

Layer-specific interhemispheric functional connectivity in rat S1fl revealed by laminar electrode recordings and resting state fMRI

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INTRODUCTION

Spontaneous BOLD fluctuations in resting state MRI have been reported to be correlated between functionally interconnected brain regions such as bilateral sensory motor system. However, the neural substrate of BOLD MRI-based functional connectivity is still not well known. In the present study, we demonstrated synchronization in spontaneous neural activity between the bilateral somatosensory cortices and layer-specific pattern in interhemispheric functional connectivity.

MATERIALS & METHODS

Six normal healthy Sprague-Dawley rats (~300g) were used for the electrophysiological recording during resting state and electrical forepaw stimulation under anesthesia using alpha-chloralose (40 mg/kg-h). The local field potential (LFP) was recorded at the sampling rate of 2000 Hz for 4 min during rest and for forepaw stimulation (1.5 mA, 3 Hz, duration of each pulse 0.3 ms). Two one-dimensional electrodes, each with multiple contacts (23 contact points with 0.1 mm separation between each contact) spanning through the entire cortical depth, were used bilaterally for simultaneous recordings from bilateral somatosensory cortices of forelimb region (3.0 mm lateral, 2.0 mm anterior from bregma. See Fig. 1A). Resting state BOLD MRI scans were taken in other two rats for 15 min under same anesthetic condition (Gradient Echo Planar Imaging: TR/TE=1000/12.89ms; FOV=2.5*2.5cm; matrix 96*96; nine contiguous 1 mm slices). Seven ROIs were drawn for each side of somatosensory cortex along the cortical depth, and the BOLD signal was detrended, bandpass-filtered (0.01~0.1 Hz) before correlation analysis.

RESULTS & DISCUSSION

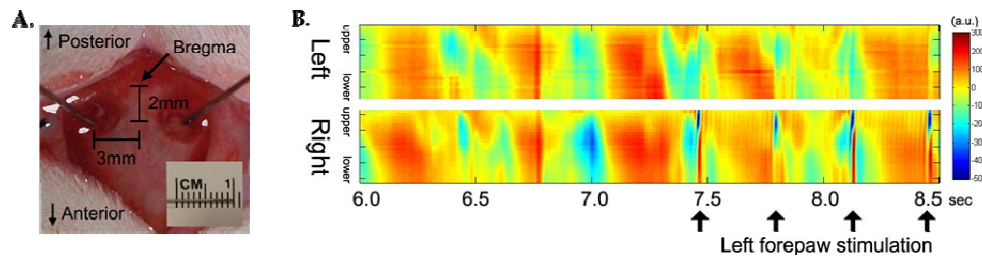


Fig 1. The electrophysiological recordings from rat bilateral S1 cortices using laminar electrodes.

A. The location of electrodes, which was on the forelimb region of rat S1 cortices. **B.** The example of recordings from the laminar electrodes. The profound spontaneous activity was observed during resting period, and superimposed upon the stimulation-evoked response.

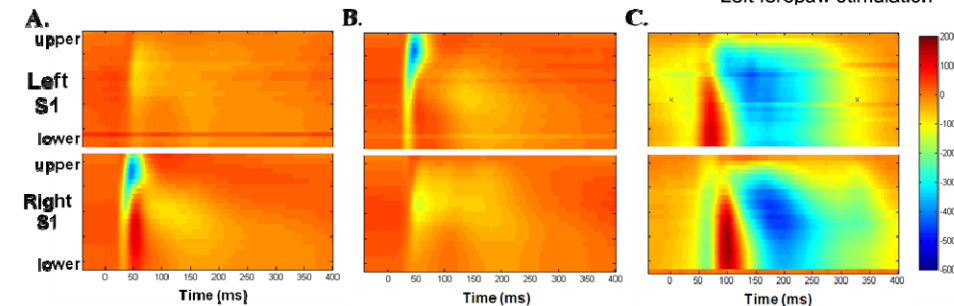


Fig 2. Comparison between the evoked response vs. the spontaneous activity.

A. The average evoked response with electrical stimulation of left forepaw. **B.** The average evoked response with right forepaw stimulation. **C.** The typical example of spontaneous activity.

Robust spontaneous activity as well as stimulus-evoked response was observed in electrophysiological recordings as shown in Fig 1B. The peak-to-peak amplitude of the spontaneous activity was about 60% of the stimulus-evoked activity. The spontaneous activity was much slower and spanned into deeper cortical depth in comparison to the evoked activity (Fig 2). These distinct spatiotemporal characteristics imply that distinct neuronal or dendritic population involved in the spontaneous activity are distinct from one in the evoked activity.

Only the spontaneous activity was highly synchronized between bilateral cortices, exhibiting almost mirrored pattern of activity. Temporal correlation between spontaneous activity from different cortical depths within and between hemispheres is shown in Fig 3, revealing layer-specific correlation pattern [1]. Interestingly, similar pattern was replicated in the resting state BOLD MRI. The fine laminar arrangement in the interhemispheric neural connectivity, e.g. corpus callosum, may mediate the interhemispheric neural communication.

CONCLUSION

We directly demonstrated neuronal functional connectivity between bilateral somatosensory cortices. The interhemispheric functional connectivity exhibited laminar specific pattern in both electrophysiological recordings and resting state BOLD MRI.

REFERENCE [1] Kim et al. Annual meetings of ISMRM 2008; no. 752

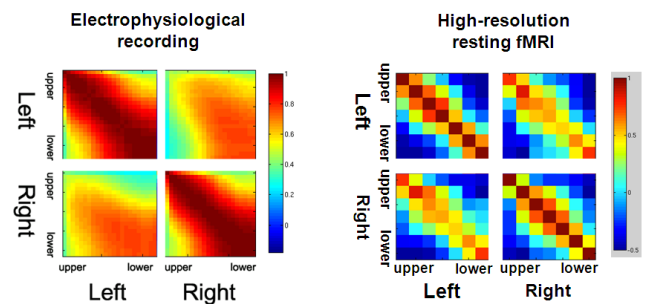


Fig. 3. Correlation coefficient between spontaneous activity from cortical depths measured by laminar electrodes (Left) and resting state fMRI (Right)