Reproducibility of pseudo-continuous ASL at 1.5T and 3T

R. L. O'Gorman[1,2], H. J. Coward[1,2], F. O. Zelaya[2], D. C. Alsop[3], and S. C. Williams[2]

[1]King's College Hospital, London, United Kingdom, [2]Institute of Psychiatry, London, United Kingdom, [3]Beth Israel Deaconess Medical Center, Boston, MA, United States

Introduction: The reproducibility of arterial spin labelling (ASL) cerebral perfusion measurements has been estimated to range between 6% and 13%, depending on the region of interest (grey matter/ white matter), the time between successive scans, and the ASL method used for perfusion imaging.[1-3] This repeatability compares favourably to that reported with alternative perfusion imaging techniques,[4,5] but it is not known to what extent this reproducibility is determined by genuine physiological fluctuations in perfusion and to what extent the variability is influenced by random noise, motion, or various instrumental factors. Applying ASL techniques at higher field strengths should increase the perfusion signal and reduce the variability arising from random noise, but may do so at the cost of an increase in physiological noise. In addition, if the observed intra-subject variability reflects genuine fluctuations in perfusion, a move to higher field strength imaging may not significantly improve the test-retest reproducibility for ASL perfusion studies. This study examines the variability in resting-state ASL perfusion measurements at 1.5T and 3T over both the short-term (from consecutive scans) and medium-term (from scans acquired at the same time each day for a week), with a view to evaluating the relative advantages of higher field strength ASL imaging in terms of the intra-subject variability.

Methods: Imaging studies were performed with 1.5T and 3T GE TwinSpeed scanners (GE Medical Systems, Milwaukee, WI, USA) using a pseudo-continuous ASL tagging scheme with a 3D interleaved spiral FSE readout.[6,7] Two consecutive ASL perfusion scans were acquired for a single subject at the same time each day for a week, first at 3T and then (on a separate week) at 1.5T. The short-term reproducibility was assessed from the percentage change in grey matter (GM), white matter (WM), and whole brain (WB) perfusion between consecutive scans, and the weekly variability was derived from the coefficient of variation (%) of the GM, WM, and WB perfusion from the 10 scans acquired over the week. The similarity between the distributions of perfusion values calculated at 1.5T and 3T was tested with a two-sample Kolmogorov-Smirnov test. The subject was scanned in an uncontrolled resting state.

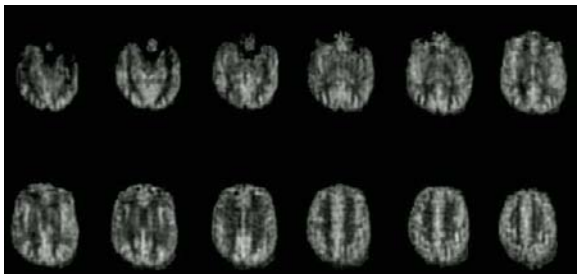
Results: The test-retest reproducibility and weekly variability of the CASL perfusion at 1.5T and 3T are shown in table 1, with the average whole-brain, grey matter, and white matter perfusion measured for each field strength shown for comparison. The 95% confidence intervals (95% CI) for the mean whole brain, grey matter, and white matter perfusion from the 10 weekly scans are also included in table 1. Example perfusion images from the 3D spiral FSE CASL sequence are shown in figure 1. Differences between the distributions of WB, GM, and WM perfusion values were not significant at the p=0.05 level, (p=0.34, 0.35, and 0.57, respectively).

Discussion: The average perfusion measured at 1.5T is consistently 5% lower than that measured at 3T, probably resulting from the lower perfusion signal associated with a shorter T_1, since the same online recon was used for both sequences (assuming the same T_1 for perfusion quantification). The variability between consecutive scans (acquired 6 minutes apart) is higher at 1.5T, but the weekly variability is lower, although since the 1.5T and 3T data were acquired on different weeks, the comparison between weekly variability in perfusion may be confounded by external factors like caffeine which are known to affect blood flow.[8] This observed increase in weekly variability at 3T is unlikely to result from an increase in physiological noise since this would presumably affect both the short-term and medium-term reproducibility equally. These results would seem to indicate that although the short-term test-retest reproducibility seen at 1.5T may be affected by random noise, the fluctuations in perfusion signal seen over the longer term at both 1.5T and 3Tare likely to reflect genuine fluctuations in resting-state perfusion. These results also suggest that at both 1.5T and 3T it should be possible to detect a 10% change in grey-matter perfusion within a session in a single subject with a single trial (with a statistical power of 50%), although more subjects or trials would be necessary to detect within-session changes in white matter perfusion. Future studies will attempt to further clarify the physiological contributions to the variability of the regional ASL perfusion signal by repeating this study with a larger group of subjects scanned in a controlled cognitive state, eg. while performing a sustained attention task.

Table 1. Test-retest reproducibility and weekly variation in ASL perfusion at 1.5T and 3T

	Average perfusion (ml/min/100ml)			Test-retest reproducibility (from consecutive scans)			Weekly variability		
	whole brain mean ± 95% CI	grey matter mean ± 95% CI	white matter mean ± 95% CI	whole brain	Grey matter	white matter	whole brain	grey matter	white matter
1.5 T	39 ± 1.3	50 ± 1.5	22 ± 0.9	4.5%	5.9%	8.8%	5.1%	4.6%	6.0%
3 T	41 ± 1.7	53 ± 2.2	23 ± 1.1	3.7%	4.2%	7.6%	6.7%	7.9%	7.5%

Figure 1. Example ASL perfusion images from the 3D spiral FSE sequence



References:

[1] Jahng GH, et al. Radiology 2005; 234:909-916. [2] Parkes LM, at al. MRM 2004; 51:736-743. [3]Floyd TF, et al. JMRI 2003; 18:649-655. [4]Gillard JH, et al. Br J Radiol 2001; 74:552-555. [5]Hwang WJ, et al. J Nucl Med 2004; 45:2007-213. [6]Garcia DM, et al. Proc ISMRM 2005; abstract 37. [7]Wang Z, et al. Proc ISMRM 2006; abstract 3403. [8] Field AS, et al. Radiology 2003; 227:129-135