Partial volume correction affects detection of task activation in arterial spin labelling data

Introduction: Partial volume effects (PVE) result from the low spatial resolution of arterial spin labelling (ASL) perfusion imaging. PVEs present a barrier to the application of ASL to statistical comparisons between groups, as inter-subject alignment of cerebral tissues at the sub-voxel level cannot be achieved through registration. PVE correction (PVEc) may improve the sensitivity of ASL in these analyses by reducing between-subject perfusion variability. This work considers the use of two existing PVEc techniques in the detection of combined visual/motor task activation from ASL data.

Methods: The study used ASL data acquired by [1] from 7 seven subjects scanned up to 4 times. In each session ASL data were acquired during rest and during a period of alternating 1 min blocks of rest and task (a flashing checkerboard and finger tapping). A multiple post-labelling delay (PLD) pCASL acquisition protocol with background suppression was used: labelling duration=1.40s, with six PLDs (0.25, 0.50, 0.75, 1.00, 1.25, and 1.50s), TR=4s, TE=13ms, 24 slices each 4.95 mm thick. For each of rest and task, 96 alternating label-control volumes were acquired in 6.4 mins of scanning. A T1 weighted structural image, head and body coil calibration images and B0 field maps were also acquired. The ASL data were analysed using BASIL tools [2] within FSL. These tools were used to correct for echo-planar imaging distortion effects, slice timing delays, and subject motion, as well as to perform label-control subtraction, averaging of repeats, and Bayesian inference of voxelwise cerebral blood flow (CBF). The analysis was performed in three ways: (1) without PVEc, (2) with PVEc using the linear regression method of [3], (3) with PVEc using the spatially regularised method of [4]. The PV estimates for methods (2) and (3) were obtained from segmentation of the T1 structural image. The CBF maps were used to detect statistically significant ($p<0.05$) task-related perfusion increases in a general linear model (GLM). This was done using the FSL *randomise* permutation testing tool to perform a paired t-test with threshold-free cluster enhancement.

Results: Results of group analysis (Figure 1) showed that task-related CBF increases were detected in the visual and bilateral motor cortices both without PVEc (method 1: yellow-orange clusters in Figure 1) and, in slightly smaller regions of brain tissue, when PVEc was performed using method 3 (blue clusters). However, smoothing inherent to the linear regression based PVEc method (method 2: green clusters) reduced the statistical power of the technique such that activation could only be detected in the visual cortex.

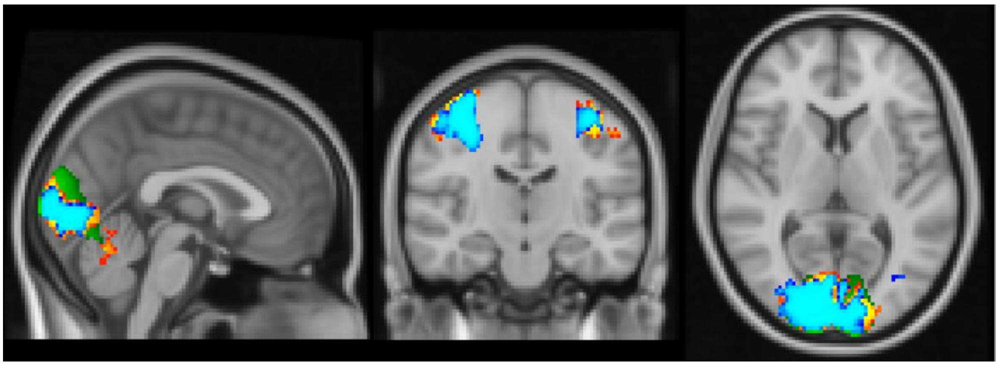

Figure 1 - Clusters of statistically significant ($p<0.05$) hyperperfusion across 7 subjects during a visual/motor task. Method: 1) yellow-orange, 2) green, 3) blue.

Conclusions: PVEc using the linear regression technique reduced sensitivity to task-based CBF changes. Spatially regularised PVEc was able to preserve the sensitivity of the non-PVEc analysis while potentially improving localisation of the task activation effect.

References: [1] J Cereb Blood Flow Metab. 2014 Dec; 34(12): 1919–1927. [2] https://github.com/ibme-qubic/oxford_asl/releases [3] Magn Reson Med. 2008 Dec;60(6):1362-71. [4] Magn Reson Med. 2011 Apr;65(4):1173-83.