NEWS

New map of brain’s surface unites structure, function

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Researchers have charted the human cerebral cortex in unprecedented detail, adding to what is known about the brain’s bumpy outer layer. The map could serve as a reference to help researchers identify alterations in the brains of people with autism[1].

The cortex has distinct regions with specialized functions that are not obvious to the naked eye, but microscopes and brain scans can reveal variations in its structure and function. Existing maps of the cortex are typically based on a single anatomical or functional feature. The new map, described 20 July in *Nature*, combines four measures: cortical thickness, the amount of insulation around nerves and two types of neural activity patterns.

“We’ve got reasonably accurate descriptions of nearly all of the major cortical areas,” says lead investigator **David Van Essen**, alumni endowed professor of neuroscience at Washington University in St. Louis, Missouri.

The map plots previously unmapped regions of the cortex and divides established ones into parts, giving researchers an expanded view of the brain. “There’s a lot more going on and a lot more detail there than we ever imagined,” says **Kevin Pelphrey**, director of the Autism and Neurodevelopmental Disorders Institute at George Washington University in Washington, D.C., who was not involved in the work.

Cortical compartments:

German neuroanatomist Korbinian Brodmann drew one of the first maps of the cerebral cortex by hand in 1909 after examining postmortem brains under a microscope. Brodmann’s map has 52 regions marked by distinct cell types and arrangements.

Since then, researchers have divvied up the cortex in various ways. Magnetic resonance imaging

(MRI) reveals the thickness of different regions and the amount of insulation around neurons. Functional MRI (fMRI) shows areas that operate in sync.

Each approach provides a different view, Van Essen says, “but no one method can do it all to our collective satisfaction.”

To create the new map, Van Essen and his colleagues drew on MRI and fMRI scans of 210 typical young men and women. The team collected the data as part of the **Human Connectome Project**, a $30 million effort launched in 2010 to map neuronal connections in the brain.

The researchers aligned measures of cortical thickness, neuron insulation and brain activity patterns for each brain. They then linked and averaged the data for all 210 participants and devised an algorithm that detects borders between cortical regions. These borders are based on sharp contrasts in at least two of the measures.

“Our strategy was to insist that we have agreement from at least two different types of information before we would accept a border between areas as being robust and real,” Van Essen says.

Personalized plots:

The resulting mosaic depicts 180 distinct regions in each of the brain’s hemispheres. After comparing their map with previous efforts, the researchers determined that 97 of their regions are new to neuroscience.

Some of these newfound regions are subdivisions of known ones. For example, the new map splits the dorsolateral prefrontal cortex — a region governing working memory, planning and attention — into 13 districts. Other areas had been largely uncharted. For example, the researchers discovered three sections along a groove at the back of the brain that seem to integrate visual information with higher-order cognition.

Van Essen’s team also devised an algorithm to generate a map of the brain of each individual in the study, revealing variations in cortical boundaries. For example, a language region dubbed ‘55b’ in most people lies between two areas involved in eye movement. But in 4 percent of individuals, the area is shifted slightly upward, swapping places with a neighboring area. And in 6 percent of people, it is in two pieces.

This individual-level analysis moves the field beyond group averages, says **Dan Kennedy**, assistant professor of psychological and brain sciences at Indiana University in Bloomington, who was not involved in the study. “It allows you to study individual differences and heterogeneity, which are important things for autism researchers to do.”

Border patrol:

The researchers validated their approach using Connectome Project brain scans from another 210 typical adults. The algorithm for individuals detected 96.6 percent of the original 360 divisions in the new set of participants, and the boundaries were similar to those in the original map.

The similarities between the maps drawn from these two sets of brains are striking, says **Nicholas Lange**, associate professor of psychiatry at Harvard University, who was not involved in the work. “This to me is really outstanding, showing the generalizability and reproducibility of this map.”

The researchers plan to release their algorithms once they finish refining them. The **data and map** are already available, although the map is certain to evolve over time.

“What we don’t have is the equivalent of satellite imagery and Google maps that go down to exquisitely high resolution of the Earth’s surface,” Van Essen says. “It’s a sobering reminder of how much further there is to go to decipher what’s really going on inside any individual person’s brain.”

REFERENCES:

1. Glasser M.F. *et al. Nature* Epub ahead of print (2016) **PubMed**