Neurons in brain's 'face recognition center' respond differently in patients with autism

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Credit: Caltech /Adolphs Lab

In what are believed to be the first studies of their kind, Cedars-Sinai researchers recording the real-time firing of individual nerve cells in the brain found that a specific type of neuron in a structure called the

amygdala performed differently in people who suffer from autism spectrum disorder than in those who do not.

Autism spectrum disorder and autism are general terms for a group of complex disorders of brain development that affect social interactions, communication skills and behaviors.

"Many studies have found that people who have autism fail to focus on the eye region of others to gather social cues and process information about emotions," said Ueli Rutishauser, PhD, assistant professor of neurosurgery and director of Human Neurophysiology Research at Cedars-Sinai, and first author of an article in the Nov. 20 issue of the journal *Neuron*. "The amygdala – which is critical for face recognition and processing of emotions – is thought to be one of the principal areas where dysfunction occurs, but this is the first time single neurons in the structure have been recorded and analyzed in patients with autism."

Researchers in Cedars-Sinai's Department of Neurosurgery and Department of Neurology, with colleagues from the California Institute of Technology and Huntington Memorial Hospital in Pasadena, "listened in" and recorded the firing activity of individual nerve cells in the amygdalae of two patients with a high-functioning form of autism as they viewed pictures of entire faces or parts of faces on a screen. Each face expressed an emotion – fear or happiness – and the patients were asked to look at the pictures to decide which emotion was expressed.

The research team then compared recordings from neurons in the patients with autism to recordings from neurons in patients who did not have autism, which led to the discovery that a specific type of neuron performed atypically in those with autism.

Different neurons respond to different aspects of a task. In the amygdala, which is known to be important for emotional memory,

certain neurons fire when a person looks at a whole face; another population responds when viewing parts of faces or certain facial features such as an eye or mouth. In the two patients with autism, "whole-face" neurons responded appropriately, but the "face-part" neurons were much more active when the patients were shown the mouth region compared to when they were shown the eyes.

"A subpopulation of neurons in these patients with autism spectrum disorder showed abnormal sensitivity to the mouth region. The amygdala neurons appeared normal from an electrical point of view, and the whole- face-sensitive neurons responded normally. Thus, the subset of face-part-sensitive neurons was specifically abnormal in autism," Rutishauser said.

The article's senior author, Ralph Adolphs, PhD, Bren Professor of Psychology and Neuroscience at Caltech, said the study presents new insights into mechanisms underlying the symptoms of autism and opens the door for further studies.

"Are there genetic mutations that lead to changes in this one population of neurons? Do the cell abnormalities originate in the amygdala or are they the result of processing abnormalities elsewhere in the brain? There are many questions yet to be answered, but this study points us in a specific direction that we believe will help understand autism," he said.

Observing the activity of single neurons in the human brain is very challenging and only rarely done, but it is the only way to explore what is happening in the brain at the very instant a person thinks. A collaboration of neuroscientists and neurosurgeons allows these rare opportunities to be used to advance knowledge of how the brain works. Similar nerve cell studies have been done in animals, but they are imperfect representatives of human thought and behavior, and without direct human feedback, neuroscientists have had to make assumptions

when interpreting animal responses. Progress in finding answers for autism has been limited because no animal model exists for the highly complex human disorder.

The autism study was made possible by patients being treated for epilepsy who underwent surgery to have depth electrodes implanted in their brains to monitor seizure-related electrical activity. Two of the patients also suffered from a high-functioning form of autism spectrum disorder.

"The amygdala is a routine target for depth electrodes to localize epileptic seizures. This provides a unique opportunity to record activity from the amygdala, a brain structure that is important for the processing of emotions and suspected to be abnormal in autism. However, until our recent discovery, it was unknown whether the human amygdala contained face-sensitive neurons," said Adam Mamelak, MD, professor of neurosurgery and director of Functional Neurosurgery at Cedars-Sinai.

In an intracranial electroencephalogram (EEG) study, each time a targeted neuron is active it fires an "action potential" – a chemical and electrical change that can be recorded for later analysis. Like never before, the researchers can witness in human subjects and in real time single cells in the brain reacting when a subject mentally processes a visual image.

Rutishauser, Adolphs and their colleagues published several recent articles on face recognition that led up to this research on autism. In one, they recorded the activity of single neurons as patients' brains processed cues from facial expressions. In another, they reported that when memory-related neurons fire in a coordinated way with certain brain waves the resulting image recognition and memories are stronger than if this synchronization does not occur.

More information: *Neuron*, "Single-neuron correlates of atypical face processing in autism," Nov. 20, 2013.

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