Introduction
Lesion detection in multiple sclerosis (MS) is an essential part of its clinical diagnosis. In addition, radiological characterisation of MS lesions is an important research field that aims at distinguishing different MS types, monitoring drug response and prognosis. To date, various MR protocols have been proposed to obtain optimal lesion contrast for early and comprehensive diagnosis of the MS disease.

In this study, we compare the sensitivity of five different MR contrasts for lesion detection: (i) the DIR sequence (Double Inversion Recovery, [4]), (ii) the Dark-fluid SPACE acquisition schemes, a 3D variant of a 2D FLAIR sequence [1], (iii) the MP2RAGE [2], an MP-RAGE variant that provides homogeneous T1 contrast and quantitative T1-values, and the sequences currently used for clinical MS diagnosis (2D FLAIR, MP-RAGE). Furthermore, we investigate the T1 relaxation times of cortical and sub-cortical regions in the brain hemispheres and the cerebellum at 3T.

Methods
10 early-stage female MS patients (age: 31.6±4.7y; disease duration: 3.8±1.9y; disability score, EDSS: 1.8±0.4) and 10 healthy controls (age and gender-matched: 31.2±5.8y) were included in the study after obtaining informed written consent according to the local ethic protocol. All experiments were performed at 3T (Magnetom Trio a Tim System, Siemens, Germany) using a 32-channel head coil [5]. The imaging protocol included the following sequences, (all except for axial FLAIR 2D with 1x1x1.2 mm³ voxel and 256x256x160 matrix): DIR (T11/T12/TR XX/3652/10000 ms, iPAT=2, TA: 12:02 min), MP-RAGE (T1/TR 900/2300 ms, iPAT=3, TA 3:47 min); MP2RAGE (T11/T12/TR 700/2500/5000 ms, iPAT=3, TA 8:22 min, cf. [2]); 3D FLAIR SPACE (only for patient 4-6, T1/TR 1800/5000 ms, iPAT=2, TA=5:52 min, cf. [1]); Axial FLAIR (0.9x0.9x2.5 mm³, 256x256x44 matrix, T1/TR 2500/9000 ms, iPAT=2, TA 4:05 min). Lesions were identified by two experienced neurologist and radiologist, manually contoured and assigned to regional locations (s. table 1). Regional lesion masks (RLM) from each contrast were compared for number and volumes of lesions. In addition, RLM were merged in a single “master” mask, which represented the sum of the lesions of all contrasts. T1 values were derived for each location from this mask for patients 5-10 (3D FLAIR contrast was missing for patient 1-4).

Results & Discussion
The DIR sequence appears the most sensitive for total lesions count, followed by the MP2RAGE (Table 1). The 3D FLAIR SPACE sequence turns out to be more sensitive than the 2D FLAIR, presumably due to reduced partial volume effects. Looking for sub-cortical hemispheric lesions, the DIR contrast appears to be equally sensitive to the MP2RAGE and SPACE, but most sensitive for cerebellar MS plaques. The DIR sequence is also the one that reveals cortical hemispheric lesions best.

T1 relaxation times at 3T in the WM and GM of the hemispheres and the cerebellum, as obtained with the MP2RAGE sequence, are shown in Table 2. Extending previous studies, we confirm overall longer T1-values in lesion tissue and higher standard deviations compared to the non-lesion tissue and control tissue in healthy controls. We hypothesize a biological (different degree of axonal loss and demyelination) rather than technical origin.

Conclusion
In this study, we applied 5 MR contrasts including two novel sequences to investigate the contrast of highest sensitivity for early MS diagnosis. In addition, we characterized for the first time the T1 relaxation time in cortical and sub-cortical regions of the hemispheres and the cerebellum. Results are in agreement with previous publications and meaningful biological interpretation of the data.


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