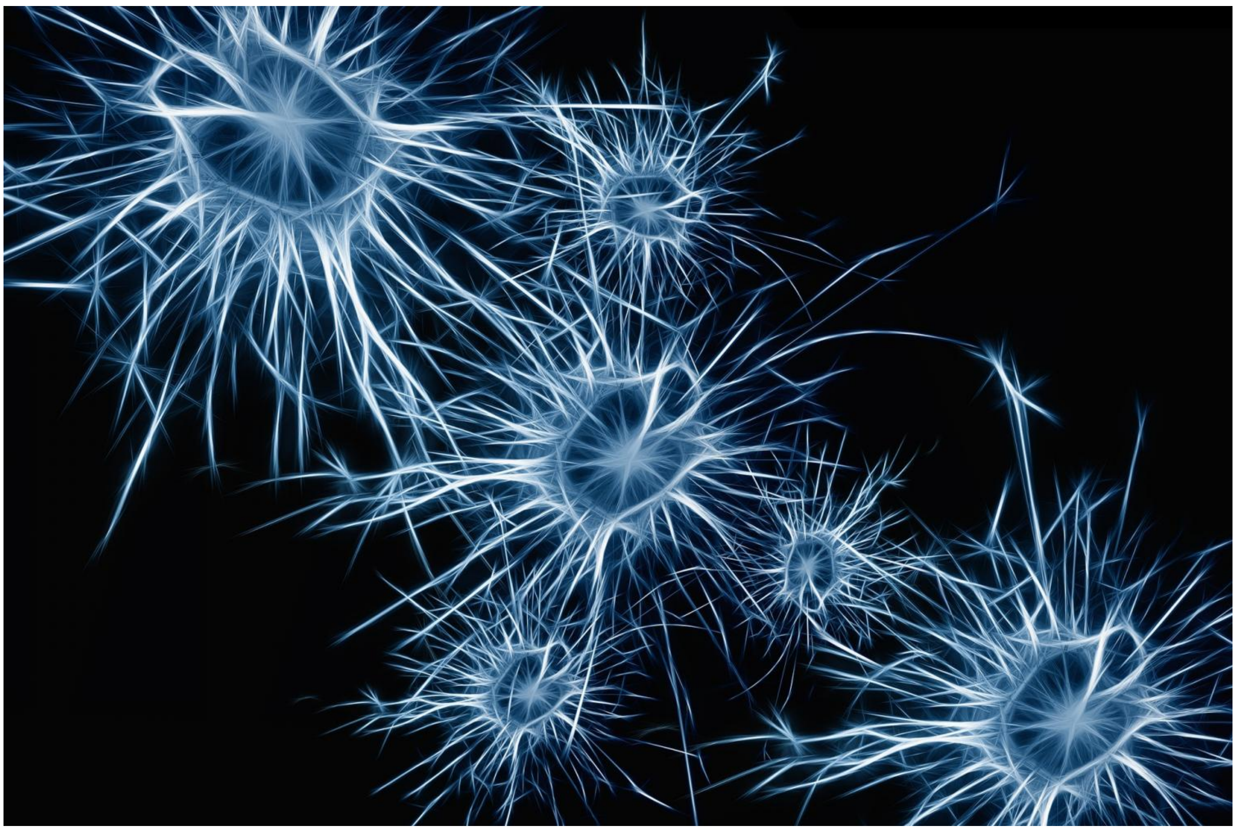
Researchers identify unique neuron that computes like a compass

February 4 2020



Credit: CC0 Public Domain

It's 5 p.m. as you leave the parking garage at work, but you realize you have no idea which way to turn to travel home. You know where you are and what street your house is on—it's just that you can't remember how to get there.

This is what happens to patients with damage to a part of their brain called the retrosplenial cortex, a key region involved in the organ's inner compass. Despite its importance for navigation, the neurons and circuits it uses to help get people from the office to home remain understudied.

By recording signals from individual neurons in the mouse brain, researchers at the University of Michigan have identified a distinct excitatory neuron in the retrosplenial cortex. The properties of this neuron are ideally suited to encode direction-related information over long durations, like a compass.

"Regular neurons in the cortex are good at encoding directional information only when you are moving your head, but what happens when your head is still? You still need to know what direction you are facing so that you can use this information to plan your route," said Omar Ahmed, assistant professor of psychology, neuroscience and biomedical engineering, and lead author of the study published in the journal *Cell Reports*.

"You ideally need another kind of neuron—a neuron that can continuously encode your orientation over long durations even when your head is not moving."

Typical excitatory neurons slow down their firing rather quickly. In contrast, the newly identified neurons can continue firing their signals at high rates for extended periods of time—they are persistent and fast.

A second difference lies in their capacity to respond to inputs—these unique neurons, called low rheobase neurons—are hyperexcitable, which means they need little input to be activated.

"A simpler name for this small yet tenacious little neuron, as suggested by my classmate, would be 'The Little Neuron That Could,'" said Ellen Brennan, the graduate student who identified these unique neurons. "It's the perfect name because it highlights the persistence that makes them optimally suited to code continued direction. In comparison, the other typical excitatory neurons here are slow and stubborn."

"So the question was, can these low rheobase neurons process directional information better than typical excitatory neurons?" said Shyam Sudhakar, a postdoctoral fellow in the Ahmed lab who created computer models of these neurons to show that the answer is "yes."

"It's important for my brain to know when I change direction, but it's not good if all my brain detects is change," Brennan said. "A compass always has to know which way is north. It wouldn't be useful without that persistent sense of direction. That is exactly what the low rheobase neurons can provide."

Ahmed's lab is now focused on understanding how these unique neurons are altered in Alzheimer's model mice.

"The retrosplenial cortex is critical for spatial orientation, but is one of the earliest brain regions to show dysfunctional activity in Alzheimer's patients," Ahmed said. "This is probably why the vast majority of Alzheimer's patients suffer from spatial disorientation and get lost easily—because their retrosplenial cells are not working as they should.

"By understanding how retrosplenial cells encode compass-like information in healthy versus Alzheimer's brains, we hope to start working towards novel therapies."

More information: Hyperexcitable Neurons Enable Precise and Persistent Information Encoding in the Superficial Retrosplenial Cortex,

Cell Reports (2020). [DOI: 10.1016/j.celrep.2019.12.093](https://dx.doi.org/10.1016/j.celrep.2019.12.093) ,
[www.cell.com/cell-reports/full … 2211-1247(19)31758-9](https://www.cell.com/cell-reports/fulltext/S2211-1247(19)31758-9)

Provided by University of Michigan