Oxford Handbooks Online

Music Training and Nonmusical Abilities

E. Glenn Schellenberg

The Oxford Handbook of Music Psychology (2 ed.)
Edited by Susan Hallam, Ian Cross, and Michael Thaut

Print Publication Date: Jan 2016
Subject: Psychology, Cognitive Psychology, Educational Psychology
Online Publication Date: May 2015 DOI: 10.1093/oxfordhb/9780198722946.013.28

Abstract and Keywords

The present chapter reviews recent findings about associations between music training and nonmusical abilities. Individuals with music training differ from untrained individuals in multiple ways, exhibiting better performance on measures of speech perception, other language abilities (reading, spelling), and spatial abilities. Musically trained individuals also tend to perform better on tests of domain-general abilities including working memory and IQ, and children who take music lessons perform particularly well in school. There is some evidence indicating that music training causes some of these effects, but advantages for musically trained individuals are often too large to be environmental in origin. Rather, pre-existing differences in music aptitude, cognitive abilities, and personality also influence the decision to take music lessons and test-taking abilities. More generally, associations between music training and nonmusical abilities are bound to be a consequence of nature and nurture, and of interactions between nature and nurture.

Keywords: music training, IQ, language, speech, spatial abilities, personality

Introduction

THE present chapter summarizes what is known about associations between music training and nonmusical abilities. (Reviews of music *listening* and cognitive abilities are provided by Schellenberg, 2012, and Schellenberg and Weiss, 2013.) Because the available literature has grown exponentially in recent years, the focus is limited to behavioral studies published since 2000 that examined music lessons taken outside of school, with a particular focus on studies published since 2005. The central issues are: (1)

whether musically trained individuals differ from their untrained counterparts in areas other than those that involve musical skills, and (2) whether such associations are the consequence of taking music lessons. One interpretive problem with quasi-experimental and correlational (hereafter correlational) studies is that pre-existing individual differences could influence whether someone takes music lessons *and* how well they perform on measures of nonmusical abilities. Such differences include music aptitude, cognitive abilities, personality, and demographic variables such as family income and other markers of socio-economic status (SES).

The first part of the review discusses associations between music and cognitive abilities in specific domains, including speech perception, other language abilities, spatial abilities, and mathematical abilities. The second part focuses on associations between music training and domain-general abilities, including IQ, academic abilities, memory, and executive functions. The final section asks whether music training is associated with social/emotional abilities and personality. **(p. 416)**

Music Training and Specific Cognitive Abilities

Speech Perception

Musically trained individuals tend to perform better than their untrained counterparts on many tasks that examine listeners' perception of speech (for reviews, see Strait and Kraus 2011, 2014). For example, professional musicians are better than individuals without formal music training at identifying syllables presented with degraded spectral information (Elmer, Meyer and Jäncke, 2012). Similarly, musicians are better than musically untrained adults at determining whether two sentences uttered in a foreign tone language are the same or different (Marie, Delogu, Lampis, Belardinelli and Besson, 2011). Such advantages extend to tasks with greater ecological validity, such as perceiving speech in noise (Parbery-Clark, Skoe, Lam and Kraus, 2009; Parbery-Clark, Strait, Anderson, Hittner and Kraus, 2011). Even 9-year-olds with only 4 years of music lessons are faster and more accurate than children without lessons at discriminating syllables that vary in fundamental frequency or duration (Chobert, Marie, François, Schön and Besson, 2011). When 5-year-olds take weekly music lessons for 16 weeks, improvements in *phonological awareness* are greater than they are for same-age children in control groups who take swimming lesson or no lessons (Rauscher and Hinton, 2011). Phonological awareness is the ability to perceive and segment the sounds of speech (i.e., phonemes).

What role does music aptitude play in associations between music training and speech perception? Tests of aptitude measure the degree to which a listener can naturally perceive and remember sequences of tones that vary in pitch or duration (e.g., Wallentin, Nielsen, Friis-Olivarius, Vuust and Vuust, 2010), and recent evidence confirms that music aptitude has a substantial genetic component (Oikkonen and Järvelä, 2014). Aptitude tests are designed to determine who would benefit most from music lessons, assuming that children with high aptitude would benefit more than those with low aptitude. If one also assumes that children with high levels of music aptitude would be more likely than other children to take music lessons, the situation is complicated by the fact that aptitude also predicts performance on tests of speech perception (Milovanov and Tervaniemi, 2011). For example, music aptitude is associated positively with phonological awareness among pre-schoolers and kindergarteners (Anvari, Trainor, Woodside and Levy, 2002; Peynircioğlu, Durgunoğlu and Öney-Küsefoğlu, 2002). In adulthood (Slevc and Miyake, 2006) and childhood (Milovanov, Huotilainen, Välimäki, Esquef and Tervaniemi, 2008), aptitude is correlated positively with the ability to perceive and/or produce sounds from a non-native language. When adults' music aptitude is measured with a test designed to identify particularly poor abilities (Drayna, Manichaikul, de Lange, Snieder and Spector, 2001), performance is associated positively with scores on several different measures of speech perception (Jones, Lucker, Zalewski, Brewer and Drayna, 2009).

Evidence that music training *causes* enhancements in speech perception comes from one study that pseudo-randomly assigned 8-year-olds to music or painting lessons for a period of 2 years (François, Chobert, Besson and Schön, 2013). The “pseudo” part ensured that the music and painting groups were matched initially in terms of cognitive abilities, sex, age, (p. 417) grade at school, and SES. The task required children to identify whether three-syllable nonsense words were presented previously in a 5-minute string of syllables. The music and painting groups performed equivalently before the study began, but the music group outperformed the painting group after 1 year of training, with an even larger difference between groups after two years. The task likely favored the trained children, however, because the syllables at exposure were sung. In another study, kindergarteners who were assigned randomly to intensive training in music (10 minutes per day, 5 days per week, 20 weeks) showed improvements in phonological awareness that were identical to those of other kindergarteners who received lessons in perceiving and segmenting the sounds of speech (Degé and Schwarzer, 2011). A third group of kindergarteners, who received training in sports, did not show similar improvement, which ruled out the possibility that maturity accounted for pre- to post-test improvements in the other two groups. Experimental designs allowed François et al. (2013) and Degé and Schwarzer (2011) to infer that music training caused improvements in performance on their particular outcome measure, but it is unknown whether the results would generalize to other tests of speech perception.

In sum, although it is reasonable to speculate that music lessons improve listening abilities in general and speech-perception abilities in particular, there is little direct evidence in this regard. In correlational studies, moreover, music aptitude would almost certainly play a role. One possibility is that music lessons *exaggerate* pre-existing differences, representing a gene–environment interaction that is emblematic of development and learning across domains (Berk, 2012). Ideally, future research would document the relative contributions of nature (music aptitude) and nurture (music training) in their influence on speech perception, and how these factors interact. Although researchers have suggested that positive associations between *duration* of training and speech perception provide evidence that music lessons are causing such associations (e.g., Strait and Kraus, 2011), individuals with high levels of music aptitude would be more likely than other individuals to take music lessons for many years on end *and* to perform well on tests of speech perception.

Other Language Abilities

Musically trained individuals also perform better than untrained individuals on measures of language abilities other than speech perception. For example, among adults, music training is associated positively with remembering lists of words that are read (Brandler and Rammsayer, 2003) or heard (e.g., Jakobson, Lewycky, Kilgour and Stoesz, 2008). Musically trained adults also exhibit advantages at making grammaticality judgments (Patston and Tippett, 2011), pronouncing irregularly spelled words (e.g., *bouquet, subtle*; Jakobson et al., 2008; Stoesz, Jakobson, Kilgour and Lewycky, 2007), and remembering lyrics (Kilgour, Jakobson and Cuddy, 2000) or short excerpts of speech (Cohen, Evans, Horowitz and Wolfe, 2011). In one instance, music training in childhood predicted a larger vocabulary (Forgeard, Winner, Norton and Schlaug, 2008). In another instance, musically trained adults showed enhanced comprehension of complicated passages of text (Thompson, Schellenberg and Letnic, 2012), a finding consistent with an earlier meta-analysis, which concluded that music training in high school is associated positively with reading ability (Butzlaff, 2000).

One might be tempted to attribute all of these observed associations to general cognitive abilities. In other words, is music training simply a marker of intelligence? This point (p. 418) is particularly pertinent because music aptitude is also associated with general intelligence (for review, see Schellenberg and Weiss, 2013). Nevertheless, even when IQ is held constant, musically trained children exhibit enhanced performance on tests of reading comprehension (Corrigall and Trainor, 2011) or spelling (Hille, Gust, Bitz and Kammer, 2011). Although these results confirm that such associations are not simply a byproduct of high IQs, they do not inform the issue of causation.

Recent experimental studies suggest, however, that music training may actually cause improvements in language abilities, including those that are necessary for reading. In a study of 8-year-olds who were assigned pseudo-randomly to 6 months of music or painting lessons, children in the music group showed larger pre- to post-test improvement in reading irregularly spelled words (Moreno et al., 2009). In a follow-up study with pseudo-random assignment of 4- to 6-year-olds to 4 weeks of daily, computer-controlled lessons in music listening or visual arts, children in the music group had larger pre- to post-test increases in vocabulary (Moreno et al., 2011a). The music group also had larger improvements on a task that required them to match arbitrary symbols with words (Moreno, Friesen and Bialystok, 2011b), a skill that is a prerequisite for learning to read.

Thus, there are many associations between music training and language abilities, although many of these could be due to individual differences in music aptitude or general cognitive ability. There is also some evidence that music training causes improvements in vocabulary and in the skills required for reading. Because the interventions have been intensive (daily) and designed specifically for the study (Moreno et al., 2011a, 2011b), or the outcome measure has been very specific (Moreno et al.,

2009), it is unclear whether the findings would generalize to typical weekly vocal or instrumental lessons, or to other measures of language ability.

Spatial Abilities

Spatial (or visuospatial) abilities represent other relatively specific abilities that have been examined in relation to music training. Rauscher (2008; Rauscher and Hinton, 2011) proposed that *spatial-temporal* abilities—those that require mentally manipulating a visual image in the absence of a physical model—are distinct from spatial abilities in general. This notion ignores the many factor-analytic studies of the intellect that have been conducted in the context of basic research (Carroll, 1993) or IQ testing (e.g., Wechsler, 2008). Spatial abilities are correlated across the various types of tests used to measure them. The correlations are never perfect due to test-specific variance, but there is no evidence that spatial-temporal tests are more highly correlated with each other than with other tests of spatial abilities.

In fact, musically trained individuals have better spatial abilities than untrained individuals whether or not the test meets Rauscher's definition of spatial-temporal. For example, advantages for adult musicians are evident on tests of mental rotation (Sluming, Brooks, Howard, Downes and Roberts, 2007), visual search (Patston and Tippett, 2011; Rodrigues, Loureirof and Caramelli, 2013; Stoesz et al., 2007), selective and divided visual attention (Rodrigues et al., 2013), judgments of line orientation (Patston, Hogg and Tippett, 2007), memory for line drawings (Jakobson et al., 2008), and the ability to arrange a set of colored blocks to match a visual image (Stoesz et al., 2007). Even in kindergarten and elementary school, music training is associated with performance on tests of spatial abilities (Rauscher and Hinton, 2011). **(p. 419)**

Evidence for causation comes from an Israeli study, in which a 2-year music-training intervention (2–3 hours/week) was introduced in some after-school centers for at-risk children (Portowitz, Lichtenstein, Egorova and Brand, 2009). Compared to control children at similar centers with no intervention, the musically trained children showed larger improvements in remembering and reproducing a complex line drawing. An earlier meta-analysis also found evidence that music training causes enhancements in spatial skills (Hetland, 2000). To summarize, music training is associated positively with spatial abilities, and there is some evidence that music training causes enhanced levels of performance. Such evidence does not rule out the possibility that children with good spatial abilities are also more likely than other children to take music lessons.

Mathematical Abilities

The question of associations between music training and mathematical abilities is particularly interesting because several properties of music are based on mathematical relations (i.e., tone durations, frequency ratios, etc.), which raises the possibility that

learning music could be accompanied by improvements in mathematical abilities. Several books on “music and mathematics” have appeared in recent years (e.g., Loy, 2006, 2007), but none discusses the possibility of associations between music training and mathematics, or overlap between the skills that are necessary for mathematics and playing music. A detailed search for research published since 2000 revealed only one empirical study in a peer-reviewed journal. Haimson, Swain and Winner (2011) asked whether mathematicians have particularly good musical skills. They required large samples of university professors in mathematics or languages to complete an online survey about their music background. The two groups did not differ on measures of music perception, music memory, music performance, or music creation. In other words, individuals who are experts in mathematics are no more musical than similarly qualified scholars in the humanities. Vaughn’s (2000) meta-analysis from several years ago found a small association between music training and mathematical abilities but no evidence for causation.

Rauscher and Hinton (2011) summarized the results from several unpublished studies, some of which assigned preschoolers from low-SES families randomly to 2 years of music lessons and compared them to control groups of same-age children assigned to computer lessons or no lessons. Each child was administered a set of 26 tests at the beginning and end of the intervention. Although the groups were equivalent on all tests at time 1, the music group had higher scores on tests of arithmetic and spatial abilities at time 2. Several aspects of these results make them less than compelling. First of all, individual differences in scores at time 1 were not held constant when analyzing scores at time 2, and there was no evidence of significantly larger group differences on some tests compared to others (i.e., no interaction). Secondly, there was no attempt to correct for multiple tests and the actual number of tests that showed group differences was not specified. More crucially, the original research never underwent the peer-review process. Thus, when considered in the context of the literature as a whole, the anomalous findings (i.e., a direct causal influence of music training on mathematical abilities) call for skepticism.

In sum, evidence of associations between music training and mathematical abilities is inconsistent, with no convincing reports of a causal association. When such associations are (p. 420) evident in correlational research, they could be due to the fact that high-functioning individuals are likely to take music lessons and to perform well on mathematics tests. There is also no obvious reason why associations with mathematical abilities tend to be weaker than those that are evident with language or spatial abilities.

Music Training and General Cognitive Abilities

I now examine the possibility that general abilities could be the source of many observed associations between music training and more specific cognitive abilities.

IQ and Academic Achievement

In general, children who take music lessons have higher IQs than their counterparts without lessons (Gibson, Folley and Park, 2009; Hille et al., 2011; Schellenberg, 2011a; Schellenberg and Mankarious, 2012). There is also a dose–response association: as *duration* of training increases, so do IQ scores (Degé, Kubicek and Schwarzer, 2011a; Degé, Wehrum, Stark and Schwarzer, 2015; Corrigall and Schellenberg, 2015; Corrigall, Schellenberg and Misura, 2013; Schellenberg, 2006). These associations remain evident when confounding variables such as SES (e.g., family income, parents' education) and/or involvement in nonmusical out-of-school activities are held constant (Corrigall et al., 2013; Degé et al., 2011a; Schellenberg, 2006, 2011a, 2011b; Schellenberg and Mankarious, 2012). Even among undergraduates who are no longer taking lessons, IQs are higher among those who took music lessons in the past (Schellenberg, 2006, 2011b).

Associations between music training and general ability extend beyond one-on-one IQ testing to performance in school, with a similar dose–response association and similar partial associations (i.e., with SES held constant; Corrigall et al., 2013; Degé et al., 2014; Schellenberg, 2006). Advantages for children with music training extend across the various subjects taught in school except for sports (Wetter, Koerner and Schwaninger, 2009). In fact, musically trained children get better grades in school than one would expect based on their IQs (Corrigall et al., 2013; Schellenberg, 2006), which implicates the involvement of other individual-difference variables, such as personality, which might help to explain why musically trained children are particularly good students.

When sample sizes are small, associations between music training and IQ often fail to reach statistical significance (Corrigall and Trainor, 2011; Parbery-Clark et al., 2011; Strait, Parbery-Clark, Hittner and Kraus, 2012). In other instances, particularly when children with a minimum amount of training (e.g., at least 3 years) are compared to children with no lessons, effect sizes are too large to be attributable to any environmental factor (Gibson et al., 2009; Hille et al., 2011; Schellenberg, 2011a; Schellenberg and Mankarious, 2012), implicating pre-existing cognitive differences. Nevertheless, associations with IQ often disappear when professional musicians are compared to control groups of professionals with no music training (for a review, see Schellenberg, 2015). In other words, children who take music lessons (p. 421) tend to have above average cognitive abilities, but professional musicians are not systematically more intelligent than musically untrained adults.

Is there any evidence that music lessons cause increases in general cognitive abilities? In one study, Iranian kindergarteners were assigned randomly to 12 75-minute music lessons taught weekly and compared to same-age children matched in gender and SES who took no lessons (Kaviani, Mirbaha, Pournaseh and Sagan, 2014). The music group had larger increases in IQ over the 12-week period. Although we can infer that music training caused the observed differences between groups, it is impossible to determine whether "music" played a central role. Any additional, structured activity with an adult

instructor may have had a similar effect. Similar evidence for a causal effect of music training on intelligence—with similar interpretive problems—was evident in a study of Israeli 6- to 12-year-old children (Portowitz et al., 2009). Children who were assigned to a 2-year music-training program had larger increases in general intelligence compared to a control group with no intervention.

One study with clearer results assigned 6-year-old Canadian children randomly to a year of keyboard lessons, voice (Kodály) lessons, drama lessons, or no lessons (Schellenberg, 2004). Increases in IQ over the year did not differ for the two music or for the two control groups, but they were larger for the combined music groups compared to the combined control groups. Notably, the music groups had larger increases on the four indexes that measure more specific abilities (verbal ability, spatial ability, processing speed, and attention), and there was no hint of larger differences between the music and control groups in some domains than in others (i.e., no interaction).

When samples are small, however, causal effects of music training on general intelligence are unlikely to be evident (e.g., François et al., 2013; Moreno et al., 2009). In one study of 4-year-olds in the US, null findings may have stemmed from the young age of the children, the short duration of the music intervention (6 weeks, 4.5 hours in total), the free-form pedagogy, or because pre-existing individual differences in general abilities were not held constant (Mehr, Schachner, Katz and Spelke, 2013). In general, though, the available evidence indicates that high-functioning individuals are likely to take music lessons, and that music lessons may exaggerate slightly their pre-existing advantages.

Memory and Executive Functioning

Associations between music training and general cognitive abilities may be a consequence of better memory or superior executive functioning, which, in turn, lead to better performance on a wide variety of tests (including those that measure IQ) and better grades in school. In line with this view, there is much evidence that the enhanced listening skills of musically trained individuals extend to tests that involve memory for non-linguistic auditory stimuli. For example, adult musicians' superior memory for music and speech extends to environmental sounds, but not to pictures of objects or to abstract works of art (Cohen et al., 2011). Music training in adulthood and childhood is also associated positively with memory for strings of digits or lists of words (or non-words), but not with memory for spatial locations (Hansen, Wallentin and Vuust, 2013; Roden, Grube, Bongard and Kreutz, 2014a). When tasks measure working memory by requiring participants to recall items in an order different from that in which they were presented (e.g., backward), advantages for adult musicians are evident with oral presentation of words or numbers, but not with visual presentation of (p. 422) colors (Parbery-Clark et al., 2011; Strait et al., 2012). In one test of older adults, a history of music training was predictive of enhanced auditory working memory but there was no association with visual memory (Hanna-Pladdy and Gajewski, 2012).

Although these findings are consistent with the idea that musically trained individuals are particularly good listeners, there are many contradictory findings showing that musicians demonstrate enhanced visual short-term (Bidelman, Hutka and Moreno, 2013) and working (Oechslin, Van De Ville, Laseyras, Hauert and James, 2013) memory, enhanced short- and long-term memory for geometric shapes as well as for words (Jakobson et al., 2008), and enhanced auditory *and* visual working memory (George and Coch, 2011; Lee, Lu and Ko, 2007). In one study of older adults, a history of music training was predictive of performance on a test of visual memory but *not* on a test of auditory memory (Hanna-Pladdy and MacKay, 2011).

Even children who have taken music lessons for only 18 months show better visual working memory at the end of the intervention compared to control children who receive additional training in the natural sciences (Roden et al., 2014a). When a 2-year "extended" music program is offered in schools, 10-year-olds who register in the program have larger improvements in visual and auditory memory over the course of the program compared to other children (Degé, Wehrum, Stark and Schwarzer, 2011b). In short, music training is often accompanied by memory advantages for auditory *and* visual stimuli. Although longitudinal studies without random assignment provide evidence that is consistent with a causal interpretation (Roden et al., 2014a; Degé et al., 2011b), it is also possible that pre-existing differences determine (1) improvements in memory later in development, and (2) who takes music lessons.

Executive functions are related to working memory but broader because they involve "conscious control of thought, emotion, and action" (Zelazo, 2004, p. 12). They also represent domain-general abilities, such as cognitive flexibility, planning, and the ability to ignore irrelevant information or to inhibit automatic but incorrect responses. Adult musicians are better than musically untrained individuals at identifying (1) the pitch of a tone presented with conflicting but irrelevant verbal information (e.g., *low* sung at a high pitch), and (2) the direction of an arrow presented with conflicting but irrelevant spatial information (e.g., an arrow pointing right but presented on the left side of a display; Bialystok and DePape, 2009). When 4- to 6-year-olds are assigned to 4 weeks of intensive training in music listening or visual arts, children in the music group have larger improvements in the ability to identify geometric figures on the basis of color while ignoring irrelevant variation in shape (Moreno et al., 2011a). In one investigation, executive functions—particularly selective attention and response inhibition—mediated the association between music training and IQ in a sample of 9- to 12-year-old children (Degé et al., 2011a). In another study, however, musically trained and untrained 9- to 12-year-olds differed substantially in IQ, slightly in working memory, but not on any measure of executive functioning (Schellenberg, 2011a).

A study of older adults that included random assignment to 6 months of individual piano lessons or a non-lessons control group reported that the intervention improved executive functioning (Bugos, Perlstein, McCrae, Brophy and Bedenbaugh, 2007). Closer inspection of the methods and results reveals otherwise. On one speeded test (*Trail-making*) that required participants to connect dots on a page—alternating between those labeled

numerically or alphabetically (1-A-2-B-3-C…), the groups did not differ at pre-test, post-test- or follow-up, and the effect disappeared when baseline performance (connecting dots labeled (p. 423) numerically) was taken into consideration. The strongest finding was on a speeded test that required participants to match symbols with digits. This test (*Digit Symbol—Coding*) was actually designed to be a measure of processing speed (Wechsler, 2008), which is not typically considered to be an executive function. Although tests of processing speed obviously require conscious control of thought, so does any test. In any event, processing speed is another domain-general ability that has a small positive association with music training in children (Roden et al., 2014b) and adults (Helmbold, Rammsayer and Altenmüller, 2005).

In short, music training is often associated positively with memory and executive functioning. In some instances, memory advantages are more likely to be evident on auditory tasks than on visual tasks because musically trained individuals are good listeners. Nevertheless, there is much evidence that music training is associated positively with visual memory. Music training also predicts performance on some tests of executive functions, particularly those that require selective attention and response inhibition, but there is little evidence that music training actually causes improvements in memory or executive functioning.

Music Training: Social-Emotional Skills, and Personality

The final section examines whether music training is associated with non-cognitive abilities or traits, including social-emotional skills and personality. Evolutionary theorists consider social cohesion to be an adaptive consequence of performing music (Huron, 2003). Specifically, music making in groups (i.e., whole communities or tribes) is thought to promote interpersonal bonding and survival of the group. Nevertheless, correlational (Schellenberg, 2006) and experimental (Schellenberg, 2004) research has failed to find an association in childhood between music training and adaptive social skills (e.g., cooperating with adults). In a study that included random assignment of 9-year-olds to 3 years of individual piano lessons or a no-lessons control group, the two groups did not differ in self-esteem at any point in time and changes in self-esteem over time were similar for both groups (Costa-Giomi, 2004). In another study of children who received a two-year music intervention, the treatment and control groups did not differ in self-esteem at the beginning or end of the study (Portowitz et al., 2009). Because the majority of children in these studies received one-on-one music instruction, it remains possible that making music in *groups* has social benefits, which would be consistent with evolutionary accounts.

Might music training be associated with emotional intelligence or emotional development? The question is reasonable because of links between music listening and emotional responding, and because music performance involves the expression of emotions (Corrigall and Schellenberg, 2013; Juslin, Chapter 13, Gabrielsson, Chapter 14, and Juslin and Lindstrom, Chapter 37, this volume). Nevertheless, in early adulthood, performance on tests of emotional intelligence has no association with duration of music training even when (1) music training predicts general intelligence (Schellenberg, 2011b; Trimmer and Cuddy, 2008), or (2) emotional intelligence predicts the ability to recognize emotions in music (Resnicow, Salovey and Repp, 2004) or speech (Trimmer and Cuddy, 2008). In childhood, 7- and 8-year-olds with music training perform better than their untrained counterparts on a (p. 424) non-auditory test of comprehending emotions *and* on a test of IQ, but their advantage on the emotion test disappears when individual differences in IQ are held constant (Schellenberg and Mankarious, 2012).

Is music training associated with one or more of the five main dimensions of personality? Two likely possibilities include *conscientiousness*, which is associated with performance in school, and *openness-to-experience*, which is associated with IQ and years of education (John, Naumann and Soto, 2008). In adulthood, duration of music training in childhood is associated positively with openness-to-experience, and this association remains evident when cognitive ability is held constant (Corrigall et al., 2013). Among 10- to 12-year-old children (Corrigall et al., 2013) and 17-year-olds (Hille and Schupp, 2014), duration of training is associated with both conscientiousness and openness-to-experience. For the 10- to 12-year-olds, associations with personality (i.e., openness-to-experience) remain evident when general cognitive ability is held constant, but the association between music training and general cognitive ability disappears when personality is held constant. Moreover, the “special” association between music training and school performance (i.e., with IQ held constant) disappears when individual differences in conscientiousness are controlled. When children begin to take formal music lessons at around 7 or 8 years of age, the best predictors of music training are the parent’s (i.e, the parent who accompanies the child to the laboratory) openness-to-experience and the child’s agreeableness (Corrigall and Schellenberg, 2015). These results are important because previous findings of associations between music training and cognitive abilities may not have been evident if individual differences in personality had been measured and held constant.

In sum, despite much anecdotal evidence, empirical findings suggest that music training is not linked with social or emotional abilities in any meaningful way, although music training in large groups may represent an exception. Links with personality are more convincing, and provide additional evidence that individual differences determine who takes music lessons and for how long.

Conclusion

Associations between music training and cognitive abilities are well established and they are *not* limited to specific domains of cognitive functioning. Music training may play a causal role in some of these associations, particularly those related to speech perception, language use, and spatial abilities. Music training may also cause small improvements in domain-general abilities such as IQ. Unless taking music lessons has transformative powers, however, the number and magnitude of the associations make it implausible that music training is causing all of them. Rather, pre-existing differences in music aptitude, cognitive abilities, and personality influence the decision to take music lessons and test-taking abilities. Indeed, many of the associations reviewed in this chapter may not have emerged if such pre-existing individual differences had been measured and held constant. More generally, associations between music training and nonmusical abilities are bound to be a consequence of nature *and* nurture, and of interactions between nature and nurture.

Future studies could attempt to provide a richer account of associations between music training and nonmusical abilities by measuring aptitude and cognitive abilities before the (p. 425) training begins. One possibility is that music training would have the strongest effects for children who score relatively high on tests of aptitude and/or IQ, because they are naturally suited for music training. It is also possible that music training would be particularly effective for children who score relatively low on aptitude and/or IQ because they have the most room for improvement.

Author Note

Preparation of this chapter was supported by the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada. Correspondence should be sent to Glenn Schellenberg, Department of Psychology, University of Toronto Mississauga, Mississauga, ON, Canada L5L 1C6 (email: g.schellenberg@utoronto.ca).

References

Anvari, S.H., Trainor, B.J., Woodside, J. and Levy, B.A. (2002). Relations among musical skills, phonological processing and early reading abilities in pre-school children. *Journal of Experimental Child Psychology*, *83*, 111–130.

Berk, L.A. (2012). *Child development* (9th ed.). Boston, MA: Pearson.

Bialystok, E. and DePape, A.M. (2009). Musical expertise, bilingualism, and executive functioning. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 565–574.

Bidelman, G.M., Hutka, S. and Moreno, S. (2013). Tone language speakers and musicians share enhanced perceptual and cognitive abilities for musical pitch: evidence for bidirectionality between the domains of language and music. *PLoS ONE*, *8*(4), e60676. doi:10.1371/journal.pone.0060676

Brandler, S. and Rammsayer, T.H. (2003). Differences in mental abilities between musicians and non-musicians. *Psychology of Music*, *31*, 123–138.

Bugos, J.A., Perlstein, W.M., McCrae, C.S., Brophy, T.S. and Bedenbaugh, P.H. (2007). Individualized piano instruction enhances executive functioning and working memory in older adults. *Aging and Mental Health*, *11*, 464–471.

Butzlaff, R. (2000). Can music be used to teach reading? *Journal of Aesthetic Education*, *34*(3/4), 167–178.

Carroll, J.B. (1993). *Human cognitive abilities: A survey of factor-analytical studies*. New York: Cambridge University Press.

Chobert, J., Marie, C., François, C., Schön, D., and Besson, M. (2011). Enhanced passive and active processing of syllables in musician children. *Journal of Cognitive Neuroscience*, 23, 3874-3887.

Cohen, M.A., Evans, K.K., Horowitz, T.S. and Wolfe, J.M. (2011). Auditory and visual memory in musicians and nonmusicians. *Psychonomic Bulletin & Review*, *18*, 586–591.

Corrigall, K.A. and Schellenberg, E.G. (2013). Music: the language of emotion. In C. Mohiyeddini, M. Eysenck and S. Bauer (Eds.), *Handbook of psychology of emotions: Recent theoretical perspectives and novel empirical findings* (Vol. *2*; pp. 299–325). Hauppauge, NY: Nova. **(p. 426)**

Corrigall, K.A. and Schellenberg, E.G. (2015). Predicting who takes music lessons: parent and child characteristics. *Frontiers in Psychology*, *6*, 282. doi: 10.3389/fpsyg.2015.00282

Corrigall, K.A. and Trainor, L.J. (2011). Associations between length of music training and reading skills in children. *Music Perception*, *29*, 147–155.

Corrigall, K.A., Schellenberg, E.G. and Misura, N.M. (2013). Music training, cognition, and personality. *Frontiers in Psychology*, *4*, 222. doi:10.3389/fpsyg.2013.00222

Costa-Giomi, E. (2004). Effects of three years of piano instruction on children's academic achievement, school performance and self-esteem. *Psychology of Music*, *32*, 139–152.

Degé, F., Kubicek, C. and Schwarzer, G. (2011a). Music lessons and intelligence: a relation mediated by executive functions. *Music Perception*, *29*, 195–201.

Degé, F. and Schwarzer, G. (2011). The effect of a music program on phonological awareness in preschoolers. *Frontiers in Psychology*, *2*, 124. doi:10.3389/fpsyg.2011.00124

Degé, F., Wehrum, S., Stark, R. and Schwarzer, G. (2011b). The influence of two years of school music training in secondary school on visual and auditory memory. *European Journal of Developmental Psychology*, *8*, 608–623.

Degé, F., Wehrum, S., Stark, R. and Schwarzer, G. (2014). Music lessons and academic self-concept in 12- to 14-year-olds. *Musicae Scientiae*, *18*, 203–215.

Drayna, D., Manichaikul, A., de Lange, M., Sneider, H. and Spector, T. (2001). Genetic correlates of musical pitch recognition in humans. *Science*, *291*, 1969–1972.

Elmer, S., Meyer, M. and Jäncke, L. (2012). Neurofunctional and behavioral correlates of phonetic and temporal categorization in musically trained and untrained subjects. *Cerebral Cortex*, *22*, 650–658.

Forgeard, M., Winner, E., Norton, A. and Schlaug, G. (2008). Practicing a musical instrument in childhood is associated with enhanced verbal ability and nonverbal reasoning. *PLoS One*, *3*(10), e3566. doi:10.1371/journal.pone.0003566

François, C., Chobert, J., Besson, M. and Schön, D. (2013). Music training and the development of speech segmentation. *Cerebral Cortex*, *23*, 2038–2043.

George, E.M. and Coch, D. (2011). Music training and working memory: an ERP study. *Neuropsychologia*, *49*, 1083–1094.

Gibson, C., Folley, B.S. and Park, S. (2009). Enhanced divergent thinking and creativity in musicians: a behavioral and near-infrared spectroscopy study. *Brain and Cognition*, *69*, 162–169.

Haimson, J., Swain, D. and Winner, E. (2011). Are mathematicians more musical than the rest of us? *Music Perception*, *29*, 203–213.

Hanna-Pladdy, B. and Gajewski, B. (2012). Recent and past musical activity predicts cognitive aging variability: direct comparison with general lifestyle activities. Frontiers in Human Neuroscience, 6, 198. doi: 10.3389/fnhum.2012.00198

Hanna-Pladdy, B. and MacKay, A. (2011). The relation between instrumental musical activity and cognitive aging. *Neuropsychology*, *25*, 378–386.

Hansen, M., Wallentin, M. and Vuust, P. (2013). Working memory and musical competence of musicians and non-musicians. *Psychology of Music*, *41*, 779–793.

Helmbold, N., Rammsayer, T. and Altenmüller, E. (2005). Differences in primary mental abilities between musicians and nonmusicians. *Journal of Individual Differences*, *26*, 74–85.

Hetland, L. (2000). Learning to make music enhances spatial reasoning. *Journal of Aesthetic Education*, *34*(3/4), 179–238.

Hille, K., Gust, K., Bitz, U. and Kammer, T. (2011). Associations between music education, intelligence, and spelling ability in elementary school. Advances in Cognitive Psychology, 7, 1–6. (p. 427)

Hille, A. and Schupp, J. (2014). How learning a musical instrument affects the development of skills. *Economics of Education Review*, *44*, 56–82.

Huron, D. (2003). Is music an evolutionary adaptation? In I. Peretz and R.J. Zatorre (Eds.), *The cognitive neuroscience of music* (pp. 57–75). Oxford: Oxford University Press.

Jakobson, L., Lewycky, S., Kilgour, A. and Stoesz, B. (2008). Memory for verbal and visual material in highly trained musicians. *Music Perception*, *26*, 41–55.

John, O.P., Naumann, L.P. and Soto, C.J. (2008). Paradigm shift to the integrative big-five trait taxonomy: history, measurement, and conceptual issues. In O.P. John, R.W. Robins and L.A. Pervin (Eds.), *Handbook of personality: Theory and research* (pp. 114–158). New York: Guilford.

Jones, J.L., Lucker, J., Zalewski, C., Brewer, C. and Drayna, D. (2009). Phonological processing in adults with deficits in musical pitch recognition. *Journal of Communication Disorders*, *42*, 226–234.

Kaviani, H., Mirbaha, H., Pournaseh, M. and Sagan, O. (2014). Can music lessons increase the performance of preschool children in IQ tests? *Cognitive Processing*, *15*, 77–84.

Kilgour, A.R., Jakobson, L.S. and Cuddy, L.L. (2000). Music training and rate of presentation as mediators of text and song recall. *Memory & Cognition*, *28*, 700–710.

Lee, Y.-S., Lu, M.-J. and Ko, H.-P. (2007). Effects of skill training on working memory capacity. *Learning and Instruction*, *17*, 336–344.

Loy, G. (2006). *Musimathics, Volume 1: The mathematical foundations of music*. Cambridge, MA: MIT Press.

Loy, G. (2007). *Musimathics, Volume 2: The mathematical foundations of music*. Cambridge, MA: MIT Press.

Marie, C., Delogu, F., Lampis, G., Belardinelli, M.O. and Besson, M. (2011). Influence of musical expertise on segmental and tonal processing in Mandarin Chinese. *Journal of Cognitive Neuroscience*, *23*, 2401–2415.

Mehr, S.A., Schachner, A., Katz, R.C. and Spelke, E.S. (2013). Two randomized trials provide no consistent evidence for nonmusical cognitive benefits of brief preschool music enrichment. *PLoS ONE*, *8*(12), e82007. doi:10.1371/journal.pone.0082007

Milovanov, R., Huotilainen, M., Välimäki, V., Esquef, P.A.A. and Tervaniemi, M. (2008). Musical aptitude and second language pronunciation skills in school-aged children: Neural and behavioral evidence. *Brain Research*, *1194*, 81–89.

Milovanov, R. and Tervaniemi, M. (2011). The interplay between musical and linguistic aptitudes: A review. *Frontiers in Psychology*, *2*, 321. doi:10.3389/fpsyg.2011.00321

Moreno, S., Bialystok, E., Barac, R., Schellenberg, E.G., Cepeda, N.J. and Chau, T. (2011a). Short-term music training enhances verbal intelligence and executive function. *Psychological Science*, *22*, 1425–1433.

Moreno, S., Friesen, D. and Bialystok, E. (2011b). Effect of music training on promoting preliteracy skills: Preliminary causal evidence. *Music Perception*, *29*, 165–172.

Moreno, S., Marques, C., Santos, A., Santos, M., Castro, S.L. and Besson, M. (2009). Musical training influences linguistic abilities in 8-year-old children: More evidence for brain plasticity. *Cerebral Cortex*, *19*, 712–723.

Oechslin, M.S., Van De Ville, D., Laseyras, F., Hauert, C.-A. and James, C.E. (2013). Degree of musical expertise modulates higher order brain functioning. *Cerebral Cortex*, *23*, 2213–2224.

Oikkonen, J. and Järvelä, I. (2014). Genomics approaches to study musical aptitude. *Bioessays*, *36*, 1102–1108. doi:10.1002/bies.201400081

Parbery-Clark, A., Skoe, E., Lam, C. and Kraus, N. (2009). Musician enhancement for speech-in-noise. *Ear and Hearing*, *30*, 653–661. **(p. 428)**

Parbery-Clark, A., Strait, D.L., Anderson, S., Hittner, E. and Kraus, N. (2011). Musical experience and the aging auditory system: Implications for cognitive abilities and hearing speech in noise. *PLoS ONE*, *6*(5), e18082. doi:10.1371/journal.pone.0018082

Patston, L.L., Hogg, S.L. and Tippett, L.J. (2007). Attention in musicians is more bilateral than in non-musicians. *Laterality*, *12*, 262–272.

Patston, L.M. and Tippett, L.J. (2011). The effect of background music on cognitive performance in musicians and nonmusicians. *Music Perception*, *29*, 173–183.

Peynircioğlu, Z., Durgunoğlu, A. and Öney-Küsefoğlu, B. (2002). Phonological awareness and musical aptitude. *Journal of Research in Reading*, *25*, 68–80.

Portowitz, A., Lichtenstein, O., Egorova, L. and Brand, E. (2009). Underlying mechanisms linking music education and cognitive modifiability. *Research Studies in Music Education*, *31*, 107–128.

Rauscher, F.H. (2008). The impact of music instruction on other skills. In S. Hallam, I. Cross and M. Thaut (Eds.), *The Oxford handbook of music psychology* (pp. 244–252). Oxford: Oxford University Press.

Rauscher, F.H. and Hinton, S.C. (2011). Music instruction and its diverse extra-musical benefits. *Music Perception*, *29*, 215–226.

Resnicow, J.E., Salovey, P. and Repp, B.H. (2004). Is recognition of emotion in music performance an aspect of emotional intelligence? *Music Perception*, *22*, 145–158.

Roden, I., Grube, D., Bongard, S. and Kreutz, G. (2014a). Does music training enhance working memory performance? Findings from a quasi-experimental longitudinal study. *Psychology of Music*, *42*, 284–298.

Roden, I., Könen, T., Bongard, S., Frankenberg, E., Friedrich, E.K. and Kreutz, G. (2014b). Effects of music training on attention, processing speed and cognitive music abilities—findings from a longitudinal study. *Applied Cognitive Psychology*, *28*, 545–557.

Rodrigues, A.C., Loureiro, M.A. and Caramelli, P. (2013). Long-term musical training may improve different forms of visual attention ability. *Brain and Cognition*, *82*, 229–235.

Schellenberg, E.G. (2004). Music lessons enhance IQ. *Psychological Science*, *15*, 511–514.

Schellenberg, E.G. (2006). Long-term positive associations between music lessons and IQ. *Journal of Educational Psychology*, *98*, 457–468.

Schellenberg, E.G. (2011a). Examining the association between music lessons and intelligence. *British Journal of Psychology*, *102*, 283–302.

Schellenberg, E.G. (2011b). Music lessons, emotional intelligence, and IQ. *Music Perception*, *29*, 185–194.

Schellenberg, E.G. (2012). Cognitive performance after music listening: a review of the Mozart effect. In R.A.R. MacDonald, G. Kreutz, and L. Mitchell (Eds.), *Music, health, and wellbeing* (pp. 324–338). Oxford: Oxford University Press.

Schellenberg, E.G. (2015). Music and nonmusical abilities. In G.E. McPherson (Ed.), The child as musician: A handbook of musical development (2nd ed., pp. 149–176). Oxford, UK: Oxford University Press.

Schellenberg, E.G. and Mankarious, M. (2012). Music training and emotion comprehension in childhood. *Emotion*, *12*, 887–891.

Schellenberg, E.G. and Weiss, M.W. (2013). Music and cognitive abilities. In D. Deutsch (Ed.), *The psychology of music* (3rd ed., pp. 499–550). Amsterdam: Elsevier.

Slevc, L.R. and Miyake, A. (2006). Individual differences in second language proficiency: does musical ability matter? *Psychological Science*, *17*, 675–681. **(p. 429)**

Sluming, V., Brooks, J., Howard, M., Downes, J.J. and Roberts, N. (2007). Broca’s area supports enhanced visuospatial cognition in orchestral musicians. *Journal of Neuroscience*, *27*, 3799–3806.

Stoesz, B., Jakobson, L., Kilgour, A. and Lewycky, S. (2007). Local processing advantage in musicians: evidence from disembedding and constructional tasks. *Music Perception*, *25*, 153–165.

Strait, D.L. and Kraus, N. (2011). Playing music for a smarter ear: cognitive, perceptual, and neurobiological evidence. *Music Perception*, *29*, 133–146.

Strait, D.L. and Kraus, N. (2014). Biological impact of auditory expertise across the life span: musicians as a model of auditory learning. Hearing Research, 308, 109–121.

Strait, D.L., Parbery-Clark, A., Hittner, E. and Kraus, N. (2012). Musical training during early childhood enhances the neural encoding of speech in noise. *Brain & Language*, *123*, 191–201.

Thompson, W.F., Schellenberg, E.G. and Letnic, A.K. (2012). Fast and loud background music hinders reading comprehension. *Psychology of Music*, *40*, 700–708.

Trimmer, C.G. and Cuddy, L.L. (2008). Emotional intelligence, not music training, predicts recognition of emotional speech prosody. *Emotion*, *8*, 838–849.

Vaughn, K. (2000). Music and mathematics: modest support for the oft-claimed relationship. *Journal of Aesthetic Education*, *34*(3/4), 149–166.

Wallentin, M., Nielsen, A.H., Friis-Olivarius, M., Vuust, C. and Vuust, P. (2010). The Musical Ear Test, a new reliable test for measuring musical competence. *Learning and Individual Differences*, *20*, 188–196.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale* (4th ed.). San Antonio, TX: Psychological Corporation.

Wetter, O.E., Koerner, F. and Schwaninger, A. (2009). Does musical training improve school performance? *Instructional Science*, *37*, 365–374.

Zelazo, P.D. (2004). The development of conscious control in childhood. *Trends in Cognitive Sciences*, *8*, 12–17. **(p. 430)**

E. Glenn Schellenberg

Psychology, University of Toronto at Mississauga

E. Glenn Schellenberg, Ph.D., Department of Psychology, University of Toronto at Mississauga