What happens to your brain when your mind is at rest?

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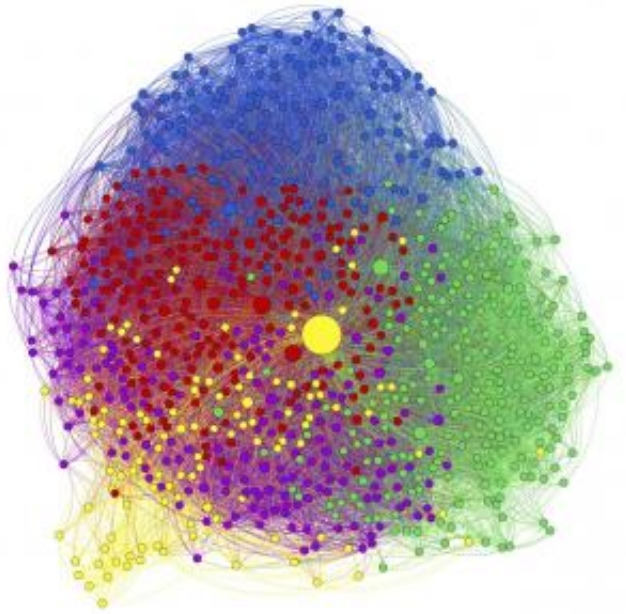

An image the human brain's default mode network, which was has come to be associated with many aspects of self representation including memory of personal events, evaluation of sensory information from the environment and body critical for decision making. It has been the focus of much recent work on the organization and function of the brain's ongoing, intrinsic activity. Credit: Marcus Raichle, Washington University

For many years, the focus of brain mapping was to examine changes in the brain that occur when people are attentively engaged in an activity. No one spent much time thinking about what happens to the brain when people are doing very little.

But Marcus Raichle, a professor of radiology, neurology, neurobiology and biomedical engineering at Washington University in St. Louis, has done just that. In the 1990s, he and his colleagues made a pivotal discovery by revealing how a specific area of the brain responds to down time.

"A great deal of meaningful activity is occurring in the brain when a person is sitting back and doing nothing at all," says Raichle, who has been funded by the National Science Foundation (NSF) Division of Behavioral and Cognitive Sciences in the Directorate for Social, Behavioral and Economic Sciences. "It turns out that when your mind is at rest, dispersed brain areas are chattering away to one another."

The results of these discoveries now are integral to studies of brain function in health and disease worldwide. In fact, Raichle and his colleagues have found that these areas of rest in the brain—the ones that ultimately became the focus of their work—often are among the first affected by Alzheimer's disease, a finding that ultimately could help in early detection of this disorder and a much greater understanding of the nature of the disease itself.

For his pioneering research, Raichle this year was among those chosen to receive the prestigious Kavli Prize, awarded by The Norwegian Academy of Science and Letters. It consists of a cash award of $1 million, which he will share with two other Kavli recipients in the field of neuroscience.

His discovery was a near accident, actually what he calls "pure serendipity." Raichle, like others in the field at the time, was involved in brain imaging, looking for increases in brain activity associated with different tasks, for example language response.

In order to conduct such tests, scientists first needed to establish a baseline for comparison purposes which typically complements the task under study by including all aspects of the task,

other than just the one of interest.

"For example, a control task for reading words aloud might be simply viewing them passively," he says.

In the Raichle laboratory, they routinely required subjects to look at a blank screen. When comparing this simple baseline to the task state, Raichle noticed something.

"We didn't specify that you clear your mind, we just asked subjects to rest quietly and don't fall asleep," he recalls. "I don't remember the day I bothered to look at what was happening in the brain when subjects moved from this simple resting state to engagement in an attention demanding task that might be more involved than simply increases in brain activity associated with the task.

"When I did so, I observed that while brain activity in some parts of the brain increased as expected, there were other areas that actually decreased their activity as if they had been more active in the 'resting state,'" he adds. "Because these decreases in brain activity were so dramatic and unexpected, I got into the habit of looking for them in all of our experiments. Their consistency both in terms of where they occurred and the frequency of their occurrence—that is, almost always—really got my attention. I wasn't sure what was going on at first but it was just too consistent to not be real."

These observations ultimately produced ground-breaking work that led to the concept of a default mode of brain function, including the discovery of a unique fronto-parietal network in the brain. It has come to be known as the default mode network, whose regions are more active when the brain is not actively engaged in a novel, attention-demanding task.

"Basically we described a core system of the brain never seen before," he says. "This core system within the brain's two great hemispheres increasingly appears to be playing a central role in how the brain organizes its ongoing activities"

The discovery of the brain's default mode caused Raichle and his colleagues to reconsider the idea that the brain uses more energy when engaged in an attention-demanding task. Measurements of brain metabolism with PET (positron emission tomography) and data culled from the literature led them to conclude that the brain is a very expensive organ, accounting for about 20 percent of the body's energy consumption in an adult human, yet accounting for only 2 percent of the body weight.

"The changes in activity associated with the performance of virtually any type of task add little to the overall cost of brain function," he continues. "This has initiated a paradigm shift in brain research that has moved increasingly to studies of the brain's intrinsic activity, that is, its default mode of functioning."

Raichle, whose work on the role of this intrinsic brain activity on facets of consciousness was supported by NSF, is also known for his research in developing and using imaging techniques, such as positron emission tomography, to identify specific areas of the brain involved in seeing, hearing, reading, memory and emotion.

In addition, his team studied chemical receptors in the brain, the physiology of major depression and anxiety, and has evaluated patients at risk for stroke. Currently, he is completing research studying what happens to the brain under anesthesia.

"The brain is capable of so many things, even when you are not conscious," Raichle says. "If you are unconscious, the organization of the brain is maintained, but it is not the same as being awake."

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