Evaluation of Reproducibility of fMRI Maps in Patients with Proven Low-Grade Brain Neoplasms

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Introduction The accuracy of fMRI measuring activation in patients with brain neoplasms has been of special interest due to its ability to detect dynamic changes in Blood Oxygen Level Dependent (BOLD) brain activity and its application in the clinical setting [1]. Previous studies have used parameters to measure reproducibility: the center of mass, the number of activated voxels (R_{size}), and the reproducibility of the location of activated voxels ($R_{overlap}$) [2,3]. Currently this study will focus on two of the three parameters: evaluating the center of mass and R_{size}. The purpose of this study is to demonstrate the test re-test reliability of fMRI within subjects with benign and biopsy proven low-grade neoplasms.

Materials and Methods FMRI activation maps with 3 different thresholds (selected standard and +/- 20%) were generated for 9 subjects with benign and biopsy proven low-grade brain neoplasms using a GE Signa 1.5T magnetic resonance imaging (MRI) scanner. The imaging protocol included a 3DSPGR T1 brain volume, and 8 BOLD-weighted functional scans. The 8 functional scans consisted of four functional tasks each performed twice. Each task verified one of the following: language (word generation task), primary and association auditory (text listening), upper limb fine motor control (alternating-limb bilateral finger tapping), and primary visual perception (8 Hz reversing checkerboard). See Figure 1. for areas of activation correlated with the reference function. Expected fMRI responses were examined in the lateral inferior/middle frontal gyri, bilateral superior temporal gyri, bilateral primary sensorimotor cortices, and posterior occipital pole respectively.

Post processing was performed using software AFNI [4]. 3D motion correction, spatial smoothing with a 9mm Gaussian filter, and coregistration with each subject's T1-weighted brain volume were applied. Correlation analysis was performed which allowed the reference timing of the BOLD response in the expected areas to be confirmed. Measures of reproducibility were calculated using the Euclidean distance and measuring the number of reproducible activated voxels, R_{size}. $R_{size} = 2* V_{smallest} /(V_i + V_j)$ where V_i is the size of the activated volume in scan1 and V_j is the size of the activated volume in the corresponding scan 2. $V_{smallest}$ is the smallest activated volume size of the two scans. The Euclidean distance measures the displacement of the center of mass (COM) of the activated clusters in each scan. Voxels that exceeded the significance threshold were used in determining the center of mass. Ideally, the COM should have a low value representing the activation within the same area. In contrast, an ideal value of R_{size} would be approximately 1 representing the number of activated voxels between the two corresponding scans.

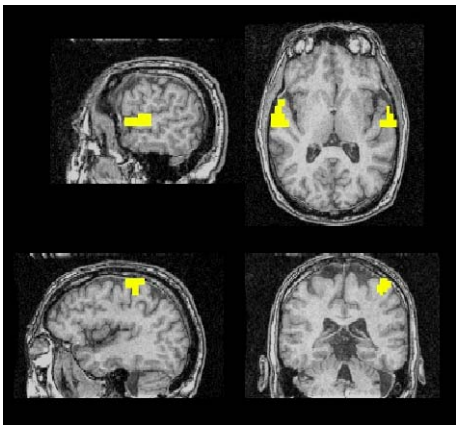

Fig. 1. Display of activated voxels for primary and association auditory while performing the text listening functional task (top row) and sensory motor cortex while performing the Alternating Finger Tapping Task with the right hand (bottom row).

Results We have investigated the reproducibility of the BOLD observed for each functional scan in subjects with benign and biopsy proven low-grade brain neoplasms. The Euclidean Distance between the center-of-mass and R_{size} was calculated to measure the reproducibility. These measures varied between 0.0 (worst) and 1.0 (best) [2]. Our average R_{size} was 0.71 for AWG, 0.68 for the right hand Alternating Finger Tapping, 0.46 for the left hand Alternating Finger Tapping, 0.88 for Text Listening R, 0.94 for Text Listening L, 0.86 for 8 Hz Checkerboard. R and L corresponds to the right and left cortex. Activation of clusters amongst subjects varied greatly for the visual perception scan. Previous published results had similar findings. Of all the task, reproducibility of activation within the Text Listening Task was proven to be highest. Difficulties in identifying the correlation of the BOLD response with the reference function and identifying the calcarine fissure may have resulted in the the 8Hz Checkerboard task results. This task had a large R_{size} value of 0.86 with a large COM distance of 8.77.

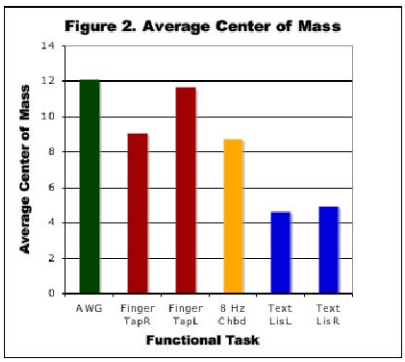

Figure 2. The average COM for each task is represented. An ideal COM value is low indicating same number of voxels become activated.

Conclusion Reproducibility of activation in repeated task indicates the reliability of fMRI procedures for mapping multiple brain functions. The regions of activation depended heavily on the threshold chosen for each task. Similar comparison of reproducibility will be made for more subjects. Testing for the reproducibility of the location of activated voxels, $R_{overlap}$, will be calculated in future work. The minimum number of clusters used and the cluster radius will be further examined to obtain more activated clusters. fMRI has proven to be a viable tool for measuring activation in patients with low-grade brain neoplasms.

Acknowledgements

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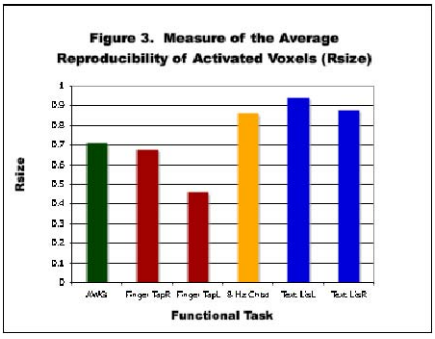

Fig. 3. Reproducibility measure, R_{size} is displayed. A value of approximately 1 is ideal in identifying the number of activated voxels.

References

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