BOLD mapping of finger movement compares with the underlying electrophysiology; a combined 7T fMRI and ECoG study

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Introduction

A key requirement for the accurate interpretation of BOLD activation is the accurate spatial co-localization of the BOLD signal with the underlying neuronal activation patterns. Several studies, predominantly in primary visual cortex and at high field strength (7T), have shown that BOLD fMRI has the potential to map activation patterns of small scale neuronal ensembles such as cortical columns [1,2,3]. However, to directly confirm whether BOLD activation maps reflect the underlying neuronal activity patterns, a comparison with accompanying neuro-electrophysiological data is required. Here, we investigate the spatial representation of finger movements on sensorimotor cortex using high density electrocorticography (ECoG) grids post-implant and presurgical BOLD fMRI at 7T in the same subjects. Both techniques measure at a similar resolution (1.5 mm), allowing for a direct link between techniques and evaluation of the BOLD spatial specificity in the case of individual finger activations.

Materials and Methods

The subjects had normal hand function and were scheduled for the implantation of ECoG arrays for the clinical purpose of epilepsy monitoring. Functional paradigm: two right handed subjects were visually instructed to move their thumb, index, or little finger (right hand) twice in a randomized order. Data acquisition: presurgical BOLD fMRI data were acquired on a Philips 7T system (16-channel head coil) using GE-EPI: TR/TE = 880/27 ms, flip angle = 65°, SENSE factor = 2.5, FOV = 155 x 155 mm2, and 13 slices on the left sensorimotor cortex (M1 and S1). Large draining vessels were identified using a high-resolution T2*w anatomy scan [4], and were excluded from analysis. ECoG; an 8x4-electrode grid (size: 12 x 23 mm2) was placed over sensorimotor area (3 mm pitch) and subjects performed the same motor task while ECoG was recorded (512 Hz). Next, z-score timecourses were obtained for the ECoG power in the high frequency broadband (6-155 Hz), using a sliding window of 2 ms. BOLD fMRI data were acquired on a Philips 7T system (16-channel head coil) using GE-EPI: TR/TE = 880/27 ms, flip angle = 65°, SENSE factor = 2.5, FOV = 155 x 155 mm2, and 13 slices on the left sensorimotor cortex (M1 and S1). Data acquisition: presurgical BOLD fMRI data were acquired on a Philips 7T system (16-channel head coil) using GE-EPI: TR/TE = 880/27 ms, flip angle = 65°, SENSE factor = 2.5, FOV = 155 x 155 mm2, and 13 slices on the left sensorimotor cortex (M1 and S1). Large draining vessels were identified using a high-resolution T2*w anatomy scan [4], and were excluded from analysis.

Results and Discussion

The spatial pattern of the ECoG and BOLD contrast maps for each finger movement (little, index and thumb) are shown in figure 1 for both subjects. Results show that movement of three individual fingers could be distinguished on a spatial span of 12 mm, corresponding to the smallest dimension of the ECoG grid. Both the ECoG and BOLD reveal the same spatial organization of finger activations in M1 for both subjects: activation patterns were organized in a way that movement of one finger versus movement of the other two fingers, using the dataglove as regressors. BOLD finger activation underneath each ECoG electrode was computed as the maximum BOLD z-value in a 5 mm search volume centered at each electrode (direction orthogonal to the electrode plane). Next, spatial correlation (Spearman coefficient, R) was used to compare the spatial distribution of finger activation of both techniques.

Conclusion

The spatial match between ECoG and BOLD fMRI for finger movements is very promising for spatial correspondence between neuronal and vascular responses. The results show that underneath the electrode grid the BOLD activation patterns are closely related to the ECoG activation patterns in the HFP power. Future work will investigate the contribution of different ECoG frequency bands in the BOLD spatial patterns, differences between primary motor and sensory activation, and the role of cortical-depth dependency.

References: