

Michael W. Weiss
E. Glenn Schellenberg

Augmenting Cognition with Music

Department of Psychology,
University of Toronto Mississauga,
Mississauga, ON, Canada L5L 1C6

5.1 Introduction

The present chapter reviews the available evidence about whether exposure to music improves cognitive abilities. Firm conclusions about whether music actually *causes* improvements in cognitive performance can be made only when researchers assign participants at random to an experience that involves music, or to another (i.e., control) experience that involves a different kind of stimulus. Without random assignment, it could easily be the case that participants with above-average cognitive abilities are more likely than other people to be attracted to music. In other words, although it might look like *music makes you smarter*, the real truth could be that smarter people are more likely than other individuals to be drawn to music.

Fortunately, assigning people at random to music-listening experiences is relatively easy. Participants come to the laboratory and the experimenter randomly assigns each participant to one of two (or more) conditions. For example, half of them might listen to music, whereas the other half would be exposed to a different piece of music, a nonmusical auditory stimulus (e.g., a narrated story), or silence. If the groups prove to differ on a test that they take immediately after listening or while they are listening, the effect can be attributed to the different conditions. Another possibility is to assign each participant to all of the different conditions, making sure that the order of the conditions (e.g., music then silence, or silence then music) is divided equally (i.e., counterbalanced) among the participants.

Assigning people at random to music lessons is more difficult. The researcher must pay for the lessons as well for control lessons that are similar to music lessons in terms of what is learned and how it is learned. If one were simply to compare individuals who do or do not take music lessons by their own volition, those with training are likely to differ from other individuals in several respects, such as general intelligence, personality, or socio-economic status, which could be the source of cognitive differences between groups. In short, determining the causal direction underlying associations between music lessons and cognitive abilities is complicated.

Finally, assigning people at random to different levels of music aptitude is impossible since aptitude is defined as the natural ability to do something. Thus, aptitude cannot be manipulated and one can never determine whether associations between music aptitude and other cognitive abilities are caused by individual differences in aptitude. Nonetheless, testing for such associations can inform us about whether music abilities are distinct from or similar to other cognitive abilities.

5.2 Music aptitude and cognitive abilities

Music aptitude is typically measured with tests that comprise several trials. On each trial, the listener decides whether two sequences of tones or drumbeats are the same or different. On “different” trials, the pitch or duration of one or more tones or drumbeats is altered in the second sequence as compared to the first.

In childhood, performance on tests of music aptitude tends to be associated positively with performance on linguistic tasks. For example, when children are asked to reproduce a word without the first or last speech sound, children who perform well on music-aptitude tests also score better on these speech tasks, regardless of mother tongue. Moreover, when asked to pronounce foreign speech sounds, children who perform well on tests of musical aptitude have better pronunciation skills. They also exhibit larger brain-activation responses when presented with a mistuned chord or with durational changes in the sound patterns of speech or music.

It is well established that performance on tests of *phonological awareness* (e.g., understanding that the words “cat” and “hat” differ only in their initial consonant) is predictive of reading skills. In other words, children who listen to speech in a careful and analytic manner tend to become relatively good readers. Some researchers have hypothesized that music aptitude – the ability to listen to *music* in a careful and analytic manner – might also be associated positively with reading skills. In line with this view, the pitch-discrimination abilities (a measure of music aptitude) of 4- and 5-year-olds are associated with phonological awareness, which in turn predicts basic reading skills [1]. In fact, music aptitude in early childhood is associated positively with reading ability even after phonological awareness and other cognitive abilities are held constant statistically [2]. Moreover, performance on rhythm-perception tasks (another measure of music aptitude) is predictive of reading ability among normally developing children, whereas children with reading disabilities perform at below-average levels on musical production and discrimination tests. In short, children who perform well on tests of music aptitude tend to be good readers.

Children who perform well on music-aptitude tests also tend to score high on general measures of cognition and intelligence. For example, young children’s music-aptitude scores are predictive of performance on tests of general cognitive and creative abilities, such as a test of working memory (Digit Span) requiring children to repeat sequences of numbers in the same and in reverse order [2]. Similarly, the music-aptitude scores of young students are associated positively with their scores on standardized tests of academic achievement that measure competence in English, mathematics, science, and technology. The music aptitude of 8- and 9-year-olds is also predictive of their general intelligence (*g*) [3], and adults who perform well on music-aptitude tests tend to perform well on a variety of measures of intelligence, including tests of spatial ability,

[1] Lamb SJ, Gregory AH. “The relationship between music and reading in beginning readers” *Educational Psychology* 1993;13:19-27.

[2] Anvari SH, Trainor LJ, Woodside J, Levy BA. “Relations among musical skills, phonological processing, and early reading ability in preschool children” *Journal of Experimental Child Psychology* 2002;83:111-130.

[3] Lynn R, Wilson RG, Gault A. “Simple musical tests as measures of Spearman’s *g*” *Personality and Individual Differences* 1989;10:25-28.

memory, verbal abilities, processing speed, vocabulary, drawing ability, and word fluency. These findings may be due, at least in part, to the fact that performance in school is associated with socioeconomic status, such that economically advantaged children tend to perform well on a variety of different measures. For example, elementary-school children who live in neighborhoods with relatively high social and economic status may perform better on tests of general intelligence *and* music aptitude.

Thus, despite well-documented associations between measures of music aptitude and cognitive abilities, the correlational nature of this research and the lack of random assignment prevent us from clearly determining the direction of causation. Nonetheless, the rules of science favor the *simplest* explanation of the available data, which, in our view, is that individuals with high levels of cognitive ability perform well on virtually any test they take, including tests of music aptitude. In other words, performance on music-aptitude tests may be considered to be a marker of general intelligence.

One problem with this interpretation comes from findings indicating that some individuals have normal intelligence yet perform poorly on tests of music aptitude. More specifically, *congenital amusia*, which is present in about 4 % of the population, is a deficiency in music perception among individuals who (1) possess otherwise normal intellectual abilities, (2) have been exposed to music to a normal degree, and (3) have no hearing loss or brain damage [4]. This disorder suggests that music aptitude represents a specific ability that is distinct from general intelligence. Thus, although the bulk of the literature suggests that music aptitude is a marker of general cognitive ability, individuals with amusia provide evidence that some aspects of music aptitude may be specific to music listening and relatively independent of other cognitive abilities.

5.3 Cognitive abilities after music listening

In the early 1990s, provocative evidence of music listening conferring brief intellectual rewards became fodder for the mainstream media, leading to an entire industry built around the notion that simply listening to certain music raises the listener's IQ. Simultaneously, the distinction between music listening and music lessons often became blurred in the mind of the media, the public, and some researchers. This section reviews the origin of the so-called *Mozart Effect* as well as subsequent research that examined cognitive performance after listening to music.

5.3.1 Origins of the Mozart effect

An article published in 1993 reported that listening to music before taking a test of spatial intelligence temporarily boosts performance

[4] Peretz I. "Musical disorders: From behavior to genes" *Current Directions in Psychological Science* 2008;17:329-333.

[5] Rauscher FH, Shaw GL, Ky KN. "Music and spatial task performance" *Nature* 1993;365:611.

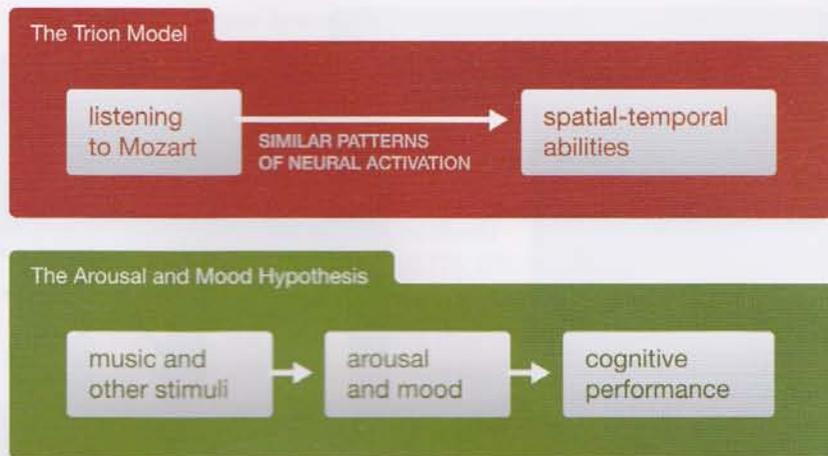


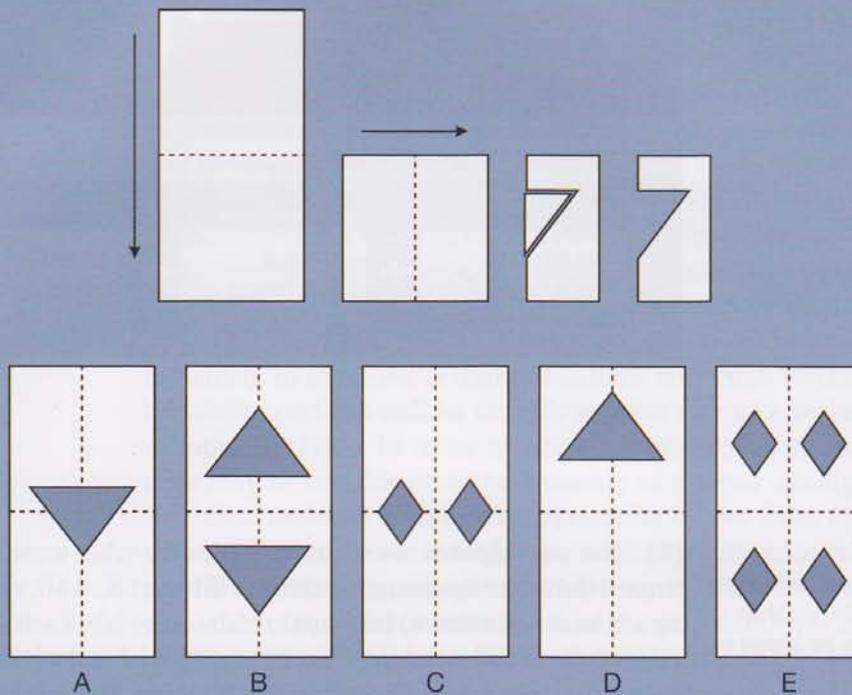
Figure 5.1
Two explanations of the so-called Mozart effect. The Trion Model (upper) specifies that listening to Mozart improves spatial-temporal abilities because both activities involve similar patterns of neural activation. The Arousal and Mood Hypothesis (lower) posits that any stimulus that improves how a participant feels (i.e., their arousal level and mood) can in turn improve their cognitive performance.

[5]. The participants were undergraduates who were exposed to three 10-minute listening conditions (Mozart K. 448, relaxation instructions, and silence) in a single visit to the lab. Each listening experience was followed by one of three spatial tasks taken from the Stanford-Binet Scale of Intelligence: *Matrices*, *Pattern Analysis*, and *Paper-Folding-and-Cutting*. The term ‘Mozart effect’ referred to the results; the best performance was evident after listening to Mozart. Although the findings were notable and appealing to scientists and laypeople, the theory that motivated the initial study was considered suspect from the beginning. The *Trion Model*, which is illustrated in Figure 5.1 (upper), claims that listening to “complex” music such as Mozart co-opts systems of neuronal activity in the cortex that normally fire in response to spatial tasks. This theory lacks empirical support in psychology since it describes a similar neural response to two very different activities: performing a spatial task and listening passively to music.

A follow-up paper from the same research group replicated the main finding [6]. Participants were tested daily over five consecutive days. On the first day, they completed a spatial task so that they could be assigned to three different groups with identical abilities for testing on subsequent days. On the second day, participants completed the same spatial task (with different items) after a 10-minute listening phase. One group listened to Mozart, a second group listened to a minimalist piece composed by Philip Glass, and the third group sat in silence. Participants in the Mozart condition performed significantly better than the other two groups on the spatial task.

[6] Rauscher FH, Shaw GL, Ky KN. “Listening to Mozart enhances spatial-temporal reasoning: Towards a neurophysiological basis” *Neuroscience Letters* 1995;185:44-47.

Paper-Folding-and-Cutting Test



108

Figure 5.2
An example item from the
Paper-Folding-and-Cutting
(PF&C) test.

Differences between groups disappeared on the third and fourth days of the study, possibly because performance had reached ceiling levels. On the fifth day, participants completed a memory task after either sitting in silence or listening to Mozart. The two groups performed equivalently. The authors interpreted these results as evidence of a special link between the music of Mozart and spatial abilities due to the fact that a spatial-ability effect was found on the second day whereas there was no memory effect on the fifth day. The memory task came at the end of five days of group testing, however, and participants may have become bored with the study. Moreover, because participants were always tested in the same groups, group dynamics may have changed over time and influenced performance.

The so-called Mozart effect was originally proposed to be a link between complex music and abstract reasoning [5], of which spatial abilities were considered to be just one type. Moreover, the researchers claimed that their three tasks measured the same ability since participants who performed well (or poorly) on one task tended to perform similarly on the other two tasks. The authors subsequently redefined the link, limiting it to associations between listening to Mozart and "spatial-temporal" abilities [6]. One of the three tasks (Paper-Folding-and-Cutting, or PF&C) was considered to provide the best test of this ability, although the other two tasks were also believed to measure spatial-temporal abilities. An example of a PF&C item is illustrated in Figure 5.2. A few years later, in an attempt

to explain why some researchers had failed to replicate the effect, the authors argued that *only* the PF&C task measured spatial-temporal abilities; the Matrices and Pattern Analysis tasks were now considered to measure other, unspecified spatial abilities. Accordingly, many failures to replicate were attributed to using the wrong task.

5.3.2 The arousal and mood hypothesis

The *arousal and mood hypothesis* [7], illustrated in Figure 5.1 (lower), provides an alternative explanation of the Mozart effect. Unlike the Trion Model, the hypothesis is based upon well-documented associations in the literature. It proposes that music modifies listeners' emotional state, which in turn alters their cognitive performance. Thus, the emotional state is said to act as a mediating factor, which can be influenced not only by listening to Mozart but also by exposure to a wide range of stimuli and experiences. Abundant evidence confirms the existence of links between music listening and emotional responding as well as between an individual's emotional state and his or her cognitive abilities.

In a series of five publications, Schellenberg and his colleagues examined the conditions under which the Mozart effect can be replicated. In their initial study [8], the researchers successfully replicated the Mozart effect, but they also found a *Schubert effect* that was equivalent in magnitude (see Fig. 5.3, top). Their participants were tested on two different days. After listening to music (Mozart or Schubert) or sitting in silence for 10 minutes, they completed one of two versions of the PF&C task. The order of the music (music-silence or silence-music) and the two versions of the PF&C tasks was counterbalanced so that the testing order was independent of the principal manipulation (i.e., music vs. silence). For both groups, performance on the PF&C task was better after listening to music than after sitting in silence.

Follow-up experiments from the same research team were similarly designed and counterbalanced. In one [8], participants completed the PF&C task after listening to Mozart or to a narrated story written by Stephen King. Performance did not differ between conditions. Listeners were also asked whether they preferred the music or the story. When preference was considered as an additional variable in the analyses, the results revealed better performance in the Mozart condition for those who preferred Mozart (another replication of the Mozart effect), but better performance in the story condition for those who preferred the story (a *Stephen King effect*). These results are illustrated in Figure 5.3 (bottom). Presumably, the emotional state of the listeners improved after listening to the stimulus they preferred.

[7] Thompson WF, Schellenberg EG, Husain G. "Arousal, mood, and the Mozart effect" *Psychological Science* 2001;12:248-251.

[8] Nantais KM, Schellenberg EG. "The Mozart effect: An artifact of preference" *Psychological Science* 1999;10:370-373.

Figure 5.3

The upper panel illustrates the mean number of items answered correctly on the PF&C test after listening to music (Mozart or Schubert) or sitting in silence [8]. Performance was better after listening to either piece of music as opposed to after sitting in silence. The lower panel illustrates the number of items answered correctly after listening to music composed by Mozart or to a story written by Stephen King [8]. Participants who preferred Mozart performed better after listening to the music. Participants who preferred Stephen King performed better after listening to the story.

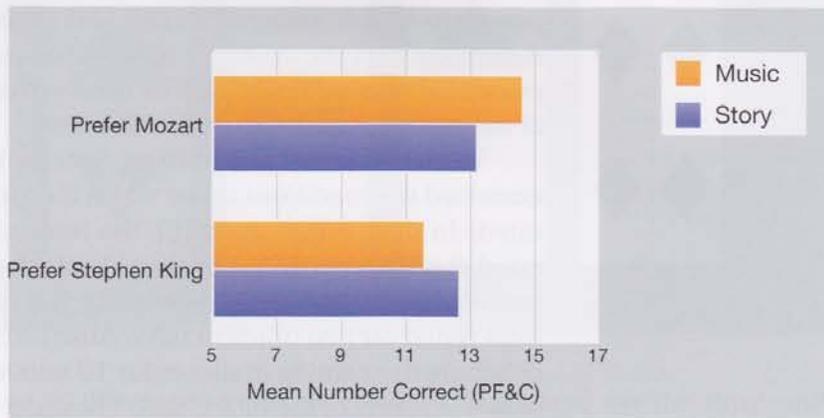
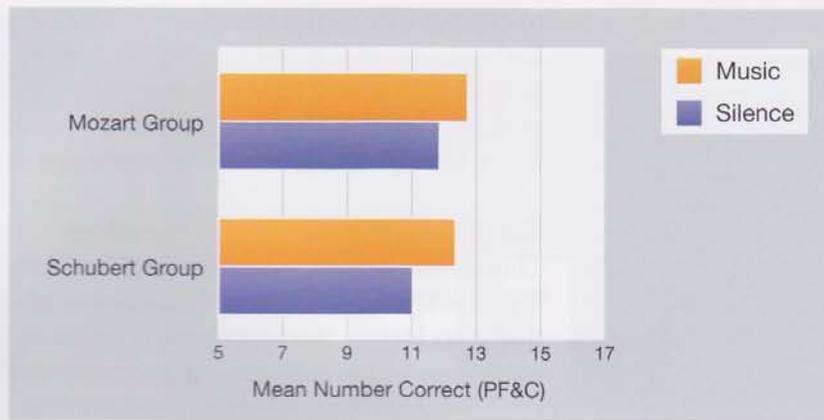


Figure 5.4

The mean number of items answered correctly on the PF&C test after listening to music (Mozart or Albinoni) or sitting in silence [7]. Performance was better after listening to Mozart than after sitting in silence. By contrast, performance after listening to Albinoni was no different than after sitting in silence.

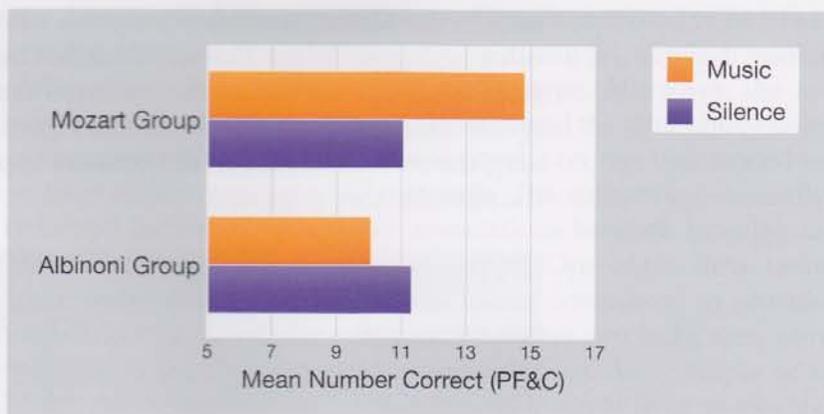
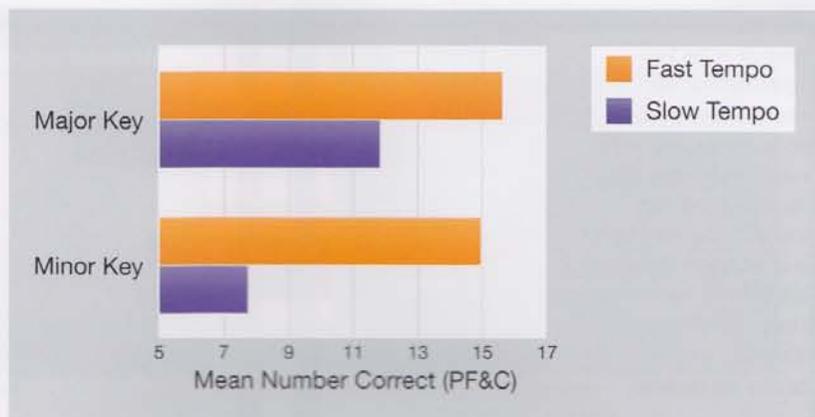


Figure 5.5

The mean number of items answered correctly on the PF&C test after listening to one of four versions of the same Mozart sonata [9]. Performance was better after listening to the fast-tempo versions compared to their slow-tempo counterparts, and to the major-key versions compared to the minor-key versions.



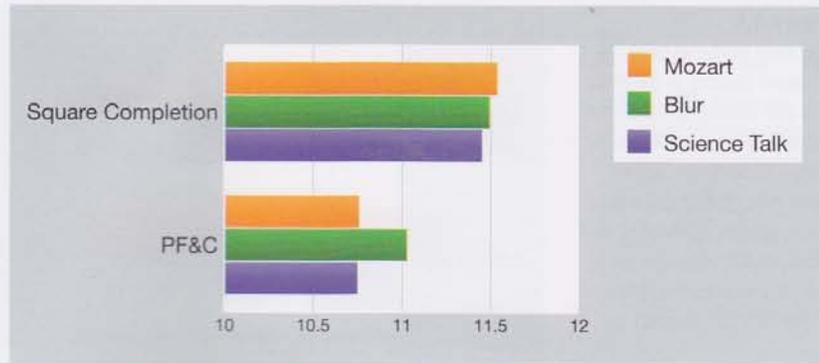
The next study [7] provided a direct test of the arousal and mood hypothesis. Each participant completed the PF&C task after listening to music and sitting in silence, and arousal and mood were measured at the beginning and end of both sessions. The music was either the same Mozart sonata used in earlier studies [5-6, 8] or an adagio composed by Albinoni. The Mozart sonata sounds happy because it has a fast tempo and it is written in a major key, whereas the adagio sounds sad because it is slow and minor. As expected, differences in PF&C performance were evident between the music and silence conditions for the Mozart group (another Mozart effect) but not for the Albinoni group (Fig. 5.4). Moreover, levels of arousal and mood improved after listening to Mozart but not after listening to Albinoni or sitting in silence. When changes in arousal and mood among the Mozart group were accounted for in the analyses, the Mozart effect disappeared.

Because Albinoni's adagio may have been associated with specific sad events in the listeners' lives (the adagio is played frequently at funerals), the next study used emotionally distinct stimuli that were derived from a single Mozart sonata but computer-manipulated so that they varied only in tempo (fast or slow) and key (major or minor) [9]. Each participant listened to one version of the sonata (fast-major, fast-minor, slow-major, or slow-minor) before completing the PF&C task, and arousal and mood were measured at the beginning and end of the test session. Performance on the PF&C task was better after listening to the fast-tempo compared to the slow-tempo versions, and also after listening to the major compared to the minor versions (see Fig. 5.5). The tempo of the music influenced listeners' arousal levels (fast tempo = higher arousal), whereas the key influenced their mood (major key = more positive mood). As predicted, most of the variance in PF&C performance was accounted for by individual differences in arousal and mood.

[9] Husain G, Thompson WF, Schellenberg EG. "Effects of musical tempo and mode on arousal, mood, and spatial abilities" *Music Perception* 2002;20:151-171.

Figure 5.6

Performance on two tests of cognitive abilities after listening to Mozart, popular music (including a song by Blur), or a scientific discussion [10]. On the easier test (Square Completion), performance did not differ across groups. On the more difficult test (PF&C), performance was better after listening to popular music compared to the other two conditions.



The emotional response to a specific piece of music undoubtedly depends on the particular group of listeners. For example, most children prefer pop over classical music. Thus, listening to pop music is likely to evoke a more positive emotional response among children, which in turn would improve performance on tests of cognitive abilities. Schellenberg and Hallam [10] tested this hypothesis with the assistance of approximately 200 schools across the UK, including more than 8000 students, and the British Broadcasting Corporation (BBC). At each school, 10- and 11-year-olds were assigned randomly to one of three rooms at exactly the same time. In one room, they heard a piece by Mozart on BBC Radio 3. In another room, they heard pop music on BBC Radio 1, including a hit single by the British band Blur. In a third room, they listened to a scientific discussion about the experiment on BBC Radio 5. Afterward, each child completed two tasks of spatial ability. Performance on the easier spatial task (Square Completion) did not differ among groups, but performance on the more difficult measure (a version of the PF&C task) varied across the three listening conditions, with better performance after listening to pop music than for the other two conditions (a *Blur effect*, see Fig. 5.6).

In a study of Japanese 5-year-olds [11], creative abilities improved after listening to or singing children's playsongs, but not after listening to classical music. Each child was initially given a piece of paper and 18 crayons, and asked simply to draw something. This drawing served as a baseline measure of their creative ability. On a subsequent day, they participated in one of four musical conditions: listening to the Mozart sonata, Albinoni's adagio, or Japanese children's playsongs; or singing playsongs. After the music experience, they drew a second picture.

Drawings from two 5-year-olds are shown in Figure 5.7. Children who heard or sang playsongs drew for a longer duration of time

[10] Schellenberg EG, Hallam S. "Music listening and cognitive abilities in 10- and 11-year-olds: The Blur effect" *Annals of the New York Academy of Sciences* 2005;1060:202-209.

[11] Schellenberg EG, Nakata T, Hunter PG, Tamoto S. "Exposure to music and cognitive performance: Tests of children and adults" *Psychology of Music* 2007;35:5-19.



Figure 5.7

Two drawings from a 5-year-old (Child 1) on the left, and two drawings from a different 5-year-old (Child 2) on the right [11]. For both children, the upper drawing is defined as the baseline. The lower drawing was completed after a music experience: listening to Albinoni (Child 1) or listening to children's playsongs (Child 2). For Child 1 and other 5-year-olds in the same condition, the baseline drawings were rated as being more creative, energetic, and technically proficient than the music drawings. For Child 2 and other 5-year-olds in the same condition, the music drawings were rated as being more creative, energetic, and technically proficient than the baseline drawings.

compared to those who heard Mozart or Albinoni. Their drawings were also judged to be more creative, energetic, and technically proficient than their baseline drawings. By contrast, drawings made after listening to Mozart or Albinoni were judged to be worse on each of these dimensions compared to baseline. The adult judges who rated the drawings were unaware of which drawing was the music or baseline drawing from each child, and which music condition the child experienced. In short, this study revealed a *children's playsong effect* on the creative abilities of Japanese 5-year-olds. Figure 5.8 provides a collage of images illustrating the various effects that have been reported (i.e., Mozart, Schubert, Stephen King, Blur, and children's playsongs) as well as instances where there was no effect (i.e., Philip Glass, Albinoni).

A final study from this research team tested the non-spatial abilities of adults with computerized versions of two subtests from a standardized IQ test [11]. One measured processing speed; the other measured working memory. Each participant was tested once after listening to Mozart and once after listening to Albinoni. At the second session, arousal levels and mood improved after listening to Mozart but declined after listening to Albinoni. Performance on both subtests was also better after listening to Mozart than to Albinoni, but the difference between groups was statistically significant only for the test of processing speed.

One again, these results indicate that the so-called Mozart effect is a consequence of changes in arousal and mood. They also

confirm that the association between listening to music and cognition extends beyond spatial abilities to processing speed, just as it extended to creative abilities in the study of the Japanese 5-year-olds. Lastly, the findings suggest that arousal and mood may influence performance on some tests more than others (as in the Blur effect study), but it does not matter whether the tests measure spatial abilities.

5.3.3 Replications and future directions

Some meta-analytic reviews of the Mozart effect find support for the effect while others find little to none. Likewise, certain research teams have been able to replicate the effect whereas others have been unsuccessful. Generally speaking, cognitive abilities tend to be better after listening to Mozart than after sitting in silence, but a similar advantage is evident when other music is used (as in Fig. 5.8).

Numerous factors could influence whether effects of exposure to music are observed, including the particular cognitive test, procedural details (e.g., group versus individual testing), and music preferences. Accordingly, simple attempts to replicate are not particularly informative, regardless of whether they succeed or fail [12]. In order to further our understanding of the association between listening to music and cognitive performance, the findings must inform us about the underlying mechanisms. The arousal and mood hypothesis provides a testable hypothesis that does not rely on music or spatial abilities to explain the effects of music listening on cognition, and both underlying mechanisms (i.e., the music's effect on the listener's emotional state; the effect of emotion on cognition) are well established in the literature.

5.4 Background music and cognitive abilities

We now turn to an issue that is more relevant to everyday life: whether background music influences cognitive abilities. Our discussion is restricted to studies that examined focused or deliberate learning on a cognitive task in the presence of background music. Incidental learning is examined in studies that test whether background music enhances memory for the content of films and advertisements, an issue that falls beyond the scope of the present chapter.

As we will see, background music causes improvements in cognitive performance in some instances. In others, background music leads to decrements in cognition or has no effect. The inconsistencies appear to be the result of two conflicting forces. On the one hand, music often improves the emotional state of the listener and influences cognitive performance as a consequence. On the other hand, an individual's capacity to attend to more than one stimulus at a time (i.e., the cognitive task and the background music) is

[12] Schellenberg EG. "Cognitive performance after listening to music: A review of the Mozart effect" In *Music, Health and Wellbeing*, MacDonald RAR, Kreutz G, Mitchell L, Eds.; Oxford University Press: Oxford UK, in press.



Figure 5.8

A collage illustrating that the so-called Mozart effect is evidenced after listening to some auditory stimuli (marked with a check) but not to others (marked with an X). Clockwise from the upper right: an album

of Japanese children's playsongs, Albinoni, Mozart, Stephen King (photo: Amy Guip), Philip Glass (photo: WNYC New York Public Radio), and Schubert. The image in the center is Damon Albarn from Blur (photo: Tony Kinlan).

limited, and the presence of background music may interfere with performance on the cognitive task.

In experimental studies of the effects of background music, the cognitive task is often a measure of working memory or reading comprehension. Working memory is involved in virtually all mental activities since information is typically processed consciously before making its way into long-term memory and becoming part of the perceiver's knowledge base. By contrast, reading comprehension involves substantially higher-order processes. Readers must attend to the printed letters, translate them into words associated with meaning, parse and understand each sentence, and consider the meaning in context. The effect of background music on reading comprehension is particularly important because (1) virtually all studying involves reading of some sort, (2) it is common for high-school or university students to listen to music while they study, and (3) understanding and remembering what one reads is crucial to academic success.

In one test of working memory, participants were asked to recall nine digits presented visually in succession while auditory stimuli were presented in the background [13]. The stimuli included speech in a foreign language, a hissing noise, instrumental music, or vocal music sung in a native or foreign language. The number of digits recalled in the correct order was highest in the silence and noise conditions, which did not differ. Instrumental music disrupted recall but not to the same degree as vocal music or speech. These results suggest that it is difficult to retain visually presented information in working memory when background music is presented simultaneously, particularly if the music has vocals. Other evidence suggests that although vocal background music impairs working memory compared with silence, instrumental music does not.

When the to-be-remembered digits are heard rather than seen, *staccato* background music is more disruptive than *legato* background music even when both types of music are instrumental. When the background music has vocals, aggressive music (e.g., heavy metal) has more detrimental effects than relaxing music on tests of working or long-term memory. Interestingly, performance on working-memory tasks can be independent of the degree to which the background stimulus is considered to be distracting by the participants. In other words, people are not necessarily aware of the negative impact of background music.

When simpler stimuli such as short sequences of syllables or tones are presented in the background, working memory for visually presented digits suffers only when the background sequence

[13] Salamé P, Baddeley A. "Effects of background music on phonological short-term memory" *Quarterly Journal of Experimental Psychology* 1989;41A:107-122.

comprises *different* tones or syllables. When one tone or syllable is simply repeated, performance is the same as in the control (silence) condition. Nonetheless, when recall tasks include measures of long-term memory, actual music – with *many* different tones – can have *no* effect on performance. For example, recognition for strings of nonsense words is unaffected by the presence of instrumental music. Moreover, if nonsense words are encoded as “translations” of real words, memory for the translations can actually be *better* when the learning occurs in the presence of instrumental music.

In a study of 10- to 12-year-olds’ memory, performance improved when the task was completed in the presence of calming and pleasant music, but declined in the presence of arousing and unpleasant music [14]. As with the studies described in the previous section, the effect of music listening on cognition appears to be mediated by arousal and mood, with *over*-arousal leading to *poorer* performance.

Studies of reading comprehension in the presence of background music report findings that are similarly ambiguous. The typical method is to ask participants to read something either with or without an accompaniment of background music. Comprehension is subsequently measured with true/false or multiple-choice questions about what the participants read. For high school students, reading comprehension sometimes improves with background music, especially at particular times of the day (i.e., the first class of the morning and afternoon, the middle of the afternoon) and for the weakest students. For university students, reading is sometimes faster and more efficient (i.e., more facts remembered) for those who listen simultaneously to fast-tempo classical music; conversely, reading is slowest and least efficient among students who listen to the same music at a slower tempo, with students who read in silence falling in between the two music groups.

Contradictory findings indicate that comprehension is sometimes *poorer* for adults who read while listening to background music compared to those who read in silence. In some instances, background music leads to decrements in reading comprehension among introverts but not among extroverts, who appear to be relatively unaffected by the presence of music. Nonetheless, when the task is changed so that participants are required simply to remember as much as they can about what they read (i.e., free recall), introverts and extroverts show similar decrements in recall after reading in the presence of background music [15]. Other studies find *no* effects of background music on reading comprehension among children, high-school students, or adults, whether they are introverts or extrovert.

[14] Hallam S, Price J, Katsarou G. “The effects of background music on primary school pupils’ task performance” *Educational Studies* 2002;28:111-122.

[15] Furnham A, Strbac L. “Music is as distracting as noise: The differential distraction of background music and noise on the cognitive test performance of introverts and extraverts” *Ergonomics* 2002;45:203-217.

When researchers examine effects of background music on cognitive abilities other than memory or reading comprehension, the results are similarly inconsistent. Studies of mathematical abilities differ from those of working memory and reading comprehension because participants typically complete a set of math problems *while* background music is presented. In the memory and reading studies described above, background music was usually played during the exposure phase (while participants see a sequence of digits or a read a passage) but not when participants' memory was tested afterward.

Among children with emotional and behavioral problems, the presence of calming instrumental music can facilitate their ability to solve math problems. For these students, calming music also serves to reduce disruptive behavior when compared to a silent environment. Again, the association between music and cognition appears to be mediated by a third factor, an emotional response to calming music that involves lower (and more optimal) levels of arousal for this group of children. For typically developing children, however, although more math problems are completed in the presence of calming music compared to silence, the number of problems solved correctly does not differ [14]. Among college students, performance on math problems does not differ if students complete the problems in silence or in the presence of soft or loud instrumental music, even though students claim that the music interferes with their performance, particularly if it is loud. In this instance, participants report a detrimental effect of background music when there is none.

The effects of background music have also been tested with special populations. For example, elderly participants with or without a diagnosis of Alzheimer's disease can list more instances from a category such as *fruit* or *vehicles* when classical music is presented in the background. Among older adults with dementia, classical music improves their ability to remember personal details from the distant past. Among psychotic children, the ability to sort toys is better when "new age" music is presented in the background than when the same task is completed in silence. Detrimental effects of background music have also been reported. For example, the mental skills required by the cognitively impaired elderly to perform routine household tasks (e.g., folding laundry, setting the table) are diminished in the presence of background music.

Other effects with typically developing individuals reveal that male children pay more attention in school classrooms when easy-listening background music is present. There is no effect for girls, however, who tend to be good at paying attention even without background music. At the university level, vocal or instrumental background music negatively affects performance on visuospatial tests, verbal tests, and writing speed. For tests of long-term memory for paired associations, performance is best in silence, intermediate with instrumental background music, and worst with vocal background music for students who do *not* typically study with music. For students who regularly study with music, on the other hand, background music has no effect on their performance.

Other characteristics of music are also relevant. For example, aggressive music leads to poor performance on tests that require participants to ignore irrelevant but conflicting information, whereas relaxing music does not. Finally, simple response times to unusual events can be improved when background music is presented at a comfortable volume, although performance deteriorates when the same background music is presented louder or softer.

In sum, effects of background music on cognition depend on several factors, rendering it impossible to reach any general conclusions about the findings. In line with this view, Hallam and MacDonald [16] presented a model of the effects of background music on cognition that includes contributions of individual differences, the listener's emotional state, the music that is presented, the listening environment, and the nature of the cognitive task. Clearly, testing and refining such a model is a formidable endeavor. It is equally clear, however, that ignoring some or most of these factors can lead to inconsistent findings.

5.5 Music lessons and cognitive abilities

Although the existence of associations between music lessons and cognitive functioning is relatively well established, several issues remain unclear. Are such associations general or specific to certain cognitive abilities? Does another mechanism mediate the association between music lessons and cognitive abilities? Do music lessons *cause* improvements in cognitive performance?

Unsurprisingly, taking music lessons is associated with better listening ability. For example, children with music training are more adept than untrained children at identifying whether a sequence of chords unfolds in a style typical of Western music, and musically trained adults outperform their untrained counterparts at identifying melodies that are presented at an unusually fast or slow tempo. Adults with music training are also better than untrained adults at identifying small mistunings in familiar melodies and at remembering short tone sequences. Their superior listening abilities extend beyond music tasks to lower-level tests of frequency discrimination and auditory processing speed.

Music lessons are also associated with performance on linguistic tests. For example, musically trained individuals remember lists of words better than untrained participants. They also exhibit better memory for prose. In fact, music training is associated positively with a host of other linguistic abilities, including vocabulary, sequencing verbal information, and reading ability. Individuals with music training also exhibit advantages on tasks that require them to detect pitch changes in spoken language or to decode the emotions conveyed by speech prosody.

[16] Hallam S, MacDonald RAR. (2009) "The effects of music in community and educational settings" In S. Hallam, I. Cross, & M. Thaut (Eds.), *The Oxford handbook of music psychology* (pp. 471-480). Oxford, UK: Oxford University Press.

One might think that links between music lessons and linguistic abilities stem from the fact that both music and language are systems of communication that rely on the transmission of auditory information. However, associations between music lessons and cognition extend well beyond language. For example, music training is predictive of enhanced performance on tests of spatial abilities. Participants with music training also outperform their untrained counterparts on mathematical tasks and on tests of memory. In fact, positive associations with music training extend to reaction-time tasks, tactile acuity, and visual-motor integration.

The diversity of associations between music lessons and cognition suggests that individuals who take music lessons tend to be high-functioning in general. Thus, one would expect music lessons to be associated with performance on measures of general cognitive abilities, including standardized tests of IQ. In one study of almost 150 children aged from 6 to 11 [17], IQ was associated with the duration of music lessons, even when family income, parents' education, and involvement in other extra-curricular activities were held constant. Moreover, such associations extended across the many subtests that standardized tests of IQ comprise. Similar but smaller associations were evident in a sample of 150 undergraduates [17], with the duration of music training in childhood predicting IQ in adulthood. In both samples, the association between music lessons and cognitive performance extended beyond IQ to academic achievement as measured by grades in school. If one assumes that music lessons are the *cause* of these effects, the results point to a dose-response effect, with larger doses (i.e., longer duration of lessons) leading to larger responses (i.e., greater increases in cognitive performance). It could just as easily be the case, however, that individuals with higher IQs are particularly likely to take music lessons for years on end and to perform well on tests of cognitive abilities.

The many differences in cognitive abilities that accompany music lessons are paralleled by distinct structural differences in the brain. These differences do *not* inform the issue of causation, however, because differences in cognitive abilities must be instantiated in the brain whether they are determined by nature or nurture. Unfortunately, quasi-experimental brain studies (i.e., *without* random assignment) of musically trained and untrained participants often assume that music lessons are responsible for the observed differences, inferring a causal link from a research design that does not allow for such inferences. Indeed, researchers often invoke the concept of *neuroplasticity* (i.e., changes in brain structure and/or function as a consequence of experience) to explain observed differences between musicians and non-musicians. Some even claim that the musician's brain is an ideal model of the phenomenon.

[17] Schellenberg EG. "Long-term positive associations between music lessons and IQ" *Journal of Educational Psychology* 2006;98:457-468.

Figure 5.9

A billboard in Tucson, Arizona, propagating the notion that playing music makes you smarter (photo: Charles Falco).



Although there is no doubt that experience and learning affect the structure and function of the brain, it is equally clear that innate factors play a central role in individual differences in cognitive performance. Indeed, over half of the variance in intelligence is determined by genetics, whereas the influence of between-family differences, such as sending children to music lessons, has been notoriously difficult to document.

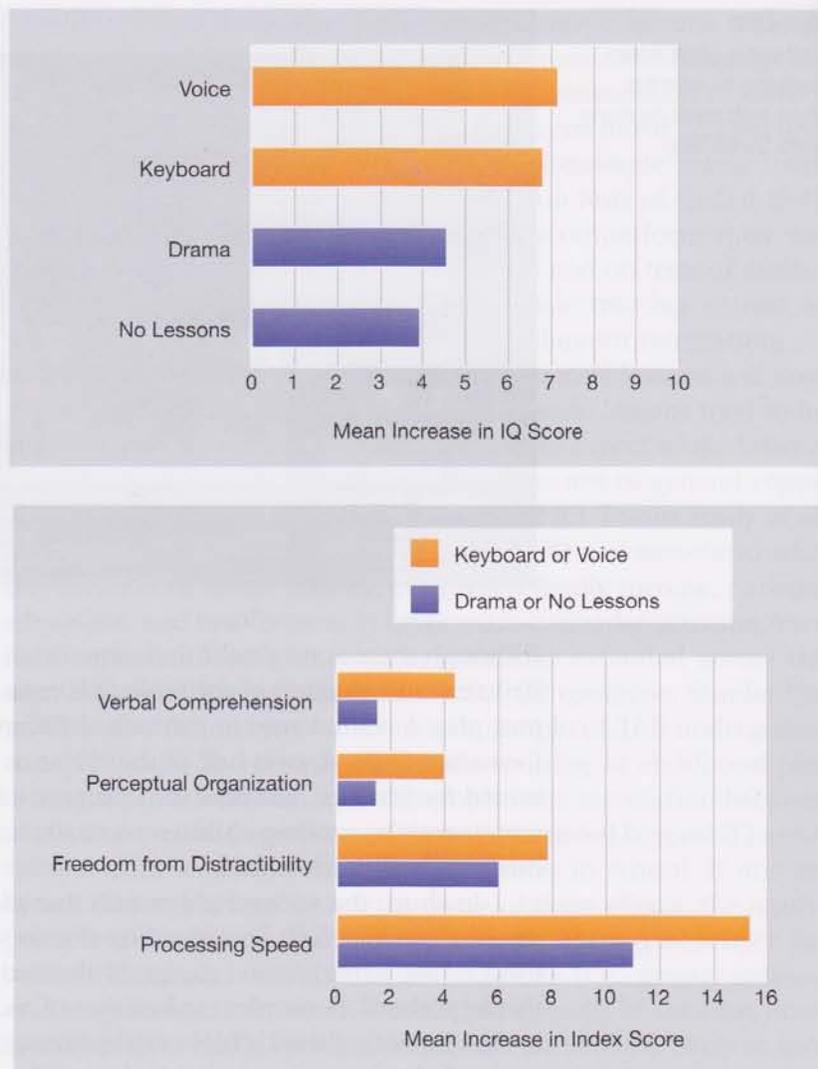
In short, the widespread notion that *playing music makes you smarter* (see Fig. 5.9) is misleading due to very few studies having used a true experimental design with random assignment to test this hypothesis. A simpler explanation of most of the available data is that individuals with higher-than-average cognitive abilities are more likely than other individuals to take music lessons, to have greater aptitude for music, and to perform well on tests of cognitive abilities.

Actual experimental evidence of a causal link between music lessons and intelligence tends to come from studies with inherent flaws, which raise doubts about the findings. Some researchers assigned participants to a control or a music intervention in a non-random fashion, whereas others used intervention protocols differing markedly from typical music lessons. Several studies failed to give control participants comparable non-music lessons, which makes it impossible to attribute the results to music per se rather than to additional instruction in any domain, additional contact with an adult teacher, and so on. Other researchers reported abnormally high levels of attrition, which raises the possibility that participants who were available for testing at the end of the intervention differed from those who dropped out.

[18] Schellenberg EG. "Music lessons enhance IQ" *Psychological Science* 2004;15:511-514.

Figure 5.10

The upper panel illustrates mean increases in IQ after a year of lessons for four groups of 6-year-olds [18]. The two music groups (voice and keyboard) had larger increases than the two control groups (drama and no lessons). The lower panel contrasts the two music groups with the two control groups on the four major indexes of the IQ test. The music groups had larger increases across indexes.



In one carefully controlled experiment [18], a sample of 144 6-year-olds was assigned randomly to one of four conditions: two music interventions (keyboard or vocal lessons), a control intervention (drama lessons), or another control condition involving no lessons. After a year of lessons, the music groups had a larger increase in IQ (7.0 points) compared to the control groups (4.3 points; Fig. 5.10, upper). These benefits extended across IQ subtests and indexes (Fig. 5.10, lower) and to tests of academic achievement. Even in this well-designed study, the music intervention differed from typical music lessons in that the children practiced minimally. This was presumably due to the fact that providing the lessons for free meant that there was no incentive for parents to encourage their children to practice as a means of getting their money's worth.

The dose-response association between music lessons and IQ [17] suggests that real musicians (i.e., those with the largest amounts of training) should often be geniuses. In fact, the association breaks down when real musicians are tested. Rather, the advantage seems to be limited to those who study music in *addition*

to their other activities. When music training is *substituted* for other activities, such as when graduate students in music are compared to graduate students in other disciplines, the association becomes inconsistent [19] or the music groups perform *worse* on measures of general intelligence [20].

Another outstanding issue concerns whether the link between music lessons and intelligence is direct or mediated by some other variable. Although a direct link can justify high-functioning children being likely to take music lessons, it has trouble accounting for effects of music lessons on IQ [18], as IQ tends to be remarkably stable across the lifespan. Some researchers have proposed the idea that *executive function* mediates the association between music lessons and cognition. Executive function is the ability to solve problems consciously, to make judgments, to plan ahead, and to inhibit incorrect responses. Executive function and IQ are correlated but not identical. Unlike IQ, executive function is modified readily by experience, especially in childhood. It is possible, then, that music lessons enhance executive function, which in turn leads to higher scores on tests of IQ.

Although executive function meets theoretical criteria for mediating effects of music lessons on intelligence, there is little supporting evidence in this regard. In one study of 9- to 12-year-old children [21], music lessons were associated with large group differences in IQ. Despite that IQ was also associated positively with executive function, music training was independent of performance on four of five tests of executive function. The sole exception was a test of working memory (Digit Span), which is also a subtest of comprehensive measures of IQ. The hypothesis that motivated the study as well as the simplest interpretation of the data is illustrated in Figure 5.11.

One particularly intriguing finding is that the association between duration of music lessons and school grades remains evident even when IQ is held constant [17]. In other words, children who take music lessons are particularly good students, above and beyond what you would predict from their IQ scores. Good students are likely to be those who are eager to learn, cooperative with adults and peers, able to concentrate, and above-average in cognitive ability. They are also likely to exhibit specific personality traits that are associated with good academic performance, such as conscientiousness, need for achievement, and intellectual openness [22].

[19] Helmbold N, Rammsayer T, Altenmüller E. "Differences in primary mental abilities between musicians and nonmusicians" *Journal of Individual Differences* 2005;26:74-85.

[20] Brandler S, Rammsayer T. "Differences in mental abilities between musicians and non-musicians" *Psychology of Music* 2003;31:123-138.

[21] Schellenberg EG. "Examining the association between music lessons and intelligence" *British Journal of Psychology* 2011;102: 283-302.

[22] Paunonen SV, Ashton MC. "Big five predictors of academic achievement" *Journal of Research in Personality* 2001;35:78-90.

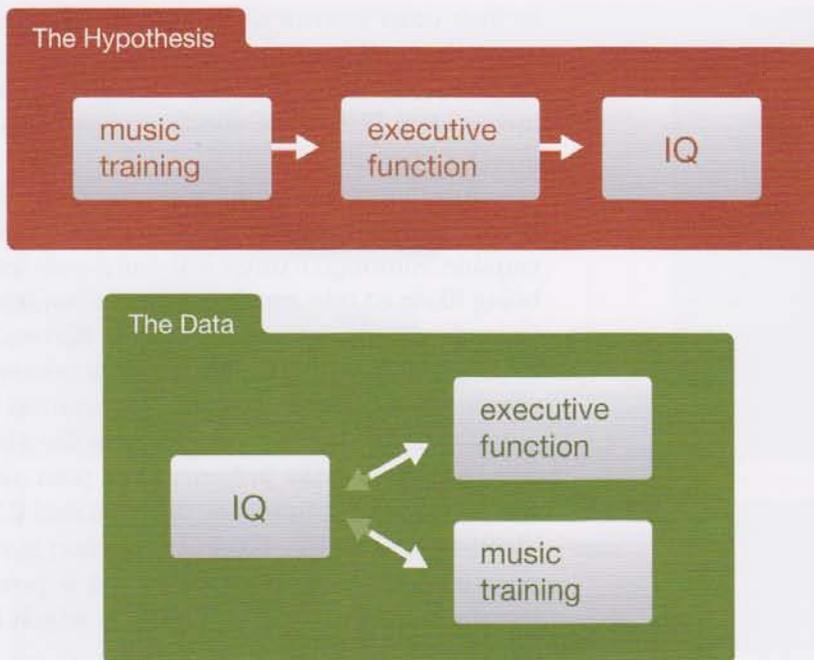


Figure 5.11

The upper panel illustrates the hypothesis that the association between music training and IQ is mediated by executive function. The lower panel indicates the simplest interpretation of the data [21], namely that high-functioning children are more likely than other children to take music lessons and to perform well on tests of executive function. The lower panel also acknowledges that music training may cause small increases in IQ, as may relatively good executive-function abilities.

This constellation of cognitive and personality characteristics leads to good performance on a variety of tests, including tests of IQ. It may also make children ideally suited for the challenges of music lessons. Exposure to additional school-like activities such as music lessons could hone their natural abilities further and enhance their pre-existing cognitive advantages. When music lessons are taken in addition to other studies and activities during the formative years, the lessons would exaggerate performance advantages on tests of cognitive ability. When music lessons take the place of other academic activities, the circular effect would end. This hypothesis has the advantage of considering innate and experiential factors, and personality as well as cognitive variables.

5.6 Conclusion

Does exposure to music improve cognitive abilities? Studies of music aptitude reveal that people who are naturally musical also exhibit advantages on a variety of cognitive tests. Such associations are likely to stem primarily from the fact that high-functioning individuals tend to perform well on almost any test they take. Nevertheless, the existence of individuals with normal cognitive functioning but poor music abilities indicates that music aptitude may be independent of general cognitive abilities in some instances.

Studies of music listening lead to the firmest conclusions, primarily because one can relatively easily assign individuals at random to different listening conditions. When music listening is followed by tests of cognitive abilities, performance can be enhanced by exposure to music if the exposure changes listeners' emotional state, particularly their arousal levels and moods, which in turn influence how they perform cognitively. At the same time, since numerous

experiences can change how one feels, music listening is “special” only because of its cultural prevalence and because it does not usually have adverse effects.

The situation becomes more complicated when music listening occurs simultaneously with learning or cognitive performance. Although background music can have positive effects on the listener’s emotional state and enhance performance, it can also be distracting and lead to decrements in performance, especially when the music has vocals. Whether background music has positive, negative, or no effects on cognition appears to be determined by multiple factors, such as individual differences in cognitive and personality characteristics, the listener’s emotional state, the listening environment, the nature of the cognitive task, and the background music itself. To complicate matters further, these factors are bound to influence cognition in an interactive and idiosyncratic manner, making it difficult to reach conclusions that apply generally across individuals and contexts.

Finally, studies of music lessons and cognition reveal that there is a positive association between music training and cognitive functioning in many domains, although such associations do not necessarily extend to professional musicians. The available evidence suggests that high-functioning individuals are more likely than their low-functioning counterparts to take music lessons, and that music lessons exaggerate their natural cognitive advantages to a small extent.

When considered as a whole, research on music aptitude, listening, and lessons suggests that our relationship to music involves both innate and environmental factors. This relationship is worthy of scientific investigation because it highlights uniquely human mental capacities. Moreover, music represents a compelling example of reciprocal influences between cognition and experience.

Acknowledgements

The preparation of this chapter was supported by the Natural Sciences and Engineering Research Council of Canada. We thank Rogério Lira for designing the figures.