EVALUATION OF K-T BLAST APPLIED TO SPIN-ECHO BASED BOLD FUNCTIONAL MRI

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Introduction

Spin-echo based strategies offer a distortion free alternative to Echo Planar Imaging (EPI) to detect blood oxygen level dependent (BOLD) signal changes[1, 2]. However, longer acquisition times and high RF power deposition restrict their widespread application. Spatio-temporal correlation (k-t)[3] approaches may be adopted to address these issues, but the temporal and spatial fidelity of k-t SENSE/BLAST applied to fMRI have not been verified, providing the motivation for this study. k-t BLAST accelerated UFLARE[2] images were acquired i) of a test object, in which signal intensity was periodically reduced ii) in normal subjects performing block design finger tapping.

Methods

UFLARE images were acquired of a test object filled with mineral oil, containing pairs of lines separated by 3, 2, 1 mm (*Figure 1*) at 3 Tesla (Philips Medical Systems, Best, The Netherlands); with an 8 -Channel Head Coil; 128 matrix, 3.5 mm slices, TR = 2.8 s, TE = 38 ms, 6 dummy echoes, 100^0 refocussing pulse, echo shift, $\tau = 0$ ms; FOV = 240 x 218 mm. Brain activation was modeled by alternating the excitation flip angle between 90^0 and 85^0 every eleven scans. Images with k-t factors of 2, 5 and 8 were reconstructed with and without the inclusion ("plug in"[4]) of the 11 lines of training data in the under-sampled data sets. Time courses of signal intensity (SI) in a region of interest (ROI) were then measured. *In-vivo* measurements were performed using a block motor paradigm (6 cycles of 11 scans rest, 11 scans finger tapping), for which FOV = 240 x 192 mm; 3 slices with 0.5 mm slice gap, UFLARE with $\tau = 30$ ms; EPI with TE=32 ms.

Results

The square wave of SI in the ROI generated by the alternating flip angle was increasingly distorted at higher k-t factors (*Fig. 2a*). However, the inclusion of training data ("plug-in"[4]) in the under-sampled data restored the true temporal profile (*Fig. 2b*). 3mm line pairs were not resolvable in the phase encoding direction in full data acquisitions, but were resolved at k-t factors ≥ 2. Functional activation in a normal volunteer was measured with displaced UFLARE combined with k-t BLAST and with EPI (*Fig. 3*). The echo train length was reduced from 104 to 13 with k-t factor 8, significantly reducing SAR.

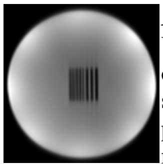

Figure 1: UFLARE image of test object, showing line pairs: 3, 2, 1 mm.

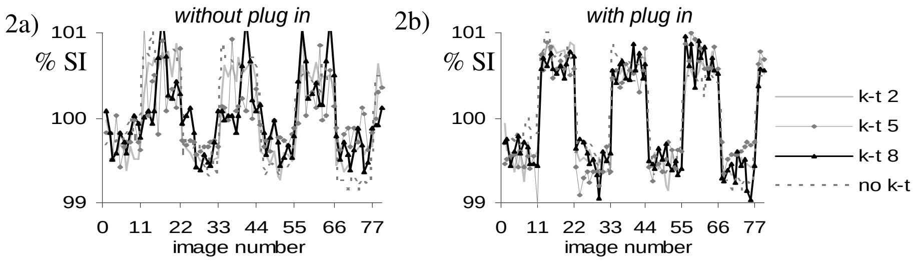

Figure 2: SI in ROI in test object as a percentage of the time averaged mean SI in a series of UFLARE images acquired with k-t BLAST. Values acquired with full data acquisition are shown for comparison. The inclusion ("plug-in") of training data in under-sampled data sets in the reconstruction[4] seems to be essential for good temporal fidelity (compare *2a* with 2*b*).

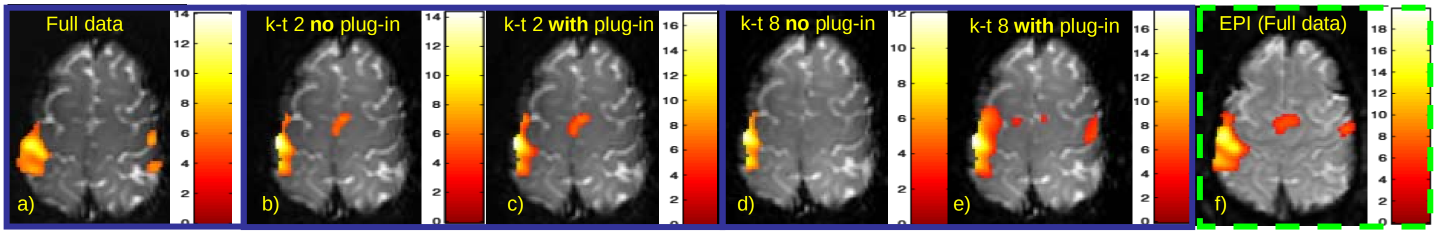

Figure 3: Neuronal activation measured using displaced UFLARE: a) Fully sampled data; b,c) k-t BLAST factor 2 without (b) and with (c) plugged in training data d,e) k-t BLAST factor 8 without (d), with (e) plugged in training data; f) EPI for comparison. Activation was more significant when training data was "plugged in" (particularly apparent with k-t 8: (e) compared with (d)). Functional paradigm: finger-tapping (6 blocks of 11 images on/off); spm5 analysis (www.fil.ion.ucl.ac.uk/spm) ($p < 0.005$ with FWE-correction, threshold = 25 voxels).

Discussion and Conclusions

Results of this study demonstrate i) the applicability of k-t BLAST to fMRI ii) the necessity of including k-t training data in the reconstruction to achieve high temporal fidelity, iii) improved spatial resolution with k-t data reduction due to shorter echo train lengths. Activation patterns conform to expectations *in-vivo*, but further investigation of the accuracy of spatial localization of BOLD responses in k-t accelerated fMRI is required. In summary, k-t BLAST/SENSE presents new opportunities for fMRI, including application of spin-echo based techniques, which do not suffer from the image distortion and signal drop out that plague EPI.

References:

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