

RELIABILITY OF MRSI BRAIN TEMPERATURE MAPPING AT 1.5T AND 3T

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Purpose: The temperature dependence of the water chemical shift permits non-invasive estimation of brain temperature in normal physiology¹, pathology² and during cooling therapy.³ Using the technique of MR spectroscopic imaging (MRSI), temperature can be mapped in two or three dimensions; however, reliability is thought to be lower than in the related single voxel spectroscopy technique⁴ and there is a need for validation. We aimed to assess within- and between-session repeatability as well as within- and between-brain variability of MRSI temperature estimation. We further aimed to assess the relative benefits of measuring brain temperature at 1.5T and 3T field strengths.

Methods: Following ethical approval, 31 healthy male volunteers (age: 30±5.0, range 22-40 years) were recruited from staff and postgraduate students. 11 of these participants were scanned on three occasions at both 1.5T (GE SIGNA with quadrature head coil, PRESS MRSI, TR/TE = 1000/144 ms, matrix 24 x 24, FoV 300 x 300 mm, slice thickness 10 mm) and 3T (MAGNETOM Verio 3T clinical scanner (Siemens AG, Healthcare Sector, Erlangen, Germany) with 12 channel head coil, semi-LASER MRSI, TR/TE = 1700/144 ms, matrix 24 x 24 with elliptical k-space sampling, FoV 300 x 300 mm, slice thickness 10 mm; performed in collaboration with the manufacturer), receiving 4 MRSI scans on each occasion. The remaining 20 subjects received a single MRSI scan at 3T. MRSI slices were acquired at the level of the corpus callosum. T2-, T1- and T2*-weighted scans were acquired to facilitate MRSI slice positioning and tissue segmentation. Temperature maps were obtained using the AMARES algorithm to determine the chemical shift difference between NAA and water resonances, as described previously.⁵ Variability and cooling effects were assessed using a mixed linear model (PASW Statistics 18).

Results: Inter-session and within-session repeatability are presented in Table 1, together with inter-voxel and inter-subject variation. There was a significant cooling effect during MRSI scanning at both 1.5T (0.10 °C/scan; P<0.001) and 3T (0.05 °C/scan; P<0.001). Average NAA linewidth at 1.5T was 4.7 Hz, compared with 7.9 Hz at 3T. Voxels containing more than 5% CSF were rejected, and a further 15% and 21% (mean) were rejected based on data quality at 1.5T and 3T respectively.



Figure 1: Temperature map in a healthy volunteer acquired at 3T.

Table 1: Variance components, determined by a mixed effects model.

	σ_{subject} (°C)	$\sigma_{\text{between-visit}}$ (°C)	$\sigma_{\text{within-visit}}$ (°C)	σ_{voxel} (°C)
1.5T	0.18 (P=0.14)	0.18 (P=0.012)	0.37 (P<0.001)	0.60 (P<0.001)
3T	0.15 (P=0.16)	0.15 (P=0.029)	0.14 (P<0.001)	0.50 (P<0.001)

Discussion: We did not find significant inter-subject variation in brain temperature at either field strength; day-to-day variation was significant but small. Reduced within-session variability at 3T is consistent with the higher signal-to-noise ratio and slightly lower linewidth (measured in ppm units) obtained at the higher field strength.² The largest contribution to variability using either scanner was the variation between voxels; possible contributions include tissue-dependent calibration coefficients⁶ and regional variation in brain temperature.

Conclusion: Performing brain temperature mapping at 3T confers a small but significant benefit with regard to random error. However, the largest source of variation at both fields arises between voxels at different locations within the brain; further analysis is in progress to establish the causes.

References: 1. Cady EB, D'Souza PC, Penrice J, Lorek A, *Magn. Reson. Med.* 1995; 33:862. 2. Marshall I, Karaszewski B, Wardlaw JM *et al.*, *Magn. Reson. Med.* 2006; 24:699. 3. Harris BA, Andrews PJD, Marshall I, Robinson TM, Murray GD, *Brit. J. Anaesth.* 2008; 100:365. 4. Childs C, Hiltunen Y, Vidyasagar R, Kauppinen RA, *Magn. Reson. Med.* 2007; 57:59. 5. Vanhamme L, van den Boogaart A, Van Huffel S., *J. Magn. Reson.* 1997;129:35. 6. Vescovo E, Levick A, Childs C, Machin G, Zhao S, Williams SR, *NMR Biomed.* 2012; doi: 10.1002/nbm.2840.