The hippocampus plays a fundamental role in the computing of uncertainty

April 30 2009

The hippocampus, a key brain region for memory and learning, codes the degree of uncertainty of potential reward situations. This fundamental role has just been demonstrated by Giovanna Vanni-Mercier and her colleagues at the Centre de neuroscience cognitive (CNRS / Université Lyon 1), working with the medical epileptology team from the Neurological Hospital in Lyon. Their work, published on 22 April 2009 in *Journal of Neuroscience*, sheds new light on the way the brain extracts and processes information about the environment.

Present in all live beings, the reward circuit is a nervous circuit that "rewards" basic survival functions (feeding, reproducing, responding to aggression) with a sensation of pleasure and satisfaction. In mammals, and particularly in primates, this circuit favors not only behavior associated with basic needs, but also more complex behavior such as learning and motivation. It can both detect cues associated with a reward and predict their occurrence based on past experience, an ability which is of use in decision-making. The reward system is made up of dopamine neurons situated in deep regions of the brain and the connections between these neurons and other brain regions.

The role played by the hippocampus in memorization and learning has been familiar to scientists for some time. But its involvement in computing reward probabilities had never before been studied. As part of the experiment, the researchers recorded activity levels in epileptic patients with a healthy (1) hippocampus while the patients learned to estimate the probability of a win for virtual slot machines. The data

showed that, when the third spinner stopped, revealing whether or not the player had won, the hippocampus emitted a transient signal whose amplitude varied with the probability of a monetary reward. The signal has peak amplitude when the uncertainty is highest. It acts as an alerting signal which helps the subject increase his or her vigilance and attention.

The hippocampus codes using a transient signal, and a posteriori, the strength of the association between the cue (the slot machine, in this case) and the associated outcome (the monetary reward, in this case). This is different from the dopaminergic neurons that code the uncertainty of the association via a constant signal emitted while awaiting the reward. Why do we have the signal? Firstly, it can complement the signal from dopaminergic neurons in associative learning, which connects a cue to its associated outcome. The uncertainty signal emitted by the dopaminergic neurons may facilitate motivation and exploration, while the signal from the hippocampus may direct attention towards the outcome of the event. This would, through a feed-back process, update the strength of the connection between cue and outcome, and later lead to situationally-appropriate behavior. Furthermore, the coding may be involved in other known functions of the hippocampus whose mechanisms were previously ignored, such as, for example, the classification of probabilities or transitional reasoning (basically, the deduction that if A>B, B>C, and C>D, then B>D).

This work confirms the fundamental role of the hippocampus in rational decision making in a context of uncertainty. The research brings new elements to our understanding of how the brain extracts and processes information and associations occurring in the environment.

(1) Electrodes were implanted into the patients, in order to define epileptogenic sites for treatment. The patients agreed to participate in the experience, which led to highly precise data recordings. The researchers had previously ascertained that the patients' hippocampuses

were normal.

More information: The hippocampus codes the uncertainty of cue-outcomes association: an intracranial electrophysiological study in humans. G. Vanni-Mercier, F. Mauguičre, J. Isnard, J-C. Dreher. *Journal of Neuroscience*, 22 April 2009.

Source: Laboratoire CNRS EN LUTTE- Physique et Mecanique des Miliieux Heterogeneous (news : web)