Information in brain cells' electrical activity combines memory, environment, and state of mind

July 17 2013

(Medical Xpress)—The information carried by the electrical activity of neurons is a mixture of stored memories, environmental circumstances, and current state of mind, scientists have found in a study of laboratory rats. The findings, which appear in the journal *PLoS Biology*, offer new insights into the neurobiological processes that give rise to knowledge and memory recall.

The study was conducted by Eduard Kelemen, a former graduate student and post-doctoral associate at the State University of New York (SUNY) Downstate Medical Center, and André Fenton, a professor at New York University's Center for Neural Science and Downstate Medical Center. Kelemen is currently a postdoctoral fellow at University of Tuebingen in Germany.

The idea that recollection is not merely a replay of our stored experiences dates back to Plato. He believed that memory retrieval was, in fact, a much more intricate process—a view commonly accepted by today's cognitive psychologists and couched in the theory of constructive recollection. The theory posits that during memory retrieval, information across different experiences may combine during recall to form a single experience. Such a process may explain the prevalence of false memories. For example, studies have shown that people mistakenly recalled seeing a school bus in a movie if the bus was mentioned after they watched the movie.

In addition, other scholarship has shown that a subject's mindset can also influence the retrieved information. For example, looking at a house from the perspective of a homebuyer or a burglar leads to different recollections—potential purchasers may recall the house's leaky roof while would-be burglars may remember where the jewelry is kept.

But while the psychological contours of retrieval are well-documented, very little is known about the neural activity that underlies this process.

With this in mind, Fenton and Kelemen centered their study on the neurophysiological processes rats employ as they solve problems that require memory retrieval. To do so, they employed techniques developed during the last two decades. These involve monitoring the electrical activity of neurons in the rats' hippocampus—the part of the brain used to encode new memories and retrieve old ones. By spotting certain types of neuronal activity, researchers have historically been able to perform what amounts to a mind reading exercise to decode what the rat is thinking and even comprehend the specifics of the rats' memory retrieval.

In their experiments, Fenton and Kelemen tested the viability of a concept, "cross-episode retrieval"— stimulating the brain activity in a given circumstance that was also activated in a previous, distinctive experience.

"Such cross-episode expression of past activity can create opportunities for generating novel associations and new information that was never directly experienced," the authors wrote.

To test their hypotheses, rats were placed in a stable, circular arena, then in a rotating, circular arena of the same size, followed by a return to the stable arena. In the rotating arena condition, the surface turned slowly, making it necessary for the rat to think about its location either in terms

of the rotating floor or in terms of the stationary room.

Overall, the results showed district neural activity between the stable and rotating conditions. However, during the rotating task, the researchers intermittently observed "cross-episode retrieval"—that is, at times, neurons expressed patterns of electrical activity under the rotating-arena condition that were similar to those activity patterns that were used in the stable-arena condition. Notably, cross-episode retrieval occurred more frequently when the angular position of the rotating arena was about to complete a full rotation and return to the same position as in the stable condition, demonstrating that retrieval is influenced by the environment.

To show that cross-episode retrieval was influenced by current state of mind, Fenton and Kelemen took advantage of an earlier finding from their experiments: during the arena rotation, neural activity switches between signaling the rat's location in the stationary room and the rat's location on the rotating arena floor. Cross-episode retrieval was also more likely when neuronal activity represented the position of the rat in the stationary room than when it represented positions that rotate with the arena. This showed that retrieval is influenced by internal cognitive variables that are encoded by hippocampal discharge—i.e., a state of mind.

"These experiments demonstrate novel, key features of constructive human episodic memory in rat hippocampal discharge," explained Fenton, "and suggest a neurobiological mechanism for how experiences of different events that are separate in time can nonetheless comingle and recombine in the mind to generate new information that can sometimes amount to valuable, creative insight and knowledge."

Provided by New York University