A Pilot Study of 2X Temporal Resolution Wideband Gradient-Echo in Rodent fMRI

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Introduction:

Functional MRI (fMRI) has been widely applied to discover the brain activity by examining the T2* weighted blood-oxygen-level-dependent (BOLD) signals [1]. However, the lacks of temporal resolution limit the capability to investigate the relationship between the neural activation and physiological process. For this purpose, Wideband MRI, the novel acceleration technique with broader bandwidth, has been developed to accelerate the data acquisition by simultaneously decoding multi-location information [2]. In this study, we aimed to integrate the 2X accelerated Wideband MRI technique to T2* gradient echo sequence (WB-GRE) on the rodent fMRI experiments with electrical stimulation. For comparison, the BOLD signal change and localization of activation among echo-planar imaging (EPI) and conventional gradient echo sequence (GRE) were demonstrated.

Methods:

Single-carrier Wideband MRI acquired multi-location information by reducing the number of phase encoding and applying an additional gradient along readout direction. All MR experiments were conducted on a 7T animal MRI system (Bruker Biospec, Ettlingen, Germany). One Sprague Dawley rats (male, 300g) were scanned under institutional approval. During fMRI, rats were anesthetized with α-chloralose (3.33cc/kg/hr) and the electrical stimulation (frequency of 3Hz and amplitude of 3mA) was applied to the left forepaw. The respiration rate was controlled in 45~50 bpm to maintain the rats physiological condition. To demonstrate the capability of mapping fMRI with WB-GRE, sequences of EPI, GRE and WB-GRE were used with the following parameters: FOV of 2.5 × 2.5 cm2, the voxel size of 313 × 313 × 1000 μm3, and TR/TE of 2000/20 ms for conventional EPI and GRE, TR/TE of 1000/20 ms for WB-GRE with 2X temporal resolution fMRI study. Each electrical stimulation session lasted for 4 minutes and tested 3 times for each sequences. The task-related fMRI data was analyzed using independent component analysis (Group ICA of fMRI Toolbox, GIFT).

Results:

Figure 1 demonstrates the results of electrical stimulation. The neural activation map using conventional EPI (Figure. 1a), GRE (Figure. 1b) and 2 times accelerated WB-GRE (Figure. 1c) were shown. The location in the right somatosensory cortex of brain activation acquired by three different sequences was consisted. The greater activation map was found in EPI and WB-GRE than the conventional GRE. The timecourse of the activation acquired by three sequences was highly consisted to the experiment paradigm (Figure. 1d). The haemodynamics response function which was conducted by the average

timecourse of each stimulation block was shown in Figure 1e. Both of EPI and WB-GRE generated the larger signal change (2% and 1.5 %, respectively) than the conventional GRE. However, more sampling points of fMRI timecourse using 2X WB-GRE demonstrate more details in haemodynamics response pattern. We have suggested the additional separation gradient in WB-GRE strengthen the dephasing effect and enhance the T2* BOLD signal change in electrical stimulation fMRI experiment.

Conclusions:

This was the first study to achieve a higher temporal resolution fMRI scanning by using Wideband technique on a rodent electrical stimulation study. In comparison of fundamental scanning parameters, our preliminary results show that WB-GRE sequence could significantly increase the temporal resolution. This benefit may bring faster scan, less motion artifacts, less physiological noise, more anatomical features or relevant functional information into future fMRI studies. The temporal SNR and spatial SNR still need to be improved using this technique for Brain Informatics Initiative in the near future.

Imaging Methods:

BOLD fMRI

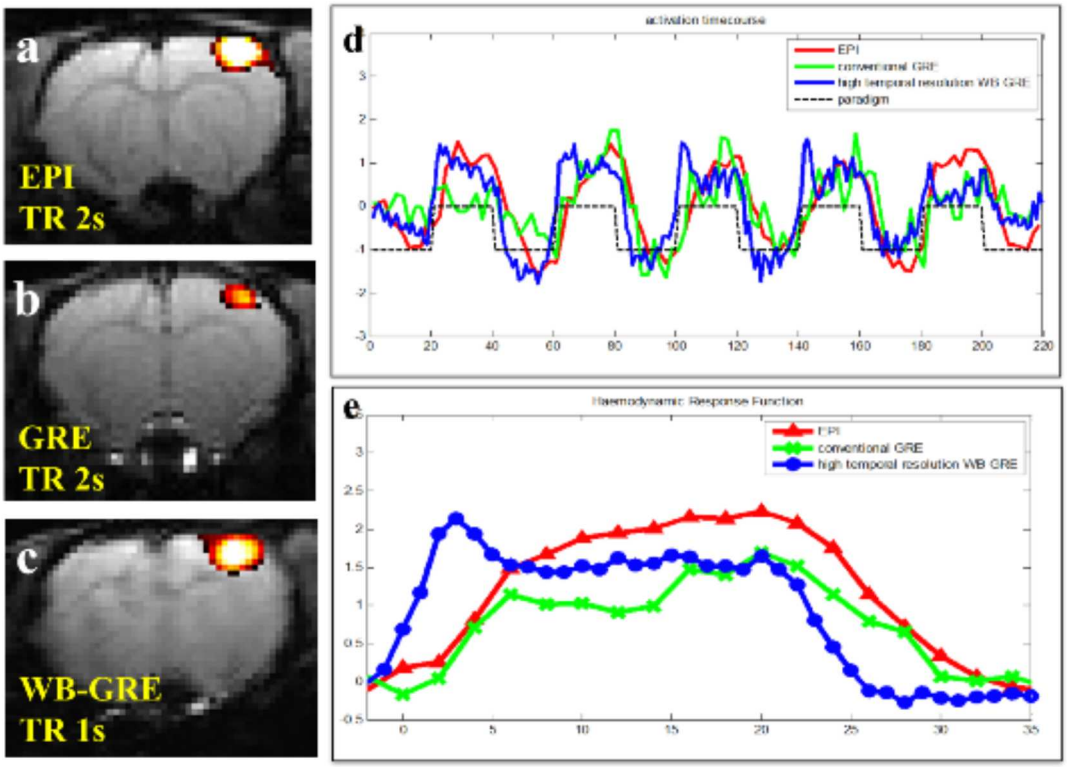

Figure 1. The activation map and timecourse of electrical stimulation fMRI study. a) the activation map acquired by EPI with TR 2s; b) the activation map acquired by GRE with TR 2s; c) the activation map acquired by WB-GRE with TR 1s; d) the activation timecourse acquired by EPI (red), GRE(green) and WB-GRE(blue); e) the haemodynamics response function obtained by using EPI (red), GRE(green) and WB-GRE(blue).