“Different dynamics of top-down cortico-cortical axons during wakefulness and sleep in primary visual cortex of mice”

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During wakefulness, information from the outside world reaches primary sensory cortical areas and then is integrated in more complex representations in higher order association cortical areas via bottom-up feedforward connections. Superimposed on the feedforward pathways, top-down feedback connections from higher order areas carrying contextual information and internally generated complex representations shape neural representations and information processing in primary sensory cortical areas. It has been shown that top-down influences in the primary visual cortex (V1) modulate the gain of visual responses during visual stimulation, for example. However, little is known about the dynamics of feedback connections during states in which the feedforward drive is greatly reduced such as sleep. To address this question, we used 2-photon calcium imaging in awake head-fixed mice to investigate the activity of retrosplenial cortex axons in V1 during wakefulness and sleep. In parallel, we performed electrocorticography (EcoG) and electromyography (EMG) recordings coupled with pupil and locomotion tracking to accurately score awake and sleep states into active wake (AW), quiet wake (QW), NREM, and REM sleep.
First, using a visual stimulation paradigm during wakefulness, a subset of retrosplenial axons showed stimulus position and orientation tuning. Next, we compared the spontaneous activity during wakefulness and sleep. Our results indicate that in another subset of axons, both mean ΔF/F and frequency of spontaneous Ca^{2+} events increased during REM sleep compared to awake or NREM periods. Finally, network correlation structure dynamics significantly changed during different awake and sleep states.
These results provide experimental evidence of increased drive in top-down feedback axons during REM sleep. Therefore, our work identifies the retrosplenial cortex as one of the cortical areas targeting layer 1 that may provide key input during internally generated experiences such as dreams.