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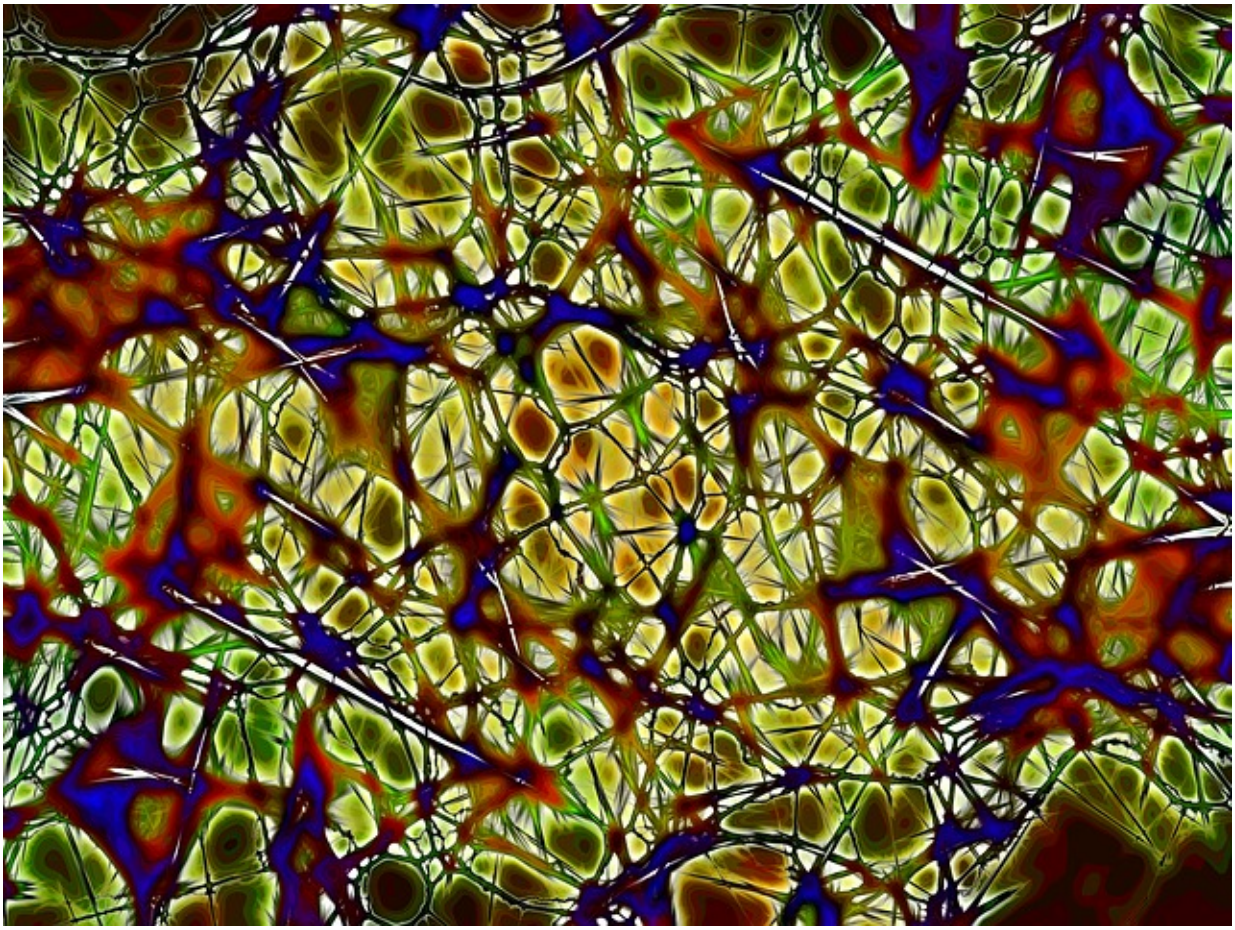
Researchers explain how vestibular system influences navigation

January 19 2016



In studying head direction cells and other neurons, Dartmouth Professor Jeffrey Taube and his colleagues have found the first direct evidence showing how the vestibular system's horizontal canals play a key role in sensing our direction in the environment. Credit: Dartmouth College

Dartmouth researchers have found the first direct evidence showing how the vestibular system's horizontal canals play a key role in sensing our direction in the environment.

The findings, which appear in the *Journal of Neuroscience*, shed light on brain activity that helps us to get around and that is impaired by trauma, stroke and neurodegenerative diseases. A PDF is available on request.

"Knowing what direction you're facing, your location, how to navigate our environment and your spatial orientation at any given moment is fundamental to survival," says Professor Jeffrey Taube, the study's senior author.

The vestibular system consists of otolith organs and semicircular canals in each ear that provide sensory information about motion, balance and spatial orientation, allowing us to establish our location and direction and to navigate our environment. A number of cell types in the brain respond in relation to where you are (place cells) and your perceived directional heading (head direction cells, which fire when an animal faces a particular direction). A third cell type (grid cells) is activated at multiple places in the environment. Previous studies have shown that vestibular information is critical for generating the head direction signal but have not confirmed whether information from all three semicircular canals or just the horizontal canals, which are primarily sensitive to horizontal head rotation, are critical for the head direction signal.

To understand how head direction cells generate their activity, the Dartmouth researchers monitored brain cells in mice that have a mutant gene that prevents their vestibular system from developing properly. Specifically, it was a part of the vestibular system responsible for sensing how you are rotating or turning in the horizontal plane. They found that these mutant mice did not have normal head direction cells, which no longer fired in a directional manner.

"Our results suggest that the neural structure for the head direction network remains intact in mutant mice, but the absence of normal horizontal canals results in an inability to control the network properly and brings about an unstable head direction signal," Taube says. "These findings are important for two reasons—they confirm previous theoretical views that this portion of the vestibular system is important for generating the head direction cell signal, and they show how the neural network, as a whole, functions in this brain area."

More information: *Journal of Neuroscience*, dx.doi.org/10.1523/JNEUROSCI.3790-14.2016

Provided by Dartmouth College

Citation: Researchers explain how vestibular system influences navigation (2016, January 19) retrieved 25 April 2024 from https://medicalxpress.com/news/2016-01-vestibular.html

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