Mozart on the Brain
Musical Misadventures in Cognition and Development

Music affects us all. We sing with it and dance to it. We accompany our most important rituals with music. We sing hymns to our Gods and pen anthems for our nations. There is no culture in the history of mankind that has not had music. Science has always tried to explain music, to tell us why and how it affects us so. Because music's influence is so subjective and the brain is so poorly understood, this subject is especially susceptible to myths and exaggerations. We take a look at two of these so-called myths. We examine the “Mozart Effect”, the idea that passively listening to classical music can make you smarter. We also examine claims of music's ability to heal the human mind and body, reviewing cases of music therapy's use with children afflicted with autism.

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What is music? Why does it have such a hold on the human species? No culture in recorded history has lacked music. Whenever people come together socially, be it for weddings or for funerals, music is there. We listen alone as well, with our iPods or just sitting at home relaxing. Is music just entertainment or does it serve a deeper function? The composer Edgard Varese once described music as “organized sound.” Does this organization please us in some way? Does it appeal to our need as humans to categorize and organize everything in our world? Why would certain combinations of organized sounds capture our attention and others fade into memory? Why does some music arouse us while other kinds relax and calm us?

Music's appeal is so overwhelming that Americans spend more money on music than on sex or drugs (Levitin, 2006). It concerns us so deeply that music has long been the subject of scientific investigation, but science has always had difficulty dealing with music. Ephemeral changes in mood and well being are hard to quantify. Like visual art, there is no definitively good or bad music, quality is in the eye of the beholder. The field of neuroscience uses functional MRIs and other imaging technology to study how the human brain responds to hearing music, but the inner workings of the brain are still so poorly understood that it is often difficult to come to conclusive results. This situation creates an atmosphere of speculation. Wild theories about music that can drive you mad and sounds that make you lose consciousness cannot be quickly disproved. These theories float in the space between science and apocrypha. Two such ideas continue to create controversy. Can music heal? Can its influences be used to bring people back to health? Also, can the mere act of listening to music have an influence on cognition? Can music actually make you smarter?
The Mozart Effect

On January 13, 1998 Zell Miller, the governor of Georgia, announced that the state budget was earmarking $105,000 so every child born in the state could be provided with a CD of classical music. He said, “No one questions that listening to music at a very early age affects the spatial-temporal reasoning that underlies math and engineering and even chess.” At a meeting with legislators he played a section of Beethoven's “Ode to Joy” and said, “Now, don't you feel smarter already?” His efforts provide an example of how popular the idea of the “Mozart Effect” (ME) had become. The notion that merely listening to classical music could actually improve a child's mental development was sweeping across the nation. Compact discs (CDs) and music books appeared that touted the power of music. There were even CDs put on the market for mothers to play for their child while still in the womb. One claimed that listening to any kind of classical music was not the answer, that it was the music of Wolfgang Amadeus Mozart specifically that produced these effects. These music products flew off the shelves, selling well over 2 million copies (Dowd, 2007). Where had these ideas about the strange cognitive power of Mozart's music come from?

The term “Mozart Effect” first appeared in 1991, in a book by Dr. Alfred A. Tomatis titled “Pourquoi Mozart.” He advocated alternative medicine solutions for dyslexia, autism and other learning disorders. Originally called “The Tomatis Effect”, the phenomena was said to have been observed as Dr. Tomatis used music with his patients during therapy sessions. He made the claim that Mozart's music actually helped to promote healing and could cure cases of depression.

The real explosion in the popularity of the concept came with the publication of
psychologist Frances Rauscher's study “Music and Spatial Task Performance” (1993). Published in the October 1993 volume of Nature, the paper began, “There are correlational, historical and anecdotal relationships between music cognition and other 'higher brain functions', but no casual relationship has been demonstrated between music cognition and cognitions pertaining to abstract operations such as mathematical or spatial reasoning” (Rauscher, Shaw, Ky, 1993). Dr. Rauscher was going to see if listening to music could help boost a test taker's performance on a math or spatial reasoning test. At the University of California in Irvine, Rauscher and her colleagues used three groups of thirty-six college age subjects for their study. One group listened to Mozart's sonata for pianos in D major for ten minutes. Another group listened to relaxation instructions designed to lower blood pressure for the same amount of time. A third group sat in silence. Directly afterwards they were given one of three abstract/spatial reasoning tasks from a Stanford-Binet intelligence scale, a pattern analysis test, a multiple choice matrices test and a paper-folding and cutting test. The researchers found that the subjects who had listened to Mozart's music scored eight to nine points higher than the subjects who listened to the relaxation instructions or the silence. People who had always been receptive to the idea that music improved cognitive powers now had a research paper in a major publication to back their claims.

Widely reported by Mozart aficionados, the ME became part of the zeitgeist. Soon after the Rauscher paper was published Alex Ross of the New York Times wrote, "researchers [Rauscher and Shaw] have determined that listening to Mozart actually makes you smarter." The Mozart effect was sparking tremendous interest in educators and the public (Waterhouse, 2006). The idea of the original research was being expanded on, creating a “scientific legend”
A former musician and music writer, Don Campbell was one of the first people who saw the commercial opportunities in this new phenomena. His 1997 book entitled, “The Mozart Effect: Tapping the Power of Music to Heal the Body, Strengthen the Mind, and Unlock the Creative Spirit” began to exploit the situation. He released collections of Mozart's music packaged as learning aides for children and adults alike. He trademarked the term The Mozart Effect™ for his growing line of commercial products. His collection now includes eighteen books on the subject and sixteen different albums of Mozart's music. He has taken the concept to much greater lengths, no longer claiming that Mozart's music just increases intelligence. He says it also helps with healing, emotions and creativity and does not let the fact that there is no scientific basis for his claims get in his way. One of his recent books, “Mozart Effect for Children”, claims that Mozart's music enhances network connections in the infant brain. His Mozart compilation collection even includes a version of Don Giovanni for the fetus (Dowd, 2007). By the end of the 20th century it was common knowledge among mothers and educators that listening to classical music, especially Mozart, was a must to help aid in the cognitive development of their children.

**Mozart's Requiem**

While the commercial success of the ME concept was unqualified, the results of the 1993 Irvine study were soon questioned. It was discovered that while the published results led one to believe that increases in spatial scores were realized in all three of the Stanford-Binet
tasks, the only test that had shown increases was the paper-folding and cutting task. Another problem noted by critics was that results were reported as full Stanford-Binet scores, but the only area tested was spatial-reasoning. The full scores reported by the study were actually partial results, tripled in order to estimate a full score (Rauscher, et al. 1993). Many complained the study may not have had a large enough sample size. Also at issue was that the tests were poorly controlled. The subjects had not been given baseline hearing tests. They had not been questioned about whether they had eaten that day, a key indicator for test performance. More importantly, they had not been queried as to their like or dislike of Mozart (Dowd, 2007).

The biggest blow to the original Irvine paper was that its results have never been reproduced by other studies. In fact, a good deal of the research done on the topic refutes the idea of a ME (Waterhouse, 2006). When confronted with these findings, Dr. Rauscher stated that the ME cannot be found under all laboratory conditions. “Because some people cannot get bread to rise does not negate the existence of a 'yeast effect'”, she said.

To be fair to Dr. Rauscher, she was one of the first to deny that merely listening to Mozart made you smarter. She is on record as saying that the original research tested spatial-reasoning skills and not overall intelligence, she and her colleagues had never made the more general claim. Her original work also pointed out that the resulting bump in cognition was temporary, lasting only ten to fifteen minutes. Also in her defense is the fact that some have found that spatial-reasoning skills do increase for Mozart listeners in similar conditions, but these studies do not point to the classical music as the reason why. One such study found scores for its Mozart listeners rose at the same rate as the scores of the relaxation listeners. It stated, “It appears that Mozart's music is sufficient to improve accuracy on this spatial-reasoning task
relative to relaxation music or silence stimulus conditions. However, the results of the accuracy measures suggest that listening to passages of repetitive relaxation music can also enhance spatial-task performance relative to silence” (Wilson and Brown, 1997). Results like these suggest an alternate explanation for the ME phenomena.

**A Scientific Interlude**

Cognitive neuroscience suggests that our ability to learn and perform well on tests depends on two types of memory. One is the ability to remember steps and procedures, like how to drive our cars. The second is our ability to remember facts, like who played centerfield for the New York Mets in a certain year. Respectively, they are called procedural and declarative memory (Eichenbaum 2004; Waterhouse, 2007; Willingham, 1998). Further research suggests that there are six different processes that influence the establishment of procedural and declarative knowledge in our memories (Waterhouse, 2007). Repetition, expecting a reward, and having sufficient sleep are a few of the processes that have been found to assist in the formation of these two types of memory. Another is excitation at the time of learning.

When something interesting or novel occurs it arouses our emotions. Emotional arousal “enhances memory formation by positively influencing the period of neurobiological activity called consolidation that establishes a memory in the brain” (Waterhouse, 2007; McGaugh, 2004; Phelps 2006). It's the reason we remember a car crash from two years ago but don't remember what we had for dinner two days ago. Could this be the process evident in the ME?

In the Irvine study the sonata used was chosen because it was “riveting” and “never boring” (Dowd, 2007). A new and novel event like participating in a scientific study and then
hearing stimulating music may be enough to trigger arousal. Compared to silence or a calming recitation of relaxation techniques, this kind of excitement could contribute to an increase in memory. This increase in memory could then lead to increased performances on spatial-reasoning questions. If this was the case then Mozart has nothing to do with the effect. Any event or condition that arouses us sufficiently should produce the same increase in scores. Some studies have shown just that, with rising spatial-reasoning scores after hearing a Stephen King short story (Dowd, 2007). Mozart may just be a pleasant way to induce emotional arousal and provide a brief improvement to spatial-reasoning skills (Waterhouse, 2006), but it seems any other arousal, if we enjoy it, is likely to have the same effect.

The final nail in the ME's coffin was the German Ministry of Education and Research's meta-analysis of the ME situation. Bombarded with requests for data and information about the ME the German government underwent the first exhaustive review of all the literature on the subject. In 2007 they reported that passively listening to music, be it Mozart or Madonna, does not increase your intelligence. According to this report the idea of the ME is now truly dead (Abbott, 2007).

While the commercial success of products associated with the ME continue to do well and the ideas behind the ME seem widely accepted by the public at large, scientists now see the ME as a flawed theory run amok. At best it's “a transient effect lasting no more than fifteen minutes after listening and the transient effect was not specific to Mozart, but to any sort of music, or even story reading, that the test subject preferred” (Abbott, 2007). In the fifteen years since its appearance the ME has gone from a hot topic with backing research and commercial use to its current status, one of science's greatest myths.
Rock and Roll Therapy

What flew quietly under the radar when the German's released their meta-analysis of the ME was that the German Ministry came to the defense of music's usefulness in a few key areas. It noted a possible effect on IQ for those who undergo musical training. Current research examined by the German's suggests the skills developed in becoming a proficient musician may aid in cognition even if passive listening may not. This left an impression on them, but another study really caught their attention. Because the Germans reviewed all research involving Mozart's music during the study, they came across a paper that claimed that listening to Mozart reduced seizure rates for people with epilepsy (Hughes, Daaboul, Fino and Shaw, 1998). In this study twenty-three of the twenty-nine patients experienced significant decreases in epileptiform activity, even from patients in comas (Hughes, 1998). Mozart's music does not make you smarter, but could it heal you?

The idea that music has therapeutic qualities is very old. Robert Burton's 17th century work “the Anatomy of Melancholy” stated that music and dance were critical to the treatment of illness, specifically mental illness. Music is played in places like hospitals and prisons to keep people calm. Some believe certain kinds of music have the ability to sooth and relax us. Studies have shown that music therapy, a rehabilitation process in which the therapist uses music with clients to improve or maintain their health, is associated with a decrease in depression, improved mood, and a reduction in state anxiety (Nayak, 2000).

In the book “Musicophilia”, the famous neurologist Dr. Oliver Sacks tells the story of one of his stroke patients, a man named Samuel. Samuel was in his sixties and had developed aphasia, an inability to speak, after suffering a stroke. Despite extensive speech therapy he was
unable to speak a full two years later. One day a music therapist at the hospital where Dr. Sacks worked, Connie Tomaino, noticed Samuel was humming. This intrigued her and she began meeting with him a few times a week to hum songs with him. Considered hopeless by speech therapists just two months before, Connie soon had Samuel singing “ole man river” and answering simple questions.

Music and speech may seem very different, but they both have “tempo, rhythm, intonation and require the use of the same phonotory and articulatory brain mechanisms” (Sacks 2007, chap. 16). Dr. Sacks thought that perhaps by working with music Samuel was priming the areas of the brain he needed for speech. Cortical areas of the brain that were inhibited by the stroke may be de-inhibited by re-experiencing language, even if that language was surrounded by music. While the results were real, possible explanations for why Samuel regained his speech are all speculative. There's just too much that is unknown about how human beings process music and language to be certain of anything. The experience did cause Dr. Sacks to wonder if this technique could be used in another area where expression seemed to be inhibited, in cases of autism.

**Tommy Redux**

The Who's 1968 rock opera “Tommy” tells the story of a deaf dumb and blind boy whose only interaction with the world is music. His parents take him to doctors, priests, prostitutes, all in an effort to wake him up, snap him out of it and find out “what is happening in his head.” Tommy would just stand in front of his mother's mirror all day and go on “amazing journeys” with the music in his head. One day his mother broke the mirror. Unable to experience music without it he had no choice but to awaken so he could be “free” and hear the music again.
Looking back, the Tommy story sounds eerily like a modern case of autism, an uncommunicative but otherwise healthy looking child with confused parents willing to try anything to break through and help. Could these modern day children be saved by music too?

Music therapy had been used for special needs patients in one form or another since the 1950's, but scientific studies of its effectiveness were scarce in the early nineties. A case study was undertaken around this time (the same time that the ME was gripping the world) to examine the effects of “MIT”, musical interaction therapy, in cases of autism. The authors of the study believed that one of the hallmarks of autism, a failure of inbuilt social timing mechanisms, could be ameliorated with extensive music therapy (Wimpory, Chadwick and Nash, 1995). The MIT method synchronizes live music with adult-child interactions and sessions involved “repetitive yet varied runs of mother-child games of swinging, patting, tickling, blowing, stroking, vocalizing, action-rhymes, and singing” (Wimpory, 1995).

A three year old girl diagnosed with severe autism was the subject of the study. She was observed for six months before the MIT was undertaken in order to establish a baseline data set. During this time detailed observations of her social skills, eye contact, social acknowledgment and other behaviors were noted. Then, with the goal of facilitating sociability and joint attention, the MIT sessions began. Sessions lasted just twenty minutes each and were given twice a week. Observations of the sessions took place for the first seven months of the twelve month treatment. What they saw was remarkable.

Every one of the social skills that were examined improved dramatically. Eye contact went from .3 events per minute to 1.9 following the onset of MIT. Social acknowledgment times dropped from taking six minutes for the girl to acknowledge her mother with some non-
acknowledgment events to being consistently under one minute with no non events at all. Child initiated involvement went from 25% to 70% and a great deal of the child's social reticence was gone. They returned twenty months later for follow up. The study reported, “MIT appears to have facilitated fundamental and lasting changes in the child's developmental pattern” (Wimpory, 1995). Music therapy, in this case at least, seemed to work.

This was just a single case though. Factors like ongoing maturity, special one time events and the influence of other developmental aides could have skewed the findings, making this one study easy to discount. Even so, newer studies seem to be confirming the results. A study of eight adults with autism reported significant improvement on psychiatric tests (BPRS and CGI) after MIT sessions (Boso, Emanuele, Minazzi, Abbamonte and Politi, 2007). A Scandinavian review of the literature on the subject found that, “significant effects were found in these studies even with extremely small samples, and the findings are important because they demonstrate the potential of the medium of music for autistic children” (Wigram and Gold, 2006).

This study also found music therapy was useful for the clinical assessment of autism commenting that, “music making is a rich medium for promoting creativity and allows for easy assessment of social engagement and non-verbal communication, areas where patients with autism and Asperger's syndrome have the most problems” (Wigram and Gold, 2006).

Music therapy is now commonly used for motor skill rehabilitation, stroke patients and people who suffer from memory disorders. It is also used extensively with special needs patients, specifically children and adults with autism.
Coda

Investigation into the matters of the Mozart effect and the healing powers of music seem to have gone in different directions. The ME is an example of one misunderstood result in one study leading to a pop culture phenomena. The scientific examination that followed the initial popularity clearly points to other factors for the possible temporary bump in cognition. Unfortunately, passively listening to music, any kind of music, does not make you smarter.

On the other hand, there does seem to be something solid behind the idea that music has therapeutic qualities. It does not suggest that if you break your leg you should retire to your room and crank up the Led Zeppelin or Stravinsky, but music used in the right situations for the right ailments and in the right way does show positive results. These examples of music's so called powers show that no idea is too strange. It comes as a relief to know that the old mother's lamentation that rock and roll is going to “rot your brain and make you stupid” was likely not true. It turns out that music wasn't going to make us any smarter, but we were not becoming dumber, and perhaps we were being healed.
References


