Introduction to Brain Imaging Analysis Methods

Course Number: TBD
Instructor: TBD
email: TBA
Office Hours: TBD
Class Meets: TBD
GSI: TBD

Course Description: This course introduces the student to data analyses and design considerations of human brain imaging experiments with an emphasis on functional magnetic resonance imaging (fMRI). Emphasis is on building deep understanding of the underlying fMRI signals and computational approaches. The goal is to not only gain mathematical understanding of data analysis choices, but also to understand their consequences on interpreting brain function.

The course is a mixture of lectures and hands-on software tutorials. The course will begin with fundamental topics including (but not limited to) understanding (1) the nature of fMRI signals, (2) the temporal and spatial resolution of fMRI, (3) the signal to noise ratio of fMRI, 4) general linear models, and (5) basic types of statistical analyses of fMRI data. Then, the course will introduce advanced approaches including fMRI adaptation, multivoxel pattern analyses, representational similarity analyses, high-resolution fMRI, as well as decoding and encoding algorithms.

Website: The bCourses website will include:
- Lecture slides (provided in advance of class and then updated)
- Reader articles
- Assignments

Textbook: *Functional Magnetic Resonance Imaging***,** Huettel et al., FMRI (Third Edition, Sinauer). The book can be rented for $64.95 from VitalSource (link: https://www.vitalsource.com/products/functional-magnetic-resonance-imaging-scott-a-huettel-v9781605354170) or purchased for $129.95 from Oxford University Press (link: https://global.oup.com/ushe/product/functional-magnetic-resonance-imaging-9780878936274?cc=in&lang=en&q=sinauer)

Lectures, readings, and tutorials/simulations:

Lecture	*Topic*	*Textbook/Reader/Tutorial*
1	Course overview	Chapter 6
2 and 3	From neural activity to hemodynamic activity	Chapter 6 Linear systems Matlab simulation tutorial
4 and 5	Properties of the BOLD Signal: Spatial and temporal resolution	Chapter 7
6 and 7	Hemodynamic Response and the Linear Systems approach	Chapter 7 Boynton & Heeger, 1996
8 and 9	fMRI data acquisition	Chapters 1 and 2
10 and 11	Signal and Noise in fMRI	Chaper 8 Kruger & Glover, 2001 Noise Matlab simulation tutorial
12 and 13	fMRI Data Quality Assurance and Preprocessing	Chapter 8
14	Student Led Debate 1: Single Unit Physiology vs. fMRI	Chapters 6 and 13 Barlow, 1972; Heeger, 2002; Logothetis & Wandell, 2004; Pitch for final project/paper proposals
15	Experimental Design 1: Block Design; General Linear Model	Chapter 9; Kanwisher, 1997
16	Statistics of fMRI-Data analyses	Chapter 10; Worsley, 1998
17	Experimental Design 2: Event-related designs	Chapter 9; Buckner & Dale, 1998
18	Experimental Design 3: Traveling Waves & Mapping	Chapter 9 Wandell, 1999
19	The importance of Visualization	Chapter 12
20	Multivoxel Pattern Analyses	Chapter 11; Haxby, 2001 Norman et al., 2006
21	fMRI adaptation	Chapter 11; Grill-Spector et al., 2006
22	Encoding and decoding models	Huth et al., 2016; Kay et al., 2008; Naselaris et al., 2011
23	Whole brain group analyses vs. High-resolution fMRI in single subjects	Weiner and Grill-Spector, 2013; Cohen et al., 2017; Nichols et al., 2017
24	Student Led Debate 2: MVPA vs. ROI analyses	

Important dates:

Student led debate 1: TBD
Student led debate 2: TBD
Linear systems Tutorial: TBD
Noise simulation Tutorial: TBD
Pitch for final project/paper: TBD
Final project: TBD

Program Learning Goals:

As part of a campus-wide project to improve undergraduate education, the Department of Psychology has identified a number of program-level goals for our curriculum. Through the mixture of lectures, readings, debates, and tutorials, this course aims to address facets of seven core program-level goals:

1. Understand basic concepts that characterize psychology and neuroscience fields of scientific inquiry, and appreciate the various subfields that form the discipline. As will be emphasized throughout the course, and in particular emphasized in the initial set of lectures, psychology and neuroscience are interdisciplinary fields that draws on diverse methodologies, including neuroimaging.
2. Develop an understanding of the central questions/issues in contemporary psychology and neuroscience and how they are tested using neuroimaging techniques with an emphasis on functional magnetic resonance imaging – the main non-invasive tool that is used to link brain activity to human cognition.
3. Develop a thorough understanding of one of the major content areas of psychology (i.e., Social/Personality, Developmental, Clinical, Cognitive, Biological). While the focus here will be biological in nature, since the course is methodological in nature, examples from each content area will be used.
4. Develop skills to critically evaluate the presentation of scientific ideas and research in original scientific papers as well as in the popular media. This goal is at the heart of the teaching philosophy used in this course. Each lecture includes book chapters and primary papers that are designed to help students develop skills to read and evaluate the primary literature – both classic and modern.
5. Become familiar with research methods used in psychological research, and become proficient in basic concepts of statistical analyses and familiar with more advanced methods in data analyses and modeling. This course fills this goal in three main ways. First, the course is geared toward familiarizing students with the methods (both basic and advanced) of fMRI, which is a major tool used to non-invasively measure the cognitive and psychological states of human individuals. Second, the discussion of the primary papers will focus on the methods and results sections of the papers, allowing the students to critically evaluate how scientists test and evaluate hypotheses – both classically and in the present. Third, the student led debates are aimed to allow the students to think critically about why (or why not) one method or analysis is better than another.

6. Learn to develop, articulate, and communicate, both orally and in written form, a testable hypothesis, or an argument drawing from an existing body of literature. These skills will be developed throughout the course – especially in the final paper/project and the student led debates. Additionally, the three lectures on experimental design explicate how different fMRI experimental designs accommodate different types of hypotheses related to different aspects of psychological theory.
7. Apply a psychological principle to an everyday problem, or take an everyday problem and identify the relevant psychological mechanisms/issues. Understanding different facets of cognitive and psychological functions is intrinsically interesting and being able to non-invasively measure the living human brain while these cognitive and psychological functions are happening enables us as scientists to better understand anatomical and functional organizational features of the brain that contribute to these psychological mechanisms. Providing the students with a proper foundation for understanding and implementing brain imaging analysis methods is crucial for understanding how to use a widely used tool (fMRI) to measure psychological mechanisms/issues non-invasively in both control and patient populations.

Course grading:

The tutorials/simulations, participation, and final project will be weighted as follows:

Participation: 10%
Student led debate 1: 10%
Student led debate 2: 10%
Linear systems Tutorial: 10%
Noise simulation Tutorial: 10%
Pitch for final project/paper: 10%
Final project/paper: 40%

All assignments will be graded on a 100-point scale and then weighted by the above formula in the determination of final grades. Grading will most likely be on a straight curve (e.g., B's between 80-89.9), but grades will be curved up if the median of the final distribution is below 80. Under no circumstances will grades be curved down. Concerns with a grade on any assignment must be addressed within two weeks of the return of that assignment. No exceptions.

Participation and RPP/Alternative Assignment:

There are two components to the participation grade. The first is based on your attendance and involvement in class. The second is based on your completion of the research participation program (RPP) requirement or an alternative assignment. I will provide a grade for participation based on the following guidelines:

<u>PART 1: Participation</u>

Someone who came almost every week, was prepared, and participated:	65 - 70
Someone who came almost every week, was prepared, but minimally participated:	60 - 65

Someone who attended most classes and participated when they came:	50 - 60
Someone who attended most classes, but minimally participated:	40 - 50
Someone who attended half and participated when they came:	30 - 40
Someone who attended half with minimal participation:	20 - 30
Someone who rarely attended:	0 - 20

PART 2: RPP Participation or Alternative Assignment

Completion of RPP 3-credit requirement	10 pts/credit
or	or
Satisfactory Completion of Alternative Assignment	30 pts

Research Participation (or alternative assignment):

Students must complete EITHER the Research Participation Program requirement or an alternative assignment.

The RPP program:
• serves as a source of voluntary participants for psychology department and other approved researchers
• respects participant rights and ethical considerations
• provides an educational and positive experience for participants

To learn how to create an RPP account and start participating in experiments, please go to the link:

http://psychology.berkeley.edu/students/undergraduate-program/research-participation-program.

Please read the document, "RPP Information for students". Then, set up a Sona account as instructed. We recommend doing this as soon as possible. If you have any questions, you can contact RPP at rpp@berkeley.edu.

The RPP requirement for the class is three credits. The RPP credits must be completed by end of the RPP period, TBD. Consider completing earlier rather than later since demand is sometimes very high near the end of the term.
Alternative Assignment:

Students who prefer to complete an alternative assignment can provide a short research proposal. For this assignment, you would propose a follow-up study to a published study. You would submit a 3-page paper in which you, a) review the goals and key findings of the published study, b) discuss follow-up experiments/measurements to that study, c) describe the methods and show your predicted results (with at least one graph or table). Papers must be posted to the bCourses folder as a single pdf that includes the 3-page paper and the published study. No late papers will be accepted.