Navigation system in rodents akin to ancient, open ocean direction-finding

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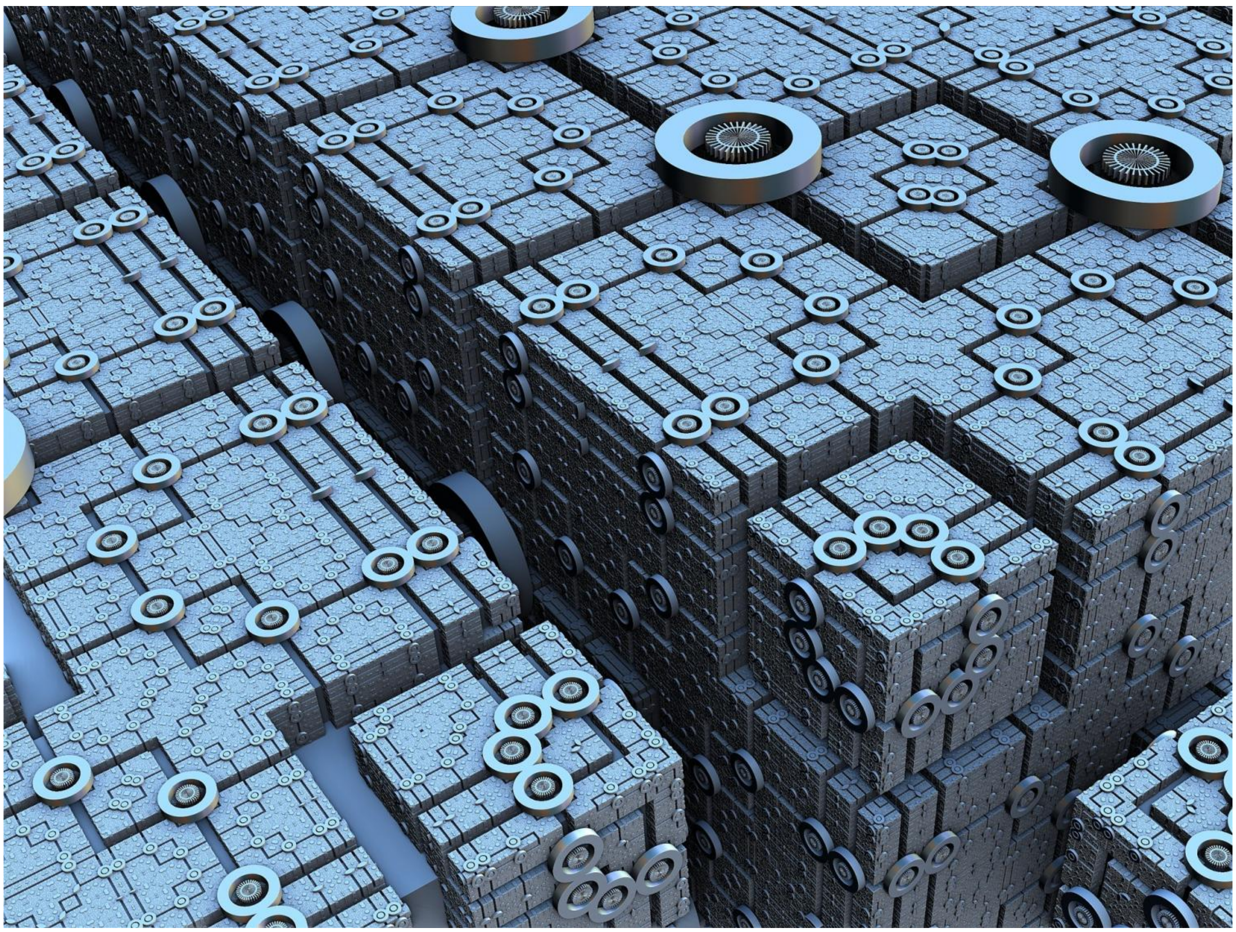

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The navigation system used by rodents is similar to that used by Pacific

Islanders in finding their way through the open ocean without a compass, a team of neuroscientists has found.

Its findings, which appear in the latest issue of the journal *Neuron*, correct a common misconception: mammals' navigation systems operate like a global positioning system (GPS), which relies on a compass-like direction sense.

"These findings offer new, compelling evidence of how our internally organized sense of direction is registered to the external world so we can navigate effectively," observes André Fenton, a professor in New York University's Center for Neural Science and the paper's senior author. "Notably, how we orient in space is not akin to a GPS; rather, our direction sense is fundamentally subjective, internally organized, and intermittently registers to external landmarks."

While many have posited that humans navigate using a GPS-like system in their brains—one that relies on a compass-like direction sense—the intricacies of this process are not clear.

However, it has been well-established that the mammalian navigation system is centered in the hippocampus and entorhinal cortices —parts of the brain crucial for understanding space and memory.

Specifically, John O'Keefe, May-Britt Moser, and Edvard Moser shared the 2014 Nobel Prize in Physiology or Medicine for their discovery of cells that signal location and distance moved—the latter of which are crucial for being oriented in space. Their work was supplemented by a finding by James Ranck, a professor at SUNY Downstate Medical Center and one of the *Neuron* paper's co-authors, who discovered neurons that signal direction.

To have a better understanding of how these neuronal pieces fit in order to navigate both stationary and rotating space, Fenton, Ranck, and their colleagues conducted a series of experiments using rats.

In it, they created a carousel-like structure that had both stationary and moving parts. The rats were trained on a navigation task that required them to know where they were in both the moving and stationary frames. During these tasks, the scientists monitored the rats' neurological activity, focusing on head-direction cells, which are most fundamental component of the navigation system.

However, the experimental results offered limited insights.

"The data were extremely clear and initially totally not understandable," says Fenton. "Despite excellent navigation, the head-direction cells stopped signaling direction in either of the stationary or rotating spatial frames."

The finding was not an uncommon one. For years, scientists have struggled to determine why laboratory rats could successfully navigate when activity in head-direction cells was quite restricted, raising questions as to how this process occurs in the brain.

Fenton then recalled the principles of etak navigation that he learned from a book, We, the Navigators: The Ancient Art of Landfinding in the Pacific, authored by New Zealand doctor David Lewis, and that Ranck had given Fenton in the early 1990s.

From the work, Fenton learned that etak navigation is practiced without a compass by Pacific Islanders as they move precisely between islands that are so small and far apart that they are mostly unseen during the journey, making small navigation errors deadly.

"Etak navigation is both very effective and subjectively conceptualized," explains Fenton. "The navigator uses knowledge of the stable locations of stars in the sky and a distant visible or imagined landmark like an island.

"Despite knowing better, the navigator imagines herself stationary and the earth moving below her boat as she travels. To navigate, the navigator orients to line up herself, the etak landmark, and a star. She then journeys so that the earth-attached etak landmark moves until it is co-linear with the navigator and the next orienting star. The navigator proceeds to the destination in a series of such etak stages."

Re-conceptualizing navigation in the etak framework, the researchers measured the directional tuning of each head-direction neuron relative to the activity of another head-direction cell in the rats. They discovered that head-direction cells signal direction by their activity in a manner that is internally consistent, no matter if the environment is stable or rotating.

In addition, this internal direction sense intermittently registers—every 10 seconds or so—to distinct landmarks in a particular space. Between registrations, the navigating rat, like the etak navigator, keeps track of where it is.

"These new findings line up with most people's sense that they can become intermittently disoriented and reoriented, especially in unfamiliar spaces," notes Fenton.

More information: Eun Hye Park et al, How the Internally Organized Direction Sense Is Used to Navigate, *Neuron* (2018). DOI: 10.1016/j.neuron.2018.11.019

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