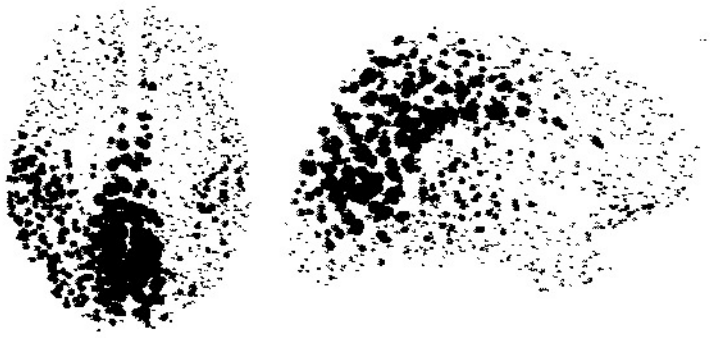
Scientists Identify the Brain's Activity Hub

By BENEDICT CAREY

The outer layer of the brain, the reasoning, planning and self-aware region known as the cerebral cortex, has a central clearinghouse of activity below the crown of the head that is widely connected to more-specialized regions in a large network similar to a subway map, scientists reported Monday.

The new report, published in the free-access online journal PLoS Biology, provides the most complete rough draft to date of the cortex's electrical architecture, the cluster of interconnected nodes and hubs that help guide thinking and behavior. The paper also provides a striking demonstration of how new imaging techniques focused on the brain's white matter — the connections between cells, rather than the neurons themselves — are filling in a dimension of human brain function that has been all but dark.

In previous studies, scientists have used magnetic resonance imaging to identify peaks and valleys of neural activity when people are doing various things, like making decisions, reacting to frightening images or reliving painful memories. But these studies, while provocative, revealed virtually nothing about the underlying neural networks involved — about which brain regions speak to one another and when. Previous estimates of network structure, based on such imaging, have been sketchy.



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NETWORKING Dots indicate the brain's busiest connections.

The new findings, while not conclusive, give scientists what is essentially a wiring diagram that they can test and refine.

"This is just about the coolest paper I've seen in a long time, and forward-looking in terms of where the science is going," said Dr. Marcus E. Raichle, a professor of neurology and radiology at Washington University in St. Louis, who was not involved in the research. He added, "They've found in the brain what looks like a hub map of the airline system for the United States."

In the study, a collaboration that included the University of Lausanne in Switzerland, Harvard and Indiana University, researchers studied the brains of five healthy male volunteers using a new technique called diffusion spectrum imaging. The technique allows scientists to estimate the density and orientation of the connections running through specific brain locations. Using a computer analysis of the results, the researchers ranked the busiest spots on the cortex in order, by the number of connections they had. Finally, they plotted those spots back onto the brain maps of the five volunteers.

The hubs clustered in each man's brain, in a region about the size of a palm, were centered atop the cortex like a small skullcap. "We haven't had a comprehensive map of the brain showing what is connected to what, and you really need the whole thing before you can ask certain questions, like what happens if activity is clogged up at one of the hubs? How does that effect function?" said Olaf Sporns, a psychologist at Indiana University and the senior author of the paper. His co-authors were Patric Hagmann, Leila Cammoun, Xavier Gigandet, Reto Meuli, Christopher J. Honey and Van J. Wedeen.

To check their findings, the researchers performed a standard functional M.R.I. scan on the participants, measuring which areas of their gray matter — which bundles of their brain cells — were most active when the men were at rest. Sure enough, the same areas overlapped with the network hubs that the group had already identified. In previous studies, activation in these areas has been associated with wandering thought and acute self-awareness. In the jargon of the field, these areas "run hot" continuously during waking hours and consume far more energy than more peripheral areas.

Dr. Sporns said continued research should help produce a complete and detailed neural wiring diagram, what he called the "connectome" of the brain. "We hope we can get to a place where we have, in effect, a brain simulator, in the same way we have computer models that can simulate the climate," he said, "so we can simulate activation patterns we see in clinical cases," like psychiatric problems and brain injuries.

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