PSYCH-204B Data Analysis Project

Objective: In this project you will analyze data from a fMRI experiment to gain understanding of the signals and data analyses of fMRI data.

There are questions you need to answer at several milestones in the data analysis pipeline outlined below. Please email your answers to these mandatory homework questions to Anthony (astiglia@stanford.edu).

The projects will expose you to different kinds of fMRI data and associated data analyses stream. Please choose one of the data sets and corresponding projects. You can do the project on your own or in pairs. If the latter, please make it clear what was the contribution of each individual.

mrVista tutorials: Anthony will lead a tutorial on initializing fMRI data using the mrVista data analysis package (http://white.stanford.edu/newlm/index.php/MrVista) in class on February 3. A second mrVista tutorial will discuss the population receptive field (pRF) model, general linear model (GLM), multivoxel pattern analysis, and projection of data to the cortical surface.

Project overview: All of the software packages needed to run mrVista, step-by-step instructions, and all three example datasets can be downloaded in a zip archive here:
http://vpnl.stanford.edu/psych204b/psych204b_project.zip

- **Project 1: How to perform retinotopic mapping & pRF estimation?** Topographic organization is a prevalent feature of brain organization. The goal of this project is to understand a technique to use fMRI to measure such topographic maps and measure population receptive fields using an example data set from the visual domain
  - Path to data in zip archive: /data/kgs012715_PRF/
  - **Dataset**: 4 runs of bars filled in with checkerboards that sweep the visual field in a systematic order. Experimental design and analysis is described in the following paper: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3073038/
- **Project 2: Can you decode category information from the ventral stream using multivoxel pattern analyses?** The purpose of this experiment is to examine if we can decode from the ventral stream the category of the stimulus presented to the subject from the distributed activity across the ventral temporal cortex.
  - Path to data in zip archive: /data/kgs012715_Localizer/
  - **Dataset:** Data contains 5 categories with 2 subcategories each: faces (adult/child); bodyparts (headless bodies/limbs); objects (cars/musical instruments); characters (psuedowords/numbers); places (houses/corridors). Stimuli were carefully controlled for low level properties (luminance, contrast, spatial frequency) across categories. Stimuli were presented in miniblocks of 8 stimuli from a single subcategory, but varied in rate (1,2,4 or 8Hz) across runs. We suggest that you use data from one presentation rate. For example, 1 or 2Hz. For the ambitious you can test if decoding varies by the rate of the stimulus

presentation. Reading: (1) http://www.ncbi.nlm.nih.gov/pubmed/11577229; (2) http://www.ncbi.nlm.nih.gov/pubmed/20457261

- **Project 3: Does functional localization of category-selective regions depend on the rate of stimulus presentation?** The purpose of this experiment is to understand the concept of functional localization and test if localization varies by the rate of the stimuli. You will localize a functional ROI with one stimulus rate and test if the selectivity is maintained when extracting signals from an experiment using a different rate. Uses the same dataset as Project 2. The first functional localizer experiment: http://www.ncbi.nlm.nih.gov/pubmed/9151747
- **Project 4: How does adaptation to faces vary across regions and transformations?** fMRI adaptation (fMRI-A) is a technique used to measure neural sensitivity to changes in the stimulus. This method is thought to obtain subvoxel resolution. The goal of this project is to understand the concept of fMRI-A and how to design and analyze such data.
  - Path to data in zip archive: /data/kgs121313_Adaptation/
  - **Data set:** Data contains 2 adaptation experiments, one testing sensitivity to face view and the other testing sensitivity to face size. Each of the experiments has a 2x2 design containing four conditions: (1) same face, same size (view); (2) same face; different size (view); 3 different face, same size(view); (4) different face, different size (view). In each mini block we had 8 stimuli presented at a rate of 2 ±Hz. A review of fMRI-A: http://www.ncbi.nlm.nih.gov/pubmed/16321563; Expected outcomes: http://www.ncbi.nlm.nih.gov/pubmed/10677037

Project Time Line

- Part 1 – Project initiation (homework 1 due 2/12)
- Part 2 – Time course analysis and visualization (homework 2 due 2/26)
- Part 3 – Summary of data analyses, results & conclusions: Student led presentations & wiki page (wiki page due on 3/10; presentations on 3/10 and 3/12)

Data analysis pipeline

Homework problems are labeled in red beside corresponding stages of data analysis. Try to answer each question after reaching its milestone as you work through the steps in the analysis pipeline.

Part 1 *– Project initiation:*

- Preprocessing steps
  - Session initialization (question 1)
  - Motion compensation within (question 2) and between (question 3) scans
  - Alignment of functional data to volume anatomy (question 4)
- **Homework 1**
  1. **Screenshot inplane slices 1 through 9**

2. **Show plots of within-scan motion compensation**
3. **Summarize between-scan motion compensation**
4. **Screenshot an ROI projected from the volume to the inplanes**

Part 2 *– Time course analysis and visualization on cortical surface:*

- Project 1: Retinotopic mapping analysis
  - Transform time series from inplane to gray matter volume
  - Set analysis parameters and run PRF model to generate retinotopic maps (question 1)
  - Extract time course of an individual voxel in visual cortex (question 2)
  - Project eccentricity and polar angle maps to the cortical surface and threshold by variance explained (*cothresh* in mrVista) > 0.1 (question 4)
- Projects 2 & 3: Functional localizer analysis & MVPA
  - Set analysis parameters and run GLM (question 1)
  - Extract time course (questions 2) and generate multi-voxel pattern (MVP) structure (questions 3) for an ROI
  - Generate a parameter map consisting of *t*-values for a statistical contrast (e.g., faces > other categories) and threshold by *t* (*meanMapMin* in mrVista) > 3 before projecting to the cortical surface (question 4)
- Project 3: fMRI-Adaptation analysis
  - Set analysis parameters and run GLM (question 1)
  - Extract time course (questions 2) and generate multi-voxel pattern (MVP) structure (questions 3) for an ROI
  - Generate a parameter map consisting of *t*-values for a statistical contrast (e.g., different > same) and threshold by *t* (*meanMapMin* in mrVista) > 3 before projecting to the cortical surface (question 4)
- **Homework 2**
  1. **Describe the hemodynamic response function used in your analysis**
  2. **Show the time course of an individual voxel (retinotopy) or ROI (localizer or adaptation)**
  3. **If analyzing localizer or adaptation data, generate MVP structure showing confusion matrix of experimental conditions**
  4. **Project the polar angle and eccentricity maps (retinotopy) or a statistical contrast parameter map (localizer or adaptation) to the cortical surface and attach screenshots**

Part 3 *– Summary of data analyses, results & conclusions*

Student led presentations: The homework is designed to get you to the point that you can pose a scientific question (within the scope of your data), form a hypothesis, and test it. While the types of questions you can ask are constrained by the experiment you are analyzing, be creative and try to address a question or issue that interests you. You will present your project to the class at the end of the quarter after outlining the motivation, analysis, results, and conclusions of your project in a wiki page.

- Information for accessing the wiki
    - Navigate to: http://vpnl.stanford.edu/internal/wiki/index.php/Psych_204B
    - Click “Create an account or log in” in the upper right corner of the wiki
    - Username: kweb
    - Password: mach
- See wiki for an example project from a previous year