Age and gender variations in T_1 measurements of white and grey matter structures within the human brain at 7 T

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INTRODUCTION: With the increasing life expectancy of humans in the developed world and neurological diseases such as Parkinson's becoming ever more prominent, a growing interest has emerged examining normal changes in brain tissue in later life. The aim of this study was to measure the longitudinal relaxation time (T_1) in cortical grey matter, deep grey matter structures including putamen and caudate head, white matter, and the genu and splenium of the corpus callosum for apparently healthy, male and female subjects aged between 40 and 80 years.

METHOD: 30 healthy subjects (age and gender shown in figure 3) were scanned after approval by the University of Nottingham Medical School Ethics Committee. Volunteers were screened for smoking, various medical conditions and neurological disorders, tested using Addenbrooke's cognitive examination, which all volunteers passed. **Image acquisition:** Subjects were scanned using a 7 T Philips Achieva MRI scanner and whole head 16-channel SENSE coil acquired using an MPRAGE sequence with parameters; TR = 13.6 ms; TE = 6.7 ms; parallel imaging SENSE factor = 2; turbo field echo (TFE) readout pulse = 8º. Turbo pulses per inversion pulse = 256 with centric phase encoding and spiral ordering of phase encoding lines through the second and third dimensions of *k*-space, shot-to-shot interval = 5 s, voxel size = 0.5x0.5x1.0 mm^3, and matrix size 384x384, z-direction voxel number = 60 and TIs 0.3; 0.6; 1.5; 2.5; 3.5; and 5 s. Total scan time per TI = 3 min 40 s. **Pre-processing:** Motion correction was performed in FSL's FLIRT Linear Registration program using a 6 parameter rigid body model with search angle of 10° in all directions and mutual information cost function. **Fitting:** The signal in the MPRAGE sequence was modelled as a function of M_0, T_1 and inversion flip angle using a stepwise model of the Bloch equations; taking account of all RF pulses in the sequence; all recovery periods; and the approach to steady state from equilibrium. A full description is given in [1]. **Measurement of T_1:** For each subject, T_1 was measured from T_1 maps using the ROIs shown in figure 2 drawn by a single blind operator using Analyze®.

RESULTS:

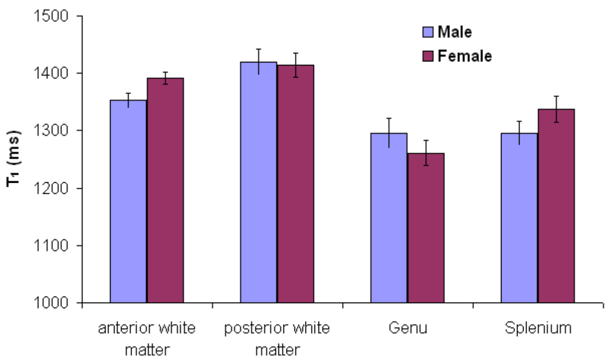

Figure 1. Gender differences for various white matter and corpus callosum ROIs.

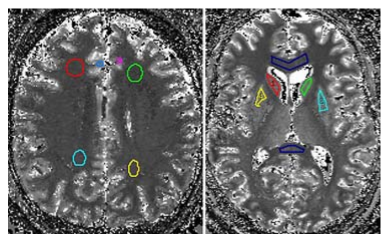

Figure 2. ROIs measured in T_1 maps.

ROI	Mean ± St dev (ms)
Corpus Callosum Splenium	1318 ± 76
Corpus Callosum Genu	1278 ± 92
Caudate Head	1806 ± 100
Grey Matter	2029 ± 108
Putamen	1758 ± 94
Posterior White Matter	1419 ± 82
Anterior White Matter	1378 ± 70

Table 1. Mean T_1 values for all ROIs measured.

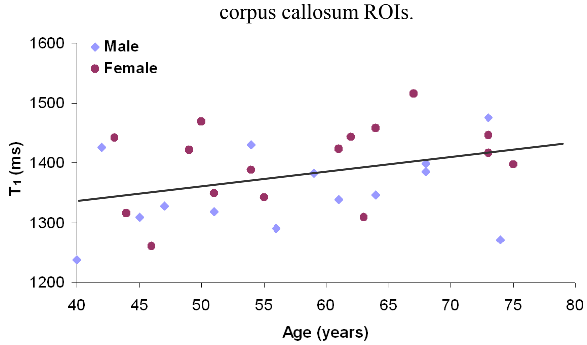

Figure 3. Anterior white matter T_1 for all subjects. *p < 0.04, gradient = 2.23 ± 2.38 (95% confidence)

Table 1 shows the mean ± st. dev. T_1 values for all ROIs measured. There was a variation in T_1 observed across the white matter (figure 1). Significant differences were found between the anterior and posterior white matter regions ($p = 0.02$), which was dominated by the male subjects, and there was also a significant difference between the genu and splenium of the corpus callosum ($p < 0.02$), which was dominated by female subjects. No significant gender effects were found in any of the regions studied although there was a trend gender effects in the anterior white matter T_1. Averaging over all white matter showed a trend for T_1 to increase with age but when this was split by gender it was found to be insignificant for females and significant for males ($p = 0.036$). For males the white matter T_1 was described by 2.7 y + 1215 ms where y is age in years. Figure 3 shows the data for one region of white matter.

DISCUSSION AND CONCLUSION: An increase in T_1 with respect to age in white matter in this range has been previously reported [2, 3, 5] and may be due to demylination or change in iron content of white matter with age [4]. Previous studies have found a difference between male and female subjects in terms of water content (based on T_1 measurements). The significant T_1 differences observed between genders in anterior white matter have previously been reported [2] but as far as we are aware this is the first report of significant T_1 within areas of the corpus callosum, probably due to the known differences in axonal structure in these regions.

REFERENCES [1] Wright et al. MAGMA. 2008. **21**(1-2). [2] Agartz, I. et al. Radiol. 1991 **181**(2). [3] Cho et al. Mag. Res. Imag. 1997 **15**(10). [4] Bartzokis, G. et al. Neurobiol. of Aging 2004 **25**(7). [5] Steen, R.G et al. JMRI 1995 **5**(1).