In Vitro and In Vivo Relaxation Times of N-acetylaspartate, Creatine and Choline at 4.7T and 7T

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Introduction

Longitudinal (T_1) and transversal (T_2) relaxation time values are mandatory for accurate quantification of Magnetic Resonance Spectroscopy (MRS) signals, for optimizing measurement protocols, for absolute quantification of brain metabolites.
In the present study, *in vitro* and *in vivo* relaxation times of N-acetylaspartate (NAA), creatine (Cr) and choline (Cho) in healthy rat brains were estimated under identical experimental conditions at 4.7T and 7T.

Method

All the experiments were performed at 4.7T and 7T on BRUKER Biospec systems. Eight healthy rats (Sprague-Dawley, 200-250g) were investigated at both magnetic fields in the central region of the brain (left part of the brain, $(3.5mm)^3$). For the estimation of *in vitro* relaxation times, Cr, Cho and NAA were dissolved separately in aqueous solutions buffered with phosphate at pH=7.0±0.1 (50mM, 10ml).The *in vitro* and *in vivo* acquisitions were performed under similar conditions. A PRESS sequence (SW=4 kHz, 4096 data-points, 128 averages) combined with outer volume suppression was used. The water signal was suppressed by variable power RF pulses with optimized relaxation delays (VAPOR). First and second order shim terms were adjusted using FASTMAP. The signals were acquired using a bird cage coil (72 mm inner diameter) for excitation and a surface coil (15mm diameter) for reception.

For *in vitro* T_1 and T_2 relaxation time estimations, time series of nine/eight signals were acquired using increasing repetition times/echo times respectively (TR=2.8, 3, 4, 5, 6, 7, 8, 9, 10s; TE=20ms) and (TE=60, 100, 200, 300, 400, 500, 600, 700ms; TR=4s).
For *in vivo* T_1 and T_2 relaxation time estimations, time series of five/six signals were acquired using increasing repetition times/echo times respectively (TR=3, 4, 5, 6, 7s; TE=20ms) and (TE=20, 40, 60, 80,100,136ms; TR=4s).
Using the jMRUI software [1], the MRS time-series signals were processed in the time-domain. Removal of residual water components was achieved using the Hankel-Lanczos singular value decomposition algorithm. The signals were then fitted using AMARES [2]. For each *in vivo* signal of the time-series, 14 Lorentzian spectral components were selected to fit the major contributions of the metabolites, the zero-order phase was estimated and the first-order phase was fixed to zero. The individual phases relative to the zero-order phase were fixed to zero. To minimize the influence of the large broad baseline components (macromolecules), the first 20 data points of the *in vivo* signals were weighted with a quarter-sine wave. The time evolution of estimated amplitudes of NAA (2.02ppm), Cr (3.03ppm) and Cho (3.20ppm) singlets were then fitted using a non-linear least square algorithm based on a mono-exponential model function.

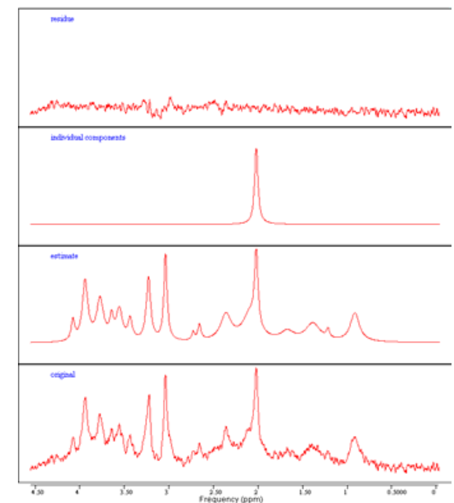

Figure 1: AMARES quantification result window (jMRUI software). From bottom to top, *in vivo* spectrum of a rat brain acquired at 7T, estimated spectrum using AMARES estimated NAA singlet, residue

Results

The mean values of the estimated T_1 and T_2 and the corresponding standard deviations are reported in Table I and Table II.

$T_1 \pm$ sd (s)	NAA	Creatine	Choline
4.7T			
In vivo rat brain	1.33 ± 0.21	1.59 ± 0.28	1.91 ± 0.25
In vitro	1.49 ± 0.02	2.11 ± 0.01	2.26 ± 0.05
7T			
In vivo rat brain	2.10 ± 0.30	1.98 ± 0.38	2.16 ± 0.40
In vitro	1.72 ± 0.04	2.16 ± 0.10	2.36 ± 0.20

Table I: The i*n vivo* and *in vitro* T_1 relaxation time estimates at 4.7T and 7T and the corresponding standard deviations for NAA, Cr and Cho.

$T_2 \pm$ sd (ms)	NAA	Creatine	Choline
4.7T			
In vivo rat brain	193 ± 25	238 ± 31	231 ± 38
In vitro	704 ± 42	762 ± 40	840 ± 10
7T			
In vivo rat brain	143 ± 31	126 ± 16	124 ± 21
In vitro	427 ± 20	425 ± 52	400 ± 24

Table II: The i*n vivo* and *in vitro* T_2 relaxation time estimates at 4.7T and 7T and the corresponding standard deviations for NAA, Cr and Cho.

Conclusion

Estimations of *in vitro* and *in vivo* metabolite T_1 and T_2 relaxation times at two different magnetic fields were performed. Field-dependent variations in T_1 and T_2 relaxation times were observed with high significance, since the measurements were performed under identical experimental conditions. The longitudinal/transverse relaxation times exhibited an increase/decrease with increasing magnetic field strength. The *in vivo* relaxation times showed a decrease compared with the *in vitro* values.

References

[1] http://www.mrui.uab.es/mrui
[2] Vanhamme L, *et al*, J Magn Reson (1997) 129: 35-43.