Fluctuations in size of brain waves contribute to information processing

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Cyclical variations in the size of brain wave rhythms may participate in the encoding of information by the brain, according to a new study led by Colin Molter of the Neuroinformatics Japan Center, RIKEN Brain Science Institute.

Brain waves are produced by the synchronized activity of large populations of neurons. Low frequency brain waves called theta oscillations are known to support memory formation. Researchers typically examine the frequency of oscillations in a given part of the brain and the timing of oscillations in different brain regions, but know very little about how variations in the size of these oscillations contribute to information processing.

Molter and his colleagues used electrode arrays to record brain waves from the rat hippocampus, a structure known to be critical for memory formation and spatial navigation, while the animals performed various behaviors, such as exploring open spaces, running through a maze and in a wheel, and sleeping. They observed fluctuations in the size of theta oscillations during all the behaviors—the brain waves did not remain the same size, but rather waxed and waned second by second.

During spatial navigation for example, individual hippocampal neurons called place cells become more active when the animal is in one or a few specific locations compared to the rest of the explored environment. The researchers found that the time of firing of many of the place cells correlated with the fluctuations in the size of the theta waves. During sleep, the activity of most of the cells was timed with the largest theta oscillations.

Even though the size of theta waves is correlated with motor behavior, their cyclic fluctuations at this time scale, observed while the rats ran and explored, were not correlated with the animals' speed or acceleration. The fluctuations are instead likely to be generated by the brain itself, as their presence during sleep also suggests they are intrinsic.

The researchers speculate that this phenomenon could be helpful for the neuronal representation of space, resolving the ambiguity of space coding by place cells that become active in multiple preferred locations.

"We are currently working on several new experiments to understand how the spatial location may affect the slow modulation and how the timing of the slow modulation affects behavior," says Molter. "We are also trying to provide a model that incorporates the theta slow modulation to help propagation of activity between cell assemblies."

More information: Molter, C., O'Neill, J., Yamaguchi, Y., Hirase, H. & Leinekugel, X. Rhythmic modulation of theta oscillations supports encoding of spatial and behavioral information in the rat hippocampus. *Neuron* 75, 889–903 (2012). www.cell.com/neuron/abstract/S0896-6273%2812%2900622-8

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