Online Research Seminar Syllabus

1. Overview

Title	**Introduction to neurotechnology**		
Mode	Online lectures and mentor sessions		
Targeted Students	Students interested in understanding how the brain works, the new applications for interacting with the brain, including brain-computer interfaces, and the relationship between biological and artificial intelligence		
Prerequisites	**High School Students**	Required course/ Knowledge	Math, Chemistry, Physics
		Recommended Materials for preparing for the course	None - course materials will be provided
	College Students	Required course/ Knowledge	Math, Chemistry, Physics
		Recommended Materials for preparing for the course	None - course materials will be provided

2. Program Introduction and Objectives

Course Description	Existing treatments for neuropsychiatric disease have limited efficacy. Neurotechnology aims to develop brain-computer interfaces that can reprogram neural circuitry, opening novel treatment paths. This class will teach the basics of neuroscience and provide a grounding in how brain-computer interfaces work and how they may change humanity in the coming decades. This class will provide students with a solid grounding in neuroscience, and they will learn some of the latest advances in this rapidly developing field. Brain-computer interfaces are a fundamental part of the emerging field of neurotechnology. New companies, such as Neuralink funded by Elon Musk, are focused on developing these technologies. Students will have the advantage of understanding the essentials of this brand new, exciting field.
Software/Tools (if any)	None needed

3. Program Schedule

Week		Lecture	Mentor Session (lab/case study, etc)	Assignment	Reading Materials
1	Topic	**How neurons work**	Membrane potential, neuronal cell dynamics, neural communication	Homework 1	Lecture notes, articles
	Detail	Explain membrane biophysics, action potentials, and neurotransmitters			
2	Topic	**Neural plasticity**	Hebbian synapse, long- term potentiation, optogenetics	Homework 2	Lecture notes, articles
	Detail	Explanation of neural plasticity at both the cellular and systems level			
3	Topic	**Sensorimotor processing**	Cochlear implants, Parkinson' s Disease, deep-brain stimulation	Homework 3 Form project groups	Lecture notes, articles
	Detail	Introduction to neural coding and the way in which neural recording and stimulation can meaningfully interact with this code			
4	Topic	**Neurotechnology and artificial intelligence**	Brain- computer interfaces, biological and artificial learning	Homework 4	Lecture notes, articles, final project guidance
	Detail	Neurotechnology for the clinic, neurotechnology tools, reinforcement learning, neural networks, ethical issues			
5	Topic	**Final Project Phase I**			
	Detail	• **Final Project Milestone:** Discuss project scope and background information • **Things to do during the class and arrangement** : Students should prepare a ~5 min presentation with few slides to describe the aims of their project and the proposed source materials. • • •			
6	Topic	**Final Project Phase II**			
	Detail	A) **Final Project Milestone:** Discuss initial findings and goals B) **Things to do during the class and arrangement** : Students should have a draft of their final presentation prepared. We will go through the draft slides in class. C)			
7	**Final Written Abstract and Oral Presentation**				

4. Problem Sets/Written Assignments/Quizzes

Total Number of Assignments	**4 assignments**	
Weekly Assignment Submission Deadlines	5 Days after the distribution/ announcement	
Will mentor grade assignment?	Yes (x)	No ( )
Will a standard answer be provided?	Yes (x)	No ( )
Will there be Quizzes? How often/how many?	No	
Other Requirements (if any)	None	

5. Final Oral and Written Project

The final project will consist of both oral and written components. Students will be organized into groups to work on the oral presentation, while the written component will be individual work. Students are required to work in **groups of 3** for the oral presentation. In special circumstances (odd number of students in class, large-scale effort), students may work in a group of 2 or 4. All groups require justification and clear delineation of team member responsibilities as to ensure substantially equal and fair division of effort in the class.

Project will be defined in week 4, and students shall make and declare teaming arrangements by week 3. Projects will include detailed phase-1 and phase-2 week-long milestones. Project will also include a presentation guideline, which will be discussed in week 4. Students will present their phase-1 results in week 5, phase-2 results in week 6, and overall summary of the project in week 7. Presentations in week 5, 6, and 7 will be in accordance with the presentation guideline provided in week 4. Presentations in weeks 5, 6, and 7 will be due 10 hours before the class. In week 7, students will also need to submit a final written abstract of their project. Additionally, each student will be required to submit a paragraph of key lessons learned in the 7-week study program including the group project.

5.1. Final Project:

Final Project Theme: The projects are open-ended, and students may choose a topic that most closely aligns with their interests and learning objectives. Topics covered in the lectures will serve as a pool of project seedling ideas.

The following is a list of example topics for the final project:

1. The pros and cons of biological and artificial intelligences.
2. An analysis of how control theory and hierarchical organization are relevant to our understanding of neuroscience.
3. A summary report on the ethical challenges posed by neurotechnology.
4. A report on how brain-computer interfaces may be expanded from their current focus on motor control.

Note: Students are free to choose one of the above topics, or they are welcome to propose one of their own in consultation with the Professor.

Final Project Format: Students are required to produce a PowerPoint presentation in weeks 5, 6, and 7, to discuss their progress and final report. Presentation template will be provided in week 3, as stated above. Additionally, each student will be required to submit a paragraph of key lessons learned in the 7-week study program including the group project.

Final Project Requirements: Follow project guidance (provided in week 4).

5.2. Oral Presentation

Oral Presentation Requirements: Stay within time limits, be clear, answer questions convincingly, follow the structure of the final project report. Students will be provided with a presentation template and guideline for delivering effective presentations.

6. Evaluation

20% of the grade will be in-class participation
40% of the grade will be continuous in-class assessment
40% of the grade will be a final report (Oral: 25%; Written: 15%)

7. Suggested Future Research Fields/Direction/Topics

Neurotechnology is a new and exciting field that promises to impact multiple areas of science, with biomedical, neuropsychiatric, and cognitive enhancement applications. Students are encouraged to keep an eye out for studies that are reported in research articles (particularly *Science*, *Nature*, *Nature Neuroscience*, and *Neuron*) as well as the broader media. The primary areas of research going forward center around brain-computer interfaces, but there is also a lot of cross-talk with the field of artificial intelligence and deep reinforcement learning.

8. Instructor Introduction

8.1 Instructor Title: Professor Joni Wallis

8.2 Instructor Bio

Dr. Wallis is a Professor at the University of California, Berkeley in the Department of Psychology and the Helen Wills Neuroscience Institute. Dr. Wallis received a Ph.D. in Anatomy from the University of Cambridge and did her postdoctoral work in the lab of Dr. Earl Miller at the Massachusetts Institute of Technology. Her research has focused on understanding the functional organization of the frontal lobe at the single neuron level and how it relates to decision-making. Her lab specializes in high-channel count recordings of electrical activity from multiple individual neurons throughout the frontal cortex and determines the information encoded by those neurons. Her research uses techniques derived from the brain-machine interface literature, such as real-time decoding and closed-loop microstimulation, with the goal of developing novel treatments for neuropsychiatric disorders that involve impaired decision-making including addiction, obsessive-compulsive disorder, and schizophrenia.