Reproducibility of DESPOT1&2 at 3.0T

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Introduction: Quantitative imaging techniques have several advantages over conventional qualitative approaches. They provide platform and hardware independent measures of tissue properties, allowing direct comparison of images which could, for example, facilitate longitudinal, multi-centre and population based imaging studies. However in order for this to be achieved high reproducibility must be shown. Driven Equilibrium Single-Pulse Observation of T1/2 (DESPOT) methods allow high resolution rapid quantification of T1 and T2. Previous studies have shown good reproducibility at low (1.5T) field strengths. At higher field strengths DESPOT suffer from B_1 and B_0 inhomogeneity induced artifacts. This study aimed to address such potential limitations whilst also measuring reproducibility of DESPOT at higher (3T) magnetic field strength.

Methods: Reproducibility was assessed on 3 GE 3.0T scanners (1 Signa HDx, 2 MR750 systems). 24 healthy participants were scanned once on each scanner in a randomized over a period of 6 months, with an extra rescan during one visit such that 8 scan-rescan datasets were available for each scanner. High-resolution relaxation time maps were derived from both DESPOT1-HIFI [1] and DESPOT2-FM methods [2]. Histogram, whole-brain and white matter-specific coefficient of variation (CoV) measures were used to assess reproducibility within and between scanners. The study was approved by the King's College London Psychiatry Nursing and Midwifery ethics subcommittee, and all participants gave written informed consent.

The scanning protocol consisted of SPGR, IR-SPGR and SSFP images with the parameters shown in Table 1. The IR-SPGR image had a TI of 450 ms and the SSFP images were acquired with two phase-cycling patterns (180° and 0°). All scanners used the body coil for RF transmission and a standard 8-channel head coil for signal reception. The total acquisition time for the whole protocol was 15 minutes.

The DESPOT1-HIFI and DESPOT2-FM processing algorithms were implemented in C++. Registration and segmentation steps were carried out using tools available in FSL [3]. Statistics were calculated with Matlab (The Mathworks). We found that some minor modifications to the published methods were required in order to mitigate inhomogeneity artifacts successfully. The B1+ map produced by DESPOT1-HIFI required smoothing before use due to a residual contribution from the underlying anatomy. DESPOT2-FM required that the image intensities were normalized by the mean across both flip-angle and phase-cycling pattern before processing to avoid noise amplification artifacts.

Results and Discussion: Table 2 shows the intra- and inter-scanner CoV for T1 and T2. Figures 1 and 2 show example CoV maps and histograms for a representative subject. T1 shows good reproducibility comparable to previous studies at 1.5T [4], except between scanner models at the edges of the brain in slab-select direction. Reproducibility is poor in CSF, most likely because the flip-angles used were chosen to be optimal for measuring the relaxation times of GM/WM and so are sub-optimal for the much longer values expected in CSF. T2 shows poorer inter- and intra-scanner reproducibility than T1. The lack of anatomical structure in the reproducibility maps suggests that acquisition artifacts may be to blame, rather than intrinsic problems with the DESPOT2 method

Conclusion: We have shown that DESPOT1 has comparable, high reproducibility 1.5T and 3T. DESPOT2 shows poorer reproducibility than DESPOT1 at 3T. Further work is required to improve correction for B_1 and B_0 inhomogeneity and to improve accuracy in CSF measures.

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References: (1) Deoni SCL. High-resolution T1 mapping of the brain at 3T with driven equilibrium single pulse observation of T1 with high-speed incorporation of RF field inhomogeneities (DESPOT1-HIFI). *Journal of Magnetic Resonance Imaging*. 2007;26(4):1106–1111. (2) Deoni SCL. Transverse relaxation time (T2) mapping in the brain with off-resonance correction using phase-cycled steady-state free precession imaging. *Journal of Magnetic Resonance Imaging*. 2009;30(2):411–417. (3) Jenkinson M, Beckmann CF, Behrens TEJ, Woolrich MW, Smith SM. FSL. *NeuroImage*. 2012;62(2):782 - 790. (4) Deoni SCL, Williams SCR, Jezzard P, Suckling J, Murphy DGM, Jones DK. Standardized structural magnetic resonance imaging in multicentre studies using quantitative T1 and T2 imaging at 1.5 T. *NeuroImage*. 2008;40(2):662-671.

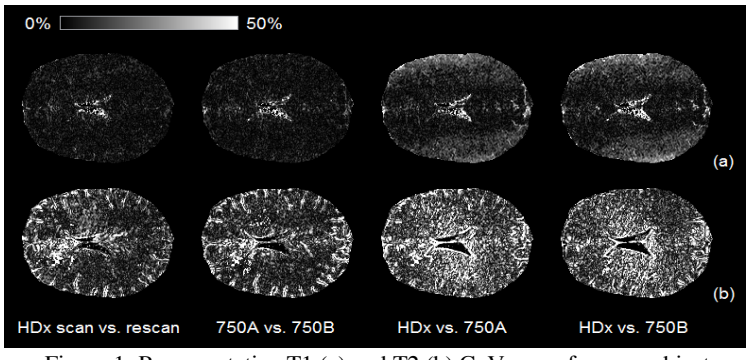

Figure 1: Representative T1 (a) and T2 (b) CoV maps for one subject

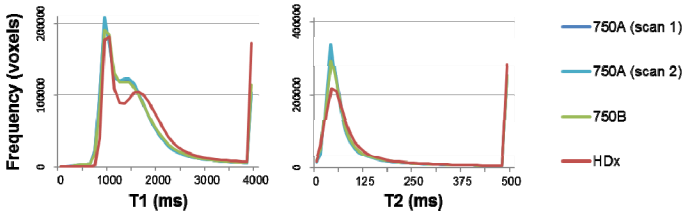

Figure 2: Representative whole-brain T1 (left) and T2 (right) histograms for one subject. The peak on the right is caused by the high value of T1 and T2 in CSF. The distribution of intensity values was different for the HDx model (red lines)

Table 1: Protocol parameters for each image type

Scan Type	Flip-Angles (°)	Matrix	Voxel Size (mm)	TE/TR (ms)
SPGR	4, 18	220x220x176	1x1x1	3.7/8.1
IR-SPGR	5	220x110x90	1x2x2	3.7/8.1
SSFP	16.5, 70	220x220x176	1x1x1	2.15/4.3

Table 2: Mean Whole-Brain and without CSF CoVs (in %) for T1 and T2 maps.

		T_1		T_2	
		Brain	**No CSF**	**Brain**	**No CSF**
Intra-scanner	**HDx**	7.5	6.0	23.3	24.3
	750A	7.9	6.3	20.0	19.5
	750B	7.6	6.2	21.1	20.3
Inter-scanner	**HDx vs. 750A**	16.9	13.0	25.8	28.3
	HDx vs. 750B	15.6	11.6	26.3	28.5
	750A vs. 750B	7.7	6.2	26.0	20.0