Brain work

Alun Anderson

Scientists will begin to map the wiring, or "connectome", of the human brain

Human brains are the most complex objects in the known universe. Inside each one are some 100 billion nerve cells wired together with a million billion connections. No computer comes close to its complexity, nor does the entire global telecommunications network, which connects only 5 billion mobile phones. In sheer numbers, the brain is just beaten by the Milky Way with its 200 billion or more stars, but they are spread across 100,000 light years, not packed into a one-and-a-half-litre capacity skull.

New brain-imaging technology, a sophisticated descendant of the magnetic resonance imaging (MRI) scanners found in many hospitals, is now making it possible to see inside living brains. With support from America's National Institutes of Health, a consortium of scientists around the world, led by Washington University in St Louis and the University of Minnesota, is working together on the Human Connectome Project. The goal is to chart the brain's major connections, see how they vary between individuals and figure out which parts of the brain work together in networks, something anatomists could never do by looking at slices of brain under a microscope. In the preliminary phase of the project, scanners have been fine-tuned and programs which visualise their data developed to provide brain-connection maps of extraordinary power and beauty. In mid-2012 the excitement will really begin as the first of 1,200 volunteers to have their brains scanned will enter the machines. Data from the first 100 of them will be made public in the autumn.

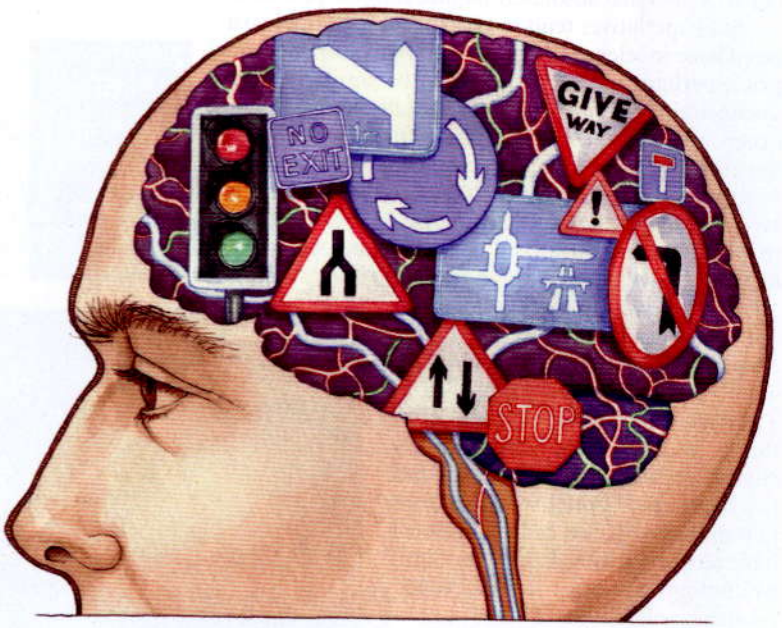
The project will open up a whole new way of thinking about the brain

Main roads of the mind

The new technology is not intended to map the bewildering detail of every single nerve cell and their connections, although other scientists are already scoring successes in doing just that for microscopic areas of animal brains and will one day extend their work to the human brain. The connectome maps will resolve features down to around a cubic millimetre of brain tissue, each of which contains hundreds of thousands of nerve cells. That resolution should provide an understandable "macroeconomic" view of the brain, making it possible to chart its key divisions and the highways that carry traffic between them (much as a map drawn to make sense of the world economy might show nations, industrial centres and the connecting trade routes, but not every working person on the planet).

New discoveries are likely. In the cerebral cortex there are about 50 areas for which good maps already exist, but they cover only about a third of the cortex, explains David Van Essen, a Washington University neuroscientist. "If this were a continent that is being explored, it is as if we have good maps of the geographic subdivisions along the fringes but there is an unknown interior. That is totally fascinating because it is where many of our higher brain functions are carried out."

Much interest will lie in comparing the brain maps from the volunteers who will be scanned. Many come in family groups that have been chosen to include identical twins as well as other siblings, making it easier to tease apart how nature and nurture affect the wiring plan of the brain. "We can explore not only the typical connections of the human brain but its dramatic variability, the differences from one individual to another that make us think and perceive and act differently," says Dr Van Essen. That in turn may give new insights into brain disorders, as there is already evidence of circuit abnormalities in autism and schizophrenia.



The focus on the brain's connections, rather than using scanners to simply look at which areas of the brain light up when we do different tasks, is itself a reflection of a deepening understanding that complex systems—whether the brain, the economy or society—are best understood as interactive, dynamic networks which operate as a whole. Olaf Sporns, a theoretical neuroscientist at Indiana University who was the first to propose that the human connectome should be mapped, thinks the project will open up a whole new way of thinking about the brain. "Perhaps we will have in the end a glimpse of the brain that reveals its basic plan," he says. "And the whole structure will be much more understandable than it is now." ■

Alun Anderson: science journalist and author

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