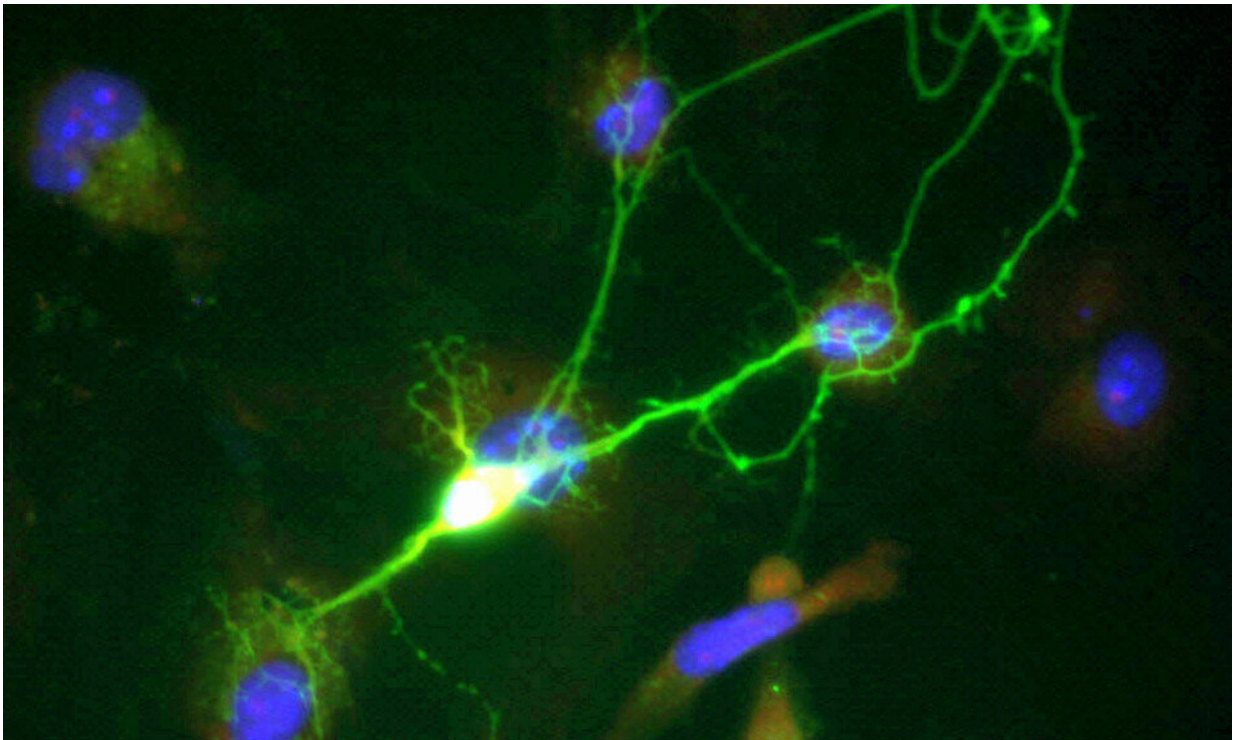


Think the brain is always efficient? Think again.

March 8 2021, by Poornima Apte



Credit: Public Domain

A Purdue University neuroscientist's findings suggest that the brain is not as efficient as we think.

To be efficient, it's best to tailor efforts to the final goal. If devices or network connections can't display or relay high-resolution images, there's

no point in streaming high-definition movies. A less fancy version not only will do, but it will stream faster without blocky artifacts.

In neuroscience, an indicator of the efficiency of relaying information is called sparse coding. Sparse coding means the brain relays (encodes) essential information with just a few (sparse) neurons.

"Entire fields have been based on the assumption that the brain must be perfectly efficient, like a machine, to do its job well," said Anne Sereno, a professor of psychological sciences and biomedical engineering. "But our research found that this is not always the case."

This surprising discovery by Sereno and her colleagues is reported in a recent *Nature Communications Biology* article, "Pseudospase Neural Coding in the Visual System of Primates."

Understanding and measuring sparseness

To measure sparseness, Sereno and her team evaluated the data being carried on each neuron. When similar data shows up across many neurons, the team can tell the process is not sparse—it is not efficient. To achieve a high degree of sparseness, each neuron or data-carrying unit must carry or relay a separate piece of information. Neurons need to relay more information with less, without an overlapping of data across various carriers.

A measure called correlation quantifies such overlap. If too many neurons carry similar information, the correlation is high. In the brain, when mechanisms are authentically sparse, there's no correlation between the [neurons](#).

"Our research examining many different cortical brain regions revealed some interesting insights: When it appears that the brain is conducting

[sparse coding](#) (using widely accepted measures of sparseness), there is actually significant correlation," Sereno said.

In such instances, the brain is pseudosparsely, or not authentically sparse.

These findings upturn the commonly held belief that the brain is the most efficient mechanism to emulate when designing a variety of engineering applications. At the same time, given that these pseudosparsely mechanisms have withstood the evolutionary process over time, perhaps there's something to be said for sparseness not always being the best way to deliver [information](#). Studying these pseudosparsely mechanisms in detail will help scientists understand various brain processes and their relevance to disease and rehabilitation.

Designing engineering processes

So, if the brain is not always efficient, how should scientists approach the design of machines? The answer: Evaluate the task and then pick and choose what to emulate.

"It is true that in instances where there is a lot of variability or [background noise](#), the brain is better able to concentrate on the task at hand," Sereno said. "But in instances where there is very little signal interference, using the brain as a model might lead to overdesign."

As an example, a [robotic arm](#) that simply picks and places objects in a [controlled environment](#) does not need to worry about noise or signal interference. Its programs can afford to be straightforward and efficient. On the other hand, autonomous driving happens in much more complex environments, with a lot more variability and noise—environments in which the brain excels. In such instances, leaning on the brain for inspiration benefits the eventual design process.

Studying pseudosparseness of brain coding delivers valuable insights not just into how the [brain](#) functions but into biomimicry and its effective applications in engineering.

More information: Sidney R. Lehky et al. Pseudosparsely neural coding in the visual system of primates, *Communications Biology* (2021). [DOI: 10.1038/s42003-020-01572-2](#)

Provided by Purdue University

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