FROM OUR ARCHIVES

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Where Do the Goose Bumps Come From?

Cognitive scientist and musician Daniel Levitin is using fMRI to tune into how the brain responds to music

By Mark McGraw

Stop someone on the street and ask him to hum the melody of a Beatles song, any Beatles song. Fan of the group or not, it's a safe bet he can do it. That doesn't mean he will, but regardless of age or musical tastes, just about everyone would know at least one of the Fab Four's songs well enough to sing a line or two on the spot, if so inclined.

Why is that? Impossibly catchy melodies, heavenly harmonies and the group's cultural impact have a lot to do with its musical staying power. But on a more cerebral level, what exactly is happening when we hear music? What makes certain songs so indelible, so memorable?

Daniel Levitin, PhD, author of the New York Times bestseller This Is Your Brain on Music: The Science of a Human Obsession, (Plume, 2007) is searching for the answers to those questions.

Dr. Levitin, a cognitive neuroscientist and professor at McGill University in Montreal, is conducting research into how and why music affects different individuals, and he is using functional MRI (fMRI) to detect which areas of the brain are responding to music. Dr. Levitin believes understanding how people enjoy music may provide insight into the workings of the most complex human organ, and the one we ultimately know the least about: the brain.

Converging paths

Given his background, it seems only natural that Dr. Levitin, 49, is conducting this particular study.

Obsessed with music and sound from a young age, he contemplated pursuing a career in the recording industry upon graduating from high school in Los Angeles in 1975. He opted instead to enroll at the Massachusetts Institute of Technology (MIT), where he studied neuroscience. While he enjoyed his studies at MIT, he couldn't resist the lure of the music world, he said in a recent interview with ADVANCE. He transferred to the Berklee College of Music, where he studied guitar and saxophone performance, plus jazz arranging. His first stab at college didn't last much longer, however, as he soon dropped out and began playing in a succession of bands.

One of those bands was the Mortals, a San Francisco-based punk outfit for whom a young Dr. Levitin played bass. The band gained a level of notoriety in the San Francisco area, he explained in This Is Your Brain On Music, even recording at a 24-track studio with engineer Mark Needham, who went on to record with artists such as Fleetwood Mac, Cake and Chris Isaak.

Those sessions proved to be "pivotal" for Dr. Levitin; sparking in him a deeper interest in how certain sounds were actually produced, and teaching him to listen to music on another level, with a more critical ear. When the band broke up, he found work as a producer. It was a brief moment in a recording studio, in fact, that helped steer him back toward academia, and ultimately toward his research using fMRI.

Dr. Levitin recalled engineering a recording session with legendary guitar player Carlos Santana. As the guitarist's distinctive sound filled the studio, Dr. Levitin felt goose bumps rising to the surface of his skin; tiny products of the indefinable excitement many music lovers feel when hearing music that moves them.

"That in itself wasn't unusual for a Santana session," he says now, "but I started wondering where those goose bumps came from."

Studying sound

Dr. Levitin soon began driving, along with friend and fellow producer Sandy Pearlman, to Stanford University in Palo Alto, where they sat in on neuropsychology lectures discussing how the human brain processes sound. He eventually enrolled at Stanford, earning a bachelor's degree in cognitive psychology and cognitive science in 1992. He later earned a PhD in psychology from Oregon University and completed a post-doctoral fellowship in neuroimaging back at Stanford University Medical School.

Dr. Levitin has studied "the science of sound" extensively throughout his career, which has also included turns as a sound consultant for Stevie Wonder, and writer for scientific journals, audio magazines and trade journals such as Billboard. He now runs the Laboratory for Music Perception, Cognition and Expertise at McGill, where he has undertaken his current research involving fMRI.

Dr. Levitin has conducted fMRI scans on dozens of individuals to date, including Rolling Stone writer Evan Serpick, for a piece that appeared in the eminent music magazine last March.

Using a 3-Tesla MRI machine, Dr. Levitin monitors his subject's brain activity while playing different pieces of music. In essence, Dr. Levitin detects which areas of the brain are responding to music by tracking the changes in blood flow to particular regions. MRI is an ideal means to perform such a task, Dr. Levitin said.

"We want to be able to localize mental operations in the brain," he said. "Because hemoglobin is slightly magnetic and an MRI machine is essentially a giant magnet, we're able to track the flow of the hemoglobin. We're looking at changes, over time, in the level of oxygenation of the blood as active neurons change their own local blood supply."

A window into the brain

For studies such as this to yield significant results, however, it is crucial to play more than one piece of music for a subject, so as to compare one scan to another, Dr. Levitin noted.

In the study involving Serpick, for example, he played three separate pieces of music through headphones for Serpick while the writer was in the MRI: Mozart's Symphony No. 41, James Brown's "Papa's Got A Brand New Bag" and "The Real Slim Shady" by Eminem.

All three compositions activated the primary auditory cortex in the left and right hemispheres, where the brain interprets pitch, timbre and rhythm. Brown's music, however, triggered the cerebellum—which controls basic motor skills�as well as the visual cortex, suggesting that Serpick was imagining "the hardest-working man in show business" putting on one of his legendary, high-energy performances. The Eminem song activated regions responsible for accessing language, as well as areas involved in pitch and rhythm processing and the medial prefrontal cortex, "which indicates I personally related to the message," Serpick wrote, "as people often do when songs have lyrics with "I" and "you.'"

Individual tastes vary, of course, and different pieces of music affect people differently, as seen in Serpick's case. There isn't yet solid scientific evidence to account for such differences, Dr. Levitin said. But regardless of the individual, hearing music that is enjoyable stimulates the reward or pleasure center of the brain—the same area that is triggered by sexual activity, or by consuming powerful narcotics.

Essentially, listening to music changes the brain's levels of dopamine, Dr. Levitin said, which is also moderated by naturally rewarding experiences as simple as eating one's favorite food, for example. He is hopeful this work will help shed light on what makes other things so pleasurable—why Da Vinci's Mona Lisa is such a popular painting or what makes chocolate so enjoyable.

There is still much to be discovered about how the human brain is wired to enjoy music, said Dr. Levitin, who along with colleagues Evan Balaban and Anjali Bhatra are also using fMRI to look at similarities in how the brain understands language and music. Moreover, his studies involving fMRI and music may ultimately inform larger issues in cognitive theory and medical research, he said, such as discovering the underpinnings of Alzheimer's disease and other neurological conditions that remain a mystery.

"Music is a window into the function of the brain," said Dr. Levitin. "[This research] is far from being trivial or a gee-whiz kind of thing. It's really a way to probe a number of different systems. Music engages a great many different systems of the brain."

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They're All Ears: Listening on Another Level

In a new study using functional MRI (fMRI) to compare music conductors and non-musicians, both groups "tuned out" their visual sense while performing a difficult hearing task. As the task became harder, however, only the non-musicians tuned out more of their visual sense, indicating that the training and experience of the conductors changed how their brains work.

The research was a joint project of Wake Forest University Baptist Medical Center and the University of North Carolina at Greensboro (UNCG) Music Research Institute.

The study of 20 conductors and 20 musically untrained subjects used fMRI, which shows which areas of the brain are active during a task. The scanner confirmed that while activity increased in the auditory part of the brain during the hearing task, activity in the visual part actually decreased.

While lying in an fMRI scanner, the subjects heard two tones that were clearly different—middle A and E on a music scale—but began at almost the same time, with only a few thousands of a second between them. The subjects had to report which tone began first. The study was made more difficult by moving the tones closer together in time. The subjects were not allowed to close their eyes.

The difficulty was adjusted for each person before the scanning to ensure that the task would be equally difficult for everyone. Because conductors are good at these kinds of tasks, the tones were moved much closer together for them.

"Because the task was equally difficult for everybody, the difference observed between conductors and non-musicians must be related to a change in how they deal with irrelevant sensory information, and not just their ability to do the task," said W. David Hairston, PhD, the study's lead author and a post-doctoral fellow in radiology and the Advanced Neuroscience Imagining Research Laboratory (ANSIR) at Wake Forest Baptist.

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