

Spontaneous increase in neuronal activity in the resting state is associated with increase in blood oxygenation

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Recent studies have demonstrated large amplitude *spontaneous* slow (< 0.1 Hz) fluctuations in functional-MRI (fMRI) signals in humans in the resting state. Importantly, these spontaneous fluctuations in Blood-Oxygenation-Level-Dependent (BOLD) signal are often synchronized over distant parts of the brain, a phenomenon termed functional-connectivity. Brain regions that show resting-state functional connectivity, forming a resting state network, are functionally related. Resting state functional connectivity has been demonstrated in humans, monkeys and rats. Despite the large body of human imaging literature on spontaneous activity and functional-connectivity in the resting state, the link to underlying neural activity remains tenuous.

Objective

To determine whether increase in locally measured neurophysiological activity at rest is associated with increase in blood oxygenation.

Methods

Neurophysiological recordings were pursued simultaneously with optical imaging of intrinsic signals (OI-IS) in anesthetized rats. We used multi-contact electrodes, in which the contacts spanned the cortical depth in cortical area S1FL. The wavelength of illumination used for OI-IS was 605 nm: the light reflected back from cortex under these conditions shows changes in blood oxygenation. Runs with fore-paw stimulation were interleaved with 10 min long runs in which no stimulation was delivered.

Results

We first averaged the evoked local field potential responses triggered by all fore-paw stimuli. Fig. 1 presents the results from one session. The different curves show the evoked local field potential response detected in different cortical depths within the cortical column. To detect events of increase in activity during spontaneous activity, we computed the correlation between the spontaneous local field potential in a moving window and the average local field potential response, separately for each cortical depth. We then averaged the time-courses of computed correlations across cortical depths. Peaks in this mean time-course of correlation indicate events in which the spontaneous local field potentials resembled evoked responses to forepaw stimulation. Fig. 2 shows the local field potentials averaged over such events in spontaneous activity from the experiment presented in Fig. 1. Last, we averaged all OI-IS data temporally aligned according to the detected events during spontaneous activity. Fig. 3 shows the OI-IS blood-oxygenation signal from an ROI around the electrode. Note the increase in blood oxygenation with a peak approximately 5 s following the increase in spontaneous neuronal activity.

Conclusions

1. Spontaneous neurophysiological activity in rat S1FL shows events in which changes in local field potentials across cortical layers resemble the corresponding changes in response to sensory stimulation.
2. These spontaneous neurophysiological events are accompanied by increases in blood oxygenation that peak approximately 5 s following the events.

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