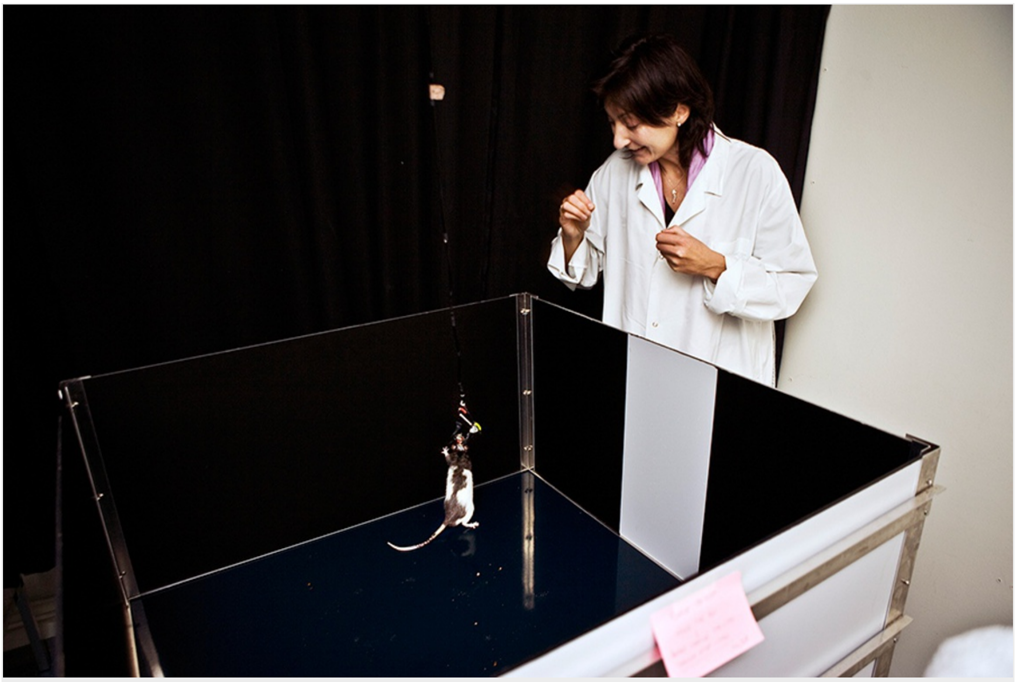
‘Speedometer’ neurons discovered in rat brains

Nobel laureates identify speed cells as a crucial component of the mammalian navigation system.

Alison Abbott

15 July 2015



Kavli Institute/NTNU

Nobel winner May-Britt Moser with one of her experimental subjects.

A long-sought neural ‘speedometer’ has been discovered in rats: a set of dedicated neurons that fire quickly when the rats move fast, and more slowly when they dawdle.

The cells are a missing component of the brain’s elaborate navigation system, which helps us to know where we are and where we have been. They were discovered[1] in a seven-year project in the lab of Edvard Moser and May-Britt Moser at the Norwegian University of Science and Technology in Trondheim. The Mosers were co-winners of last year’s Nobel Prize in Physiology or Medicine for their 2005 discovery of another fundamental part of the brainsystem: GPS-like grid cells, which fire according to position in space.

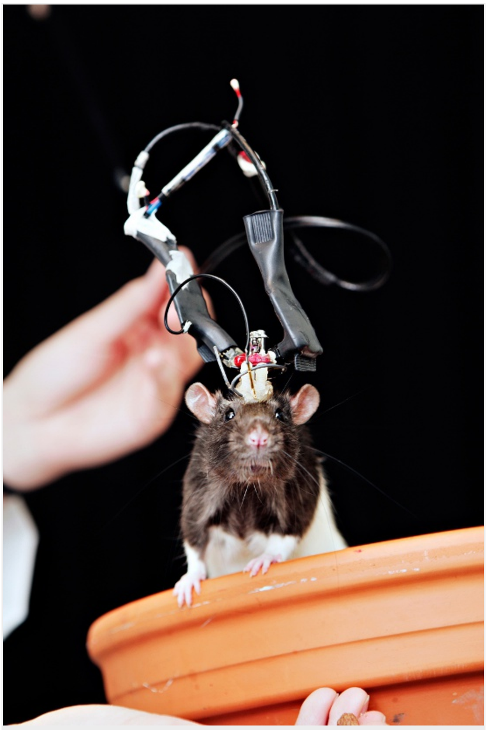
Neuroscientists have discovered other navigation-related cells: first ‘place cells’, which fire when animals are in a particular location, and later other neurons that fire in response to borders or to changes in the direction the head is facing. (The place cells were described in the 1970s by John O’Keefe of University College London, who shared the Nobel with the Mosers.) Information from all these cells helps the brain to create an internal map of location. But speed cells are required to allow the map to be updated in real time.

Rat race

The Mosers and their team implanted electrodes into the brains of 26 rats, in and around a structure called the entorhinal cortex, where grid cells are also found. The electrodes were sensitive enough to pick up signals from individual neurons.

The rats had been trained to run in a kind of bottomless car — rather like that of cartoon character Fred Flintstone, as the Mosers note in their paper. The rat-sized car was fixed on rails, and pulled along a four-metre track at speeds defined by the experimenters. The rats, aware that a chocolate treat awaited them at the end of the track, moved voluntarily at the fixed speed while the scientists recorded from their electrodes. To make sure that the neurons responded to speed in the absence of physical constraints, the scientists also recorded as the rats ran around in an open space looking for treats. The rats were allowed to rest in shallow flowerpots between sessions.

Over more than 2,000 recording sessions, the researchers recorded from a total of 2,497 cells in the entorhinal cortex. They found that 15% of them were speed cells, firing faster or slower according to the rats' speed, irrespective of which direction they moved in, and independent of whether the room was light or dark.



Geir Mogen/NTNU

A rat resting in a flower-pot in the Mosers' lab.

Precision measurement

The cells were fully dedicated to speed detection, and responded so strongly that the scientists could accurately decode a speed signal from just half a dozen neurons.

"Weak speed signals had been seen in the brain, but this new class of cells give us a clear, powerful signal," says Nachum Ulanovsky of the Weizmann Institute of Science in Rehovat, Israel, who studies navigation neurons in bats. "The difference is like the speedometer in your car measuring 50 m.p.h. quite accurately — rather than with a plus or minus error of 40 m.p.h.." Researchers currently assume that neural navigation systems are fairly similar across mammals, although it would be difficult to look for the speed cells in humans.

"Whether the navigation picture is complete is another matter," says Edvard Moser. Other, as-yet undiscovered, cell types may turn out to be important, he says, as might the interactions between all of the various navigation cells. "The next step is to understand how the different cell types work together to produce a sense of location — and how the map is used for navigation."

Nature | doi:10.1038/nature.2015.17981

References

1. Kropff, E., Carmichael, J. E., Moser, M.-B. & Moser, E. I. *Nature* http://dx.doi.org/10.1038/nature14622 (2015).