Evidence found of continuous phase transition when rats move from sleep to awake

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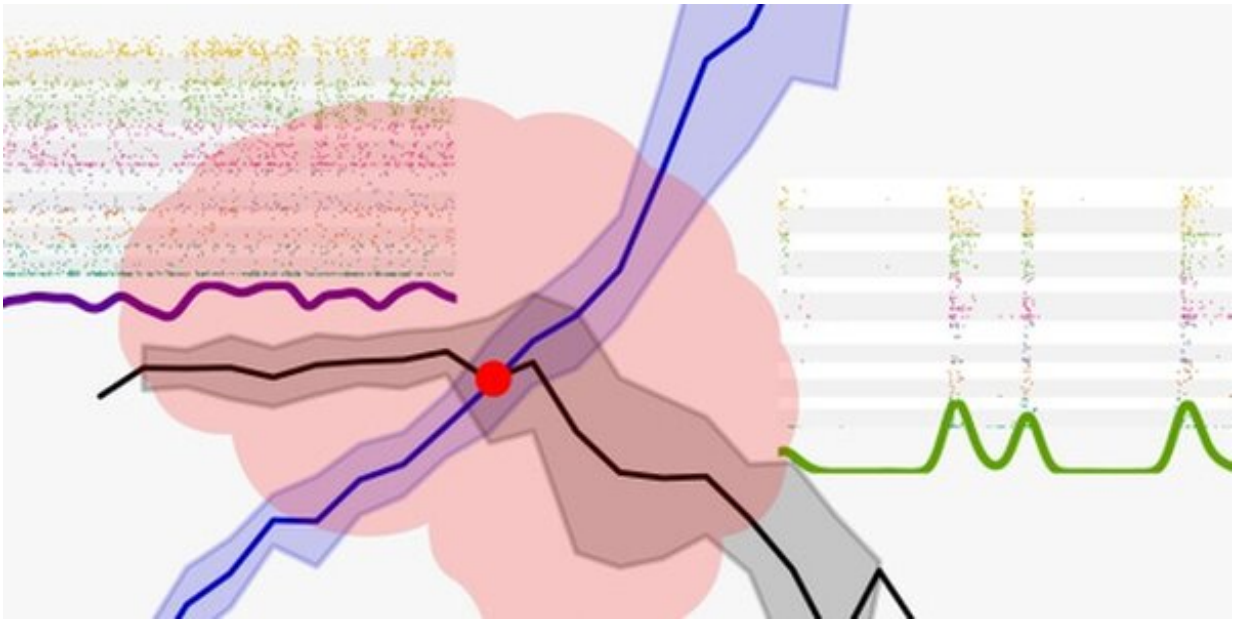

Credit: N. A. P. de Vasconcelos/Federal University of Pernambuco, via Physics

A team of researchers with affiliations to institutions in Brazil, Portugal and Spain has found evidence of a continuous phase transition occurring in the brains of rats when they move from sleep to wakefulness. In their paper published in the journal *Physical Review Letters*, the group describes their study of sleeping rats and what they found.

The brain goes through a type of transition into sleep and then again when waking, but the types of transitions that occur are still mostly unknown. Some researchers have suggested that the process appears to involve percolation-like phase transitions. Also, prior research has shown that brain activity is different in the two states. There are synchronous spikes when awake, and asynchronous spikes when asleep. In this new effort, the researchers took a closer look at the actual transition as it occurred in real time in rat brains.

The work involved observing and measuring brain signals in the cerebral cortex as several rats moved from wakefulness to sleep—some were anesthetized and others were allowed to fall asleep naturally. The team observed what they describe as avalanches of activity, in which there were periods of no spiking at all (silence), followed by a period of a rapid succession of spiking, followed by silence again. The researchers described the number of spikes in an avalanche as its size; the amount of time that it lasted was defined as its lifetime. They then analyzed the data mathematically. In so doing, they found that the spikes in the avalanches followed power laws. They suggest this indicated scale invariance, which in math terms means a critical point was reached. The data showed that rat brains undergo a continuous phase transition, which mitigates against percolation theories.

The researchers repeated their experiments on monkeys and mice and report that they found similar power-law distributions. They also found that the exponents in the power laws they applied were not the same as those found in prior experiments. They suggest this indicates that phase transitions related to the sleep cycle belong in a different "universality class."

More information: Antonio J. Fontenele et al. Criticality between Cortical States, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.122.208101

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