

 NEURONAL NETWORKS

## In the rich club

Within the brain's networks, certain key regions have been revealed to be 'hubs' — they form many connections with other brain areas and have a large influence on overall network organization. In a new study, van den Heuvel and Sporns now show that these hub regions are also highly mutually interconnected, forming a 'rich club' of brain areas that are crucial for efficient brain communication.

The authors performed diffusion tensor imaging on 21 healthy individuals and used these data to determine the structural connectivity of 68 cortical regions and 14 subcortical regions. Next, the authors examined the data in more

detail by applying graph theory, a mathematical approach that enables the properties of complex networks to be profiled. This analysis revealed the presence of a rich-club core in the brain's network: a set of 12 hub regions that are more densely interconnected than any other sets of brain regions, and to which almost all of the other regions examined are connected. These comprised regions with known roles in fundamental aspects of brain function, including the precuneus, superior frontal and parietal cortex, hippocampus, putamen and thalamus.

To determine the importance of these rich-club regions in overall network function, the authors simulated the effects of 'attacks' that damage particular nodes (or brain regions) by reducing the weights of their connections. They found that targeted attacks on regions that comprised the rich club had a much greater effect on network efficiency than random attacks that could affect any part of the network.

These results add new information to our growing understanding of network organization in the brain. The existence of a rich club of brain regions that are particularly important for overall communication in the brain provides clues as to how diseases that affect these key regions might affect overall brain function.

*Katherine Whalley*

“ targeted attacks on regions that comprised the rich club had a much greater effect on network efficiency than random attacks ”



**ORIGINAL RESEARCH PAPER** van den Heuvel, M. P. & Sporns, O. Rich-club organization of the human connectome. *J. Neurosci.* **31**, 15775–15786 (2011)

**FURTHER READING** Bullmore, E. & Sporns, O. Complex brain networks: graph theoretical analysis of structural and functional systems. *Nature Rev. Neurosci.* **10**, 186–198 (2009)