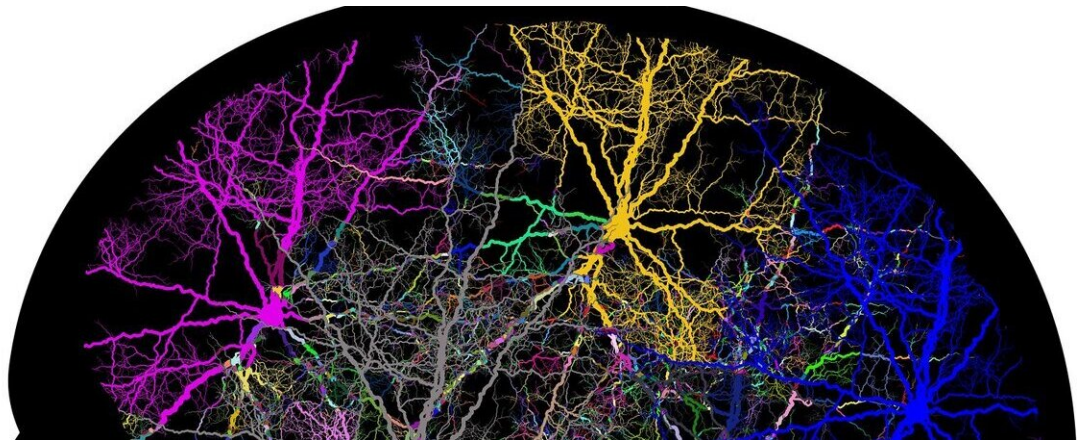


Breathing: The master clock of the sleeping brain

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Ludwig Maximilian University of Munich neuroscientists have shown that breathing coordinates neuronal activity throughout the brain during sleep and quiet.

While we sleep, the brain is not switched off, but is busy with "saving" the important memories of the day. To achieve that, brain regions are synchronized to coordinate the transmission of information between them. Yet, the mechanisms that enable this synchronization across multiple remote brain regions are not well understood. Traditionally, these mechanisms were sought in correlated [activity](#) patterns within the brain. However, LMU neuroscientists Prof. Anton Sirota and Dr.

Nikolas Karalis have now been able to show that [breathing](#) acts as a pacemaker that entrains the various brain regions and synchronizes them with each other.

Breathing is the most persistent and essential bodily rhythm and exerts a strong physiological effect on the autonomous nervous system. It is also known to modulate a wide range of cognitive functions such as perception, attention, and thought structure. However, the mechanisms of its impact on cognitive function and the brain are largely unknown.

The scientists performed large-scale in vivo electrophysiological recordings in mice, from thousands of neurons across the limbic system. They showed that respiration entrains and coordinates [neuronal activity](#) in all investigated brain regions—including the hippocampus, medial prefrontal and [visual cortex](#), thalamus, amygdala, and nucleus accumbens—by modulating the excitability of these circuits in olfaction-independent way. "Thus, we were able to prove the existence of a novel non-olfactory, intracerebral, [mechanism](#) that accounts for the entrainment of distributed circuits by breathing, which we termed "respiratory corollary discharge," says Karalis, who is currently research fellow at the Friedrich Miescher Institute for Biomedical Research in Basel. "Our findings identify the existence of a previously unknown link between respiratory and limbic circuits and are a departure from the standard belief that breathing modulates [brain](#) activity via the nose-olfactory route," underlines Sirota.

This mechanism mediates the coordination of sleep-related activity in these [brain regions](#), which is essential for memory consolidation and provides the means for the co-modulation of the cortico-hippocampal circuits synchronous dynamics. According to the authors, these results represent a major step forward and provide the foundation for new mechanistic theories, that incorporate the respiratory rhythm as a fundamental mechanism underlying the communication of distributed

systems during memory consolidation.

The research was published in *Nature Communications*.

More information: Nikolaos Karalis et al, Breathing coordinates cortico-hippocampal dynamics in mice during offline states, *Nature Communications* (2022). [DOI: 10.1038/s41467-022-28090-5](https://doi.org/10.1038/s41467-022-28090-5)

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