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Interactive Exploration of fMRI Images within anatomical MRI Volume Reconstruction

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INTRODUCTION: The representation of eloquent cortical functions (receptive and productive language, memory, and sensory and motor functions) through functional magnetic resonance imaging (fMRI) may greatly enhance the outcomes of various neurosurgical resection procedures (tumor, vascular, epilepsy) [1,2] if these visual data presented to the surgeon during surgery are accurate, and easy to use. Accurate interactive visualization may further reduce patient, surgical and neurosurgery risks if these data sets are accessible to image-guided surgical navigational systems. The following system was used to demonstrate the complexity and distribution of one eloquent function, receptive language comprehension in a 29YO adult right handed M with a history of LTL PC epileptic seizures.

METHODS: An interactive 3D reconstruction and visualization system was developed that allowed multiple fMRI data slices acquired in various orientations to be integrated into SPGR volumes. Following localizer scan series, patient was scanned for vascular changes (BOLD) fMRI protocols (TE=60; TR=3000; Flip angle 90 degrees; FOV= 20 x20; 1 NEX; 128x128 matrix: 5.0mm thickness). Timing was controlled by PC using XMCD's, and digitized speech. During BOLD, each listened to a list of questions, which formed a "story" He heard 32 digitally recorded questions (MUL=7.21, SD 1.66;mode=6), paced at 1/ 10.0 sec., binaurally. He performed sequential finger opposition task (SFO) (30.0/30.0sec). Two BOLD image series of 3 slices were collected: Ax. and Cor Obl. During BOLD sequences he listened to and produced silently a noun that fit an aural definition, e.g., "a sea-going vessel that began with S or B." Subsequently, these data sets were analyzed using various statistical procedures (MEDX) and statistical parametric maps were constructed. These maps were merged into SPGR volume using all needed scanner acquisition parameters to map the fMRI images to the SPGR volume coordinates. Cells of the SPGR volume where the fMRI values exceeded ROI statistical significance levels (usually $p< .0001$) statistically defined thresholds were marked by special values. Once the merging was complete, the integrated volume was subjected to contour surface construction algorithms [3]. This system constructs two contour surfaces, corresponding to SPGR and the fMRI data. These were displayed using different colors to distinguish one from the other. The SPGR surface was displayed as a transparent surface, in order to reveal the fMRI surface in the interior, as illustrated in Fig 1.

RESULTS: 192 images were obtained for BOLD fMRI within each task (768 total). Eight specific regions of interest were chosen for further extensive analysis: L v R (motor cortex; posterior temporal-parietal-occipital junctions; STG; and FG. Image and statistical analyses showed that the left, but not the right, posterior TPO junction ROI was far more active during question comprehension of the sentences. Composite maps in the same image matrix space were constructed. This visualization system allowed the interactive viewing of the merged volume (scaling, rotation or translation) on graphics workstations, with hardware assisted rendering. Opacity of the SPGR surface reconstruction can be varied. The reconstruction can be clipped to reveal interior structures. Finally, the visualization system also displayed the merged volume along the axial, coronal and sagittal planes, complementing the 3D view.

CONCLUSION: 3D visualization methods for displaying SPGR whole volume anatomical merging with BOLD fMRI protocols were useful in lateralizing and localizing eloquent cortical regions activated in language reception and comprehension and represent a 3D volumetric and merging series that could be displayed on neurosurgical navigational systems.

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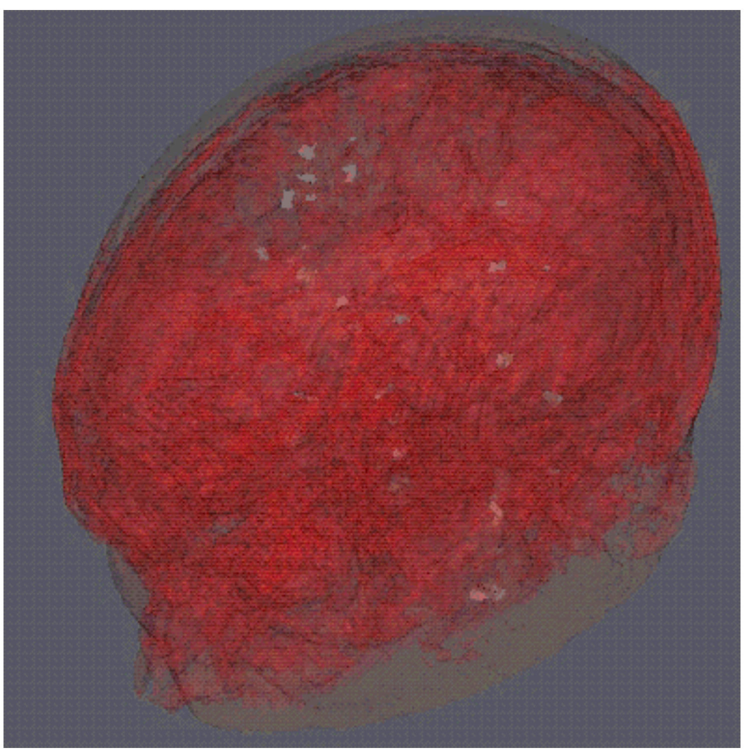

Figure 1: *f*MRI-MRI Merge. 3D rendering of SPGR volume (transparent), integrated with axial oblique *f*MRI slice. Active areas are in white.

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