PRESS RELEASE

A mystery of episodic memory solved

Researchers in Bonn clarify how separate groups of neurons cooperate to embed memories in their context

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Bonn, 7 January – The human brain must be able to link memory content to the circumstances in which it occurs. Researchers in Bonn have now discovered how the human brain uses two different groups of neurons to store content and context separately. These nerve cell groups work together in a coordinated manner to form memories, rather than mixing signals in the activity of individual cells. The study results have now been published in the renowned journal *Nature*.

Humans have the remarkable ability to remember the same person or object in completely different situations. We can easily distinguish between dinner with a friend and a business meeting with the same friend. "We already know that deep in the memory centers of the brain, specific cells, called concept neurons, respond to this friend, regardless of the environment in which he appears," says Prof. Florian Mormann from the Clinic for Epileptology at the UKB, who is also a member of the Transdisciplinary Research Area (TRA) "Life & Health" at the University of Bonn. However, the brain must be able to combine this content with the context in order to form a useful memory. In rodents, individual neurons often mix these two pieces of information. "We asked ourselves: Does the human brain function fundamentally differently here? Does it map content and context separately to enable a more flexible memory? And how do these separate pieces of information connect when we need to remember specific content according to context?" says Dr. Marcel Bausch, working group leader at the Department of Epileptology and member of TRA "Life & Health" at the University of Bonn.

Watching the human brain in real time

To investigate this, the Bonn researchers used the electrical activity of individual neurons in the brains of people with drug-resistant epilepsy. For purely diagnostic purposes, electrodes were implanted in the hippocampus and surrounding brain regions of these patients – regions that are essential for memory. While their seizures were being recorded to determine whether they were eligible for surgery, they voluntarily participated in experiments on a laptop. They were shown pairs of images that they had to compare based on different questions. For example, they had to decide whether an object was "bigger" if the trial began with the question "Bigger?". "This allowed us to observe how the brain processes exactly the same image in different task contexts," says Mormann.

The research team analyzed more than 3,000 neurons and identified two largely separate groups of neurons: Content neurons fired in response to specific images (e.g., a biscuit, regardless of the task. Context neurons fired in response to specific task contexts (e.g., the question "Bigger?"), regardless of the image shown. In contrast to rodents, very few neurons

encoded both simultaneously. "A key finding was that these two independent groups of neurons encoded content and context together and most reliably when the patients solved the task correctly," says Bausch.

The connections between them strengthened over the course of the experiment: the firing of a content neuron began to predict the activity of a context neuron a few tens of milliseconds later. "It seemed as if the 'biscuit' neuron was learning to stimulate the 'Bigger?' neuron" says Mormann. This happens in the sense of a gatekeeper for the flow of information, such that only the relevant context that was previously active is retrieved. This process, known as pattern completion, allows the brain to reconstruct the complete memory context from only partial information. "This division of labor probably explains the flexibility of human memory: the brain can reuse the same concept in countless new situations without needing a specialized neuron for each individual combination, by storing content and context in separate 'neural libraries'" says Bausch, and Mormann adds: "The ability of these neuronal groups to link spontaneously allows us to generalize information while preserving the specific details of individual events."

Although the study used specific questions as interactive contexts on a laptop, there are also other contexts that are passive, such as the room you are in. It remains to be determined whether these everyday background contexts are processed by the same neural mechanisms. In addition, the mechanisms must also be tested outside the clinical setting. An important next step will be to investigate whether deliberately disrupting the interaction between these neurons prevents a person from retrieving the correct memory in context or making the right decision.

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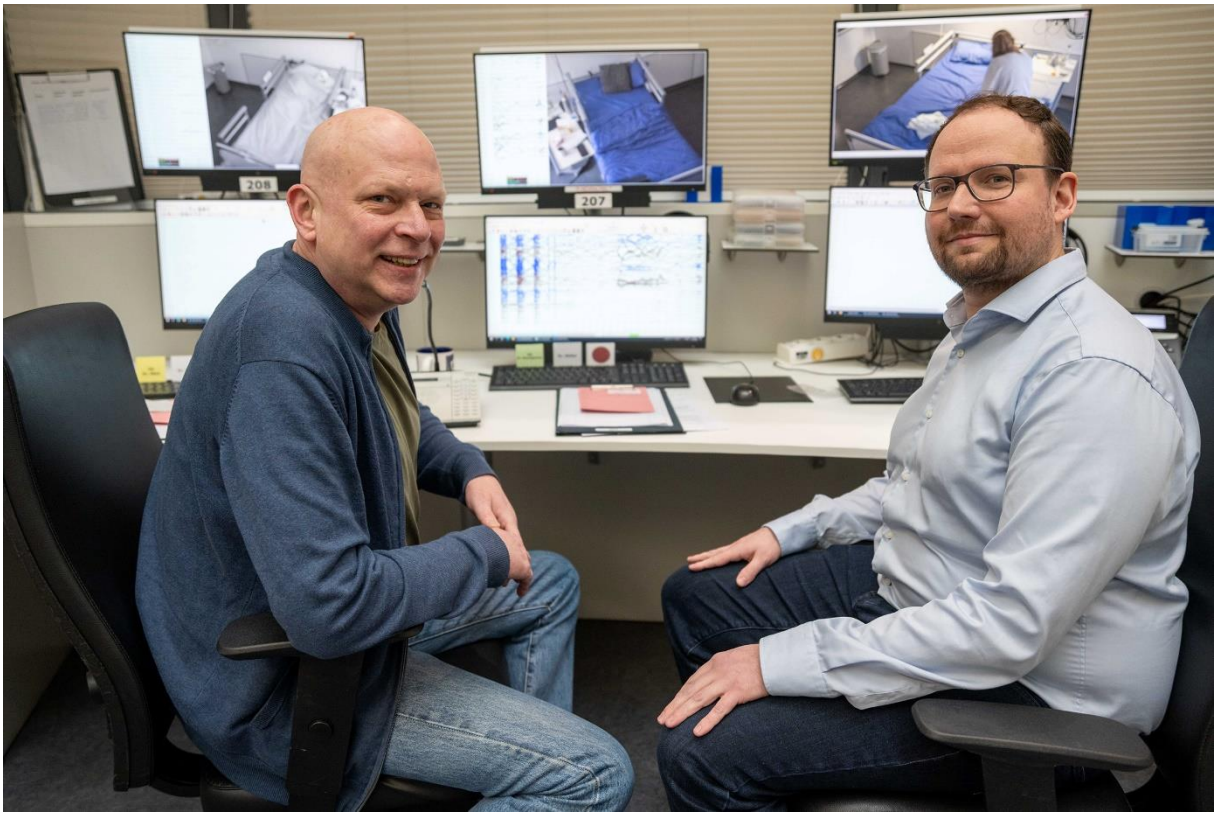

Caption: A mystery of episodic memory solved:
(from left) Prof. Florian Mormann and Dr. Marcel Bausch clarify how separate groups of neurons cooperate to embed memories in their context.

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About the University Hospital Bonn: As one of Germany's leading university hospitals, Bonn University Hospital (UKB) combines excellence in medical care and research with high-quality teaching. Every year, UKB treats more than half a million outpatients and inpatients. Around 3,500 students are enrolled in medicine and dentistry, and over 600 individuals receive training in healthcare professions annually. With around 9,900 employees, UKB is the third-largest employer in the Bonn/Rhein-Sieg region. In the „Focus hospital rankings", UKB is rated the top university hospital in North Rhine-Westphalia and has the second-highest case mix index (an indicator of treatment complexity) of all university hospitals nationwide. In 2024, UKB secured nearly €100 million in third-party funding for research, development, and teaching. For the fourth consecutive year, the F.A.Z. Institute recognized UKB as both "Germany's Training Champion" and "Germany's Most Desirable Employer." For current figures and further information, please refer to the annual report at: geschaeftsbericht.ukbonn.de