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Thinking and choosing in the brain: Researchers study over 300 lesion patients

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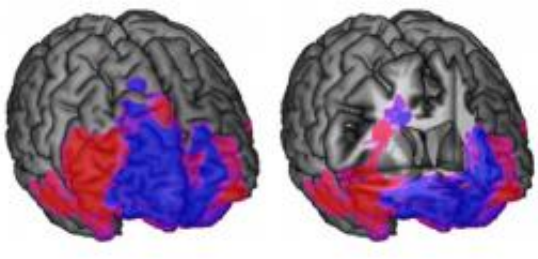

MRI scans of a human brain show the regions significantly associated with decision-making in blue, and the regions significantly associated with behavioral control in red. On the left is an intact brain seen from the front — the colored regions are both in the frontal lobes. The image on the right is that same brain with a portion of the frontal lobes cut away to show how the lesion map looks in the interior. [Credit: California Institute of Technology]

The frontal lobes are the largest part of the human brain, and thought to be the part that expanded most during human evolution. Damage to the frontal lobes—which are located just behind and above the eyes—can result in profound impairments in higher-level reasoning and decision making. To find out more about what different parts of the frontal lobes do, neuroscientists at the California Institute of Technology (Caltech) recently teamed up with researchers at the world's largest registry of brain-lesion patients. By mapping the brain lesions of these patients, the team was able to show that reasoning and behavioral control are dependent on different regions of the frontal lobes than the areas called

upon when making a decision.

Their findings are described online this week in the early edition of the *Proceedings of the National Academy of Sciences* (*PNAS*).

The team analyzed data that had been acquired over a 30-plus-year time span by scientists from the University of Iowa's department of neurology—which has the world's largest lesion patient registry. They used that data to map brain activity in nearly 350 people with damage, or lesions, in their frontal lobes. The records included data on the performances of each patient while doing certain cognitive tasks.

By examining these detailed files, the researchers were able to see exactly which parts of the frontal lobes are critical for tasks like behavioral control and decision making. The intuitive difference between these two types of processing is something we encounter in our lives all the time. Behavioral control happens when you don't order an unhealthy chocolate sundae you desire and go running instead. Decision making based on reward, on the other hand, is more like trying to win the most money in Vegas—or indeed choosing the chocolate sundae.

"These are really unique data that could not have been obtained anywhere else in the world," explains Jan Glascher, lead author of the study and a visiting associate in psychology at Caltech. "To address the question that we were interested in, we needed both a large number of patients with very well-measured lesions in the brain, and also a very thorough assessment of their reasoning and decision-making abilities across a battery of tasks."

That quantification of the lesions as well as the different task measurements came from several decades of work led by two coauthors on the study: Hanna Damasio, Dana Dornsife Chair in Neuroscience at the University of Southern California (USC); and Daniel Tranel,

professor or neurology and psychology at the University of Iowa.

"The patterns of lesions that impair specific tasks showed a very clear separation between those regions of the frontal lobes necessary for controlling behavior, and those necessary for how we give value to choices and how we make decisions," says Tranel.

Ralph Adolphs, Bren Professor of Psychology and Neuroscience at Caltech and a coauthor of the study, says that aspects of what the team found had been observed previously using fMRI methods in healthy people. But, he adds, those previous studies only showed which parts of the brain are activated when people think or choose, but not which are the most critical areas, and which are less important.

"Only lesion mapping, like we did in the present study, can show you which parts of the brain are actually necessary for a particular task," he says. "This information is crucial, not only for basic cognitive neuroscience, but also for linking these findings to clinical relevance."

For example, several different parts of the brain might be activated when you are making a particular type of decision, explains Adolphs. If there is a lesion in one of these areas, the rest of your brain might be able to compensate, leaving little or no impairment. But if a lesion occurs in another area, you might wind up with a lifelong disability in decision making. Knowing which lesion leads to which outcome is something only this kind of detailed lesion study can provide, he says.

"That knowledge will be tremendously useful for prognosis after brain injury," says Adolphs. "Many people suffer injury to their frontal lobes—for instance, after a head injury during an automobile accident—but the precise pattern of the damage will determine their eventual impairment."

According to Tranel, the team is already working on their next project, which will use lesion mapping to look at how damage to particular brain regions can impact mood and personality. " There are so many other aspects of human behavior, cognition, and emotion to investigate here, that we've barely begun to scratch the surface," he says.

More information: "Lesion Mapping of Cognitive Control and Value-based Decision-making in the Prefrontal Cortex," *Proceedings of the National Academy of Sciences.*

Provided by California Institute of Technology

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