Spatial specificity of CBV and BOLD fMRI in monkey striate cortex at 4.7T and 7T

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Introduction

High resolution fMRI allows us to determine more accurately the origins of the fMRI signal. This has shown that even at high field, the GE-BOLD signal has still a large vascular contribution [1]. Alternative methods like SE- and monocrystalline iron oxide nanocolloid (MION)-based methods have been shown to be spatially more specific than conventional BOLD, and are able to reveal functional subunits in the cortex [2-6]. Here we compare the specificity of BOLD and CBV fMRI methods in the macaque; its striate cortex shows very obvious laminar structure in anatomical images, allowing accurate determination of the precise location of the fMRI activation.

Methods

MR imaging was performed on dedicated vertical 4.7T/40cm and 7T/60cm primate scanners (Bruker Biospec). A saddle-shaped volume coil was used in combination with a 25 or 30 mm receive surface coil. Experiments were performed on healthy adult monkeys (*macaca mulatta)* as described previously [7]. MION was injected i.v. as a slow bolus at 8 mg/kg. The visual stimulus was a full field rotating checkerboard presented to both eyes. For anatomical imaging, a FOV of 51.2x38.4 mm was used with a spatial resolution of 100 μm^2, TE/TR 18/2000 ms. For fMRI, *16-shot, multi-slice* GE-EPI and SE-EPI were acquired with an in-plane resolution of 333x250 µm. FOV 64x48 mm, matrix 192x192, EPI acquisition window 23 ms, TE/TR 20/750 ms for GE-EPI and TE/TR 46/2000 ms for SE-EPI. FOR CBV imaging, TE was reduced to 17 ms for GE-EPI and 35 ms for SE-EPI. All data analysis was performed in MatLab (the Mathworks) and image registration with SPM.

Results

Figure 1a shows a high-resolution anatomical image after injection of MION obtained at 4.7T. The intracortical vessels are clearly visible as well as the Gennari line at 1.2 mm depth. Fig 1b shows a SE-EPI after MION injection with the peak of the functional activation in layer IV. In Fig 2a-d the cortical profiles of four different contrasts (GE-EPI, SE-EPI, MION GE-EPI and MION SE-EPI) are visualized (at 4.7T). Spatial specificity was highest for SE-BOLD and SE-MION, although SE-MION has a higher %-change and t-values. Although the GE-MION also peaks in layer IV, the GE methods result in a less specific pattern of functional activation. A similar pattern was observed at 7T although the % functional signal change using MION was lower than at 4.7T.

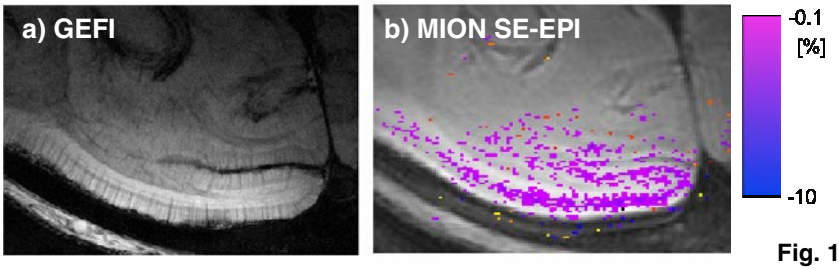

Fig. 1

Discussion

Highest spatial specificity is achieved using SE-based methods. No differences in specificity of the %-signal change were observed between SE and SE-MION. At 4.7T there is a benefit in using MION, because of increased SNR. The higher specificity of GE-MION over GE-BOLD can be mostly explained by the dropout of signal from larger vessels, for instance at the pial surface.

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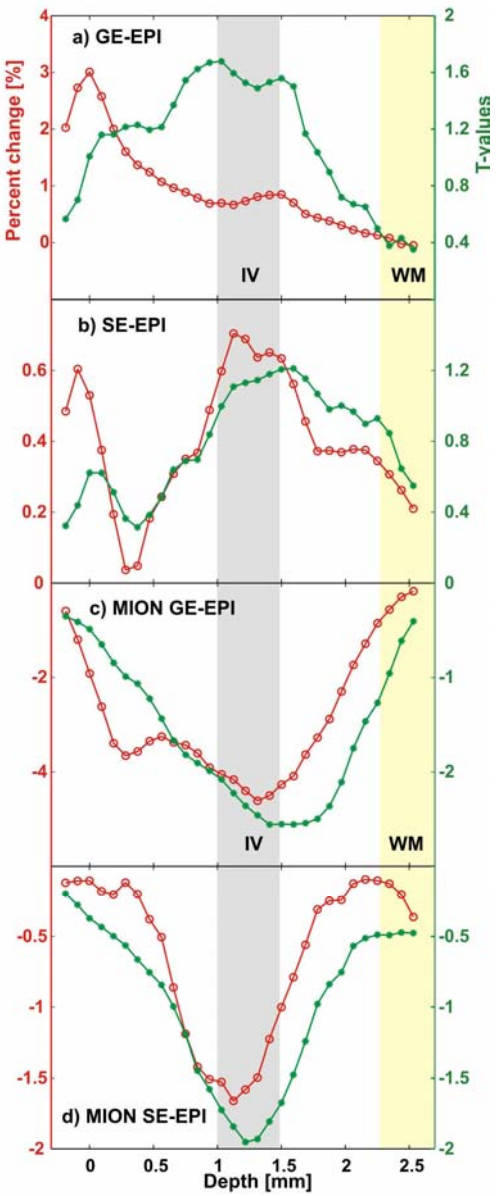

Fig. 2