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NEURAL CODING

Speed awareness

For animals (and humans) to successfully navigate their environment, their brain must perform path integration to construct an 'internal map' of their surroundings. Over the past half-century, several specialized populations of cells that encode the information essential to perform this task have been identified within the rodent hippocampus and entorhinal cortex. A recent report from the Moser group now describes one of the remaining 'missing pieces' of the path integration system: a population of cells that are dedicated to signalling the speed of an animal's movement.

A 'speed signal' is a necessary component of all models of path integration, and there has been considerable debate about the nature and source of this signal in the brain. To identify the neurons that might provide this information, Kropff *et al.* recorded the activity of thousands of neurons across the medial entorhinal cortex (MEC) of 26 rats. In the first experiment, the rats walked or ran along a linear track. To control the animals' running speed, they were placed in a bottomless 'Flintstones' car' that could be moved along the track at a constant speed, or rapidly accelerated or decelerated by the researchers. In a second experiment, the neurons' firing was recorded as the animals moved freely around an open chamber. In both cases, the authors identified a number of 'speed cells' whose firing rate demonstrated a linear relationship with the animal's running speed, but was not affected by the animal's spatial location. Further analysis of the timing of cell firing showed that the cells actually encoded a prospective speed signal: their firing rate correlated with the animal's speed around 50–80 ms in the future.

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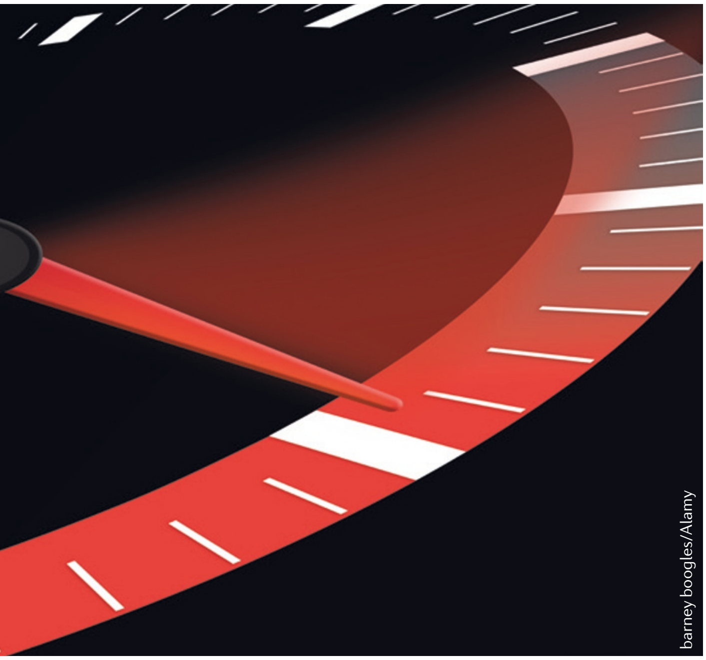

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The speed cells constituted approximately 15% of the total cells recorded. By comparing their functional properties with those of other established populations of cells in the MEC, such as grid cells, head-direction cells and border cells, the authors were able to establish that the speed cells are a separate population of functionally dedicated cells. To confirm that the cells' firing rates could accurately encode speed, the authors fed data from 2–6 simultaneously recorded speed cells from one animal into a computerized linear decoder. The decoder was able to accurately determine the animal's actual running speed based on the firing rate of 4–6 cells, showing that the information from only a few speed cells can be used to encode speed.

In order for the signal encoded by the speed cells to contribute to path integration, it is essential that it is not affected by the animal's context. The authors used data collected in previous work in which neuronal firing was recorded as rats moved around two different rooms to show that the relationship between firing rate and running speed in cells that could now be identified as belonging to the speed cell population was not altered in different environments. Likewise, the encoding of speed by these cells did not require visual input, as there were no changes in the firing rate–speed relationship of these cells when the animals were tested in the light or in the dark.

The identification of a specific population of speed cells has important implications for our understanding of the mechanisms used by the brain to map an animal's position in its environment. How information from each of the specialized populations of neurons in the MEC is integrated is an essential question for future work.

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ORIGINAL RESEARCH PAPER Kropff, E. *et al.* Speed cells in the medial entorhinal cortex. *Nature* **523**, 419–424 (2015)
FURTHER READING Moser, E. I. *et al.* Grid cells and cortical representation. *Nat. Rev. Neurosci.* **15**, 466–481 (2014)