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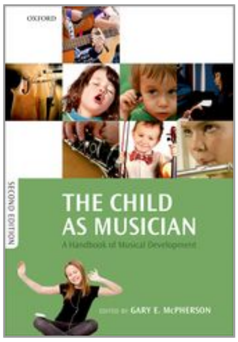

The Child as Musician: A handbook of musical development

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Music and nonmusical abilities

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[–] Abstract and Keywords

This chapter examines whether exposure to music is associated with nonmusical abilities. Such exposure includes music listening and formal training in music. Performance on tests of cognitive abilities can be enhanced after listening to music, but these effects are due to positive changes in emotional state. Effects of listening to background music while engaged in a cognitive activity are poorly understood because multiple factors are involved. Taking music lessons in childhood is associated positively with verbal and visuospatial abilities, as well as with memory and IQ. Although experimental studies indicate that music lessons can cause small increases in cognitive abilities, the large associations observed in real-world contexts must be attributable, at least in part, to pre-existing differences in music aptitude, general cognitive abilities, and/or personality.

Keywords: music lessons, music training, music aptitude, IQ, personality, intelligence, cognition, personality

Music and nonmusical abilities: Introduction

In this chapter, I examine claims about nonmusical consequences of exposure to music. Over the past 20 years, the possibility that *music makes you smarter* has sparked the imagination of researchers, the popular press, and the general public. But is there any truth to this idea? If so, what is the evidence? Could music also improve social skills? Although definitive answers are elusive for the most part, my goal is to provide an overview of what is known from behavioral studies, focusing primarily on those published since 2000.

At the outset, we might ask why people care about nonmusical benefits of exposure to music. Do we have similar concerns about other subjects, such as mathematics, English, or chemistry?

Would we value physics *less* if we knew that it did *not* lead to improvements in drama? Although the question is tongue-in-cheek, it highlights the fact that all academic disciplines are not considered equal. Somehow, music's status as an art form reduces its status as a discipline, which means that music is more likely than other subjects to be eliminated from school curricula when budgets are cut. Indeed, in the neo-conservative, belt-tightening climate of the late twentieth century, government-supported education programs in music were often slashed or threatened. Consequently, the idea that music might have collateral benefits was welcomed with open arms as a way of saving or reviving programs. It suggested that music could be *more* than just an art form. In fact, music could be a conduit for improvements in other domains.

These historical and contextual factors helped to exaggerate the timeless and universal appeal of quick fixes to complex problems. Consider intelligence as measured by IQ tests. Competition for admission to the best schools and universities is stiff, and a few extra IQ points could make a difference. In fact, IQ is predictive of academic achievement, job performance, income, health, longevity, and dealing successfully with the demands of everyday life (e.g., Deary, 2012; Kulkofsky & Ceci, 2006; Nisbett et al., 2012). Thus, it is no wonder that the public paid attention to media reports that simply exposing oneself to music leads to a boost in IQ. It is difficult to imagine a simpler fix (music) to such a complex problem (intelligence).

In contemporary Western society, exposure to music typically takes one of two forms: listening and performing. Music listening is everywhere, both by design and by accident. People buy CDs, they watch and hear music videos on TV, they listen to music on the radio, they download MP3 files and stream music from the Internet, and they attend concerts. Much of the time, music is playing in the background while the person does something else, like studying or driving a car. People also *overhear* music without choosing to do so or having any say in what they hear, while shopping, eating in restaurants, and so on. By contrast, performing music is relatively rare in Western society. Although many children take lessons for a year or two, only a small minority studies music year in and year out, practicing regularly on a daily basis. The stark contrast between simply listening to music on the one hand, and actively pursuing a musical education or performing music regularly **(p.150)** on the other hand, makes it highly unlikely that the two activities would have similar effects on nonmusical aspects of human behavior. As I have argued previously (Schellenberg, 2005), it is important to treat these two forms of exposure to music separately. Accordingly, associations with nonmusical abilities will be examined first in respect to music listening, and then in respect to music training. Although this handbook focuses on children and music, issues examined in the present chapter are applicable across the lifespan. Hence, relevant research with adults is also considered, particularly in the case of music listening. In the case of music training, which is typically initiated in childhood, it matters less whether the sample comprises children or adults.

Music listening

Studies of effects of music listening on intellectual functioning typically ask one of two questions: whether performance on some kind of task is influenced *after* listening to music or *while* listening to music. The former question asks whether music might put you in the right frame of mind for subsequent intellectual activity, whereas studies of background music ask whether music helps or hinders performance on the foreground (i.e., *primary*) task that takes place concurrently.

Performance after listening

Contemporary interest in nonmusical benefits of exposure to music was instigated by the publication of an article in *Nature* in 1993 (Rauscher, Shaw, & Ky, 1993). The researchers tested the spatial abilities of undergraduates after exposure to ten minutes of classical music, relaxation instructions, or silence. The students were administered three subtests from a widely used test of IQ. Performance was better after listening to music than in the other two conditions. Because the music was a recording composed by Mozart, the effect became known as the *Mozart effect*. The effect was short-lived (ten to fifteen minutes), meaning that it lasted about as long as the actual music listening that occurred before the tests.

Why did these findings create such a fuss, which included widespread coverage in the popular media and state-wide policy changes in daycare centers? One likely reason is that the authors reported their results as IQ scores, suggesting a very simple fix to a complex problem, namely that listening to Mozart increases intelligence. Another reason is that the authors did not consider well-established findings from psychology or neuroscience to explain the link between music listening and test performance. Instead, they suggested that passive listening to “complex” music (e.g., the Mozart piece they used as a stimulus) enhances abstract reasoning in general, including spatial reasoning. In other words, they proposed a direct causal link between listening to Mozart and spatial abilities, which the media extended to intelligence in general.

Researchers subsequently tried to replicate and extend the effect using a variety of outcome measures and different pieces of music. They were successful in some instances, but not in others. A meta-analysis of almost forty studies and over three thousand participants found evidence for small, short-term improvements in performance on spatial tasks after listening to Mozart compared to no music (typically silence; Pietschnig, Voracek, & Formann, 2010). Nevertheless, an effect of similar magnitude was evident for studies that compared spatial abilities after listening to other music (i.e., *not* composed by Mozart) to no music. Thus, the authors concluded that “there is little evidence left for a specific, performance-enhancing Mozart effect” on spatial abilities (p. 314). For example, spatial abilities can also improve after listening to music composed by Bach (Ivanov & Geake, 2003) or Yanni (Rideout, Dougherty, & Wernert, 1998). The effect does not extend to minimalist music composed by Philip Glass (Rauscher, Shaw, & Ky, 1995), however, which many listeners dislike because of its use of repetition.

(p.151) My colleagues and I (Husain, Thompson, & Schellenberg, 2002; Nantais & Schellenberg, 1999; Schellenberg & Hallam, 2005; Schellenberg et al., 2007; Thompson, Schellenberg, & Husain, 2001) conducted a series of studies that sought to 1) replicate the original effect and 2) make systematic alterations to the method in order to highlight what was driving it. (For a more detailed overview of this research and the historical context, see Schellenberg, 2012.) We hypothesized that the effect was due to between-condition differences in affective state, specifically arousal levels (how alert participants are) and mood (how pleasant they feel). A wide body of research confirms that affective states influence cognitive performance (e.g., Beal et al., 2005; Cassady & Johnson, 2002; Dutton & Carroll, 2001; Eich & Forgas, 2003; Grawitch et al., 2003), and that music listening is an efficient way (but not the only way) to influence how you feel (Juslin & Västfjäll, 2008; van Goethem & Sloboda, 2011;

Västfjäll, 2001/2). In fact, people listen to music precisely for its emotional impact (Lonsdale & North, 2011). From this viewpoint, the link between Mozart and spatial abilities is just one example of how a stimulus that makes you feel good can also improve performance on a variety of tests.

We initially confirmed that spatial abilities were better after ten minutes of exposure to music composed by Mozart than after ten minutes of sitting in silence (Nantais & Schellenberg, 1999). We also found a virtually identical advantage when music composed by Schubert was compared to silence. When we contrasted listening to Mozart with listening to a narrated story, the effect disappeared, but there was an interaction between participants' preferences and the listening condition. Listeners who preferred Mozart did better on the spatial test after listening to Mozart; those who preferred the story did better after listening to the story. In short, because we found a "Schubert effect" and a "story effect," we clarified that the so-called Mozart effect was not specific to Mozart in particular or to music in general.

Our second study included another comparison of Mozart with silence, plus a comparison of a piece written by Albinoni with silence (Thompson, Schellenberg, & Husain, 2001). We also measured listeners' arousal levels and moods. The Mozart sonata (used previously by Nantais & Schellenberg, 1999, and Rauscher, Shaw, & Ky, 1993) is an up-tempo, happy-sounding piece in a major key. Albinoni's *Adagio* is a slow-tempo, sad-sounding piece in a minor key. The results from the affective measures showed that after listening to Mozart, arousal levels increased and mood improved, but after listening to Albinoni, arousal levels decreased and mood declined. As expected, there was no advantage on the spatial task after listening to Albinoni compared to silence, but we successfully replicated the Mozart effect once again. When we used statistical means to hold constant participants' changes in arousal and mood, the Mozart advantage on the spatial task disappeared.

We then examined which features of the Mozart sonata cause changes in arousal and mood, which, in turn, lead to enhanced cognitive performance (Husain, Thompson, & Schellenberg, 2002). We created four versions of the same Mozart sonata, which varied in tempo (fast or slow) and mode (major or minor), and we measured arousal and mood before and after listening. Spatial abilities were better among listeners who heard the fast rather than the slow versions, and for those who heard the major rather than the minor versions. The tempo manipulation influenced arousal but not mood; the mode manipulation influenced mood but not arousal. As in Thompson, Schellenberg, & Husain (2001), changes in arousal and mood accounted for most of the variance in performance on the spatial task, with higher scores associated with higher levels of arousal and more positive moods.

In order to show that the Mozart effect generalized to tests that do *not* measure spatial abilities, in the next study we used tests of processing speed and working memory after participants listened to Mozart or Albinoni (Schellenberg et al., 2007). We again found improvements in arousal **(p.152)** and mood after listening to Mozart, but decreases in arousal and mood after listening to Albinoni. Increases in arousal and more positive moods were accompanied by better performance on the test of processing speed, but not on the test of working memory. In other words, although tests of some abilities may be more susceptible than others to affective states, whether the test measures spatial abilities is irrelevant.

The type of music that puts listeners in an optimal emotional state is almost certain to depend critically on who the listeners are. In line with this view, we showed that cognitive benefits are more likely after 10- and 11-year-olds listen to popular music than to Mozart (Schellenberg & Hallam, 2005). We then sought to generalize the findings even further by examining the creative abilities of Japanese 5-year-olds (Schellenberg et al., 2007). The children made drawings after a musical experience that consisted of listening to Mozart or Albinoni (i.e., the pieces used earlier), listening to familiar children's songs, or singing children's songs. Compared to the children who heard classical music, those who sang or listened to familiar songs spent a longer time drawing, and their drawings were judged by independent raters to be more creative, energetic, and technically proficient.

To summarize, effects of music on spatial abilities do not depend on music composed by Mozart, as Pietschnig, Voracek, & Formann's (2010) meta-analysis confirmed. Specific characteristics of music affect arousal and mood, which, in turn, affect performance on many tasks. Nonmusical stimuli that lead to better affective states compared to control conditions can show similar effects. The best music for improving how listeners feel and consequently how they perform depends on who the listeners are. Although listening to music composed by Mozart can indeed make a listener feel good and perform well, the term "the Mozart effect" is misleading because the effect does not depend on listening to Mozart, or even on listening to music. Moreover, the claim of a special causal link between listening to complex music and spatial abilities is without merit.

Performance while listening

The majority of music listening occurs while listeners are doing something else at the same time (Sloboda, O'Neill, & Ivaldi, 2001). For example, activities such as driving are accompanied by music listening around 90% of the time (North, Hargreaves, & Hargreaves, 2004). The term "background music" means that music listening is a secondary activity, with the "foreground" activity assuming more importance, which is why it is called the *primary* task. Whether background music has enhancing, detrimental, or no effects on the primary task is important because the stakes can be high. A mother may rightfully ask whether her teenage son can learn anything when he is studying for an exam with Metallica playing at full volume. Similarly, a police officer could ask whether listening to music in the car played a role in a traffic accident. As we will see, the available literature does not allow us to give definitive answers to these questions.

At the most basic level, effects of background music on the primary task are the consequence of two independent factors. First, we need to consider how music makes listeners feel. If a driver is getting sleepy, listening to up-tempo dance or rock music could have an arousing effect such that it improves performance on the primary task (i.e., driving in this case), and reduces the chance of falling asleep and getting into an accident. In the Mozart-effect studies reviewed here, music usually had a *positive* influence on the listeners' affective state, primarily because the goal was to examine whether music listening could *improve* performance on a task performed subsequently. In principle, researchers could have asked instead whether music might impair performance, particularly if the music was disliked or made listeners feel sleepy. Similar positive or negative effects could be evident with background music. For example, when a driver is agitated or **(p.153)** nervous, up-tempo dance or rock music could be over-stimulating. By contrast, a piece of music that sounds peaceful or boring could increase the chance that a driver suffering from fatigue falls asleep at the wheel. Clearly, the match between music and listeners —including their current emotional state—is a crucial factor.

We also need to consider that regardless of how we are feeling, working memory has a finite capacity, which means that there is a limited amount of information people can process at any point in time (Cowan, 2005; Engle, 2002; Kane et al., 2004). In some instances, the presence of music could mean that there is less than an optimal amount of cognitive resources left for the primary task. In other words, a bottleneck limits the total amount of information that can be processed simultaneously. When music is difficult to ignore because it is loud or because it has lyrics, it is likely to take up more of the available information that can pass through the bottleneck. The likelihood of exceeding cognitive capacity decreases, however, when the primary task is over-learned or habitual. Such routine activities take up fewer cognitive resources than unfamiliar tasks. For example, people who take the same route to work for years on end use only a small percentage of their total cognitive resources while driving, which allows them to carry on detailed conversations or listen closely to music at the same time. When it rains or snows heavily, however, the primary task becomes more effortful and drivers often instinctively turn down the radio or end the conversation. In general, the more difficult the primary task, the more cognitive resources it will use, leaving fewer resources for music listening and a greater chance of a bottleneck.

Whether background music creates a processing bottleneck is independent of its emotional effect on listeners. In other words, music’s emotional impact can be small or large, or negative or positive, whether or not the demands of the primary task, combined with listening to background music, exceed capacity. People could listen to a well-liked, up-tempo song that makes them feel good while they are reading relatively complicated text. The music may enhance their affective state, but it could also overtax their cognitive resources such that they are less likely to comprehend and remember what they read. According to Hallam and MacDonald (2009), a complete account of the effect of background music must also consider basic demographic variables (e.g., age, personality), the specific primary task (i.e., subject matter), the specific piece of music, the music’s volume and familiarity, and whether the listener is alone and/or in a familiar environment.

These different factors help to explain why background music can have positive, negative, or no effects on the primary task. Indeed, in a meta-analytic review of studies conducted with adults, there was no effect of background music on a variety of primary tasks, even though individual studies reported effects ranging from strongly negative to strongly positive (Kämpfe, Sedlmeier, & Renkewitz, 2011). More detailed analyses in the same review showed that background music tends to have a small disruptive influence on reading comprehension and memory, even though it typically improves affective states and athletic performance. Another conclusion was that performance on the primary task is quicker or slower if the tempo of the music is fast or slow, respectively.

Let us turn now to empirical studies that examined effects of background music on cognitive performance, in order to illustrate some of the contradictions in the literature that preclude general conclusions that apply across listeners, contexts, tasks, and different kinds of music. In one study, my colleagues and I examined the influence of background music on reading comprehension in a sample of college students (Thompson, Schellenberg, & Letnic, 2012). The question is important because students often listen to music while studying, typically with the explicit goal of understanding and remembering what they are reading. Our participants listened to instrumental classical music while reading short passages of text. They subsequently answered multiple-choice **(p.154)** questions about the text in silence. Students who listened to a loud and fast version of the sonata showed performance decrements compared to a control group of students who read in silence. The most interesting finding, however, was that reading comprehension was unaffected while listening to quiet and slow, quiet and fast, or loud and slow versions of the same sonata. In other words, the bottleneck effect was observed only when the music had many notes in relatively rapid succession that could not be ignored because of the volume.

Other researchers documented that background music with lyrics disrupts adults' performance on a low-level test of attention, whereas instrumental versions of the same music have no effect (Shih, Huang, & Chiang, 2012). In this case, additional resources required to process the words lead to a bottleneck effect. Differential effects on attention have also been observed as a function of how much listeners like the music. In one instance, background music that was strongly liked or disliked led to decreases in performance (Huang & Shih, 2011). Presumably, deeper emotional engagement meant that more attention was directed toward the music and away from the primary task. Individual differences in personality also play a role, with introverts more likely than extraverts to show detrimental effects of background music (Cassidy & MacDonald, 2007; Dobbs, Furnham, & McClelland, 2011). Introverts have higher baseline levels of arousal compared to extroverts, which make them less likely to seek out external social stimulation. They are therefore more likely to become over-aroused by the presence of background music, which leads them to perform poorly on the primary task.

What do we know about effects of background music in childhood and the early teenage years? Anderson and Fuller (2010) examined whether background music affected reading comprehension among seventh and eighth graders. The method involved reading passages of text and answering multiple-choice questions (as in Thompson, Schellenberg, & Letnic, 2012), either in silence or while listening to hit recordings presented at a moderate volume. The results showed that background music hindered reading comprehension and that a detrimental effect was evident in 75% of the students. The marked difference compared to relatively benign effects observed with college students could be due to multiple factors: the music had lyrics, it was presented while reading *and* while answering the comprehension questions, the students were younger and tested in groups, and the same students were tested in silence *and* with background music. In any event, the discrepancy across studies that asked the same question highlights the difficulty in making broad conclusions about background music on cognitive performance. Moreover, other studies of 10-year-olds (Bloor, 2009) and 11- and 12-year-olds (Furnham & Stephenson, 2007) failed to find *any* effect of background music on reading comprehension. Nevertheless, because positive findings are rare, the results highlighted here imply that Kämpfe, Sedlmeier, & Renkewitz's (2011) conclusion (i.e., that background music has a small negative effect on reading comprehension among adults) extends to younger listeners.

Another study of eighth-grade students reported no effect of background music (i.e., pop songs) on a memorization task (Pool, Koolstra, & van der Voort, 2003). In a study of college students, however, performance on a memory test was negatively impacted by the presence of background music (Perham & Vizard, 2011), whether it was liked (e.g., Lady Gaga, Arcade Fire) or disliked (thrash metal). Thus, we have another discrepancy except that the negative finding was evident among the college students instead of the eighth-graders. Other studies of young adults reported a small positive effect of background music on memory (de Groot, 2006), no effect (Jäncke & Sandmann, 2010), or a negative effect when the background music was highly arousing (e.g., heavy metal; Cassidy & MacDonald, 2007). In one sample of 11- to 12-year-olds, calming background music improved memory compared to silence, whereas music considered unpleasant (i.e., a jazz piece by John Coltrane) hindered memory (Hallam, Price, & Katsarou, 2002). Because **(p.155)** negative findings tend to be more common and stronger than positive findings, at least among adults, Kämpfe, Sedlmeier, & Renkewitz (2011) concluded that background music has a small negative effect on memory. There is no reason to doubt that a similar effect extends to younger listeners.

Bloor (2009) reported that performance on an arithmetic test was better in silence than when listening to Mozart for 10-year-olds, who were unlikely to have developed an appreciation for classical music. In another study of the arithmetic abilities of 10- and 11-year-olds, the children completed more items in the presence of calming music compared to silence, but the number of correct answers did not differ across conditions (Hallam, Price, & Katsarou, 2002). In a study of emotionally disturbed 9- and 10-year-olds, however, calming music improved arithmetic performance, presumably because it also reduced the number of disruptive incidents (Hallam & Price, 1998). Calming background music can also improve pro-social responding (i.e., endorsing altruistic acts) among 11- to 12-year-olds, whereas unpleasant music has the opposite effect (Hallam, Price, & Katsarou, 2002). For children, calming background music is likely to lower arousal levels, which could improve concentration, attention, cooperation, and good behavior more generally. Because calming music tends to be slow with relatively few notes per second, it is unlikely to create a cognitive bottleneck with the primary task.

In sum, whether background music has positive, negative, or no effects on the primary tasks depends on multiple factors. In general, background music appears to be slightly detrimental for reading comprehension or memory. Positive effects are most likely when the music puts listeners in an optimal emotional state for learning, such as when calming music reduces arousal levels in active children.

Music lessons

I will now examine whether music *lessons* are associated with nonmusical abilities. At the outset, it is important to highlight a few critical issues. We know that our personal experiences change us—how we think or feel, what we believe to be true, how we look at things (works of art, legal contracts), and so on. It should come as no surprise, then, that taking music lessons is associated positively not only with music-performance abilities, but also with music-listening skills. Such perceptual and cognitive advantages include: 1) better discrimination of pure tones (Parbery-Clark et al., 2009; Schellenberg & Moreno, 2010), complex tones (Bidelman, Hutka, & Moreno, 2013; Ruggles, Freyman, & Oxenham, 2014), and tone sequences (Bidelman, Hutka, & Moreno, 2013; Forgeard et al., 2008); 2) an ability to detect smaller mistunings to familiar melodies (Schellenberg & Moreno, 2010); 3) enhanced memory for familiar and unfamiliar music (Cohen et al., 2011); 4) faster pitch processing (Bidelman, Hutka, & Moreno, 2013; Jakobson, Cuddy, & Kilgour, 2003; Schellenberg and& Moreno, 2010) and faster temporal processing (Rammsayer & Altenmüller, 2006); and 5) better identification of melodies accompanied by anomalous chords, even after only eight months of music lessons (Corrigall & Trainor, 2009). Although such skills are useful for musicians, the benefits are logical outcomes of taking music lessons and playing music. A more provocative question is whether music lessons are accompanied by improvements in one or more nonmusical domains.

A second point involves the *specificity* of observed links between music lessons and cognitive abilities. If the claim that taking music lessons makes you smarter is to have any real meaning, it is important to show that music is special in this regard, because if reading, chess, ballet, and swimming lessons confer similar benefits, it would be more accurate to say that out-of-school activities *in general* have cognitive benefits. The issue of specificity also applies to the nonmusical **(p.156)** outcome variable. If benefits of music lessons are hypothesized to be stronger in some domains (e.g., language) than in others (e.g., spatial abilities), researchers need to show that any observed associations are not simply the consequence of general abilities (e.g., IQ or working memory), and that differential associations (e.g., for language but not for visuospatial abilities) are evident in the same sample of participants.

A third point is that taking music lessons is associated with basic demographic variables. For example, children who take music lessons tend to come from families with higher than average incomes, and their parents tend to have more education than the average parent (Corrigall, Schellenberg, & Misura, 2013; Norton et al., 2005; Roden, Könen et al., 2014; Schellenberg, 2006, 2011a,b; Southgate & Roscigno, 2009). Musically trained individuals may also differ in terms of ethnicity and cultural background compared to participants with no training (Schellenberg, 2011a,b; Southgate & Roscigno, 2009). These associations are problematic because socio-economic status (SES) is correlated positively with IQ (Corrigall et al., 2013; Schellenberg, 2006, 2011a; Schellenberg & Mankarious, 2012), cultural background is predictive of academic abilities (Campbell & Xue, 2001; Chen & Stevenson, 1995; Schellenberg & Trehub, 2008; Southgate & Roscigno, 2009), and linguistic background (e.g., native vs. non-native speaker) can influence verbal abilities (Schellenberg, 2011b). In short, associations between music lessons and cognitive functioning could stem from other variables.

A fourth problem is that even when potential confounding variables are held constant by statistical means, partial associations between music lessons and cognitive abilities do not allow us to conclude that music lessons are actually *causing* increases in abilities. In fact, the direction of causation could be in the opposite direction: children with better cognitive abilities might be more inclined than other children to take music lessons, as Roden, Könen et al. (2014) documented. All correlational studies and quasi-experiments have this limitation. Correlational studies examine whether two or more continuous variables (e.g., duration of musical training and intellectual abilities) increase and decrease in tandem. Quasi-experiments compare children or adults who are categorized into groups based on pre-existing differences (e.g., musically trained or untrained, musicians or nonmusicians). Either way, because individuals are not assigned at random to music training, no inferences about causation can be made.

The only way to infer causation is to conduct a true experiment with random assignment of children to music lessons. The random assignment assures that it is extremely unlikely that extraneous variables (e.g., SES, involvement in nonmusical activities) would differ between conditions. Even then, the extent of the inferences is limited by the particular comparison conditions. For example, one could recruit a sample of children and randomly assign half of them to music lessons, with the other half receiving no lessons. After a year or two of lessons, the music group might have higher scores on one or more tests of intellectual abilities. One could then infer appropriately that music lessons caused the difference between groups. It would remain unclear, however, whether *music* played a central role. Because the comparison group received no additional lessons of any kind, it is possible that nonmusical aspects of the lessons (e.g., additional contact with an adult instructor) were the source of the effect, and that similar results would be evident for other out-of-school activities.

In light of these rather far-reaching problems, let us turn to the available research. What do we know about nonmusical benefits of music lessons? As a first pass, we might ask whether musical abilities tend to be correlated with other abilities. Gardner's (2006) theory of *multiple intelligences* implies that musical abilities (i.e., which he calls musical *intelligence*) are distinct and independent from other abilities (or other intelligences). Accordingly, if the human mind has autonomous and independent mechanisms handling specific types of input (i.e., linguistic, musical, and so on; **(p.157)** Peretz & Coltheart, 2003), improvements in musical abilities are unlikely to be accompanied by improvements in nonmusical domains.

When researchers examine whether music *aptitude* (natural musical ability) is associated with other cognitive skills, participants are usually selected without regard to music training and administered two or more tests (for a detailed review see Schellenberg & Weiss, 2013). At least one of the tests measures aptitude and at least one other test measures a nonmusical ability. Aptitude is typically quantified by asking participants over several trials whether two unfamiliar musical patterns have the same melody or rhythm. Performance on these types of task tends to be correlated positively with general intelligence (Helmbold, Troche, & Rammsayer, 2006; Norton et al., 2005) and auditory short-term memory (Hansen, Wallentin, & Vuust, 2013; Wallentin et al. 2010), as well as with verbal abilities, including acquisition of a second language (Milovanov & Tervaniemi, 2011; Posedel et al., 2012; Slevc & Miyake, 2006), reading ability (Anvari et al., 2002; Huss et al., 2011), and phonological awareness (Anvari et al., 2002; Forgeard, Schlaug, et al., 2008; Huss et al., 2011; Loui et al., 2011; Peynircioğlu, Durgunoğlu, & Öney-Küsefoğlu, 2002; Tsang & Conrad, 2011).

Because music aptitude is associated with a variety of other abilities including general intelligence, the simplest explanation is that intelligent children perform well on a wide variety of tests. In some instances, however, associations between music aptitude and language abilities are evident even when general cognitive ability is held constant (Anvari et al., 2002; Milovanov et al., 2010). The situation is also complicated by the fact that some populations (e.g., individuals with Williams syndrome or autism spectrum disorder) tend to have better music skills than one would expect from their general abilities (Heaton, 2009; Levitin et al., 2004). Moreover, other populations have impaired musical abilities but otherwise normal cognitive functioning (Peretz, 2008). In short, if one were to consider only atypically developing individuals, one might conclude that musical abilities are relatively autonomous and distinct from other abilities. For typically developing individuals, however, music aptitude tends to co-vary with general cognitive abilities, although it may have particularly strong associations with language abilities. Such associations are particularly problematic for determining causation because high-aptitude individuals would be more likely than their low-aptitude counterparts to take music lessons, particularly for extended durations of time.

Some theorists hold that taking music lessons is associated with benefits in specific nonmusical abilities, rather than with cognitive abilities in general. According to Patel (2011), mental representations of music (e.g., melodies) and language (e.g., words) are distinct, but the operations that are used to manipulate and order these representations are shared across domains. In principle, then, music training could lead to improvements in linguistic ability. Other scholars propose that taking music lessons, particularly keyboard lessons, causes improvements in spatial and mathematical abilities (Rauscher & Hinton, 2011).

My review begins with correlational and quasi-experimental studies, which seek to document associations between music training and nonmusical abilities that exist in the real world. I then review experimental studies to evaluate the possibility that music lessons *cause* improvements in nonmusical abilities.

Correlational studies and quasi-experiments

When considered as a whole, correlational and quasi-experimental studies provide evidence that is consistent with the *general* hypothesis (i.e., music lessons affect intellectual abilities generally). They are also consistent with the possibility that children with high IQs—who do well on many **(p.158)** outcome measures—are more likely than other children to take music lessons and to come from families with relatively high SES (e.g., Roden, Könen et al., 2014).

In the language domain, an abundance of evidence confirms that musicians are better than nonmusicians on tasks that measure speech perception (for reviews see Asaridou & McQueen, 2013; Strait & Kraus, 2011), such as the ability to understand speech in a noisy environment (Parbery-Clark et al., 2009; Parbery-Clark, Strait, & Kraus, 2011; c.f. Ruggles, Freyman, & Oxenham, 2014). In other words, the good listening skills of musically trained individuals extend beyond music to speech. Musically trained individuals also show advantages at remembering 1) short excerpts of speech (Cohen et al., 2011), 2) lists of words that they read (Brandler & Rammsayer, 2003) or hear (Franklin et al., 2008; Hanna-Pladdy & Gajewski, 2012; Hansen, Wallentin, & Vuust, 2013; Ho, Cheung, & Chan, 2003; Jakobson et al., 2008; Roden et al., 2014; Roden, Kreutz, & Bongard, 2012), and 3) lyrics that are spoken or sung (Kilgour, Jakobson, & Cuddy, 2000).

Musically trained adults are also better than their untrained counterparts at pronouncing irregularly spelled words (e.g., cellist, simile, thyme; Jakobson et al., 2008; Stoesz et al., 2007), making grammaticality judgments (Patston & Tippett, 2011), and comprehending and remembering relatively complicated passages of text (Thompson, Schellenberg, & Letnic, 2012). Among children 8 to 11 years of age, music training is predictive of a larger vocabulary (Forgeard, Winner et al., 2008). Among 6- to 9-year-olds, duration of music training predicts performance on a test of reading comprehension (i.e., identifying a missing word in a sentence or paragraph), even when IQ is held constant (Corrigall & Trainor, 2011). Similarly, 8- and 9-year-old boys who play a musical instrument make fewer spelling mistakes compared to other boys, even when IQ is held constant (Hille et al., 2011). In a long-term longitudinal study that monitored children from 6 to 12 years of age, those who took music lessons had larger improvements than other children in second-language abilities (re: comprehension, pronunciation, and vocabulary), even when SES was held constant (Yang et al., 2014). In short, musically trained individuals show enhanced performance on a variety of measures of language ability.

Performance advantages for musically trained individuals extend beyond language, however, to tasks that measure the capacity of auditory working memory (Franklin et al., 2008; George & Coch, 2011; Parbery-Clark et al., 2009; Parbery-Clark et al., 2011; Strait et al., 2012; c.f. Bailey & Penhune, 2012). In some instances, an advantage for musically trained individuals is evident with auditory stimuli (verbal or otherwise), but *not* with visuospatial stimuli (e.g., buildings on a map, line drawings, abstract art, spatial locations; Brandler & Rammsayer, 2003; Cohen et al., 2011; Hansen, Wallentin, & Vuust, 2013; Ho, Cheung, & Chan, 2003; Parbery-Clark et al., 2011; Roden, Kreutz, & Bongard, 2012; Strait et al., 2012; Tierney, Bergeson, & Pisoni, 2008), which is consistent with the idea that musically trained individuals are particularly good listeners.

In other instances, musicians show an advantage on tests of auditory *and* visuospatial memory (George & Coch, 2011; Jakobson et al., 2008), or on tests of working memory for orally *and* visually presented verbal stimuli (Ramachandra, Meighan, & Gradzki, 2012). Psychophysical measures of temporal discrimination also show advantages for musicians over nonmusicians whether the stimuli are auditory or visual (Rammsayer, Buttkus, & Altenmüller, 2012). In one instance, older musicians outperformed same-age nonmusicians on a test of visuospatial memory, but *not* on tests of auditory memory (Hanna-Pladdy & MacKay, 2011). In a study of younger adults, musicians performed better than nonmusicians on a visuospatial test, but nonmusicians performed better on a test of vocabulary (Bailey & Penhune, 2012). Music training has also been associated with enhanced visuospatial working memory in samples of adults (Bidelman, Hutka, & Moreno, 2013; Oechslin et al., 2013) and children (Roden, Grube et al., 2014). Other ways of measuring visuospatial abilities (e.g., visual search, visual attention, copying line drawings) reveal similar **(p.159)** advantages for musicians over nonmusicians (Patston & Tippett, 2011; Rodrigues, Loureiro, & Caramelli, 2013; Stoesz et al., 2007).

An illustrative example comes from a quasi-experiment conducted with 10-year-olds (Degé et al., 2011). The children came from different classes at the same school. Some of them registered in an extended music curriculum that was provided in their school for two years, others did not. The extended curriculum involved weekly training on one or more instruments, three music classes, and between two and four hours practicing in the school choir or orchestra. The normal curriculum had one music class per week. The variables of interest were tests that measured visual memory for colors and auditory memory for sounds. At the beginning of the study, the two groups did not differ in sex, IQ, SES, or music aptitude. Improvements over the two-year period on *both* memory tests were greater among the children in the extended curriculum. When considered in conjunction with the research reviewed here, it is clear that positive associations between music training and cognitive performance are *not* limited to language or even to the auditory domain.

Indeed, a series of meta-analyses from 2000 concluded that taking music lessons is predictive of improved reading (Butzlaff, 2000), visuospatial (Hetland, 2000), and mathematical (Vaughn, 2000) abilities. The issue of associations between music training and mathematics is particularly interesting because of the widespread belief that the two domains are intimately linked. In actual fact, empirical evidence is inconsistent. In one study, high-school students completed a self-report measure of musicianship and tests of mathematical abilities (Bahr & Christensen, 2000). Although effect sizes were medium to large in magnitude (ds ≈ .7), positive associations between musicianship and mathematical skills were at the cusp of statistical significance (i.e., just under or over) depending on the subject matter. In a longitudinal study that followed children from 6 to 12 years of age, taking music lessons had no association with performance on a standardized test of mathematical abilities (Yang et al., 2014). In a study of adults, highly skilled mathematicians (i.e., university professors) were no more musical than professors from the humanities (Haimson, Swain, & Winner, 2011).

Despite some inconsistencies with mathematics, music training tends to be associated with general cognitive abilities. The most compelling evidence in this regard comes from studies showing that musically trained children and adults tend to score higher than untrained individuals on IQ tests (Corrigall, Schellenberg, & Misura, 2013; Degé, Kubicek, & Schwarzer, 2011; Degé et al., 2014; Gibson, Folley, & Park, 2009; Hille et al., 2011; Roden, Könen et al., 2014; Schellenberg, 2006, 2011a,b; Schellenberg & Mankarious, 2012). When music training is treated as a continuous variable, a dose–response association can emerge: as duration of music training increases, so do IQ scores (Corrigall, Schellenberg, & Misura, 2013; Degé et al., 2014; Degé, Kubicek et al., 2011; Schellenberg, 2006). The association between music training and IQ remains evident after accounting for possible confounding variables (e.g., SES) (Corrigall, Schellenberg, & Misura, 2013; Degé, Kubicek et al., 2011; Schellenberg, 2006, 2011a,b; Schellenberg & Mankarious, 2012), and it is evident across the component subtests, which measure a broad range of different cognitive abilities (Schellenberg, 2006, 2011a,b; Schellenberg & Mankarious, 2012).

Because associations between music training and IQ are not always large, significant associations are more likely in large samples (e.g., $N \geq 90$) (Corrigall, Schellenberg, & Misura, 2013; Degé et al., 2014; Hille et al., 2011; Degé, Kubicek et al., 2011; Roden, Könen et al., 2014; Schellenberg, 2006) than in small samples ($30 < N < 40$) (Parbery-Clark et al., 2011; Strait et al., 2012). For the children tested by Corrigall and Trainor (2011), the correlation between duration of training and IQ had a medium effect size ($r \approx .3$) (Cohen, 1992), but it was only marginally significant because of the small sample ($N = 46$). Similarly, in Skoe and Kraus (2012), adults with six or more years **(p.160)** of training in childhood had IQs that were 5.6 points higher (more than one-third of an *SD*) than untrained adults, but the difference was not significant because of the small samples (15 per group). Nevertheless, in some comparisons of musically trained and untrained individuals with samples of 40 or more (half trained, half untrained), an IQ advantage for the trained participants is significant and substantial in magnitude (e.g., half of an *SD* in Gibson, Folley, & Park, 2009 and Hille et al., 2011; two-thirds of an *SD* in Schellenberg, 2011a; one *SD* in Schellenberg & Mankarious, 2012).

Positive associations have also been identified between music training and the set of domain-general cognitive abilities called *executive functions*, which include working memory as well as any other mental activity that involves conscious control of thought, such as selective attention, mental flexibility, planning, inhibiting unwanted responses, and so on. Positive associations with music training have been reported for tasks that measure selective attention (e.g., responding to a high pitch sung with the word “low”) among younger adults (Bialystok & DePape, 2009), and set shifting among older adults (Bugos et al., 2007). Could individual differences in executive functions explain the link between music training and higher-level cognitive functioning, as some scholars (Hannon & Trainor, 2007; Schellenberg & Peretz, 2008) have proposed?

In one study of 9- to 12-year-olds (Degé, Kubicek et al., 2011), children who varied in duration of music training were tested on five measures of executive functioning: selective attention (listening to a list of words and responding only to the word “red”), task shifting (sorting “animal” cards on the basis of one feature such as number, then on another feature such as color, and then another feature, and so on), planning (drawing the hands on a clock to correspond to a given time, telling the time from a clock without numbers), inhibition (saying “square” when a circle is presented and vice versa, saying “up” when an arrow pointing down is presented and vice versa), and fluency (connecting dots with lines in different ways). Performance on all five tests was correlated positively with duration of training and with IQ. More importantly, the link between duration of training and IQ disappeared when performance on the executive functions was held constant. Mediation analyses revealed that the link between music training and IQ was due to the fact that music training improved performance on the measures of selective attention and inhibition, which in turn led to improvements in IQ.

In another study with a similar design and children of the same age, musically trained and untrained 9- to 12-year-olds did *not* differ on measures of executive functions (except for working memory), even though the groups differed substantially in IQ (Schellenberg, 2011a). Some of the measures were arguably more complex than those used by Degé, Kubicek et al. (2011) (e.g., Tower of Hanoi is a complicated higher-level planning task), but some were quite similar (e.g., saying “sun” for moon and vice versa), so there is no obvious reason for the discrepancy. Moreover, in a longitudinal study that followed 7- to 8-year-olds over a period of 18 months, improvements on a test of selective attention were greater for a control group receiving training in natural sciences than for children taking music lessons, although the music group showed greater improvement on a test of processing speed (Roden, Könen et al., 2014). At present, then, it is unclear whether executive functions explain links between music training and general cognitive ability.

Another point of contention involves *how* IQ is measured. The associations described here came primarily from measures of IQ that include subtests of crystallized intelligence (e.g., defining words) *and* fluid intelligence (e.g., pattern recognition). When the test is a relatively pure measure of fluid intelligence (e.g., Raven’s or Cattell’s test), associations are less reliable and several null findings have been reported (Bialystok & DePape, 2009; Bidelman, Hutka, & Moreno, 2013; Franklin et al., 2008; Helmbold, Rammsayer, & Altenmüller, 2005; Lima &

Castro, 2011b; **(p.161)** Oechslin et al., 2013; Schellenberg & Moreno, 2010; Sluming et al., 2002; Yang et al., 2014). In one instance (Brandler & Rammsayer, 2003), nonmusicians had higher scores than musicians on each of the four subtests from Cattell's test. Null findings have also been evident when the Matrix Reasoning subtest from the Wecshler tests—which is similar to Raven's test—is used to estimate fluid intelligence (Parbery-Clark et al., 2012; Patston, Hogg, & Tippett, 2007; Patston & Tippett, 2011; Strait et al., 2010).

In other instances, however, music training is associated positively with fluid intelligence among adults (Bailey & Penhune, 2012; Thompson, Schellenberg, & Husain, 2004; Trimmer & Cuddy, 2008) and children (Degé, Kubicek et al., 2011; Forgeard, Winner et al., 2008; Hille et al., 2011). Moreover, musically trained individuals often show similar advantages on the crystallized *and* fluid subtests of IQ tests (Schellenberg, 2006, 2011a,b; Schellenberg & Mankarious, 2012). To complicate matters further, most of the null findings with fluid intelligence compared highly trained (or professional) musicians to equally educated and experienced nonmusicians. In short, associations with IQ tend to be evident primarily when musically trained children or adults are compared with their untrained counterparts. When actual musicians are compared to nonmusicians, such associations are unreliable.

If taking music lessons in childhood and adolescence is associated with general cognitive ability, we should except to see similar associations with performance in school. Indeed, in childhood, average grade in school tends to increase as duration of out-of-school music training increases (Corrigall, Schellenberg, & Misura, 2013; Degé et al., 2014; Schellenberg, 2006). This dose–response association is also evident for scores on a standardized test of educational achievement (Schellenberg, 2006). For third to sixth graders, children who take private music lessons outside of school have higher grades than other children in all school subjects except for sports (Wetter, Koerner, & Schwaninger, 2009). When college freshmen are asked about their final year of high school, duration of music training in childhood is associated positively with average grade (Schellenberg, 2006). Such associations remain evident when family differences in SES are held constant (Corrigall, Schellenberg, & Misura, 2013; Schellenberg, 2006; Wetter, Koerner, & Schwaninger, 2009).

One provocative finding is that for children in elementary school, duration of music training is associated with average grade, even when IQ is held constant (Corrigall, Schellenberg, & Misura, 2013; Schellenberg, 2006). Because musically trained children are better students than would be expected based on IQ alone, other individual differences, such as personality, must be playing a role. In line with this view, as duration of music training increases, so does academic self-concept, even when IQ, SES, and grades in school are held constant (Degé et al., 2014). More conventional dimensions of personality are also likely to be implicated, particularly *conscientiousness*, the dimension that best predicts performance in school, and *openness-to-experience*, the dimension that is most closely linked to IQ. Conscientiousness is self-explanatory. Openness-to-experience refers to intellectual curiosity, preference for novelty, and interest in the arts.

Corrigall, Schellenberg, & Misura (2013) tested large samples of 10- to 12-year-old children and college freshmen. For the freshmen, duration of music training was associated at least as strongly with personality—primarily openness-to-experience—as it was with cognitive ability. For the children, the link between music training and cognitive ability disappeared when conscientiousness and openness-to-experience were held constant. Moreover, the unexplained link between music training and performance in school (i.e., with IQ held constant) disappeared when individual differences in conscientiousness were held constant. Earlier in development (7 to 9 years), the parents' openness-to-experience and the child's agreeableness are the best predictors of music training (Corrigall & Schellenberg, 2015). These findings raise the possibility that many of the **(p.162)** associations with cognitive abilities reviewed here may have disappeared if personality were held constant.

Other researchers have asked whether taking music courses in *school* is associated with performance in other subjects. In one sample of 14- to 17-year-olds, students who took a music course performed better than other students across the various subjects taught in high school (Cabanac et al., 2013). In another sample of 150,000 students in twelfth grade, scores on a standardized test of academic achievement were analyzed as a function of whether the students took a music course in eleventh grade (Gouzouasis, Guhn, & Kishor, 2007). The music students went on to have higher grades than other students on the mathematics and biology subtests, but not in English. By contrast, taking a visual arts course in eleventh grade had no association with performance in twelfth grade.

A study of over fifteen thousand ninth- to twelfth-grade students included more than nine hundred students enrolled in an instrumental music ensemble (Fitzpatrick, 2006). The design was *retrospective*, with the goal of predicting performance on a standardized test of achievement when the students were in fourth, sixth, or ninth grade. At all three time points, future music students had higher grades in science, mathematics, and reading compared to the other students. In short, good students were more likely to enroll subsequently in a music ensemble. This pattern held for students from both low- and high-SES backgrounds. Southgate and Roscigno (2009) examined performance *prospectively* in reading and mathematics, following over four thousand kindergarteners to fifth grade, and almost eight thousand eighth graders through high school. Taking school music courses was predictive of future reading achievement in both samples, and of future mathematics achievement in the younger sample, even after controlling for SES, ethnic background, and prior achievement. By controlling for prior achievement, the analyses ruled out the possibility that observed associations arose solely because good students were particularly likely to take music classes, as the Fitzpatrick study suggested.

In a recent study of this sort, Elpus (2013) examined a sample of over thirteen thousand American students to determine whether taking music courses in high school was predictive of scores on college entrance exams (either the SAT or the ACT). In general, exam performance was better for students who had completed and passed at least one music course compared to other students. Performance also improved as the number of music credits increased. Neither association remained significant after holding constant demographic variables, grade-point average, and whether students were receiving special education. In other words, individual differences in cognitive ability and demographics appear to determine who takes music courses and who does well academically. In line with this view, Miksza (2010) reported that high-school students who enrolled in band classes tend to exhibit more pro-social behaviors and to have better school attendance, in addition to having higher scores on a standardized test of mathematics achievement. Even before entering high school (i.e., in sixth or eighth grade), good students from high-SES families are more likely than other students to enroll in band classes (Kinney, 2008).

Might associations with music training extend to other nonmusical abilities such as social skills or emotional competence? In general, there is little convincing evidence in this regard. In some cases (Lima & Castro, 2011b; Thompson, Schellenberg, & Husain, 2004) but not others (Trimmer & Cuddy, 2008), music training is associated positively with the ability to understand the emotional meaning of prosody in speech. Similarly, in some instances (Lima & Castro, 2011a) but not others (Resnicow, Salovey, & Repp, 2004), music training is associated with the ability to decode emotions expressed by instrumental music. When emotional intelligence is tested in adulthood, musically trained and untrained participants do not differ (Schellenberg, 2011b). When emotion comprehension is tested among 7- and 8-year-olds, the performance advantage for musically **(p.163)** trained over untrained children disappears when IQ is held constant (Schellenbeg & Mankarious, 2012). Parental reports also suggest that social skills are unrelated to music training among 6- to 11-year-olds (Schellenberg, 2006). The vast majority of the training in these studies involved *private* music lessons, however, and it is possible that *group* lessons could be associated with social skills or emotional intelligence.

In sum, correlational and quasi-experimental studies reveal many associations between music training and nonmusical abilities without informing us about the direction of causation. In many instances, such associations might not remain evident if variables such as personality were measured and held constant in the analyses. Regardless, the available data show clearly that music training tends to be associated with cognitive abilities in general (but not with social–emotional abilities), and that such associations often remain evident when SES is held constant. Longitudinal studies without random assignment (e.g., Degé, Wehrum et al., 2011; Roden, Grube et al., 2014; Roden, Könen et al., 2014; Roden, Kreutz, & Bongard, 2012; Yang et al., 2014) provide evidence that is consistent with causation but inconclusive because genetically determined individual differences that are not evident earlier in development may emerge later due to maturation.

True or almost-true experiments

I will now review experiments that assigned children randomly to a music intervention or to a control condition. These studies allow for inferences of causation and are relatively few in number, so they are discussed in some depth. Because random assignment of individual children to different conditions is often difficult or impractical, researchers sometimes opt to assign entire classes to a music intervention and compare them to other classes with a different or no intervention. Compared to true random assignment, results from these "random group" experiments are more prone to the influence of extraneous effects, such as the particular teacher, the particular class, and/or the particular school.

Several studies examined whether music training causes improvements in linguistic abilities, including phonological awareness, vocabulary, and reading. In one study, classrooms of kindergarteners were assigned to four months of music training and compared to same-age children from other schools (Gromko, 2005). The children with music training showed larger improvements on a test of phonological awareness over the four-month interval, but not on tests of identifying letters or reading nonsense words. Another longitudinal study of phonological awareness assigned kindergarteners individually to intensive training (20 weeks, five days/week, ten minutes/day) in music, sports, or phonological skills (Degé & Schwarzer, 2011). Improvements over the course of the intervention (i.e., 100 sessions) were substantial for the phonological-skills group, as one would expect. A more surprising finding was that identical improvements were evident in the music group. The role of maturity was ruled out because similar improvements were not apparent in the sports group.

Other researchers examined language abilities before and after instruction in music or visual arts. In one study, 8-year-olds were assigned to music or painting lessons so that the groups were similar in IQ, verbal working memory, and reading ability when the study began (Moreno et al., 2009). In both groups, the training involved two 75-minute lessons per week for 24 weeks. Only the music group showed improvement from pre- to post-test on tasks that required them to read irregularly spelled words or to detect subtle pitch violations in speech. In a follow-up study, younger children 4 to 6 years of age were assigned to four weeks of daily training in music listening or visual arts (Moreno et al., 2011). The groups were matched initially in SES, previous training in the arts, and IQ. Before and after the training session, children were tested on measures **(p.164)** of vocabulary and visuospatial ability, and on a test of executive function (selective attention) that required them to attend to geometric figures that varied in color while ignoring variation in shape. Only the music group showed significant improvement from pre- to post-test on measures of vocabulary and selective attention. Neither group showed improvement in visuospatial ability. The ability to match unfamiliar visual symbols with familiar words—a skill required for reading—also improved more for the music group than for the visual-arts group (Moreno, Friesen, & Bialystok, 2011).

In a similar experiment with a longer intervention, 8-year-olds were assigned to two years of music or painting lessons (François et al., 2013). Lessons were 45 minutes, twice weekly in the first year (October to May), and once a week in the second year. As in the studies by Moreno and colleagues (Moreno et al., 2009; Moreno et al., 2011), the two groups were initially formed to be similar in terms of demographics and general ability. The outcome measures included a comprehensive battery of cognitive measures, as well as a speech-segmentation task that required children to listen to a long string (five minutes) of sung nonsense syllables, and subsequently to identify which syllables tended to follow one another when the syllables were spoken rather than sung. Although improvement over time was similar across groups on the cognitive tests, performance on the speech-segmentation task showed greater improvement for the music group. Nevertheless, sung presentation at initial exposure—with each syllable matched with a distinct pitch—may have provided a mnemonic cue that was more useful for the music group than for the painting group.

Rauscher and Zupan (2000) tested a different hypothesis—that music lessons lead to improvements in visuospatial abilities. They assigned two classes of kindergarten children to receive 20-minute keyboard lessons twice a week for eight months. Two other classes received no lessons. All children were pre- and post-tested on three tests of spatial skills. Compared to the control classes, the keyboard classes had significantly larger increases over the course of the intervention on all three tests. These effects disappeared a year later for children who stopped taking lessons, but they continued to increase for children who continued taking music lessons (Rauscher, 2002). In fact, children who took lessons continuously from kindergarten through third grade proved to have better spatial skills than children who started lessons in second grade. These results suggest that music training, particularly training that begins early in life, may improve visuospatial abilities. It is unclear, however, whether similar benefits would be found for verbal or mathematical abilities, or for general intelligence. It is also unclear whether other types of training (in drama, gymnastics, etc.) would have similar benefits.

Rauscher and Hinton (2011) reviewed the method and results from a longitudinal but unpublished study that assigned at-risk preschoolers (i.e., from Head Start programs) randomly to two years of music (piano, singing, or rhythm), computer, or no lessons. Children in the music groups showed greater improvements from pre- to post-test on measures of auditory, spatial, and arithmetic abilities. Such beneficial effects were still evident in second grade, two years after the lessons had ended. Although these findings are impressive, it is impossible to evaluate them thoroughly because the review article simply summarized the method.

In another experimental study (Costa-Giomi, 1999), 9-year-old children from low-income families received three years of weekly piano lessons taught individually, or no lessons. The original sample included 117 children, but only 78 attended all of the testing sessions and were included in the analyses. A test of cognitive abilities, which provided an overall score as well as separate scores for verbal, quantitative, and visuospatial abilities, was administered at the beginning of the study and each year thereafter. Although the groups did not differ at the beginning or end of the study, there was a small advantage for the music group on the overall score after the **(p. 165)** second year, and on the visuospatial subtest after the first and second years. There were no group differences in academic achievement (measured by a standardized test or by report cards), except that children who took piano lessons had higher grades in music (Costa-Giomi, 2004). Studying children who begin music lessons at an earlier age might yield results that are stronger, more interpretable, and less temporary.

In a large-scale field experiment, I assigned 144 6-year-olds randomly to a year of weekly keyboard or Kodály (primarily voice) music lessons, or to control groups that received drama or no lessons (Schellenberg, 2004). All lessons were taught in groups of six children, and an IQ test was administered before and after the interventions. IQ scores increased from pre- to post-test in all four groups, but these increases were larger in the music groups (i.e., seven points), which did not differ, than in the control groups (four points), which also did not differ. The large sample and small levels of attrition (i.e., only 12 children dropped out mid-way through the study) meant that the difference between the music and control groups was statistically significant. Importantly, the advantage for the music groups was evident across the 12 subtests that measure different aspects of cognitive ability.

Follow-up studies sought to test the generalizability of these findings by recruiting samples of children from different cultures. In one study that assigned Greek kindergartners to a year of weekly keyboard lessons (Zafranas, 2004), the children improved significantly on five of six subtests of an IQ test, but there was no control group and hence no way to rule out the role of maturity or test/re-test effects. In a sample of Iranian 5- and 6-year-olds (Kaviani et al., 2014), 30 were assigned to a three-month intervention that provided them with music lessons taught weekly for 75 minutes (12 lessons in total, Orff method). Another 30 children matched for sex, age, and SES received no training of any sort. Before and after the training, all children were administered four subtests from an IQ test, which measured visuospatial, quantitative, and verbal abilities as well as short-term memory. The music group had a significant increase in IQ (calculated from all four subtests) from pre- to post-test, but the control group did not. For three of four subtests (all but quantitative ability), the pre- to post-test increase was greater for the music group.

In a study conducted in Israel, 81 6- to 12-year-olds were recruited from after-school programs designed for children considered to be at-risk because of low SES and problems at school (Portowitz et al., 2009). Children from three different centers were assigned to a two-year music intervention. Children from a fourth center served as controls. Each week, children in the music groups had lessons for two to three hours, they attended a music-appreciation class for one hour, and they performed in a group ensemble. Although the music and control groups performed similarly on a test of fluid intelligence (Raven's) before the intervention, the increase from pre- to post-test was greater for the music groups. The music groups but not the control group also showed significant improvements on a test of visuospatial abilities. In the Iranian (Kaviani et al., 2014) and Israeli (Portowitz et al., 2009) studies, the control groups had no additional training of any sort, so it is impossible to attribute the positive results to music per se, although the results are consistent with those reported by Schellenberg (2004).

As in the quasi-experiments discussed previously, increases in IQ as a consequence of music training are rare in experiments with small samples (N = 24: Chobert et al., 2014, and François et al., 2013; N = 32: Moreno et al., 2009). In one instance, the increase in IQ from pre- to post-test was 5 points higher (1/3 of an *SD*) in the music group compared to the painting group (Moreno et al., 2009). The lack of statistical significance stemmed from the small sample as well as from large individual differences that arose because of the short interval (six months) between testing sessions, which meant that increases in IQ were unusually large for both groups (12 points for the music group, seven points for the painting group).

(p.166) Another study assigned almost eighty 4-year-olds randomly to 45-minute music or visual-arts classes, which were taught once a week for six weeks, or to a no-lessons control group (Mehr et al., 2013). After the intervention, there was *no* difference between groups on tests of vocabulary, discriminating different numbers of dots, and visuospatial abilities. Because of the young age of the children, the music lessons did not involve conservatory-style instrumental training, but focused instead on singing and moving to music with a parent. The lessons in visual arts were similarly free-form. Thus, the null findings could be a consequence of the short training program (4.5 hours total), the curriculum, and/or the age of the children.

Social rather than cognitive benefits may be more likely when music interventions, such as that used by Mehr et al. (2013), are designed specifically to be interactive. For example, Gerry, Unrau, and Trainor (2012) assigned 6-month-olds to six months of weekly music lessons that focused on singing and movement with a parent. A control group of same-age infants had an equivalent amount of passive exposure to music. Social–emotional improvements were greater among the infants in the interactive group. In another study, 4-year-olds were trained in a ten-minute game that required synchronizing movements with an experimenter and another child, either with or without the presence of music (Kirschner & Tomasello, 2010). Children in the music condition subsequently exhibited higher levels of cooperation and helping. Small improvements in empathy and emotional intelligence were also evident when 8- to 11-year-olds were assigned to a short-term music intervention that emphasized interactions with other children (Rabinowitch, Cross, & Burnard, 2013).

Such social–emotional advantages are rarely evident, however, for interventions that use more typical pedagogies. In a study of 9-year-olds from low-income families, the music and control groups did not differ significantly in self-esteem at any time during the study (Costa-Giomi, 2004). Similarly, at-risk 7- to 9-year-olds who took part in a two-year music program did not differ from other children in self-esteem at the beginning or the end of the intervention (Portowitz et al., 2009). In my study, with random assignment of children to one year of keyboard, Kodály, drama, or no lessons, there were no group differences at pre- or post-test for maladaptive social skills, but children in the *drama* group showed significant improvement in adaptive social skills, which distinguished them from children who had music lessons or no lessons (Schellenberg, 2004). In other words, drama lessons conferred benefits in social behavior, but music lessons did not.

In sum, the experimental evidence highlights that music lessons can lead to small improvements in cognitive abilities. In some instances there are domain-general improvements, as reflected in measures of IQ. In other instances, music lessons promote the development of visuospatial abilities and, particularly, listening skills, which may lead to improvements in language development more generally (e.g., vocabulary or reading skills). Associations between typical music lessons and social skills are rarely evident, although these could emerge when music training takes place in an interactive social context.

Conclusions

Music listening can change how you feel, and how you feel can influence performance on a variety of tasks. The particular music or genre of music that makes listeners feel good depends on the particular context and who the listeners are. Sometimes, effects of music on arousal levels and mood linger for a while, such that performance on tests administered immediately afterward is influenced by the previous listening experience. When tests are administered concurrently with music listening, the situation is complicated by other factors, such as the capacity of working memory, **(p.167)** familiarity with the music, the characteristics of the music, the difficulty of the test, individual differences in personality and age, and so on. Thus, one can make few generalizations about effects of background music that apply across individuals and contexts. Nevertheless, for children and for adults, it is more common to find negative effects on reading comprehension and memory than it is to find positive effects.

Music training and nonmusical abilities are a different issue. Correlational and quasi-experimental studies reveal associations that can be large in magnitude and domain-general, yet observed associations in experimental studies tend to be small or task-specific. Does music training cause improvements in cognitive abilities, are high-functioning children more likely than other children to take music lessons, or do other variables (e.g., personality) account for some or all of the observed associations? Although it is common to believe that only one of these views holds true, there is no logical reason preventing all three from co-occurring.

The best evidence for causation comes from my study with random assignment of 6-year-olds to music, drama, or no lessons (Schellenberg, 2004). Random assignment necessitated providing the lessons for free, however, which meant that the children practiced very little, typically less than 30 minutes per week. In other words, although the experimental and longitudinal design was ideal for determining causation, it created an artificial context that bore little resemblance to the real world. Other positive evidence from experimental studies had very restricted outcome variables, like pronouncing irregularly spelled words (Moreno et al., 2009), remembering strings of nonsense syllables (François et al., 2013), or phonological awareness (Degé & Schwarzer, 2011). In one instance, the intervention involved very short-term but intensive training in listening rather than instrumental or vocal lessons (Moreno et al., 2011).

In correlational and quasi-experimental studies, cognitive differences between musically trained and untrained children are often much too large and general to be attributable to any environmental factor (e.g., Gibson, Folley, & Park, 2009; Hille et al., 2011; Schellenberg, 2011a; Schellenberg & Mankarious, 2012). If long-term interventions (e.g., Head Start) designed specifically to enhance general abilities meet with only modest success (Love et al., 2013), it would be miraculous for music lessons to be causing such associations. In fact, the view that *smarter, more conscientious, and open kids take music lessons* explains most of the available data parsimoniously. Music lessons may exaggerate these pre-existing differences, however, perhaps especially for memory, some language abilities, and visuospatial skills.

It is almost certain that music lessons improve listening abilities, even in nonmusical contexts, with potential consequences for language. But with a few exceptions (Degé & Schwarzer, 2011; François et al., 2013; Moreno et al., 2009; Moreno et al., 2011; Moreno, Friesen, & Bialystok, 2011), most of the available evidence is correlational and irrelevant to the issue of causation (for reviews see Asaridou & McQueen, 2013; Strait & Kraus, 2011). Presumably, like any ability, listening abilities would be a consequence of nature and nurture, and normally distributed. One would also expect that performance on tests of music aptitude—designed to measure natural listening abilities—would be correlated with performance on other listening tests, such as those that measure different aspects of speech perception (Schellenberg, 2015). If so, individuals with low levels of music aptitude and poor listening skills would be unlikely to take music lessons, particularly for long durations of time, which guarantees an association between listening abilities and music training *before* the training begins. The bottom line is that it is counter-productive to focus solely on nature or nurture as a contributing factor to any ability. A complete understanding of musical abilities and their association with nonmusical abilities requires careful consideration of interactions between genes and the environment (Schellenberg, 2015).

(p.168) The major take-home points about music training and nonmusical abilities can be summarized as follows:

- ◆ Music training is associated with listening abilities, language abilities, visuospatial abilities, general intelligence, and academic achievement, and these associations often remain evident when SES is held constant.
- ◆ Associations are much less consistent when real musicians are studied, except for listening abilities, performance on some language tasks, and visuospatial abilities.

- ◆ The role of executive functions in the associations is unclear.
- ◆ *Group* music lessons may be associated with improved social–emotional skills.
- ◆ Music training is also associated with personality variables. In fact, associations with personality may be as strong or stronger than associations with cognitive abilities, which can disappear when personality is held constant.
- ◆ There is some experimental evidence that music lessons cause small increases in general cognitive abilities, but an abundance of real-world evidence indicating that taking music lessons has a strong association with cognitive abilities. Considered jointly, these findings suggest that high-functioning children are more likely than other children to take music lessons, which may exaggerate their initial advantages.

On a theoretical level, associations between music training and different cognitive abilities, including IQ, provide little support for proposals of modularity for music, music as a distinct intelligence, or "special" links between music and sub-domains of cognitive functioning such as language or mathematics. On a more practical level, if a child seems "musical" and is interested in learning music, taking lessons might have some nonmusical benefits. It cannot hurt. As for public policy, advocating for inclusion of music in school curricula on the basis of positive nonmusical benefits may be misguided, because this position tacitly admits that music is not valuable in its own right. A better message might be that music training promotes skill development and creativity in an inherently pleasurable context, and that it is eminently reasonable to teach children about the only thing that makes people everywhere dance, dream, and connect with one another.

Author note

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Reflective questions

1. How can we explain the so-called Mozart effect?
2. Does background music improve or impair performance on the primary task?
3. Is there a special link between music training and language abilities?
4. How do children who take music lessons differ from other children?
5. Do music lessons *cause* the observed associations with cognitive abilities?

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