

MOZART AND THE MIND: FACTUAL AND FICTIONAL EFFECTS OF MUSICAL
ENRICHMENT

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The “Mozart effect,” a term coined by the Los Angeles Times, refers to the finding that college students who listened to the first ten minutes of a Mozart sonata (K. 448) scored higher on a spatial-temporal reasoning task immediately afterwards—an effect which lasted approximately 10 minutes. The original research report, first published by my colleagues and me in the journal *Nature* (Rauscher, Shaw, & Ky, 1993), received a disproportionate amount of attention from the popular press. To our horror, the finding has spawned a “Mozart Effect” industry that includes books, CDs, web sites, and all manner of hyperbole. Articles with titles such as “Mozart Makes You Smarter” and “Mozart Makes the Brain Hum” have led readers to believe that classical music in general, and Mozart in particular, can improve babies’ math scores later in life, improve scores on the Scholastic Aptitude Test (SAT), and turn average healthy children into Einsteins. Unfortunately, press reports of scientific findings are powerfully seductive to parents, educators, and policy makers. In fact, Georgia Governor Zell Miller, based on his understanding of these results, asked legislators to purchase classical music CDs for every newborn baby in the state. “No one doubts that listening to music, especially at an early age, affects spatial-temporal reasoning that underlies math, engineering, and chess.”

Far from no one doubting it, there is no evidence at all for the claim that listening to classical music CDs improves children’s spatial-temporal reasoning—or any other aspect of intelligence, for that matter. The scientific reports made no claims about general intelligence, SAT scores, or babies.

Although the term “Mozart effect” initially referred to the transitory increase of certain visuospatial task scores following listening to a particular Mozart sonata, the phrase has generalized to include, for example, the effects of music instruction on spatial-temporal task performance. In numerous studies preschoolers, kindergartners, and second-graders who received piano instruction scored higher on spatial-temporal tasks than control groups who received other instruction or no training (see, for example, Rauscher, 1999). My goal in this chapter is to share with you the most recent research in this area. Because this is an area where there is considerable temptation to overstate the scientific findings in the interest of a particular advocacy position, I caution the reader to employ a conservative interpretation of the data presented here. Although the research has strong implications for policy and practice, it is important to keep in mind that these studies were designed with an eye towards determining the parameters of a scientific effect rather than with an eye towards application. Questions to be addressed will include (1) what have researchers discovered about instrumental instruction and spatial-temporal reasoning? (2) What is the best age to begin instrumental instruction for spatial-temporal enhancement? (3) How long do the effects of instrumental instruction on spatial-temporal reasoning persist? (4) How might musical experiences affect cognitive development? (5)

Does enhancing spatial-temporal reasoning improve mathematics scores? (6) What are the implications of this research for educators and public policy?

In order to understand the effects of instrumental instruction on children's spatial-temporal reasoning, it is necessary to understand what is meant by "spatial-temporal." Virtually every healthy human has some degree of spatial-temporal intelligence. To maneuver an armchair through a doorway and around a corner, for example, one needs to picture its shape and which way to turn it before one lifts it. Even animals can reason spatially. One researcher in the field of spatial cognition, for example, reports an event he noticed while watching a German shepherd play fetch with its owner (Cooper & Shepard, 1990). The owner threw a long stick over the backyard fence, and the dog pranced over and immediately placed his head through an opening where a board in the fence had fallen off. The dog grabbed the stick horizontally, jerked backward and, one moment before the stick would have rammed the fence, rotated his head 90 degrees to pull the stick neatly through the hole in the vertical direction. One can never know whether the dog's foresight was conscious but, writes the researcher, "Might [there] not have been a preparatory mental rotation of the stick"--a rotation, I might add, similar to the one that lets you picture this whole episode in your head as you read? Children show this form of intelligence as soon as they start building block towers or putting together puzzles, and later as they reason about ratios and fractions. Individuals with highly developed spatial skills often become architects, sculptors, engineers, graphic designers, painters, mathematicians, physicists—and musicians.

Lois Hetland, a researcher from Harvard University, recently published a statistical review (i.e., meta-analysis) of all the causal studies she could find that explored the effects of instrumental instruction on spatial abilities (Hetland, 2000). Although not all studies showed positive effects, overall the data were convincing. Hetland concluded, “Active instruction in music does appear to enhance spatial-temporal performance for preschool and elementary-aged children, at least while instruction is occurring and at least up through two years of instruction. The effect is...remarkably consistent across this population of studies...It is a solid finding.”

The typical study included in Hetland’s analysis compared spatial-temporal scores of two to four groups of children. One group received music instruction and the other(s) received either no instruction or instruction in an alternative activity to control for the Hawthorne Effect.¹ Instruction was provided either individually or in groups of approximately 10 children, and lasted for 10 to 60 minutes for periods ranging from 6 weeks to 2 years. In most studies children were taught the piano or xylophone, generally in conjunction with Orff or Kodály techniques that included listening, singing, movement, and learning to read music. Spatial-temporal reasoning was typically tested before and after instruction began.

The primary outcome of Hetland’s analysis was that active music instruction led to dramatic improvement of children’s spatial-temporal task scores. In addition to this finding, Hetland made several other interesting discoveries. To determine if the effect

¹ The Hawthorne Effect is the phenomenon that whenever one introduces something new into a curriculum or program, it has an enhancing effect on a variety of behaviors.

was stronger for younger than older children, Hetland compared the post-test scores of children aged 3-5 years to those aged 6-12. Her results suggest that the spatial abilities of younger children are more enhanced by active music instruction than are those of older children. This finding is consistent with the notion that the age at which music instruction begins is related to structural changes in the brain. The four-year study reported below illustrates the importance of Hetland's finding.

School District of Kettle-Moraine Study: Kindergarten

Children from four kindergarten classrooms at two Wisconsin public elementary schools in the School District of Kettle-Moraine participated. Some children received piano keyboard instruction (keyboard group) and others received no special training (no music group). We began by pre-testing all the children using two spatial-temporal tasks, a puzzle solving task and a block building task, and one pictorial memory task. Based on previous research, we predicted improvement for the spatial-temporal tasks only.

Immediately following the pre-testing, a music specialist visited each classroom to provide the keyboard group with 20-minute piano lessons two times per week for the remainder of the school year (8 months). Children were taught in groups of eight to ten. The instruction involved singing and moving to the compositions of the current and subsequent weeks, rhythmic clapping and solfege, ear training, music notation, improvisation, interval and dynamic exercises, and keyboard performance. The children in the no music group engaged in journaling activities with their kindergarten teacher during music lessons. These children were not permitted access to the keyboards.

Children were post-tested twice, once following four months of lessons and a second time following eight months. For both the spatial-temporal tasks the children who had received the keyboard lessons scored significantly better than the children who had not. Although no differences in pretest scores were found between the two groups of children, after only 4 months of instruction the keyboard group's puzzle solving scores were 38% higher than those of the no music group. The keyboard group's scores had improved by 52%. These enhancements were similar in magnitude to those found in

similar studies using preschoolers as participants, despite the chaotic setting of the kindergarten classroom and the participation of older (5 to 6-year-old) children.

Furthermore, after 8 months of lessons the difference between the two groups' scores had increased in magnitude. The keyboard group scored 46% higher than the no music group, representing a 65% improvement. Similar results were found for the other spatial-temporal task, block building. As predicted, scores on the memory task did not differ significantly for the two groups following lessons. Thus, in contrast to what the Mozart zealots would claim, music training effects were limited to spatial-temporal skills; they did not generalize to other skills.

Kettle-Moraine Study: First Grade

We returned to the schools the following year, at the end of the first grade, to retest the children. The school district had partially expanded its kindergarten keyboard program into the first grade. Therefore, some first grade children received keyboard lessons and others did not, depending upon the logistics of classroom assignment. We thus had three groups of children to retest. Some children received keyboard instruction for one year (in kindergarten), and did not receive instruction the second year (in first grade). These children therefore had a one-year gap in their instruction, after which they were retested. A second group of children received music instruction for two years (in kindergarten and first grade) and were retested after each year of instruction. Finally, a third group received no music instruction at all. All children were tested using the same three tasks used earlier.

Results indicated that the children who received keyboard instruction only in kindergarten scored 15% lower on the puzzle solving task one year after their lessons had ended. In fact, these children's scores were not significantly different from the scores of the children who had never received lessons. However, the scores of the children who continued lessons through the first grade had increased by approximately 17% since kindergarten. Finally, the children who received no lessons showed only the improvement one would expect from age. The block building task followed a similar trend. Again, no effects were found for the memory task. *These data suggest that one year only of keyboard music instruction will not induce long-term effects on spatial-temporal task performance.* Either the instruction must continue indefinitely for the effects to persist (use it or lose it), or some critical amount of training is required to produce lasting effects on spatial cognition. Unfortunately, it is too early in the research to determine which of these two explanations is correct.

Kettle-Moraine Study: Second Grade

The following year we returned to the schools to retest the children yet again. After viewing the data, the district superintendent had decided to provide keyboard lessons to all her elementary school children. All children were to receive instruction every year. This decision provided us with three groups of children to retest, all of whom had participated in our study in previous years. One group had received keyboard instruction in kindergarten and second grade only (not in first grade), a second group had received the instruction in all three grades (kindergarten, first, and second grades) and a

third group had received instruction in the second grade only. We administered the same three tasks as before, after the children had completed the second grade.

The data show that the children who received lessons in kindergarten and second grade, but not in first grade, improved by approximately 37% after their lessons were reinitiated in the second grade. The children who received lessons for all three years continued to improve, although the improvement from first to second grade was not significant (14%). This may be due to the presence of a ceiling effect.² Finally, children who received the lessons in the second grade only did not improve significantly.

Consistent with Hetland's (2000) analysis, these data suggest that the effects of keyboard instruction on spatial-temporal task performance are found primarily for those children who begin training at the earliest ages.

Kettle-Moraine Study: Third Grade

We collected additional data from these children the following year, after they had completed the third grade. This time we used a more difficult version of the puzzle solving task. The block building and memory tasks were not administered.

As before, three groups of children were retested, some of whom received lessons in kindergarten, second, and third grades, some of whom received lessons from kindergarten through third grade, and some of whom received lessons in second and third grade only. Because of the difference in task difficulty between the test items we

² "Ceiling effect" refers to the failure to observe any improvement in performance owing to the fact that the participant is already performing at maximum capacity.

administered in third grade and those administered earlier, we did not compare the data collected following the third grade with those collected in previous years. However, we were able to compare the scores of the three groups of third grade children.

The data are compelling. The children who received keyboard instruction for four consecutive years (through the third grade) scored 30% higher on the task than children who received instruction in kindergarten, first, and third grades, and 52% higher than the children who began instruction in second grade. This lends further support to the importance of beginning the instruction early.

Summary

Consistent with previous studies this longitudinal study found that young children who were provided with music instruction scored higher on spatial-temporal tasks compared to children who did not receive the instruction. The effect was significant after four months of instruction. No enhancement was found for a non-spatial task—pictorial memory. However, when the music instruction was terminated the children's scores began to decrease. The children who received instruction over the entire four years of the study continued to score higher on the spatial-temporal tasks. Finally, scores of the children who began instruction in the second grade did not improve significantly, and these children continued to score lower than all other groups in the third grade.

Lois Hetland's meta-analysis provides further information regarding several variables of interest to researchers and educators. In addition to age-of-onset differences, she found that one-on-one instruction may lead to stronger spatial skills than group

lessons, although group lessons, as demonstrated above, do appear to be effective. Furthermore, Hetland's analysis revealed that instruction on the keyboard, rather than another musical instrument, may not be necessary for spatial enhancement, although she recommends caution in interpreting this finding: Only 5 of the studies included in her analysis did not include keyboard instruction. Also, the inclusion of movement in the music instruction did not affect spatial skills. Programs that included movement produced similar effect sizes as those that did not include movement. Finally, learning to read music may play a role. Although learning standard musical notation does not appear to be necessary for spatial enhancement, programs of music instruction that included literacy resulted in greater spatial-temporal enhancements than programs of instruction that did not.

Theoretical Interpretations

The effects of music instruction on spatial-temporal abilities have been explained by two types of theories. Neuroscientific theories assert that music instruction induces physiological changes in brain structure that consequently affect spatial-temporal processing (Leng & Shaw, 1991). Indeed, recent research suggests that the brains of musicians are different from those of nonmusicians. For example, two structural magnetic resonance imaging (MRI) studies have found that musicians who began piano instruction prior to age 6 or 7 had larger corpus callosi and greater asymmetry of the planum temporale (the brain's sound signal processor) relative to nonmusicians (Schlaug, Jancke, Huang, & Steinmetz, 1995a; Schlaug, Jancke, Huang, Staiger, & Steinmetz,

1995b). Furthermore, violinists who began training prior to age 12 displayed greater cortical representation of the digits of the left hand than nonmusicians (Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995). Finally, one study found that musicians who started playing before age 9 showed greater auditory cortical representation than those who began instruction after age 9 or nonmusicians (Pantev et al., 1998). Again, there was a significant positive correlation between effect size and the age at which subjects initiated instruction: musicians who began instruction before age 9 displayed the largest effects. These differences in the brains of musicians and nonmusicians may be related to findings of improved spatial-temporal abilities in children who began music instruction at an early age.

Transfer theories, on the other hand, suggest that playing a musical instrument and performing a spatial-temporal task require similar cognitive skills, and thus the skills involved in making music may transfer to spatial-temporal task performance (Rauscher, 1999). One approach to examining the nature of the relationship between music and spatial-temporal reasoning is to analyze the cognitive requirements shared by these two domains. For example, several of the musical elements described by Serafine (1988), including temporal succession, nontemporal closure, transformation, and abstraction, may have parallel elements in the visuospatial domain. Perhaps the cognitive skills required to process this type of information are used in performing both musical and spatial-temporal tasks.

The Link Between Music and Math

An important practical question remains. Will children who score higher on spatial-temporal tasks as a function of music instruction also score higher on mathematical tasks? Although significant correlations have been found between spatial-temporal task performance and mathematical ability, only two studies have addressed the hypothesis that music instruction affects mathematical reasoning. The first study (Gardiner, Fox, Knowles, & Jeffrey, 1996) found that first- and second-grade children who received seven months of supplementary music and visual arts classes achieved higher standardized mathematics scores than children who received the schools' typical music and arts training. However, because the two treatments were initiated together it is difficult to determine which intervention, music or art training, may have been responsible for the improvement.

The second study (Graziano, Peterson, & Shaw, 1999) compared the mathematical reasoning (in particular reasoning about ratios and fractions) of second-grade children assigned to four groups: (1) keyboard instruction coupled with exposure to a computer game designed to develop spatial-temporal reasoning; (2) English instruction coupled with the same spatial-temporal training; (3) spatial-temporal training only; (4) no treatment. Results indicated that the mathematical reasoning scores of the children whose treatment included the music instruction were significantly higher than those of the children in the other groups. It is unfortunate that the researchers did not include a fifth group of students who received keyboard instruction only. However, this study does suggest that music instruction may enhance reasoning related to certain mathematical

abilities, and confirms the role of spatial-temporal reasoning in some mathematical operations.

Implications for Public Policy

The research reported in this paper has public policy implications. It seems clear that children derive measurable educational benefits from music training beyond those directly related to music. I believe that the results of these studies must be included in music education advocacy efforts. Arguments that emphasize the extra-musical benefits of music instruction are effective and have saved school music programs. Disadvantaged children, whose caregivers can afford neither the time nor the money to provide music lessons, stand to lose the most if school music programs are cut back or eliminated. I suggest that music advocates use all available evidence to convince policy makers of the importance of a music education for all our children.

Nevertheless, I feel it is important to acknowledge the possible dangers associated with an argument of music for math's sake. Care must be taken to ensure that scientific goals do not displace developmentally appropriate instruction. Decisions regarding music education curricula should be based on musical goals only. Consistent with recent recommendations of the National Association for the Education of Young Children (Bredekamp & Copple, 1997), a position statement containing guidelines for the establishment of age-appropriate music curriculum has been published by the Music Educator's National Conference (1994). MENC recommends a focus on singing, listening, movement, instrumental instruction, creativity, and music literacy as well as the

development of musical knowledge of melody, rhythm, timbre, and form. Musical play is also highly recommended, as is the encouragement of individual creativity. Kenney (1997) outlines specific teaching strategies relevant to these instructional goals for newborns to children age eight. I encourage scientists and educators to attend carefully to these guidelines when considering the application of these research findings.

John Bruer, president of the James S. McDonnell Foundation and a leader in the funding of educational research, cautions us that “neither neuroscientists nor behavioral scientists have the vaguest notion of how differences in brains translate into differences in IQ or how a brain that can pass third grade differs from one that cannot” (Bruer, 1994). He further comments that “...I don’t want to discount [brain research] because eventually we will know much more. In twenty years, it’s conceivable we will understand the brain circuitry involved in reading, for example, and how learning to read changes neural circuitry as the skills mature.” However, today’s students and teachers cannot wait twenty years for neuroscience to unequivocally demonstrate the nature of the link between brain function and cognition. The current research suggests that music instruction improves children’s spatial abilities, whether due to neurophysiological mechanisms or not. I believe that to exclude this research from discussions arguing for music in the schools is to do a disservice to the children whose lives will be affected when music programs are eliminated. Yes, there is much more research needed to provide converging evidence and no, music is not a panacea for poor academic achievement. However, it seems clear that music has benefits to intellectual development that transcend music itself.

Suggested Readings

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