration.

At the same time, several studies reached a consensus that musical training has a positive effect on EF in children, with special emphasis on inhibitory control and enhancement of working memory. They also shared a common approach that employed musical training interventions and assessed cognitive outcomes through standardized tests and tasks designed to measure EF. Each study examined children at different stages of development, from preschool through early elementary school, providing a comprehensive view of the impact of music throughout childhood.

2.3.3 Research Gaps and Directions

While these studies provided valuable insights into the effects of music intervention on children's EF, several gaps remain. The duration of music programs varies, and there is a need for long-term studies to determine the sustainability of observed effects. The current body of research has established a connection between music training and improved EF in children, with a particular emphasis on the potential of early intervention. However, there are gaps in understanding the long-term effects of music training on EF beyond the immediate post-intervention period. Future research should focus on longitudinal studies that track the development of EF over extended periods, particularly in adolescents, to determine the lasting impact of music training. Additionally, the heterogeneity in methodologies and participant demographics makes it challenging to draw definitive conclusions. Thus, future research should focus on standardized intervention programs and control groups to isolate the effects of music from other variables. There is also a need for research into the specific components of music that contribute to cognitive enhancements, as well as the exploration of different music genres and their potential differential impacts. Furthermore, investigating the impact of music education on a broader range of cognitive functions and across various socioeconomic backgrounds could provide a more comprehensive understanding of its utility in educational contexts. Meanwhile, there is a need for research that explores the specific components of music training that contribute most effectively to EF development, as well as the potential for different types of music training (e.g., vocal vs. instrumental) to have varying effects on EF. Finally, investigating the mechanisms through which music training influences EF, such as neuroplasticity and cognitive transfer, could provide deeper insights into the relationship between music and cognition.

3. General Discussion

The research on the impact of musical intervention on children's cognitive development has important theoretical and practical implications for the fields of music education, language, and cognitive therapy.

From a theoretical point of view, the research points out that music and cognitive development are strongly related. Music, in its structured and patterned auditory stimulation, may act to activate neural networks supporting attention, memory, and executive functions (i.e., Roden et al., 2014). The improvements in IQ, reading fluency, and executive functions suggest that music education could be used as a tool for improving cognitive abilities. These findings practically support the incorporation of music programs into educational curricula, especially for children who might struggle to learn through traditional academic tracks. With music as an enhancer of cognitive potentials, educators are able to create more active and adaptive learning environments that address the various natures and needs of student learning.

In the context of language and cognitive therapy, music intervention now emerges as a promising adjuvant therapy. Improvement in verbal memory and verbal reasoning skills, as observed in many studies, suggest that music might play a key role in language acquisition and therapy (i.e., Giomi, 2004). The rhythmic and melodic structures of music may provide a scaffold for language learning, aiding in the acquisition of phonemic awareness and vocabulary. Additionally, engagement with music requires coordination at multiple levels of cognitive processes, including attention and memory, which are often impaired in a variety of cognitive disorders. Thus, music therapy may provide a complementary method to traditional cognitive therapy and therefore may enhance treatment outcomes by embedding the therapeutic process in a more enjoyable and engaging procedure for children.

One major pragmatic concern is multifaceted. Educators should recognize music as far more than a subject, however it functions as a gateway to achieve intellectual development. Research underlines the role music can play in fostering academic achievements and intellectual growth (Bhide et al., 2013; Kaviani et al., 2013; Moreira et al., 2013; Schellenberg, 2004). Policymakers should note this as a means of valuing cognitively developing young populations and consider budgeting schools, particularly public ones in low-SES districts.

The research therefore points out to psychologists and therapists that music is a very powerful tool even in a therapeutic setting (Rickard et al., 2012). By including music in treatment sessions, it could further help in the improvement of treatments for children with delayed speech, attention deficits, or other cognitive impairments. The emotional and social sides of these music-making activities should not be underestimated in contributing to the general well-being and social skills of children.

The integration of music into education and treatment processes provides a prolific avenue to enhance cognitive development in children. Research into music intervention does not stop at the effects on children themselves but continues to affect educators, therapists, and even policymakers both theoretically and practically. As future research continues to untangle the complexities of how music interacts with the developing brain, it becomes increasingly evident that music has the potential to change the current paradigm of educational practices and therapeutic approaches. It is beyond necessary that these insights be turned into specific strategies capable of marshaling the power of music in support of children's cognitive, linguistic, and emotional welfare.

4. Conclusion

A thorough literature review regarding the effects of music intervention on children's cognitive development brings to light a complex yet promising landscape. The empirical data indicates that music intervention is potentially effective in enhancing children's cognitive skills, especially in the spheres of IQ, academic achievement, and executive functions. These findings give credibility to the fact that music can be used as a tool for improving cognitive skills and furthering academic success, therefore supporting its inclusion into the mainstream curriculum.

The theoretical implications are deep, pointing to the possibility that music may stimulate neural networks associated with higher cognitive processes. In practical terms, this would suggest that music education is not simply an extracurricular activity but an integral part of a holistic approach to education that can play a role in the cognitive and academic development of children. The consistency

of these effects across studies with different methodologies and participant demographics strengthens the case for music's role in cognitive enhancement.

However, this research also emphasizes that what needs further investigation is the long-term effects of music intervention, what specific components of music education drive cognitive benefits, and what are the mechanisms of such effects. This implies that future studies should try to fill these gaps, longitudinally in design to track the development of cognition for an extended period, and through controlled trials that can isolate the unique contributions of music from other variables.

In conclusion, while the present body of research provides a sound basis on which to advocate including music in educational practices, it also calls for further insight and a more detailed understanding of the ways in which music may be used to maximize the cognitive and academic potential of children. The potential of music to transform educational outcomes and improve cognitive development is huge and hence justifies continued investment in research and practical applications in educational settings.

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