Integrated Magnetic Field Variation Correction for Quantitative fMRI

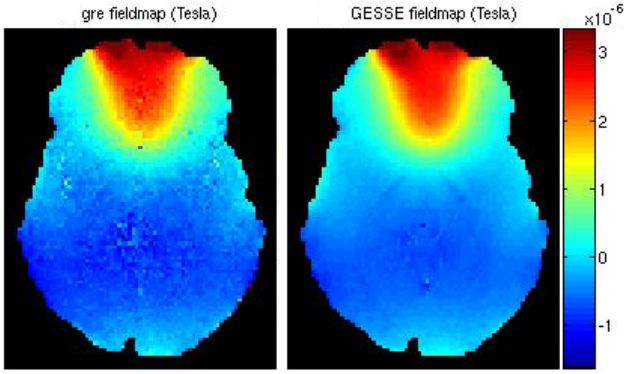
J. D. Dickson[1], G. B. Williams[2], S. G. Harding[2], T. A. Carpenter[2], and R. E. Ansorge[1]

[1]Cavendish Laboratory, Cambridge University, Cambridge, Cambs, United Kingdom, [2]Wolfson Brain Imaging Centre, Cambridge University, United Kingdom

Introduction: Imaging blood oxygenation has been shown to be a powerful method of assessing the extent of cerebral vascular impairment [4]. Recent efforts have been made to obtain this information by quantifying the BOLD signal using the GESSE (Gradient Echo Sampling of a Spin Echo) sequence [1]. The results are promising but the method has required separately acquired fieldmaps to correct for macroscopic variations in background field strength. These fieldmaps require accurate coregistration to the GESSE data and increase acquisition time; this is of crucial importance in interventional imaging. This study shows that external field mapping can be avoided by using an integrated method based on the phase data from the GESSE sequence. Using this new algorithm we have produced OEF maps that agree closely with those from PET studies. We have also shown that the GESSE sequence is capable of delineating grey and white matter on the basis of T_2 decay.

Methods: All experiments were performed on a 3T Siemens scanner. The GESSE sequence had the following parameters: FOV 192x256x105mm, sampling matrix 96x128x21, TR=2700ms, NEX=4. The spin echo was at 40ms and coincided with the 7th gradient echo (GE) out of a total of 41. The phase data were temporally unwrapped and the rate of phase evolution over the GEs 5-10 was used to produce the GESSE fieldmap which was then fitted with a 3D b-spline to reduce noise. The amplitude data were filtered by a Gaussian window to increase SNR. The field variation corrected data were then fitted to the model in [1] which accounts for signal from components of grey and white matter, extracellular fluid and blood. The fieldmapping sequence (gre) consisted of two gradient echo images separated by 2.46ms. Their phases were spatially unwrapped and the difference used to produce the fieldmap. The human brain datasets were obtained from a healthy volunteer. The study was approved by the local ethics committee.

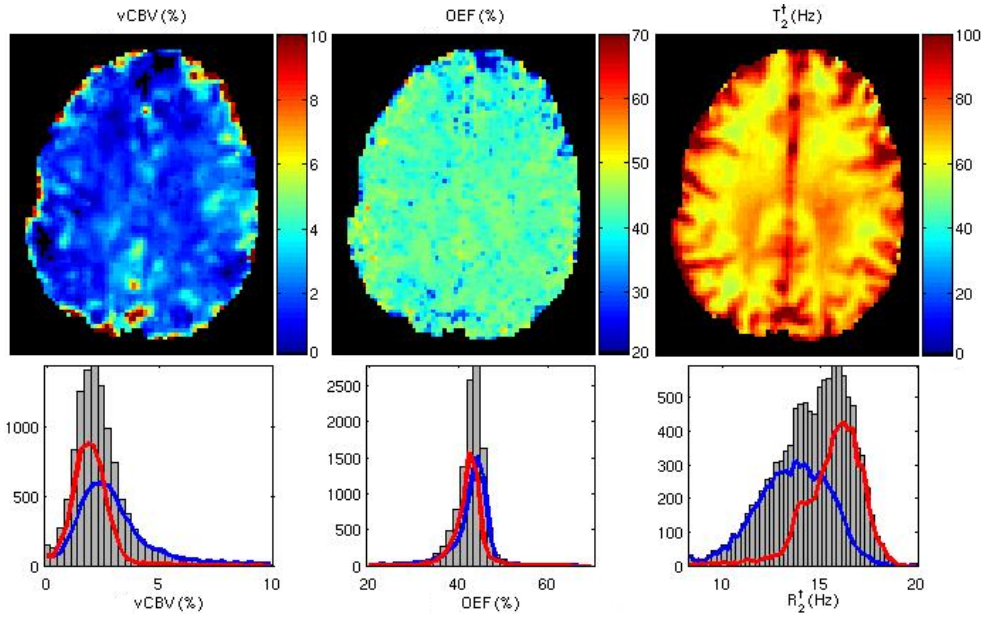
Fig.1 : Fieldmaps produced by each algorithm



Results: Fig. 1 shows that the fieldmap from the GESSE phase data is equivalent to the fieldmapping sequence. The GESSE amplitude data were corrected for macroscopic field variations using an integrated algorithm based on the GESSE fieldmap. By fitting a model based on [1] we were able to produce OEF, vCBV and T_2 maps such as those shown in Fig. 2. Red and blue lines correspond to white and grey matter respectively.

Discussion: By replacing external fieldmapping by a method based on the GESSE phase data we were able to reduce the acquisition time and ensure that the fieldmaps did not need to be coregistered with the GESSE amplitude data. The field variations that need to be corrected for vary over distances that are greater than the GESSE voxel size. Therefore the limited resolution did not constitute a problem. The corrected data produced OEF maps with a modal value of 43%. This has previously been observed in PET studies. The T_2 map showed the expected significant variation between grey and white matter. It is hoped that the sequence will also be able to reflect the variations in OEF over the physiology associated with stoke/cerebral vascular disease.

Fig. 2: Physiological parameters derived from the GESSE datasets



References:

[1]. He and Yablonskiy, *MRM*, 2007. 57(11): p.115-126. [2] An and Lin, *MRM*, 2002. 47: p.958-966. [3] Yablonskiy and Haacke, *MRM*, 1994. 32(6): p.749-763. [4] Menon et al, Brain, 2005. 128(8): p.1939-42.