An investigation of GRAPPA in conjunction with fMRI of the occipital cortex at 3T

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Introduction

Generalized autocalibrating partially parallel acquisition (GRAPPA) is a type of parallel imaging technique that enables the number of lines of k-space sampled to be reduced by a factor (R) in comparison to a standard fourier encoded image. A full FOV image is achieved by a simple mathematical fitting procedure of the ACS lines to the undersampled dataset in the frequency domain.
Single shot EPI has long been used to investigate neuronal function (fMRI). The combination of EPI with parallel imaging techniques is of interest for a number of reasons. The most documented problems associated with EPI are blurring due to $T2^*$ decay, and image distortions due to off resonance spins. Minimising the echo train length of the EPI acquisition can reduce both these effects. Due to the fact that EPI samples the whole of k-space in one TR, GRAPPA in conjunction with EPI enables the echo train length to be increasingly reduced as the reduction factor is increased. Furthermore, reduced reconstruction times are expected with increasing reduction factor. This study demonstrates the effect on BOLD response from visual stimulation at 3T when using GRAPPA in conjunction with single shot EPI.

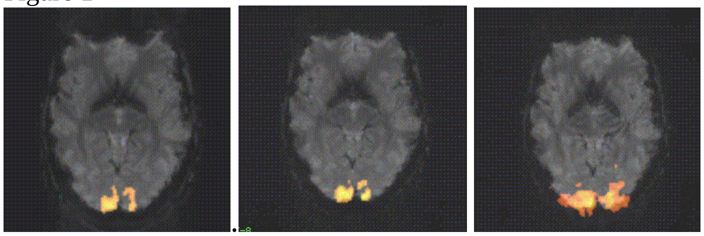
Methods

Five normal subjects were scanned on a 3T Siemens Trio MRI scanner following ethics approval and their informed consent. Images were acquired using an 8-channel head array coil. Axial slices were positioned to cover the whole occipital cortex. Single shot EPI images were acquired with parameters: flip angle 90-degrees; FOV 24cm; 22 slices of 4mm; 84 volumes; matrix 128x128; receiver bandwidth 1776Hz; TE 46s (R=1); TR 3s (the interscan interval was maintained). Each subject was required to fixate on a cross in the centre of a projected VDU. The visual paradigm was a standard rotating chequerboard consisting of six 21s (7 scans) epochs of stimulus and rest. Each subject experienced the paradigm for reduction factors of 1 (standard EPI), 2 and 3 for visual stimuli of 10% and 100% contrast. The contrast of the chequerboard was altered based on a sinusoidal waveform used to create the stimulus in Matlab. The peak of the waveform represents white with the trough representing black, thus 100% contrast. The reduction factors and presentation of the two types of contrast were randomised for each subject.

Results

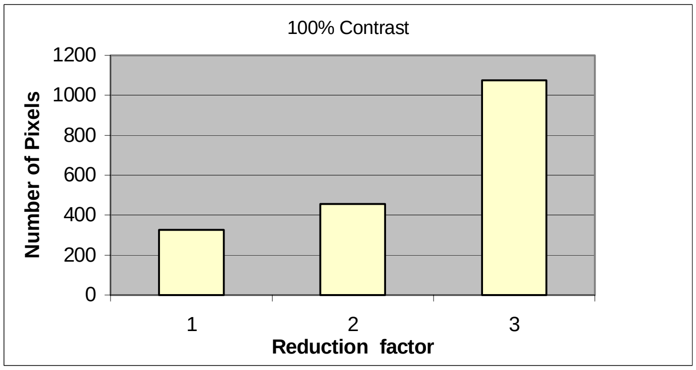
SPM 99 was used to analyse the results. Resultant statistics were height corrected for multiple comparisons to $p<0.05$. As expected, the study showed that the 100% contrast stimuli provided greater activation of the occipital lobe in comparison to the 10% contrast in all subjects. In all cases, the implementation of GRAPPA did not decrease BOLD signal, and activation was localised to the occipital cortex (Figure 1). Results of the reduction factor in relation to BOLD signal showed that in four out of the five subjects, the number of pixels activated increased as the reduction factor was increased for the 100% contrast, as shown in figure 2 for one subject. In the fifth subject there was very little difference in activation between the three reduction factors.

Figure 1



R=1 R=2 R=3

Figure 2



Discussion

This work has shown that the use of GRAPPA has no detrimental effect on BOLD signal, indeed there is increased extent of activity with increased reduction factor. It is postulated that due to the TE reducing with increasing reduction factor, there is more signal detected at higher reduction factors. To this end, GRAPPA offers better delectability of activation provided the stimulus is significant. GRAPPA also produced reduced susceptibility artifacts, reduced acoustic noise and reduced reconstruction time. Further investigation is required to establish the effects of parallel imaging on the BOLD response for cognitive, motor and emotional paradigms.

References

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