High-Resolution fMRI using SENSE at 3 Tesla

Conny F. Schmidt[1], Klaas P. Pruessmann[1], Peter Boesiger[1]

[1]*Institute for Biomedical Engineering, University and ETH Zurich*

INTRODUCTION

To improve spatial resolution in fMRI, we propose combining the CNR benefit of high field strength [1] with the parallel imaging technique SENSE [2]. Reducing the echo train length of single-shot EPI (sshEPI), SENSE mitigates gradient and susceptibility issues and thus permits pushing spatial resolution beyond current limitations.

In this work we demonstrate high-resolution SENSE fMRI (HR-EPI) at 3 Tesla using a bilateral opposite finger-tapping paradigm and compare it to data acquired with conventional single-shot EPI (LR-EPI).

METHODS

Measurement parameters:

- 3 T whole body system (Philips Intera), TR body coil, 8-element head receiver array (MRI Devices Corporation, Waukesha WI, USA)
- 6 transverse slices containing primary motor areas
- partial Fourier 77%, FOV 180mm, TR 2s, TE 35ms
- high-resolution SENSE-sshEPI (HR-EPI): 0.9 x 0.9 x 5 mm^3, acq. matrix 192 x 192, SENSE acceleration factor 2.7
- conventional sshEPI (LR-EPI): 1.6 x 1.6 x 5 mm^3, acq. matrix 112 x 112
- 6 healthy volunteers, mean age 29 ± 7 years

Stimulus and Paradigm:

- bilateral opposite finger tapping, 4 x 20s-on/off periods

Postprocessing:

- FEAT (FMRIB's Easy Analysis Tool) [3]: motion correction, high-pass temporal filtering
- Statistical analysis: FILM (FMRIB's Improved Linear Model) [3] with local autocorrelation correction, z > 3.5, cluster significance p = 0.01

RESULTS AND DISCUSSION

The high-resolution images show improved spatial detail compared to the conventionally acquired images (Fig. 1). The sensitivity to geometric distortions was reduced from 130 μm/Hz in the LR-EPI data to 77 μm/Hz in the HR-EPI data.

With both acquisition strategies the CNR was sufficient for statistical analysis. Activation foci in the primary motor areas, especially along the central sulcus, were well depicted. The detected total activated area, however, was significantly smaller at HR than in the LR-EPI data and the average percent BOLD signal change was larger in the HR-EPI data (Tab. 1). Moreover, a small fissure without activation separates two highly activated areas in the HR-EPI data. This fissure is not be resolved in the LR-EPI data (Fig. 1, black arrow).

The distribution of BOLD signal change > 5 % is essentially the same for HR-EPI and LR-EPI data, while pixels with low BOLD signal change (< 1.5 %) are hardly detected in the HR-EPI data. Lowering the statistical threshold of the HR-EPI data (z > 2.8) to account for lower CNR reveals increased sensitivity to lower BOLD signal changes; however BOLD signal changes well below 1.5 % are still hardly detected.

These results suggest that the observed loss in activated area at high resolution results from reduced SNR, while the increase in percent BOLD signal changes may be related to higher spatial specificity and hence reduced partial volume effect.

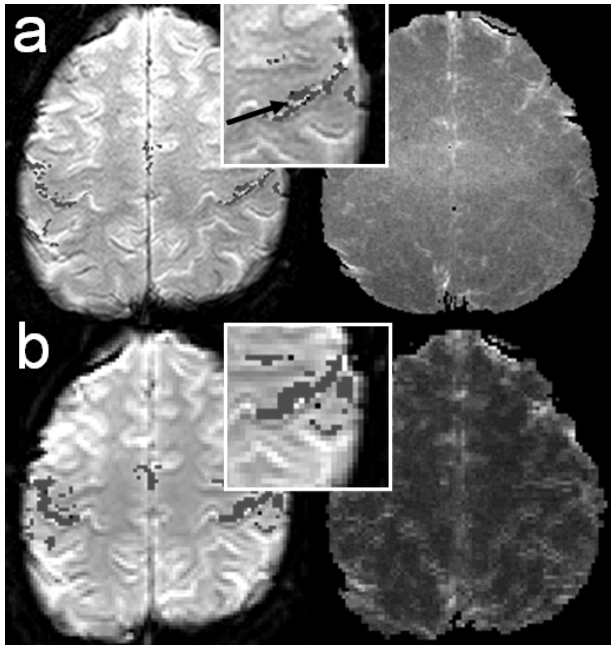

Figure 1: Activation maps overlaid on sample sshEPI images taken from the functional time-series, with enlarged detail (left). (a) HR-EPI (b) LR-EPI. Comprehensive noise maps are an immediate measure of functional signal stability (right).

	SNR	CNRact	activ. area [10^3 mm^2]	Z	BOLD/BOLD[%]
HR-epi	30.3 ± 1.5	1.71 ± 0.18	9.7 ± 6.2	5.4 ± 0.4	6.3 ± 0.9
LR-epi	68.4 ± 5.4	2.24 ± 0.33	23.9 ± 17.2	5.9 ± 0.5	4.1 ± 1.0
HR-epi/LR-epi [%]	44.4 ± 1.9	76.5 ± 5.7	42.6 ± 10.9	90.8 ± 3.6	155.7 ± 24.0

Table 1: SNR values averaged over the whole brain, CNR values averaged within the activated area, activation area, z values and BOLD signal changes for HR-EPI and LR-EPI data. Values are given as absolute values averaged over subjects (mean ± SD) as well as ratios between HR-EPI and LR-EPI data.

REFERENCES

[1] Krüger et al., Magn. Reson. Med. **45**: 595-604 (2001) [2] Pruessmann et al., Magn. Reson. Med. **42**: 952-962 (1999) [3] www.fmrib.ox.ac.uk/fsl