Visualizing a memory trace

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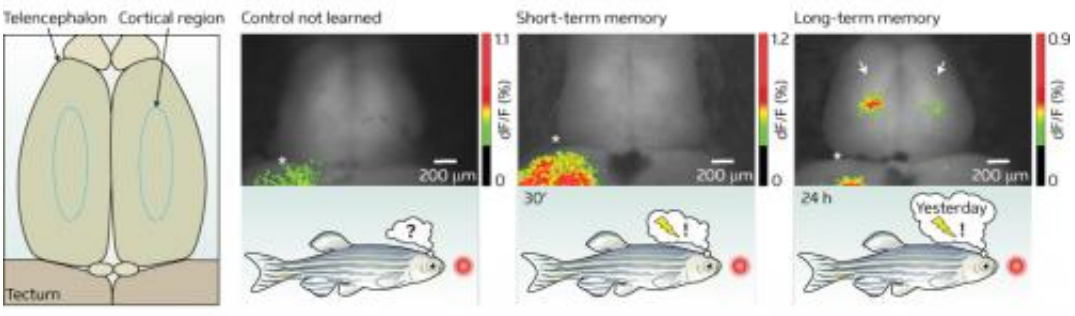

Figure 1: Neuronal activity in the zebrafish telencephalon is associated with long-term memory of learned avoidance behavior. Credit: 2013 Elsevier

In mammals, a neural pathway called the cortico-basal ganglia circuit is thought to play an important role in the choice of behaviors. However, where and how behavioral programs are written, stored and read out as a memory within this circuit remains unclear. A research team led by Hitoshi Okamoto and Tazu Aoki of the RIKEN Brain Science Institute has for the first time visualized in zebrafish the neuronal activity associated with the retrieval of long-term memories during decision making.

The team performed experiments on genetically engineered zebrafish expressing a fluorescent protein that changes its intensity when it binds to calcium ions in neurons and thereby acts as an indicator of neuronal activity. "Neurons in the fish cortical region form a neural circuit similar to the mammalian cortico-basal ganglia circuit," says Okamoto.

The fish were trained on an avoidance task by placing individual fish into a two-compartment tank and shining a red light for several seconds into the compartment containing the fish. If the fish did not move into the other compartment in response to the light, it was 'punished' with a mild electric shock. After several repetitions, the fish learned to avoid the shock by switching compartments as soon as the light came on.

The researchers then examined the neuronal activity of the fish under the microscope in response to exposure to red light. One day after the learning task, the fish showed specific activity in a discrete region of the telencephalon, which corresponds to the cerebral cortex in mammals, when presented with the red light. However, just 30 minutes after the learning task no activity was observed in this part of the brain (Fig. 1). The results suggest that this telencephalonic area encodes the long-term memory for the learned avoidance behavior. Confirming this, removing this part of the telencephalon abolished the long-term memory but did not affect learning or short-term storage of the memory.

In humans, the ability to choose the correct behavioral programs in response to environmental changes is indispensable for everyday life, and the ability to do so is thought to be impaired in various psychiatric conditions such as depression and schizophrenia.

"Combining the neural imaging technique with genetics, we will be able to investigate how neurons in the cortico-basal ganglia circuit choose the most suitable behavior in any given situation," says Okamoto. "Our findings open the way to investigate and understand how these symptoms appear in human psychiatric disorders."

More information: 1.Aoki, T., Kinoshita, M., Aoki, R., Agetsuma, M., Aizawa, H., Yamazaki, M., Takahoko, M., Amo, R., Arata, A., Higashijima, S.-I. et al. Imaging of neural ensemble for the retrieval of a learned behavioral program. *Neuron* 78, 1–14 (2013).

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