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Scientists create a model for the neural basis of expectation

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It is known that sensory stimuli – especially powerful ones like taste – are affected by expectation, which is a trigger to improving stimuli detection, distinction and reaction. Yet, scientists know little about how expectation shapes the cortical processes of sensory information. Now Alfredo Fontanini, PhD, and Giancarlo La Camera, PhD, of the Department of Neurobiology and Behavior in the College of Arts and Sciences and the Renaissance School of Medicine at Stony Brook University, together with their postdoctoral fellow, Luca Mazzucato (now at the University of Oregon), have developed a theoretical model of how the primary gustatory cortex can mediate the expectation of receiving a taste.

In a paper published in *Nature Neuroscience*, the researchers detail their model which theoretically explains the neural basis of expectation.

The data show experimental evidence that a state of expectation is mediated by an acceleration of the neural activity generated by certain populations of neurons. The authors built a biologically plausible model of this phenomenon based on the modulation of the brain's own spontaneous activity.

"Neurons in the cortex appear to be continuously active and erratic, giving us a messy sensation of what neurons are doing," says La Camera. "Our model sheds a potential light on the meaning of such continuous activity and proposes a mechanism through which it could be mediating expectation."

The model also explains how the faster onset of coding states is due to a generic acceleration of the sequences of neural states. The acceleration is caused by the presence of the anticipatory cue (a pure tone) used in the experiments to signal the forthcoming delivery of a taste. The faster speed of the sequence brings forward in time the representation of the taste.

"Presumably, a state of expectation, or 'readiness' is mediated by faster or more accurate internal representation of what is happening. Our model says that our internal representations of expected events are formed earlier compared to when the same events are unexpected," says LaCamera.

Another important contribution of the authors' model is the explanation of why a generic anticipatory cue can set in motion a faster sequence dynamics. This part of the model can be understood in terms of the mathematical theory of complex dynamical systems.

To understand the brain's activity during expectation, the researchers relied on a metaphor invented in physics of a motion within a complex landscape of valleys and peaks. Some specific locations in such landscape correspond to the internal representations of the taste stimuli. To reach the relevant locations sometimes a peak must be climbed. According to the model, the effect of the anticipatory cue is to reduce the height of the peaks, so that motion is faster and the relevant representations occur earlier.

Although the empirical demonstration of the principle was performed in the gustatory cortex, the model may go beyond taste processing as it posits, as a general theory, that expectations can be mediated by a change in the dynamics of certain cortical circuits.

"For this reason," add the authors, "we do not exclude that other processes such as attention and decision making may be explained by an analogous mechanism."

More information: L. Mazzucato et al. Expectation-induced modulation of metastable activity underlies faster coding of sensory stimuli, *Nature Neuroscience* (2019). DOI: 10.1038/s41593-019-0364-9

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