How visual representations are improved by reducing noise in the brain

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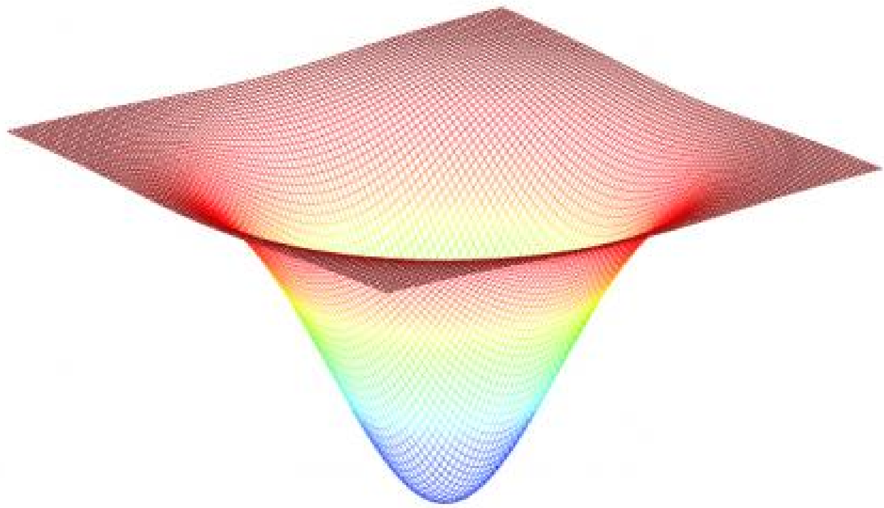
A rhesus macaque (macaca mulatta) during a neuroscientific test at the DPZ. Credit: Lalitta Suriya-Arunroy

Neuroscientist Suresh Krishna from the German Primate Center (DPZ) in cooperation with Annegret Falkner and Michael Goldberg at Columbia University, New York has revealed how the activity of neurons in an important area of the rhesus macaque's brain becomes less variable when they represent important visual information during an eye movement task. This reduction in variability can improve the perceptual strength of attended or relevant aspects in a visual scene, and is enhanced when the animals are more motivated to perform the task.

Humans may see the same object again and again, but their brain response will be different each time, a phenomenon called neuronal noise. The same is true for rhesus macaques, which have a visual system very similar to that of humans. This variability often limits our ability to see a dim object or hear a faint sound. On the other hand, we benefit from variable responses as they are considered an essential part of the exploration stage of learning and for generating unpredictability during competitive interactions.

Despite this importance, brain variability is poorly understood. Krishna of the DPZ and his colleagues Annegret Falkner and Michael Goldberg at Columbia University in New York examined the responses of neurons in the monkey brain's lateral intraparietal area (LIP) while the monkey planned eye movements to spots of light at different locations on a computer screen. LIP is an area in the brain that is crucial for visual attention and for actively exploring visual scenes. To measure the activity of single LIP neurons, the scientists inserted electrodes thinner than a human hair into the monkey's brain and recorded the neurons' electrical activity. Because the brain is not pain-sensitive, this insertion of electrodes is painless for the animal.



The image shows a so-called LIP valley.

Krishna and his colleagues could show how the activity of LIP neurons becomes less variable when the macaque performs a task and plans an eye movement. The reduction in variability was particularly strong where the monkey was planning to look and when the monkey was highly motivated to perform the task. This creation of a valley of reduced variability centered on relevant and interesting aspects of a visual scene may help the brain to filter the most important aspects from the sensory information delivered by the eye. The scientists developed a simple mathematical model that captures the patterns in the data and may also be a useful framework for the analysis of other brain areas.

"Our study represents one of the most detailed descriptions of neuronal variability in the brain. It offers important insights into fascinating brain functions as diverse as the focusing of visual attention and the control of eye movements during active viewing of visual scenes. The brain's valley of variability that we discovered may help humans and animals to interact with their complex environment," says Krishna.

More information: Annegret L. Falkner, Michael E. Goldberg and B. Suresh Krishna: Spatial Representation and Cognitive Modulation of Response Variability in the Lateral Intraparietal Area Priority Map. The *Journal of Neuroscience*, 9 October 2013, 33(41): 16117-16130; DOI: 10.1523/JNEUROSCI.5269-12.2013

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