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The Long-Term Effects of Childhood Music Instruction on Intelligence and General Cognitive Abilities

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Abstract

This article reviews research on the effects of music instruction on general cognitive abilities. The review of more than 75 reports shows (1) the consistency in results pertaining to the short-term effects of music instruction on cognitive abilities and the lack of clear evidence on the long-term effects on intelligence; (2) the complex nature of the relationship between music instruction and intellectual measures due to the intervention of factors associated with who is interested, studies, perseveres, and succeeds in learning music; and (3) the importance of music practice on the long-term cognitive benefits of music instruction.

Keywords

childhood music, children, cognitive abilities, intelligence, IQ, music instruction

Research on the effects of music education on children's development has revealed a number of cognitive benefits associated with music engagement including improvements in intelligence, spatial abilities, phonological awareness, verbal memory, processing of prosody, academic achievement, processing of sound, and neurological development. Recent publications have discussed the extensive literature on the benefits of music participation focusing on children and young people (Hallam, 2010), the educational context of music lessons (Costa-Giomi, 2012), methodological and interpretative problems of such research (Schellenberg & Peretz, 2008), and the neurobiological effects of music instruction (Strait & Kraus, 2011). In this article, I will review selected studies to address the question of whether the cognitive benefits of music instruction are long lasting.

Correlational and Longitudinal Studies

The relationship between music and intelligence has been studied extensively for almost a hundred years (e.g., Hollingworth, 1926; see Costa-Giomi, 2012 for review). Researchers comparing the IQ of adults with and without music instruction have found, with a few exceptions (Brandler & Rammsayer, 2003; Helmbold, Rammsayer, & Altenmuller, 2005), a difference favoring musicians (e.g., Antrim, 1945; Schellenberg, 2006). Why those with musical training outperform their peers in tests of intelligence or tasks often included in intelligence tests has been the focus of much research and debate. A wide variety of cognitive tasks and skills have been studied using diverse methodologies and designs. Some of the skills studied include spatial abilities (Bilhartz, Bruhn, & Olson, 2000; Brochard, Dufour, & Després, 2004; Costa-Giomi, 1999; Gromko & Poorman, 1998; Hetland, 2000; Hurwitz, Wolff, Bortnick, & Kokas,1975; Orsmond & Miller, 1999; Rauscher et al., 1997; Sluming, Brooks, Howard, Downes, & Roberts, 2007; Stoesz, Jakobson, Kilgour, & Lewycky, 2007; Zafranas, 2004), verbal skills (Bolduc, 2009; Brandler & Rammsayer, 2003; Chan, Ho, & Cheung, 1998; Costa-Giomi, 1999; 2004; Costa-Giomi & Ryan, 2006; Douglas & Willatts, 1994; Forgeard, Winner, Norton, & Schlaug, 2008; Franklin et al., 2008; Gardiner, Fox, Knowles, & Jeffrey,1996; Ho, Cheung, & Chan, 2003; Hurwitz et al.,1975; Jakobson, Cuddy, & Kilgour, 2003; Jakobson, Lewycky, Kilgour, & Stoesz, 2008; Kilgour, Jakobson, & Cuddy, 2000; Magne, Schön, & Besson, 2006; Marques, Moreno, Castro, & Besson, 2007; Mei, Li, Long, Chen, & Dong., 2008; Moreno et al., 2009; 2011; Piro & Ortiz, 2009; Schön, Magne, & Besson, 2004; Thompson, Schellenberg, & Husain, 2004), and memory (Bugos, Perlstein, McCrae, Brophy, & Bedenbaugh, 2007; Costa-Giomi & Ryan, 2006;

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Degé,Wehrum, Stark, & Schwarzer, 2011; Franklin et al., 2008; Huntsinger & Jose, 1991; Lee, Lu, & Ko, 2007; Tierney, Bergeson, & Pisoni, 2008).

The results of most of these studies suggest that music instruction produces improvements in these specific abilities and skills. However, because of the correlational design of many of these investigations, it is difficult to establish the direction of causality unequivocally. For example, decades ago, Farnsworth (1946) and Ross (1936) proposed that bright students are more inclined to study music than are other students. If so, intelligence would predict music participation instead of the other way around. It is also possible that the superiority of musicians over nonmusicians in cognitive tests is caused by other preexisting cognitive and demographic characteristics. Ideally, researchers would test music and nonmusic participants prior to the start of music instruction and years later to establish the extent of the cognitive benefits provided by music learning. But such long-term experimental studies are obviously difficult to complete, and, not surprisingly, rare.

Although there is a notable scarcity of experimental research on the long-term effects of music instruction, many longitudinal investigations have been completed on the short-term effects of learning music. Most of these studies have been based on music interventions lasting less than one year (Bilhartz, et al., 2000; Gromko & Poorman, 1998; Graziano, Peterson, & Shaw; 1999; Hetland, 2000; Hurwitz et al.,1975; Kokas, 1969; Moreno et al., 2009; 2011; Orsmond & Miller, 1999; Persellin, 2000; Piro & Ortiz, 2009; Rauscher, Shaw, & Ky., 1993; Rauscher et al., 1997; Rauscher & Zupan, 2000; Schellenberg, 2004; Taetle, 1999; Thompson et al., 2004; Zafranas, 2004). Their results have consistently shown the positive effects of weeks and months of music instruction on general and specific cognitive abilities in children. However, they have provided no information about whether longer music interventions would result in larger cognitive gains or whether the cognitive benefits persist after the discontinuation of lessons.

Long-Term Effects

Few experimental studies have investigated the effects of music interventions lasting more than a year on children's intellectual abilities. Their results are conflicting as some provide no evidence that music lessons result in long-term IQ improvements (Costa-Giomi, 1999; Schlaug, Norton, Overy, & Winner, 2005; Hyde et al., 2009; Zulauf, 1993/1994) and others suggest that instrumental school music programs improve IQ or specific cognitive abilities. (Portowitz, Lichtenstein, Egorova, & Brand, 2009; Rauscher & Hinton, 2011). Portowitz et al. (2009) completed a 2-year study with elementary school children attending an enrichment music program at selected public after-school daycares. The program consisted of music lessons for the children and professional training on mediation techniques for their teachers. The findings showed that the children participating in the 2-year enrichment program outperformed their peers at another daycare (i.e., control group) in tests of cognitive abilities. However, the lack of randomization of the sample and the existence of confounding variables raise the question of whether the effects of the treatment were due to the music lessons, the mediation techniques used by the teachers, or other factors associated with the experimental daycares.

Rauscher and Hinton (2011) reported results of unpublished longitudinal studies in which young children were provided with 48 weekly music lessons over a period of 2 years. The results showed that children who participated in the lessons scored significantly higher in specific visual and auditory subtests identified as requiring spatial and temporal skills than did children in a control group. However, no differences in the total scores in IQ tests between the two groups of children were reported. Based on the results of other longitudinal investigations completed with elementary at-risk children, Rauscher and Hinton proposed that the nonmusical outcomes of music instruction depend on the quality of the music program as well as the age of the children. They reported that children who participated in up to 3 years of a poor-quality piano program showed no improvements in a variety of cognitive tests but those younger children provided with just 1 year of quality instruction showed significant gains in quantitative and spatial-temporal tasks.

Contradicting the positive results of these investigations, Schlaug and colleagues found no significant improvements in general intelligence in 5- to 7-year-olds provided with 14 months of piano or string lessons (Schlaug et al., 2005) or 15 months of keyboard instruction (Hyde et al., 2009). Two other experimental studies that focused on the cognitive effects of 3 years of music lessons did not provide evidence that the cognitive benefits of music instruction are longlasting either (Costa-Giomi, 1999; Zuluaf, 1993/1994). The results of these studies showed no cognitive gains in children engaged in piano instruction (Costa-Giomi, 1999) or in an intensive school music program (Zuluaf, 1993/1994). Interestingly, Costa-Giomi and Ryan (2006), who followed randomly assigned experimental and control children from the start of music instruction, during 3 years of music study, and 7 years after the discontinuation of lessons, did find the expected short-term cognitive benefits. Children taking piano lessons outperformed their nonmusic peers in cognitive tests after 1 and 2 years of instruction (Costa-Giomi, 1999; Costa-Giomi & Ryan, 2006). However, the superiority of the music group was short-lived as there

were no differences in cognitive performance between the groups at the end of the third year (Costa-Giomi, 1999). Additionally, 7 years after the lessons stopped, no cognitive advantages associated with childhood music instruction were detected (Costa-Giomi & Ryan, 2006).

Mediating Variables

The review of the existing longitudinal research on the effects of music engagement on intelligence presents us with the puzzling results that 1 year of lessons improves IQ (e.g, Hetland, 2000) but 3 years do not (Costa-Giomi, 1999; Zuluaf, 1993/1994; but see Rauscher & Hinton, 2011 for both supporting and contradicting results). This may be particularly disconcerting considering the reported superior performance of musicians on intelligence and selected cognitive tests. However, if one takes into consideration the many variables at play in the process of becoming a musician or succeeding in learning to play an instrument, it may be possible to reconcile the seemingly contradictory findings.

There are numerous variables that can affect this process, and they start doing so even before the onset of lessons. Some children, but not others, show interest in taking lessons; some parents, but not all, provide the opportunity for their children to learn music; some children drop out of the lessons while others continue and persevere; and some students excel in the development of musical skills over the years while others lag behind (see Costa-Giomi, 2012 for review). Variables such as family income (e.g., Kinney, 2010; Southgate & Roscigno, 2009), parental education (e.g., Elpus & Abril, 2011; Duke, Flowers, & Wolfe, 1997), family structure (e.g., Elpus & Abril, 2011; Kinney, 2010), student achievement (e.g., Fitzpatrick, 2006; Kinney, 2010), and student personality (Costa-Giomi, 2006; Corrigal, Schellenberg, & Misura 2013) can indeed affect who pursues, perseveres, and ultimately succeeds in learning music. The analysis of the characteristics of students who participate in music instruction privately or at school for years shows that they come from a rather privileged environment in terms of socioeconomic status, parental education, family structure, parental support, and opportunity to participate in extracurricular activities (Southgate & Roscigno, 2009; also see review by Costa-Giomi, 2012).

The existence of these confounding variables questions the extent of the contribution of music instruction to the development of general cognitive abilities. The results of studies on the academic performance of music and nonmusic students (Kinney, 2008; 2010), correlational analyses of the relationship between music and intelligence (Degé, Kubicek, & Schwartzer, 2011; Schellenberg, 2006), and experimental investigations based on long-term interventions (Costa-Giomi, 1999) make it apparent that the relationship between music engagement and IQ changes overtime and that certain mediating factors become significant years after the start of music instruction.

For example, Schellenberg (2006) studied the relationship between the length of involvement in music and IQ among children with an average of less than 2 years of music instruction and adults with an average of 8 years of music engagement. He found that the correlation between IQ and duration of music involvement was weaker for the adult sample than for the children sample. In fact, length of music involvement accounted for 12% of the variance in children's IQ but only 4% of the adults' IQ. The results of Costa-Giomi (1999) also suggest that the direct effect of music instruction on general cognitive abilities may diminish as the effect of other variables increases. Costa-Giomi found significant cognitive improvements after 1 and 2 years of piano instruction and no significant effects after 3 years. But she also found that motivational variables such as amount of weekly practice and attendance to lessons became significant predictors of cognitive gains during the third year of lessons and not before. In fact, these variables accounted for 22% of the improvement in cognitive abilities of those taking 3 years of piano lessons.

What all these results combined suggest is that certain variables may become more critical over time. As these variables start affecting the relationship between music instruction and intelligence, the direct effect of music instruction on children's IQ can diminish. This may explain Schellenber's findings (2006) about the lower predicting value of music instruction on IQ in a sample with extensive music participation than in a sample with limited music experience, and Costa-Giomi's results on the effects of motivation to learn an instrument on children's IQ after 3 years of lessons but not earlier.

Another question relevant to the discussion about the long-term cognitive benefits of music instruction and the effects of mediating variables on IQ is what happens to the cognitive gains associated with music instruction once the lessons are discontinued. This question is important considering that many children start learning music with the intention of becoming proficient on an instrument, yet they discontinue instruction after a few months or years of lessons (e.g., Mawbey, 1973; Waggoner, 2004). Indeed we know very little about the cognitive changes that occur once music instruction is discontinued as most experimental studies have failed to provide information about participants who drop out of the treatments. Costa-Giomi (1999), who completed an experimental investigation with a randomized sample, found that children who stopped taking lessons during the first 2 years of piano instruction scored significantly lower in an IQ test than did children who completed 2 years of lessons,

and no differently than children who had not participated in music instruction. Similarly, Rauscher and Hinton (2011) reported that the general cognitive gains of a sample of children participating in 8 months of keyboard instruction disappeared once the lessons were discontinued but were reestablished once resumed. However, the authors reported that with another nonrandomized sample of children, certain cognitive benefits persisted 2 years after the music lessons ended. Overall, there is little evidence that the intelligence gains associated with music instruction outlast the treatment. Further research on whether the cognitive benefits of music lessons persist after the discontinuation of lessons would help understand the long-term contribution of music instruction to children's cognitive development.

Neurological Basis of IQ Improvements

Why and how do music lessons affect intelligence and general cognitive abilities? Neurological studies conducted during the past 15 years have investigated the biological foundations for the reported cognitive benefits of music instruction. Such research has identified specific functional and structural brain differences between those engaged and not engaged in music instruction and the changes that musical practice produces to the brain's organization (see Jäncke, 2009; and Wan & Schlaug, 2010 for reviews). Their results have helped explain musicians' advantages in the processing of sound in music and language contexts (e.g., Strait & Kraus, 2011) but have provided little evidence of why or how music instruction affects performance in intelligence or general cognitive abilities tests. Neurological studies completed with children (Fujioka, Ross, Kakigi, Pantev, & Trainor, 2006; Hyde et al., 2009; Meyer et al., 2011; Shahin et al., 2004; Shahin et al., 2010; Wehrum et al., 2011) support the findings of those conducted with adults related to changes in the processing of sound associated with music lessons. However, most of the studies completed with children did not include measures of intelligence (Fujioka et al., 2006; Meyer et al., 2011; Shahin, Larry, & Trainor, 2004; Shahin, Trainor, Roberts, Backer, & Miller, 2010) or didn't find significant effects of music instruction on IQ (Hyde et al., 2009; Schlaug et al., 2005). The neurological mechanisms by which music instruction improves general abilities such as intelligence are still unclear.

What is clear is that intensive or extensive music practice contributes to neurological reorganization (see Jäncke, 2009; and Wan & Schlaug, 2010 for reviews). This has been observed after short intensive practice (e.g., Pascual-Leone, 2001) or months or years of practice (e.g., Hyde et al., 2009; Schlaug et al., 2009; Shahin, Roberts, & Trainor, 2004; Shahin, Trainor, Roberts, Backer, & Miller., 2010; Strait & Kraus, 2011). As mentioned earlier, most reported changes are related to neurological functions associated with the processing of sound in verbal and nonverbal contexts but not with performance on IQ tests. However, the findings of neurological studies have emphasized the importance of practice on brain reorganization. Two longitudinal studies have shown that the intensity of musical practice affects the degree of change in specific neurological functions in children engaged in more than 2 years of music instruction (Ellis, Bruijn, Norton, Winner, & Schlaug, 2013; Schlaug at al., 2009). These results are supported by behavioral research indicating that the long-term nonmusical effects of music instruction are dependent on the intensity of practice behaviors after 2 years of piano lessons (Costa-Giomi, 1999). Obviously, there's value in investigating how cognitive abilities are affected by the extent and intensity of music practice rather than simply by the duration of music instruction.

Conclusions

In summary, research has identified short-term general cognitive benefits associated with music instruction and shown that sustained practice produces neurological changes associated with improvements in specific sound-related cognitive tasks. Longitudinal studies, however, have provided no clear evidence that improvements in intelligence or general cognitive benefits are long lasting or that they persist after 1 or 2 years of music instruction. It is apparent that the relationship between music instruction and cognitive abilities becomes more complex as engagement in music continues over time. Factors such as family characteristics, personal traits, and motivation may diffuse the direct impact of music instruction on general cognitive abilities throughout the years.

As researchers continue to investigate the effects of music instruction on children's cognitive abilities, it is important to consider the implication of their findings. Do the short-term cognitive benefits associated with music instruction have an impact on children's academic endeavors and quality of life? How do the improvements in the processing of sound benefit children's development? Do these cognitive benefits contribute to their future lives as adults? We do not have clear answers to these questions yet. But to set realistic expectations about the cognitive benefits of music instruction, it is necessary that we continue to address them.

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