**Brain Science and AI course final project**

**Overview**

The final project will consist of a small research project on a topic related to computational neuroscience and the application of AI to brain science. You will conduct either **original data analysis/modeling work** or provide **an in-depth exposition of a related topic**, culminating in an oral presentation.

**Project Structure**

**Groups**: 1- 5 people

**Project presentation** (final weeks of class): Time for each team depends on total number of projects.

**Key principle**: Keep your scope manageable - not too broad, not overly complicated!

**Projects types:**

1. **Data analysis and modeling:**

**Description:** Choose a computational neuroscience or NeuroAI topic that are based on or extend our class material. Conduct original modeling work, simulations, or data analysis.

**Example topics (based on course tutorials):**

Build upon GLM, CNN, RNN, or network analysis tutorials with new applications

**Neural coding extensions**: Apply GLMs or encoding models to datasets (e.g., Allen Brain Observatory, IBL data, or other publicly available neural data)

**Representation analysis**: Use dimensionality reduction or representational similarity analysis on neural or artificial neural network data

**NeuroAI comparisons**: Compare representations between brain areas and artificial neural networks (e.g., using CNN or other models)

**Dynamical systems modeling**: Implement state-space models, HMMs, or RNN dynamics for neural data analysis.

**Brain network analysis**: Apply graph theory methods to connectome data or functional connectivity

**Generative modeling**: Use generative models to understand neural population activity or sensory processing

**Suggested approach:**

Start with tutorial provided in class or an open Github repo with analysis or modeling code.

Implement a core component of the model/analysis.

Apply it to relevant data or extend it in a novel direction.

Generate insights through systematic exploration of model behavior or data patterns.

1. **Research summary:**

Provide an in-depth, didactic explanation of a computational neuroscience or NeuroAI topic that extends beyond our class coverage (no modeling is necessary).

**Example topics:**

**Advanced neural coding theories**: Information bottleneck, predictive coding, or Bayesian brain hypotheses

**Cutting-edge NeuroAI methods**: Foundation models for neuroscience, neural latent models, or brain-inspired AI architectures

# Theory deep dives: Efficient coding theory, criticality in neural networks, or continual learning in biological systems

**Methodological expositions**: Advanced dimensionality reduction techniques, causal inference in neuroscience, or modern experimental methods (optogenetics, calcium imaging analysis)

**Cross-disciplinary connections**: Quantum approaches to consciousness, information geometry in neural coding, or developmental neuroscience modeling

**AI agent for neuroscience**

**Suggested approach:**

Create explanatory diagrams where helpful.

Break down mathematical concepts step-by-step.

Provide intuitive explanations alongside formal descriptions.

Connect the topic to themes from our class.

**Data Resources**

You are encouraged to use real neural data for modeling projects:

**Allen Brain Observatory**: Visual cortex recordings during behavioral tasks

**International Brain Laboratory (IBL)**: Standardized decision-making task data across labs

**Primate datasets**: Available through various repositories (see Week 2 tutorial materials)

**Public repositories**: CRCNS, DANDI, or other open neuroscience datasets

**Evaluation Criteria**

Your project will be assessed on your ppt and presentation:

**Proper citation of sources:** figures and quotes need proper citation

**Logic and reasoning:**

**Clarity of communication**: Presentation quality

**Scope management**: Appropriate depth for the time constraints

**Quality**: Validity of analysis and visualization (for Type A) / novelty and importance (for Type B)

**Technical rigor**: Appropriate use of computational methods and mathematical understanding

**Timeline and Milestones**

**Topic proposal due**: Week 8 (11/6) - settle down team arrangement

**Progress check-in**: Week 11 (11/27) - progress check by TA

**Final presentations**: Weeks 14-15 (12/18 and 12/25)

**Additional Notes:**

Start thinking about projects early - good computational neuroscience projects require time for both understanding and implementation.

Remember that negative results or unexpected findings can be just as valuable as confirmatory results - focus on clear methodology and honest interpretation.