Guidelines for Presenting Methods and Results in Neuroimaging

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Introduction

There is great variability in the reporting of neuroimaging results [1]. Reports often lack sufficient detail to reproduce or even evaluate an experiment. Given that reproducibility is a central principle of the scientific method, this has led other fields to publish guidelines for reporting analyses (e.g. [2] for EEG). We believe that a similar set of standardized guidelines would greatly benefit the field of neuroimaging by allowing researchers to evaluate, compare and reproduce findings across experiments and research modalities.

The purpose of this poster is to present a first draft of "Best Practices" for the reporting of neuroimaging methods. Initial work has been collected in a web page [3] and our ultimate goal is attract input across the whole field of neuroimaging. For reasons of space we report only the guidelines for statistical analysis in fMRI, although eventually we intend to include other neuroimaging modalities and stages of analyses.

Reporting fMRI Methods

Software

For any method that utilizes software, report software name and version. If no explicit version number available, report date software last updated.

Experimental Design

1. **Design specification**
   - Number of blocks or trials per session, number of sessions per subject
   - Software and version used for paradigm presentation

Data Collection

1. **Image Acquition Properties**
   - Magnet model & strength
   - Functional Acquisition
     - Type: EPI, Sprial; with SENSE?
       options: spiral in, in/out; SENSE acceleration factor, etc.
     - Spatial: Image dimensions and voxel size
       orientation, if not axial
       Image reporting coverage, if not whole brain
     - Timing: TE, TR, flip angle, number of images per session, number of sessions
   - Structural Acquisition
     - Type: e.g. 3D SPGR
     - Spatial: Image dimensions and voxel size
       relationship to functionals (e.g. co-planar)
       orientation if not axial
     - Timing: TE, TR, flip angle

2. **Pre-processing: Intrasubject**
   - Anatomical Images
     - Homogenity correction
     - Geometric corrections, if any (e.g for inter-site studies)
   - Functional Images
     - Geometric or EPI distortion corrections, if any
     - Motion correction
       if non-default option used, report: image similarity metric, optimization method, and interpolation method.
     - Slice timing correction
       Order (before or after motion correction)
       if non-default option used, report: type of interpolation used and reference slice
   - EPI motion-susceptibility correction, if any

3. **Pre-processing: Intersubject**
   - Affine (9 or 12 parameters?) or Nonlinear
     if non-default, non-linear settings (e.g. polynomial order (AIR), basis size/cut-off and regularization (SPM))
     if non-default, interpolation method
   - Reference space, specific reference image and resolution. e.g. "SPM2's MNI EPI 2x2x2mm template"
   - Coordinate space: MNI, or MNI converted to Talairach (reference particular conversion transformation)
   - ROI Definition (if any)
     Talairach? AAL? Functionally defined (details)

4. **Pre-processing: Smoothing**
   - Size smoothing kernel
   - What type of kernel (if not Gaussian)
   - Is smoothing done separately at 1st and 2nd levels?

Statistical Modeling

1. **1st-level, Intrasubject Modeling**
   - Block or event; if block, duration of blocks.
   - Convolution with Hemodynamic response function? If not default, HRF basis and parameters
   - Additional regressors used
     e.g. motion, behavioral covariates
   - Drift model e.g. DCT with cut off of X seconds; cubic polynomial
   - Autocorrelation modeling
     if non-default used, specify details
     e.g. "Global approximate AR(1) autocorrelation for $\rho \approx 0.5$, changed from SPM default of $\rho \approx 0.2$"
   - Estimation method (OLS or GLS) if non-default used
   - Effect/Contrast definition
     Describe exactly what effects are subtracted from which
     Useful to define short-hand names (e.g. AUDSTIM, VISSTIM) to facilitate precise contrast description

2. **2nd-level, Intersubject Modeling**
   - Whether first level intersubject variances are assumed to be homogeneous (SPM & simple summary stat methods: yes; FSL: no).
   - If multiple effects per subject, method to account for correlation
     e.g. "SPM nonsphericity modeling used to allow different variances for each effect and inter-effect correlations"

3. **Inference on Statistic Image (thresholding)**
   - Use corrected inferences!
     Uncorrected infererence only acceptable if working with ROI (data averaged within ROI) or if one-voxel region is identified a priori.
     Note: Some authors rely on heuristic methods which have been shown (in peer-reviewed literature) to control false positives for a given scanner/voxel size/TR/TE/Nscan combination. If such methods are used there must be specific reference to such literature and explicit confirmation that identical scanning parameters have been used.
   - Type of search region considered (whole brain, subvolume, etc)
     List volume in voxels *and* cubic centimeters.
   - If not whole brain, give exact definition of region
     e.g. Coordinates bounds, public data repository, atlas labels.
     Best is to illustrate search region with figure
   - Inference Method
     - Voxel-wise:
       FWE or FDR, α-level
       Statistic value of actual threshold used
     - Cluster-wise:
       Cluster-defining threshold
       FWE α-level
       Cluster size of actual threshold used
     - RESEL count and FWHM smoothness, if Random Field Theory used

Omissions and Overstatements

If you have a pet-peeve about the way neuroimaging methods are reported, or feel that the list demands too much of the investigator *let us know!* Email the first author with comments `nichols@umich.edu`. Over a dozen people have contributed to this listing (see below) and we seek input from many more.

References: [1] Nielsen (2003) The Brede database: a small database for functional neuroimaging. NeuroImage 19(2). [2] Picton et al (2000) Guidelines for using human event-related potentials to study cognition: recording standards and publication criteria. Psychophysiology. 37(2):127-52. [3] Nichols et al (2005-) Guidelines for Presenting Neuroimaging Analyses. http://www.sph.umich.edu/ nichols/NIpub/

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