How the 'noise' in our brain influences our behavior

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Neural variability may provide a unique window into brain function. Credit: NomeVisualizzato & Cassidy Dickens, CC0

The brain's neural activity is irregular, changing from one moment to the next. To date, this apparent "noise" has been thought to be due to random natural variations or measurement error. However, researchers at the Max Planck Institute for Human Development have shown that this neural variability may provide a unique window into brain function. In a

new Perspective article out now in the journal *Neuron*, the authors argue that researchers need to focus more on neural variability to fully understand how behavior emerges from the brain.

When neuroscientists investigate the brain, its activity seems to vary all the time. Sometimes activity is higher or lower, rhythmic or irregular. Whereas averaging brain activity has served as a standard way of visualizing how the brain "works," the irregular, seemingly random patterns in neural signals have often been disregarded. Strikingly, such irregularities in neural activity appear regardless of whether single neurons or entire brain regions are assessed. Brains simply always appear "noisy," prompting the question of what such moment-to-moment neural variability may reveal about brain function.

Across a host of studies over the past 10 years, researchers from the Lifespan Neural Dynamics Group (LNDG) at the Max Planck Institute for Human Development and the Max Planck UCL Centre for Computational Psychiatry and Ageing Research have systematically examined the brain's "noise," showing that neural variability has a direct influence on behavior. In a new Perspective article published in the journal *Neuron*, the LNDG in collaboration with the University of Lübeck highlights what is now substantial evidence supporting the idea that neural variability represents a key, yet under-valued dimension for understanding brain-behavior relationships. "Animals and humans can indeed adapt successfully to environmental demands, but how can such behavioral success emerge in the face of neural variability? We argue that neuroscientists must grapple with the possibility that behavior may emerge because of neural variability, not in spite of it," says Leonhard Waschke, first author of the article and LNDG postdoctoral fellow.

A recent LNDG study published in the journal eLife exemplifies the direct link between neural variability and behavior. Participants' brain activity was measured via electroencephalography (EEG) while they

responded to faint visual targets. When people were told to detect as many visual targets as possible, neural variability generally increased, whereas it was downregulated when participants were asked to avoid mistakes. Crucially, those who were better able to adapt their neural variability to these task demands performed better on the task. "The better a brain can regulate its 'noise,' the better it can process unknown information and react to it. Traditional ways of analyzing brain activity simply disregard this entire phenomenon," says LNDG postdoctoral fellow Niels Kloosterman, first author of this study and co-author of the article in *Neuron*.

The LNDG continues to demonstrate the importance of neural variability for successful human behavior in an ongoing series of studies. Whether one is asked to process a face, remember an object, or solve a complex task, the ability to modulate moment-to-moment variability seems to be required for optimal cognitive performance. "Neuroscientists have seen this 'noise' in the brain for decades but haven't understood what it means. A growing body of work by our group and others highlights that neural variability may indeed serve as an indispensable signal of behavioral success in its own right. With the increasing availability of tools and approaches to measure neural variability, we are excited that such a hypothesis is now immediately testable," says Douglas Garrett, Senior Research Scientist and LNDG group leader. In the next phases of their research, the group plans to examine whether neural variability and behavior can be optimized through brain stimulation, behavioral training, or medication.

More information: Leonhard Waschke et al, Behavior needs neural variability, *Neuron* (2021). DOI: 10.1016/j.neuron.2021.01.023

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