Imaging Battery for Brain Quantification

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Target Audience: Clinicians and scientists interested in fast quantification of MR parameters of the brain.

Purpose: To quantify, with high resolution, key parameters of the brain in an efficient period of time. In this work we demonstrate the acquisition of eight key parameters including: B_0 and B_1 field inhomogeneity, coil sensitivity profiles, T_1, T_2, T_2*, net magnetization (M_0), and magnetic susceptibility (χ). Whole brain coverage was achieved with millimeter isotropic resolution in a scan time of <26 minutes.

Methods: Imaging was performed with a 3T MR scanner (Discovery 750, GE Healthcare, WI). A human subject (26 year old, female) was imaged with the protocol in Table 1. From the brain image data, brain extraction and mask erosion were applied. Using sequence 1, the induced magnetic field (B_0), was calculated by fitting the phase evolution to the echo time. Using the magnetic field, background field removal was applied [1], to obtain the M_0 estimate. Dipole inversion was used to calculate the magnetic susceptibility (χ) [2]. T_2* was also calculated with sequence 1, by fitting the echo decay curve. The B_1 field map was calculated using sequence 2 and the method described by Voigt, *et al.* [3]. Coil sensitivity profiles were estimated from sequence 3, which obtained images from each of the coils. T_1 and T_2 maps were calculated using DESPOT1 and DESPOT2, respectively, as described by Deoni, *et al.* [4], with the B_1 map and sequences 3 through 6.

Table 1: Imaging sequences used to obtain quantitative maps.

#	Sequence	Parameters									
		FOV (cm)	TR (ms)	TE (ms)	α	BW (±kHz	slice thickness (mm)	Matrix Size	Aqn Time	Num Echos	Acceler-ation Factor
1	meSPGR	25.6 × 25.6 × 12.8	2000 ms	2.2-21.7 ms	15	62.5	2	256 × 256 × 128	4:12	8	2
2	Interleaved	25.6 × 25.6 × 12.8	16-60 ms	1.7 ms	60	62.5	4	128 × 128 × 32	5:53	1	1
3	SPGR 1	25.6 × 25.6 × 12.8	7.0 ms	3.1 ms	4	31.25	1	256 × 256 × 128	3:58	1	1
4	SPGR 2	25.6 × 25.6 × 12.8	7.0 ms	3.1 ms	18	31.25	1	256 × 256 × 128	3:58	1	1
5	bSSFP 1	25.6 × 25.6 × 12.8	6.7 ms	3.3 ms	4	125	1	256 × 256 × 128	3:47	1	1
6	bSSFP 2	25.6 × 25.6 × 12.8	6.7 ms	3.3 ms	18	125	1	256 × 256 × 128	3:47	1	1
								Total Time	25:35		

Results: Figure 1 shows axial and sagittal slices of the desired parameters. Images of similar quality to those found in the respective references were produced in this experiment. The signal to noise ratio of the respective maps were of high quality, and the concerns with accuracy were in the bias that might arise from using a two-point algebraic calculation such as that used in DESPOT.

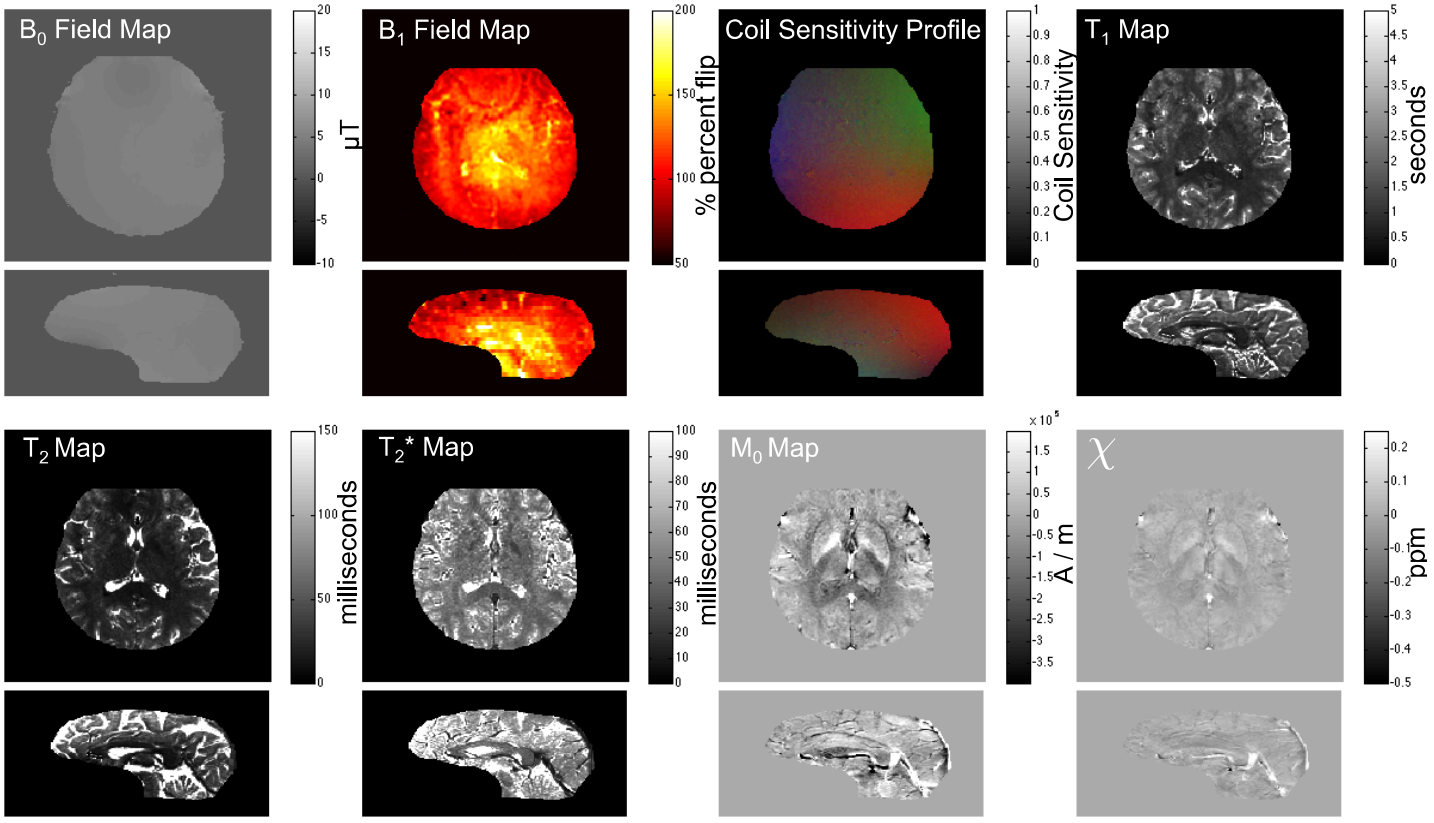

Figure 1: Parameter maps obtained from the protocol.

Discussion: There are a host of methods that can be used to acquire the parameters described above. Here we selected methods and parameters that provide key MR parameters within a limited acquisition time. Data collected here can be used for improved simulation of the Bloch equations with a sum of spin vectors model [5].

References: [1] Hongfu S, *et al.*, MRM, 2013 (In Press) **[2]** Liu J, *et al.*, Neuroimage, 2013;59(3):2560-2568 **[3]** Voigt T, *et al.*, MRM, 2010;64(3):725-733 **[4]** Deoni, *et al.*, MRM, 2005;53(1):237-241 **[5]** Kwan RKS, *et al.*, IEEE TMI, 1999;18(11):1085-1097