Graduate School of Public Health
Department of Epidemiology
Course Number: EPIDEM 2019

- Course Title: Introduction to Multimodal Neuroimaging
- Term/Academic Year: Spring 2020
- Dates: Fridays 11:00-1:10, SPRING, 2020
- Location: GSPH, Room A215 - Crabtree
- Credits: 2
- Course co-directors

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Summary of course:

Great advances in neuroimaging techniques allow unprecedented accuracy in visualizing molecular, cellular, and system physiology and functions. The Introduction to Multimodal Neuroimaging Course will teach the underlying principles of neuroimaging techniques, including data modeling and visualization. Special emphasis will be on the discussion of the strengths and limitations of each technique, and on novel approaches to utilize complementary imaging modalities. The course will utilize basic lectures and workshops that emphasize the integration of multiple imaging modalities.

The course has four components::

Neuroimaging lectures: lectures will allow students to learn the basic principles and required instrumentation for each imaging modality. For each neuroimaging modality, the following two components will be covered:

- Technology of acquisition, underlying physics with practical illustrations, and physiologic principles (e.g. cerebral blood flow, ligand/protein binding);
- Applications in current studies.

Workshops/Chalk talks: informal talks are led by PIs of multimodal neuroimaging studies with the goal to encourage students to discuss their multimodal independent projects. These *chalk talks (literally: talks while using chalk on a board!)* will demonstrate the synergy of multimodal neuroimaging protocols in ongoing studies. The students will participate by presenting their own multimodal project, thus engaging the entire class, the instructors, and the speaker in a creative discussion pertaining the importance of multiple complementary imaging modalities in science. Synergy with other methods will cover: structural MRI for registration of PET images, MEG/EEG for obtaining neural activity while improving spatio/temporal resolution, physiological and structural measures to characterize early stages of small vessel disease.

Journal club: Students' led discussion of recent papers as they pertain to their projects.

Presentation**:** Students will present their project during the last day of class.

Learning Objectives:

After this course, students will be able to:

- Compare the underlying principles, potential, and limitations of structural magnetic resonance imaging (MRI), diffusion tensor imaging (DTI), functional MRI (fMRI), positron emission tomography (PET), magnetoencephalography (MEG), electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), and optical imaging.
- Identify the main principles of paradigms' design, collection and processing of neuroimaging data.
- Present examples of multi-modal neuroimaging projects.

Textbook

No textbook required. Ad hoc literature will be provided by the lecturer in advance. Examples of relevant articles are provided below; however, given the fast pace of technological advancement in neuroimaging, it is likely that the list of articles will change from year to year.

Examples:
Int J Stroke. 2011 Feb;6(1):47-59. doi: 10.1111/j.1747-4949.2010.00552.x. Magnetic resonance imaging in cerebral small vessel disease and its use as a surrogate disease marker. Patel B[1], Markus HS.

Brain. 2011 Jun;134(Pt 6):1635-46. doi: 10.1093/brain/awr066. Epub 2011 Apr 13. Neuronal dysfunction and disconnection of cortical hubs in nondemented subjects with elevatedamyloid b urden.Drzezga A[1], Becker JA, Van Dijk KR, Sreenivasan A, Talukdar T, Sullivan C, Schultz AP, Sepulcre J, Putcha D, Greve D, Johnson KA, Sperling RA.

Neuroimage. 2014 Jan 15;85 Pt 1:6-27. doi: 10.1016/j.neuroimage.2013.05.004. Epub 2013 May 16. A review on continuous wave functional near-infrared spectroscopy and imaging instrumentation and methodology. Scholkmann F[1], Kleiser S, Metz AJ, Zimmermann R, Mata Pavia J, Wolf U, Wolf M.

Cereb Cortex. 2010 Sep;20(9):2055-68. doi: 10.1093/cercor/bhp280. Epub 2009 Dec 23. Life-span changes of the human brain white matter: diffusion tensor imaging (DTI) and volumetry. Westlye LT[1], Walhovd KB, Dale AM, Bjørnerud A, Due-Tønnessen P, Engvig A, Grydeland H, Tamnes CK, Ostby Y, Fjell AM.

Prerequisite/Recommended preparation
Instructor permission required. Students should contact the instructor to discuss the level of knowledge of brain structure and function.

Grading Scale:
Honors >75%, Satisfactory 50-75%, Unsatisfactory <50%

Student Performance Evaluation:

50% ***Poster*** – the poster will summarize the combined use of at least two imaging modalities to address a certain research question. A layout of the poster will be provided, to ensure the critical points will be addressed. Students will work in groups. Each group chooses the condition and the neuroimaging modalities. The goal of this assignment is to demonstrate that two modalities combined are necessary to advance the understanding of the pathophysiology of the chosen neurological/neurocognitive disease. Students will be assessed on the quality and completeness of the information provided in the poster. A first draft is due half-way through the course, after class #9. This draft is due to the instructors and peers. Final presentations are during the last class. Late assignment will be deducted 10 of the max 25 points.

Scores are weighted as follows:

Addresses the importance of using multimodal neuroimaging approach**= up to 25 points**

Contribution to the group project **= up to 25 points** (your contribution is scored by your team mates, see details below on how these points will be assigned)

50% ***In class participation.***

Scores are weighted as follows:

- Discuss the project during the chalk talks: Students will work in groups to present their multimodal project in class it is advised **= up to 10 points**
- Leading Journal Club **= up to 20 points**
- Providing written feedback to your peers' work **= up to 20 points**

How will we assess the contribution to the group project? The intellectual ownership and contribution for each member of the team must adhere to the ICMJE uniform requirements for manuscripts submitted to medical journals <http://www.icmje.org/> as follows:

1. Substantial contributions to conception and design of the proposal
2. Drafting the report or revising it critically for important intellectual content
3. Final approval of the version to be submitted.

General supervision of the research group does not constitute authorship. Each team member will email the instructors a score for each of the other team members, ranging from 0 (no contribution) to 25 (max contribution). This information will be used to compute the final grade. The instructors will consider these scores confidential.

Policy about attendance: Students are allowed one excused absence with advanced notice. Additional absences will need to be made up with a 2-page critical review of that session's readings. Early departure from class or late arrival will be accepted only if less than 10 minutes. Missing more than 15 minutes of class time will be accepted only if accompanied by an excuse, otherwise it will be marked as an absence.

CourseWeb/BlackBoard Instruction

The instructors may be using the University's CourseWeb (Blackboard) for instructional support: reading material will be available to the students prior to class. Students are expected to download reading material and handouts prior to each class.

Accommodation for Students with Disabilities

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, 412-648-7890 as early as possible in the term.

Academic Integrity

All students are expected to adhere to the school's standards of academic honesty. Cheating/plagiarism will not be tolerated. The Graduate School of Public Health's policy on academic integrity, which is based on the University policy, is available online in the Pitt Public Health Academic Handbook www.publichealth.pitt.edu/home/academics/academic-requirements. The policy includes obligations for faculty and students, procedures for adjudicating violations, and other critical information. Please take the time to read this policy.

Sexual Misconduct, Required Reporting, and Title IX

The University is committed to combatting sexual misconduct. As a result, you should know that University faculty and staff members are required to report any instances of sexual misconduct, including harassment and sexual violence, to the University's Title IX office so that the victim may be provided appropriate resources and support options. What this means is that as your professor, I am required to report any incidents of sexual misconduct that are directly reported to me, or of which I am somehow made aware.

There are two important exceptions to this requirement about which you should be aware:

A list of the designated University employees who, as counselors and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: www.titleix.pitt.edu/report/confidentiality

An important exception to the reporting requirement exists for academic work. Disclosures about sexual misconduct that are shared as part of an academic project, classroom discussion, or course assignment, are not required to be disclosed to the University's Title IX office.

If you are the victim of sexual misconduct, Pitt encourages you to reach out to these resources:

- Title IX Office: 412-648-7860
- SHARE @ the University Counseling Center: 412-648-7930 (8:30 A.M. TO 5 P.M. M-F) and 412-648-7856 (AFTER BUSINESS HOURS)

If you have a safety concern, please contact the University of Pittsburgh Police, 412-624-2121.
Other reporting information is available here: www.titleix.pitt.edu/report-0

Schedule of Sessions and Speakers

DATE 2020			TOPIC	Speakers
	wk	date		
	1.	1/10	Introduction, Basics of MRI I **JOURNAL CLUB**	Rosano/Huppert
	2.	**1/17**	Basics of MRI II	Huppert
	3.	**1/24**	Structure I (T_1, T_2, ultra-high field).	Howard J Aizenstein, MD, PhD Psychiatry, Pitt, CNBC Director, Geriatric Psychiatry Neuroimaging Laboratory haizenstein@gmail.com
	4.	**1/31**	Principles of BOLD response and functional connectivity	Huppert
	5.	**2/7**	fMRI task-related **JOURNAL CLUB**	Kirk Erickson, Ph.D. Psychology, Pitt, CNBC Director, Brain Aging & Cognitive Health Lab kiericks@pitt.edu
	6.	**2/14**	PET	Charles Laymon, PhD Physicist and Assistant Professor of Radiology laymoncm@upmc.edu
	7.	**2/21**	Structure II (Diffusion weighted imaging to measure connectivity).	Fang-Cheng (Frank) Yeh, MD, PhD Neurological Surgery Director, Fiber Tractography Lab frank.yeh@pitt.edu
	8.	**2/28**	MEG and EEG	Avniel Singh Ghuman, PhD Director, MEG Research Lab asg50@pitt.edu
	9.	**3/6**	fNIRS **JOURNAL CLUB**	Huppert ***1st draft of the poster due today***
	3/13		WEEK OF SPRING BREAK – NO CLASS	
	10.	**3/20**	**Topics' Revisions** **Chalk Talk**	Huppert /Rosano *Return your critique of your peers' posters* *(each person reviews 2 posters)* *(each group will receive reviews from 6 peers and the instructor)*
	11.	**3/27**	**chalk talk**	Finnegan Calabro, PhD Assistant Professor of Psychiatry and Bioengineering Co-Director, Neurocognitive Development Lab FJC20@pitt.edu
	12.	**4/3**	**chalk talk**	Ann D. Cohen, PhD Assistant Professor of Psychiatry, ADRC Imaging Core Director cohenad@upmc.edu
	13.	**4/10**	**chalk talk**	*Cecile D Ladouceur, PhD* Director, Cognitive-Affective Neuroscience & Development Lab ladouceurcd@upmc.edu
	14.	**4/17**	**Poster presentation** **Retreat**	**students, instructors**

- Basics of MRI I and II: Overview of physics, MRI hardware and software. Anatomical localization via use of atlases (e.g,Talairach, MNI) will be covered. Safety issues surrounding the magnetic environment and human subject preparation will be discussed.

- Structure I: The basics of MRI will be covered, including T_1, T_2, and T_2* contrast mechanisms, optimization of sensitivity and contrast, and common image artifacts. Additionally, we will demonstrate specialized MRI techniques including fluid-attenuated inversion recovery (FLAIR). Basic anatomical MRI image post-processing techniques will be discussed, including segmentation, co-registration, brain normalization for across-subject comparison, correction of shape distortions due to magnetic field inhomogeneity, quantitative brain morphometric, 3-D rendering, and susceptibility weighted imaging. Examples will include images acquired with 3 and 7 Tesla scanners.
- Structure II: The lecture will cover the principles of diffusion-weighting, DTI, validities, limitations, and future directions. The use of commercial software packages for visualizing fiber connectivity will be described.
- Principles of BOLD response and functional connectivity. - The lecture will cover the basic principles of the hemodynamic response, with implications to quantify resting state connectivity.
- Functional MRI- task related. The lecture will cover the nature of BOLD response, optimizing pulse sequences for signal/contrast, inhomogeneity, and temporal/spatial resolution in relationship to task-related paradigms. Experimental design will be introduced, including block and event designs, within and between subject designs, and specialty designs (habituation, phase lag).
- Positron Emission Tomography (PET). Overview of physical principles, PET instrumentation, data acquisition, quantitative corrections (e.g. scatter, attenuation), and image reconstruction methods. Physiologic principles will be discussed to measure cerebral blood flow, cerebral glucose metabolism, ligand/protein binding, and amyloid.
- Functional near-infrared spectroscopy (fNIRS). Principles of data acquisition and interpretation of continuous wave, frequency domain, and diffuse correlation spectroscopy forms of fNIRS using commercially available as well as custom-built NIRS instruments. Data processing will be discussed, including image reconstruction of optical data.