Medical Xpress

Network measures predict neuropsychological outcome after brain injury

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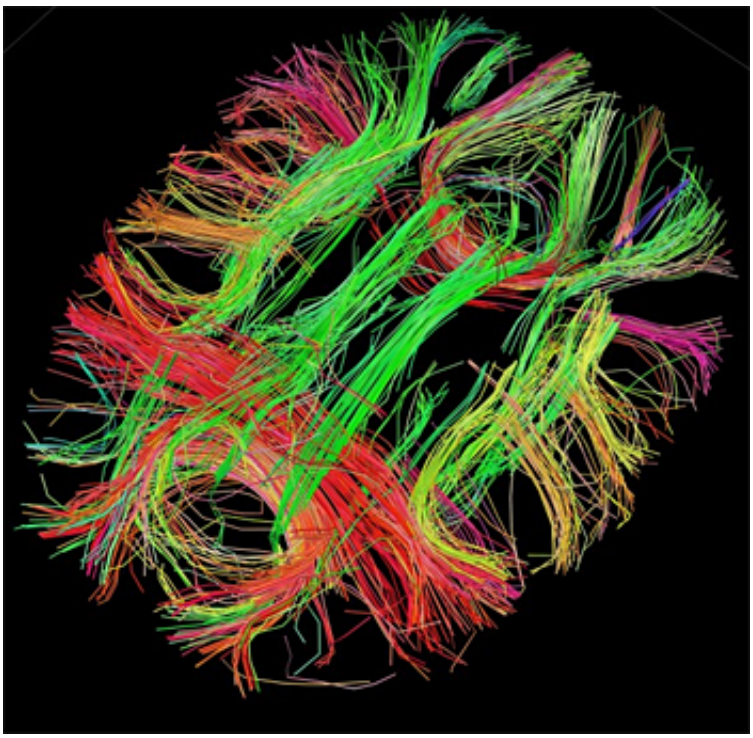

White matter fiber architecture of the brain. Credit: Human Connectome Project.

Cognitive neuroscience research has shown that certain brain regions are associated with specific cognitive abilities, such as language, naming, and decision-making.

How and where these specific abilities are integrated in the brain to support complex cognition is still under investigation. However, researchers at the University of Iowa and Washington University in St. Louis, Missouri, believe that several hub regions may be especially important for the brain to function as an integrated network.

In research published online Sept. 15 in the Early Edition of the *Proceedings of the National Academy of Sciences*, scientists studied neurological patients with focal brain damage, and found that damage to six hub locations—identified in a model developed at Washington University using resting state fMRI, functional connectivity analyses, and graph theory—produced much greater cognitive impairment than damage to other locations.

Doctors have long observed that despite having similar locations or extent of brain injury, patients often present with wide-ranging degrees of impairment and exhibit different recovery trajectories. A better understanding of brain networks and hubs may improve the understanding of outcomes of brain injuries (for example, stroke, resection, or trauma) and help inform prognosis and rehabilitation efforts.

"We were able to identify a set of brain hubs and show that damage to those locations unexpectedly causes widespread cognitive impairments," says David Warren, cognitive neuroscientist at the University of Iowa and lead study author. "We hope that this framework will help neurologists with diagnosis and prognosis, and neurosurgeons with surgical planning."

Two contrasting views of brain hubs exist. One view focuses on the sheer number of connections between brain regions, with those regions showing the most connections considered hubs.

Warren and his colleagues contend that the number of connections a given region makes may not reflect the importance of a region to network function because it can be strongly influenced by network size. Instead, their framework defines hubs as brain regions that show correlated activity with multiple brain systems (rather than regions). The authors predicted that because hubs should be critical for brain function and complex cognition, damage to true hubs should produce widespread cognitive impairment.

This study evaluated long-term cognitive and behavioral data in 30 patients in the Iowa Neurological Patient Registry—19 with focal damage to one of the authors' six target hub locations and 11 with damage to two control locations that fit the alternative hub definition.

On average, patients with lesions to target hubs had significant impairment in nine major cognitive domains—orientation/attention, perception, memory, language skills, motor performance, concept formation/reasoning, executive functions, emotional functions, and adaptive functions. In contrast, the group with lesions to control hubs was significantly impaired in just three of the nine domains (executive functions, emotional functions, and adaptive functions).

Additionally, the target group had significantly greater cognitive deficits than the control group in seven of nine domains (all except perception and emotional functions), again showing the widespread cognitive effects of target hub lesions.

"With a grant from the McDonnell Foundation, we're planning to follow up by exploring the effects of damage to additional brain hubs, examining how damage to hubs alters brain activation, and studying neurosurgery patients prospectively before and after their surgeries," says senior study author Daniel Tranel, professor of neurology in the UI Carver College of Medicine and psychology in the College of Liberal

Arts and Sciences. "We think that this work could have a tremendous influence on clinical practice."

More information: Network measures predict neuropsychological outcome after brain injury, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1322173111

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