

Short echo-time 3D-TSE with and without VASO preparation for functional MRI

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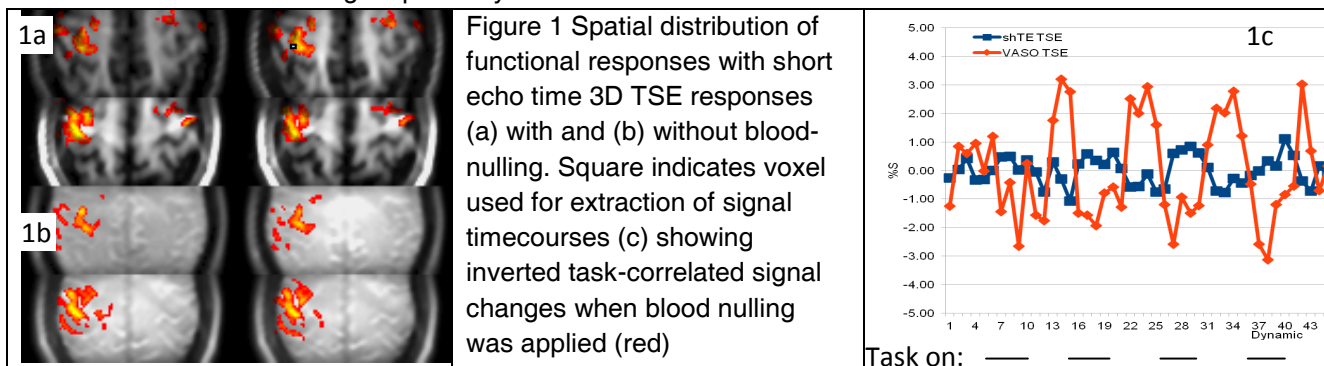
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Purpose: Short echo time (shTE) turbo-spin echo (TSE) pulse sequences are considered very weakly sensitive to blood oxygenation level dependent (BOLD) signal changes, and have been proposed to avoid cancellation of functional responses in blood nulled vascular space occupancy (VASO) fMRI studies where task-related increases in blood volume lead to decreases in signal (1,2). A positive functional contrast in shTE TSE studies has, however, been reported by some authors and attributed to changes in extravascular water distribution termed SEEP (3). Our purpose was to determine whether functional contrast in shTE TSE-based VASO experiments might be contaminated by BOLD or SEEP effects.

Methods: A 3D-TSE sequence without (shTE TSE; TE/TR/TD_{dyn} 8.5ms/2400ms/9.6s, FOV: 210x52x12mm, Matrix 160x40x8, Refocussing Angle 180deg, Turbo factor 80, echo spacing 8.5ms, 70 dynamics, centre-out sampling) and with blood-nulling (VASO; TI 600ms) was used to acquire image series from the hand sensorimotor area of the cerebral cortex during a block-design finger tapping task (block duration 48s, 9 blocks). The inversion time assumed suppression of longitudinal relaxation during the TSEcho train. For comparison purposes, a BOLD-sensitive gradient-echo EPI series was also obtained (TE/TR/TD_{dyn} 35ms/3000ms/3s, FOV: 230x230x120, Matrix 64x64x30, Excitation Flip Angle 90deg, 70 dynamics) with the same task. The finger tapping task was self-paced left-hand finger tapping, and controlled via auditory commands.

fMRI time-series were motion-corrected, and an independent component analysis (MELODIC, fsl) used to identify 7 components for denoising prior to a glm (FEAT, fsl) with a single regressor convolved with the default hemodynamic response function. Spatial smoothing was limited to a 1.5mm FWHM. Voxels were considered to show a significant functional response using a p-value < 0.005 with cluster-wise correction for multiple comparisons. We present results from the first 2 subjects who participated in the study.

Results: Functional responses were found using both variants of the shTE TSE sequence within the area of BOLD response seen with conventional EPI-based fMRI. The spatial correspondence of responses was striking (Figures 1a and 1b), but having an inverted response when blood-nulling is applied (Figure 1c; bars indicate task blocks). The sequences yielded similar maximum functional contrast to noise ratios of 4.0 and 4.6 (on % signal changes of 0.98% and 3.6%) without and with blood-nulling respectively.



Discussion: The inverted functional response when blood-nulling is applied indicates the expected VASO changes. The robust functional contrast in shTE TSE without blood nulling may also be consistent with this effect, but our results are not sufficient to exclude contributions from SEEP, or BOLD that would run counter to the VASO contrast in blood-nulled measurements. The functional contrast to noise ratio in both cases are similar. Nonetheless, the small fractional signal change in the non-nulled case suggests that BOLD and SEEP and inflow effects make only minor contributions. The 3D TSE strategy used here is hampered by limited spatial coverage and low temporal efficiency relative to conventional EPI. Improvements are likely possible however, as we have not made use of parallel imaging techniques, nor pursued extremely long echo trains that may reduce scan time.

References: 1. Stroman P, et al. *Magnetic Resonance in Medicine* 49:433–439 (2003). 2. Cretti F, et al. *ESMRMB* 2009 187. 3. Poser B, Norris D. *Magn Reson Mater Phy* (2007) 20:63–67.