GPS in the head? Rhythmic activity of neurons to code position in space

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Prof. Dr. Motoharu Yoshida and colleagues from Boston University investigated how the rhythmic activity of nerve cells supports spatial navigation. The research scientists showed that cells in the entorhinal cortex, which is important for spatial navigation, oscillate with individual frequencies. These frequencies depend on the position of the cells within the entorhinal cortex. "Up to now people believed that the frequency is modulated by the interaction with neurons in other brain regions", says Yoshida. "However, our data indicate that this may not be the case. The frequency could be fixed for each cell. We may need new models to describe the contribution of rhythmic activity to spatial navigation." The researchers report in the *Journal of Neuroscience*.

Rhythmic brains find their way

„The brain seems to represent the environment like a map with perfect distances and angles", explains Yoshida. "However, we are not robots with GPS systems in our head. But the rhythmic activity of the neurons in the entorhinal cortex seems to create a kind of map." The activity of individual neurons in this brain region represents different positions in space. If an animal is in a certain location, a certain neuron fires. The rhythmic activity of each cell may enable us to code a set of positions, which form a regular grid. Computer simulations of previous studies suggested that signals from cells in other brain regions influence the rhythmic activity of the entorhinal neurons. Using electrophysiological recordings in rats and computer simulations, Yoshida and his colleagues examined the nature of this influence.

Expressing the cellular rhythm in numbers

In order to simulate the input signals from other cells, Yoshida and his colleagues varied the voltage at the cell membrane (membrane potential). A change of the membrane potential from the resting state to more positive values thereby resembled an input signal from another cell. The membrane potential of the cells in the entorhinal cortex is not constant, but increases and decreases periodically; it oscillates. The scientists determined how fast the membrane potential changed (frequency) and how large the differences in these changes were (amplitude), when they shifted the mean membrane potential around which the potential oscillated.

Position determines the frequency

In the resting state, the membrane potential oscillations of the entorhinal cells were weak and in a broad frequency range. If the membrane potential was shifted to more positive values, thus mimicking the input of another cell, the oscillations became stronger. Additionally, the membrane potential now fluctuated with a distinct frequency, which was dependent on the position of the cell within the entorhinal cortex. Cells in the upper portion of this brain region showed oscillations with higher frequency than cells in the lower portion. However, the frequency was independent of further changes in membrane potential and thus largely independent of input signals from other cells.

More information: Yoshida, M., Giocomo, L.M., Boardman, I., Hasselmo, M.E. (2011) Frequency of Subthreshold Oscillations at Different Membrane Potential Voltages in Neurons at Different Anatomical Positions on the Dorsoventral Axis in the Rat Medial

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