Voxel Based Analysis of 3D Double Inversion Recovery for the detection of cortical abnormalities in drug resistant epilepsy

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Introduction: Focal cortical dysplasias and heterotopias are a recognized cause of epilepsy. Indication for drug resistant epilepsy surgery relies on precise localization and delineation of the epileptogenic zone and lesion identification is an important issue. Visual detection and delineation of little or occult focal cortical dysplasia and heterotopias on MR images are sometimes difficult. Several 3D T1-w voxel-based morphometry (VBM) methods have been proposed to automatically identify and suggest potential abnormalities to the reader [1, 2]. Moreover, studies have shown the ability of Double Inversion Recovery (DIR) imaging, by nulling white matter and cerebrospinal fluid signal, to detect intracortical lesions in MS and Epilepsy [3-5]. In this study we propose to evaluate, at 3T and using VBM the ability of 9-minute 3D DIR to detect cortical and juxtacortical lesions in drug resistant epileptic patients.

Materials and Methods: 21 drug resistant epileptic patients (8 men, 13 women, mean age=25.9±9 y.o.) and 20 healthy control subjects (8 men, 12 women, mean age=29.3±9.6 y.o.) were scanned on a 3T Siemens Verio MR scanner (VB17 software release) with a 32-channel head coil. The imaging protocol consisted of 3D T1 MPRAGE (TR/TI/TE=1900/2.98/900ms, 9°, 1x1x1mm^3, 4min26s) and 3D DIR (TR/ TI1/TE=7500/3100/ 73ms, 1.3x1x1mm^3, 9min08s) sequences. Images were processed using Matlab/SPM8. 3D T1-w preprocessing consisted in segmentation of the gray matter (GM), spatial normalization and Gaussian smoothing. 3D DIR preprocessing consisted in registration on the 3D T1-w segmented GM, intensity and spatial normalization and Gaussian smoothing. Individual 3D patient T1-w and 3D DIR images were compared to healthy subject images using the General Linear Model. Comparison of extension maps (gray matter probability maps) was undertaken in order to outline brain locations abnormally filled with gray matter [1]. Junction and modulated junction maps were calculated and compared in order to detect blurred gray-white matter areas as illustrated in Figure 1 [2].

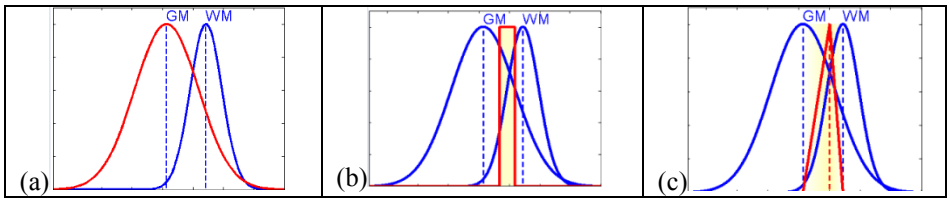

Figure 1 : Extension (a), junction (b) and modulated junction (c) criteria

Results: 3D T1 and 3D DIR VBM analysis detected gray matter abnormalities in 9/21 patients. Results ($p<0.001$) obtained on a 14y.o. female presenting a dysplasia are shown in Figure 2. The dysplasia is detected on the 3D T1-w based extension, junction and blurry distance map as well as on the 3D DIR based extension map. Additional blobs are detected with 3D DIR in frontal and temporal juxtacortical areas.

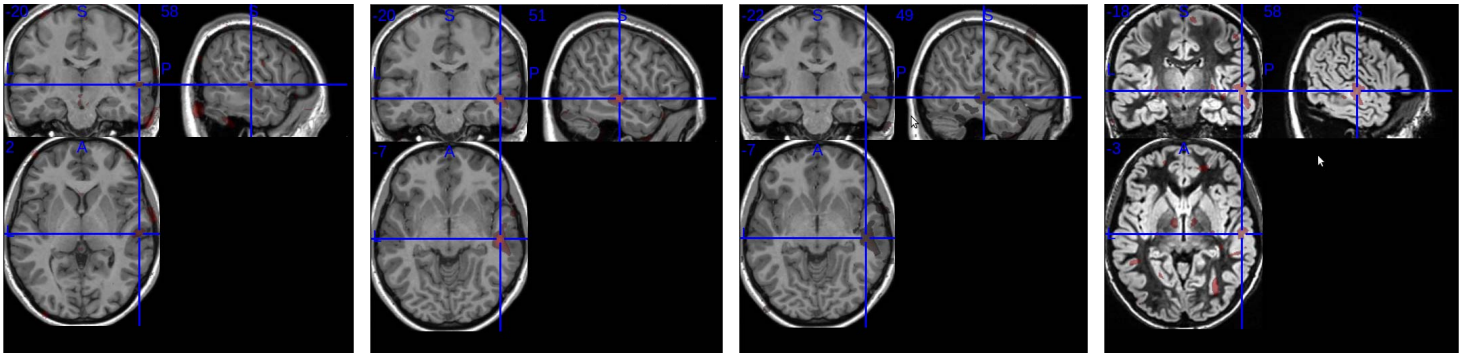

Figure 2 : 3D T1-w based extension map (a), junction map (b); blurry distance map (c) and 3D DIR based extension map (d)

Discussion: 3D DIR VBM analysis shows potential in detecting cortical abnormalities. 3D DIR extension maps provide an improved and more specific delineation of cortical structures. Further work will investigate the use of alternate registration frameworks (e.g. DARTEL), improved intensity normalization of 3D DIR images and joint 3D T1-w/DIR analysis to improve detection sensitivity and specificity.

References: [1] Wilke et al. NeuroImage. 2003 [2] Huppertz et al. Epilepsia. 2008 [3] Rugg-Gunn et al. Neuroimage 2006. [4] Nelson et al, Multiple Sclerosis 2011. [5] Zhang et al. Journal of Computer Assisted Tomography. 2011