Medical Xpress

Scientists map the frontiers of vision

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There's a 3-D world in our brains. It's a landscape that mimics the outside world, where the objects we see exist as collections of neural circuits and electrical impulses.

Now, scientists at the Salk Institute for Biological Studies are using new tools they developed to chart that world, a key step in revolutionizing research into the neurological basis of vision.

For the first time, the scientists have produced neuron-by-neuron maps of the regions of the mouse brain that process different kinds of visual information, laying the groundwork for decoding the circuitry of the brain using cutting-edge, genetic research techniques only possible in mice.

"In the field of cognitive research, this puts the mouse on the map - by putting the map on the mouse," says James Marshel, a Salk research associate. Marshel and Marina Garrett, a graduate student at University of California San Diego, were lead authors on a paper reporting the advance in the December 22 issue of *Neuron*.

To understand the extraordinarily complex computations of the human brain, including those behind visual cognition, scientists have mostly relied on studies on primates, such as monkeys, our closest relatives in the animal kingdom, and the most like us in terms of cognitive ability.

Researchers have identified what portions of the primate brain process different aspects of the sensory information they gather from the outside world. In particular, a great deal is known about what regions of the primate brain process certain visual information, helping them identify objects and follow their movements in three-dimensional space.

"We've learned a lot about how our eyes feed information to our brains, and a huge portion of our brain is devoted to processing this information," says Edward Callaway, a professor in Salk's Systems Neurobiology Laboratory, whose laboratory conducted the research. "Vision is a terrific system for understanding how the brain works and, ultimately, for studying mental diseases and consciousness."

Powerful new scientific tools are emerging that could allow scientists to better understand the human brain by studying the relatively simpler brains of mice. These methods allow scientists to alter genes, the instructions in DNA that control the behavior of cells - including the neurons that form brain circuits. By using genetic methods for mapping brain connections and controlling the activity of cells, scientists hope to generate detailed wiring diagrams of the brain and probe how these circuits function.

"While mice can not replace the work that is being done in monkeys, these research techniques are much further along in mice than in monkeys," Callaway says. "The ability to modify neural activity using genetic tools and to study the resulting changes in brain and nerve activity is revolutionizing neuroscience."

Although such genetic engineering techniques in mice offer huge potential, little was known about what areas of the mouse visual cortex - the high-level brain region that computes the meaning of signals from the eyes - were responsible for processing different elements of the visual information.

To remedy this, Callaway and his colleagues set out to chart a map of the mouse's visual processing system. They injected mice with a calcium-sensitive fluorescent dye that glows when exposed to a certain color of light. The amount of calcium in nerve cells varies depending on the activity level of the neurons, so the scientists could measure the activity of brain cells based on how brightly they glowed.

The scientists then displayed different types of visual stimulus on a television monitor and recorded what parts of the brain glowed. To make the recordings, they used a high-resolution camera capable of discerning the activity of individual nerve cells.

They found that a mouse's visual field, the area of three-dimensional space visible through its eyes, is represented by a corresponding collection of neurons in its brain. The researchers precisely recorded which neurons were associated with which area of the animal's visual field.

The scientists studied seven different areas of the animal's visual cortex containing full neuronal "maps" of the visible outside world, and found that each area has a specialized role in processing visual information. For instance, certain areas were more sensitive to the direction objects move in space, while other areas were focused on distinguishing fine detail.

With these maps of brain function in hand, the Salk researchers and others now have a baseline against which they can compare the brain function of mice in which circuit function is manipulated using genetic methods. Ultimately, Callaway says, understanding in detail how the mouse brain works will illuminate the workings of the human mind.

"This gives us new ways to explore the neural underpinnings of consciousness and to identify what goes wrong in neural circuits in the case of diseases such as schizophrenia and autism," Callaway said.

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