

The brain doesn't navigate quite like a GPS

Neuroscientists' discovery of grid cells, popularly known as the brain's GPS, was hailed as a major discovery. But new results suggest the system is more complicated than anyone had guessed.

Just like a driver in a car, the brain needs some basic navigational instruments to get around, and it is not an idle analogy. In fact, scientists have found brain cells that are similar to speedometers, compasses, GPS and even collision warning systems.

That simple analogy, however, may belie the more complex way our brains actually map out the world, Stanford researchers report April 6 in *Neuron*. While some of the neurons in our internal navigation systems look a lot like speedometers or compasses, many others operate flexibly, each one encoding a dynamic mix of navigational variables, like a compass that somehow transforms into a GPS when driving downtown.

It's a discovery that could change the way we think about navigation in the brain, said Lisa Giocomo, an assistant professor of neurobiology in the School of Medicine and member of Stanford Bio-X and the Stanford Neurosciences Institute. In fact, it might even challenge one of our most basic assumptions about how neurons work.

Beginning at the boundary

The project began in 2014 when Giocomo and Surya Ganguli, an assistant professor of applied physics, got a Bio-X seed grant to take a closer look at how the brain finds its way around. It was the same year a Nobel Prize was awarded for the discovery of grid cells, specialized neurons that help animals keep track of where they are in their environments. At the time, they were hailed as the brain's GPS.

But something was off: While some neurons fell within the ballpark of how a grid cell was supposed to behave, most provided only noisy, error-prone navigation, like a GPS on the fritz. That led Ganguli, Giocomo and Kiah Hardcastle, a Stanford Neurosciences Institute graduate fellow, to wonder whether the brain had a way to correct those errors.

As it turns out, the brain does have a way: boundary cells, so named because they fire when nearing walls and other landmarks. By tracking neuron firing in mice as they walked around a square box, the group found that boundary cells help reset wayward grid cells, much like stumbling on a familiar spot helps reorient someone who had been hopelessly lost.

That finding, published in 2015, was significant in its own right – until then, no one understood how grid cells could track position error-free over long distances. But something more surprising was in store.

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