Music Training

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Introduction

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. True experiments with random assignment are relatively rare because they are costly and because attrition limits the possibility of long-term studies. Although strong associations are often reported, experimental studies tend to yield small effects or results that are limited in scope (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 allow for inferences 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 long-standing question asks whether music lessons have putative effects that transfer to *specific* cognitive domains (e.g., visuospatial skills, language) or whether they might enhance domain-*general* cognitive abilities, such as executive functions

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T. Strobach, J. Karbach (eds.), *Cognitive Training*,
DOI 10.1007/978-3-319-42662-4_13

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 high-risk 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 two-year music enrichment program, which included 2–3 h 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 may have a similar effect, and randomization of centers rather than individuals 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 posttest on block design (i.e., a visuospatial subtest from the Wechsler IQ tests) did not differ between the two groups of children.

Other scholars argue for extensive connections between music training and language skills. Relevant theories suggest that mental processes for music and language overlap (e.g., Kraus and Chandrasekaran 2010; Patel 2011), which implies that linguistic rather than visuospatial skills are most likely to improve from music training. In line with this view, 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 (e.g., Parbery-Clark et al. 2009) but not in others (e.g., Ruggles et al. 2014). 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).

Despite the fact that reported associations extend to speech, language, and reading, evidence for causation is 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). In sum, associations between music training and language abilities are well documented, and it seems likely that music training plays a causal role. Nevertheless, experimental evidence that allows for unambiguous causal inferences is limited to outcome variables that measured 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). Experimental evidence from three different countries also indicates that music lessons may cause small improvements in IQ scores. For example, when Canadian 6-year-olds were randomly assigned to one year of music lessons (keyboard or voice) or to control conditions (drama or no lessons at all), larger pre- to posttest improvements in IQ were evident in the two music groups compared to the two control groups (Schellenberg 2004). In another study of Iranian preschoolers, children assigned to three months of weekly music lessons had larger gains in IQ compared to a control group with no lessons (Kaviani et al. 2014). In a third study of Israeli children, improvements in IQ were greater among children exposed to an enriched program in music, compared to control children without such a program (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, convincing evidence that music training causes small increases in IQ comes from a single study.

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 h 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 who took music lessons in childhood, 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

The focus of much research to date has involved identifying associations between music training and high-level cognitive abilities, but it is unclear why such associations would emerge (Colzato and Hommel this volume; Taatgen this volume). One possibility is that music lessons train executive functions, including working memory, which in turn promote general cognitive enhancements (e.g., Alloway et al. this volume; Karbach and Kray this volume; Schellenberg and Peretz 2008). On this view, transfer occurs when executive functions are improved during the course of music training. Indeed, in some instances, musically trained individuals outperform their untrained counterparts on auditory and nonauditory tests measuring executive functions (Roden et al. 2014; Zuk et al. 2014), and, 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). Thus, 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 (including speech) stimuli (Kraus and Chandrasekaran 2010). These subcortical changes are 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 (Strait et al. 2014), and brainstem responses become more precise after music training (Kraus et al. 2014). It remains to be seen whether brainstem responses actually mediate any associations between music lessons and language.

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, 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. Moreover, in typically developing children, rhythm-perception abilities are associated positively with grammatical abilities (Gordon et al. 2015).

A final mechanistic explanation comes from the OPERA hypothesis (Patel 2011). It 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.

Future research could focus on evaluating and comparing the existing theoretical approaches, 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. 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 (Degé and Schwarzer 2011; Flaugnacco et al. 2015; Moreno et al. 2011; Thomson et al. 2013). Thus, future research could compare the effects of different kinds of music training.

Characteristics of the Trainee

Music training is correlated with cognitive skills in some samples of individuals but not in others (see 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.

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), 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. 2015). 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. 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 practical implications. For example, music interventions may provide an enjoyable way for children with dyslexia to improve certain 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. For example, 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 also their nonmusical skills such as focus, attention, intelligence, literacy, and school performance. Economic pressures, as a result, 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 has implications regarding 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 an interdisciplinary examination of the cultural contexts of producers and consumers of such research.

Conclusion

Despite having received much research attention, studies of transfer effects of music lessons have predominantly involved correlational designs, which make 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, we propose that 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.

Acknowledgment Supported by the Natural Sciences and Engineering Research Council of Canada.

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