Study: A rich club in the human brain

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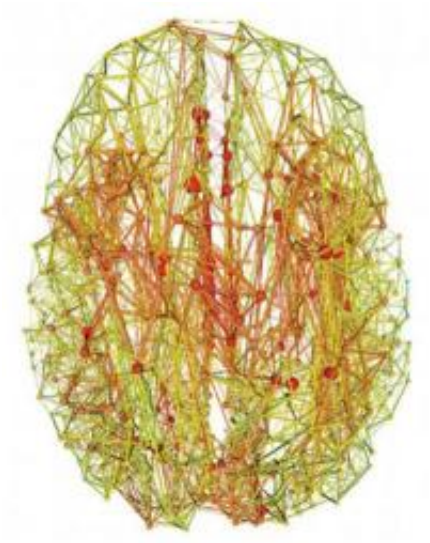

This image shows the group connectome, with the nodes and connections colored according to their rich-club participation. Green represents few connections. Red represents the most. Credit: Reprinted with permission: Van den Heuvel, et al. *The Journal of Neuroscience* 2011

Just as the Occupy Wall Street movement has brought more attention to financial disparities between the haves and have-nots in American society, researchers from Indiana University and the University Medical Center Utrecht in The Netherlands are highlighting the disproportionate influence of so called "Rich Clubs" within the human brain.

Not all regions of the brain, they say, are created equal.

"We've known for a while that the brain has some regions that are 'rich' in the sense of being highly connected to many other parts of the brain," said Olaf Sporns, professor in the Department of Psychological and Brain Sciences in IU's College of Arts and Sciences. "It now turns out that these regions are not only individually rich, they are forming a 'rich club.' They are strongly linked to each other, exchanging information and collaborating."

The study, "Rich-Club Organization of the Human Connectome," is published in the Nov. 2 issue of the Journal of Neuroscience. The research is part of an ongoing intensive effort to map the intricate networks of the human brain, casting the brain as an integrated dynamic system rather than a set of individual regions.

Using diffusion imaging, which is a form of MRI, Martijn van den Heuvel, a professor at the Rudolf Magnus Institute of Neuroscience at University Medical Center Utrecht, and Sporns examined the brains of 21 healthy men and women and mapped their large-scale network connectivity. They found a group of 12 strongly interconnected bihemispheric hub regions, comprising the precuneus, superior frontal and superior parietal cortex, as well as the subcortical hippocampus, putamen and thalamus. Together, these regions form the brain's "rich club".

Most of these areas are engaged in a wide range of complex behavioral and cognitive tasks, rather than more specialized processing such as vision and motor control. If the brain network involving the rich club is disrupted or damaged, said Sporns, the negative impact would likely be disproportionate because of its central position in the network and the number of connections it contains. By contrast, damage to regions outside of the rich club would likely cause specific impairments but would likely have little influence on the global flow of information throughout the brain.

Sporns said the cohesive nature of the rich club's interconnections was surprising and unexpected. It would not have been implausible to have highly connected nodes that did not interact or influence each other to the same degree.

"You sort of wonder what they're talking about when they're communicating with each other," he said. "All these regions are getting all kinds of highly processed information, from virtually all parts of the brain."

The rich club, said van den Heuvel, might be the "G8 summit of our brain."

"It's a group of highly influential regions that keep each other informed and likely collaborate on issues that concern whole brain functioning," he said. "Figuring out what is discussed at this summit might be an important step in understanding how our brain works."

Sporns said he and van den Heuvel hope the findings and subsequent research could shed light on the network basis of brain disorders affecting mental health. Van den Heuvel's prior research has already shown characteristic disturbances of brain networks in schizophrenia. Whether these disturbances specifically affect the brain's rich club is an open question.

Interest in creating a comprehensive map of the human brain's neural connections, the connectome, has accelerated in the last few years. In the U.S., the National Institutes of Health are currently funding a project involving a consortium of more than 70 scientists, including Sporns, who are working together to create a first map of the human connectome. Similar projects are planned or already under way in Europe and Asia.

"People are coming around to the idea that mapping the connectome is

not only technically feasible but also very important to do," Sporns said. "It's a fundamental step towards understanding the brain as a networked system. Networks are everywhere these days, found in technology, social media and economics, ecology and systems biology -- They're becoming more and more central in many areas of science. The human brain is perhaps the most challenging example to date."

Provided by Indiana University