The “Mozart Effect”:

Does Mozart Make You Smarter?

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CS 99L—“How are we to know?”

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Introduction

In the October 14, 1993 issue of *Nature* magazine, UC Irvine researchers Frances Rauscher, Gordon Shaw, and Katherine Ky published a short, one-page article entitled "Music and spatial task performance," which detailed their research involving exposing college students to 10 minutes of Mozart's Sonata for Two Pianos in D Major (K. 448), a relaxation tape, or silence, followed by a test on spatial reasoning, taken from the Stanford-Binet intelligence test. Their research showed a statistically significant rise in scores from those students who had listened to the Mozart sonata. The popular response was phenomenal.

Newspapers around the country christened their finding "the Mozart effect," and the Mozart recording used in the study quickly sold out in the Boston area (Shaw 2000, 5). In Georgia, Governor Zell Miller became so enthralled at the results of the study that, with Beethoven's "Ode to Joy" playing in the background, he called for the legislature to allocate $105,000 to give a free classical music tape or CD to every new mother in the state (AAAS 1998). Tennessee soon followed suit with a similar bill; Florida now requires day-care centers to play classical music, and a New York community college now has a "Mozart effect study room" (Gladwell 2000). Classical music radio stations latched on to the idea, one publishing a letter in its newsletter from a listener who claims that she turned on the station and "immediately, my test scores improved" (Brin 1998, 11). A cottage industry sprung up, as Don Campbell (a long-time advocate of music therapy) had the foresight to trademark "The Mozart Effect," adding fuel to the fire by publishing a book by that title. The book actually only devotes two and a half pages to the UC Irvine study, the rest of its pages filled with anecdotes, pseudoscience, and conjecture. One chapter even claims that music can alleviate AIDS, allergies, and Diabetes (Campbell 1997, 226-252)! A recent cursory search on Amazon.com turned up half a dozen compact disc titles, with names like “Better Thinking Through Mozart,” “Mozart for Your Mind,” a whole series of “Music for the Mozart Effect,” and even “Ultrasound—Music for the Unborn Child” (featuring Mozart’s music).

Is this intense reaction justified? Even the original researchers agree that the media have over-inflated the findings. One, Gordon Shaw, recently released a book, *Keeping Mozart in Mind*, which largely has the goal of communicating the real importance of his research to laypeople who have been led astray by the media-fed frenzy. His colleague, Frances Rauscher, has repeatedly denounced the over-reaction in the popular press. “I'm horrified—and very surprised—over what has happened,” she said. “It’s a very giant leap to think that if music has a short-term effect on college students that it will produce smarter children. When we published the study results, we didn't think anyone would care. The whole thing has really gotten out of hand” (Jones 1999). In particular, she criticizes people who claim that children should listen to Mozart to make them smarter: “I think the evidence is solid enough to say, ‘Let’s improve and expand our music education programs for young children,” but there is no evidence that just listening to music will do anything. “One of the things we have to be careful about is jumping to conclusions that we don’t have data on at all…I find that ‘Mozart makes you smarter’ thing is quite a bit of a leap.” (Viadero 1998). Others have noted that, while some of Don Campbell’s claims are backed up by research in music therapy, “if Mozart’s music were able to improve heath, why was Mozart himself so frequently sick?” (Linton 1999).

While some researchers charge Rauscher and Shaw with adding to the hype, contributing "to this excitement by linking the Mozart effect with the production of long-term cognitive enhancement through music education" (Steele, Brown, and Stoecker 1999), most agree that "the researchers were professionally circumspect with their conclusions…the media that reported them were not." (Linton 1999).

Attempts to Replicate the First Experiment

Although the media have exaggerated the extent of their findings, even Rauscher and Shaw were surprised that there would be such an easily measurable difference in spatial-reasoning task level after such a short exposure to the music. As a result, both they and other researchers have attempted several times to replicate the findings of the 1993 experiment, to assess its validity and determine the extent of the "Mozart effect."

Such attempts to reproduce the 1993 have met with mixed results; some have, indeed, reproduced the findings, while others fail to show a significant effect of listening to Mozart's music. How can this be explained? One explanation offered by Rauscher and Shaw is that the Mozart effect only applies to certain "spatial-temporal tasks" (Rauscher and Shaw 1998, 837-838). Upon re-analyzing their original 1993 study, they found that while subject's scores on the Pattern Analysis and Matrices tests improved slightly, the only *significant* improvement was shown in the Paper Folding and Cutting (PF&C) task, a spatial-temporal task (836-837).

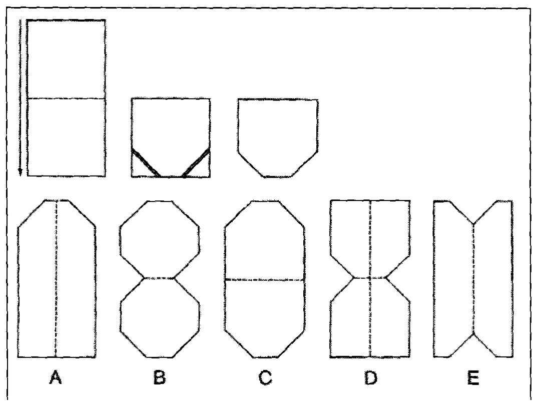
Indeed, experiments involving different, non-spatial-temporal tasks as dependent measures largely failed. Two studies using Raven's Advanced Progressive Matrices (APM) failed to show any significant improvements by subjects who listened to the same Mozart sonata used in the 1993 study (Newman et al. 1995; Stough et. al. 1994). While the researchers emphasized that "the Raven's tests are regarded as general tests of intelligence which require spatial aptitude, inductive reasoning and perceptual accuracy…all qualities underlying spatial IQ" (Stough et. al. 1994), others note that APM tests spatial *recognition* using "physical similarities [in] visually presented stimuli" while PF&C, mental rotation, and jigsaw puzzles "require mental transformation of the stimuli" (Nantais and Schellenberg 1999).

Another study attempted to replicate the Mozart effect using the Revised Minnesota Paper Form Board Test, which involves mental rotation of two-dimensional figures, also failed to show a statistically significant result (Carstens, Huskins, and Hounshell 1995). Although the test does involve mental rotation, the researchers noted that the Revised Minnesota Paper Form Board Test is a "Spatial Orientation" test, while the tasks used by Rauscher and Shaw in their 1993 study are "Visualization" tests (Carstens, Huskins, and Hounshell 1995).

Likewise, an attempt to show the Mozart effect using a backwards digit span task in which participants had to recite a list of digits backwards also failed (Steele, Ball, and Runk 1997). The researchers claimed that the task "is of interest as a spatial reasoning task because it requires rotation or transformation of the sequence" (1180) but acquiesced that the task is only "quasispatial" and thus the failure to replicate could be attributable to the different dependent measure (1182).

While attempts to reproduce the Mozart effect using non-spatial-temporal tasks have largely failed, researchers using spatial-temporal tasks have been able to replicate the 1993 findings, albeit to a lesser degree. One group of researchers testing the theory using mazes (a spatial-temporal task) noted that the Mozart effect "received support from our data" (Wilson and Brown 1997, 368). A former skeptic, Eric Siegel of Elmhurst College, tried to disprove the theory using a test in which subjects had to rotate the letter "E," and found to his surprise that subjects who listened to Mozart performed better. “It was as through they had practiced the test,” he exclaimed (Kliewer 1999).

The most prevalent and successful measure of the Mozart effect, however, has been using the Paper Folding and Cutting subtest of the Stanford-Binet intelligence test (PF&C).



An example PF&C question; subjects are told that the paper is folded and cut as shown on top, and asked which of the letters corresponds to the unfolded paper (in this case, the answer is C).

One study, entirely controlled by computer, tested PF&C items and found that subjects who had listened to Mozart did better than those who sat in silence (Nantais and Schellenberg 1999). Another study tested two different PF&C items, and found that Mozart listeners did better than those who listened to a relaxation tape (Rideout, Dougherty, and Wernert 1998). The researchers noted that the effect was “not dramatic, but nonetheless reliable in the predicted direction” (Rideout, Dougherty, and Wernert 1998). The original researchers also re-tested their theory using both a PF&C task as well as short-term memory; Mozart listeners improved in PF&C performance but not in the memory task (Rauscher, Shaw, and Ky 1995). They emphasized that “the PF&C task is not simply a spatial recognition task; it is a temporal series of spatial tasks” (Rauscher, Shaw, and Ky 1995, 46).

Nevertheless, not all attempts to reproduce the Mozart effect findings using PF&C have succeeded. One study used PF&C tasks as well as matrices, and "found no significant difference between the spatial task performance scores of subjects in the two conditions, although the researchers note cryptically that "post-hoc analyses provided some interesting findings" but do not elaborate what these analyses or findings were (Kenealy and Monsef 1994). A series of studies done in 1999 also failed to replicate the Mozart effect despite using PF&C tasks (Steele et al 1999).

Theories to Explain the Mozart Effect

The original, 1993 study was developed out of a theory of brain organization developed by one of the researchers called the "trion model" which hypothesizes a natural symmetry to the brain based on an earlier theory posited by Vernon Mountcastle (Shaw 2000, 73-85). When Shaw's colleague, Xiaodan Leng, ran these trion models through a music synthesizer, they were stunned that classical-sounding music erupted from the loudspeakers (Leng and Shaw 1991). Rauscher, drawing on this research, suggested that if music acts as a sort of "pre-language" of the brain, certain kinds of music (such as Mozart's) might facilitate brain function, even on a short-term basis. As a result, Rauscher and Shaw explain the higher scores on spatial-temporal tasks by stating that such music causes "short-term causal enhancement of pattern development" (Rauscher, Shaw, and Ky 1995, 45).

Even researchers who believe in the Mozart effect are unlikely to cite the trion model by name; most note that the Mozart effect resembles the similar (and more widely accepted) psychological phenomena known as priming (e.g., Nantais and Schellenberg 1999). Priming refers to the "warming up" of brain neurons when stimulated by a task; for example, someone who has just calculated a large number of sums will have his or her neurons “primed” for that activity, so that he or she will do better at a similar task than someone whose brain isn’t similarly “warmed up.” The controversial element of this explanation of the Mozart effect is that listening to music and executing spatial-temporal tasks don’t seem to have anything to do with each other; nor is listening to music a particularly active, engaged experience. However, as the area of the brain which is stimulated by complex music is co-located with are of brain used in spatial-reasoning tasks, it seems that this theory could have some weight (whether or not one subscribes to the more specific trion model explanation).

Nevertheless, other researchers suggest that arousal or mood states may be responsible for the effect. There is evidence that one will perform better at abstract reasoning tasks when one is mildly aroused and in a good mood; if music can place on in a mildly aroused, happy state, this may explain the Mozart effect.

Arousal has been largely discounted as a theory for explaining the Mozart effect, despite assertions that “if listening to Mozart improves cognitive performance at all, it's by improving overall cognitive arousal and concentration” (Chabris, qtd. in Jones 1999). The original, 1993 study checked participants’ pulse rates, and found no significant difference in arousal. Nevertheless, some note that comparing Mozart’s music to relaxation instructions “means that one cannot state whether listening to Mozart improved performance or listening to the progressive relaxation tape reduced performance” (Steele, Ball, and Runk 1997, 1183). Indeed, if “relaxation instructions aim to reduce arousal…it is not surprising that they should impair subsequent cognitive performance” (Chabris 1999). Still, the original study used both silence *and* relaxation instruction controls, neither of which showed a significant reduction in pulse rate.

Additionally, few of the studies that have attempted to reproduce the Mozart effect have shown a significant drop in scores by subjects who listened to relaxation tapes as opposed to silence.

While arousal (a physical variable) can largely be discounted, it is also possible that mood (an emotional variable) could explain the effect. One study used the Profile of Mood States test to measure mood levels after listening to the Mozart sonata versus a composition by Philip Glass, "Music with changing parts." They found much more positive mood scores for the Mozart sonata, and hypothesized that since "differences in mood have been shown to affect performance on other cognitive tasks," this mood difference might explain better performance on some tasks after listening to Mozart (Steele, Bass, and Crook 1999). Nevertheless, this particular study failed to show any significant improvement by the Mozart group, so while mood enhancement may explain the Mozart effect, it cannot be shown in this study (for there must *be* an effect before one can explain it!).

Some studies do lend weight to similar theories involving pleasure and interest in the listening condition. One study, which used a comedy routine as verbal distractor either before or after Mozart recording; found "no significant effect" despite using the PF&C test (Steele, Brown, and Stoecker 1999). Likewise, another study found that when subjects liked a Stephen King story used as a control more than Mozart's music, they performed better (Nantais and Schellenberg 1999). This suggests that perhaps any "**pleasant or interesting** auditory stimulus" may do as well as music, or that perhaps boring or unpleasant controls decrease performance (Nantais and Schellenberg 1999). They concluded:

> …although listening to music composed by Mozart might contribute to an improved performance on subsequently presented spatial-temporal task, our research provide no evidence that the improvement differs from that observed with other engaging auditory stimuli that are equally pleasing to participants (Nantais and Schellenberg 1999).

One difficulty with all of these arousal and mood theories is that if, indeed, music merely raises arousal or mood levels, wouldn't one assume that such arousal or mood levels would improve *all* cognitive tasks, not just spatial-temporal ones?

Another difficulty in explaining the Mozart effect is explaining what it is about the music that creates the effect, and what other music might work. Most studies have used the same Mozart Sonata for Two Pianos in D major (K.448), but a few have tested other music as well. Tests using music by both Schubert and Yanni produced results similar to Mozart's music (Nantais and Schellenberg 1999; Rideout, Dougherty, and Wernert 1998). The latter piece was chosen because it was "similar to the Mozart piece in tempo, structure, melodic and harmonic consonance, and predictability," but it remains to be seen which of these variables is the most important (Rideout, Dougherty, and Wernert 1998). On the other hand, tests with both Philip Glass's extremely repetitive "Music with changing parts" and popular British "dance or trance" music failed to show any effect, suggesting that "complexly structured music, regardless of style or period, may enhance spatial-temporal task performance more readily than repetitious music" (Rauscher and Shaw 1998, 839).

Nevertheless, another study using "repetitive angelic female voices" rather than relaxation tape "in order to provide a musical control" found that it "also enhance[d] spatial-task performance relative to silence" (Wilson and Brown 1997, 367, 369). Additionally, much of Mozart's music is repetitive in nature, including the oft-used Sonata in D major. While it is clear that some music works and some does not, it seems that the distinction between "complexly structured" and "repetitious" music does not fully explain the phenomenon.

What is it about the music, then? Tempo? Instrumentation? Harmony? Melody? Counterpoint? A strong beat, or lack thereof? There are dozens of musical variables that could be studied in an attempt to explain what music provides a similar effect. Still, Shaw seems to think that the selection of the Mozart sonata's first movement was a fortuitous one: "I believe that there is something extremely special about this Mozart Sonata, and in particular the first movement….I believe that this first movement offers a 'gold mine' in learning about higher brain function" (Shaw 2000, 162). Shaw believes that "the brain's response to this music is like the Rosetta Stone for decoding the neurophysiological structure of the brain" (Forbes 1999). While it is possible that this sonata just happens to be especially significant, the data suggests that it is not uniquely so.

Significance and Future Questions

Some have analyzed the various studies and concluded that the Mozart effect is not significant, most famously Christopher Chabris' meta-analysis published in *Nature* magazine, the very journal in which the original study was published (Chabris 1999). Chabris noted that even when one constrains the effect to spatial-temporal reasoning tasks, "it is still about 75 percent smaller than originally claimed, and not statistically significant" (Cromie 1999).

While even the original researchers have amended their claims to cover only spatial-temporal tasks and attempts to replicate the findings have not been nearly as successful, others disagree with Chabris' assessment. Lois Hetland at the Harvard Graduate School of Education examined more studies and found that "Mozart listeners outperformed other groups more often than could be explained by chance, although the effect was usually much weaker than Shaw and Rauscher saw" (Kliewer 1999).

There are, however, a number of other variables that could account for the differences between the experiments. Only one (Nantais and Schellenberg 1999) was completely controlled by computer, and thus experimenters could have given subtle clues that the subjects were expected to do better with Mozart. However, even computer control cannot make the experiment double-blind; as one reporter noted, “How do you keep the participants from knowing it’s Mozart on the CD?” (Forbes 1999).

Another important variable is what the subjects were told to do (and what they *did* do) while the music was playing. “Did the students who listened with care…perform differently than those who just sat back and let the music wash over them?” (Linton 1999). In one study, “to ensure subjects’ attention to the music, they were told that they would subsequently be asked five questions regarding the music” (Rideout, Dougherty, and Wernert 1998). This study was one of the more successful in reproducing the Mozart effect, suggesting that attention to the music is an important aspect of the Mozart effect.

A similar variable not addressed at all in the literature is the volume at which the music is played. Any college student can attest to the difference between quiet background music and music being “blasted” out of loudspeakers or headsets. Likewise, it remains to be seen whether there is a placebo effect, depending on what the subjects were told that the test was about; perhaps students told that this is “a test of whether listening to Mozart makes you smarter” would do better after listening to Mozart merely because it was suggested in the instructions.

Also, as Shaw thinks that the first movement of the Sonata in D is so important, one must ask whether everyone used the first movement. Most recordings of the first movement are about eight minutes long, and thus in order to fill out the full 10-minute listening condition, researchers must have either had the track on a loop or played the first half of the second (slow) movement. This could also explain some of the discrepancies between the studies.

Conclusion

So, should you run out to Borders and grab an armload of Mozart recordings? It certainly wouldn't do any harm, but it has yet to be conclusively proven whether *any* music does almost as well to increase your spatial-reasoning ability; furthermore, any effect may have more to do with mood, arousal, or enjoyment than anything else. As for parents who bombard their children with classical music from an early age (even before birth), again there is nothing wrong with the practice, but even Gordon Shaw cautions, referencing a study in which rats were subjected to Mozart 12 hours a day: "[Parents] *should not give their infants such long listening exposure to the Mozart Sonata as Rauscher did with her rats*" (Shaw 2000, 246, emphasis in original).

Nevertheless, it is clear that the media and popular culture have inflated the various findings far beyond their original intent. Only certain kinds of spatial reasoning have shown improvement, and even that improvement is fleeting at best. Still, as Shaw notes, "it's certainly a no-lose situation" (Viadero 1998), as the worst that can happen is that one listens to some good music!

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