

# The "Mozart Effect": Hard Science or Hype

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## Abstract

The positive effects of the music of Wolfgang Amadeus Mozart on spatial reasoning ability have become a popular topic. Some studies suggest that listening to Mozart has a short-term positive effect on spatial IQ. Others suggest that prenatal and early childhood exposure to music can lead to long-term positive effects. However, some attempts to duplicate and generalize these findings have failed. This paper explores the research behind such claims in an attempt to demystify the current hype.

## Introduction

The positive effects of the music of Wolfgang Amadeus Mozart on spatial reasoning ability have become a popular topic. Some studies suggest that listening to Mozart has a short-term positive effect on spatial IQ (Nantais, 1997; Nguyen, Shaw, & Tran, 1996; Rauscher, Shaw, & Ky, 1993; Rauscher, Shaw, & Ky, 1995; Rauscher, Shaw, Levine, Ky, & Wright, 1994; Rideout, Dougherty, & Wernert, 1998; Rideout & Taylor, 1997; Wilson & Brown, 1997). Others suggest that prenatal and early childhood exposure to music can lead to long-term positive effects (Costa-Goimi, 1997; Douglas & Willatts, 1994; Hurwitz, Wolff, Bortnick, & Kokas, 1975; Rauscher, Robinson, & Jens, submitted 1998; Rauscher et al., 1997; Spychiger, 1993). These studies have led to broad claims in the popular press that view this as a panacea. For example, a popular news broadcast has reported that, "anyone can benefit from this" (NBC News, 1994, September 1). Further unqualified claims have stated that "It (music) clears our minds and has been known to make us smarter." (Campbell, 1997, p. 1) However, not all researchers would agree and many efforts to duplicate and generalize this effect have been either unsuccessful (Kenealy, 1994; Newman et al., 1995; Steele, Ball, & Runk, 1997; Stough, Kerkin, Bates, & Mangan, 1994) or have had mixed results (Wilson & Brown, 1997).

## Initial Studies

In the early '90s Rauscher, Shaw, and Ky at the University of California, Irvine performed a study examining the effects of music on spatial task performance (Rauscher et al., 1993). They tested thirty-six college students' performance on a set of three standard IQ spatial reasoning tasks (Thorndike, Hagen, & Sattler, 1986). Each test was preceded by one of three conditions: (1) listening to 10 minutes of Mozart's sonata for two pianos in D major, K488; (2) listening to 10 minutes of relaxation instruction; or (3) 10 minutes silence. All the students participated in each of the

conditions. Their results showed that the IQ scores following the music condition were significantly (8-9 points) higher than the other two conditions. Furthermore, the order of condition and the order of task was not significant (condition was balanced for order to compensate for a possible practice effect). They speculated that the complexity of the music was a factor of the increased performance and suggested that music lacking such complexity or that was repetitive might, in fact, decrease performance. They also noted that this effect was temporary and did not last more than 15 minutes.

In the years that followed, Rauscher and her colleagues performed follow-up studies that supported their initial findings (Rauscher et al., 1995; Rauscher et al., 1994). These subsequent studies used a mixture of conditions including other types of music and stories. In all of the studies, the effect was temporary. Furthermore, these tests were performed over a five-day period and after the second day there was no significant difference between the Mozart condition and the silence condition. The researchers speculated that this might have been due to a ceiling effect caused by practice.

## Inconsistent Results

### University of Auckland, New Zealand Study

In an effort to replicate and extend the results from UC, Irvine, Stough, Kerkin, Bates, and Mangan performed a similar study using 30 subjects, but they changed the condition and measurement (Stough et al., 1994). In order to test the hypothesis that repetitive music might decrease spatial IQ (Rauscher et al., 1993), the relaxation condition was replaced with 10 minutes of disco music that had a repetitive beat throughout. Also, the dependant measurement was changed from the Stanford-Binet test (Thorndike et al., 1986) to the Raven's Advanced Progressive Matrices (APM) (Raven & Court, 1992).

The results of their test showed that while there was a small mean difference in scores across conditions in the predicted direction, these differences were not significant. The researchers suggested that the APM was a more general test of IQ that requires spatial aptitude, inductive reasoning, and perceptual accuracy, all of which contribute to spatial IQ. The researchers concluded that further research in this area would *not* be of any benefit.

## SUNY, Albany Study

Citing other studies that failed to show a “Mozart Effect” (Kenealy, 1994; Stough et al., 1994), Newman, Rosenbach, Burns, Latimer, Matocha, and Vogt tried to duplicate the conditions of the original study by Rauscher *et al.* (Rauscher et al., 1993) while improving its design (Newman et al., 1995). Newman *et al.* pointed out that the posttest-only design of the Rauscher *et al.* study permitted ambiguous interpretation of the results: the control conditions (relaxation and silence) may have depressed performance while the Mozart condition may have depressed it less or not at all. For this reason, the researchers choose to perform a pretest and posttests within subjects. As a consequence, the researchers used a different measurement than that of the Rauscher *et al.* study. Instead of the Stanford-Binet test they used the APM (also used by Stough *et al.* (Stough et al., 1994) described above). This allowed them to generate the required number of equivalent tests so both pre- and post-treatment tests could be administered. A second change was in testing for the conditions between rather than within subjects. This was to control any possible order effect. Rauscher *et al.* tested within subject by rotating the subjects through the conditions, which they claimed controlled for order, but it is unclear exactly how this was done. Newman *et al.* added a dimension to the test by surveying the subjects to ascertain their musical preferences and education. They speculated that some subjects might have had exposure to classical music for years, while others may have had little prior exposure. This, they claimed, could affect the level of listener's enjoyment, perception, and attention.

In analyzing their results they first performed a two-tailed *t* test of the pre and posttest scores for gender. This yielded no significant difference so they collapsed subsequent tests across this variable. They also used an analysis of variance (ANOVA) and ruled out any significant differences between the three group's pretest scores. They then performed an ANOVA of the pre and posttest scores (condition was used as a between-subject variable and testing time was used as a within-subject variable). This showed that there was a practice effect that was equal across condition group. Next the posttest scores were analyzed (using the pretest scores as a covariance). This showed no significant difference between condition group and thus did not support the Rauscher *et al.* experiments. In analyzing the scores using music training as the factor, no significant difference was found. Interestingly, the subjects who reported liking classical music scored significantly *lower* than those who did not.

## Appalachian State University Study

In another attempt to extend the results of Rauscher, Shaw, and Ky (Rauscher et al., 1993; Rauscher et al., 1995), Steele, Ball, and Runk at the Appalachian State University studied the effect of Mozart's music on backwards digit span performance (Steele et al., 1997). A backwards digit span task requires a person to listen to a series of digits and then recall them in reverse order. The decision to use this task as the dependent measure was based on the suggestion of Rauscher *et al.* that tasks including spatial and temporal transformations should be affected by music. Based on other research (Carroll, 1993; Das, Kirby, & Jarman, 1979),

Steele *et al.* concluded that backwards digit span tasks involved spatial reasoning because it required rotation of the digit sequence. They also noted that there was a strong correlation between performance on this type of task and performance on tests such as the APM.

Steele *et al.* found no improvement on backwards digit span tasks after exposure to the Mozart condition. One explanation offered for the inconsistent results was that different dependant measures were used in experiments supporting the effect vs. experiments that did not support the effect. They also added that the dependant measure could not be the *only* factor since other studies used paper folding tasks (Kenealy, 1994) (like those used by Rauscher *et al.*), but found no effect.

## An Explanation of the Inconsistent Results

Because of the lack of support from the aforementioned studies, Rauscher and Shaw wrote a clarifying response paper (Rauscher & Shaw, 1998). The goal of this paper was to explain the theory behind the effect and to suggest reasons why some studies have not been able to reproduce it.

## Neurological Theory

The "trion" model of the cerebral cortex (Leng & Shaw, 1991; McGrann, Shaw, Shenoy, Leng, & mathews, 1994; Shaw, Silverman, & Pearson, 1985; Shenoy, Kaufman, McGrann, & Shaw, 1993) motivated the initial studies on the effect of Mozart's music on spatial-temporal tasks. Rauscher and Shaw describe this as a mathematical representation of Mountcastle's model (Mountcastle, 1997) of the cerebral cortex. They describe that the neural firing patterns that occur during spatial-temporal tasks are similar to those that occur for music cognition. Citing Leng and Shaw, they propose that *exposure* to music might excite the cortical firing patterns used during spatial-temporal reasoning and thus might have a priming-like effect, which would improve performance (Leng & Shaw, 1991).

## Aspects of Spatial Tasks

Rauscher and Shaw make the distinction between *spatial recognition* tasks and *spatial-temporal* tasks. Spatial recognition tasks require the ability to recognize and classify physical similarities among objects. Spatial-temporal tasks are more complex. In addition to requiring the recognition of object relations, they explained, spatial-temporal tasks require the ability to transform mental images of an object without the use of a physical model. In their original study (Rauscher et al., 1993), they used the Stanford-Binet test, which included three tasks. However, only one of the tasks, the paper-folding task, measured spatial-temporal reasoning. The other two tasks required only spatial recognition skills. Leng and Shaw predicted that exposure to music would only affect spatial-temporal tasks and would not affect spatial recognition tasks (Leng & Shaw, 1991). Upon reexamination of their original data, Rauscher and Shaw confirmed this prediction: the scores on the paper folding task were significantly higher after listening to Mozart, while the scores on the other two tests were not. Therefore, they concluded that

exposure to music might affect spatial temporal tasks, but not tasks that only required spatial recognition.

### Experiment Design

**Dependant Measure** Of the three studies cited above that do not support the Mozart effect, two (Newman et al., 1995; Stough et al., 1994) used the Raven's APM as the dependant measure and one (Steele et al., 1997) use a backwards digit span task. Rauscher and Shaw suggest that these measures do not test spatial-temporal reasoning and therefore, it should not be surprising that they were not enhanced by the Mozart condition. To further support their claim, the authors cited the work of Eliot and his colleagues who have created a taxonomy of spatial tasks (Eliot, 1980; Eliot & Smith, 1983; Stumpf & Eliot, 1995). Included in this taxonomy are paper-folding and maze tasks. Studies using paper folding as the dependent measure have shown a significant positive performance gain after exposure to Mozart (Rauscher et al., 1993; Rauscher et al., 1995; Rauscher et al., 1994; Rideout et al., 1998; Rideout & Taylor, 1997). Likewise, a study using maze tasks as the measure have also shown an effect (Wilson & Brown, 1997). Rauscher and Shaw went on to suggest that, "two components of the spatial-temporal tasks -- spatial imagery and the temporal ordering of spatial components -- are essential for the Mozart effect." They noted that the matrices tasks from the APM lacked both of these components and that the backwards digit span task lacked spatial imagery.

**Procedure** Rauscher *et al.* (Rauscher et al., 1993) choose not to use a pretest design, like that used by Newman *et al.* (Newman et al., 1995), because they feared that such a design might result in a practice effect that might obscure other effects. This prediction was later confirmed by a later study (Rauscher et al., 1995). Further studies using pre and posttest designs showed no Mozart effect until a distracter task was used between the pretest and the listening condition (Nguyen et al., 1996; Rideout & Taylor, 1997). Rauscher and Shaw concluded that, "practice effects may conceal the effects of listening to music unless a delay period is introduced between the pretest and the listening condition during which subjects are cognitively engaged in a disparate activity."

**Choice of Music** As mentioned above, Wilson and Brown performed a study using maze tasks as the dependant measure (Wilson & Brown, 1997). In this study, Mozart's piano concerto No. 23 in A major was used as the listening condition instead of Mozart's sonata for two pianos in D major, which was used by Rauscher *et al.* (Rauscher et al., 1993). Their results also showed improvements in spatial task ability after the music condition. Nantais also performed a study showing an effect after exposure to classical music (Nantais, 1997). In this study, Schubert's fantasia for piano and 4 hands in F minor were used as listening conditions. Both yielded enhanced performance.

Rideout, Dougherty, and Wernert performed an experiment to test the generality of musical characteristics needed to produce the effect (Rideout et al., 1998). They used the paper-folding task that was used by Rauscher *et al.* (Rauscher et al., 1993), but they included an additional, contemporary

music selection. In addition to using the Mozart piano sonata, they also used a piece by Yanni (Acroyali/Standing in Motion). The Yanni piece was chosen because it was similar to Mozart's in tempo, structure, melodic and harmonic consonance, and predictability. A relaxation tape was used as the control condition. Their results showed a significant effect for the two music conditions. Furthermore, the effect from both musical conditions was not significantly different from each other.

Contrasting these studies, Rauscher, Shaw, and Ky showed no effect after exposure to minimalist or contemporary dance music (Rauscher et al., 1995). Because of this, Rauscher and Shaw concluded that, "these varied findings suggest that complexly structured music, regardless of style or period, may enhance spatial-temporal task performance more readily than repetitious music." However, Don Campbell, author of the popular book, *The Mozart Effect* (Campbell, 1997) does not completely agree and suggests special status for Mozart's music over the music of others. Campbell makes general references to the work of French physician Alfred Tomtias, M.D. According to Campbell, Tomatias has found a greater and more consistent effect on spatial perception from exposure to Mozart's music than from other composers like Bach or Beethoven. As Campbell states:

Clearly, the rhythms, melodies, and high frequencies of Mozart's music stimulate and charge the creative and motivational regions of the brain. But perhaps the key to his greatness is that it all sounds so pure and simple. Mozart does not weave a dazzling tapestry like that great mathematical genius Bach. He does not raise tidal waves of emotions like the epically tortured Beethoven. His work doesn't have the stark plainness of Gregorian chant, a Tibetan prayer, or Shaker hymn. He doesn't soothe the body like a good folk musician or slam it into motion like a rock star. (p. 27)

Campbell also suggests that the power of Mozart's music comes from the facts surrounding his birth. Mozart's prenatal and childhood experience was saturated with music. Both of his parents were musicians and this exposure throughout his early years had enhanced Mozart's neurological development. But this ignores the fact that many famous composers, including Bach and Beethoven (Kamien, 1984), were born into musical families.

**Mood-State Explanations** Many believe that music is strongly connected to the limbic system, which is central to emotional processing (Dunbar, 1996; Spychiger, 1998). Music can reliably be used to manipulate emotions, evoking states of melancholy and despair or elation and joy (Campbell, 1997; Pinker, 1997; Waters, 1998). There have also been many studies showing that mood can affect cognition (for example see Matlin, 1998). Therefore, it makes sense that music may have an indirect effect on cognition. But these effects are most certainly short-term.

### Long-Term Effects of Prenatal and Early Childhood Exposure to Music

Up until now, the focus of this paper has been on the short-term effects of music on spatial-temporal tasks. Another,

and perhaps more significant aspect of the relation between music and cognition is its potential long-term effects.

In a recent paper, Katie Overy posed the question; "can music really 'improve' the mind?" (Overy, 1998) This opened a discussion about the potential long-term effects of music on cognition. In one study that was cited, primary school children received music instruction instead of other subjects over a three year period (Spychiger, 1993). The results showed slightly increased language and verbal skills compared to their peers who had no music training. Furthermore, the test group was able to keep up with their peers in the subjects that were sacrificed during their music training. Other studies have shown similar results with enhanced verbal skills (Douglas & Willatts, 1994; Hurwitz et al., 1975). Still others have shown increased spatial reasoning abilities in students who have had music lessons (Costa-Goimi, 1997; Hurwitz et al., 1975; Rauscher et al., 1997). Caution should be used, however, before concluding any causal relationship. Lamont points out that there are a number of factors that lead children to start and continue music training (Lamont, 1998). These include the children's own motivation, support from parents and teachers, and available economic resources. All of these factors can influence scholastic achievement so it would be prudent to use caution before drawing any conclusions.

In addition, the SUNY Albany study (discussed above) showed no such correlation between music training and test scores (Newman et al., 1995). However, it should be pointed out that this study used a *post hoc* survey to assess participants' musical training. Therefore, there was no control over the consistency, style, and quality of the training that was received. It seems clear that an operational definition of "training" would be useful in these situations.

In a response to Overy's paper, Rauscher cited some interesting neurological evidence indicating a correlation between musical training and brain development (Rauscher, 1998). One cited study found that the *planum temporale*, a part of the cerebral cortex believed to be used to process language and categorize sound, was larger in the left hemisphere than it was in the right hemisphere of musicians vs. non-musicians ( Schlaug, Jancke, Huang, & Steinmetz, 1994). Further examination found that this was related to musicians who had perfect pitch and who began their training before the age of seven (Schlaug, Jancke, Huang, & Steinmetz, 1995). Some believe that the increased development of this area of the brain may be linked to greater language skills (Campbell, 1997; Pinker, 1997).

It was also found that the *corpus callosums*, the part of the brain that connects the left and right hemispheres of the brain, was larger in musicians (Schlaug et al., 1994). This supports Campbell who believe that music enlarges neural pathways and stimulates learning and creativity (Campbell, 1997).

## Discussion

It is clear that there is growing evidence that support the claims that music can enhance verbal and spatial-temporal ability. However, this is by no means a panacea. The short-term effects that have been found are so ephemeral and are confined to such a narrow range of tasks that it is ques-

tionable as to whether any practical applications will come from this research. Any hope that these results will directly influence educational policy seems misguided (i.e., it seems unlikely that music will be piped into America's classrooms anytime soon). This research may, however, help guide theories regarding the architecture of the mind, which might indirectly influence educational theory

Howard Gardner has developed theories about the architecture of the mind with the hope that these theories will help guide education policies (Gardner, 1983). The studies showing the short- and long-term effects of music on the brain seem to support Gardner's theory. According to Gardner, the mind is made up of multiple intelligences. These include linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, and two forms of personal intelligence. Gardner further claims that under normal circumstances, these intelligences interact with and build upon one another. The links shown in the studies cited in this paper between music, linguistic and spatial-temporal abilities seem to support Gardner's claim.

Steven Pinker is perplexed in trying to find a selective advantage leading to the evolution of musical intelligence, but he explains how music interacts with other mental faculties (Pinker, 1997). To Pinker, "music is auditory cheesecake, an exquisite confection crafted to tickle the sensitive spots of at least six of our mental faculties." He points out that it is very noticeable when an accented syllable in a lyric is aligned with an unaccented note or vice versa. Pinker claims that this suggests that "music borrows some of its mental machinery from language -- in particular, from prosody, the contours of sound that span many syllables." He also points out the similarity between sound and visual perception in what he calls "auditory scene analysis." In visual scene analysis, the viewer takes raw visual stimulus and segregates surfaces from their backdrops. Similarly, the listener takes raw frequencies and segregates the streams of sound that come from different sources. For instance, the soloist is differentiated from the orchestra or a voice from a noisy room. These are just two of the examples of the interconnection between mental processes given by Pinker. He gives other examples of links to functions such as emotional calls, habitat selection, and motor control. The point is that music seems to be connected to other processes in the mind and the implication is that music stimulation may have extra-musical benefits.

Many of the studies of the long-term, extra-musical effects from music training are motivated by music teachers hoping to defend and promote music education. However, many are also motivated by interest in neurobiology and psychology. It seems that these studies do support the agenda of those promoting music education. As Spsychiger has shown, students who were engaged in music training, at the expense of other subjects, were able to keep up with, and in some cases surpass, their peers (Spychiger, 1993). This suggests that, contrary to critics trying to cut music education, music training should *not* be counter indicated.

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