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New machine learning algorithm reduces need for brain-computer interfaces to undergo recalibration

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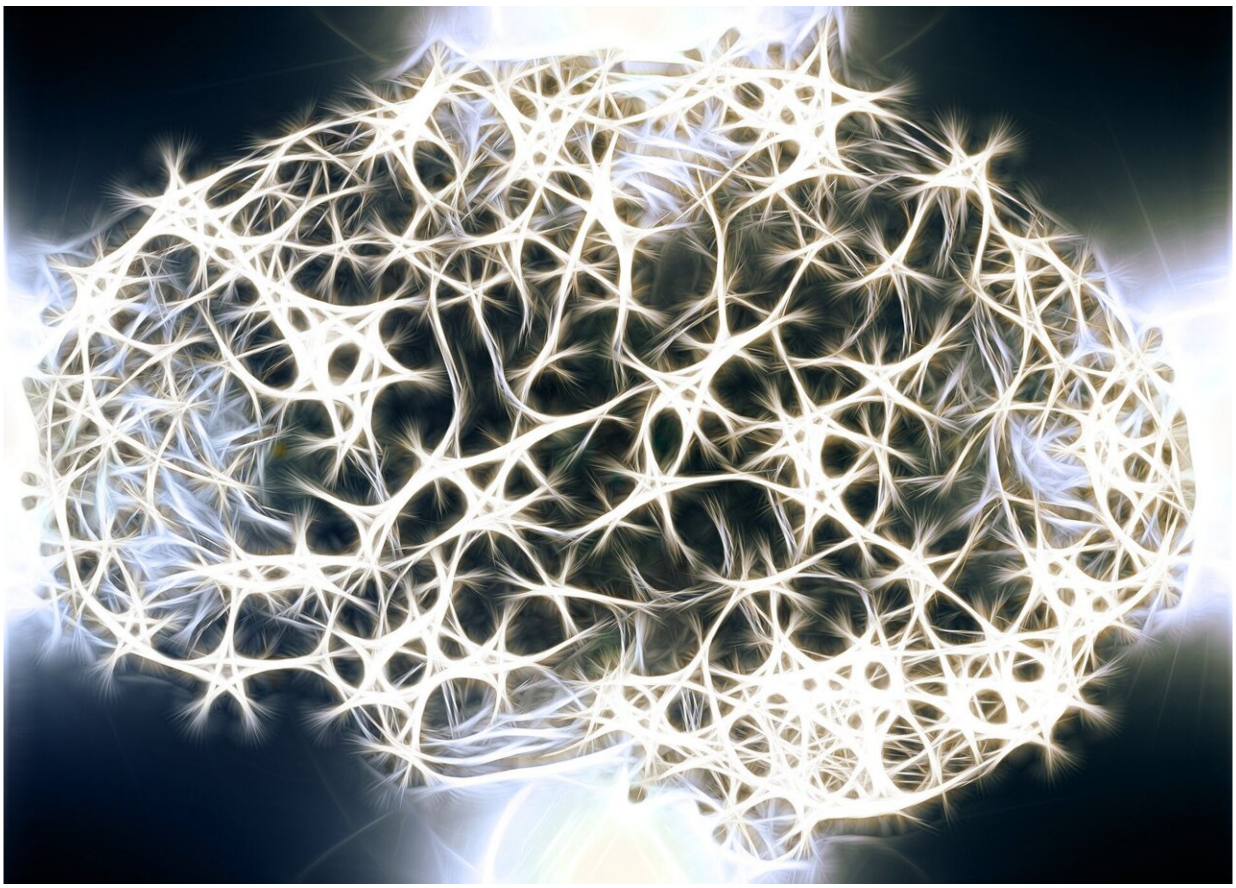

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Researchers from Carnegie Mellon University (CMU) and the

University of Pittsburgh (Pitt) have published research in *Nature Biomedical Engineering* that will drastically improve brain-computer interfaces and their ability to remain stabilized during use, greatly reducing or potentially eliminating the need to recalibrate these devices during or between experiments.

Brain-computer interfaces (BCI) are devices that enable individuals with motor disabilities such as paralysis to control prosthetic limbs, computer cursors, and other interfaces using only their minds. One of the biggest problems facing BCI used in a clinical setting is instability in the neural recordings themselves. Over time, the signals picked up by BCI can vary, and a result of this variation is that an individual can lose the ability to control their BCI.

As a result of this loss of control, researchers ask the user to go through a recalibration session which requires them to stop what they're doing and reset the connection between their mental commands and the tasks being performed. Typically, another human technician is involved just to get the system to work.

"Imagine if every time we wanted to use our cell phone, to get it to work correctly, we had to somehow calibrate the screen so it knew what part of the screen we were pointing at," says William Bishop, who was previously a Ph.D. student and postdoctoral fellow in the Department of Machine Learning at CMU and is now a fellow at Janelia Farm Research Campus. "The current state of the art in BCI technology is sort of like that. Just to get these BCI devices to work, users have to do this frequent recalibration. So that's extremely inconvenient for the users, as well as the technicians maintaining the devices."

The paper, "A stabilized brain-computer interface based on neural manifold alignment," presents a machine learning algorithm that accounts for these varying signals and allows the individual to continue controlling the BCI in the presence of these instabilities. By leveraging the finding that neural population activity resides in a low-dimensional "neural manifold," the researchers can stabilize neural activity to maintain good BCI performance in the presence of recording instabilities.

"When we say 'stabilization,' what we mean is that our neural signals are unstable, possibly because we're recording from different neurons across time," explains Alan Degenhart, a postdoctoral researcher in electrical and computer engineering at CMU. "We have figured out a way to take different populations of neurons across time and use their information to essentially reveal a common picture of the computation that's going on in the brain, thereby keeping the BCI calibrated despite neural instabilities."

The researchers aren't the first to propose a method for self-recalibration; the problem of unstable neural recordings has been up in the air for a long time. A few studies have proposed self-recalibration procedures, but have faced the issue of dealing with instabilities. The method presented in this paper is able to recover from catastrophic instabilities because it doesn't rely on the subject performing well during the recalibration.

"Let's say that the instability were so large such that the subject were no longer able to control the BCI," explains Byron Yu, a professor of electrical and computer engineering and biomedical engineering at CMU. "Existing self-recalibration procedures are likely to struggle in that scenario, whereas in our method, we've demonstrated it can in many cases recover from those catastrophic instabilities."

"Neural recording instabilities are not well characterized, but it's a very large problem," says Emily Oby, a postdoctoral researcher in neurobiology at Pitt. "There's not a lot of literature we can point to, but anecdotally, a lot of the labs that do clinical research with BCI have to deal with this issue quite frequently. This work has the potential to greatly improve the clinical viability of BCIs, and to help stabilize other neural interfaces."

Other authors on the paper include CMU's Steve Chase, professor of biomedical engineering and the Neuroscience Institute, and Pitt's Aaron Batista, associate professor of bioengineering, and Elizabeth Tyler-Kabara, associate professor of neurological surgery. This research was funded by the Craig H Neilsen Foundation, the National Institutes of Health, DSF Charitable Foundation, National Science Foundation, PA Dept of Health Research, and the Simons Foundation.

More information: Stabilization of a brain–computer interface via the alignment of low-dimensional spaces of neural activity, *Nature Biomedical Engineering* (2020). DOI: 10.1038/s41551-020-0542-9 , www.nature.com/articles/s41551-020-0542-9

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