

# The Musical Brain

## Interview with Charles Limb, M.D.

by Melissa Hartman

*Charles Limb cannot remember a time when he didn't play an instrument. Music was a passion that endured through high school, a political science major at Harvard, and medical school at Yale.*

*Today, Dr. Limb is a cochlear implant surgeon, Associate Professor of Otolaryngology–Head and Neck Surgery at the Johns Hopkins School of Medicine, and an adjunct faculty member at the Peabody Institute. He's also a saxophonist, a composer, and a self-described music addict. Here, he discusses his lifelong love of music and the career that has blossomed from it.*

### When did music become a scientific interest for you?

I always found it odd that music—essentially an abstract percept derived from acoustic vibrations in the air—was so meaningful to me. My passion for it seemed somehow disproportionate. In medical school, when I was taking Gross Anatomy and dissected out the ear, I started to realize that part of the reason I was passionate

about music was that I found the whole process of auditory perception of complex sounds interesting.

By the time I finished medical school, I knew that I was going to become an otolaryngologist, and in particular, a hearing specialist. The clinical field of medicine that I practice is called neurotology, which is basically the study of the ear's interaction with the brain.

### Your most recently published research involved jazz musicians improvising while in the fMRI scanner. Why did you want to image improvisation?

I've always liked jazz, and that's what I play and a lot of what I listen to. Jazz is about improvisation. When you're listening to live jazz, you're going to hear something that's never

been played before and will never be played again. That's why it's been described as “the sound of surprise.” It's really intriguing to me that somebody can generate, on the spot, high-level music that they've never played before. It's remarkable. It's spontaneous composition at a very rapid rate.

When I was at the National Institutes of Health learning fMRI techniques, I had this idea that we might be able to study jazz using fMRI. It was a goofy idea I had, really just out of fun. But I brought up the idea with my mentor at the NIH, who is also really interested in music. As we delved into it, we realized that there's not a lot of research on creativity, and that musical improvisation might be a great way to model it. After a several-year process, I had a piano keyboard made that could go into the scanner. I could play the piano in there, hear the piano, and record my brain activity.

Then I had to think about the scientific paradigm. I wanted to constrain it so that it was scientifically valid, but on the other hand, I didn't want to constrain it so much that it wasn't musically valid. I wound up using two paradigms. In the first, the musicians were either playing a scale in quarter notes to a metronome, or they were improvising on scale notes to a metronome. In the second paradigm, they either played a C-minor blues melody I had written for them and that they'd memorized, or improvised something based on that melody on the spot.

### What did you find?

During both types of improvisation, there were two areas in the prefrontal cortex that had opposing activity—one part went way up and one part went way down. The part that went way up, the medial prefrontal cortex, is the part of the brain that has to do with one's self-expression, such as autobiographical narrative and things that are self-referential. The part that went way down in activity is the part that's your self-censoring, filtering and feedback mechanism.

In these musicians, during improvisation, the self-

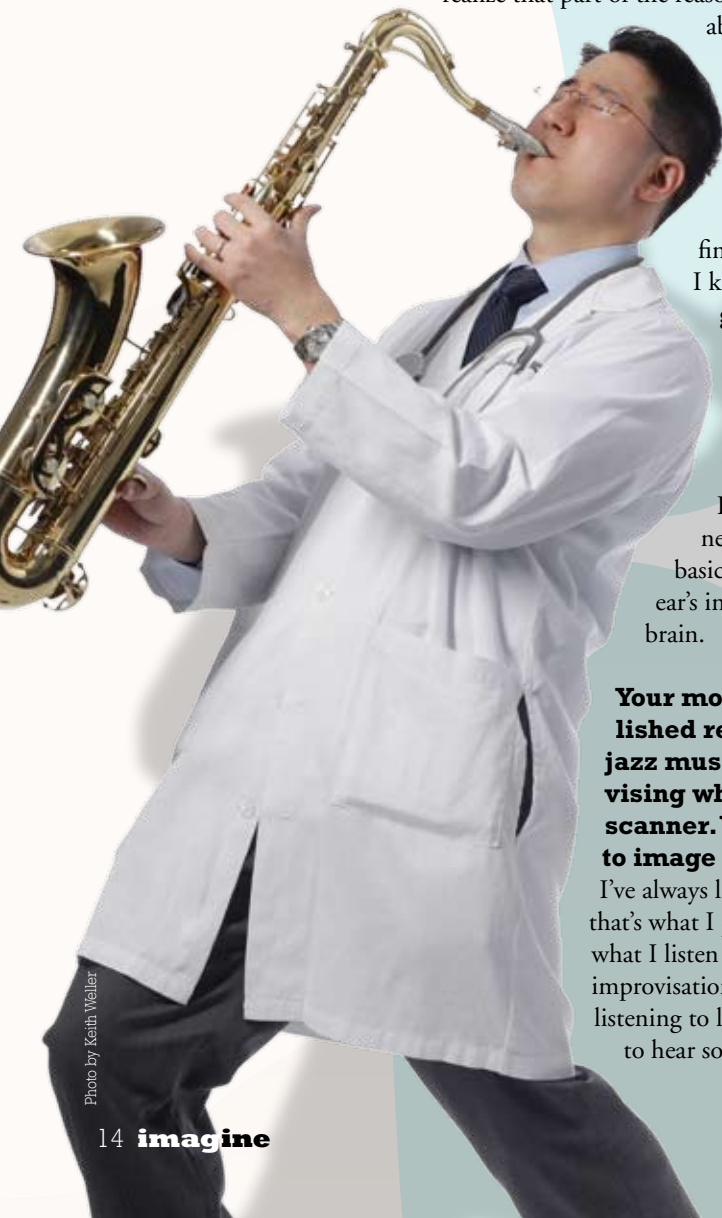


Photo by Keith Weiler

expressive areas went way up and the self-limiting areas turned way down. In the end, we think that may be the hallmark of what happens when someone is doing something spontaneously creative.

Dreaming leads to a similar dissociation within the prefrontal cortex. In a way, there's a certain "sound of surprise" to a dream—it's certainly not governed by an apparent logic. A lot of people would say the same thing about jazz. There's a basis for the music being played, but you can't predict it, that's for sure.

**You collaborated with Marin Alsop, the Baltimore Symphony Orchestra's music director, on a series of concerts called "CSI Beethoven." Why did this project interest you?**

As a hearing specialist, it is hard to ignore the fact that Beethoven was deaf in his later career, yet still composing music. As I looked into what was known about his hearing loss and the course of his illness, I started wondering, if Beethoven were my patient today, what would I think?

I read his letters and statements of people who knew him, trying to get any bits of personal information that would allow me to extract a relevant medical history. I realized that the beginning of his hearing loss was in the high frequencies. I generated theoretical audiograms based on certain years of his life, and then correlated those years of his life to the pieces he was writing at the time. Then, I took recordings using period instruments and ran them through algorithms that were filtered according to the audiogram, to try to reconstruct what it might have sounded like to somebody whose hearing loss was getting worse as he got older.

At the premier of the Ninth Symphony, as far as we can tell, Beethoven was profoundly deaf. I can't help but wonder how he conceived of all that in his mind's ear, put it on paper, and had it come out perfectly.

**The mind's ear: Is that something you might be able to identify with fMRI?**

I think we can get there. It's an abstract concept, and it's hard to verify using objective parameters because you can't easily measure something that's imagined. But there are several studies on this idea of musical imagery. If you stop and think about a piece of music, you can somewhat re-create it in your brain. You can go through the process of it almost as if you're hearing it, especially if it's a piece you know well. Highly trained musicians are able to do that just by reading a score. Beethoven was able to do it to an excessive degree.

**I read that you'd like to design a music-based hearing test. How would that be different from what's currently available?**

When you get a hearing test now, what you hear is, "Beep, beep." I've always found it amusing but also a little frustrating that to study the auditory system, we look at the lowest levels of performance, not the highest.

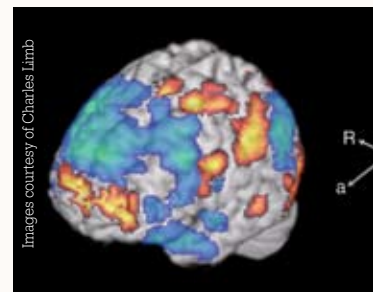
If you're a trained musician and you notice that something very subtle has changed about your hearing, our hearing tests are often unable to pick it up. I want to take musical elements and use them to study things like temporal pattern processing and complex spectral processing in a way that's a little more relevant to real life than a lot of our typical test methods. It might be that the only patients who really want that kind of testing done are musicians. But if we want to understand how somebody hears something as complex as music, maybe we need to use more complex tests than just beeps.

**Is there more musical research on the horizon for you?**

There's a lot going on in my lab, but I'll be very honest with you: a lot of it comes down to research funding. Unfortunately, now is not a great time in the scientific world for research funding, particularly for projects that aren't disease-oriented. There's no "jazz disease," so the NIH isn't exactly throwing funds my way to study these questions. Experiments are expensive, so you have to find funding sources that want these things done. I have five to ten experiments lined up in my head, but I have to find ways to fund them.

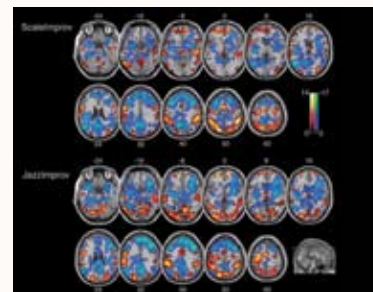
**Is there anything else you wanted to share about your work?**

I always did what made me happy, and I never regretted it. I'm a fairly practical person—I'm far from the starving artist who's committed to just painting his paintings in his studio. I mean, I'm a surgeon at a very large academic hospital. But I got here by following my passions. It's a combination of what I love, what's practical, and what I'm good at, and finding the intersection of those three. I think most ambitious younger people are hoping to find that one day, but a lot of them don't feel that they're allowed to choose a career on the basis of what they love, like that's not a valid decision. But I believe that doing what I love has always made me better at what I do. It motivates me because I love it. **i**



Images courtesy of Charles Limb

Three-dimensional surface projection of activations (red/yellow) and deactivations (blue/green) associated with improvisation during the jazz paradigm.



Dr. Limb's study showed that during spontaneous improvisation, areas of the brain associated with self-expression were activated (red/yellow), while areas associated with self-limiting were deactivated (blue/green).