SEED

WATCHING A MUSICIAN IN THE THROES OF AN IMPROVISATIONAL SOLO CAN BE LIKE WITNESSING AN ACT OF DIVINE INTERVENTION. BUT EMBEDDED MEMORIES AND CONSPIRING BRAIN REGIONS, SCIENTISTS NOW BELIEVE, ARE THE TRUE SOURCE OF AD-HOC CREATIVITY.

The Improvisational Brain
FEATURE BY **AMANDA ROSE MARTINEZ**


Credit: Flickr user maistora

One summer at the annual Bremen Music Festival in Germany, Robert Levin, a classical pianist, was in the midst of improvising a passionate and wild cadenza during Beethoven's "C Major Piano Concerto." A cadenza is a passage in a concerto during which the orchestra ceases and a soloist strikes out on his own, improvising within the style of the piece. Up until the early nineteenth century, many classical composers wrote space for these cadenzas within their works. Levin is one of a handful of musicians who has taken it upon himself to revive the practice of classical improvisation. He is world renowned for his ability to effortlessly extemporize in the styles of several composers, including Mozart, Beethoven, Schubert and Mendelssohn. In this particular concert, however, Levin had gotten himself into a bit of a pickle.

"I was going whole hog," Levin said, thanks to the permission Beethoven gave his renderers to modulate or change keys during his cadenzas. "I had gone really far afield and was in F sharp major. That's as far away from C major as you can possibly get because if you keep going, you start to get closer to the other side."

"It's like the world," Levin said, drawing a parallel to the structure of musical scales. "You go more than 12,500 miles around the equator and you might as well keep going."

At this point, Levin pounded some F sharp major chords, and for a split second, he paused. "I was shocked at how far off I was and how crazy this all was," Levin said. "I thought to myself: 'Oh my god! How am I going to get home?' "

Imagine the pressure: Levin is sitting at the piano. A full orchestra of musicians, with instruments poised at the ready, not to mention the conductor, Sir John Eliot Gardner, are waiting for Levin to finish out the cadenza, so that they can resume the piece. And then there is the festival audience of thousands, some of whom, according to Levin, had sensed his predicament and audibly gasped.

"I looked down at the keyboard and imagined myself saying: 'Save me! Help me!' " said Levin. "And literally—I felt this—I thought the keys looked up at me and said: 'You got yourself here. You get yourself out.' "

What happened next, Levin said, was truly miraculous. "I started to play again. And so to speak, I slid on the banana peel of a diminished seventh chord and through some enharmonic sleight of hand—it was not planned—I suddenly found myself within sight of my front door, and I got home."

There is something fascinating about the act of musical improvisation—that moment when a musician departs from the score, embarking on a thematically relevant, yet wholly spontaneous composition. We normally think of it as the province of jazz musicians, conjuring the iconic image of a sax player wailing through riffs in a smoky, dim-lit club. John Coltrane and Bill Evans were masters. Miles Davis was never much for rehearsal. He used to gather his band in the studio, rattle off a few suggestions for the broad shape each track should take, and hit record.

But many of the early classical composers—Mozart, Beethoven, Bach, Liszt—were also known for improvising entire portions of their concerts. Liszt had a penchant for soliciting musical themes from his audience. Before a show, anyone could jot down a few bars of melody on a piece of paper. Some were original. Others were bits of recognizable tunes from the time, a popular symphony or aria. Liszt would then pull one of these melodies out of a hat and use it as a launching point. He'd reharmonize it or play it backwards, always wresting from it a spirited improvisation that could last for several minutes.

Regardless of genre, the appeal of improvisation is its danger. It's an act of audacity, says Levin, but ultimately an act of profound humanity, given that it's a communication between the performer and the audience. The musician takes a huge risk, trusting, hoping that his brain and fingers will successfully allow him to "walk the tight rope over the precipice and arrive at the other side," Levin says. "Or you might crash and burn. You never know." But the spectators, as they live vicariously through the musician's adventure, love him for it.

How do musicians do this? When he's ready to begin a cadenza, Levin says, he doesn't have a plan. As many other seasoned improvisers claim, he just starts playing. It's intuitive. But, Levin admits, he didn't always know how to improvise. He had to learn. So the question remains: how can a skill that in its truest form is innate be learned?

Aaron Berkowitz, a cognitive ethnomusicologist, who took on the task of demystifying improvisation as the focus of his dissertation work at Harvard, has a theory. He likens the process of learning to improvise to that of learning a second language. Initially, he says, it's all about memorizing vocabulary words, useful phrases and verb conjugation tables. Your first day, you might learn to say: How are you? I'm fine. "These are like the baby steps beginning improvisers take. They learn the structure of the blues. They learn basic chords and get the form down," said Berkowitz. But they're still very limited in what they can do.

A dedicated musician will immerse himself in the recordings of his chosen genre or composer, just as a language student might absorb foreign films or tapes of people speaking. Over time, both musician and student accumulate more phrases and ways to combine them. "But you still can't really invent anything. [The language learner] can't talk about politics or the environment," Berkowitz said. "You're still thinking: 'Uh oh, here's comes a verb. I have to put it in the past tense. I have to put it at the end of the sentence before I can say this whole phrase."

But eventually, through constant practice, you get to the point where, scientists believe, these processes get pushed down into the subconscious. They don't need to be consciously worked out anymore. They become a subroutine. Suddenly you realize you're saying things you haven't heard or memorized. You're able to free-associate. Your brain begins exerting control at a higher level, directing bigger chunks of information that can be expressed as whole ideas.

The trajectory of acquiring a language, according to Berkowitz, where you begin with learned phrases, achieve fluency, and are eventually able to create poetry mirrors perfectly the process of learning to improvise. In the same way a language student learns words, phrases and grammatical structure so that later he can recombine them to best communicate his thoughts, a musician collects and commits to memory patterns of notes, chords and progressions, which he can later draw from to express his musical ideas.

Berkowitz was halfway through medical school at Johns Hopkins when he decided that his long-evolving interest in the intersection of music, music cognition and cognitive neuroscience could no longer be ignored. He decided to focus on improvisation mainly as a result of seeing Levin, a professor in Harvard's music department, perform. "I was pretty blown away," said Berkowitz. "If you want to talk about improvisation, he's one of the grand masters."

As it turns out, Berkowitz's theory seems to explain Levin's road to improvisational mastery almost exactly. For his early and intense exposure to Mozart, whose style was the first in which he learned to improvise, Levin credits his father, a dental ceramist. "He was absolutely taken with him," Levin said. "He would smuggle 78s of Mozart into the house when we needed food more than we needed shellac records."

When Levin was 12, he began a rigorous course of study with the legendary music teacher, Nadia Boulanger, in France. Levin credits Boulanger for giving him "a toolbox that contained everything that I needed for the rest of my life as a musician." Later, when Levin began to improvise in Mozart's style, he discovered he had in place the requisite musical vocabulary and grammar thanks to Boulanger's keyboard harmony, sight-reading and transposition exercises.

Fluency arrived for Levin during thousands upon thousands of hours of practice. At a certain point, he acquired a Mozart mindset, which consists, says Levin, of a collection of idiosyncratic musical details—rhythms, chords, turns of phrase—that recall the distinct language of the composer.

What came next, however, was the somewhat unsettling period when he began improvising in concert, which, with all its risk, was a completely different beast. “At first I thought, I’d better have a safety net,” Levin said. Three hours before a performance, Levin would be lying there in his hotel room bed, trying to work out a mental roadmap for his impending cadenza. He’d get it all planned out and think “fine, I don’t have to worry about it.”

But inevitably, during performance, Levin would stray from his roadmap, forcing a choice. “You can think about what you should be doing instead of what you are doing and screw up completely or you can ditch everything you were going to do because you aren’t there, you’re somewhere else.”

Eventually, Levin just let go, and in doing so, made the crucial transition from fluency to poetry. “Now I prepare absolutely nothing,” he said. “The orchestra is playing and I know I’ve got twelve seconds, I’ve got eight, I’ve got six, I’ve got four, and if nothing comes into my head, I just start playing. I start to play a scale. I start to play something. And as I play, I know something is going to come to me.”

At this level of musical cognition, the improviser often achieves a seamless trade-off between his conscious and subconscious knowledge. He knows he’s creating the music and feels very much in control, yet he also feels as if he’s watching himself play, a paradox that Berkowitz calls the creator/witness phenomenon. “They’ll be playing and something happens that they didn’t quite expect,” Berkowitz said. “Then they react to that and it kind of starts this dialogue where the improviser is steering the ship, but is also being steered by the ship.”

Levin confirms this phenomenon, recalling his miraculous recovery at Bremen. “I was certainly the protagonist. Nobody else was calling the shots,” Levin said. “But, at the same time, I was watching myself do this and said: ‘Whew! Lucked out.’ ”

With a rough idea of how musicians learned to improvise, Berkowitz decided to go a step further. He wanted to know specifically how the musician’s brain acted differently when it was improvising as opposed to when it was just playing a scripted melody. Berkowitz teamed up with Daniel Ansari, a neuroscientist at the University of Western Ontario, and together they designed an experiment that would attempt to isolate the brain regions responsible for the aspect of improvisation that requires creativity.

Berkowitz had his test subjects, all classically trained pianists with an average of 13 years piano experience, perform a series of four musical tasks while inside an fMRI machine. A noninvasive brain imaging technique, fMRI uses powerful magnets to measure blood flow to brain regions that are being activated and deactivated during neural activity. As each subject lay recumbent in the machine, he or she would play a small, plastic piano-like keyboard, which had five keys. The first task constrained both melody and rhythm, and required subjects to play pre-memorized, five-note-long melodies while maintaining a fixed rhythm with the aid of a metronome. The other three tasks included improvisation in some form: one allowed the subject to create rhythms, while playing the memorized melodies; another had the subject create melodies in time to the metronome; and the third permitted freestyle generation of both melody and rhythm.

When Berkowitz and Ansari looked at the subjects’ brain maps, they found three regions that were activated during all tasks that involved improvisation, whether it was rhythmic or melodic. When it comes to determining the roles these regions might play in improvisation, Berkowitz is cautious, emphasizing that fMRI is just a tool—an inference tool—that allows assumptions to be made based on what is known about the region’s general function, but offers no definitive answers. Still, the implications are provocative.

One of the regions, the anterior cingulate, is enlisted for most cognitive tasks, especially when the brain needs to decide between a surfeit of potentially conflicting responses. A neuroscience test called the Stroop task has become famous for riling up this region. Researchers show subjects the word “red,” but it’s written in the color blue. They’re then asked to either read the word aloud or say what color it is. “You feel your brain sort of freeze for a second,” said Berkowitz, an indication that the anterior cingulate is working hard. During improvisation, the musician has myriad, varied choices for what to play at any given moment, so it makes sense that this region would be fired up.

Another activated region, the dorsal premotor cortex, acts as a type of command center for crucial sensory input about where the body is and how it negotiates space. If the body has to move, what will be its goal and how fast should it go? Analyzing this input, the region issues a plan of action. When the musicians started to improvise, this region, already active during the playing of memorized melodies, ramped up significantly, possibly due to the musicians' need to execute anything they could conceive of playing.

The third region Berkowitz identified—the inferior frontal gyrus/ventral premotor cortex—has long been known as an area key to our ability to understand and produce language. While more recent studies have linked it to music processing, Berkowitz and Ansari are the first to show that it plays a role in generating music as well. This would seem to strengthen the theory that music functions similar to language in the brain.

These results were published in 2008, but Berkowitz and Ansari released another study in early 2010 that took their investigation of improvisation one step further, pitting musicians against non-musicians. Keeping the setup and tasks the same, the scientists isolated an additional brain region that appears to be involved in improvisation. Called the right temporo-parietal junction, this region powers up when a new stimulus occurs in our environment, stealing our attention.

"For example, if you're walking through the forest, it's all trees, brown and green, and then suddenly something red pops out," Berkowitz said. "This is the area that might say 'Oh, something in my field of vision has changed and I need to draw attention to it.' " When the musicians were playing memorized melodies, this region was active, but as they began to improvise, the region shut down. The non-musicians showed no change in the region regardless of their task. Turning off this region, Berkowitz said, likely allows musicians to apply a steely focus to their improvisation—a feat, which according to Levin is critical. "If the brain gets distracted because the rhinestones on the pendant of the woman in the third row suddenly catch the light and for even a fraction of a second you lose focus, the music can lose its sense."

Within weeks of Berkowitz's first study coming out, a separate fMRI study on improvisation was published by Allen Braun, head of the Language Branch at the National Institutes of Health and Charles Limb, an otolaryngologist at Johns Hopkins Hospital. Where the Berkowitz/Ansari study tried to zero in on only those brain regions responsible for creativity during improvisation, the Limb/Braun study took a more holistic approach. Its goal was to glimpse every brain region enlisted in any aspect of improvisation.

Designing musical freedom into the study, which focused specifically on jazz, was challenging. Limb casts jazz and science, respectively, as the ultimate free spirit and control freak. "They're just not really natural bedfellows," he says.

Limb, a jazz saxophonist and self-described music addict whose lab resembles a recording studio due to its full-size piano keyboard and profusion of speakers, worked for two years with a California engineer to design a realistic, 35-key, plastic keyboard. He asked his subjects, all consummate jazz pianists, to perform two sets of musical tasks, while lying recumbent in the fMRI machine with the keyboard resting on their laps. The first set, intended to be simple, either had the pianists play a C major scale in sequence or allowed them to improvise, one note at a time within that scale. The second set was more complex. The subjects either played a short, pre-learned jazz tune composed by Limb or they improvised over a prerecorded four-piece band.

Results showed a veritable symphony of activated and deactivated brain regions during improvisation, which included the regions noted by Berkowitz and Ansari. The strangest activity, Limb said, occurred in the prefrontal cortex, where the scientists observed a surge in medial prefrontal activity, the "self-expressive, autobiographical brain region," and, simultaneously, a broad deactivation in the lateral prefrontal regions, the area that governs self-consciousness and inhibition. In other words, in the improviser's brain, the area that imposes self-restraint powers down, allowing the region that drives self-expression, which ramps up, to proceed virtually unchecked. "This notion of trying to tell your own musical story, without the constraints of caring how well it's going as you're saying it, was really pretty intriguing," Limb said.

And so it happened for Robert Levin, seated at the piano, seized with panic, at the concert hall in Bremen. Memories of note patterns and chords embedded by thousands of practice hours, we may be certain, arose from his subconscious, flooding his brain. His lateral prefrontal regions said "This is it—time to tell your musical narrative," while his medial prefrontal region reassured him, saying "Don't worry about how it comes out." His right temporo-parietal junction turned down the dial on any audience gasps, his anterior cingulate made a series of snap decisions, and his dorsal premotor cortex organized them into a motor missive, which it then sent out to his fingers. A split second later, Levin started to play, and before he knew it, he was home.

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