IMPACT OF GEOMETRIC DISTORTIONS ON 3T FMRI RETINOTOPIC MAPS

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Introduction: Analyzing fMRI data confined to the cortical ribbon is a natural way to increase detection sensitivity using anatomical constraints [1,2,3]. Such a cortical oriented analysis, associated with unfolding techniques for visualization purpose, is currently used for retinotopic mapping of visual areas [4,5,6,7]. fMRI retinopic mapping requires several processing steps [7]: first functional T2*-weighted scans are coregistered to the high contrast structural T1-weighted scan. Second, the structural image is segmented, the cortical surface is reconstructed under the form of a mesh and unfolded or flattened. Third, functional activations, generally detected using Fourier analysis, are assigned to the surface via interpolation to the positions corresponding to the nodes of the cortical mesh. Fourth, spatial smoothing in the surface and detection of visual field sign allow for retinotopic visual areas delineation. Geometric distortions in single shot EPI sequences are a major issue since it can hamper the matching between functional and structural scans, the positions of the voxels assigned to the surface and thus areas delineation. We quantitatively show in this paper the impact of such distortions on 3T retinotopic maps and demonstrate the importance of distortion corrections.

Methods: Three volunteers underwent an examination for individual retinotopic mapping on a 3T whole body scanner (Bruker, Medspec). The stimuli consisted of periodically expanding and contracting rings and rotating wedges. The functional images were acquired using a standard 2D single shot EPI sequence (bandwidth = 100 kHz) sensitive to the spatial inhomogeneities of the main static field, resulting in geometric distortions in the phase encode direction (antero-posterior in our case). Two gradient echo sequences (TE=5 and 14.1 ms) were further acquired in order to derive the B0 field map for distortion correction purpose [8]. Data analysis for each subject was performed as follows. The displacement map, proportional to the measured B0 field map, was computed. Cortical activations were respectively detected in response to each stimulus and assigned to the cortical mesh using BALC software [7]. This assignment was performed using two processing ways, i.e. with (P1) and without (P2) applying a distortion correction. For all voxels assigned to the surface, 3D and 2D distances were calculated between positions obtained using P1 and P2. Visual areas were delineated and the mean distance between their borders derived from P1 and P2 was computed. For each visual area derived from P1, the number of activated voxels wrongly assigned to that area when using P2 was calculated.

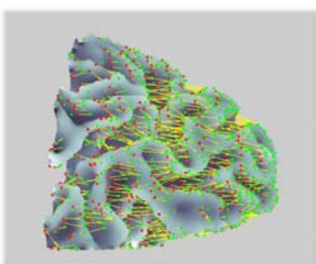

Fig. 1: 3D displacements of the projected activations on the occipital cortical surface.

Results: Fig. 1 shows the 3D displacement map between P1 (green points) and P2 (red points). Histograms of 3D and 2D displacement values are shown in Fig.2. Clearly, due to distortions, voxels can be assigned to the wrong sulcus bank and small 3D displacements can lead to large 2D displacements on the flat maps. Figure 3 shows typical 2D-projected voxels wrongly assigned using P2, which can either stay in the same area or jump onto another area using P1. Fig.4 details the proportion of wrongly assigned voxels with P2 in each retinotopic area. Between P1 and P2, the distance between the borders of the visual areas varies from 0,2 to 1,4 mm, which is the order of magnitude obtained in a reproducibility study [7]. The global displacement of borders remains relatively small probably because displacements and borders are roughly in the same antero-posterior direction.

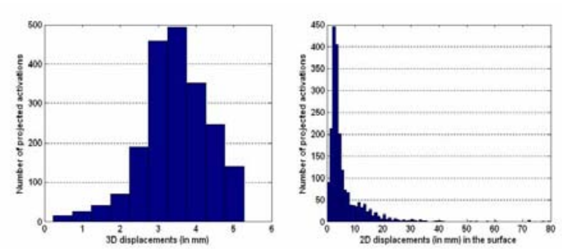

Fig. 2 : 3D and 2D displacements histograms: 3D displacements between 0 and 5 mm lead to 2D displacements between 0 and 80 mm.

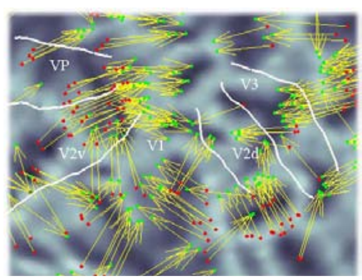

Fig. 3: 2D displacements on the flattened cortical surface showing visual areas misallocations.

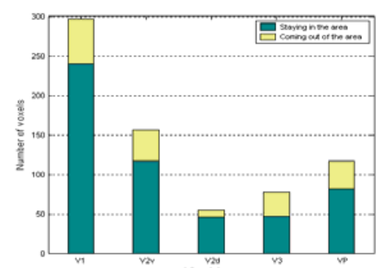

Fig. 4: Number of visual areas misallocation (yellow) over the total (green+yellow) for V1, V2v, V2d, V3, and VP visual areas.

Conclusion: Our results clearly show the impairment of retinotopic maps due to spatial distortions at 3T using a standard EPI sequence. Mainly, it results in the misallocation of functional voxels on the cortical surface, and thus to the potential misinterpretation of cognitive results based on retinotopic maps. This stresses the importance of distortion correction prior to surface assignment.

References:

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