Neuroscientists propose new theory of brain flexibility

November 15 2007

Carnegie Mellon University neuroscientist Marcel Just and Stanford postdoctoral fellow Sashank Varma have put forward a new computational theory of brain function that provides answers to one of the central questions of modern science: How does the human brain organize itself to give rise to complex cognitive tasks such as reading, problem solving and spatial reasoning? Just and Varma's theory, called 4CAPS, is described in the fall issue of the journal *Cognitive, Affective, and Behavioral Neuroscience*.

More than a decade of research involving functional Magnetic Resonance Imaging brain scans in hundreds of laboratories has yielded a tremendous amount of information about what parts of the brain are activated when a person performs various tasks. Some researchers have been tempted to conclude that a simple one-to-one relationship exists between high-level mental tasks and brain areas. For example, some believe that a specific brain area is responsible for a specific cognitive task, such as identifying a face.

Just and Varma, however, propose that the evidence reveals a more complex picture in which thinking is a network function — a collaboration of several brain areas that is constantly adapting itself, based on the task at hand and the brain's own resources and biological limitations. The collaborating parts of the brain, according to Just, are like members of a sports team whose players substitute in and out of the action. 4CAPS (an acronym for Capacity Constrained Concurrent Cortical Activation-based Production System), proposes a decentralized process by which members of the cortical team volunteer themselves when their strengths are called for, but also permits less efficient but capable members to step forward when the primary player is injured or disabled, as might occur as a result of a stroke. Just and Varma have constructed a number of computational models to demonstrate this process, such as a model that understands English sentences.

A unique characteristic of the theory is that it can accurately predict the change in brain activation that results from some types of brain damage or disease. For example, if a stroke damages the part of the brain known as Broca's area — which is located in the left prefrontal cortex and is involved in language processing — the corresponding site on the right side of the brain often becomes activated during language processing, even within hours after a stroke. According to 4CAPS, the same dynamic allocation mechanism that allows brain areas to volunteer themselves on a moment-by-moment basis would also come into play if Broca's area were damaged, and would allow any excess computational load to spill over to the right hemisphere mirror site on a more permanent basis. Another example occurs with Alzheimer's disease, where the damage to some brain areas causes additional "helper" areas to be recruited to perform a task, additional areas that are not typically used by control subjects who do not have the disease.

"Many brain-imaging studies have shown as the nature of the task changes, so does the set of activating brain areas," said Just, the D.O. Hebb Professor of Psychology. "It is as though substitutions of team players are being made dynamically in response to changes in the game."

"We credit this dynamic mechanism with the fluidity or adaptability of human intelligence, and with much of the plasticity that occurs with learning or with recovery from brain damage," Just said.

4CAPS provides a framework for scientists and medical researchers to better understand nascent topics in neuroscience, such as how brain areas communicate and collaborate with one another during the thought process and how this can go awry. For example, Just and his colleagues have proposed an influential theory of autism, called the underconnectivity theory, that attributes the disorder to poor connectivity and hence communication between frontal areas of the brain and more posterior areas. The individual areas still have their specializations, according to the theory, but they cannot communicate as well with each other, and may develop a tendency to operate more independently of each. The theory also provides an account of what limits our ability to do multitasking.

"The thousands of facts that scientists have learned from brain imaging studies cry out for some sort of organization, some way to impose coherence, and ultimately to understand the brain system that is producing the results," Just said. "The theory provides a new conceptual framework for understanding how the fluidity of thought arises from the dynamics of brain activity.

"As neurological issues arise in education, aging and development, and as a basis for a knowledge-based economy, it will become increasingly important that human brain function be understood by students, parents and educators, patients and doctors, trainees and managers, citizens and policy-makers."

Source: Carnegie Mellon University

Citation: Neuroscientists propose new theory of brain flexibility (2007, November 15) retrieved 25 April 2024 from
https://medicalxpress.com/news/2007-11-neuroscientists-theory-brain-flexibility.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.