PROTON METABOLITE B1–CORRECTED T1 MAPPING IN THE HUMAN BRAIN AT 3 TESLA

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Introduction: Although $TR \approx 1.2T_1$, optimizes the SNR/unit time for a θ=90° flip-angle (1), the unknown metabolites T_1 distribution, as well as 20-40% radio-frequency field (RF, $\mathbf{B_1}$) variations in the human brain (2), reduce the accuracy of quantitative proton MR spectroscopy (^{1}H-MRS). In this study we investigated the regional *N*-acetylaspartate (NAA), creatine (Cr) and choline (Cho) T_1s in several gray and white matter (GM, WM) brain structures of the healthy human brain at 3 T. To correct for the effect of $\mathbf{B_1}$ variations on the accuracy of the T_1s we used the TriTone three-point protocol that optimizes their precision/unit-time (3), in three dimensional (3D) ^{1}H MRS that allowed extensive (~25% of the brain) coverage at $(1.0\ \text{cm})^3$ spatial resolution. We tested two implicit assumptions often made: First, that the *inter*-subject metabolite T_1 distributions are similar and need not be measured every time. Second, that T_1s are similar enough that one value per metabolite suffices for accurate metabolic quantification for all brain regions.

Methods: Six healthy adults (3 male) 23 to 29 (mean 27) years old were recruited and gave written consent. All experiments were done in a 3T scanner (Siemens, Erlangen, Germany) using a transmit-receive head coil (MRInstruments, Minneapolis MN). Following axial and sagittal MRI, a 10_{AP} cm × 8_{LR} cm × 4.5_{IS} cm VOI was graphically prescribed, shimmed and excited using *TE*=41 ms PRESS. The three-point TriTone that varies all acquisition parameters to yield the maximum precision per total experiment time prescribed: TR_1=1000 ms, θ_1=105º, TR_2=1100 ms (17 min.); θ_2=30º (19 min.); and TR_3=4900 ms, θ_3=125º, N_3=1 (84 min.) with $N_1=N_2=N_3=1$ average at each point. The entire protocol took just under 2 hours, inclusive.

Results: The $\mathbf{B_1}$-corrected T_1s observed across the 3520 voxels (6 subjects × 320 voxels each, plus one subject's six serial scans) were: **NAA, 1233±21, Cr, 1240±18 and Cho, 1115±16 ms** [mean±standard error of the mean (SEM)]. Their *intra*- and *inter*-subject T_1 histograms, shown in **Fig. 1**, exhibit excellent similarity in both peak position and overall shape, characterized by the SEM of their FWHM divided the FWHM, of 3.7%, 2.8%% and 3.9%. These suggest the *inter*- as well as the *intra*-subject T_1 reproducibility to be better than 4%. The mean metabolite T_1s in five different brain structures, are compiled in **Table 1**. They show the NAA, Cr and Cho T_1s to be similar within GM and within WM but to also be significantly (15 - 20%) longer in the latter.

		NAA (ms)	Cr (ms)	Cho (ms)
GM	Caudate	1454±122	1562±136	1374±230
	Thalamus	1366±97	1333±80	1064±58
	Putamen	1364±64	1354±112	1339±124
	GM Average	**1395±30**	**1416±73**	**1259±98**
WM	Splenium of CC	1193±67	1094±193	1003±85
	Centrum semiovale	[a]1267±73	[a]1227±74	[a]1017±37
	WM Average	**1230±37**	**1161±66**	**1010±7**

Table 1: Mean±SEM values of proton T_1s at 3 T in the various GM and WM brain regions and structures studied.

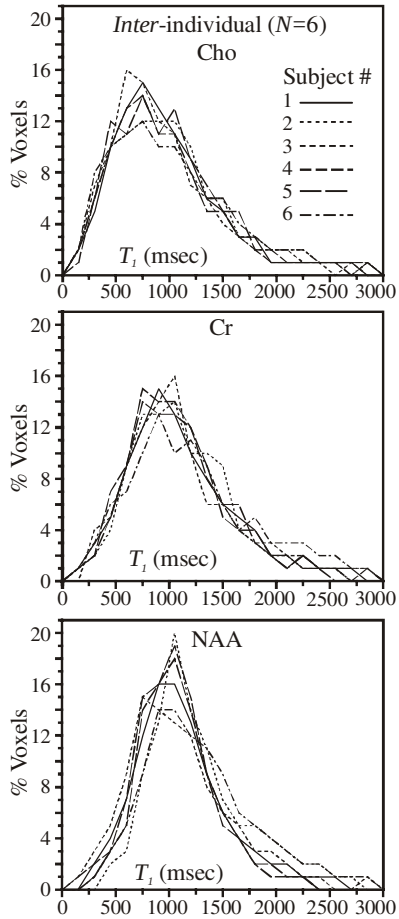

Fig 1: T_1 Histograms from all voxels in the VOIs of the 6 subjects. Note their position and shape similarity.

Discussion and Conclusion: The results show that the human brain $\mathbf{B_1}$-corrected T_1s at 3 T are gratifyingly reproducible. Their variations between several WM and GM structures in a cohort of healthy young individuals indicate that for purposes of metabolic quantification expedient use of one (global average) T_1 value for each metabolite is justifiable in that it is sufficient to reduce the level of fluctuations that result from residual T_1–weighting to below the voxel SNR. The inter-subject overlap of the T_1 histograms for these metabolites indicates that they are likely characteristic to within very few percent (at least) among healthy young individuals of both genders and therefore, individual T_1 measurements may be unnecessary since they should not yield different results.

References

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3. Fleysher R *et al.* Magn Reson Imaging 2008;26(6):781-789.