UNIVERSITÉ DE GENÈVE

PRESS RELEASE

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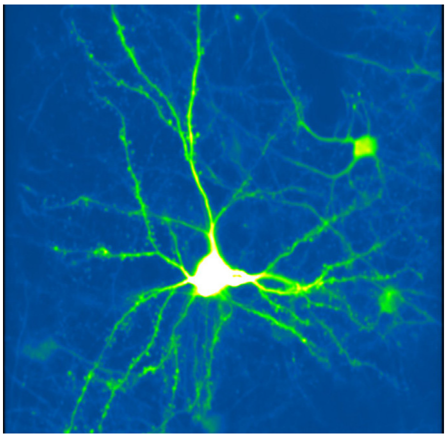
The brain shapes what we feel in real time

A UNIGE team has discovered a new brain mechanism responsible for modulating sensory signals. It could be involved in the perception threshold of our senses.



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Cortical neuron expressing green fluorescent protein, imaged in the living mouse brain using two-photon microscopy. Its dendritic extensions reach the cortical surface (top of the image), where they form synaptic connections with thalamic inputs that modulate neuronal excitability—and ultimately, perception

Pictures

The cerebral cortex processes sensory information via a complex network of neural connections. How are these signals modulated to refine perception? A team from the University of Geneva (UNIGE) has identified a mechanism by which certain thalamic projections target neurons and modify their excitability. This work, published in *Nature Communications*, reveals a previously unknown form of communication between two regions of the brain, the thalamus and the somatosensory cortex. It could explain why the same sensory stimulus does not always elicit the same sensation and open up new avenues for understanding certain mental disorders.

The same sensory stimulus can be perceived clearly at times, and remain vague at others. This phenomenon can be explained by the way the brain integrates stimuli. For example, touching an object outside our field of vision may be enough to identify it...or not. These perceptual variations remain poorly understood, but may depend on factors such as attention or the disruptive presence of other stimuli. What is certain, according to neuroscientists, is that when we touch something, sensory signals from receptors in the skin are interpreted by a specialised region called the somatosensory cortex.

On their way to it, the signals pass through a complex network of neurons, including a crucial structure in the brain called the thalamus, which serves as a relay station. However, the process is not one-way. A significant portion of the thalamus also receives feedback from the cortex, forming a loop of reciprocal communication. But the exact role and functioning of this feedback loop are still unclear. Could it play an active role in how we perceive sensory information?

A new modulatory pathway

To explore this question, neuroscientists at UNIGE studied a region at the top of pyramidal neurons of the somatosensory cortex, rich in dendrites – extensions that receive electrical signals from other neurons. “Pyramidal neurons have rather strange shapes. They are asymmetrical, both in shape and function. What happens at the top of the neuron is different from what happens at the bottom,” explains Anthony Holtmaat, full professor at the Department of Basic Neurosciences (NEUFO) and the Synapsy Centre for Neuroscience Research for Mental Health at UNIGE’s Faculty of Medicine, and director of the study.

His team focused on a pathway in which the top of pyramidal neurons in mice receives projections from a specific part of the thalamus. By stimulating the animal’s whiskers – the equivalent of touch in humans – a precise dialogue between these projections and the dendrites of pyramidal neurons was revealed. “What is remarkable, unlike the regular thalamic projections known to activate pyramidal neurons, is that the part of the thalamus providing feedback modulates their activity, in particular by making them more sensitive to stimuli,” says Ronan Chéreau, senior researcher at NEUFO and co-author of the study.

An unexpected receptor

Using cutting-edge techniques – imaging, optogenetics, pharmacology and, above all, electrophysiology – the research team was able to record the electrical activity of tiny structures such as dendrites. These approaches helped clarify how this modulation works at the synaptic level. Normally, the neurotransmitter glutamate acts as an activation signal. It helps neurons transmit sensory information by triggering an electrical response in the next neuron. In this newly discovered mechanism, glutamate released from thalamic projections binds to an alternative receptor located in a specific region of the cortical pyramidal neuron. Rather than directly exciting the neuron, this interaction alters its state of responsiveness, effectively priming it for future sensory input. The neuron then becomes more easily activated, as if it were being conditioned to better respond to a future sensory stimulus.

“This is a previously unknown pathway for modulation. Usually, the modulation of pyramidal neurons is ensured by the balance between excitatory and inhibitory neurons, not by this type of mechanism,” explains Ronan Chéreau.

Implications for perception and disorders

By demonstrating that a specific feedback loop between the somatosensory cortex and the thalamus can modulate the excitability of cortical neurons, the study suggests that thalamic pathways do not simply transmit sensory signals, but also act as selective amplifiers of cortical activity. “In other words, our perception of touch is not only shaped by incoming sensory data, but also by dynamic interactions within the thalamocortical network,” adds Anthony Holtmaat. This mechanism could also contribute to understanding the perceptual flexibility observed in states of sleep or wakefulness, when sensory thresholds vary. Its alteration could also play a role in certain pathologies, such as autism spectrum disorders.

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