Psy 8960 – fMRI: Biological Basis and Experimental Design
Spring Semester, 2006

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Course Description

The course will cover 1) the rudiments of MRI techniques, with particular emphasis on artifacts and constraints in EPI, 2) the biological basis of the fMRI signal, discussing the underlying neuroscience and vascular physiology, 3) experiment design and execution, and 4) the fundamentals of data analysis. Students will be asked to complete and present a short research project at midterm; the final project will comprise presentation of simulated data and analysis for a novel experiment design.

The class will meet Tuesdays and Thursdays, 9:45 – 11:00 in 203 Elliott Hall. Format is lecture and group discussion. Assignments and supplementary materials will be posted on the course website: http://vision.psych.umn.edu/~caolman/courses/Spring2006.

Grading and Attendance policies

The course is offered for three credits, graded on an A-F basis (A: 93 – 100, A-: 90 – 92, B+: 88 – 89 …, C-: 70 – 72; students taking the course pass/fail will receive an S (satisfactory) for grades higher than D+.)

- Attendance and participation (including submission of weekly assigned exercises) will constitute 40% of the grade.
    - 20% of the course grade will be based on weekly assignments, which will be given full credit if turned in on time. Arrangements for submitting late assignments must be made before the due date to receive partial credit for the assignment.
    - 20% of the course grade will be based on an attendance sheet that will be passed around at every class period. Excused (pre-arranged or sick) absences will be counted as attendance.
- The mid-term project will constitute 30% of the grade.
- The final project will constitute 30% of the grade.

Weekly assignments

Short problem sets will be handed out at the beginning of each week and due a week later. They are designed to provide concrete instantiations of the material covered in the lecture and will vary in format: short-answer, multiple choice, matching, calculation and/or data simulation/analysis. Matlab^{TM}-based simulations and demonstrations will be used in lecture and assignments. Students who prefer to work in a different programming language are welcome to do so, but should make arrangements with the instructor ahead of time.

Mid-term and Final projects

The mid-term project will be a short (2 – 4 page) research paper describing ideas for addressing a current problem in functional MRI. References should be taken from textbooks and/or primary literature (*Magnetic Resonance in Medicine* and *NeuroImage* are examples of journals likely to have appropriate methodological papers). Tailoring the topic to the student's particular interests is encouraged. The paper should A) demonstrate the student's understanding of the physical and/or physiological principles underlying the problem or imaging artifact and B) describe one potential method for addressing the problem using readily available scanner technologies, pulse sequence and/or experiment design. Students should discuss their selected topic with the instructor before beginning research. Examples of projects: z-shimming for reduction of signal-loss in orbito-frontal cortex; segmented or reduced field-of-view EPI acquisition to reduce distortion in inferior brain regions; smoothing of data to control for spatial correlation between voxels; adjusting repetition time (TR) of imaging sequence to avoid aliasing of cardiac rhythm into frequency band of block-design experiments.

The final project will comprise simulation and analysis of data. As with the weekly assignments, Matlab^{TM} is the preferred programming environment, but students are welcome to work with the tools most appropriate for their project. The general structure of the project will be:

- Experiment design: description of an unanswered question in the fields of psychology or neuroscience which can be answered by an fMRI experiment, and the design of a corresponding experiment
- Simulation of a small volume of noise-free data, based on plausible models of neural and hemodynamic responses
- Simulation of data with noise (including spatial and temporal correlations as appropriate)
- Development of analysis protocol, including estimates of confidence intervals (students should demonstrate facility with the General Linear Model, but more advanced analysis techniques can be investigated if they are more appropriate to a student's interests)
- Validation of the model by comparison between analysis results and noise-free simulated data

Students will submit for grading the following: a document describing the analysis and simulation (including appropriate equations) and code for generating and analyzing data. Because the data are generated, file sizes should total less than 5MB. Students will give informal presentations of their work during the last week of class. A significant portion of class time will be devoted to developing and implementing these models. An example project will be presented in class after the mid-term. Weekly assignments during the second half of the course will be building blocks for the final project.

Date	Topic	Description
Jan 17	Introduction	Overview of course content and goals
Jan 19	Neuroscience	Neurons: architecture and computation
Jan 24		Cell metabolism and blood flow regulation
Jan 26		BOLD overview
Jan 31	General Imaging	Magnets and protons; relaxation and image contrast
Feb 2		Pulse sequences
Feb 7		Gradient echo
Feb 9		2D and 3D Pulse sequences: navigating k-space
Feb 14	EPI	Pulse sequence review; spin echo
Feb 16		Drop-out
Feb 21		Distortion
Feb 23		SNR
Feb 28	BOLD	Deoxyhemoglobin: endogenous contrast agent
Mar 2		Imaging with T2* contrast
Mar 7		Spatial localization (CBF, SE, GE)
Mar 9		Functional specificity of BOLD
Mar 13		Spring Break
Mar 15		Spring Break
Mar 21	Exp't design	Example project. *mid-term projects due
Mar 23		TBD
Mar 28		Modeling the experiment: baselines and controls
Mar 30		Physical practicalities and human subjects
Apr 4	Pre-processing	Data handling: software packages and data formats
Apr 6		Pre-processing (trend removal, motion compensation …)
Apr 11	Voxel selection	Anatomical definition of regions of interest
Apr 13		Functional definition of regions of interest
Apr 18	Linear models	Design matrix, correlation, and convolution
Apr 20		Deconvolution and trial-triggered averaging
Apr 25	Noise and error	Confidence intervals
Apr 27		Noise sources
May 2	Final projects	In-class presentations and discussion
May 4		In-class presentations and discussion
		No class during finals week