WESTERN UNIVERSITY
LONDON CANADA
Department of Psychology
2025-2026

Psychology 9223
Neuroimaging of Cognition
Winter 2025

1.0 CALENDAR DESCRIPTION

Brain imaging, particularly functional magnetic resonance imaging (fMRI) and more recently functional near-infrared spectroscopy (fNIRS) have become common tools to study human brain regions and networks involved in cognitive functions. The course will be comprised of a combination of lectures and tutorials. The lectures will cover brain imaging technology, current techniques for experimental design and analysis, and a discussion of the merits and limitations of neuroimaging as a tool for understanding human brain function. By the end of the class, students should be able to read, understand, and critique papers in brain imaging and have a sufficient foundation to begin to use fMRI or fNIRS as a tool in their own research.

Prerequisites: Formally none, though some background in psychology, neuroscience, and basic statistics (correlations, *p* values, *t* tests, ANOVAs) will be assumed.

Enrollment in this course is restricted to graduate students in Psychology and Neuroscience, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

2.0 COURSE INFORMATION

Instructor: Dr. Jody Culham

Office: Western Interdisciplinary Research Building 4118
Phone Number: 519-661-3979
E-mail: jculham@uwo.ca
Office Hours: By appointment through http://jodyculham.youcanbook.me/

Teaching Assistant: To be determined
Office Hours: By appointment
Email: To be determined

Lectures: Mondays 11:30 am – 1:30 pm, WIRB 1110 (in-person)
Tutorials: Thursdays 2:30 - 4:30 pm, WIRB 1110 (in-person)

3.0 TEXTBOOK AND SOFTWARE

Free drafts of chapters of the following textbook will be made available. Suggestions and corrections about textbook drafts will be most welcome.

> Culham, J. C. & Goebel, R. (In preparation). *A Practical Handbook for fMRI Analysis and Design*. Psychology Press (Taylor & Francis).

Additional optional course readings will also be provided on Dropbox in pdf format.

Western BrainsCAN Transforming brain research.

Resources for data collection and tutorial development were generously provided by the Canada First Research Excellence Fund (CFREF) BrainsCAN grant to Western and by Jody Culham's unrestricted funds. [*http://www.uwo.ca/brainscan/*](http://www.uwo.ca/brainscan/)

BrainVoyager

Tutorials will utilize a free educational version of BrainVoyager, BrainVoyager EDU (for Mac or PC) that works with the teaching data set. A download link will be provided once BV EDU has incorporated the course data.

Tutorials are found at https://www.newbi4fmri.com/

You will need a non-crappy computer (i.e., no netbooks or tablets) but the most computationally intensive steps will have been run for you. If necessary, external hard drives with data can be provided.

Although the course utilizes BrainVoyager EDU, this is NOT a course on how to use BrainVoyager. The emphasis is on concepts that generalize across software platforms.

4.0 COURSE OBJECTIVES & LEARNING OUTCOMES

- To provide students with a critical overview of how brain imaging research can contribute to cognitive neuroscience research.
- To provide students with a strong foundation in understanding the logic of the General Linear Model (GLM) for statistical analysis, particularly for brain imaging data
- To use the GLM logic as a foundation for understanding the effects of artifacts, preprocessing, choice of model parameters, and experimental design
- To provide students with sufficient understanding of neuroimaging approaches that they can read and critique articles on the topic and make appropriate choices regarding experimental design and analysis
- To give students a conceptual understanding of the technical details of fMRI (like MR physics, the BOLD response, and preprocessing steps) without requiring a strong background in physics, biology, or mathematics.
- To give students a hands-on understanding of brain imaging analysis, with an emphasis not on "which buttons to push" in any particular software package but rather on why one might make certain decisions about design and analysis regardless of the software.
- To foster skills in critical thinking, project selection and refinement, hypothesis generation, hypothesis testing, and oral presentations

5.0 EVALUATION

Students will complete hands-on tutorials that reinforce their understanding of concepts from the lectures. Each student will get a free copy of BrainVoyager EDU software for their preferred computer (typically their own laptop/desktop). Data will be downloadable online (or on request, may be provided on an external drive). Students will complete tutorials in a weekly session where the professor will be available to answer questions and provide guidance. The tutorials aim to teach general concepts in fMRI data analysis rather than platform-specific steps.

Material from the tutorials (based on lectures and readings) will be tested in two tests.

Class Participation: 5%

1/5 attended sporadically
2/5 attended regularly
3/5 attended regularly; occasionally asked questions or contributed to discussion
4/5 attended regularly; frequently asked questions or contributed to discussion
5/5 attended regularly; regularly made insightful contributions to questions and discussions

Two Tests: 2 x 20%

Short answer, multiple choice, true/false, fill in the blank, definitions
1 hour each

Final Project Proposal:10%
Final Project Presentation: 45%

Each student will work alone or in a team (up to 4 people) to do one of the following projects:

1) Write a proposal for an fMRI project. The project **can not** be part of the student's thesis or other coursework.
2) Perform an analysis of the course data, justifying choices about analysis strategy and preprocessing steps.
3) Analyze existing data (e.g., from the human connectome project or other extant data from your supervisor). The analysis **can not** be part of the student's thesis or other coursework.
4) Develop a new teaching module to highlight key issues in fMRI/fNIRS design and analysis. Tutorials should provide step-by-step instructions to teach specific theoretical concepts using actual data, with more of an emphasis on foundational ideas rather than "which buttons to click." As one example, a tutorial may include a new module that could be given as an optional assignment for students in future years (e.g., analyzing DTI data). As another example, a tutorial may convert an existing tutorial in Brain Voyager into a different software platform (SPM, FSL, AFNI). Tutorials should include an assignment to gauge whether tutees have successfully mastered core concepts. The professor and TA will be available to provide assistance and advice with concepts, software, and development.

The scope of the projects should be commensurate with the number of team members. Tutorials may be adapted for future classes and for www.fMRI4newbies.com, with appropriate credit to the developers; thus submission of a tutorial includes consent for this. Grading will be based on the demonstrated mastery of the key concepts and will take into consideration the students' level of past fMRI experience.

Students whose projects involve data analysis in BrainVoyager (EDU or regular version), especially for non-course data, should consult the professor early about the steps needed to convert and process the data.

A brief (1-page, single-spaced) proposal will be due midway through the course to ensure students start planning projects with ample time for completion.

The final project will be presented in a presentation of up to 15 minutes, followed by a live question and answer period with the professor and TA. Presentation grade will be based on the demonstration of mastery of fMRI design and analysis concepts (70/90 points) and the quality of the presentation (20/90 points).

If students use generative AI (e.g., ChatGPT) on the assignment, they must append a brief statement disclosing how they used it. Students take ultimate responsibility for the content they submit. If inappropriate use is suspected, the student will be interviewed by the professor and asked to demonstrate an understanding of the content. See Section 9.0 below.

Grading

<=78	Disappointing
79-81	Okay
82-83	Solid
84-86	Good – typical of expectations for average graduate student (without grade inflation)
87-88	Great
89-90	Excellent
91-94	Outstanding
>=95	Walks on water, stops speeding locomotives with mind power alone, should be teaching the course instead of Dr. Culham

6.0 EVALUATION SCHEDULE

Test 1	Thurs. Oct. 30
Test 2	Thurs. Dec. 4
Proposal	Fri. Nov. 21
Presentation	Dec. 16

7.0 LECTURE AND TUTORIAL SCHEDULE

Date	**Topic**
Mon. Sept. 8	Organizational Meeting; Course format and expectations; Why fMRI?
Thurs. Sept. 11	*Refresher: Thinking About Stats Intuitively*
Mon. Sept. 15	Lecture 1: Basics of fMRI and data structures; Course experiment (Ch. 2)
Thurs. Sept 18	*Tutorial 1: fMRI data structures*
Mon. Sept. 22	No lecture: Prof away
Thurs. Sept 25	*No tutorial*

Mon. Sept. 29	Lecture 2: fMRI Statistics and Maps (Ch. 3)
Thurs. Oct. 2	*Tutorial 2: fMRI Statistics and Maps*
Mon. Oct. 6	Lecture 3: The General Linear Model (Ch. 4)
Thurs. Oct. 9	*Tutorial 3: General Linear Model (single participant)*
Mon. Oct 13	No class (Thanksgiving)
Thurs Oct. 16	*No tutorial*
Mon. Oct. 20	Lecture 4: fMRI preprocessing and quality assurance (Ch. 5)
Thu. Oct. 23	*Tutorial 4: Statistical corrections (Multiple comparisons; Temporal autocorrelation)*
Mon. Oct. 27	Lecture 5: Experimental Design: Conditions (Ch. 7); Details about Course Projects
Thurs. Oct. 30	*Test on Tutorials 1-4 (20%); Tutorial 5: fMRI preprocessing and quality assurance: Motion artifacts*
Mon. Nov. 3	No lecture (Reading Week)
Thu. Nov 6	*No tutorial (Reading Week)*
Mon. Nov. 10	Lecture 6: Experimental Design: ROI vs. Voxelwise Approaches; Non-independence issues
Thurs. Nov.13	*Tutorial 6: fMRI preprocessing and quality assurance: Spatiotemporal smoothing*
Mon. Nov. 17	Lecture 7: Experimental Design: Timing (Ch. 8)
Thurs. Nov. 20	*Tutorial 7: Event-related designs; event-related averages, deconvolution*
Fri. Nov. 21	*Final project proposal due (10%)*
Mon. Nov 24	Lecture 8: Group data (Ch. 6)
Thurs. Nov. 27	*Tutorial 8: Spatial normalization and group GLM*
Mon. Dec. 1	Lecture 9: Multivoxel pattern analysis (MVPA)
Thurs. Dec. 4	*Test on tutorials 5-8 (20%); Tutorial 9: Multivoxel pattern analysis (MVPA)*
Mon. Dec. 8	Lecture 10: Independent Component Analysis, Connectivity and Resting State
Thurs. Dec 11	*Tutorial 10: ICA, Connectivity and Resting State*
Mon. Dec 15	Lecture 11: Enough MRI Physics to Talk to your MR Tech; Neural Basis of BOLD
Tues. Dec. 16	*Final project presentations (45%)*

9.0 STATEMENT ON ACADEMIC OFFENCES

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf
Additionally, if written work will be assigned in the course and plagiarism-checking software might be used, the following statement to this effect must be included in the course outline:

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

For the purposes of this course projects, the following are NOT allowed:

- The utilization of resources (including wording) developed by others without appropriate attribution (if you don't understand what plagiarism is, find out and make sure you don't do it). This includes copying methods from other papers. It is better to propose simple, modern methods that you understand than to copy a complex, possibly outdated, approach from a published paper.
- The utilization of work done towards the student's thesis or other courses for credit in this course. This does not preclude later benefits to students' proposals from the work done for this course; for example, students in past years have written project proposals and later decided to actually conduct the study.
- The utilization of ideas discussed in depth with colleagues or supervisors without due credit.

Students may use Generative AI (e.g., ChatGPT) as an aid during preparation of the proposal and presentation (e.g., to improve wording); however, students must take ultimate responsibility for the content, including accurate citations, design and analysis choices that reflect course content, and a key role in idea generation if proposing a new experiment. If students use generative AI on the assignment, they must append a brief statement disclosing how they used it. As specified in Western's policies, "Graduate students must be prepared to defend all aspects of their work, including those produced using generative AI." See https://grad.uwo.ca/about_us/policies_procedures_regulations/ai.html

If in doubt, consult the professor early.

10.0 HEALTH/WELLNESS SERVICES

Students who are in emotional/mental distress should refer to Mental Health@Western http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.

11.0 ACCESSIBLE EDUCATION WESTERN (AEW)

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program.

Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW), a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.