



## Cognitive maps discovery – Far-reaching implications for contemporary neuroscience

Otkriće kognitivnih mapa – dalekosežni značaj za savremenu neuronauku

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The Nobel Prize in Medicine this year is shared by the three scientists whose research shed light on the concept of spatial orientation in the brain.

The movement started in the early development of life on Earth, from the most primitive to highly complex forms equipped with systems for multimodal navigation in space and time.

You guess, it is about the ability of man to recognize the coordinates of the current position and future projection of the trajectory in the world that surrounds it.

And even though this ability has been perfected from generation to generation for millions of years, marking the development of primates, understanding this infallible mechanism in neuroscience have been indicated only in recent decades.

More than 40 years ago, a young researcher, John O'Keefe, at the University College London published the first results of several years of research related to the recordings of neuronal firing in the dorsal hippocampus of freely moving experimental animals capacities<sup>1, 2</sup>. The results of these studies suggest the striking spatial correlates of neuronal firing that come from the so-called "place-cells" whenever the animal is at a particular location in a maze. This finding later led John O'Keefe and Nadel<sup>3</sup> to propose that the hippocampus could be the seat of a cognitive map.

Such cognitive maps, to further speculate, could be used not only for spatial navigation throughout the environment, but also as a memory framework upon which the significant items and episodes of experience could be superimposed. So, declarative memory in mammals could be lay down over the cognitive maps of spatial orientation.

Let me be provocative for a moment.

Was not this already known in the ancient times, as the Art of Memory, attributed to Pythagoreans ?

Actually, it was.

The Art of Memory is a mnemonic technique that was used to organize memory, especially during the epoch of the Renaissance as well as in the Western esoteric tradition, as for very long speeches of public orators.

To use this method one should walk through a building several times, viewing distinct places within it, in the same order each time, using it as the framework where one would place images or signs that would be used in the chains of associations later to connect one memory with another. One goal of the technique was without doubt, to maximize human mental capacities<sup>4</sup>.

Does this resemble to the experimental animals or subjects who store spatial maps and declarative memory in the hippocampus and the entorhinal cortex as O'Keefe and Nadel were speculated?

Research that followed the O'Keefe's pioneering work, in the next decades showed that the neural cells of the adjacent brain region, the medial entorhinal cortex show hexagonal patterns of activity stretching over the space traversed, similar to the lines that indicate the geographic coordinates on the earth's surface<sup>5-7</sup>. These findings of the so-called "grid-cells" come out from research of a Norwegian couple May-Britt and Edvard Moser, from Kavli Institute for Systems Neuroscience in Trondheim, Norway, making a "whole- frame image" complete.

But why were these discoveries chosen as ground breaking in the field of medicine for this year?

At the elementary level it is about knowing how mental functions are represented in the brain, but far-reaching implications are more complex.

Decoding the patterns of electrical activity in the neural networks was limited until recently primarily to the earliest stages of cortical processing, e.g. allowing the brain to repre-

sent sensory experiences from the external world – such as light and sound.

On the contrary, many were skeptical that it is possible to connect the complex brain functions such as memory, reasoning or imagination with neural firing at most high-end association cortices, primarily due to the increasing decoupling of neural activity as the more synaptic relays are added.

It is about getting to know the programming language which is used by the human nervous system to provide ways that information is integrated across hierarchical levels.

O'Keefe and the Moser couple discoveries of “place” and “grid” cells, led for the first time to breaking the “programmer code” deep in the brain, at the high end of the cortical hierarchy. Those findings could be the first steps at the long journey of learning the operating language of the brain.

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