Single-Cell Recognition Research Finds a Halle Berry Neuron

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World travelers instantly identify the architectural sails of the Sydney Opera House from most any angle. Movie aficionados immediately recognize Oscar-winner Halle Berry beneath her "Catwoman" costume or in an artist's caricature. Even the letters of her name — "H-A-L-L-E-B-E-R-R-Y" — conjure a concept in the mind's eye.

But how does the human brain translate varied and even abstract visual images into a single instantly and consistently recognizable concept? A research team led by neuroscientists at UCLA and the California Institute of Technology shows the process begins with a single brain cell.

Reporting in the June 23 edition of the peer-reviewed journal Nature, the research team finds that individual neurons are able to recognize people, landmarks and objects — even letter strings of names. The findings suggest a consistent, sparse and explicit code that may play a role in transforming complex visual representations into long-term and more abstract memories.

"This new understanding of individual neurons as 'thinking cells' is an important step toward cracking the brain's cognition code," said senior investigator Dr. Itzhak Fried, professor of neurosurgery at the David Geffen School of Medicine at UCLA and professor of psychiatry and biobehavioral sciences at the Semel Institute for Neuroscience and Human Behavior at UCLA. "As our understanding grows, we one day may be able to build cognitive prostheses to replace functions lost due to brain injury or disease, perhaps even for memory."

"Our findings fly in the face of conventional thinking about how brain cells function," said senior investigator Christof C. Koch, the Lois and

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Victor Troendle Professor of Cognitive and Behavioral Biology, professor of computation and neural systems at Caltech. "Conventional wisdom views individual brain cells as simple switches or relays. In fact, we are finding that neurons are able to function more like a sophisticated computer."

This study is the latest of several landmark observations made in recent years by the UCLA team, which is probing the underpinnings of the human mind at the single-neuron level in humans. Two years ago they identified single cells in the human hippocampus specific to places during human navigation.

The body of work is an example of the power of neurobiological research using data drawn directly from inside a living human brain. Most neurobiological research involves animals, post-mortem tissue or imaging.

In contrast, Fried and his UCLA team draw data directly from the brains of consenting clinical patients with epilepsy at UCLA Medical Center who have been wired with intracranial electrodes to identify the seizure origin for potential surgical treatment.

"Our ability to record directly from the living brains of consenting clinical patients is an invaluable tool for unraveling neural mysteries more efficiently and accurately," Fried said.

For the latest study, the research team recorded responses from the medial temporal lobe, which plays a major role in human memory and is one of the first regions affected in patients with Alzheimer's disease. Responses by individual neurons appeared on a computer screen as spikes on a graph.

In the initial recording session, subjects viewed a large number of images of famous people, landmark buildings, animals, objects and additional images chosen after an interview. To keep the subjects focused, researchers asked them to push a computer key to indicate whether the image was a person.

After determining which images prompted a significant or strong response in at least one neuron, additional sessions tested response to three to eight variations of each of those images.

Responses among the eight subjects varied with the person and stimulus.

For example, a single neuron in the left posterior hippocampus of one subject responded to 30 out of 87 images, firing in response to all pictures of actress Jennifer Aniston, but not, or only very weakly, to other famous and non-famous faces, landmarks, animals or objects. The neuron also did not respond to pictures of Jennifer Aniston together with actor Brad Pitt.

In another instance, pictures of actress Halle Berry activated a neuron in the right anterior hippocampus of a different patient, as did a caricature of the actress, images of her in the lead role of the film "Catwoman" and a letter sequence spelling her name.

In a third subject, a neural unit in the left anterior hippocampus responded to pictures of the landmark Sydney Opera House and Baha'i Temple, and also to the letter string "Sydney Opera," but not to other letter strings, such as "Eiffel Tower."

In addition to Fried and Koch, the research team included Rodrigo Quian Quiroga of Caltech and UCLA, Leila Reddy of Caltech, and Gabriel Kreiman of the Massachusetts Institute of Technology.

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Online resources:

- UCLA Division of Neurosurgery: http://neurosun.medsch.ucla.edu/
- Semel Institute for Neuroscience and Human Behavior: http://www.npi.ucla.edu/
- David Geffen School of Medicine: http://www.medsch.ucla.edu/
- Christof Koch (Caltech):

http://www.klab.caltech.edu/~koch/

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