Visual objects are represented by a distributed network in the human brain

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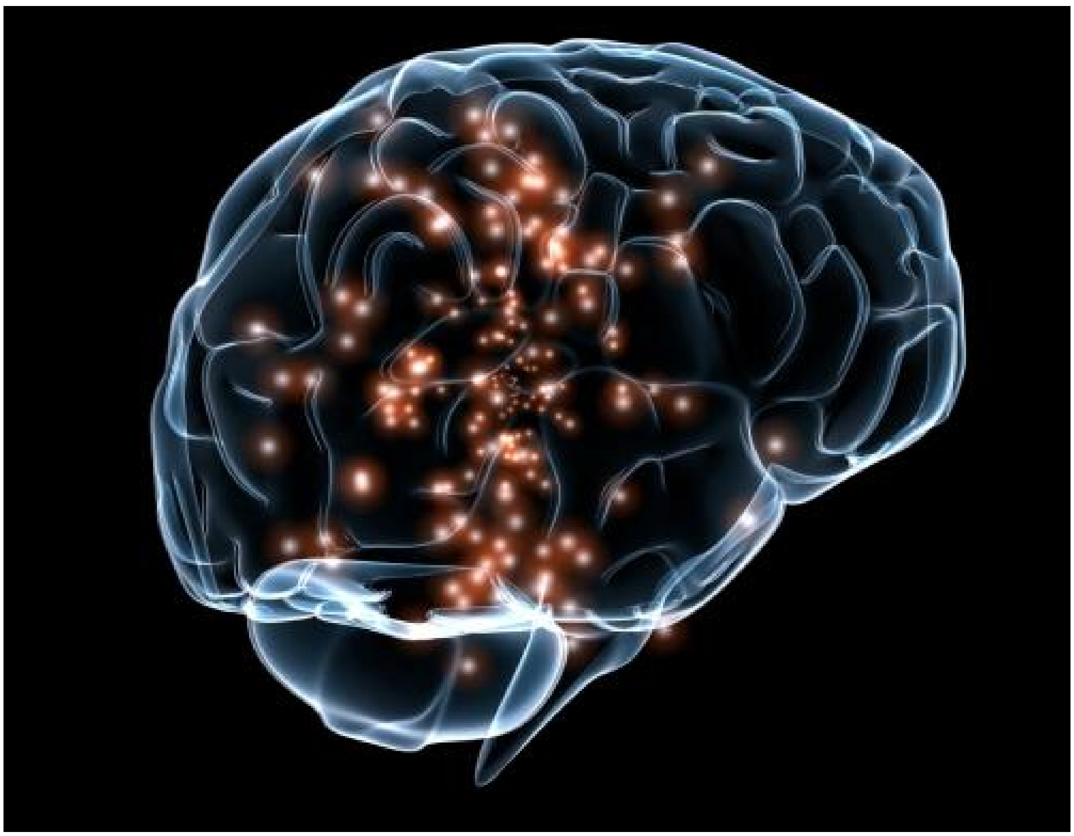

Credit: Wikimedia Commons

LSU Psychology Professor Megan H. Papesh was part of a research team whose study appeared in the online-first edition of the *Journal of Neuroscience* on Wednesday, April 1. The research, jointly conducted by scientists from the Barrow Neurological Institute and Arizona State

University, involves recording single-neuron activity in the brains of epilepsy patients who require electrodes implanted to monitor seizures. With the electrodes in place, processes such as perception and memory can be studied at the level of individual neurons.

The research focused on a hotly contested topic in cognitive neuroscience, testing the idea of "grandmother cells" in the human brain. In the past decade, several prominent studies suggested that individual brain cells are finely tuned to fire selectively to very specific concepts. For example, a neuron in the hippocampus may be quiet as the person views hundreds of images of animals, people and objects, but will fire rapidly when the person sees a photo of the actress Halle Berry. This same neuron will fire in response to various different images of Berry, and also to her name, suggesting that the neuron represents the person herself, not merely her appearance. Given such results, researchers have argued that neural representations of concepts are "sparse," a hypothesis that concepts are coded in the brain by small collections of highly selective neurons.

The new study featured in the *Journal of Neuroscience* used the basic same method as earlier experiments that suggested sparse coding. Patients viewed many images and names, and simply decided whether each stimulus represented a person or an animal/landmark. For every concept, there were four different representations shown six times each. Despite using nearly the same method as prior studies, the new results provide strong evidence for distributed coding, with different objects creating firing-rate changes across many neurons. Of the recorded neurons that were active, most responded to multiple, often unrelated, concepts. Only one recorded neuron out of 1,532 behaved like the grandmother cells from previous studies.

What accounts for this dramatic difference across experiments? Papesh and her colleagues suggest that new memories for specific stimuli might be the key. Whereas patients in the new experiment saw particular images only six times, the volunteers in previous studies saw individual images up to 50 times. Taking the old and new studies together, the results suggest that episodic memory for particular images can tune individual neurons to behave in a highly selective fashion. But, as a general rule, people rarely encounter identical images of people or places dozens of times, and the human brain presumably evolved its coding schemes long before photography existed. The brain is adapted to robustly recognize new images as examples of known categories, despite changes in appearance.

The new results suggest that classification is achieved by sharing the computational load across large sets of neurons. In a broadly distributed system, small responses from thousands of neurons represent knowledge; losing cells would have essentially no impact on the ability to recognize objects or people. The combined results of these studies testify to the incredible flexibility of the human brain, which can classify newly encountered objects while also forming stable episodic memories for specific images.

More information: Distributed Representation of Visual Objects by Single Neurons in the Human Brain, The *Journal of Neuroscience*, 1 April 2015, 35(13): 5180-5186; DOI: 10.1523/JNEUROSCI.1958-14.2015

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