Application for QIBA Project Funding

Title of Proposal: Quantitative Measures of fMRI Reproducibility for Pre-Surgical Planning - Development of Reproducibility Metrics		
QIBA Committee/Subgroup: fMRI		
NIBIB Task Number(s) which this project addresses: 1,3,5,6,7,9		
Project Coordinator or Lead Investigator Information		
Last Name: Voyvodic	First Name: James	Degree(s): PhD
Institution/Company: Duke Brain Imaging and Analysis Center		

Please check the primary category for this proposal from among the following:

- [x] 1. Identification of Technical Characteristics and Standards
  - [ ] a. Creation and refinement of protocols for image acquisition, analysis, quality control, etc., for specific clinical utility
  - [ ] b. Phantom development and testing
  - [ ] c. Identification and assessment of intra-reader bias (1) and variance across scanners and centers
  - [ ] d. Identification and assessment of inter-reader bias and variance across scanners and centers
  - [ ] e. Other
- [x] 2. Clinical Performance Groundwork
  - [ ] a. Assessment of intra-reader sensitivity and specificity
  - [ ] b. Assessment of inter-reader sensitivity and specificity
  - [ ] c. Other
- [ ] 3. Clinical Efficacy Groundwork
  - [ ] a. Assessment of correlation between new biomarker and 'accepted-as-standard' method
  - [ ] b. Characterization of value in clinical trials
  - [ ] c. Characterization of value in clinical practice
  - [x] d. Development/merger of databases from trials in support of qualification
  - [ ] e. Other
- [x] 4. Resources (money and/or people) committeed from other sources.

Ongoing or completed funded studies will provide datasets that can be used to address issues of reproducibility. Existing personnel are available for study design, data processing/analysis and report generation but will have to be partially re-tasked to support this project.

Development of Reproducibility Metrics (PI: James Voyvodic, PhD)

Project Description: This sub-project will develop metrics for quantifying reproducibility within and across fMRI scans, and it will apply those metrics to existing data sets to assess the reproducibility of fMRI results both within and across scanning sessions. The metrics to be developed will be based on using the AMPLE normalization algorithm (Voyvodic, 2006) to assess reproducibility and will include both voxel-wise and ROI-based measures of the consistency of fMRI activation maps over time. The results of this study will help address NIBIB Tasks 1, 3, 6, 7, and 9. Demonstration and quantification of reproducibility is an essential step in the development of the QIBA Profile for fMRI.

Primary goals and objectives: This study will use 3 existing data sets already available at Duke. These include: 1) 400 presurgical patients (91% cancer, 5% AVM, 3% epilepsy) who underwent Duke's standard clinical language and motor paradigms in single scan sessions (some patients performed tasks more than once in the session) and provided informed consent for their data to be used in research; 2) 12 healthy control subjects scanned using the standard clinical language and motor paradigms in repeated sessions (session intervals between 1 day and 5 years); and 3) data sets from the FBIRN consortium study (www.birncommunity.org), in which 5 control subjects performed the same sensory-motor and cognitive tasks at 10 different sites, with 2 scan sessions at each site.

Initial analyses will focus on using the AMPLE normalization algorithm to assess reproducibility both within and across scan sessions for repeated scans of individual subjects. Based on previous results (Voyvodic, 2006; Voyvodic et al., 2009) we hypothesize that AMPLE normalized maps of language, motor, and primary sensory brain areas will be consistent across repeated scans. This study will test that hypothesis by determining quantitative measures of reproducibility. Initially these measures will include peak location, volume spatial extent, percent overlap, and relative ROI amplitude for each active brain region. Multiple normalized amplitude thresholds will be compared for each ROI to fully characterize the spatial distribution of BOLD activation signals. Another key metric will be AMPLE temporal stability, which we hypothesize will be highly correlated with other quantitative QA measures (e.g. head stability and task performance), with inter-scan reproducibility, and with ratings of confidence in functional localization by expert raters. Other reproducibility metrics will be explored as needed based on our empirical characterization of repeated scan results. Identification of QA criteria correlated with good reproducibility will be an important step toward fully qualifying the claims of the QIBA fMRI profile.

Deliverables: This project will calculate QA and AMPLE normalization metrics for all scans in each of the 3 data sets, and reproducibility metrics for all repeated scans in those data sets. We will make our Duke patient and control data sets generally available, as well as all the quantitative metrics generated by this study. We will also work closely with Dr. DeYoe's sub-project to coordinate application of the AMPLE algorithm and other quantitative metrics in those data sets.

Timeline:

Months 1-2: All 3 data collections are currently organized in a local imaging data base. The first step of this study will be to finish atlas registration and preparing all 530 data sets for scripted analysis.
Months 3-4: Run analysis scripts to perform AMPLE normalization and generate temporal stability and other automated QA metrics for all data sets.
Months 5-6: Calculate reproducibility metrics for all repeated scans. Compare reproducibility.
Months 7-8: Analyze variability in repeat scan normalization factors.
Months 9-10: Final reproducibility analyses and meta-analyses with DeYoe subproject.
Months 11-12: Prepare reports/papers and integrate results into QIBA profile. Share data sets.

Cited:

J.T. Voyvodic JT (2006). Activation mapping as percentage of local excitation (AMPLE): fMRI stability within scans, between scans, and across field strengths, Magnetic Resonance Imaging, 24:1249-1261.

Voyvodic JT, Petrella JR, and Friedman AH (2009) "fMRI activation mapping as percentage of local excitation: Consistent presurgical motor maps without threshold adjustment", JMRI 29:751-759.