The improvising brain: Getting to the neural roots of the musical riff

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Aaron Berkowitz at the keyboard.

(PhysOrg.com) -- What's involved when a musician sits down at the piano and plays flurries of notes in a free fall, without a score, without knowing much about what will happen moment to moment? Is it possible to find the sources of a creative process? Is it possible to determine how improvisation occurs?

Aaron Berkowitz, a Harvard graduate student in ethnomusicology, and Daniel Ansari, a psychology professor at the University of Western Ontario, recently collaborated on an experiment designed to study brain activity during musical improvisation in order to get closer to answering these questions. The Harvard Mind/Brain/Behavior Initiative awarded the collaborators a grant to look at musical improvisation in trained musicians, utilizing brain scans done with functional magnetic resonance imaging (fMRI) technology. A resulting paper, “Generation of Novel Motor Sequences: The Neural Correlates of Musical Improvisation,” was published in the journal *NeuroImage*, and received the journal’s 2008 Editor’s Choice Award in Systems Neuroscience.

“There are essentially two basic questions in music cognition,” says Berkowitz. “First, how does the brain ‘do’ music? That is, what parts of the brain are involved, and how do they interact, when people listen to or perform music? Second, what can studying music tell us about the brain? When music is heard or played, the brain calls on many more general cognitive processes, for example, perceiving patterns in sounds or converting visual information [in a musical score] to auditory or motor information.”

The perception and performance of music have been studied by scientists; most famously, looking at what listening to classical music — like Mozart — can do to the developing brain. But looking at brain activity during the process of music improvisation is new.

Improvisation is not exclusive to music, says Berkowitz. Nor is it a pure flight of invention. “It’s spontaneity within a set of constraints,” Berkowitz explains. “Imagine: You slip on ice, and you do a sort of little dance to regain your balance — maybe in a way you’ve never ‘danced’ before; but though the sequence of movements might be novel, it’s made up of the individual movements that are possible given what the body can do and where it is in space.” Musical improvisers also work within constraints. “Those bebop players play what sounds like 70 notes within a few seconds. There’s no time to think of each individual note. They have some patterns in their toolbox,” says Berkowitz.

Berkowitz and Ansari were interested in the brain regions that underlie improvisation. The team used 12 classically trained pianists in their 20s with an average of around 13 years of piano training as subjects for the study.

Since the brain is active, even at rest, Berkowitz and Ansari first needed to design a way to subtract out brain activity common to hearing or producing music so they could isolate the neural substrates of the spontaneous creative aspect of improvisation. “If you were to put someone in an fMRI scanner and have them improvise, nearly the whole brain would likely be involved. We needed a way of isolating what is unique to improvising, namely, spontaneous novel action sequences.”

To meet that need, Ansari and Berkowitz designed a series of four activities. In the two general types of tasks, they had subjects either improvise melodies or play pre-learned patterns. Comparing brain activity in these two situations allowed Berkowitz and Ansari to focus on melodic improvisation. Subjects did each of these two general tasks either with or without a metronome. When there was no metronome marking time, subjects improvised their own rhythms. Comparing conditions with and without metronome allowed Berkowitz and Ansari to look at rhythmic improvisation. A key point is that when the subjects played patterns (instead of improvised melodies), they could choose to play them in any order. "The idea," says Berkowitz, "was that there would still be some spontaneity in decision making here, but the choices would be more limited than when they were improvising."

“We were trying to isolate creativity — or novelty,” explains Berkowitz. “It’s not that we expected to uncover some region of the brain nobody had ever noticed before and call it ‘the improvisation area.’ We wanted to see which brain areas were involved in improvisation. This tells us something about what these regions might be doing in improvisation, and it could even shed new light on these areas, since we would be showing that they are involved in improvisation.”

Ansari and Berkowitz discovered an overlap between melodic improvisation and rhythmic improvisation in three areas of the brain: the dorsal premotor cortex (dPMC), the anterior cingulate (ACC), and the inferior frontal gyrus/ventral premotor cortex (IFG/vPMC).

"The dPMC takes information about where the body is in space, makes a motor plan, and sends it to the motor cortex to execute the plan. The fact [that] it's involved in improvisation is not surprising, since it is a motor activity. The ACC is a part of the brain that appears to be involved in conflict monitoring — when you're trying to sort out two conflicting possibilities, like when you to read the word BLUE when it's printed in the color red. It's involved with decisionmaking, which also makes sense — improvisation is decision making, deciding what to play and how to play it." The IFG/vPMC is perhaps one of the most interesting findings of their study. "This area is known to be involved when people speak and understand language. It's also active when people hear and understand music. What we've shown is that it's involved when people create music."

Improvising, from a neurobiological perspective, involves generating, selecting, and executing musical-motor sequences, something that wouldn't surprise musicians. But in terms of brain research, it's a new piece of information. And each new study contributes to understanding different regions of the brain and the networks they make up, ultimately moving our understanding that much further.

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