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Neuroscience + Music = ??

Probing Beyond "The Mozart Effect"

"So what are you studying in college?"

"I'm majoring in neuroscience and minoring in music."

"Oh…(insert head tilt) interesting. Two totally unrelated fields. What's that like?"

This is a conversation I have with virtually every person I meet, with the exception of the (increasingly less rare) person who has read a book by Oliver Sacks. A connection between the fields may not necessarily be intuitive at first glance, but it certainly does exist. What we label as the "hard sciences" and the fine arts are often polarized in the academic spectrum of subjects, and they are often taught in buildings on opposite ends of university campuses. Admittedly, astrophysics and studio art do not seem to be directly related fields of study.

But neuroscience and music in particular seem to go hand-in-hand. Neuroscience is arguably the most beautiful and most emotionally involved field of the sciences; it is, after all, the fascinating study of our own brain—the single organ in our body that controls our actions, our thoughts, and our emotions. Somewhere in there is our 'mind', with which we make mental notes, control our direction of thoughts, and feel "brain dead" at the end of an exhausting day. Music, on the other hand, can be considered the most rational and logically driven field of the arts. I would challenge anyone in disagreement to play any Bach fugue, for instance, and try to musically balance all those voices without relying on logic and systematic practice.

Perhaps a more relatable analogy is the following: performing music is, in a sense, similar to performing magic. Musicians transform dots of ink on a page into music that enters the ears and colors the mind. Hearts tremble, imaginations run wild, and love blossoms to music, and yet closer inspection of the source of such powerful emotions reveals a mere systematic pressing of notes and pulling of strings (in the case of pianists). And therein lies the magic. Just as magicians train themselves to become experts of deception and perception, pianists do the same. They practice playing the notes, refining their technique until their audience is deceived into believing the music is simply and easily flowing out of the piano. They come up with ways to convey the desired motions and *e*motions at every moment until they have perfected the performance of their interpretation; and from the same performance, each listener perceives a different experience, tailored to their individual memories, emotional capacities, and imaginations. In order to convey a convincing performance that succeeds in all of the above, both magicians and musicians must study the ways in which the human brain perceives stimuli. And indeed, neuroscientists do the same, studying the mechanisms by which the brain perceives different stimuli. Put that way, the work of neuroscientists and musicians may not seem so different, after all.

For many media-literate audiences, the first thought that comes to mind when hearing the words “neuroscience” and “music” in the same sentence may be “The Mozart Effect”. The exact meaning of this term has been exaggerated and oversimplified by the media since its inception, and researchers have scrambled to disillusion the public with numerous studies showing the inconsistency of the results. And yet, the skewed version of The Mozart Effect lives on, telling mothers that playing music to their unborn babies will make them smarter. Not just any music—classical music by none other than Wolfgang A. Mozart, a child prodigy himself. So how and where did this all begin?

In 1993, Rauscher et al. published a study in *Nature* that demonstrated a temporary improvement in performance on abstract spatial reasoning tests after 10 minutes of listening to Mozart's sonata for two pianos in D Major, K488. Two other listening conditions (relaxation music designed to lower blood pressure and pure silence) were also tested, and no enhancement was found with these conditions. The improvement was shown to last for no longer than 15 minutes after the listening period, and was only tested for spatial reasoning. The researchers presented their findings as changes in the subjects' spatial IQ scores, which quickly led to the widely publicized version: that listening to Mozart leads to higher general IQ scores. The 1993 study have since proven to be controversial, with some researchers confirming the results, and others being unable to reproduce them.

Another interesting twist: the subjects in this study were 36 college students—so how did The Mozart Effect become baby-centered? The credit for this misconception goes to Don Campbell, the best-selling author of, among 22 other books, "The Mozart Effect" and "The Mozart Effect for Children". Campbell studied under renowned pianist Nadia Boulanger (whose name should instantly ring a bell for every classical pianist, if not every musician) at the American Conservatory in

Fontainebleau for several years as a teenager. After continuing his musical education in organ and education, he traveled as an organist, choral conductor, and music critic in Germany, Japan, and Texas. Campbell struck gold in 1997, however, when he published “The Mozart Effect: Tapping the Power of Music to Heal the Body, Strengthen the Mind, and Unlock the Creative Spirit”, in which he claimed that exposure to music in utero can have a lifelong effect on health, learning, and behavior—namely, that sounds and music can be used to stimulate learning and memory capabilities in babies. Since then, Campbell has also released countless CD/book sets: “The Mozart Effect®: Music for Babies Set”, “Complete Original The Mozart Effect® Collection”, etc. The Mozart Effect Resource Center also maintains an archive of publications in popular press concerning the application of music in health and early childhood education, with titles ranging from “While in Surgery, Do You Prefer Abba or Verdi?” (NYT) to “Mozart ‘Aids Eye Check Accuracy’” (BBC).

In 1998, this idea entered the realm of public policy when the governor of Georgia announced that $105,000 of the state budget would be used to fund the provision of classical music CD’s to every newborn child in the state of Georgia, stating that no one questioned that listening to classical music would improve a child’s spatial-temporal reasoning and make them “smarter”. In the past decade, businesses such as The Mozart Effect® and Baby Einstein™ have flourished as the idea of enhancing babies’ intelligence with visual and acoustic stimulation spread like wildfire. The ever-growing pool of applicants to competitive colleges in the U.S. only furthered this obsession as the generation of baby boomers felt the rising competition and growing pressure to help their children achieve acceptance into top-tier universities.

On the other hand, the scientific community—true to form—has remained largely skeptical of these findings. Various studies have been published concerning the effect of Mozart on test performance. Some have suggested that classical music simply improves certain people's moods and thereby enhances their spatial reasoning (which assumes familiarity and preference for classical music in these subjects), while others have reported that the particular rhythmic qualities of Mozart's music mimic rhythms in the brain (suggesting a more universal effect). In 2004, Rauscher and Li published a study using rats as molecular models in studying the effects of music on neural development. They found that rats that were played the Mozart Sonata showed increased expression of neural growth factor BDNF (brain-derived neurotrophic factor), learning and memory compound CREB (cAMP response element-binding transcription factor), and synapsin I (a synaptic growth protein) in the hippocampus. Using rats that had listened to equivalent amounts of white noise as controls, Rauscher and Li showed that the music group performed better on learning and memory tests than their control counterparts. This may parallel the demonstrated increase in hippocampal neurogenesis of rats that live in enriched environments (toys, running wheel, etc.); perhaps the increased external stimuli, regardless of the type, influences neural development during the critical period.

Music therapy has been used in clinical settings for adults as well, with arguably less controversy surrounding its effects. Patients with Alzheimer's, aphasia, amusia, depression, and numerous other neurological disorders have benefited from the clinical use of music.

For example, transcranial direct current stimulation (tDCS) is a painless, noninvasive neuromodulatory technique that can be used to increase or decrease the activity of a particular region of the brain. It affects perception, cognition, and motor control through such modulation of regional brain activity, and has been shown to be optimal for auditory studies. It is known to have therapeutic effects on patients suffering from stroke, depression, tinnitus, and is currently used as an experimental therapy for patients with chronic pain. For example, in stroke patients, the combination of anodal tDCS on the lesion side of the brain and cathodal tDCS on the healthy side has been shown to speed the recovery process, including improved ability to grasp and perform finger/wrist movements. Despite wide reports of therapeutic effects of tDCS, however, little is known regarding how tDCS affects the brain.

Further research into other music-related therapies and techniques will continue to elucidate the effects of music and other auditory stimuli on neural development. Hopefully, the intersection of neuroscience and music will gain a larger presence in the science community and new studies will provide new perspectives on the true relationship between music and the brain. Whether these future findings will confirm or discredit Rauscher’s findings, only time will tell.

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