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Neurobiology

How our brain temporally organizes our memories of past events

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When you and your friends reminisce about your last year of high school, the memories are characterized by your perspective and experience making them unique. How can your brain chronologically place these events? Who are the main players in this process?

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The ability of the brain to represent time is fundamental for human experience. When something remarkable happens to us, our brain records it as a video. When we remember it, we recall also the location and time sequence in which the event occurred, in addition to the event itself. This is called episodic memory. Episodic memory is long-term memory recalling, specific events or situations. Since each person has a different perspective and experience of an event, each episodic memory is unique. In a recent study, researchers identified the specific cells in the human brain - known as time cells - that are responsible for storing this information in a way that lets us remember the right sequence of events.

The existence of time cells was previously described in mouse brain, but no evidence of these cells was shown in humans until now. Time cells are located in the hippocampus, in the temporal lobe of the brain. The hippocampus was already known to be important for memory but also for navigation. This area of the brain is activated when a sequence of the events is being processed, and damage to the hippocampus prevents this process from taking place. For example, when patients with Alzheimer's disease suffer from damage to the hippocampus, they lose the ability to recall some memories and to create new long-term ones. Proving that time cells exist in the human brain will allow us to study the physiological mechanisms involves in remembering sequences of events. And will help advance the study of human memory, as well as possible treatments for diseases affecting the temporal activity of the brain, such as Alzheimer's disease or schizophrenia.

To verify the existence of time cells in the human brain, a behavioral experiment was performed. The participants had to do a recall task - a classic assay for episodic memory. Participants were asked to study a list of 12 or 15 words, which appeared on a screen for 30 seconds, then were distracted with an unrelated task before being asked to freely recall as many words of the list as they could remember. In the meantime, the brain activity of each participant was recorded by microelectrodes. All participants were patients with severe epilepsy awaiting surgeries, thus had microelectrodes already implanted in their hippocampus and other areas of the brain as part of the pre-surgical procedure.

Behavioral performance during these sessions exhibited an already known pattern: participants could better recall the first and last couple of words, displaying the so called serial position effect - when the position of an item on a list impacts how well it is remembered. The scientists focused their attention on the activity signals coming from a small population of cells based in the hippocampus area - where mouse-studies identified time cells. These cells activated during the 30 second when each word was displayed, and were likely helping participants remember the order of the words on the list. Therefore, researchers could further support that these are indeed time cells.

Researchers were also able to confirm the presence of hippocampal cells called ramping cells, that increase or decrease their activity during the time span of a given task. Their data, together with previous mouse model studies, show that ramping cells encode the temporal information of a given task and provide a link between the temporal context and the selection of the right hippocampal time cells population to perform the task.

It is important to point out that just because we have time cells it does not mean that our brain processes time information mechanically second by second, like a ticking clock. It is more likely that time cells record time while distorting it according to other variables like our mood. When we are having a very good time with our loved ones, time seems to fly, but when waiting for the COVID-19 pandemic to end, time seems to pass extremely slowly.