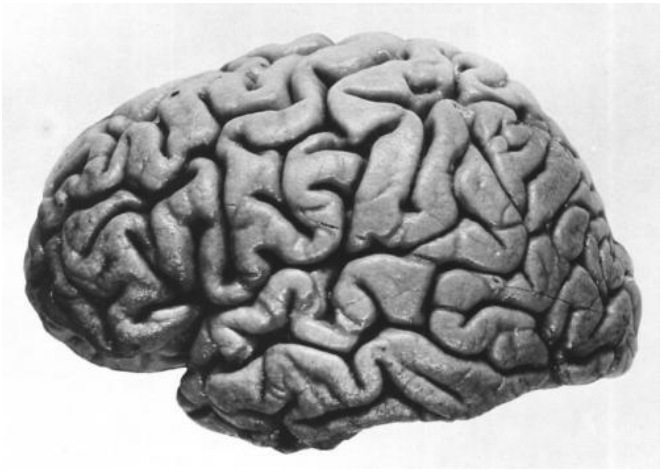
# Researchers tie unexpected brain structures to creativity—and to stifling it

28 May 2015



Left hemisphere of J. Pi?sudski's brain, lateral view. Credit: public domain

Investigators at Stanford University have found a surprising link between creative problem-solving and heightened activity in the cerebellum, a structure located in the back of the brain and more typically thought of as the body's movement-coordination center.

In designing the study, the researchers drew inspiration from the game Pictionary.

The cerebellum, traditionally viewed as the brain's practice-makes-perfect, movement-control center, hasn't been previously recognized as critical to creativity. The new study, a collaboration between the School of Medicine and Stanford's Hasso Plattner Institute of Design, commonly known as the d.school, is the first to find direct evidence that this brain region is involved in the creative process.

"Our findings represent an advance in our knowledge of the brain-based physiology of creativity," said the study's senior author, Allan Reiss, MD, professor of radiology and of psychiatry and behavioral sciences.

The study, to be published May 28 in *Scientific Reports*, also suggests that shifting the brain's higher-level, executive-control centers into higher gear impairs, rather than enhances, creativity.

"We found that activation of the brain's executive-control centers—the parts of the brain that enable you to plan, organize and manage your activities—is negatively associated with creative task performance," said Reiss, who holds the Howard C. Robbins Professorship in Psychiatry and the Behavioral Sciences.

"Creativity is an incredibly valued human attribute in every single human endeavor, be it work or play," he continued. "In art, science and business, creativity is the engine that drives progress. As a practicing psychiatrist, I even see its importance to interpersonal relationships. People who can think creatively and flexibly frequently have the best outcomes."

The collaboration began about 3 ½ years ago when Grace Hawthorne, MFA, MBA, a consulting associate professor at the d.school who teaches a design-thinking skills course called "Creative Gym," and one of her students approached Reiss, who has previously studied humor and other higher-level cognitive functions. They asked if he could objectively measure creativity, the better to confirm that Hawthorne's course can enhance it.

"We didn't know that much about how to do that," Reiss said. "So we decided to design a study that would give us baseline information on creativity's underlying neurophysiological processes."

**How do you measure creativity?**

As much as creativity may be in demand, it's not so easy to measure. At least 25 or 30 previous studies, mostly of professionally creative people

such as jazz musicians and Emmy Award winners, have tried to look at neural correlates of creativity, said the study's lead author, Manish Saggar, PhD, an instructor in psychiatry and a member of the teaching team at the d.school.

"Everybody wants to think creatively," Saggar said. "But how do you get somebody to actually do that on command? Forcing people to think creatively may actually hamper creativity."

The problem is exacerbated by the fact that subjects' brain processes are monitored while they're confined inside a dark, cramped MRI chamber. This environment is not exactly the first place that comes to mind when you're thinking about places where creativity can flower, Saggar said.

"Creativity has to be measured in a fun environment," he said. "Otherwise, you're bound to have anxiety and performance issues."

Saggar came up with the idea of borrowing an approach from Pictionary, a game in which players try to convey a word through drawing to help their teammates guess what the word is. He selected action words like "vote," "exhaust" and "salute." Then he, Reiss and their colleagues serially tested 14 men and 16 women in an MRI chamber, recording activity throughout their brains via functional MRI scans while they drew either a word or, for comparison, a zigzag line, which required initiation and fine-motor control but not much creativity. Participants were given 30 seconds per word, long enough for a decent scan but short enough to elicit spontaneous improvisation and stave off boredom.

"We didn't tell anyone, 'Be creative!' We just told them, 'Draw the word,'" Reiss said.

The drawings were captured on a special MRI-safe electronic tablet designed by study co-author Robert Dougherty, PhD, research director at the Stanford Center for Cognitive and Neurobiological Imaging. The drawings were then sent to Hawthorne and Adam Royalty, a researcher at the d.school and co-author of the study. Hawthorne and Royalty separately rated the drawings on five-point scales of appropriateness—did it depict what it was supposed to?—and creativity—how many elements were in the drawing? How elaborate was it? How original?

When they emerged from the MRI chamber, subjects were asked to rate the words they'd been asked to draw for relative difficulty. Increasing subjective difficulty of drawing a word correlated with increased activity in the left prefrontal cortex, an executive-function center involved in attention and evaluation. But high creativity scores later assigned by the raters were associated with low activity in the executive-function center. Higher creativity scores were associated with higher activation in the cerebellum.

On analysis, a number of brain areas were more active when subjects were engaged in drawing words than when they were drawing zigzag lines. Peak activation occurred in the cerebellum and regions of the cortex known to be involved in coordinating motor control or acting as a visual sketchpad. The latter regions' involvement in detailed drawing wasn't particularly surprising.

**'The more you think about it, the more you mess it up'**

But the heightened activity in the cerebellum was unexpected, as was its association with high creativity scores subsequently assigned by the raters. In monkeys, this brain region has been found to be especially active in learning and practicing new movements.

But those monkey findings may have thrown researchers off, Saggar said. Newer studies show that, unlike the monkey cerebellum, the human cerebellum has robust connections not only to the motor cortex, the brain's higher movement-control center, but to the other parts of the cortex as well.

"Anatomical and, now, functional evidence point to the cerebellum as doing much more than simply coordination of movement," Saggar said.

He and his colleagues speculate that the cerebellum may be able to model all new types of behavior as the more frontally located cortical

regions make initial attempts to acquire those behaviors. The cerebellum then takes over and, in an iterative and subconscious manner, perfects the behavior, relieving the cortical areas of that burden and freeing them up for new challenges.

"It's likely that the cerebellum is the coordination center for the rest of brain, allowing other regions to be more efficient," said Reiss.

"As our study also shows, sometimes a deliberate attempt to be creative may not be the best way to optimize your creativity," he said. "While greater effort to produce creative outcomes involves more activity of executive-control regions, you actually may have to reduce activity in those regions in order to achieve creative outcomes."

Saggar put it more bluntly. "The more you think about it, the more you mess it up," he said.

Provided by Stanford University Medical Center