Sub millimeter analysis of Specificity of SE, GE, and ASE BOLD responses in the Human Visual Cortex

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Introduction:

Sub-millimeter spatial resolution applications are becoming of increasing interest in fMRI. Several animal and human studies have successfully mapped high resolution functional organizations. However, it is not known which fMRI technique (which depends on field strength), maximizes contrast to noise as well as specificity to capillaries for sub-millimeter functional mapping. In this work we examine this problem by comparing functional maps, at 0.5mm in plane resolution, of gradient echo BOLD, spin echo BOLD, and asymmetric echo BOLD in human visual cortex at 7 Tesla.

Background:

Vasculature plays an important role in coupling neuronal activity to MR detectable signals through the BOLD mechanism. BOLD signals originate from intravascular and extravascular effects, and from both large vessels, and capillaries. Unlike at lower fields (e.g. 1.5 to 4 T), Hahn Spin echo (HSE) BOLD at 7T is expected to originate from dynamic averaging associated with capillaries only, providing optimal specificity. Gradient recalled echo (GRE) BOLD signals are expected to increase in specificity with increasing magnetic field also due to the suppression of intravascular effects caused by the decrease in blood T_2 with increasing magnetic fields. However, residual blood contribution may persist even at 7T because of the necessity to use shorter echo times at this field magnitude. Using asymmetric spin echoes (ASE) it will be possible to eliminate the blood contribution at 7T and maintain the GRE BOLD contrast associated with extravascular static dephasing. It is not known, however, how far in the venous tree these static extravascular effects propagate going from capillaries to large vessels.

Methods:

Studies were conducted at 7T using slab selective FOV reduction (1) for HSE (TE= 50 ms) and ASE, and k-space segmentation was used for GRE BOLD (TE= 23 ms). ASE was weighted with 15 msec (T_2*), and 33 msec of (T_2). Visual stimulation was used to assess the BOLD signals of differing contrasts. To suppress gross subject motion, a bite bar was used. The visual stimuli were presented through fiber optic video goggles (Avotec, inc.).

Results:

The results from one subject are shown in Fig.1. All three of the signals show significant activation, however, there appears to strong activation which lies *around* large blood vessels in the GRE map, as well as the ASE map, but not in the HSE map.

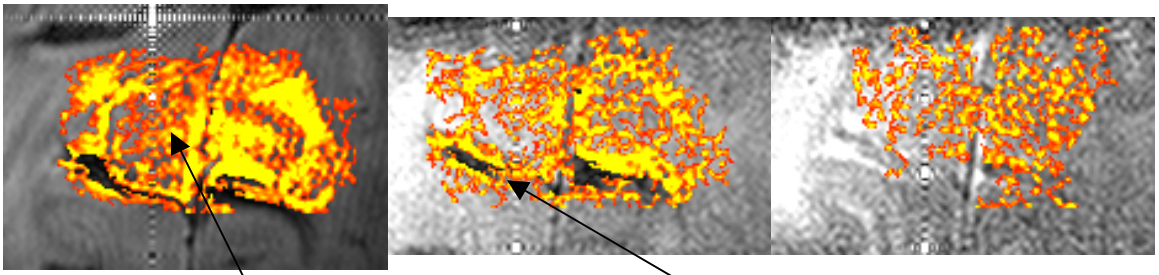

Fig.1. The GE map is on the far left, the asymmetric is in center, and the SE on the far right.

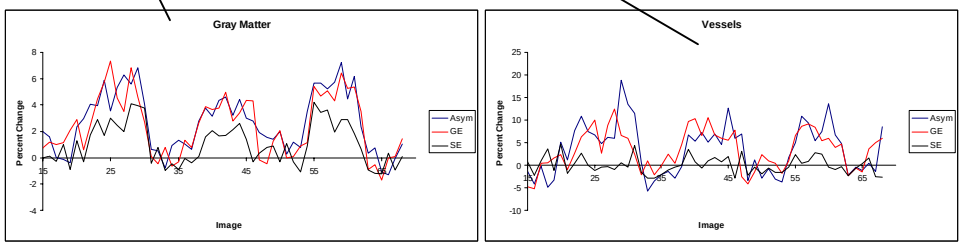

Fig.2 Timecourses from each of the three maps in gray matter and areas around blood vessels.

Conclusions:

Functional maps were generated with 0.5mm in plane spatial resolutions. Contrast to noise (CNR) is clearly better in the GRE and the ASE, but some of this contrast clearly involves signal changes around large blood vessels. Even in the absence of blood contributions, extravascular BOLD effects associated with large vessels are detectable at 7 Tesla. ASE with more weighting towards T_2 changes may diminish very large vessel signals (extravascular BOLD) providing a compromise in CNR and specificity.

References:

1. Duong et al, Magn. Reson. Med, 48:589-593 (2002).

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