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The Mozart Effect: Music Listening is Not Music Instruction

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"The Mozart effect" originally referred to the phenomenon of a brief enhancement of spatial-temporal abilities in college students after listening to a Mozart piano sonata (K. 448). Over time, this term was conflated with an independent series of studies on the effects of music instruction. This occurrence has caused confusion that has been perpetuated in scholarly articles, such as the one by Waterhouse (2006) and that persists in the minds of the general public. Here this article emphasizes the distinction that must be made between research on music listening and research on the more cognitively complex and educationally significant phenomena of music instruction. This article stresses that improvements in spatial-temporal skills associated with music instruction are not "free." This article also discusses theories of transfer and mechanisms of learning as they relate to this topic.

In her article, Lynn Waterhouse (2006) advises educators to exercise caution when attempting to apply the theories of multiple intelligence, the Mozart effect, and emotional intelligence to educational practice. She urges educators to consider alternative explanations from both the neuroscientific and psychological literatures before basing educational practice on these theories. The article addresses Waterhouse's concerns regarding the Mozart effect.

We suggest that Waterhouse's (2006) representation of the Mozart effect confuses two separate avenues of research, one involving the effects of *listening* to a particular Mozart sonata on spatial-temporal cognition and the other exploring the effects of music *instruction* on cognitive performance. The initial listening study (Rauscher, Shaw, & Ky, 1993) received widespread attention from the popular media, who first coined the term "Mozart effect" (Knox, 1993). The main finding of this study was that one specific composition of Mozart enhanced adult spatial test performance for up to about 15 min. There was no indication that other Mozart pieces would have this effect or that the effect was in any way specific to Mozart. Unfortunately, as Waterhouse correctly asserts, this discovery created a "scientific legend" (Bangerter & Heath, 2004) with the edict "Mozart makes you smarter." This led to a Mozart effect industry and eventually to Georgia Governor Zell Miller's proposal to send every newborn baby home from the hospital with a classical music CD.

MUSIC LISTENING: THE MOZART EFFECT

Much of the controversy concerning the Mozart effect is due to the misconception that Mozart's music can enhance general intelligence (Newman et al., 1995; Rauscher, 1999; Steele, Ball, & Runk, 1997; Stough, Kerkin, Bates, & Magnan, 1994). Waterhouse (2006) states that the Mozart effect has since proven difficult to replicate and cites "a meta-analysis [Chabris, 1999] of 16 Mozart effect studies [that] found no change in IQ or spatial reasoning ability." Unfortunately, the majority of the studies analyzed by Chabris used inappropriate tasks, music, and diverse research methods. However, a more recent meta-analysis of 36 studies involving 2,465 subjects found that the Mozart effect is moderate and robust but that "it is limited … to a specific type of spatial task that requires mental rotation in the absence of a

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physical model" (Hetland, 2000a, p. 136)—that is, spatial-temporal tasks. Waterhouse also cites an article by McKelvie and Low (2002) that found that "compared to control participants, there was no improvement in the spatial IQ scores of children who listened to a Mozart sonata." The children's spatial scores were compared before and after they listened to Mozart, popular children's songs, or relaxing music. No differences between conditions were found, despite the finding that the children preferred listening to the popular music. Waterhouse failed to cite a study that did find significant improvement in the spatial-temporal scores of primary school children after listening to both a Mozart sonata and a composition by J. S. Bach. The children's musical backgrounds had no effect on the outcome (Ivanov & Geake, 2003). A third study also using children as subjects compared the effects of listening to Mozart or popular music or engaging in a discussion about the experiment (Schellenberg & Hallam, 2005). The researchers found that the children scored higher on a spatial-temporal task following the popular music but not following the Mozart sonata or discussion. They concluded that "positive benefits of music listening on cognitive abilities are most likely to be evident when the music is enjoyed by the listener" (p. 6). Other studies also support the conclusion that the Mozart effect is largely due to arousal or mood rather than to Mozart or the specific composition (Chabris, 1999; Nantais & Schellenberg, 1999; Schellenberg, Nakata, Hunter, & Tamoto, in press; Thompson, Schellenberg, & Husain, 2001). However, given the contradictory findings of the studies on children, we agree with Waterhouse that educational practice should not be influenced by this area of research. Few studies used child participants, the effect may be limited to certain types of tasks, and the outcome is exceedingly brief.

MUSIC INSTRUCTION

A second area of investigation, however, deserves further consideration by educators: the effects of music instruction on children's cognitive abilities. To avoid confusion, and because they have nothing at all to do with Mozart, we prefer that the instruction studies not be referred to as the Mozart effect, although others have unfortunately generalized the term to refer to any effect of music on behavior (e.g., Campbell, 1997). The instruction studies, unlike the listening studies, have profound implications for educational practice. Our research consistently shows that young children provided with instrumental instruction score significantly higher on tasks measuring spatial-temporal cognition, hand-eye coordination, and arithmetic (Rauscher, 2001, 2002; Rauscher, LeMieux, & Hinton, 2005; Rauscher et al., 1997; Rauscher & Zupan, 2000). Other researchers have found similar effects (see Hetland, 2000b, for review). More recently, a study by Schellenberg (2004) showed small but significant increases in generalized IQ for children randomly assigned to receive music instruction compared to control groups of children who received drama instruction or no special training. Effects of music instruction have been found to persist for at least 2 years *after* the instruction was terminated (Rauscher, LeMieux, & Hinton, 2005). Although the age of the participants, the methods used, and the outcomes achieved are distinctly different from those of the listening studies, Waterhouse (2006) also refers to this phenomenon as the Mozart effect. She asserts that "the research findings from 1993 [referring to the original listening study] onward led to the conclusion that experience of music, and especially of Mozart's music, whether for a brief time or over a longer period, whether listened to or played, significantly improved spatial cognitive skills." We know of no studies, anecdotal evidence, or popular press accounts suggesting that performing Mozart's music affects spatial cognition or any other domain of intelligence. Waterhouse further confuses the two sets of findings when she states that "Rauscher (2002) suggested that the Mozart effect might work either through transfer of learning from the music domain to the visual-spatial domain, or through changing the physical structure of the brain." Rauscher's reasoning concerned the effects of music *instruction,* not the effects of listening to a Mozart sonata—the so-called Mozart effect. We do not suggest that listening to Mozart's music transfers to spatial task performance or that it changes the physical structure of the brain. In fact, the article Waterhouse cited to support her conclusion (i.e., Rauscher, 2002) included nothing about possible mechanisms for the effects of listening to Mozart. The article reported a study on the effects of music instruction and possible mechanisms for instruction's effects on cognition. We believe that Waterhouse's conflating the listening studies with the music instruction studies will lead to greater misinterpretation of the research by educators, politicians, and laypeople. Care must be taken to distinguish these independent research findings so as not to compound the misunderstandings that already exist.

SPATIAL SKILL IMPROVEMENTS ARE NOT "FREE"

Much of Waterhouse's (2006) critique of the Mozart effect is based on her misinterpretation of a statement made by Rauscher (2002). Waterhouse claims that "when asked whether children's spatial skills might be better improved directly through practice rather than indirectly through music, Rauscher argued that music … offers 'free' improvement of spatial skill—i.e., the enhancement of skill without any practice." This is not the case. Rauscher's (2002) response to that question emphasized that she instructs her music specialists to "teach the children using their best musical judgment, and the effects will follow" (p. 276). This does not imply, however, that the effects are free or that they will magically appear without practice. The children are, after all, learning to play a musical instrument, which requires sophisticated spatial-temporal training. Brochard, Dufour, and Després (2004) suggest that " … learning to play a musical instrument and/or read musical scores involve the development of specific perceptual, cognitive, and motor skills which are likely to transfer to other behaviors" (p. 103). These researchers found improved visuospatial skills in musicians compared to nonmusicians using a reaction time task. Vertical discrimination was tested by presenting subjects with a small target dot either above or below a horizontal reference line. Horizontal discrimination was tested by presenting the dot either to the left or to the right of a vertical reference line. Two different experimental conditions were employed. In one condition ("line on"), the reference line was present during the presentation of the dot. In the other condition ("line off"), the reference line was absent. The subjects' task was to indicate which side of the reference line the dot was flashed. The researchers predicted that

> … if musical expertise has a long-term influence on visual-spatial abilities, … musicians' performance on both perceptual "line on" and imagery "line off" conditions [would] be significantly better than nonmusicians. Moreover, if this effect relies on a more efficient use of visual representations, an advantage of musical expertise should be greater in the imaging ("line off") conditions. (p. 104)

The data fully supported these predictions. In addition, the researchers found superior performance for the musicians on the vertical dimension in the imaging (line off) condition and attribute this finding to musicians' long-term practice of reading a musical score. "Reading a musical score is far less linear than reading a text and relies more on processing information on the vertical axis … " (p. 106). The authors suggest that the emphasis on the vertical dimension when one reads a musical score affected mental representations on that portion of the visual field. They conclude that "such perceptual and imagery advantages partly explain why music instruction generally increases children's scoring in visuospatial tasks (such as paper folding, mental rotation, and tridimensional reasoning) which all involve the mental manipulation of visual representations on several dimensions" (p. 106). Thus, the knowledge gained from studying a musical instrument may transfer to spatial-temporal (or mathematical) problem solving without specific practice in the target domain. However, substantial learning must occur in the musical domain. Hence the spatial task improvement is not free or without effort.

TRANSFER

Transfer is defined as the ability to extend what has been learned in one context to new contexts (e.g., Byrnes, 1996). Researchers interested in transfer were initially guided by theories that emphasized the similarities between the initial learning experience and later learning. Thorndike (1913) proposed that the amount of transfer that could occur between two domains was dependent on the similarity of the elements of the domains. The more equivalent the elements of the two domains, the greater the likelihood of positive transfer. The primary emphasis was on drill and practice. Modern transfer theories also take learner characteristics (e.g., whether relevant principles were extrapolated) into account (e.g., Singley & Anderson, 1989). Thus, transfer is always a function of the relation between what is learned and what is tested. Measuring the overlap between the original domain of learning and the novel one requires a theory of how knowledge is represented and conceptually mapped across the domains. Singley and Anderson argue that transfer between tasks is a function of the degree to which the tasks share *cognitive* elements. This hypothesis is hard to test experimentally until the task components are identified. Thus, a complete understanding of spontaneous transfer from music to another domain of reasoning (e.g., spatial-temporal reasoning or arithmetic) is possible only to the extent that the cognitive elements of the two domains can be identified. For example, the part-whole concept is a very important construct for many mathematical problems. This concept requires understanding the relation between parts to wholes, such as when learning percents, decimals, and fractions. In music, the part-whole concept is especially relevant in the conceptualization of rhythm. A literate musician is required to continually mentally subdivide the beat to arrive at the correct interpretation of rhythmic notation. The details of the problem are certainly different, the context has changed, but the structure of the problem is essentially the same as any part-whole problem posed mathematically. Perhaps this relation helps explain the finding that children who received instruction on rhythm instruments scored higher on part-whole mathematics problems than those who received piano or singing instruction (Rauscher, LeMieux, & Hinton, 2005). We believe that further investigation into the components common to musical and mathematical knowledge will aid in the understanding of these transfer effects.

MECHANISMS OF LEARNING

Waterhouse (2006) states that "cognitive neuroscience research has discovered six processes that influence the establishment of long-term procedural and declarative memory": repetition, excitation, reward, carbohydrate consumption, sleep after a learning session, and avoidance of drugs and alcohol. We believe there is more to learning than the six constructs Waterhouse identified. For example, in order for learners to gain insight into their learning and their understanding, frequent feedback is critical (Ericsson, Krampe, & Tesch-Romer, 1993). This feedback need not be rewarding. Students need to monitor their learning and actively evaluate their strategies. Playing a musical instrument requires vigilant instantaneous examination of what has already occurred in the performance (e.g., up-bow vs. down-bow, fingering) as well as thinking ahead to prepare for future challenges. Students are continually reflecting on their performance and that of others, and they are learning from their own and others' mistakes. At the end of most music lessons, student and teacher discuss what the student did, how he or she did it, and why. This metacognitive approach engages students as active participants in their learning by focusing their attention on critical elements, encouraging abstraction of procedures, and evaluating their own progress toward understanding—all processes that have been shown to encourage transfer across domains (Singley & Anderson, 1989). Perhaps the reflective and analytical skills involved in learning an instrument encourage the transfer of musical knowledge to spatial domains.

Waterhouse (2006) emphasizes that procedural skills improve as a function of repetition and that "there is no evidence, other than evidence for the Mozart effect, to suggest that significant cognitive skill improvement can take place without … repetition of that skill; or excitement associated with the skill activity." Because she continually confuses the listening studies with the music instruction studies, we are not certain which Mozart effect Waterhouse refers to in this context. Our comments here pertain to the instruction studies. We agree that the development of expertise occurs only with major investments of time. For example, a study of 250 musically trained young people found strong correlations between proficiency in a musical instrument and the number of hours per day spent practicing (Sloboda, Davidson, Howe, & Moore, 1996). Children who were later accepted to specialized music schools practiced approximately 2 hr per day by age 12. This represents a 400%–800% increase compared to average children learning a musical instrument, who at that age practiced only approximately 15–30 min per day. We suggest that practicing a musical instrument, even for a few minutes each day, engages spatial-temporal cognition and thereby contributes to spatial-temporal learning.

Waterhouse's (2006) second criterion for improved cognitive skill, also discussed in her section on arousal, is "excitation associated with the skill activity." We contend that playing a musical instrument also satisfies this criterion. In his treatise on the art of playing keyboard instruments, C. P. E. Bach (1778/1985) stated that "a musician cannot move others unless he too is moved" (p. 152). Emotions are clearly important to musicians wishing to communicate to an audience or to express their own feelings. Motivation to become a musician is characterized by hedonism—that is, cherishing music as a means to generate positive emotion (Persson, Pratt, & Robson, 1996). Furthermore, performing a composition for an audience of even one person (which all music students have done when playing for their teachers) is inherently an arousing activity. Thus, playing a musical instrument is accompanied by excitation, and the transfer of musical knowledge to spatial-temporal knowledge does not "contradict the current cognitive neuroscientific understanding of the basis of skill improvement" as Waterhouse asserts.

In her section entitled "Other Proposed Brain Mechanisms for the ME," Waterhouse (2006) states that "no evidence for the cross-domain transfer of learning from music to spatial skill has been found" and cites Schellenberg (2003) to support this contention. We believe this statement misrepresents Schellenberg's position. In fact, Schellenberg (2003) suggests that "positive transfer effects to nonmusical domains, such as language, mathematics, or spatial reasoning could be similarly unique for individuals who take music lessons" (p. 444) and further states that

> … the ability to attend to rapidly changing temporal information, skills relevant to auditory stream segregation, the ability to detect temporal groups, sensitivity to signals of closure and other gestalt cues of form, emotional sensitivity and fine motor skills … should be particularly likely to transfer to a variety of nonmusical domains. (p. 444)

Research grounded in near-transfer theory has indeed shown relations between music instruction and a variety of cognitively related skills (see, e.g., Gromko, 2004). Although studies specifically testing transfer as a mechanism are extremely difficult to implement due to an insufficient understanding of the overlap of the cognitive components inherent in the two domains (as discussed previously), we suggest that transfer remains a potential explanation for improved cognitive abilities following music instruction.

Waterhouse's (2006) critique includes a brief mention of a study that found improved maze learning following music exposure in rats (Rauscher, Robinson, & Jens, 1998). Citing Steele's (2003) critique of the study, she reports that "the rats [in Rauscher et al., 1998] … were unlikely to have improved their maze learning from hearing a Mozart sonata because … adult rats are deaf to the majority of tones in a Mozart sonata." Waterhouse's conclusion is unwarranted. Steele's analysis of rat auditory thresholds was incorrect, as was the note count and fundamental frequencies he recorded for the Mozart sonata. The rats likely heard a substantially higher percentage of notes than Steele reported, and other musical factors that he did not consider may be important as well. These factors, as well as Steele's other criticisms of Rauscher et al., have been addressed in depth elsewhere (Rauscher, 2006). Moreover, Rauscher et al.'s behavioral data have been replicated by other researchers who have shown that improved maze performance following exposure to the Mozart sonata is related to synaptic plasticity (Chikahisa et al., 2006). Although we do not claim that the mechanism for cognitive enhancement in rats is the same as for that in humans, we believe the research with rats suggests a neurophysiological basis for improved spatial performance following music exposure, perhaps related to cognitive transfer.

CONCLUSION

Like Waterhouse, we recommend caution when applying the findings of music instruction to educational practice, although they certainly seem worthy of further investigation in educational settings. Indeed, this research represents an excellent example of what has become known as a “design experiment.” Design experiments are described as educational research experiments carried out in a complex learning context to determine how an innovation affects student learning and educational practice (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Real-life educational contexts are, in turn, excellent settings for experimental tests of an intervention. We believe such experiments are a crucial research approach within the broader context of partnerships involving teachers, educational researchers, and scientists. We do not, however, advocate teaching music to students to improve their visuospatial or mathematical skills. We agree with Hetland and Winner (2001):

> If the arts are given a role in our schools because people believe the arts cause academic improvement, then the arts will quickly lose their position if academic improvement does not result … The arts must be justified in terms of what the arts can teach that no other subject can teach. (p. 3)

Although findings of a Mozart effect (i.e., the listening studies) may be of little educational value, the music instruction studies hold much more educational promise. Both sets of studies are of scientific importance because they suggest that music and spatial task performance share common elements and may be psychologically and neurologically related. We believe researchers should continue to search for links between music instruction and cognitive performance because disregarding these effects may overlook a potentially important educational intervention.

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