T_2 Relaxation Times in the Human Brain at 7 T

M. Marjanska[1], E. J. Auerbach[1], R. Valabregue[2], P-F. Van de Moortele[1], G. Adriany[1], and M. Garwood[1]
[1]Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States, [2]Hôpital Pitié-Salpêtrière, Paris, France

Introduction

To obtain absolute concentrations of metabolites from spectra obtained at long echo times, the knowledge of both the *J*-modulation and T_2 relaxation times is required. The T_2 relaxation times at 7 T have been reported previously for the methyl protons of *N*-acetylaspartate (NAA) and the methyl protons of total creatine (creatine + phosphocreatine, tCr) (1,2). The aim of this study was to measure T_2 relaxation times in different brain regions of the singlets and *J*-coupled metabolites.

Methods

Normal volunteers (n = 3) were studied after giving informed consent according to the procedures approved by the Institutional Review Board. MR experiments were performed using a 7-T, 90-cm horizontal bore magnet (Magnex) equipped with a Siemens console. A home-built 16-element transmission line head array (3) was used for transmit and receive, and transmit phase of each coil channel was controlled with individual 1 kW CPC amplifier and optimized based on a previously published algorithm (4).

In vivo ^{1}H NMR spectra were acquired from four voxels positioned in different brain regions (occipital lobe (OC), motor cortex (MC), basal ganglia (BG) and cerebellum (CR)) using a previously described LASER sequence (5) in which the AHP and first two AFP pulses were replaced by a slice-selective sinc pulse. The echo time was extended by adding delays around the last AFP pulse in the sequence, and the spectra were collected at six echo times: 35, 70, 105, 140, 175, 210 ms. Sixty four averages were acquired.

Statistical analysis was conducted using SAS Software for Windows (version 9.1, SAS Institute, Cary, NC). One-way analysis of variance (ANOVA) with a Tukey post hoc test was used to compare the T_2 relaxation times at each location for each metabolite.

Results and Discussion

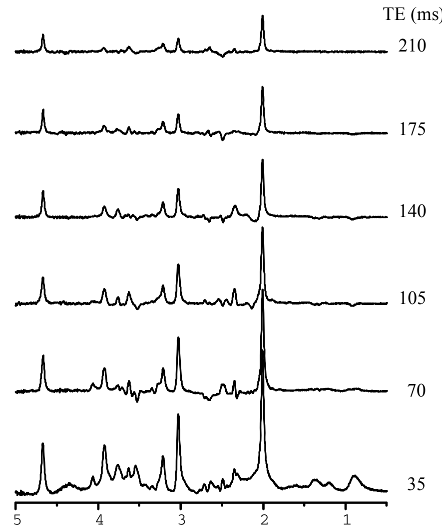

Figure 1. ^{1}H NMR spectra obtained at 7 T with a modified LASER sequence from the 19.7 mL voxel placed in the human occipital lobe. T_R = 4.5 s, N_{EX} = 64, no line-broadening.

Figure 1 shows the quality of representative spectra obtained from the occipital lobe at different echo times from one volunteer. The singlet resonances become smaller with increasing echo time while the multiplet resonances also undergo *J* modulation. The mean values, standard deviations (SDs), and mean R^2 values for the T_2 values of water and metabolites measured at 7 T in four brain regions are listed in Table 1. The relative SDs were typically 5% to 10%, but were larger for the aspartyl resonances of NAA (mNAA) in all the brain regions, for all metabolites in the basal ganglia, for *s*Ins, Tau and GSH resonances in the cerebellum, and for the *m*Ins and Tau resonances in the motor cortex.

Conclusions

The T_2 relaxation times were measured in four brain regions. Regional differences in the T_2 relaxation times were observed. Additionally, differences in T_2 relaxation times for different moieties in the same molecule were also observed.

Acknowledgements: This work was supported by NIH grants: BTRC P41 RR008079 and P30 NS057091 and the W.M. Keck Foundation.

References: 1. Tkac, I. *et al.*, *Magn Reson Med* **46**:451 (2001). **2.** Michaeli, S. *et al. Magn Reson Med* **47**:629 (2002) **3.** Adriany, G. *et al.*, *Magn Reson Med* **59**:590 (2008). **4.** Metzger, G. *et al.*, *Magn Reson Med* **39**:396 (2008). **5.** Garwood, M. *et al.*, *J Magn Reson* **153**:155 (2001).

Table 1. T_2 values (mean ± SD) of water and metabolites measured at 7 T. For each substance (water or metabolites) means with different letters in superscript differ at 0.05 significance level.

Voxel			OC		MC		BG		CR	
	Compound	Group	T_2 (ms)	R^2	T_2 (ms)	R^2	T_2 (ms)	R^2	T_2 (ms)	R^2
	water		47 ± 1^{b}	0.9991	47 ± 1^{b}	0.9996	41.2 ± 0.8^{a}	0.99993	48 ± 3^{b}	0.9997
singlets	NAA	$^2CH_3$	132 ± 6^{a}	0.994	168 ± 6^{b}	0.996	130 ± 11^{a}	0.97	191 ± 7^{c}	0.998
	tCr	$N(CH_3)$	$95 \pm 3^{a, b}$	0.9997	$113 \pm 2^{b, c}$	0.9988	90 ± 11^{a}	0.996	131 ± 8^{c}	0.9991
	tCr	$^2CH_2$	84 ± 2^{a}	0.9985	108 ± 5^{b}	0.995	81 ± 15^{a}	0.994	$102 \pm 3^{a, b}$	0.998
	tCho	entire molecule	152 ± 3^{a}	0.992	$139 \pm 9^{a, b}$	0.997	121 ± 5^{b}	0.984	200 ± 17^{c}	0.996
	*s*Ins		96 ± 8^{a}	0.95	112 ± 4^{a}	0.96	80 ± 20^{a}	0.85	130 ± 20^{a}	0.87
J-coupled	NAA	$^3CH_2$	90 ± 11^{b}	0.80	110 ± 30^{b}	0.80	69 ± 12^{b}	0.85	170 ± 12^{a}	0.536
	Glu	entire molecule	93 ± 4^{b}	0.95	98 ± 4^{b}	0.985	88 ± 10^{b}	0.96	139 ± 8^{a}	0.93
	GSH	entire molecule	61 ± 3^{a}	0.88	97 ± 8^{b}	0.74			$80 \pm 10^{a, b}$	0.908
	*m*Ins	entire molecule	95 ± 2^{b}	0.982	100 ± 15^{b}	0.988	87 ± 6^{b}	0.988	160 ± 20^{a}	0.985
	taurine	entire molecule	$93 \pm 7^{a, b}$	0.80	$90 \pm 16^{a, b}$	0.8	85 ± 10^{b}	0.89	120 ± 20^{a}	0.83