Brain Imaging with 7T vs. 9.4T: A direct Comparison of MR parameters and SNR

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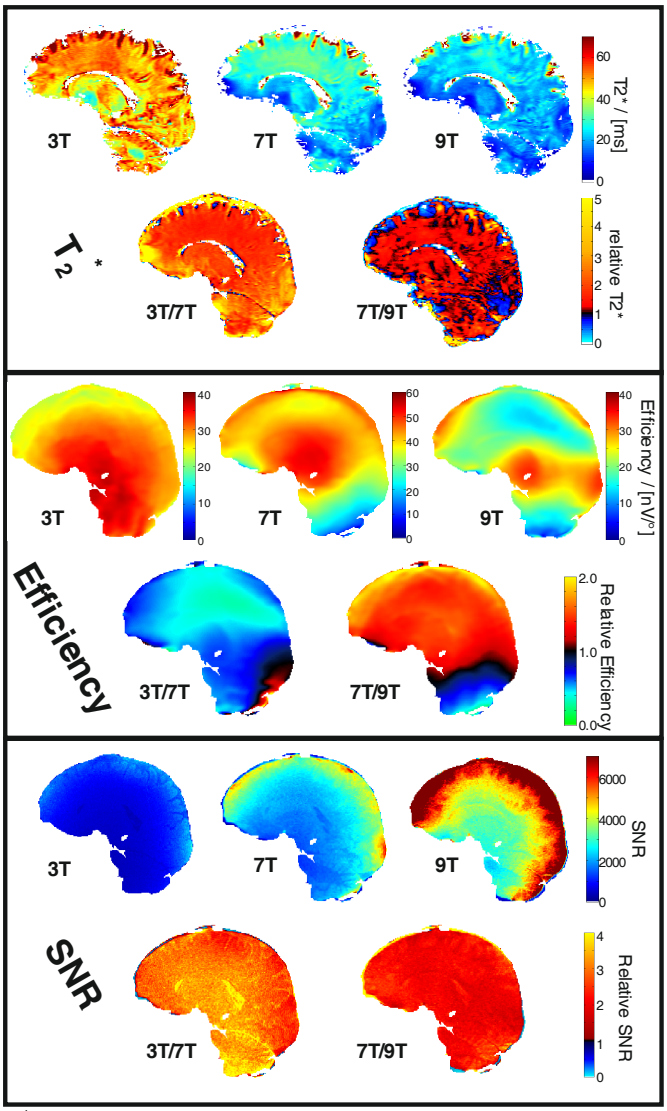
Introduction: While 7T has become a standard for ultra high field MR, the tendency towards even larger fields poses the question of whether the less favorable relaxation times, the inhomogeneous B_1 fields and the increasingly difficult coil design still allow us to take advantage of the expected gain in intrinsic SNR. Here, a direct comparison between 3T, 7T and 9.4 T shows the main differences between these field strengths in SNR and MR parameters.

Methods: At all fields, tight fitting helmet-shaped coils of similar size and similar number of receive elements (3T: Siemens, 32 elements, body coil excitation; 7T: Nova, 32 elements, local birdcage excitation, 9.4 T: homebuilt [1], 31 elements, local 16 element CP excitation) were used. T_1 in white matter was determined using a single-voxel inversion recovery sequence. A T_2^* map was acquired, using a 3D-multi echo gre sequence. An AFI sequence was used to determine B_1 and transmit efficiency . Finally, a 3D-gre sequence with a spatial resolution of $(1mm)^3$ and a nominal flip angle of 4° was used to determine SNR. In addition, the same scan was repeated without the excitation pulse to get the noise correlation information. SNR was determined with a pseudo-multiple replica technique [2] with 128 repetitions. The data was then corrected for flip angle and relaxation time to obtain the theoretical SNR for a 90°/TR=∞ sequence at all field strengths.

Results: Values for T_1 and T_2^* are shown in the table below. The efficiency maps show the significant increase in B_1-field homogeneity with increasing field strength (relative standard deviation over the cerebrum: 12% (3T), 23% (7T), 26% (9.4T)). SNR increases strongly with field strength. Over the entire cerebrum, the increase is 2.81±0.21 from 3T to 7T and 1.91±0.28 from 7T to 9.4 T. Maps of the parameters are shown in the figure. In addition, the relative changes of the parameter values with varying field are shown.

Discussion: While we could show the strong increase in intrinsic SNR with current coil technology, the drop in B_1-homogeneity and T_2^* demand for improved imaging techniques to realize the full potential of 9.4 T.

References: [1] Shajan et al., MRM 2013, [2] Robson et al., MRM 2008



T_2^*, Transmit efficiency and SNR at different field strengths. Shown are the absolute parameter values and the field-dependent differences.

	T_1			T_2^*		
	3 T	7 T	9.4 T	3 T	7 T	9.4 T
White	947 ± 66.1	1334 ±21.7	1427 ±51.8	47.9 ±6.0	27.3 ±5.5	21.6 ±4.5
Gray				56.5 ±11.0	30.9 ±14.7	24.8 ±11.6