How attentional modulation affects neural response covariability in the human brain

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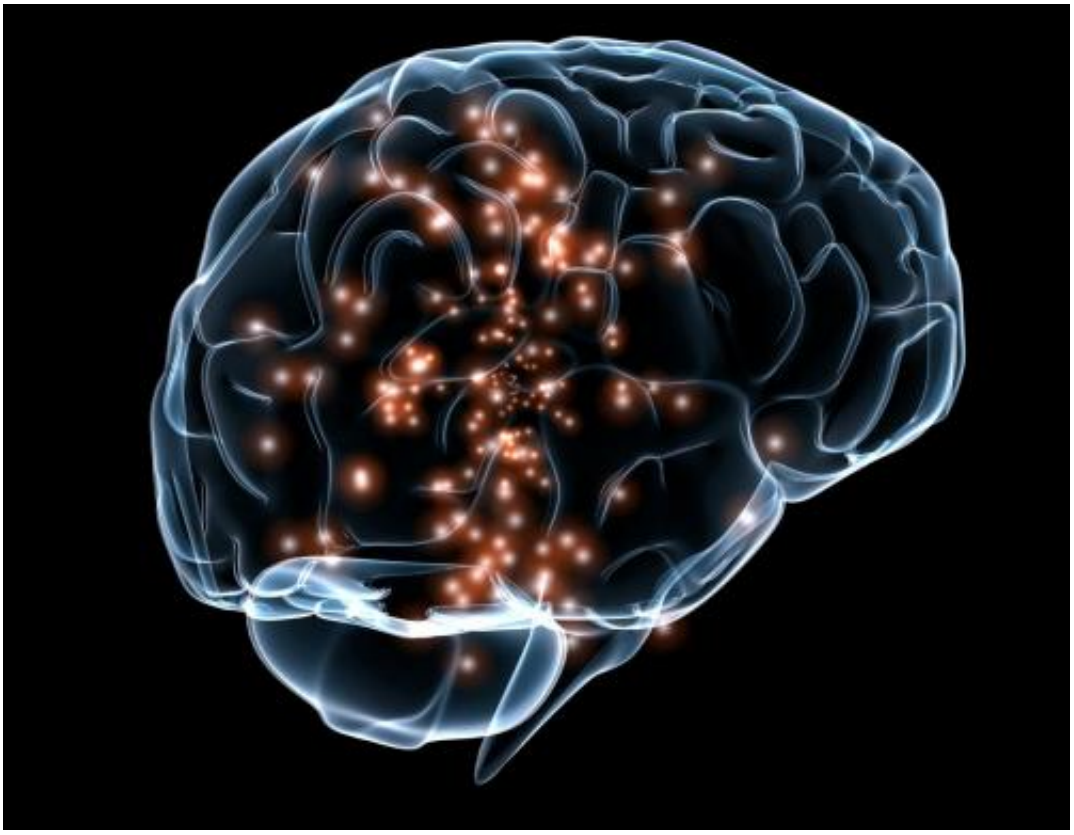

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A fundamental goal of cognitive neuroscience is to understand how information is encoded and the mechanisms that improve encoding efficiency in the brain. Regulating the response covariability in the neuron population could significantly improve encoding efficiency.

However, the human brain is a hierarchical neural system, and it is unclear how attention modulates neural response covariability in different functional regions. Furthermore, the neural pathway that regulates such covariability modulation is also unknown.

To answer these questions, Drs. He Sheng, Zhang Jiedong, and Jiang Yong from the Institute of Biophysics (IBP) of the Chinese Academy of Sciences have used ultra-high field magnetic resonance imaging (7T MRI) to obtain high-resolution functional signals from the human visual cortex under different attentional states. Their findings reveal the effects of attentional modulation on the covariability of neural responses and related computational principles.

The study was published in the *Proceedings of the National Academy of Sciences* on Oct. 9.

The researchers found reliable neural encoding of experimental stimuli in both the primary visual cortex (V1) and the higher visual cortex (posterior parietal cortex, PPC). However, attentional modulation of neural response covariability was only observed in V1 but not in PPC.

Through further analysis, they found that the contribution of covariability to the information encoding was different in the two regions. In V1, computationally removing the covariation in the neural activity significantly increased the efficiency of information encoding, but in PPC, the same manipulation had almost no effect on information encoding. This explains why attention regulates neural responses differently in the two regions.

To further clarify the relationship between response covariability and neural encoding, the researchers examined the transmission of neural information between visual cortex and parietal regions. They found that attention significantly enhanced the transfer from high-dimensional

encoding in V1 to low-dimensional encoding in PPC. This finding suggests that the dimensionality of information encoding in different brain regions may determine the relationship between response covariability and neural encoding efficiency.

Finally, the researchers found that although the covariability within PPC was not modulated by attention, its neural responses could predict the amplitude of covariability modulation in V1, revealing a top-down regulatory pathway of this neural modulation mechanism.

The brain's mechanisms for increasing the efficiency of information encoding are complex. "Our study provides important insights into how the brain coordinates functional regions at different stages of information processing at the systemic level, and enhances perceptual sensitivity by regulating covariability in specific neuron populations," said He Sheng from IBP, corresponding author of the study.

More information: Yong Jiang et al, Different roles of response covariability and its attentional modulation in the sensory cortex and posterior parietal cortex, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2216942120

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