CONTRAST AT ULTRA-HIGH FIELD: RELAXATION TIMES IN THE RAT BRAIN AT 16.4 T

R. Pohmann[1]
[1]Magnetic Resonance Center, Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Introduction: Knowledge of the relaxation times is vital for adjusting sequence parameters for optimum SNR or contrast. For MR imaging at ultra-high fields, the relaxation times also play an important role in determining the advantage of the field strength, since the longer T_1 and shorter T_2 may partially compensate for the linear SNR gain in anatomical imaging, while causing additional gain in other applications, like perfusion or functional MRI. Here, we have performed highly accurate measurements of the relaxation times in the rat brain at a field strength of 16.4 T to predict SNR and contrast behavior at ultra-high field.

Materials and Methods: All experiments were performed with a 16.4 T magnet with a bore size of 26 cm, interfaced to a Bruker console. A quadrature surface coil with a homebuilt TR-switch and preamplifier was used for excitation and signal reception. T_1, T_2 and T_2^* were each measured in six rats with different ages under isoflurane anaesthesia. During the experiments, the animals were maintained at a constant temperature of 37°C controlled by a rectal sensor. Measurement techniques were selected for accuracy and insensitivity to B_1 inhomogeneities caused by the transmit field of the surface coil. In all experiments, six 0.6 mm slices were scanned with a spatial resolution of 180 µm^2. For the T_1 measurements, an inversion-recovery sequence with a RARE readout was used. 17 images with different T_1 between 400 ms and 8000 ms were acquired with a repetition time of 13 s. T_2 was measured with a single spin echo sequence, using 11 echo times between 7.5 ms and 87 ms. To obtain T_2^* data, gradient echo images with 11 different echo times between 3 ms and 35 ms were acquired. The relaxation time values of different anatomical structures were calculated by positioning circular ROIs in the image, adding the signals from the selected voxels and fitting the exponential function corresponding to the relaxation time in question. For obtaining relaxation time maps, the SNR was boosted by applying a Hanning-filter to the raw data before reconstruction, thereby effectively decreasing the resolution by a factor of two, and then fitting the exponential function to every image point.

Results: Table 1 shows relaxation times of selected anatomical structures. T_1 ranges from 1800 ms in the colliculus to above 2300 ms in cortical gray matter and hippocampus. T_2 in the brain is between 20 ms (corpus callosum) and around 25 ms (cortex, hippocampus), while mean T_2^* values lie between 13 ms and 22 ms for the same structures, though the latter showing strong local variations. No differences were found between right and left hemispheres, while T_1 showed a significant variation with age in almost all anatomical structures. The relaxation time maps, Fig. 1, allow clear distinction between the different structures.

	T_1	Stdev	N_{ROIS}	T_2	Stdev	N_{ROIS}	T_2^*	Stdev	N_{ROIS}
somatosensory cortex	**2194.4**	97.7	42	**23.9**	1.2	45	**19.5**	2.5	42
auditory cortex	**2289.2**	91.3	14	**23.6**	1.4	10	**19.7**	1.7	16
motor cortex	**2313.9**	77.9	12	**25.1**	1.1	10	**20.6**	4.1	14
caudate putamen	**2193.7**	88.5	48	**24.0**	1.2	44	**19.8**	2.0	55
corpus callosum	**2072.6**	97.1	22	**19.6**	1.2	24	**13.6**	1.5	29
thalamus	**2141.4**	144.6	32	**23.5**	1.6	34	**20.0**	2.1	40
hippocampus	**2330.5**	97.1	24	**25.1**	1.7	20	**20.2**	3.0	32
dentate gyrus	**2370.8**	71.0	48	**25.9**	1.3	40	**17.6**	3.2	40
colliculus	**1840.4**	74.1	22	**20.7**	1.2	23	**14.8**	2.2	28
cerebellum	**2120.5**	120.9	24	**24.0**	1.5	26	**17.4**	1.8	25
accumbens nucleus	**2306.3**	64.5	12	**24.8**	0.8	10	**22.0**	1.8	14
septal nucleus	**2288.6**	76.3	19	**25.9**	0.6	16	**22.0**	2.4	21
bulb	**2311.7**	84.3	40	**25.8**	1.2	28	**21.4**	2.4	24
muscle	**2442.7**	181.5	15	**15.3**	1.3	12	**13.4**	1.5	31

Table 1: *Values (in ms) of the relaxation times for selected anatomical structures, with standard deviations and total number of ROIs used to obtain the values.*

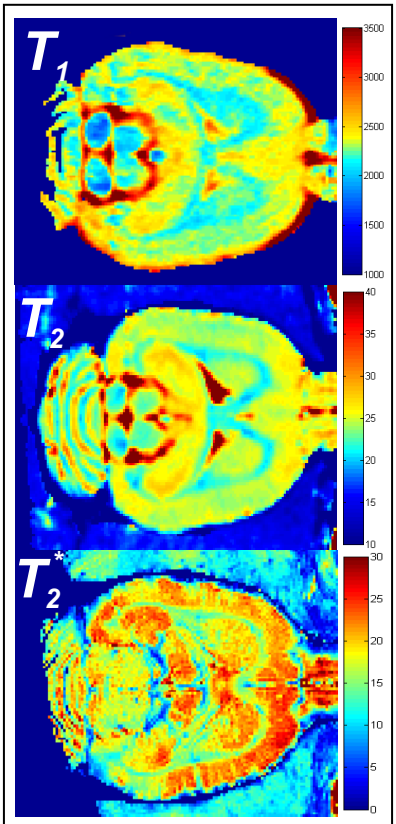

Figure 2: *Relaxation time maps for a representative slice*

Conclusion:
The relaxation times in the rat brain were measured with high accuracy. As expected from measurements at lower fields, T_1 continues to increase with field strength, while T_2 and T_2^* get lower. Both factors limit the growth in SNR with increasing field strength for many applications.