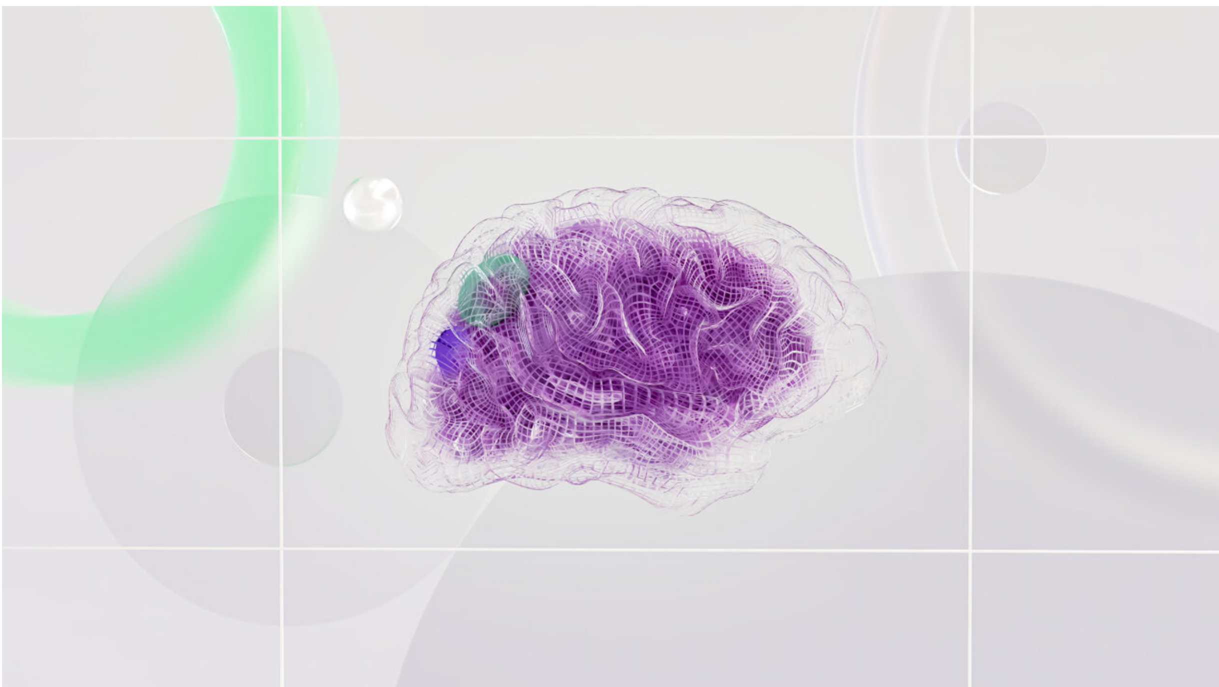
Medical Xpress

Recording the entire nervous system in real time will unlock secrets of the brain

August 12 2015, by Risto Kauppinen



Credit: Google DeepMind from Pexels

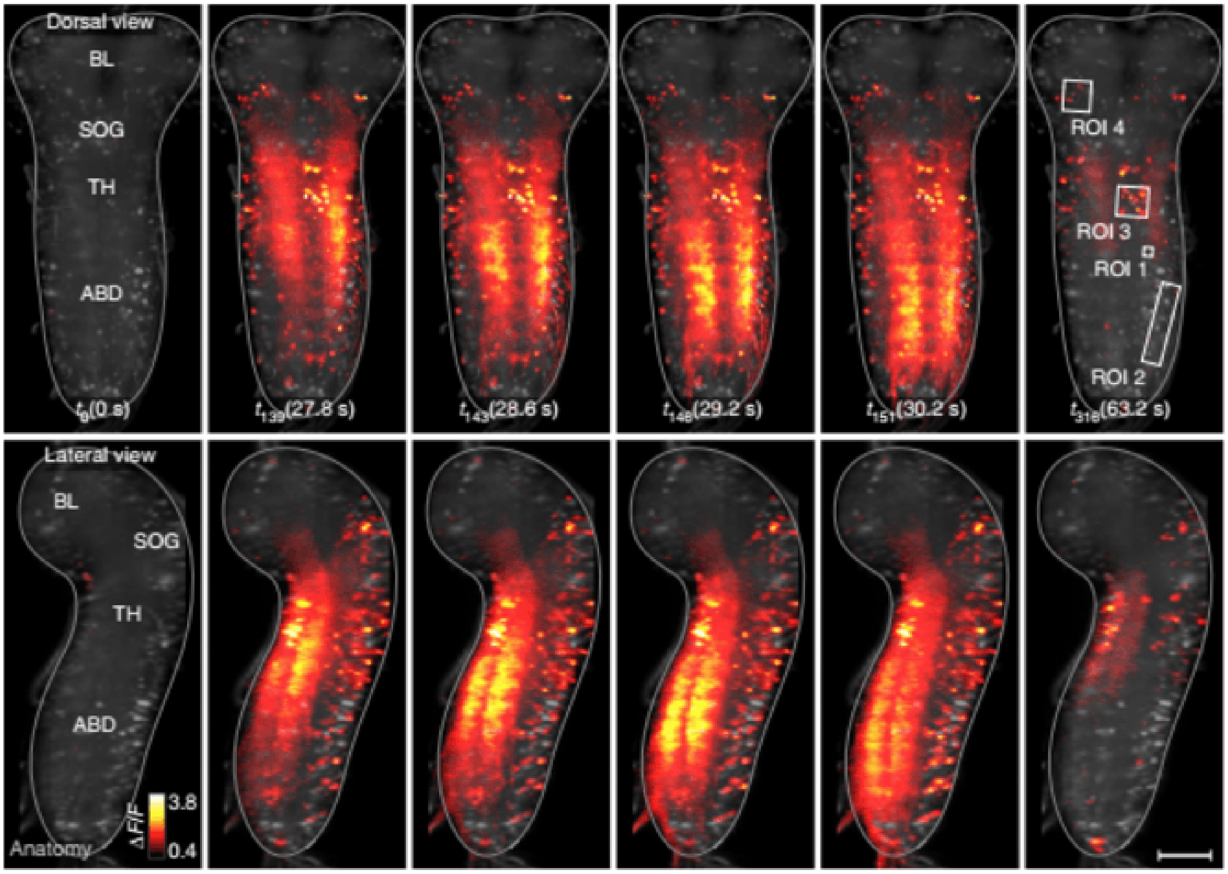
There are around 100 billion neurons in the human brain, each connected to hundreds of neighbours. Analysing the link between neural activity in the brain, and the behaviour that causes it, could shed light on both areas. Now, a team of scientists has engineered imaging techniques to map neuronal firing in an entire nervous system at high speed, an approach which might one day unlock our understanding of animal behaviour.

Science has already uncovered much about the nervous system, so we have a fairly comprehensive picture of how the central nervous system (CNS) functions at the microscopic and molecular level.

The next step is to scale up our understanding of how these functions work at the level of the entire nervous system. The first nervous structural connection map of this kind, of *C. Elegans*, a tiny worm with only 302 neurons, was published in 1986. But today's neuroscientists can go much further, combining structural and functional connections to understand how they operate – a field referred to as connectomics.

Making connections

Connectomics draws scientists from engineering, physics, chemistry and computer sciences into neuroscience, where a variety of techniques using advanced equipment can generate images, called multimodal imaging. We expect connectomics to unveil the biology that lies behind the mental and physical processes required when organisms execute complex tasks and, ultimately, to reveal the neural basis of our cognitive behaviour.



Neurons firing in the central nervous system of a Drosophila larva. The time sequence goes from left to right. Credit: Lemon et al/Nature

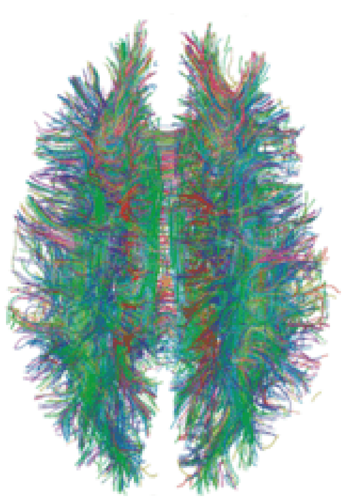
These images are created by probing tissues with a combination of different imaging methods, such as the MRI scanning and EEG commonly employed in hospitals. Because each method targets a different aspect of the brain, multimodal imaging is the ideal approach to generate an image that represents the functioning of an entire system.

Using these and other techniques, a team of neuroscientists have monitored neuronal network activity over the entire central nervous system of a fruit fly larva. The the fruit fly (*Drosophila*) larva has a central nervous system small enough to be confined within a microscope's field of view.

High speed and fine detail

Engineers constructed a high-speed simultaneous multi-view (hs-SiMView) microscope, capable of taking images of anatomy on microscopic scales and recording the firing of neurons by capturing images five times every second.

The high sampling frequency is achieved by moving both the light source and detection planes together, relative to the stationary object, to create 3D image data. Using the equipment, the study's authors were able to image the central nervous system and ventral nerve cord (like the spinal cord in mammals) of *Drosophila* larvae. They captured more 10,000 neurons firing while the the central nervous system was artificially excited in patterns that mimicked crawling backward and forward.



White Matter Connections obtained with MRI tractography. Credit: Xavier Gigandet et al, CC BY

The aim was to understand how high-order control centres in the brain coordinate basic movement. The results were functional maps of neural networks in the fruit flies, highlighting how individual neurons were connected and how their firing patterns controlled movement. These neural circuit maps form the first functional connectomics ever made of the neuronal activity behind movement control at high spatial resolution. Future studies could look at other movements or circumstances and continue to build a more comprehensive map of *Drosophila* – a major achievement for neuroscience.

From flies to mammals

The US has launched the BRAIN initiative to use this kind of technology to learn more about the human brain, modelling functional systems like the retina. Being able to simultaneously detect the firing of neurons at micrometre resolution, several times per second isn't possible yet for the complex mammalian nervous system, but projects such as the Human Connectome Project have made great progress, creating imaging hardware that suits human brain structures.

MRI is one of the key avenues of exploration due to its non-invasive nature and good resolution. Scientists working at the Human Connectome Project have provided stunning images of structural connections in human white brain matter using a dedicated MRI scanner. This is still at an early stage, yet further technical developments are likely to yield new knowledge about the structural and functional connectivity of the human brain.

Source: The Conversation