Music Training

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Contents

Abstract Positive correlations often emerge when researchers ask whether music lessons influence nonmusical cognitive abilities. Experimental studies tend to yield small effects, however, or results that are unlikely to generalize broadly. Here, we review recent empirical studies and suggest that future research could benefit by considering (1) whether transfer effects of music training are domain general or domain specific, (2) mechanisms of transfer, (3) characteristics of the training program, (4) characteristics of the trainee, and (5) the sociocultural context in which the training and research is conducted.

Over the last two decades, researchers have examined whether taking music lessons has a positive influence on nonmusical cognitive abilities. Such an influence would represent a form of *transfer*. The most common design (i.e., correlational) involves comparing musically trained and untrained individuals, which makes it impossible to determine whether music lessons are the cause rather than consequence of improved cognitive performance. Nevertheless, psychologists and neuroscientists routinely but erroneously infer causation from the results of correlational studies

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T. Strobach, J. Karbach (eds.), *Cognitive Training*,
https://doi.org/10.1007/978-3-030-39292-5_21

(Schellenberg 2019; see also Cochrane and Green, this volume), which creates confusion among researchers, the media, and the general public.

True experiments with random assignment are relatively rare because they are costly and because attrition limits the possibility of long-term studies. Experimental studies also tend to yield results that are limited in scope or much smaller effects than the associations reported in correlational studies (for reviews see Schellenberg and Weiss 2013; Swaminathan and Schellenberg 2014). In the present chapter, we review studies published since 2000, with an emphasis on those that inform the issue of causation. We highlight five issues that future research could seek to clarify: (1) whether transfer effects are domain general or domain specific, (2) mechanisms of transfer, (3) characteristics of the music program, (4) characteristics of the trainee, and (5) the sociocultural context.

Domain-General or Domain-Specific Transfer?

One longstanding question asks whether music lessons have putative effects that transfer to *specific* cognitive domains (e.g., visuospatial skills, language abilities) or whether they might enhance domain-*general* cognitive abilities, such as executive functions and intelligence. Correlational evidence documents that musically trained individuals exhibit advantages relative to their untrained counterparts on a wide variety of visuospatial tasks (for review see Schellenberg and Weiss 2013). Longitudinal and experimental results offer a less consistent picture.

For example, one study examined children from families with low socioeconomic status who were having difficulties in school (Portowitz et al. 2009). The children were enrolled in remedial programs at four different after-school centers. Three of these incorporated a 2-year music-enrichment program, which included 2–3 hours per week of music listening, individual instrumental lessons, and group performances. Compared to children at the center without the program, children who received the intervention showed larger improvements in the ability to remember and copy a complex line drawing. Nevertheless, *nonmusical* programs of similar intensity could have a similar effect, and randomization of centers rather than individuals (as in Jaschke et al. 2018) raises the possibility that other differences among centers may have played a role. Moreover, in another study that compared an intensive, 4-week, computerized, music-listening program to a similar program in visual art (Moreno et al. 2011), improvement from pre- to post-test on a visuospatial task (Block Design) did not differ between the two groups of children.

Other scholars argue for specific connections between music training and language skills. Relevant theories suggest that music training fine-tunes listening abilities, which lead to improvements in speech perception in particular, which ultimately have cascading effects that extend to higher-level language abilities such as reading (e.g., Kraus and Chandrasekaran 2010; Patel 2011). This perspective implies that linguistic rather than visuospatial skills are most likely to improve from music

training. Supporting evidence indicates that music training is correlated with a wide range of speech skills (for review see Schellenberg and Weiss 2013), including linguistic stress processing, the perception of intonation in speech, speech segmentation, and phonological perception. It is unclear why musicians are better than nonmusicians at perceiving speech in noise in some instances (Parbery-Clark et al. 2009; Tierney et al. 2019) but not in others (Boebinger et al. 2015; Madsen et al. 2019). Musically trained individuals also show advantages on higher-level language tests such as those that measure verbal short-term, long-term, and working memory; vocabulary; reading; and acquisition of a second language (for review see Schellenberg and Weiss 2013).

Nevertheless, associations between music training and language abilities can disappear when music aptitude or IQ is held constant (Swaminathan and Schellenberg 2017; Swaminathan et al. 2018). Convincing evidence for causation—from longitudinal studies with random assignment—is also limited. For example, in one instance, improvements on a brief test of vocabulary (Moreno et al. 2011) were larger among children who took 4 weeks of daily training in music listening compared to children who took a similar amount of training in visual arts. In another instance, 6 months of music or painting training led to larger improvements in pronouncing irregularly spelled words among children taking the music lessons (Moreno et al. 2009). Two other experimental studies found that phonological awareness was enhanced after music training (Degé and Schwarzer 2011; Flaugnacco et al. 2015). Other evidence of positive effects on phonological awareness, auditory memory, or vocabulary came from longitudinal studies *without* random assignment, which allowed self-selection to play a role (Linnavalli et al. 2018; Roden et al. 2012). In sum, associations between music training and language abilities are well documented, and music training could, in principle, play a causal role. Experimental evidence that allows for unambiguous causal inferences is limited, however, to outcome variables that measure very narrow aspects of reading or language use (e.g., phonological awareness).

If music training is associated with both visuospatial *and* language skills, might variance in all three domains (music, visuospatial, and language) be a consequence of general cognitive abilities? Or does music training have widespread transfer effects that influence such abilities, which include intelligence and executive functions? General cognitive improvements could manifest as improvements in specific cognitive abilities whether or not they are attributable to music lessons.

Correlational evidence confirms that musically trained children and adults often have substantially higher IQ scores than their untrained counterparts and that additional music training predicts larger IQ advantages (for review see Schellenberg and Weiss 2013). For example, Canadian children with music training can have IQ scores that are one standard deviation higher than their untrained counterparts (Schellenberg and Mankarious 2012), whereas Finnish adult musicians can have IQs that are one-third of a standard deviation higher than nonmusicians (Criscuolo et al. 2019).

Experimental evidence from three different countries indicates that music lessons may cause small improvements in IQ scores. For example, when Canadian 6-year-olds were randomly assigned to 1 year of music lessons (keyboard or voice) or to control conditions (drama or no lessons at all), larger pre- to post-test improvements in IQ were evident in the two music groups compared to the two control groups (Schellenberg 2004). In studies conducted in Iran and Israel, children who were assigned to a music intervention had larger gains in IQ compared to control groups with no lessons (Kaviani et al. 2014; Portowitz et al. 2009). Although the generality across cultures is reassuring, it is not clear from the Iranian and Israeli results whether the increase in IQ scores was a consequence of *music training* per se, because the control groups had no comparable, nonmusical experience (i.e., there was no "active" control group; Schmiedek, this volume), which means that other aspects of the music programs may have contributed to the findings. In short, good evidence that music training causes small increases in general cognitive ability comes from a single study, yet these results could not be replicated in a large sample of children living in the UK (Haywood et al. 2015). Moreover, a recent meta-analysis reported a negative correlation between quality of design and the size of the effect: the better the design (e.g., random assignment, active control group), the *smaller* the cognitive advantage for children who receive music training, which implies that substantial "effects" are actually the consequence of sub-optimal designs (Sala and Gobet 2017b). Another recent review of the literature found "suggestive" evidence of beneficial by-products of music lessons in childhood, but failed to draw any clear conclusions (Dumont et al., 2017).

Even in correlational studies, music training sometimes has only a marginal or no association with IQ (Schellenberg and Moreno 2010). For example, null or mixed results often occur when highly trained musicians are compared with individuals who have similar amounts of nonmusical training or education (e.g., Brandler and Rammsayer 2003; Helmbold et al. 2005). Moreover, in a recent study, preschool children were assigned to either 6 weeks of group music lessons or no lessons at all (Mehr et al. 2013). The music training had no reliable effects on cognitive abilities. In this instance, however, the children may have been too young for music lessons, or the training may have been too brief (4.5 hours total).

In any event, the available findings make it difficult to attribute most of the effects observed in correlational studies to music lessons, because (1) one would expect such effects to be particularly reliable among individuals with the greatest amount of training and (2) effect sizes from actual experiments are much smaller than those that are typically reported in correlational studies. A simpler explanation is that children who take music lessons, and adults with a history of music training, differ from other individuals in multiple ways, including cognitive abilities, personality, and demographic variables. In some instances, however, music training may exaggerate individual differences that were present before the lessons began.

Mechanisms of Transfer

Although researchers have identified associations between music training and higher-level cognitive abilities, it is unclear why such associations would emerge (Colzato and Hommel, Taatgen, this volume). Indeed, evidence for far transfer—between distantly related domains—is elusive, whether the training focuses on music, chess, or working memory (Sala and Gobet 2017a). Some researchers suggest, however, that music lessons train executive functions, including working memory, which in turn promote general cognitive enhancements (e.g., Schellenberg and Peretz 2008).

Indeed, in some instances, musically trained individuals outperform their untrained counterparts on auditory and non-auditory tests measuring executive functions (Roden et al. 2014; Zuk et al. 2014). Moreover, in one case, the association between music training and IQ appeared to be completely mediated by executive functions (Degé et al. 2011). In another instance, however, music training was associated with IQ but not with executive functions except for working memory (Schellenberg 2011). In a recent longitudinal study of children from underprivileged backgrounds, those who took music lessons after school exhibited an enhanced ability to delay gratification compared to their counterparts who took sports or no after-school program (Hennessy et al. 2019). The effect was weak and transient, however, appearing on only one of two tasks, and evident after 3 years of training but not after 4 years. The music group also improved from 2 to 3 years on a test of response inhibition. Because there was no random assignment and an attrition rate of 32%, the findings might actually suggest that less impulsive children were more likely than other children to take music lessons for years on end. In short, it is still an open question whether the association between music training and general cognitive ability is mediated by executive functions.

Other researchers suggest that music lessons train the auditory brainstem to make high-fidelity copies of auditory stimuli (Kraus and Chandrasekaran 2010). These subcortical changes are often correlated with speech and higher-level language skills including reading and are thought to mediate the language benefits of music training. In line with this hypothesis, musically trained individuals exhibit more precise brainstem responses to speech stimuli (Kraus et al. 2014; Strait et al. 2014). It remains to be seen, however, whether brainstem responses actually mediate any associations between music lessons and language.

A different mechanistic explanation of links between music training and language comes from the OPERA hypothesis (Patel 2011), which posits that music lessons train speech skills when five conditions are met: (1) the speech skill shares a neural overlap (*O*) with a music skill, (2) the music skill involves particularly precise (*P*) auditory processing, (3) the music training has positive emotional (*E*) consequences, (4) the lessons involve repetition (*R*), and (5) the lessons require focused attention (*A*). This theory is largely untested, and it is unclear whether these five conditions are necessary and sufficient for transfer and/or whether transfer is contingent on all five conditions being met.

Another view holds that overlap between language and music abilities occurs primarily in the temporal domain (Goswami 2012; Tallal and Gaab 2006), which implies that *rhythm*-based music interventions are most likely to be effective in training language skills. Evidence consistent with this theory comes from a study of children with dyslexia who were assigned to 6 weeks of auditory rhythm training, to a commercially available phoneme-discrimination intervention, or to a control group (Thomson et al. 2013). Compared to the control group, the rhythm and phoneme groups improved more on tests of phonological processing over the course of the study. In another experimental study of children with dyslexia and an active (painting) control group, 30 weeks of rhythm-based music training improved phonological awareness and pre-reading skills (Flaugnacco et al. 2015). Rhythm-perception abilities are also associated positively with grammatical abilities among typically developing children (Gordon et al. 2015), although the association extends to other tests of language ability (speech perception) and other tests of musical ability (memory for music; Swaminathan and Schellenberg 2019).

Meta-analyses of older adults suggest that music practice may enhance healthy aging by way of specific training mechanisms (i.e., those that are learned during practice), specific compensatory mechanisms (i.e., those that improve specific cognitive problems), and general compensatory mechanisms (i.e., those that improve general cognitive functioning; Román-Caballero et al. 2018), yet it is unknown how much musical expertise is required to predict beneficial effects and whether any benefits continue after interventions have ended (Christie et al. 2017). Future research could focus on evaluating and comparing the different mechanistic explanations of links between music training and nonmusical abilities, as well as on constructing new theories that generate empirically testable hypotheses. Theoretical multiplicity will undoubtedly promote debate and growth in the field.

Characteristics of the Music-Training Program

Private and small-group music lessons emphasize individual accomplishment and skill mastery. Larger, group-based lessons, by contrast, are more likely to emphasize collective outcomes. It is therefore possible that private music training is more effective than group-based lessons at improving scores on tests of cognitive ability, which by definition measure individual ability and accomplishment. Indeed, a recent longitudinal study of group-based music lessons found that advantages emerged only after extended training (Slater et al. 2015). Specifically, after 2 years of lessons, children demonstrated improved performance on a test that measured the ability to perceive speech in the midst of background noise. A separate group of children, who received 1 year of the same lessons, did not show improvement on the same test.

Other experimental studies with individual lessons or lessons taught in small groups have found advantages even with shorter-term interventions, such as when lessons are taught daily for 2 weeks (Moreno et al. 2011), daily for 20 weeks (Degé and

Schwarzer 2011), weekly for 36 weeks (Schellenberg 2004; Thomson et al. 2013), or twice weekly for 30 weeks (Flaugnacco et al. 2015). It is important to note, however, that in the short-term studies with daily training, the lessons focused primarily on music listening rather than learning to play an instrument. In other words, music lessons may be more likely to improve language-related outcomes if the lessons emphasize listening skills. As noted earlier, language benefits could also be more likely if the lessons target rhythm skills (Flaugnacco et al. 2015; Thomson et al. 2013). In any event, many successful music interventions adopted nonstandard pedagogies, which limit the degree to which the findings generalize (Degé and Schwarzer 2011; Flaugnacco et al. 2015; Moreno et al. 2011; Thomson et al. 2013).

Studies of older adults (Guye et al., this volume) and very young children (Rueda et al., this volume) provide converging evidence that characteristics of the music program are an important consideration. For older adults, a recent meta-analysis concluded that the specific focus of instrumental training can differentially affect the consequences of the intervention (Kim and Yoo 2019). For children attending kindergarten, positive associations with language abilities (vocabulary, phonological awareness) emerge after 2 years of music *playschool* (Linnavalli et al. 2018). In short, efficacious interventions need to be age-appropriate and designed specifically for the intended cognitive benefits.

Characteristics of the Trainee

Music training is correlated with cognitive skills in some samples of individuals but not in others (cf. Katz et al., this volume). As noted, highly trained musicians often do not show an IQ advantage compared to equally qualified individuals in nonmusical domains (Brandler and Rammsayer 2003; Helmbold et al. 2005). Thus, the association with general cognitive abilities may emerge primarily when music training is an additional activity rather than an individual's primary focus.

The probability that music training has positive side effects might also increase when the trainee (1) does not come from a privileged background (Barbaroux et al. 2019); (2) experiences atypical developmental trajectories, such as children with dyslexia (Flaugnacco et al. 2015; cf. de Vries and Geurts, this volume); or (3) is very young (Bowmer et al. 2018; cf. Ruede et al., this volume) or very old (Kim and Yoo 2019; cf. Guye et al., this volume). Indeed, two recent reviews reached a similar conclusion: consideration of individual differences is essential for documenting whether music training has actual cognitive benefits (Benz et al. 2016; Costa-Giomi 2015; see Karbach and Kray; Katz et al., this volume).

Other findings suggest that the association between music lessons (or musical involvement) and cognitive ability may be explained by personality factors, particularly the dimension called Openness-to-Experience (Corrigall et al. 2013; Corrigall and Schellenberg 2015; cf. Katz et al., this volume), which is characterized by curiosity, intellectual engagement, and aesthetic sensitivity. These findings imply that musically trained individuals may perform well on intelligence tests because they

tend to be particularly interested in learning new things, including music. Moreover, common genetic factors appear to underlie intelligence *and* the propensity to practice music (Mosing et al. 2016).

In short, correlations between music training and cognitive ability may stem from preexisting differences. When considered jointly with evidence for small cognitive benefits of music training (e.g., Schellenberg 2004), it is likely that some individuals benefit more than others from music lessons (cf. Karbach and Kray, this volume). More generally, the study of music training and transfer is well suited to exploring gene-environment interactions (Schellenberg 2015). Future research could consider how preexisting trainee characteristics interact with music training to influence cognitive outcomes.

The Sociocultural Context

The issue of transfer effects from music training to nonmusical cognitive skills has clear practical implications. For example, music interventions may provide an enjoyable way for children with dyslexia to improve reading-related skills (Flaugnacco et al. 2015; Thomson et al. 2013). The study of transfer also has the potential to influence the nature of training and music. Across cultures, music and teaching occupy different places in social life and in their relation to other activities. With a few exceptions (e.g., Kaviani et al. 2014; Swaminathan and Gopinath 2013; Yang et al. 2014), most investigations of transfer have focused on samples of Western individuals learning Western music, which raises the possibility that many findings are Western-specific. Unlike most other cognitive-training programs, music and music training are cultural products that are meaningful in different ways to different individuals (see Colzato and Hommel, this volume).

Music lessons require time, effort, and money. Parents, educators, and policy makers are often motivated to invest in music lessons so that children develop their musical talents and improve their nonmusical skills, such as focus, attention, intelligence, literacy, and school performance. As a result, economic pressures could cause certain types of music programs to be privileged over others. For example, if school-based group lessons are not particularly effective at training nonmusical skills, they could lose financial backing, which would affect who has access to music lessons and what kind of lessons. In sum, because we are dealing with a real-world form of training nested in cultural contexts, the line between the laboratory and real world cannot be neatly defined. It is therefore important that research on music training and transfer becomes a multidisciplinary effort that considers the cultural contexts of producers and consumers of such research and training.

Conclusion

Despite having received much research and media attention, studies of transfer effects of music lessons have predominantly involved correlational designs, which makes it impossible to determine whether music lessons are the cause rather than consequence of improved cognitive performance. Moreover, the relatively small number of experimental and longitudinal studies that exist tends to report small, limited, or mixed effects. As a way forward, future research could examine the extent to which music lessons train general and specific cognitive abilities, the mechanisms by which such transfer occurs, the characteristics of the trainee and training program, and the larger social context in which such training is received.

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