How memory is read out in the brain: MB-V2 nerve cells enable the read-out of associative memories

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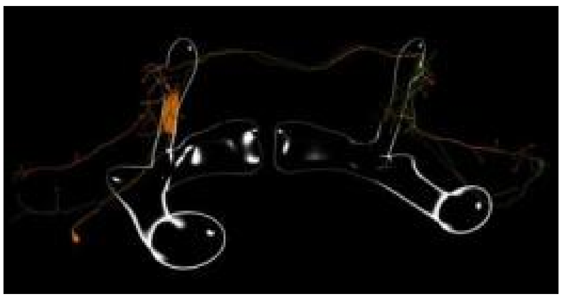

3-D-reconstruction of two MB-V2 nerve cells in the fruit fly brain. The cells receive information from the mushroom body (white) and relay them the lateral horn in return. Credit: MPI of Neurobiology/Foerstner

What happens if you cannot recall your memory correctly? You are able to associate and store the name and face of a person, yet you might be unable to remember them when you meet that person. In this example, the recall of the information is temporarily impaired. How such associative memories are "read out" in the brain remains one of the great mysteries of modern neurobiology. Now, scientists from the Max Planck Institute of Neurobiology in Martinsried and from the Ecole Superieure de Physique et de Chimie Industrielles in Paris, with an international team of colleagues, took the first step to unravel this mechanism.

Fruit flies have the ability to remember. The brain of these minute animals can store different pieces of information and associations and can recall these for a long time. In comparison to the human brain, which boasts about 100 billion cells, the brain of the fruit fly is, of course, a lot smaller. However, many of the basic principles are the same in both species. Thus, the straightforward structure of the fly brain, with its modest hundred thousand cells, enables the scientists to decode processes at their point of origin: in other words, on the individual cell level.

Nerve cells with read-out function

In their experiments, the neurobiologists conditioned the fruit flies to associate a certain odor with a mild electrical stimulus. After repeating this classical conditioning experiment only once, the flies had already got the message and turned away from the pertaining odor. The key in this experiment was that the scientists could temporarily deactivate specific nerve cells. This was done by a combination of special genetic techniques which allowed certain nerve cells to be deactivated through a change of ambient temperature. In this way, the scientists could show that the behavior of the flies was not altered, when certain nerve cells were deactivated only while the flies recalled the associated memory. The responsible nerve cells, known as MB-V2 cells, had to be intact in order for the flies to fully retrieve the associative memory. These cells were, however, not important for the flies' ability to associate odor and electrical stimulus or to stabilize the formed memory. The results thus indicated that MB-V2 cells are involved in a memory 'read-out' pathway.

Alternative pathways of memory processing

Prior to this experiment, it was known that olfactory information is processed in the lateral horn of the fly's brain. As a result of such processing, certain behavior, such as innate odor avoidance or approach, can be released. In contrast, the mushroom body is the site in the fly brain, where a positive or negative value is given to the odor information. Here, the neutral odor is associated with the negative sensation of the electric stimulus to form an aversive odor memory. The neurobiologists' results, which were now published in *Nature Neuroscience*, showed that MB-V2 cells receive information from the mushroom body and that they, in turn, relay to the nerve cells in the lateral horn.

"For the first time, we demonstrated the function of this alternative pathway via which a learned odor directs avoidance behavior for the memory recall", Hiromu Tanimoto, one of the two leaders of the study, explains. Instinctive behavior, such as the avoidance of certain odors, operates directly via the lateral horn and, as such, remains unperturbed by deactivation of the MB-V2 cells.

"The identification of these cells and the role they play in recalling the contents of the memory are significant milestones on the way to gaining an understanding of how memory guides animal behavior", Tanimoto explains. Perhaps one day, science will thus be able to explain why our brains sometimes get stuck, when trying to call up certain pieces of information. Such knowledge would, for example, be an important prerequisite in the development of drugs to combat certain memory deficiencies.

More information: Julien Séjourné, Pierre-Yves Plaçais, Yoshinori Aso, Igor Siwanowicz, Séverine Trannoy, Vladimiros Thoma, Stevanus R Tedjakumala, Gerald M Rubin, Paul Tchénio, Kei Ito, Guillaume Isabel, Hiromu Tanimoto & Thomas Preat
Mushroom body efferent neurons responsible for aversive olfactory memory retrieval in Drosophila
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