

Functional Magnetic Resonance Imaging: Data Acquisition and Analysis

Lecture: Monday & Wednesday, 3 – 4 pm (4-231)

Lab: Monday, 12.30 – 2 pm (1-115, unless otherwise noted in schedule)

Advanced Topics Seminar: Wednesday, 2 – 3 pm (4-261)

Course directors: Sue Whitfield-Gabrieli <swg (at) mit.edu>
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Description: This course provides background necessary for designing, conducting, and interpreting fMRI studies in the human brain. Covers in depth the physics of image encoding, mechanisms of anatomical and functional contrasts, the physiological basis of fMRI signals, cerebral hemodynamics, and neurovascular coupling. Also covers design methods for stimulus-, task-driven and resting-state experiments, as well as workflows for model-based and data-driven analysis methods for data. Instruction in brain structure analysis and surface- and region-based analyses. Laboratory sessions include data acquisition sessions at the 3 Tesla MRI scanner at MIT and the Connectom and 7 Tesla scanners at the MGH/HST Martinos Center, as well as hands-on data analysis workshops.

Prerequisites: [18.05](#) (Introduction to Probability and Statistics), [18.06](#) (Linear Algebra), or permission of instructor. Introductory or college-level neurobiology, physics, and signal processing are helpful but not required.

Units: 2-3-7

Web site:

<https://learning-modules.mit.edu/class/index.html?uuid=/course/HST/fa17/HST.583>

Textbook: S. A. Huettel, A. W. Song, and G. McCarthy, *Functional Magnetic Resonance Imaging*, 3rd ed., Sinauer Associates, 2014.

Other recommended textbooks:

- R. B. Buxton, *Introduction to Functional Magnetic Resonance Imaging: Principles and Techniques*, 2nd ed., Cambridge University Press, 2009.
- F. G. Ashby, *Statistical Analysis of FMRI Data*, MIT Press, 2011.
- Todd Vanderah and Douglas Gould, *Nolte's The Human Brain: An Introduction to its Functional Anatomy*, 7th ed., Elsevier, 2015.
- M. A. Bernstein, K. F. King, and X. J. Zhou, *Handbook of MRI Pulse Sequences*, Elsevier, 2004.

- R. W. Brown, Y.-C. N. Cheng, E. M. Haacke, M. R. Thompson, and R. Venkatesan, *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, 2nd ed., Wiley-Blackwell, 2014.
- D. W. McRobbie, E. A. Moore, M. J. Graves, and M. R. Prince, *MRI from Picture to Proton*, 2nd edition, Cambridge University Press, 2007.
- R. A. Poldrack, J. A. Mumford, and T. E. Nichols, *Handbook of Functional MRI Data Analysis*, 1st edition, Cambridge University Press, 2011.

Grading: 40% homework assignments, 25% midterm exam, 25% final exam, 10% class participation.

Schedule:

Wed Sep 6	Sem	Brief introduction to course <i>Whitfield-Gabrieli / Polimeni / Yendiki</i>
	Lec	Introduction to fMRI — N.B. time: 2:30-4pm <i>Bruce Rosen</i>
Mon Sep 11	Lab	fMRI Experiment Lab: McGovern Imaging Center — N.B. room: 46-1164 <i>Atsushi Takahashi / Whitfield-Gabrieli</i>
	Lec	Neural Systems I <i>Brad Dickerson</i>
Wed Sep 13	Sem	Human subject safety, ethics, and privacy <i>Randy Gollub</i>
	Lec	Neural Systems II <i>Brad Dickerson</i>
Mon Sep 18	Lab	The life cycle of imaging data <i>Sonia Pujol</i>
	Lec	MRI Physics I <i>Larry Wald</i>
Wed Sep 20	Sem	Parallel imaging and Simultaneous Multi-Slice methods for fast fMRI <i>Kawin Setsompop</i>
	Lec	MRI Physics II <i>Larry Wald</i>
Mon Sep 25	Lab	TableTop MRI Physics Lab — N.B. room: 38-561z <i>Atsushi Takahashi / Giorgia Grisot</i>
	Lec	MRI Physics III <i>Larry Wald</i>
Wed Sep 27	Sem	Experimental design <i>Randy Gollub</i>
	Lec	Matrix algebra for fMRI data Primer <i>Doug Greve</i>
Mon Oct 2	Lab	Hands-on MR Physics: McGovern Imaging Center — N.B. room: 46-1164 <i>Atsushi Takahashi / Polimeni</i>
	Lec	Stats 1, Preprocessing <i>Doug Greve</i>

Wed Oct 4	Sem	Toward quantitative neuroimaging biomarkers <i>Randy Gollub</i>
	Lec	Stats 2, Time-series analysis I <i>Doug Greve</i>
Mon Oct 9		No Class (Indigenous People's Day)
Wed Oct 11	Sem	Big Data in neuroimaging <i>Satra Ghosh</i>
	Lec	Stats 3, Time-series analysis II <i>Doug Greve</i>
Mon Oct 16	Lab	Lab intro/Statistical analysis of fMRI data I <i>Yendiki / Houlihan</i>
	Lec	Stats 4, Group analysis I <i>Donald McLaren</i>
Wed Oct 18	Sem	Study design and power analysis <i>Mark Vangel</i>
	Lec	Stats 5, Group analysis II <i>Donald McLaren</i>
Mon Oct 23	Lab	Statistical analysis of fMRI data II <i>Yendiki / Houlihan</i>
	Lec	Mid-Term Exam
Wed Oct 25	Sem	Stats 7a, Seed-based resting-state connectivity <i>Whitfield-Gabrieli</i>
	Lec	Graph theory and Brain Network Analysis <i>Lisa Nickerson</i>
Mon Oct 30	Lab	Statistical analysis of fMRI data III <i>Yendiki / Houlihan</i>
	Lec	Stats 7b, Dynamic connectivity & Applications <i>Whitfield-Gabrieli</i>
Wed Nov 1	Sem	Inference from Connectivity: PPI & Causality <i>Donald McLarn</i>
	Lec	Stats 8, Preprocessing and exploratory analysis for resting state fMRI <i>Lisa Nickerson</i>
Mon Nov 6	Lab	Statistical analysis of fMRI data IV <i>Yendiki / Houlihan</i>
	Lec	Stats 9, Multiple subject ICA <i>Lisa Nickerson</i>
Wed Nov 8	Sem	Machine learning and multivariate pattern analysis for fMRI <i>Satra Ghosh</i>
	Lec	Stats 10, Non-parametric statistical analysis <i>Doug Greve</i>

Mon Nov 13	Lab	Functional Connectivity <i>Whitfield-Gabrieli</i>
	Lec	Stats 11, Computational modeling for fMRI <i>Poornima Kumar</i>
Wed Nov 15	Sem	Physio 3, Task related regional changes <i>Div Bolar</i>
	Lec	Physio 2, Neural activity, metabolism & blood flow in the brain <i>Div Bolar</i>
Mon Nov 20	Lab	Presurgical Mapping & Clinical decision making based on fMRI <i>Sonia Pujol</i>
	Lec	Physio 1, Cerebrovasc. anat. and neural regulation of CNS blood flow <i>Rob Barry</i>
Wed Nov 22	Sem	Physio 4, origins of BOLD contrast <i>Div Bolar</i>
	Lec	Physio 5, Non-BOLD measures of brain physiology & activity <i>Div Bolar</i>
Mon Nov 27	Lab	Quality Control for fMRI data <i>Whitfield-Gabrieli</i>
	Lec	Diffusion MRI <i>Yendiki</i>
Wed Nov 29	Sem	High-resolution spinal cord fMRI & DWI <i>Julien Cohen-Adad</i>
	Lec	Ex vivo MRI: Histological validation of structural data <i>Jean Augustinack</i>
Mon Dec 4	Lab	MGH 7 Tesla/Connectome scanner N.B. location: Charlestown Navy Yard, Bldg 149, Bay 5 <i>Yendiki / Polimeni / Giorgia Grisot</i>
	Lec	Spatial registr., normalization and surface-based anatomical analysis <i>Iman Aganj</i>
Wed Dec 6	Sem	PET-MRI synergy <i>Marco Loggia</i>
	Lec	Structure-function integration <i>David Salat</i>
Mon Dec 11	Lab	7T and Diffusion analysis <i>Yendiki / Houlihan</i>
	Lec	Multi-modal data fusion analyses <i>Lisa Nickerson</i>
Wed Dec 13	Sem	Future of spatial and temporal resolution in fMRI <i>Polimeni</i>
	Lec	Large-scale neuroimaging initiatives <i>Lisa Nickerson</i>
TBD		Final Exam