Medical Xpress

Researchers clarify the function of highly specialized nerve cells in memory

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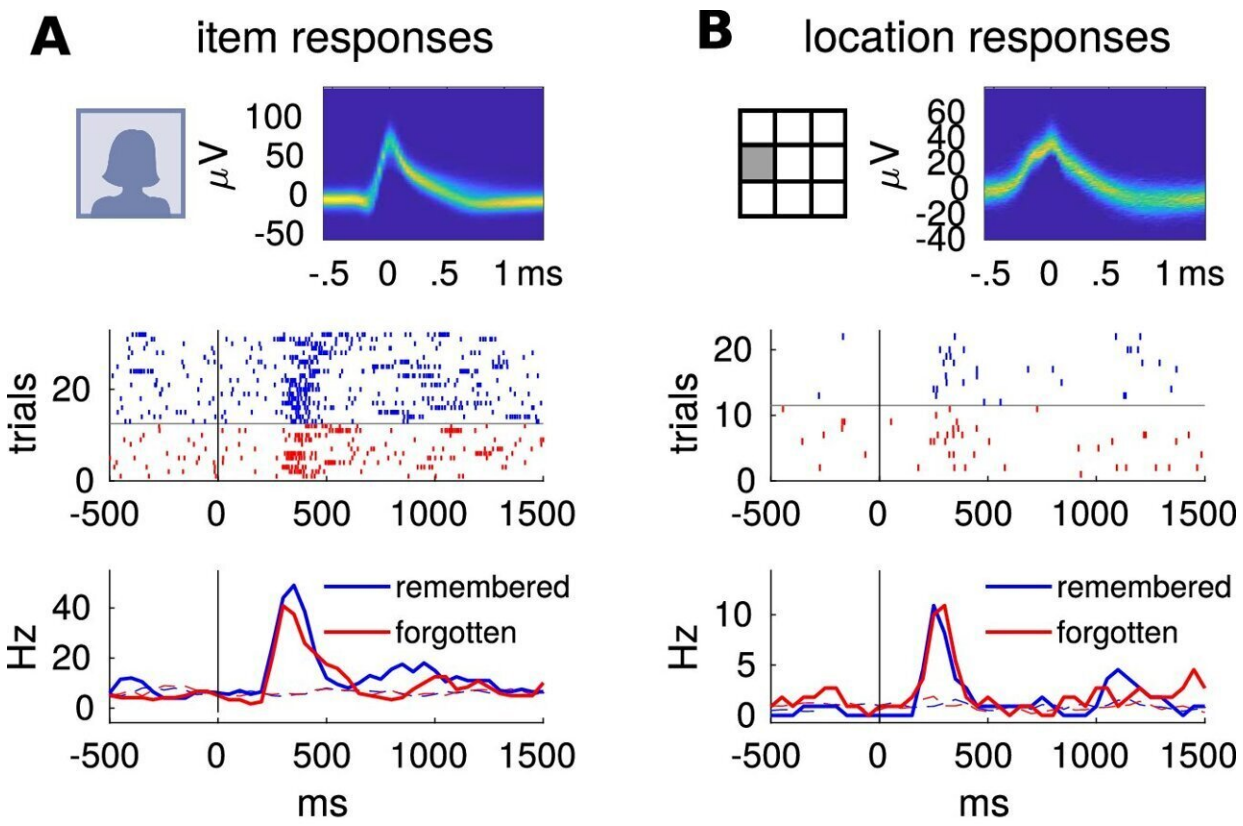

Examples of item and location-specific responses. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-52295-5

Specialized nerve cells in the temporal lobe react highly selectively to images and names of a single person or specific objects. Researchers at

the University Hospital Bonn (UKB) and the University of Bonn have provided direct evidence for the first time that the so-called concept neurons are indeed the building blocks of our memory for experiences. Their results have now been published in *Nature Communications*.

Certain nerve cells in the brain become active whenever they are confronted with different images or the name of a specific person or the identity of an object. They are highly selective and do not react to other people or objects. These so-called concept neurons have so far only been found in humans, and only in the medial temporal lobe, which is essential for memory formation.

An international research team led by Prof. Florian Mormann from the Department of Epileptology at the UKB, who is also a member of the Transdisciplinary Research Area (TRA) "Life & Health" at the University of Bonn, has already confirmed their important function for working memory in a study from 2017, in which individual concept neurons representing specific persons or objects keep memory content available for a short time.

These neurons remain active until a new image is shown and another neuron is stimulated. In addition, the research team was even able to use the activation of the concept neurons during the working memory phase to predict whether the test subjects would later correctly remember the image that had already been shown.

But how a successful transfer of the experiences into the episodic memory, which stores autobiographical events and experiences including place and time, works, was previously unclear.

"We therefore pursued the hypothesis that these concept neurons provide the building blocks that are put together to form a memory of an experience," says first author Sina Mackay, a doctoral student at the

University of Bonn in Prof. Mormann's research group at the UKB.

Concept neurons are the building blocks of memory; (from left) Sina Mackay and Prof. Florian Mormann investigate the function of specialized nerve cells in memory formation. Credit: Rolf Müller, Universitätsklinikum Bonn

Neuronal activity provides 'what' and 'where' in memory formation

For its scientific work, the Bonn research team uses a special feature of the Clinic for Epileptology at the UKB—one of the largest epilepsy centers in Europe. Here, people with severe forms of epilepsy can have surgical and other treatments.

In some cases, electrodes are first implanted in the brain to localize the source of the seizure. As a side effect, the research team can measure the electrical activity of individual neurons while epilepsy patients perform tasks—for the current study, it was an associative memory paradigm, in which people or objects were assigned to a specific position on the screen.

The researchers carried out measurements in the medial temporal lobe and the parahippocampal cortex, which houses location cells. This time, they focused not only on the behavior of concept neurons, but also on the behavior of location cells, which reacted to certain positions on the screen on which the images were shown, regardless of which images were displayed at that position.

While Prof. Mormann's research team had already found a prediction effect, the Bonn researchers have now been able to show that the activity of concept neurons in the medial temporal lobe and place neurons in the parahippocampal cortex predicts the correct memorization of concept–location pairs.

"In both the object-selective and location-selective neuron populations, the firing rates were significantly higher if they were later remembered correctly," says Mackay. In contrast, the remaining neurons, which make up more than 90% of these regions, did not predict successful memory formation, underscoring the highly specific role of concept and location neurons.

"We assume that the mediotemporal concept neurons and possibly also the parahippocampal place cells, which are involved in our daily experiences, are reactivated during the consolidation of memory—for example during deep sleep," says Prof. Mormann, who believes that future studies are needed to investigate this hypothesis.

More information: Sina Mackay et al, Concept and location neurons in the human brain provide the 'what' and 'where' in memory formation, *Nature Communications* (2024). DOI: 10.1038/s41467-024-52295-5

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