In search of memory storage

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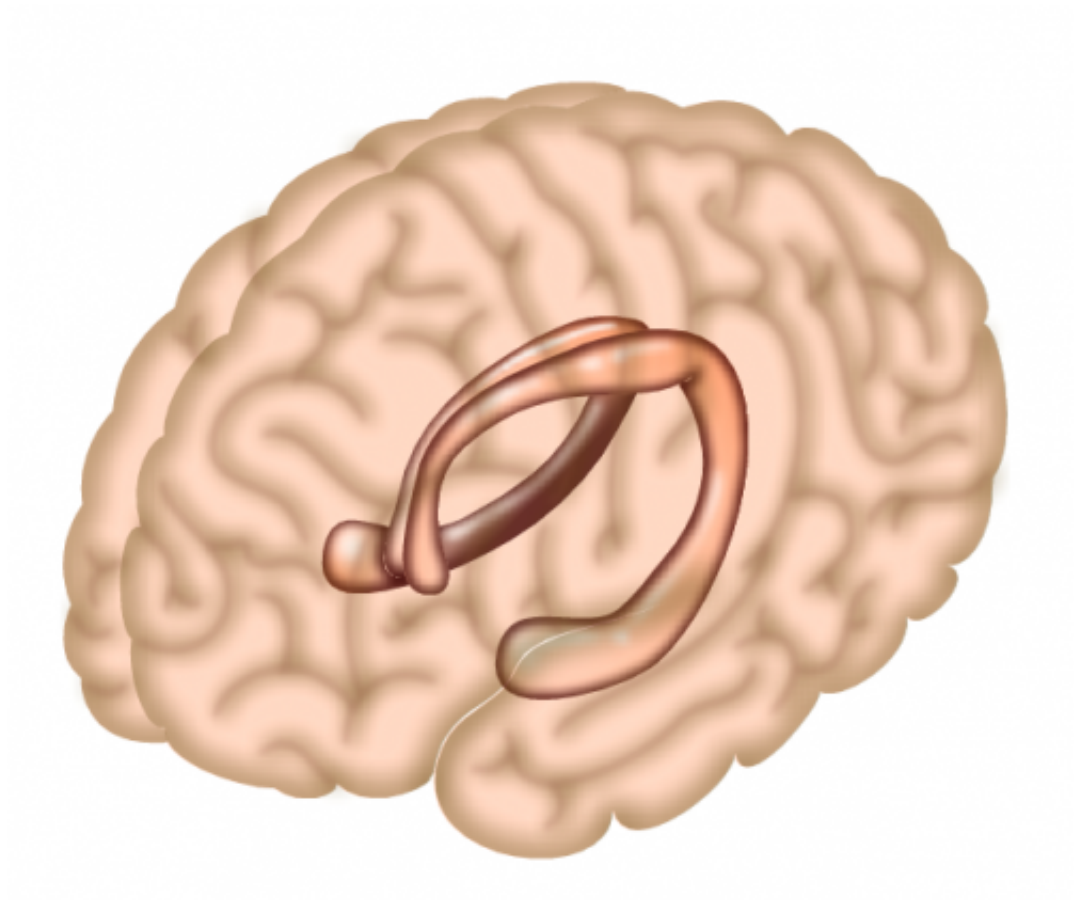

The hippocampus is a region of the brain largely responsible for memory formation. Credit: Salk Institute

The hippocampus plays a crucial role in memory formation. However, it is not yet fully understood in what way that brain structure's individual regions are involved in the formation of memories. Neuroscientists at the

Collaborative Research Center 874 at RUB have recreated this process with the aid of computer simulations. Their findings challenge the model of memory forming in the hippocampus established to date. Their results have been published in the journal *PLOS Computational Biology*.

Unique anatomy of the hippocampus

The hippocampus' importance for memory forming becomes evident once that brain structure is damaged: information no longer arrives in the long-term memory; everything that happened longer than a few minutes ago is forgotten. The hippocampus' remarkable anatomy, from which it derives its name (hippocampus=seahorse), supports its functional principle. It is made up of several distinct regions: the information first arrive at the so-called "Gyrus dentatus". From here, the neurons transmit to the "Cornu Ammonus" region CA3, which, in turn, projects to CA1. Neuroscientists assume that the CA3 region is where memories are stored.

Functional model traces the path of memory

Based on that anatomical structure, a functional model of the hippocampus has been developed in the last years and tested with the aid of computer simulations. The hippocampus initially reduces information from the cerebral cortex, turning them into small distinctive memory pieces. The process is called "pattern separation". The memory pieces are subsequently transmitted to the CA3 region and saved. The CA3 region is assumed to fulfil an auto-associative function. That means it is capable of deriving complete information from a short note. The technical term for this process is "pattern completion". In the next step, the CA1 region is responsible for transmitting the complete information back to the cerebral cortex, where it is retrieved as a memory.

Hippocampus regions work together not the way we assumed

RUB neuroscientists Torsten Neher, Prof Dr Sen Cheng and Prof Dr Laurenz Wiskott have now calculated on the basis of a number of computer simulations that this model has to be fundamentally reconsidered. Using an artificial neuronal network, based on a rat hippocampus, they have tested in what way the information is processed by the network, where it is stored and how it is retrieved as memory. Their results have demonstrated that the CA1 region is probably more strongly involved in the completion of memory stimuli than has been assumed to date. Thus, memories could be decoded even without the highly dendritic neurons of the CA3 region.

Researchers surprised

Moreover, memories do exist that cannot be separated – most specifically those that help us navigate through a familiar environment. For this purpose, mental maps are generated in the CA3 region which depict distances and relations. In this case, an auto-associative approach, based on information not resembling each other, would inhibit the memory process. "It did surprise us to see that the system works so much more efficiently without pattern completion in CA3. After all, it challenges a model that has been established for more than 20 years," says Torsten Neher.

Capacities for other tasks

The RUB researchers' computer model suggests that storage and decoding of information happens for the most part between the cerebral cortex and CA1. This, in turn, opens up CA3 capacities for other important tasks which are now to be studied. This hippocampus region

could, for example, be able to project sequences of autobiographic memories.

More information: "Memory Storage Fidelity in the Hippocampal Circuit: The Role of Subregions and Input Statistics," *PLoS Comput Biol* 11(5): e1004250, DOI: 10.1371/journal.pcbi.1004250

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