Nature Reviews Neuroscience | AOP, published online 30 July 2008; doi:10.1038/nrn2475

CORTICAL PROCESSING

States of change

Mice explore their environment by rapidly moving their whiskers back and forth (whisking); this sends sensory information to the primary somatosensory barrel cortex through the infraorbital nerve (ION). When the animal starts whisking, the change in its behavioural state is reflected in changes in its cortical network dynamics, but how these changes are generated is not known. A study by Poulet and Petersen now reveals that the membrane potential (V_m) of neurons in the mouse somatosensory barrel cortex are synchronized during quiet wakefulness, but that this synchronicity is significantly reduced through a central mechanism when the mouse is whisking.

Previous studies that recorded electroencephalograms (EEGs) and measured local-field potentials (LFPs) in anaesthetized animals had shown that slow oscillations in local network activity are characteristic of a quiet brain state. Now, intracellular recordings that measured V_m oscillations in layer 2/3 barrel cortex neurons in behaving mice reveal that quiet wakefulness is characterized in individual neurons by slow, subthreshold V_m fluctuations. Interestingly, the amplitude of the V_m oscillations was significantly reduced during whisking.

How is this change in the electrical 'brain state' generated? The authors determined that the change is generated centrally, rather than by the sensory input, as it persisted in mice in which the IONs had been transected. Furthermore, simultaneous dual whole-cell recordings from neighbouring barrel cortex neurons showed that V_m changes in both cells were closely correlated during quiet periods, but that whisking reduced this correlation. Next the authors investigated the correlation between local network activity and single-neuron V_m dynamics, by simultaneously recording V_m, LFP and EEG data in behaving mice. They showed that fluctuations in V_m during quiet wakefulness correlated closely with LFP and EEG measurements; however, these measurements were not correlated during whisking.

The authors then investigated V_m dynamics prior to the firing of individual action potentials (APs) during quiet wakefulness and whisking. They found that barrel cortex neurons fire APs at low rates during both rest and whisking. No synchronous AP activity was observed in neighbouring neurons, indicating that individual APs are triggered by neuron-specific synaptic input. They also found that the signal-to-noise ratio for the initiation of APs is significantly higher during whisking than during quiet wakefulness. These characteristics are ideal for reliable information processing in networks with sparse APs.

Taken together, these findings suggest that resting states are associated with synchronous, slow, large-amplitude cortical oscillations, whereas active processing modes are associated with desynchronized electrical activity. Future studies will shed light on the central mechanisms that generate these brain-state changes and how their function affects behaviour.

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ORIGINAL RESEARCH PAPER Poulet, J. F. A. & Petersen, C. C. H. Internal brain state regulates membrane potential synchrony in barrel cortex of behaving mice. *Nature* 16 July 2008 (doi: 10.1038/nature07150)

FURTHER READING Diamond, M. E., von Heimendahl, M., Knutsen, P. M., Kleinfeld, D. & Ahissar, E. 'Where' and 'what' in the whisker sensorimotor system. *Nature Rev. Neurosci.* **9**, 601–612 (2008)