Functional Magnetic Resonance Imaging using Super-Resolved Spatially-Encoded MRI

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Introduction

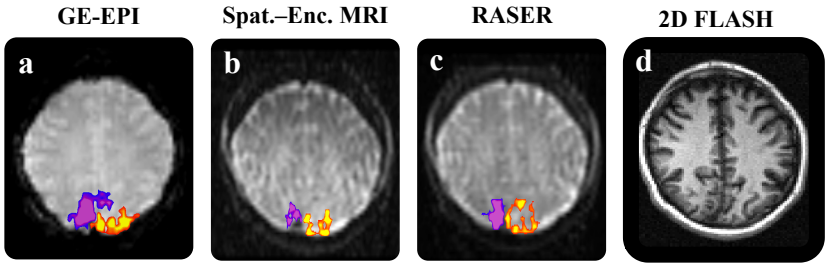
The robustness of detecting activation in fMRI data is affected by the type of imaging sequence and reconstruction algorithm used. This facet of functional MRI experiments, is expressed for example in the different sensitivity and specificity of Spin-Echo (SE) EPI and Gradient-Echo (GE) EPI sequences. Recent development of a new single-scan imaging scheme provides an alternative tool for fMRI, based on spatial- rather then frequency- encoding [1]. Compared to its EPI counterparts, this scheme was shown to provide higher robustness to field inhomogeneity artifacts, albeit suffered from lower a-priori spatial resolution which could only be compensated at a cost of greatly increasing the corresponding SAR deposition [2,3]. In this study we present a post-processing algorithm which is based on super-resolution principles, and can resolve the lower spatial-resolution issue while retaining the fMRI activation data, resulting from the BOLD effect.

Methods

Experiments were performed on a 3T Siemens scanner with a four channels head coil. Three volunteers participated in the fMRI study after written consent. Half circular shifting checkerboard pattern (consisting of black & white concentric rings) was used to stimulate the primary visual cortex by alternating between left and right visual field during 6 min scans consisting of 6 blocks of 30 sec left and 30 sec right orientations. Functional time series were acquired using GE-EPI and two spatially-encoded based sequences: RASER [2] & Spatially-Encoded MRI [3]. Imaging parameters were matrix size: 48x64, bandwidth: 2004 Hz/pixel, TR: 2 sec. The echo times were 30 ms for GE-EPI and 87 ms for RASER and the Spatially-Encoded MRI. Activation maps were computed based on statistical *t-test* of the experimental time series, using STIMULATE software package [4].

Results

Significant activation of the left (violet) and right (yellow) visual cortex was observed in all three subjects, arising respectively from the right and left stimulations. The attached figure shows activation maps from one of the subjects, overlaid on the corresponding single-scan images produced by (**a**) GE-EPI (**b**) Spatially-Encoded MRI and (**c**) RASER. Super-resolution reconstruction was used to generate the set of images from which the activation maps in (**b**) and (**c**) were calculated. It is readily observed that all three protocols produce an activation pattern which is consistent with the stimulus scheme.



Discussion

The current study confirms the capability of the super-resolution processing to provide high-quality time series images, having equal resolution to those produced by EPI, while preserving the signal BOLD effect. Another intriguing aspect of the spatial-encoding sequences is their spatial specificity when detecting neuronal activation [5]. This specificity can be attributed to the ability of this type of sequences to genuinely refocus T_2^* relaxation [2,3]. Hence, the underlying changes in T_2 can be probed, unraveling a BOLD effect mechanism, which is more closely coupled to the actual activation region. We believe that these findings, together with the inherent robustness to field inhomogeneities, attest to the viability of super-resolved spatial-encoding MRI as an alternative scheme for collecting fMRI data.

References

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