TR and TE dependence on low frequency BOLD fluctuations

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Introduction

Low frequency fluctuations (LFFs) in the resting state (RS) BOLD signal have been utilized to map functional connectivity in the rat brain [1]. The BOLD signal contains contributions from cerebral blood flow (CBF), cerebral blood volume (CBV), and the local rate of oxygen consumption ($CMRO_2$). RS data collected with CBV weighting results in a significant shift of the low frequency power spectrum compared to traditional BOLD scans. RS BOLD typically results in evenly distributed power in the low frequency range (0.0 Hz – 0.4 Hz), while CBV RS scans result in the majority of low frequency power localized at 0.2 Hz [2]. By modifying the TR and TE of resting state scans, the weighted contribution of each component (CBF, CBV, and $CMRO_2$) on the low frequency BOLD signal is altered. In the work presented in this abstract, we examine the dependence of the selection of the TR and TE variables on low frequency resting state data.

Materials and Methods

Seven Sprague-Dawley male rats (250-350g) were imaged using a 9.4 T Bruker scanner (gradient strength of 20 G/cm, rise time 100 μs), with a two coil actively decoupled system, and anesthetized using medetomidine (bolus- 0.05mg/kg; infusion- 0.01 mg/kg/hr). A single shot gradient-echo EPI sequence was used with a combination of TR and TE values. To investigate the dependence of altering the TR on the resting state data, the TE was fixed at 15ms while TR was changed to 100ms, 200ms, 250ms, 300ms, 500ms, and 1000ms for six separate RS scans. To examine the effects of altering TE, TR was fixed at 300ms and TE was shifted between 15ms and 30ms in increments of 3ms resulting in six additional resting state scans. Scan time for all TR and TE dependence scans was six minutes. Data collection order was randomized to remove any contributions from systematic influences. The primary somatosensory cortex (SI) was used as a seed region. Power spectra were plotted using Matlab and divided into 0.02 Hz bins. The power in each bin was normalized by dividing the bin power by the sum of all power in the low frequency range (<0.4 Hz) to determine the percentage of power in each band. Visual examination of the power spectra resulted in three distinct 'bands' of interest in the low frequency range (Band 1, 0.0 Hz – 0.8 Hz; Band 2, 0.8 Hz – 0.16 Hz; Band 3, 0.16 Hz – 0.24 Hz). Power in each band was calculated for all TR and TE dependent scans, and plotted as percentage of the total low frequency power.

Results and Discussion

For the TE dependence scans (Figure 1, top), short TE scans (15 ms, 17ms, and 21ms) resulted in the lowest power in Band 1, with power increasing for both bands 2 and 3. For the longer TE scans (24ms, 27ms, and 30ms) power in the first band was high and decreased for bands 2 (only 24ms and 27ms) and 3. The reversal of the low frequency power distribution suggests that the primary BOLD component influencing the spectrum has been altered. This shift is likely related to the effective echo times of individual components contributing to low frequency BOLD RS data. The physiological components contributing to the higher end of the low frequency spectrum (0.16 Hz – 0.24 Hz) have a shorter echo time while the components contributing to the lowest frequency components of the signal (0.0 Hz – 0.08 Hz) have a longer echo time. By varying the TE we are effectively weighting the scan more heavily towards one contributing component or another. The TR dependence scans (Figure 1, bottom) showed similar power across all frequency bands for the TRs of 200ms, 250ms, and 300ms. For TRs of 100ms, 500ms, and 1000ms the power was highly variable between bands. Variance of the data within each band was also measured and was higher in the 100ms, 500ms, and 1000ms scans than in the 200ms, 250ms, and 300ms data. Lower variance suggests greater consistency in the data collected with TRs of 200ms, 250ms, and 300ms. Our results show that the selected TR and TE for resting state scans significantly influence the distribution of power in the low frequency spectrum. The optimal parameters for resting state scans would be determined by the user's desired weighting from each component of the LF BOLD signal.

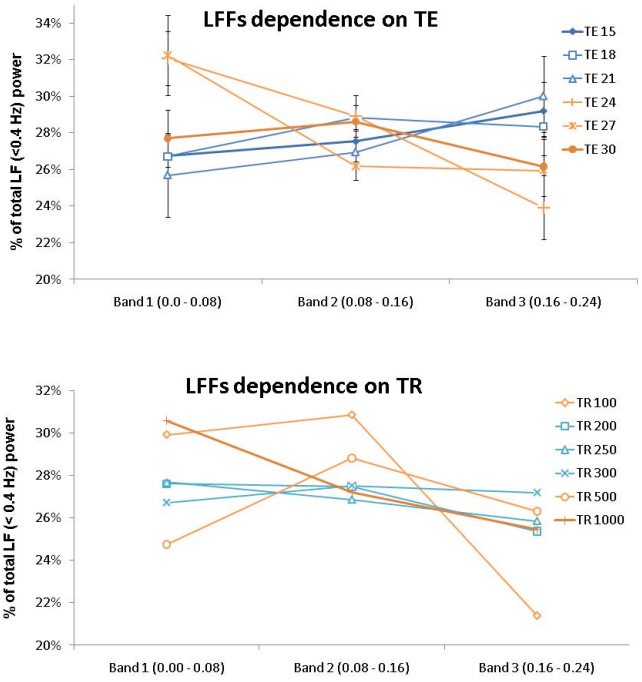

Figure 1: Top: LFFs dependence on altered TE values. The x axis contains physiologically relevant frequency bands that have been used previously in resting state studies [3]. The y axis is a measure of the percent of total low freqency power that falls within each of these bands. Bottom: LFFs dependence on altering the TR.

References

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[3] Majeed, W et al. J Magn Reson Imaging. 2009; 30: 384-392.