High Resolution 3T GR-EPI in the Caudal Brain

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Introduction

Given problems of susceptibility-related signal loss in low resolution EPI, doubts have been raised as to the rigour of the many published amygdala activation studies at less than 2 T (Merbolt, 2001). We have performed a systematic study to optimise GR-EPI for the amygdalae at 3T. Image orientation was established via B_0 field maps, and in-plane resolution and slice thickness by SNR in the amygdalae. T2* was measured with the optimised parameters, standard parameters and FLASH scans as a reference. The optimised protocol was tested for the SNR achieved in time-series data.

Methods

Seventeen healthy subjects were scanned with a 3T Bruker Medspec whole-body scanner and standard birdcage head coil. 2D gradient echo scans were acquired at three echo times for the generation of B_0 maps (Windischberger, 2003). Single-shot EPI protocols were employed with matrix sizes such as to give 1-4 mm in-plane resolution, slice thickness from 1mm to 6mm, and receiver bandwidths in the range 100-200kHz. To allow T2* to be calculated with both standard EPI parameters (axial slices, 64x64 matrix and 4mm slices) and optimised EPI parameters (axial slices, 128x128 matrix size and 2mm thick slices), repeated measurements were made with TE_{eff} of 40 - 90 ms in 5ms intervals and with FLASH scans the same geometry as the optimised EPI as a reference. Time-series data (NR=100, TR=2s) were acquired with the standard and optimised EPI protocols.

Results

Variations in B_0 across the amygdalae in the cranio-caudal (CC) and anterior-posterior (AP) directions were 1.5Hz/mm and 1.0 Hz/mm in the medio-lateral (ML). SNR was found to increase linearly with slice thickness in the cortex. In the amygdalae, however, optimum SNR was subject-dependant, and peaked around 2.0 - 2.5 mm slice thickness. The sum of four 2 mm thick slices spanning the amygdalae showed an SNR increase of 57% over two 4 mm thick slices covering the same area. The sum of eight 1 mm thick slices provided only an additional 13% in SNR, however. With a slice thickness of 2mm, a matrix size of 128x128 was found to be satisfactory to reduce signal loss in frontal areas so that the amygdalae could be delineated (Figure 1). T2* in the amygdala was measured to be 22 ms measured with standard EPI parameters and 48 ms with optimised EPI. The FLASH reference value was 43 ms. Time-series data acquired with these parameters showed a 60% increase in the amygdalae over that achieved with a standard protocol (Figure 2), despite measuring with twice the receiver bandwidth.

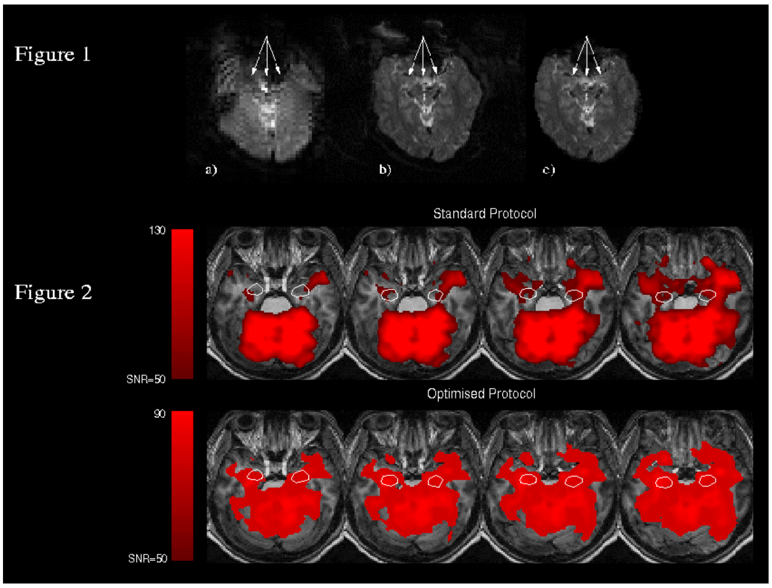

Figure 1: A comparison of a slice through the amygdalae a) using a standard EPI protocol with 47 μl voxels b) with the optimised protocol with 6 μl voxels, and c) distortion-corrected version of b). Arrowheads indicate the anterior boundary of amygdala signal, apparent in optimised images.

Figure 2: Time-series SNR values exceeding 50 overlayed in red on axial anatomic sections covering the amygdalae (caudal to cranial from left to right) for the standard EPI protocol and the optimised protocol. The approximate location of the amygdalae has been outlined (white circles).

Conclusions

B_0 field variation shows the coronal and sagittal orientations to offer no benefit over axial imaging, which provides optimum brain coverage. A matrix size of 128x128 was adequate to allow identification of the amygdalae. The highest SNR for a given scanning time was achieved for summed 2 mm slices. T2* in the amygdala increased from 22 ms with standard parameters to 48 ms with optimised parameters (43 ms with FLASH), close to the cortical value of 52 ms, showing effective reduction of intravoxel dephasing. An increase in time-series SNR of 60% over standard EPI offers this as a promising protocol for sound fMRI studies of the amygdalae.

References

Merboldt KD et al. (2001) NeuroImage 14: 253-57.
Windischberger C et al. (2003). MAGMA 16, Supplement 7. Abstracts (electronic only). DOI: 10.1007/s10334-003-0017-5, s13.

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