

## 10th Annual Meeting of the Organization for Human Brain Mapping

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Abstract Number: 759.412001  
Last Modified: 15 Jan 04

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### **Insights into Multi-Site fMRI Repeatability: Scanner Differences in Sensitivity and Smoothness**

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#### Introduction:

The FIRST-BIRN (FBIRN) project is composed of a team of 11 universities studying brain dysfunction with fMRI in schizophrenia. One goal of the project is to characterize the quality and sensitivity of fMRI data collected at the 11 sites and to study the impact of possible inter-site differences on pooled group studies. Toward this end, we have evaluated the sensitivity (to the BOLD effect) and inherent smoothness (spatial correlation) of the fMRI images. Below, we report substantial, highly significant inter-site differences in sensitivity and smoothness. Site differences in smoothness are clearly related to site differences in sensitivity.

#### Methods:

The ten FBIRN sites reported on here have a variety of MRI scanners, and field strengths (5@1.5T, 4@3.0T, 1@4.0T, 4@Siemens, 5@GE and 1@Picker). They employ several different functional acquisition sequences (6 EPI, 3 spiral, 1 double echo EPI). Five volunteers traveled to 10 sites and had identical fMRI studies performed. All the sites used a 3000 msec TR with 35 axial slices. The TE for 1.5T was 40 msec and for 3T and 4T was 30 msec. The (nominal) voxel size was 3.44 X 3.44 X 4.00 mm. The sensorimotor paradigm (85 TRs, 5 TRs rest, 5 TRs active,...) included a finger tapping component designed to activate primary motor cortex. The data were analysed in a conventional manner with AFNI (time-shifted, motion-corrected, detrended, correlated with a square wave convolved with an HRF).

To measure sensitivity for the motor cortex ROI, we determined the correlation threshold (Pearson  $r$ ) for each study to optimally match a canonical motor cortex activation pattern. The threshold at which each study best matched this pattern was considered an index of sensitivity for that study. Pearson  $r$ 's were converted to a linear scale prior to statistics.

Smoothness was measured on unaltered images with the AFNI program 3dFWHM. It measures the extent of spatial correlation corresponding to each axis as a Gaussian FWHM (Forman et al., 1995). We present data only on the FWHM for the Y-axis.

#### Results:

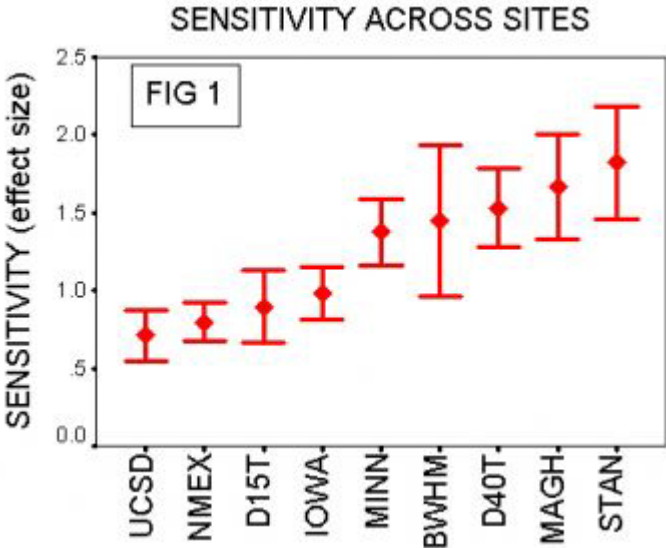
There were highly significant differences between the sites on sensitivity to the BOLD effect in the

motor cortex (Fig 1) ( $F = 22.4, df = 8, 32, p < 0.0001$ ). There were also inter-site differences in apparent smoothness of the raw functional images (Figure 2, A and B – same subject, different 1.5T scanners) and in measured smoothness (FWHM Y) (Fig 3) ( $F = 590.4, df = 8, 45, p < 0.0001$ ). There was a significant relationship between smoothness and sensitivity across sites (Fig 4)( $F(\text{linear}) = 5.5, df, 1, 83, p = 0.02; F(\text{quad}) = 3.84, p = 0.0535$ ).

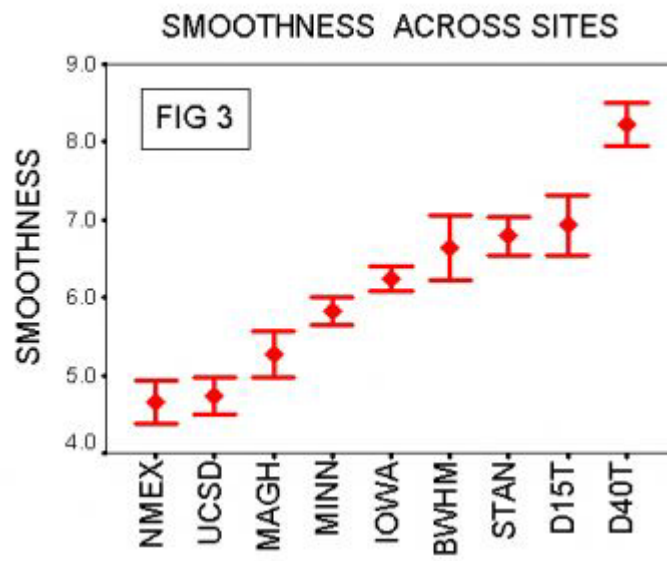
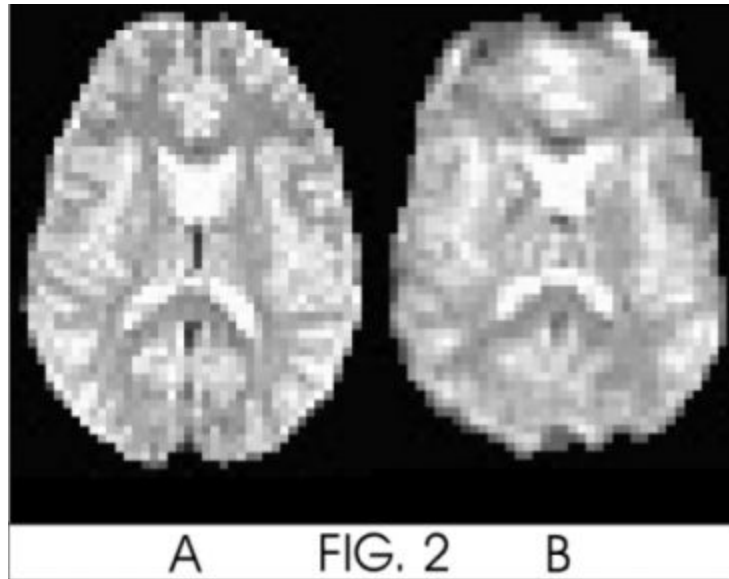
Discussion:

There are important "site" differences in sensitivity to the motor cortex BOLD effect. These differences will have to be taken into account before data from the sites can be merged. There are also marked site differences in smoothness of raw functional images from the 10 fBIRN sites. These differences may be related to imaging method (EPI vs. spiral), gradient performance, image reconstruction method, reconstruction filter settings, and field strength. There is a significant curvilinear relationship between smoothness and sensitivity across the sites. The possibility of reducing inter-site differences in sensitivity by smoothing the functional images to an equal level is under examination.

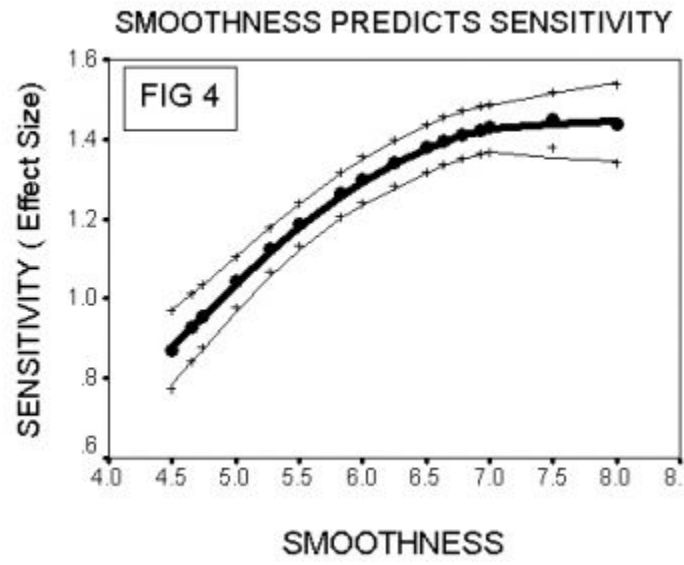
References: Forman SD et al. Magn Reson Med, 33:636-47, 1995;



Sensitivity Differences across Sites



Smoothness Differences across Sites



**Relationship between Smoothness and Sensitivity**