BY TRACY ILENE MILLER

Science and Song

Song and Science

THIS IS YOUR BRAIN ON MUSIC

Daniel Levitin

Okay, before we go any further, take a moment to answer this question (no reading ahead!): does the word *at* appear in "The Star Spangled Banner"?

Find it?

Now, another question: how did you get to your answer? Did you do like most people and fast-forward through the verses (maybe even mumble-sing, your head rocking back and forth like an energetic metronome) until you came to, ah, there it is: "What so PROUD-ly we hailed, at the twilight's last gleaming. . . ."

A musician turned cognitive neuroscientist writes new refrains on the brain and the neural impulses that drive our love for music—from Handel to hip-hop.

You might feel silly, but consider: when put through this test, professional musicians must go through the same process to get to the *at* in our national anthem. Daniel Levitin, M.S. '93, Ph.D. '96, in his best-selling book *This Is Your Brain on Music: The Science of a Human Obsession* (Dutton, 2006), walks us through this small experiment to demonstrate simply that, with or without musical training, we all encode the experience of song in similar ways. We store the important tones of a piece with similar accuracy and develop "musical contour" naturally. In both his book and his ongoing research, Levitin probes our intuitive sense of music to challenge those evolutionary theorists who posit that music is mere "cheesecake"—an incidental pleasure without which the human species could get along just fine. Levitin instead places music—the complex stimuli that get us tapping our feet and sometimes humming along with melodies we haven't heard in thirty years—more squarely as an essential piece in the framework of human evolution and cognitive development.

Ross West

What distinguishes Levitin in his field of cognitive neuroscience is not only his use of both nonmusicians and musicians in his research, but also his emphasis on real-world music and, in particular, popular music. Levitin has shown that musical knowledge comes as readily from listening to the Police's "Roxanne" or "Every Breath You Take" on your car radio as from a symphony hall rendition of Handel's *Messiah*. Levitin, a professor and cognitive psychologist who runs the Laboratory for Music Perception, Cognition, and Expertise at McGill University in Montreal, conducts experiments with classical music as well as tunes as familiar as "Happy Birthday," Elvis's "Jailhouse Rock," and Eminen's "The Real Slim Shady."

Who better to explore this territory than a musician and former record producer. Before Levitin received his Ph.D. in 1996, he had already gone gold and platinum nine times working with artists as different as Blue Öyster Cult and Stevie Wonder. Here's a man whose publication credits span the distance from *Billboard* magazine to *Child Neuropsychology*.

And it's not as if he has given up his music industry connections. Conversations with Levitin are sprinkled with references to times spent with such rock 'n' roll hall-of-famers as Joni and Carlos (neither of whom require a last name), pop culture icon Cher (who has no last name), and current alternative rock phenomenon Arcade Fire.

But the chasm between his two worlds was never wide; music has never been far from science. Levitin had a childhood fascination with audio equipment (in the generation when hi-fi technology advanced and exploded on the American market) and with music as varied as rock legends Cream and piano jazzman George Shearing. Graduating high school a year early in 1975, Levitin headed to MIT for a degree in electrical engineering—to learn how to build sound equipment. In a quirky preview of his future, Levitin remembers reading in an elective course a slim volume by Michael Posner about cognition. Posner, now professor emeritus of psychology at the University of Oregon, would become Levitin's adviser nearly fifteen years later.

Although he quit MIT to play guitar, Levitin was struck by the notion that "you could construct an experiment, just like a chemist would construct an experiment . . . and probe the origins of thoughts and come up with an answer. I found that very stimulating and remarkable," he says.

He continued reading his *Scientific Americans* and buying books on psychology even as he moved west and began playing lead guitar in the country-western Alsea River Band, working Waldport and Oregon Coast venues covering songs such as "Poison Love" and "Crazy." He progressed in the industry from session musician to, eventually, record producer in California.

But he still had time for science. "When I established myself as a record producer, I needed a hobby," he says. So naturally, "since music was my job, why not have science as a hobby."

Levitin took calculus at the University of California at Berkeley "in my spare time" and drove to Stanford University to take classes in the only department that was exploring music and the brain—psychology.

"I never really stopped thinking about science," he says. "I think science is more an outlook or a disposition than just a career or a field of inquiry. You have people who have scientific temperament whether they are scientists or not."

Levitin came to a crossroads in 1990. His interest was flagging in a music industry that was dropping rock greats such as Elvis Costello because of sluggish record sales. But for a friend's coaching, Levitin may have become a llama rancher in Oregon, playing his guitar and writing songs. The longtime friend was Lewis Goldberg, a UO professor who studied personality psychology. Goldberg persuaded Levitin he had the temperament and mindset for academia.

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And he was right.

Levitin returned to Stanford to finish his undergraduate degree in cognitive psychology and cognitive science, while also lecturing on audio recording in the music department. His work began to take the field in new directions by asking questions about the neural basis of our affinity for song and music's impact on us as an indicator of, among other things, how our memory works.

In a significant experiment, Levitin worked on the notion that, unlike classical pieces that could be played by many different performers and still be considered the same song, most rock or pop tunes have a single canonical, or standard, recording. In other words, listeners associate "New Year's Day" with the U2 release, and any other version registers as significantly as Muzak. Same with songs like "New York State of Mind" (clearly Billy Joel) or "Like a Virgin" (any doubts?).

With that in mind, Levitin invited people to a campus laboratory to sing. He excluded songs that had multiple versions (for instance, avoiding the confusion of what to sing when thinking "Twist and Shout": the Isley Brothers or the Beatles?) and recruited nonmusicians to sing popular songs. The results were surprising. More than forty subjects, who complained and protested their way through their favorite pop songs, exhibited similar "music memory." They matched the correct key, or absolute pitch, of the originals at least two-thirds of the time and the tempo with a 4 percent margin of error. When the recordings of the subjects were played side-by-side with the pop-star versions, it almost sounded as if they were all singing together.

That experiment signaled a slight shift in cognitive neuroscience in two ways. First, before then, much of the research into the way the brain processes music had been done with pings and dings or simple rhythms in a laboratory.

"Most pitch perception work had been done in pure tones," says Michael Posner. "[Levitin] had a more natural way of studying music in its real-world context. He opened up the psychology of music to a more ecologically valid way of study."

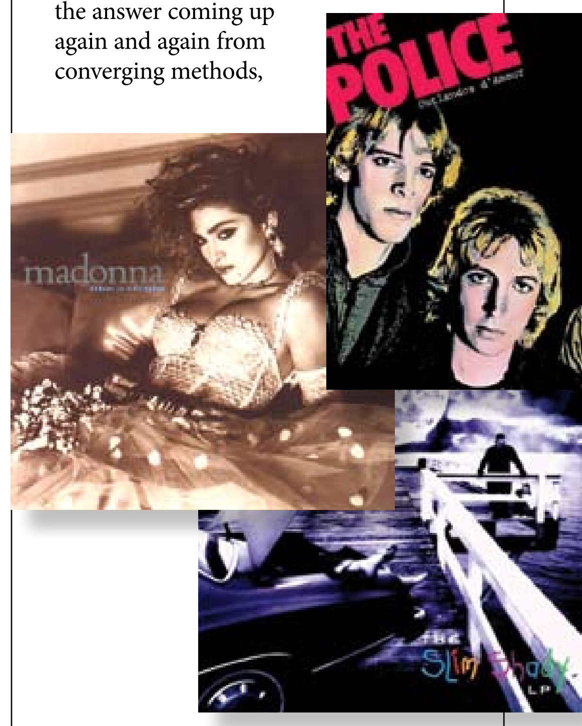
Second, the experiment gave credence to the idea that "absolute features of music are encoded in memory," Levitin writes. "And there is no reason to think that musical memory functions differently from, say, visual, olfactory, tactile, or gustatory memory."

In 1992, Levitin moved to the University of Oregon to continue his work. He says his experience studying with psychology professors Posner, Doug Hintzman, and Helen Neville did two things: made him a scientist and instilled the notion of taking a cross-disciplinary approach to problems.

"They taught me to think that I had to have evidence for every statement that I made—and what counted as good evidence—and it wasn't enough to just be satisfied that I had seen something happen once, or in one way," Levitin says. "I had to make sure it wasn't anomalous, to not just poke at a question from one direction."

Applying that lesson in his current work, he uses genetic models (for instance, the study of populations with gene-linked abnormalities, including Down and Williams syndromes), neuroimaging, psychophysics, and "plain old experimental psychology."

The way most programs work, Levitin says, "you train experts in one methodology. [But at the UO] I was trained as a true cognitive neuroscientist, to use all the tools available to really attack the problem from multiple directions. The idea being, if you see the answer coming up again and again from converging methods,



different technologies, different methodologies, then you know you are onto something."

It was only during his postdoctoral work that Levitin began to use functional magnetic resonance imaging (fMRI) to map neural networks affected by music. The images he saw reinforced the notion that "music is distributed throughout the brain"—that music is, in a sense, a whole-body experience: it manipulates our emotions and forces our toes to tap, hips to sway, and fingers to snap.

And even while we have a collective appreciation for music as a culture, Levitin's work showed that individuals hear the music differently based on personal experience—a then-novel idea in the study of brain mechanisms and music as memory.

Mapping the networks of the brain with fMRI has led cognitive psychologists to understand *where* (not only *when*) the brain responds to a given musical stimulus, what the pattern of response is in the brain, and what brain mechanisms underlie emotion and memory. So far, fMRI results have led to more questions than answers. For example, how is it that an Alzheimer's patient loses most of his or her memory to the disease but can still instantly recall (as perhaps you can?) a favorite song from age fourteen?

On one level, Levitin says, the answer is that, in our lives, times of intense social bonding or intense emotional experience, which for many of us peak around age fourteen, fixes music to our brains. (In other words, your favorite songs will almost certainly date you.) That's also the time when the brain starts pruning unused neural connections to form the adult brain. That critical pruning process also begins to set our individual musical tastes—which may very well account for one generation's disdain for Elvis, and the next's for rap.

But there's another gap Levitin is working on, says Harry Price, professor of music and chair of music education at the UO—the one between music theorists and psychologists. Price teaches one of two courses at Oregon with the same name: Psychology of Music. His class is in the School of Music and Dance, and the other is in Levitin's old department, psychology, taught by Assistant Professor Mike Wehr.

Price, who uses *This Is Your Brain on Music* in his class, sees Levitin's work moving the two sides, the scientist and the musician-artist, toward what Levitin describes as working from the same vein of truth.

"With the new research coming out examining how experience and emotion impact music, musicians and scientists both are more comfortable with messy," says Price, "—that music is a whole, not a part, and the stimulants for study are not always safely contained within a lab. The experiments can be creative and interesting and still be credible."

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For instance, Price points to one study where listeners are given different information about a piece of recorded music. One group is told the performance is by a graduate student; a second group is told it's by a professional performer. The results: the second group gave higher marks to the performance.

If we consider that listeners are affected by cultural and experiential references, "the point is that psychology and emotion overshadow our experience with music," says Price. "The grad student group was ready for the performance to not be as good."

While Price is looking at music from the perspective of nurture (social and behavioral factors that affect how music is perceived), he says Wehr in the psychology department looks at it from nature: from the view of physics and biology—the nervous system response—with a bit of music theory thrown in.

In addition to the textbooks Wehr relies on for his specifically scientific focus on music, he plans to use Levitin's popular book as supplemental reading.

"The book, I think, covers very well the themes of the material I want to get across," Wehr says.

By exploring the themes of musical organization (for example, interval, melody, harmony, and tonality) and its relationship to higher brain function and theory, Wehr's goal "is to give students the tools [of analysis] to start asking interesting questions about their favorite song, or music that they find powerful." When students are exposed to experiments and modes of analysis, Wehr finds they come up with new ways to look at music and ask questions. For instance, why do people like some kinds of music and not others? Why does a different version of a well-known song elicit different emotional content? How do people with autism or Williams syndrome perceive music?

Wehr says this technical approach often brings up fears that music will lose its mystery and be less enjoyable. But the classroom experience says otherwise.

Students "listen to music and experience it in a richer and more meaningful way," Wehr says. "They think about it in a way they haven't before and translate that into a new perceptual experience."

The goal of the cognitive neuroscientist, Levitin says, is "to understand thought processes, memories, emotions, and experience. And the brain just happens to be the box that all this happens in."

Which is the reason Levitin wrote his book. He shows how music is a foundation of thought, a real world wide web: music appreciation links philosophy, history, mechanical inventions, and cultural connection (or disconnection). And even without training, nonmusicians have internalized the tools to understand and better appreciate music by examining its underlying structure. He stresses that knowing music—whether tribal folk or Tchaikovsky, Tupac or Tormé—is basic to all humans. Music is not just the purview of experts and virtuosos but is accessible to anyone with a stick, a voice, or an iPod in hand.

Tracy Ilene Miller, M.S. '06, is a Eugene freelance writer and editor and an adjunct instructor at the UO School of Journalism and Communication and at Northwest Christian College. She has been editor of several publications, including Oregon Cycling *magazine, writes for* The Register-Guard, *and is a contributor to the online magazine* Culinate.