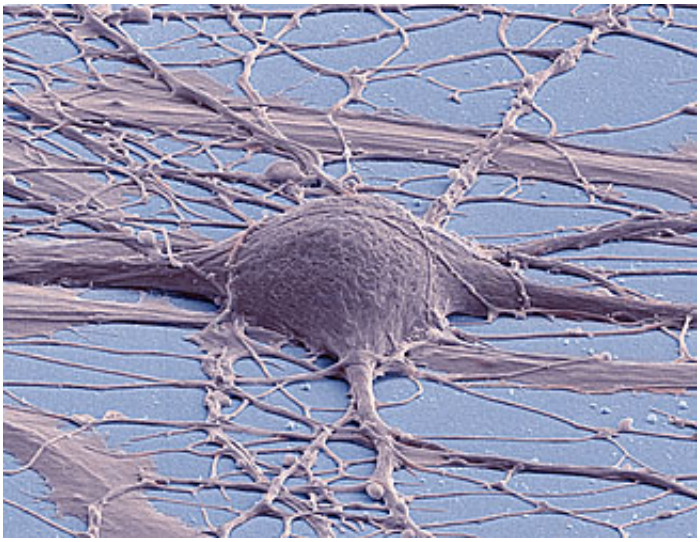
Hippocampal neuron responses associated with memory distinctions

August 6 2015, by Christopher Packham



This is a scanning electron micrograph (false color) of a human induced pluripotent stem cell-derived neuron. Credit: Thomas Deerinck, UC San Diego

(Medical Xpress)—Human memory is remarkably adaptive and specific, enabling the crucial distinction between two similar events—for instance, recalling where you parked your car this morning as opposed to where you parked it yesterday. It has been largely established that the medial temporal lobe forms declarative memories of facts and events, but researchers have noted that damage specific to the hippocampus can lead to deficits in recognition characterized by the impaired discrimination of similar items.

Therefore, it is believed that the hippocampus is responsible for separating overlapping memories in order to support memory specificity. While it's possible via fMRI to study the firing of hippocampal neural networks via BOLD signals, it is not sensitive enough to study single neuron activity. So an international group of researchers devised a novel study of 25 pharmacologically resistant epilepsy patients who had been implanted with intracranial depth electrodes for medical diagnostic purposes. The researchers have published their findings in the *Proceedings of the National Academy of Sciences*.

Prior to experimental sessions, subjects were shown photographs of 10 famous people. During the experimental sessions, they were shown different photographs of the same people. The use of novel photographs diminished repetition and suppression effects noted in other studies. Subjects were instructed to learn 10 photos, which were presented among three alternating blocks—retrieval blocks consisted of studied photographs, unstudied photographs of the same face, and new, unstudied faces.

During the discrimination task, the researchers recorded the subjects' neural activity via the intracranial electrodes. Analysis of the collected data revealed a greater proportion of selectivity for the studied photographs in the hippocampi of subjects who performed well on the recognition test. The data suggests that the hippocampus plays a specific role in differentiating similar inputs, and that neuronal firing rates correlate with subjects' performance on the memory discrimination task.

In addition to mnemonic discrimination, neurons in the hippocampus also play a role in generalization and maintaining flexible relationships between events. Thus, single neurons can be highly selective, firing in response to a particular famous person, but also respond to different images of the same famous person.

But in the present study, the participants were asked to memorize specific individual photographs and discriminate them from "lures"—different photos of the same person. The authors clarify: "It is thus possible that top-down influences of task instructions change the firing patterns in the hippocampus. Under these circumstances, modulation of hippocampal activity by projections from other areas may confer additional selectivity and hippocampal neurons may fire in a more restricted manner to specific memorized stimuli."

The authors conclude that their study provides neuronal evidence for a hippocampal role in human memory, and they suggest that the formation of distinct representations for similar memories is expressed in the differential firing of hippocampal neurons. "These results can be used to inform circuit-level models of the role of the hippocampus in the encoding and retrieval of distinct episodic memories," they write.

More information: "Specific responses of human hippocampal neurons are associated with better memory." *PNAS* 2015 ; published ahead of print August 3, 2015, DOI: 10.1073/pnas.1423036112

Abstract

A population of human hippocampal neurons has shown responses to individual concepts (e.g., Jennifer Aniston) that generalize to different instances of the concept. However, recordings from the rodent hippocampus suggest an important function of these neurons is their ability to discriminate overlapping representations, or pattern separate, a process that may facilitate discrimination of similar events for successful memory. In the current study, we explored whether human hippocampal neurons can also demonstrate the ability to discriminate between overlapping representations and whether this selectivity could be directly related to memory performance. We show that among medial temporal lobe (MTL) neurons, certain populations of neurons are selective for a previously studied (target) image in that they show a significant decrease

in firing rate to very similar (lure) images. We found that a greater proportion of these neurons can be found in the hippocampus compared with other MTL regions, and that memory for individual items is correlated to the degree of selectivity of hippocampal neurons responsive to those items. Moreover, a greater proportion of hippocampal neurons showed selective firing for target images in good compared with poor performers, with overall memory performance correlated with hippocampal selectivity. In contrast, selectivity in other MTL regions was not associated with memory performance. These findings show that a substantial proportion of human hippocampal neurons encode specific memories that support the discrimination of overlapping representations. These results also provide previously unidentified evidence consistent with a unique role of the human hippocampus in orthogonalization of representations in declarative memory.

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