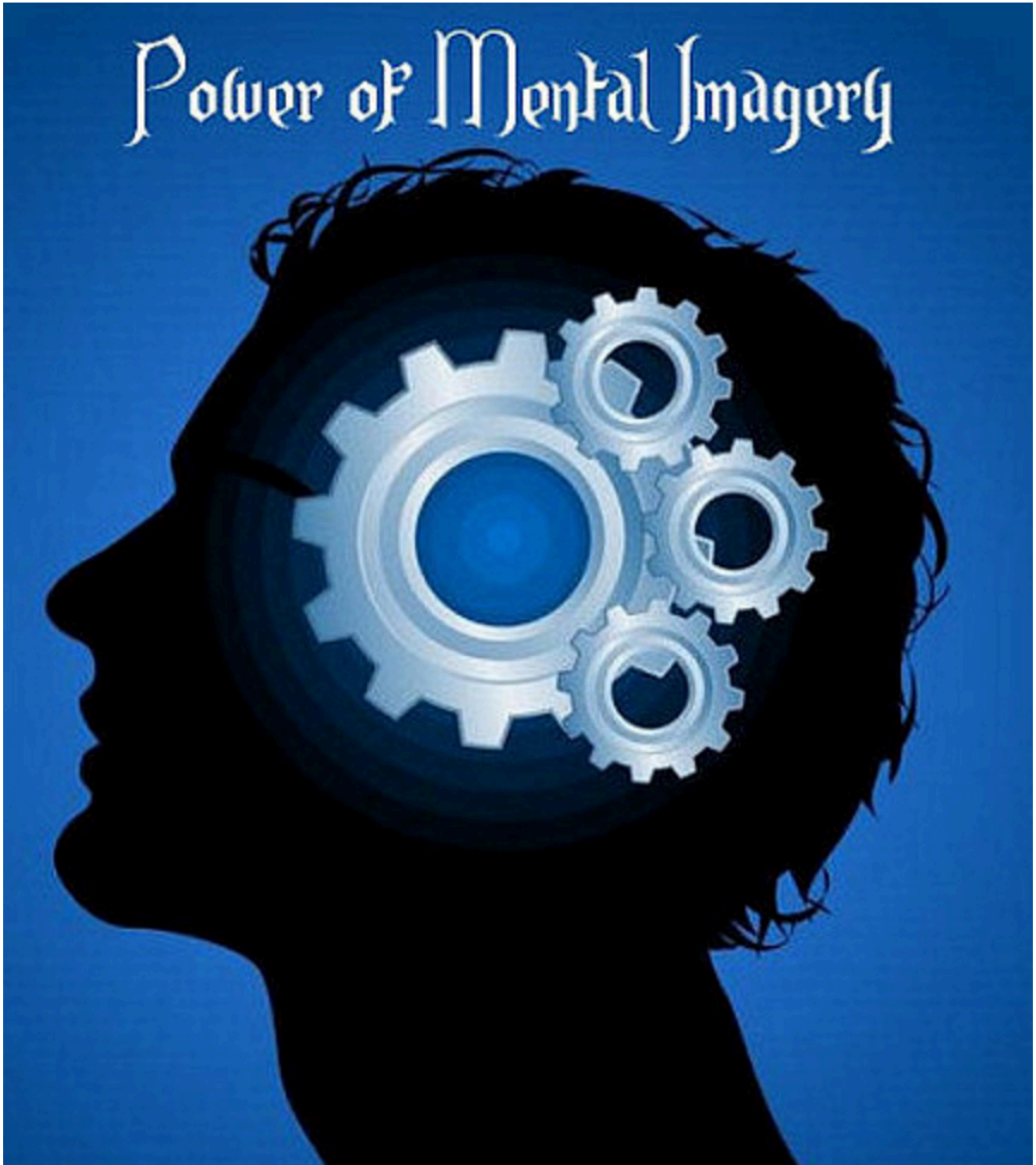


ELL788

Date: 22nd Sept. 2016

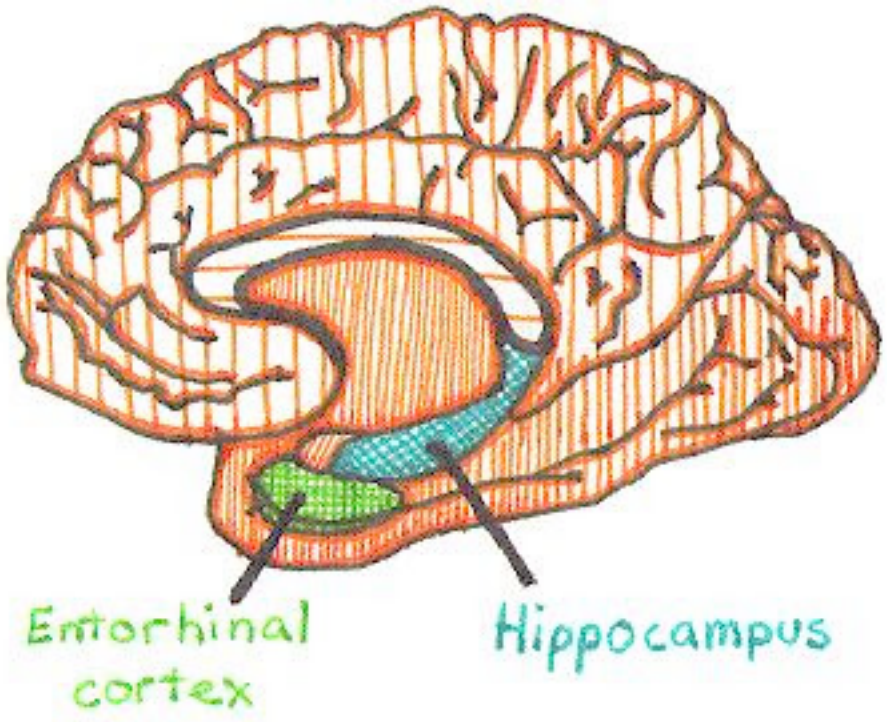
Perceiving the world!

Mental imagery (varieties of which are sometimes colloquially referred to as "visualizing," "seeing in the mind's eye," "hearing in the head," "imagining the feel of," etc.) is quasi-perceptual experience; it resembles perceptual experience, but occurs in the absence of the appropriate external stimuli. It is also generally understood to bear intentionality (i.e., mental images are always images of something or other), and thereby to function as a form of mental representation.

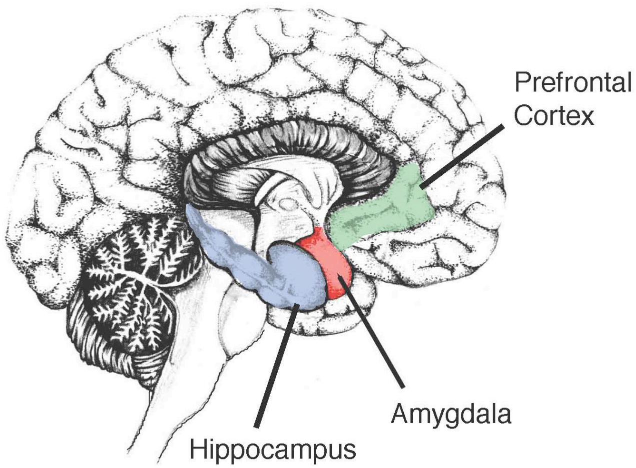
The sense of place and the ability to navigate are fundamental to our existence. The sense of place gives a perception of position in the environment. During navigation, it is interlinked with a sense of distance that is based on motion and knowledge of previous positions.

- How do we know where we are?
- How can we find the way from one place to another?
- And how can we store this information in such a way that we can immediately find the way the next time we trace the same path?

In 2014, Nobel Laureates have discovered a positioning system, an "inner GPS" in the brain that makes it possible to orient ourselves in space, demonstrating a cellular basis for higher cognitive function.


Entorhinal
cortex
Hippocampus

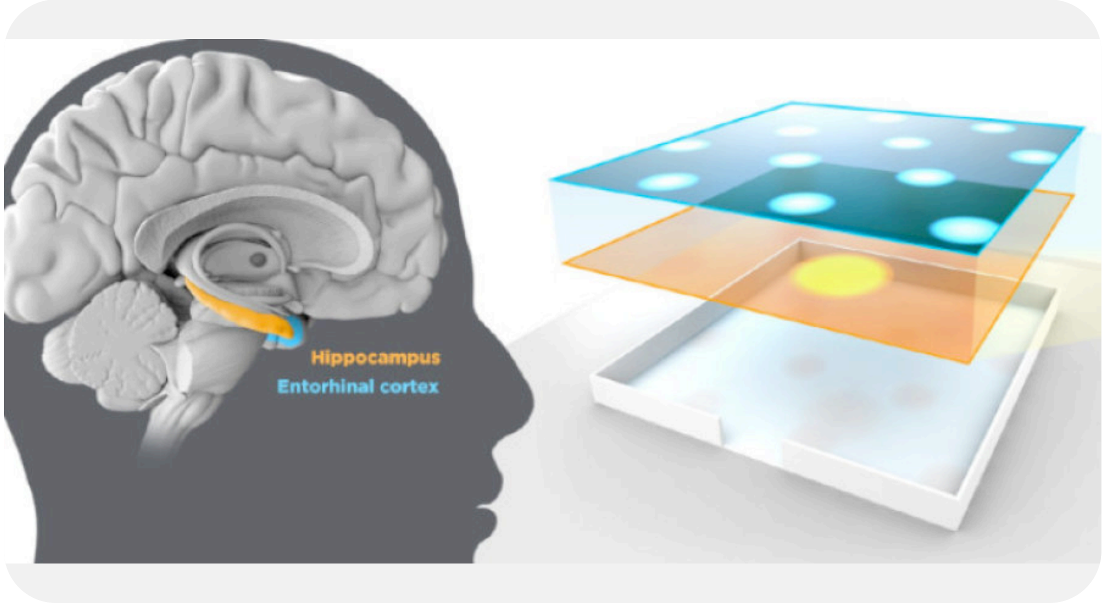
John O´Keefe and the place in space



John O´Keefe was fascinated by the problem of how the brain controls behaviour and decided, in the late 1960s, to attack this question with neurophysiological methods. When recording signals from individual nerve cells in a part of the brain called the hippocampus, in rats moving freely in a room, O'Keefe discovered that certain nerve cells were activated when the animal assumed a particular place in the environment. He could demonstrate that these "place cells" were not merely registering visual input, but were building up an inner map of the environment. O'Keefe concluded that the hippocampus generates numerous maps, represented by the collective activity of place cells that are activated in different environments. Therefore, the memory of an environment can be stored as a specific combination of place cell activities in the hippocampus. He first reported this result in 1971.

May-Britt and Edvard Moser find the coordinates

May-Britt and Edvard Moser were mapping the connections to the hippocampus in rats moving in a room when they discovered an astonishing pattern of activity in a nearby part of the brain called the entorhinal cortex. Here, certain cells were activated when the rat passed multiple locations arranged in a hexagonal grid. Each of these cells was activated in a unique spatial pattern and collectively these "grid cells" constitute a coordinate system that allows for spatial navigation. Together with other cells of the entorhinal cortex that recognize the direction of the head and the border of the room, they form circuits with the place cells in the hippocampus. This circuitry constitutes a comprehensive positioning system, an inner GPS, in the brain.



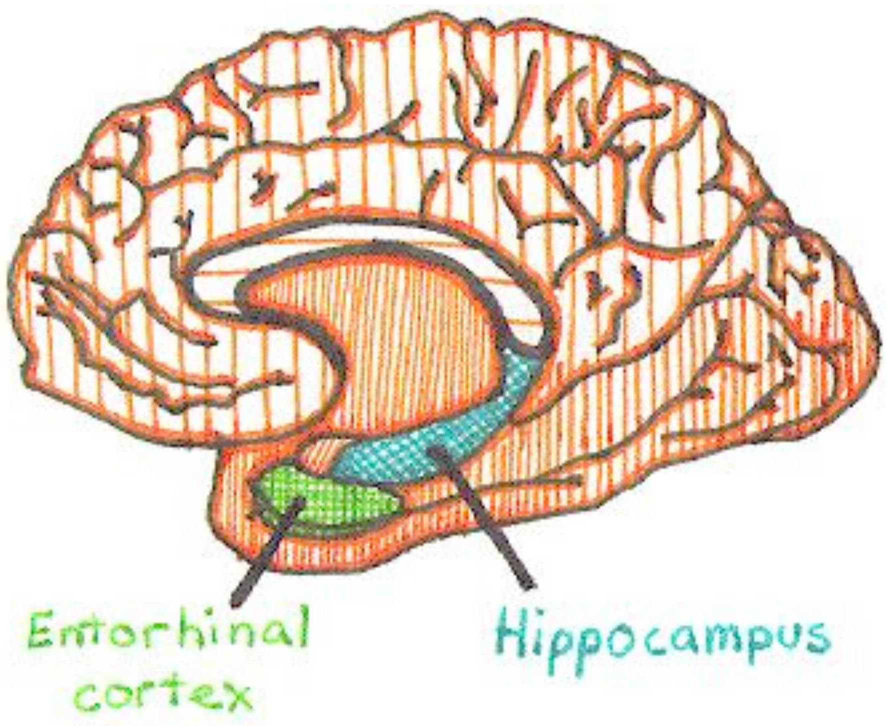
- More than three decades later, in 2005, May-Britt and Edvard Moser discovered another key component of the brain's positioning system. They identified another type of nerve cell, which they called "grid cells," that generate a coordinate system and allow for precise positioning and path finding. Their subsequent research showed how place and grid cells make it possible to determine position and to navigate.

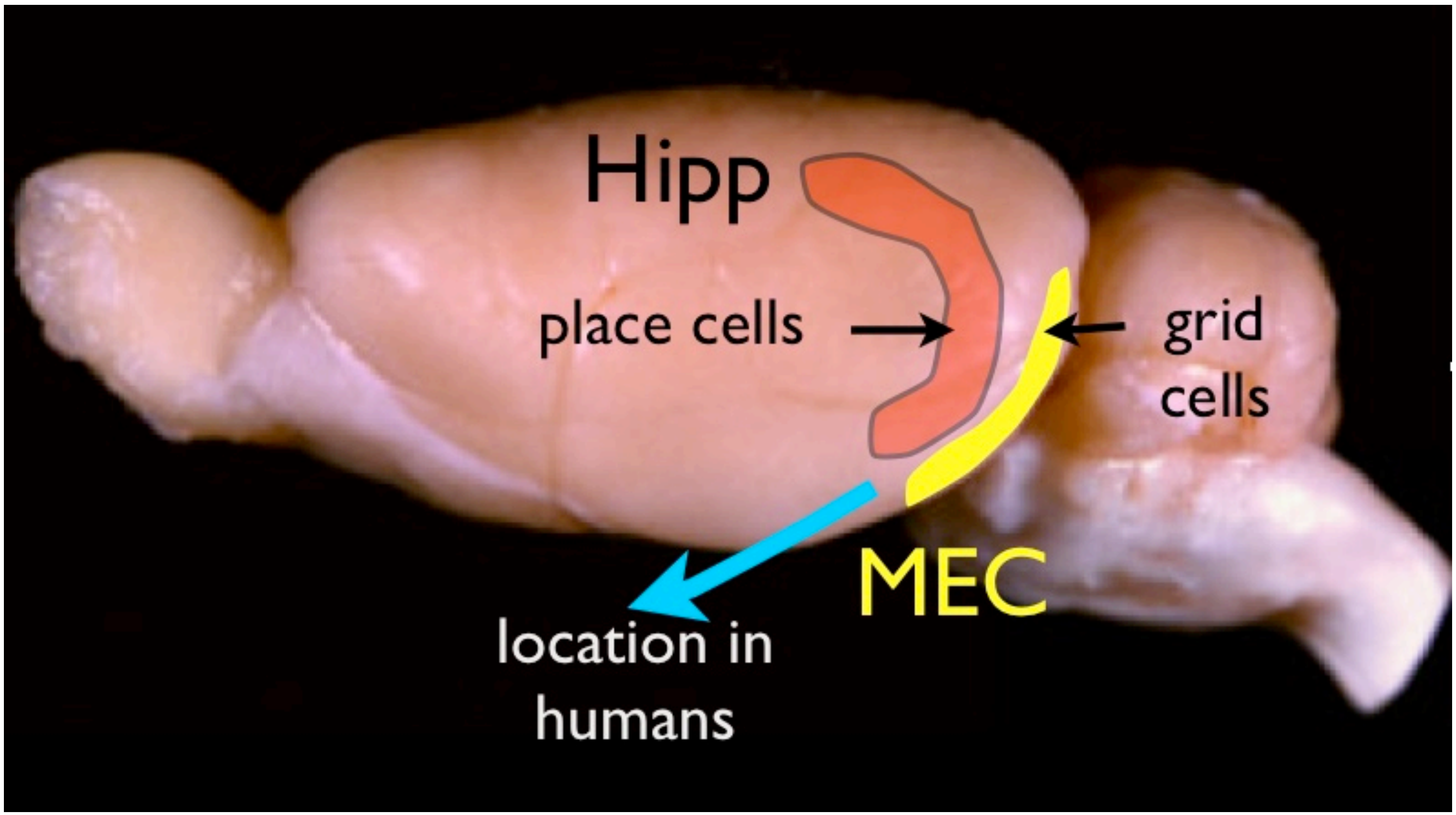
- The discoveries of John O´Keefe, May-Britt Moser and Edvard Moser have solved a problem that has occupied philosophers and scientists for centuries -- how does the brain create a map of the space surrounding us and how can we navigate our way through a complex environment?

A place for maps in the human brain

- Recent investigations with brain imaging techniques, as well as studies of patients undergoing neurosurgery, have provided evidence that place and grid cells exist also in humans. In patients with Alzheimer´s disease, the hippocampus and entorhinal cortex are frequently affected at an early stage, and these individuals often lose their way and cannot recognize the environment. Knowledge about the brain´s positioning system may, therefore, help us understand the mechanism underpinning the devastating spatial memory loss that affects people with this disease.

- The discovery of the brain's positioning system represents a paradigm shift in our understanding of how ensembles of specialized cells work together to execute higher cognitive functions. It has opened new avenues for understanding other cognitive processes, such as memory, thinking and planning.


Entorhinal
cortex
Hippocampus


Hipp
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location in
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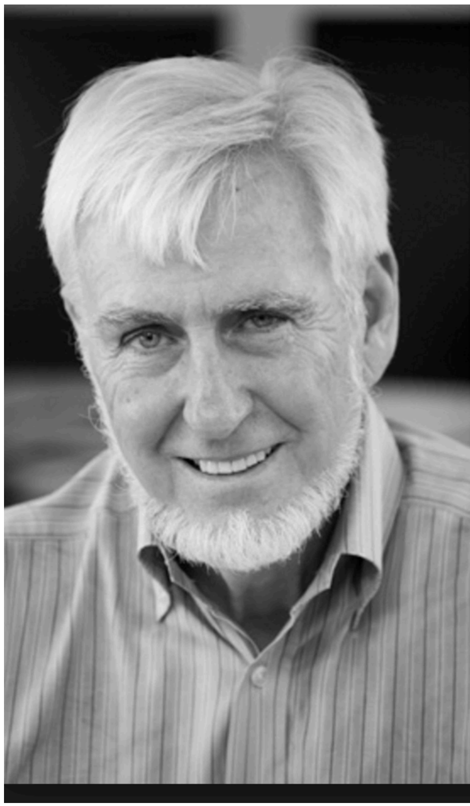
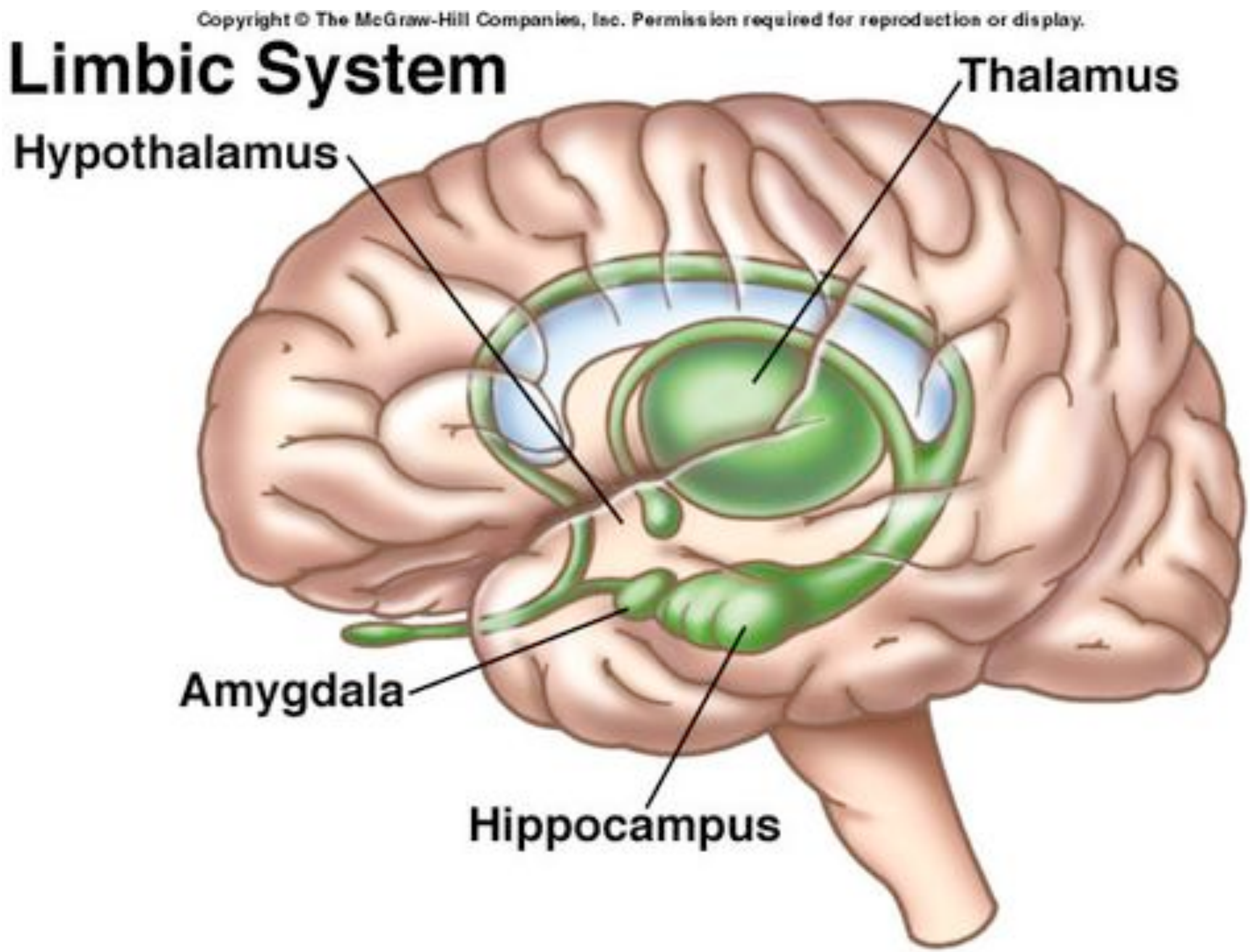
2014 Nobel Prize in Physiology or Medicine


John O´Keefe


May-Britt Moser


Edvard Moser



The limbic system supports a variety of functions including emotion, behavior, motivation, long-term memory, and olfaction. Emotional life is largely housed in the limbic system, and it has a great deal to do with the formation of memories.

- *The factors contributing to the development of spatial imagery skills are not well understood*
- *Here we ask whether visual experience shapes these skills.*

- Sensory input across multiple modalities (vision, audition, touch and proprioception) is rich with information about the spatial structure of our environment and the objects therein. The redundancy of these multiple sources, and their strong interactions while providing robustness, also makes it difficult to titrate their individual contributions

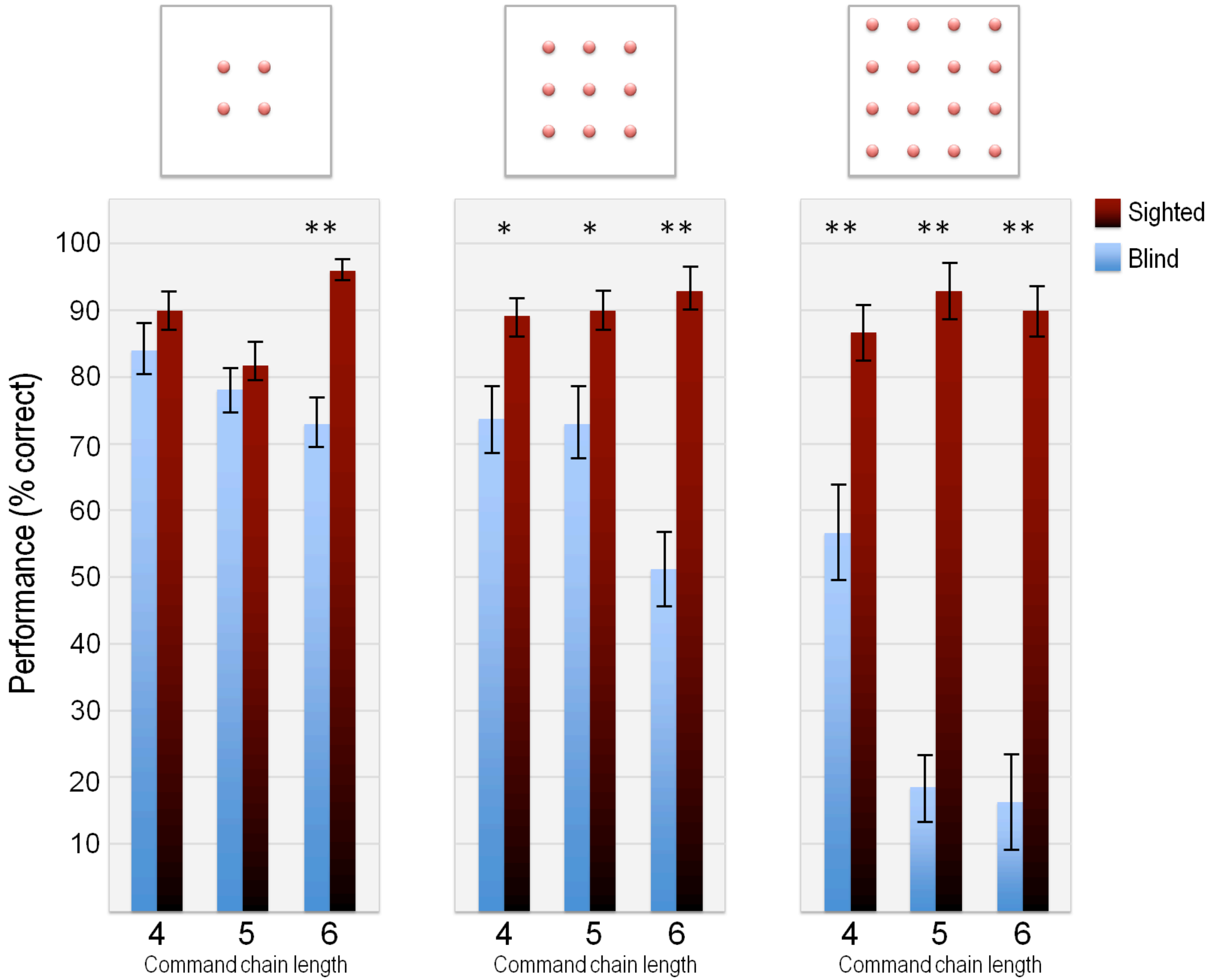
- One way of providing insight into this issue is to determine whether spatial skills change after the introduction of a sensory stream that an individual had been deprived of since birth.

- Obvious ethical considerations rule out forced sensory deprivation as an experimental manipulation with human subjects. This question has, therefore, remained largely unaddressed thus far.

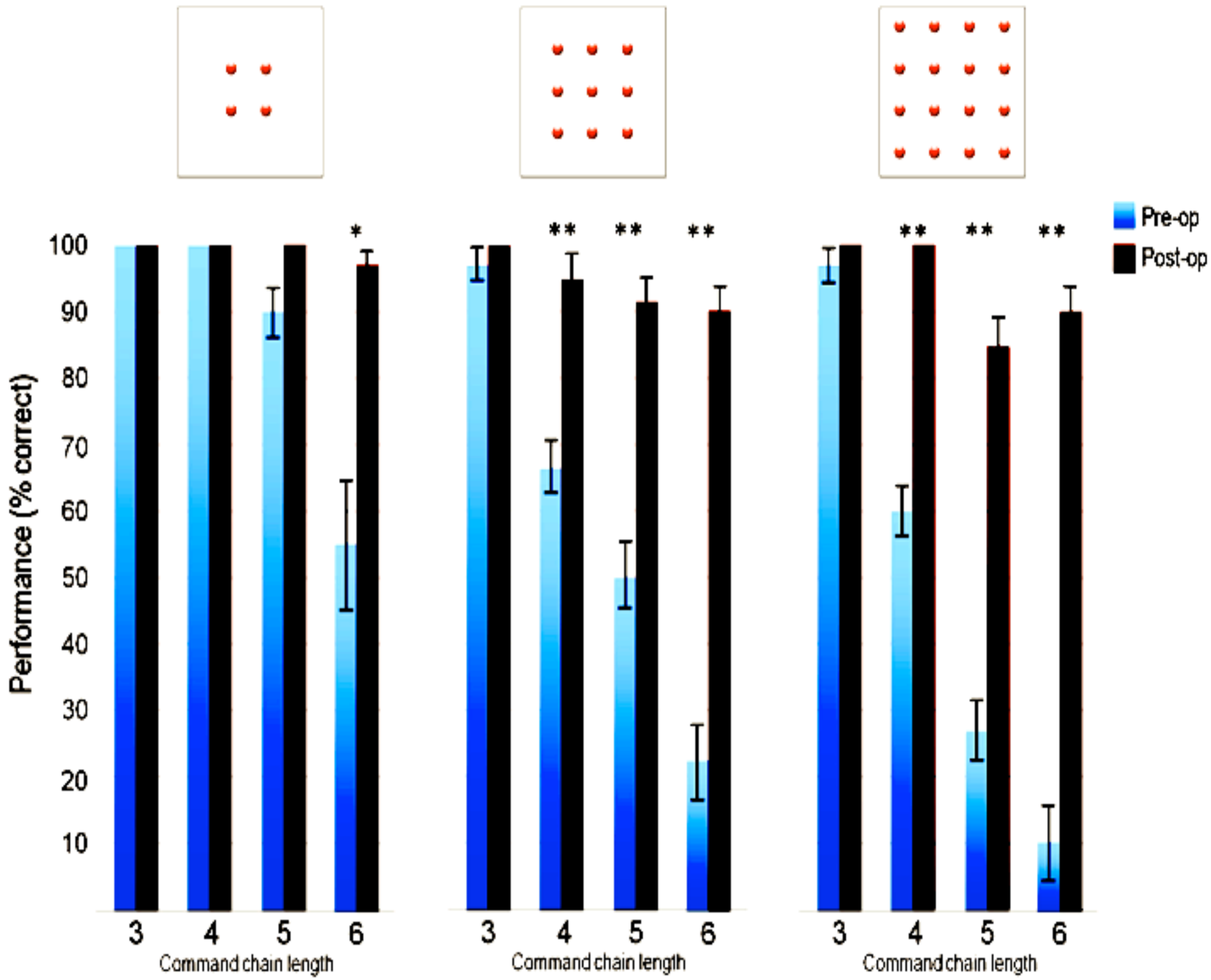
- The basic finding from these studies is that people born without sight are able to mentally experience spatial representations
- Several studies have found that congenitally blind individuals perform less accurately than age-matched sighted participants in spatial imagery tasks
- However, the robustness of these group differences is debatable. Some studies have argued that visual experience is neither necessary nor sufficient for the development of spatial representations


(a)
(b)
(c)

Mean performance accuracy for blind and sighted (blindfolded) groups



Performance of congenitally blind children on spatial reasoning tasks of different complexities before and after gaining sight



- Our goal was to examine whether visual experience contributes to spatial imagery skills.
- We find that a basic level of spatial imagery can be developed even with very limited visual experience
- However, spatial imagery skills of congenitally blind children improved significantly and rapidly after the onset of sight.

These results suggest that visual experience can significantly enhance spatial imagery capabilities.

- Besides demonstrating that internal spatial representations are enriched by visual information, the results reported here also bear on the question of when such enrichment can happen?
- Much as there are sensory critical periods (Daw, 2006), there could also be a critical period for the development of spatial imagery skills.

We are led to conclude that either the ability of vision to contribute to spatial skills is not subject to a strict critical period or the critical period, if it exists, extends beyond the late teenage years

These findings raise several interesting questions: THREE are highlighted here

- First, does the nature of spatial imagery change qualitatively when the blind gain sight (Kaski, 2002; Röder, Rösler, & Hennighausen, 1997)? If so, do the newly sighted use an imagery system that is fundamentally different from the one they used preoperatively? Or is the postoperative system a more elaborated version of the same one that they used preoperatively?
- Second, what kinds of learning and representational change mechanisms can account for the rapidity with which spatial imagery abilities change after the onset of sight?
- From an applied perspective, our results point to the capacity for improvement in spatial skills well into adolescence. Thus, our third question is, can such improvement be achieved in any way other than through sight-restoring surgeries? This question is of relevance to the many blind individuals whose blindness is currently not treatable.

Gandhi et al. 2014