

Graduate School of Public Health

Department of Epidemiology

Course Number: EPIDEM 2019

- Course Title: Introduction to Multimodal Neuroimaging
- Term/Academic Year: Spring 2022
- Dates: SPRING, 2022; **Mondays 11:00-1:00**

Location: ZOOM

- 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 focus on the integration of multiple imaging modalities.

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; nanomolecules, photoacoustic)
- Applications in current studies.

Presentations: Students will present their project during the last 2 weeks 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 B¹, 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 elevated amyloid burden. Drzezga A¹, 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 F¹, 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 LT¹, 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; the students are required to follow this layout. Students may work in groups. 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 on 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.

The focus of this course is on neuroimaging, hence most of the points to your project pertain multimodal neuroimaging considerations; accordingly, neuroimaging should be featured prominently in the background, significance and impact.

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 teammates, see details below on how these points will be assigned)

50% In class participation.

Scores are weighted as follows:

- Ask questions, either by email or in person= **up to 30 points**
- Providing written and oral feedback to your peers' work = **up to 20 points**

How will you 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.

Canvas

The instructors may be using the University's Canvas 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. We will use a password protected Shared folder. It is the students' responsibility to check that class material is being uploaded.

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

Diversity Statement

The University of Pittsburgh Graduate School of Public Health considers the diversity of its students, faculty, and staff to be a strength and critical to its educational mission. Pitt Public Health is committed to creating and fostering inclusive learning environments that value human dignity and equity. Every member of our community is expected to be respectful of the individual perspectives, experiences, behaviors, worldviews, and backgrounds of others. While intellectual disagreement may be constructive, no derogatory statements, or demeaning or discriminatory behavior will be permitted.

If you feel uncomfortable or would like to discuss a situation, please contact any of the following:

- the primary course instructor or course director;
- the [Pitt Public Health Associate Dean responsible for diversity & inclusion](#)
- the University's Office of Diversity and Inclusion at 412-648-7860 or www.diversity.pitt.edu/make-report/report-form (anonymous reporting form).

Schedule of Sessions and Speakers

Week/date 2022	TOPIC	How to prepare for this class ?	Speakers
1. 1/10	Introduction to course Applications in a multimodal study	Watch Video on Functional Neuroanatomy; Read Papers on designing Population Neuroscience studies	Rosano
1/17	Martin Luther King, Jr. Holiday		
2. 1/24	Principles of MRI	Slides and papers	Huppert
3. 1/31	Structure I- GM regions (T ₁ , T ₂ , ultra-high field)	Slides	Minjie Wu, PhD miw75@pitt.edu T. S. Ibrahim, PhD tibrahim@pitt.edu
4. 2/7	Perfusion and Neurovascular coupling	Slides	Huppert
5. 2/14	Structure II- WM tracts Diffusion tensor (1hr) Resting state (1hr)	Slides - Review on GRAPH	A Versace, MD amv29@pitt.edu J. Hengenius, PhD, James.Hengenius@pitt.edu
6. 2/21	fNIRS – physics (1hr) Applications in a multimodal study (1hr)	Slides	Huppert Rosano
7. 2/28	fMRI task-related (1hr) Overview of neuroenergetic methods (1hr)		M. Coutanche, PhD, marc.coutanche@pitt.edu Rosano
8. 3/7	Spring Break 3/6 – 3/13		
9. 3/14	MEG (1hr) EEG (1hr)	Slides	A. S.Ghuman, PhD asg50@pitt.edu D. F Salisbury, PhD, salisburyd@upmc.edu
10. 3/21	PET Physics (1hr) Applications in a multimodal study (1hr)	Slides	C Laymon, PhD laymoncm@upmc.edu F. Calabro, PhD fjc20@pitt.edu
Mid-term paper due. email first draft of poster today by 5 PM			
11. 3/28	MRS	Slides	Claude
<i>Return your critique of your peers' posters (each person reviews 2 posters) email the instructors (filename "poster#_your initials") (each group will receive critiques from 4 peers and the instructors)</i>			
12. 4/4	Topics revision /Small group discussion		Rosano/Huppert
13. 4/11	Topics revision /Small group discussion		Rosano/Huppert
14. 4/18	Multimodal: In vivo and postmortem comparisons	Slides	Julia Kofler, MD jkofler@pitt.edu
15. 4/25	Posters' Presentation		

- 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.