Spatial Specificity of High Resolution Gradient Echo (GE) BOLD and Spin Echo (SE) BOLD fMRI in Cat Visual Cortex at 9.4 T.

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Introduction

fMRI based on hemodynamic responses evoked by neuronal activity is the most widely used method for studying brain function. However, the accuracy of functional mapping in these methods is expected to be degraded by limitations imposed by the vascular and metabolic control in the brain. We recently reported a comparison of point spread functions (PSF) of high resolution GE BOLD and CBF based fMRI in cat visual cortex (area 18) at 9.4 T (1), which provided a quantitative relationship between spatial specificities of both fMRI techniques. In this study, the PSF of GE BOLD and SE BOLD fMRI were addressed and were compared with previous results.

Methods

MR imaging of the cat visual cortex was performed on a 9.4 T/31 cm horizontal MRI scanner equipped with a magnetic field gradient coil capable of 30 G/cm with a two-coil rf system: a large-saddle coil (10 × 4 cm^2) that serves as a transmitter, and a small surface coil (2 cm I.D.) as a receiver. The following fMRI parameters were employed: number of image segmentations = 2; data matrix = 64×64; FOV = 2×2 cm^2; slice thickness = 2 mm. GE BOLD parameters: image TR = 2 s; TE = 14 ms. SE BOLD parameters: image TR = 4 s; TE = 40 ms. The oblique imaging slice through the visual cortex (area 18) was positioned on the areas activated by the stimulation. The slice was positioned below the cortical surface in the border zone so as to avoid surface vessels. Contiguous areas of the upper- and lower visual fields were alternately stimulated with sinusoidal wave gratings in one of four orientations (0°, 45°, 90°, 135°), in order to obtain a retinotopic border between two adjacent parts in area 18. The measurements of all orientation stimuli were averaged and zero-filled in k-space to a data matrix of 128 × 128 before analysis. PSF from activation maps of both methods were estimated by identifying the crossing points and base lines of the upper visual field and lower visual field cross correlation coefficient (CCC) profiles perpendicular to the retinotopic border, and then measuring the full width at half maximum (FWHM) of the location of overlap between the two profiles.

Results

Fig. 1 shows smoothed profile curves of GE BOLD and SE BOLD data, and the PSF of GE BOLD, SE BOLD, and CBF based fMRI at 9.4 T. In Fig. 1 (a) and (b), the cross correlation coefficient (CCC) values were almost constant in the activated part of the visual field and started to decrease at the retinotopic border. The FWHM of PSF of GE BOLD was approximately 1.6 mm. With half the number of animals studied so far, the data for the PSF of SE BOLD was not as symmetric at the retinotopic border; nevertheless an upper limit of 1.0 mm was measurable, with the sharper edge taken alone giving a smaller number (~0.5 mm). Fig. 1 (c) shows that the comparison of the PSF of GE BOLD, SE BOLD and CBF based fMRI.

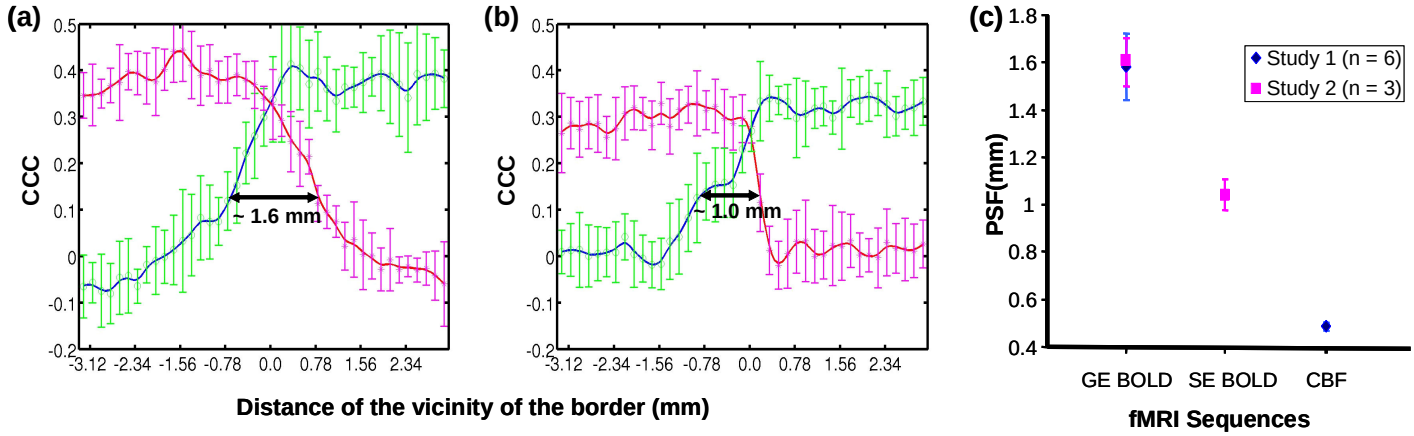

Figure 1. Averaged activation profiles (three cats) of GE BOLD (a) and SE BOLD (b). The red line and asterisks represent activation of the lower stimulus, and the blue line and circles indicate activation of the upper stimulus. Error bars represent the standard deviations[KU2]. (c) The comparison of the PSF from the previous study (1) (study 1: GE BOLD and CBF) and this study (study 2: GE BOLD and SE BOLD).

Discussion

The PSF of GE BOLD and SE BOLD were simultaneously determined at high resolution of 156×156 μm^2, and were compared with previous results (1). The results of this study indicate that the specificity of SE BOLD fMRI is higher than GE BOLD, presumably because SE BOLD at high fields is sensitive to changes originating from the microvasculature. The PSFs of GE BOLD from this and the previous studies have the same value, and it is in good agreement with the measurement from the microvasculature component of the human data at 7 T (2). This and earlier result suggest that CBF and SE BOLD functional maps are spatially localized in the sub-millimeter domain, and thus may provide a proper tool for the investigation of columnar structures in the mammalian cortex.

References

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