Neural Network Models of Social and Cognitive Processes
Psych 450L, Fall 2013
TTh 10-11:50AM, SGM 718

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Overview
The goal of computational neuroscience is to understand how neural processes give rise to cognition, motivation, and emotion. This course introduces students to basic concepts and tools in computational neuroscience (Neural Network Models) through a combination of lectures, weekly homework exercises, and a final project selected by students in their own area of interest.

Goals: How does the brain perceive, want, feel, and think? This course will introduce you to the ideas and methods in computational cognitive and social neuroscience that have been applied to answering this question. Specifically, we focus on simulating cognitive, perceptual, emotional and motivational processes using neural network models, which provide a bridge between behavioral and biological levels of analysis. A core set of computational principles based on well-established properties of neural processing in the cortex will be introduced and used throughout the course to account for a wide range of cognitive, emotional, and motivational phenomena. This focused and unified approach makes potentially difficult material easier to learn, and allows us to explore more complex and interesting phenomena. We start by understanding the basic computational and biological properties of individual neurons and networks of neurons, which give rise to basic processing mechanisms like spreading activation, inhibition, and multiple constraint satisfaction. We then discuss learning mechanisms (Hebbian, error-driven, reward learning), which all networks of neurons require to perform any reasonably complex task. We then examine a range of phenomena within this framework, including attention, memory, language, higher-level cognition, motivation, emotion, and personality.

Grads & Undergrads: This course is designed for advanced undergraduates and graduate students. Undergrads need not feel intimidated by the presence of graduate students in the class. More will be expected of the grads than the undergrads, especially when it comes to the final projects. Also, undergrads will be responsible for fewer of the homework questions.

Requirements: The course is geared toward students with a strong background in psychology and/or neuroscience. Prior exposure to basic concepts in cognitive psychology and neuroscience is essential for this course. The course prerequisites are Introduction to Psychology (Psyc 100) or permission of the instructor. The models used in the course are mathematically based, but only algebra and some simple calculus-level concepts are required. The focus will be on intuitive and practical applications, not on theoretical derivations. Computer programming experience is not required, because the models are accessible via a graphical interface.

Text: The text is a wiki based 2nd edition of the original text, *Computational Explorations in Cognitive Neuroscience, Understanding the Mind by Simulating the Brain* by Randall C. O'Reilly and Yuko Munakata (MIT Press, 2000). It can be accessed at: **http://grey.colorado.edu/CompCogNeuro/index.php/CCNBook/Main**

You can download a pdf of the latest version of the book from the above link or you can buy a Kindle version of it from Amazon for $.99.

This is an excellent book that stands out from other neural network text in that it integrates the introduction of basic concepts with hands-on exercise.

It is also essential that you download the simulation environment*, Emergent,* for your computer and specific operating system from http://grey.colorado.edu/emergent no later than the first week of school. The exercises and simulations for this course can be downloaded at: http://grey.colorado.edu/CompCogNeuro/index.php/CCNBook/Sims/All

Journal articles that describe particular models will also be assigned each week during the latter part of the class. The particular articles we cover will partially depend upon the interests of the class.

Reading/Writing Assignments: In weekly assignments, students will learn how to build neural network models using a powerful and intuitive neural network software package*, Emergent.* Students will also complete simulation exercises where they explore the properties of various pre-built models of cognitive phenomena. For their final project, students will develop a neural network model that addresses some psychological phenomenon of interest to them, and write up the results of these simulations.

Organization: The course is divided into two parts: (1) introduction to basic concepts and tools in computational neuroscience; (2) application of concepts and tools to the understanding of specific brain functions.

Computational Cognitive Neuroscience

1. Introduction
CCNBook/Intro

Part I -- Basic Computational Mechanisms ***(lectures and weekly homework exercises)***

2. The Neuron
CCNBook/Neuron
CCNBook/Neuron/Biology
CCNBook/Neuron/Electrophysiology

3. Networks
CCNBook/Networks

4. Learning Mechanisms
CCNBook/Learning

Part II -- Cognitive Neuroscience ***(lectures, student project development and presentations)***

5. Brain Areas
CCNBook/BrainAreas

6. Perception and Attention
CCNBook/Perception

7. Motor Control and Reinforcement Learning
CCNBook/Motor

8. Learning and Memory
CCNBook/Memory

9. Language
CCNBook/Language

10. Executive Function
CCNBook/Executive

The text will be followed closely. In addition, relevant journal articles and chapters describing particular neural network models will be distributed for class on *Blackboard*.

Lab: The latter part of each class will be a lab, where we will go over some of the computer simulation explorations. These explorations are the centerpiece of the course, and provide a unique exploratory learning opportunity. You will perform many what-if scenarios to understand what aspects of the brain's biology are important for producing specific cognitive and emotional phenomena. You will simulate the effects of brain damage in these models, to understand neuropsychology (the study of brain-damaged patients). The computer models enable complete control and dynamic, colorful visualization of these explorations, providing a unique ability to understand how cognition emerges from the brain. You will document these explorations by answering the simulation exercises questions outside of class.

Evaluation: Your grade will be based on four components in the following proportions:
Simulation exercises 40%
Reading reactions 20%
Final project 30%
Class participation 10%

Simulation Exercises: The simulation exercises are interspersed throughout the text. Unless otherwise noted, you should answer all of the exercise questions for each chapter, turning them in in class on the date shown in the schedule. You must write them up *individually*. We want to see that each person individually understands the material, so this should be evident in your writeup. It is best to write down results and first drafts of answers as you work through the exercises — they can take a while to run and you don't want to have to run them repeatedly. Exercises turned in late will be penalized 5% for each day after the due date.

Reading reactions: For each chapter, you will be asked to email a few sentences about the topic you found most interesting in the chapter and why. These reading reactions are designed to ensure that you are keeping up on the reading and to inform us about your interests. Reading reactions should be emailed to *read@usc.edu* prior to the class meeting when they are due.

Final Project: The final project is an opportunity for you to use simulations to examine some psychological phenomenon of interest to you. This project will require careful preparation and thought, so I strongly recommend that you begin your work early. *Do not be overly ambitious* — relatively clear and simple but thoughtful work is preferred to a complicated half-baked mess. Do not be misled by the relative simplicity of running the canned exercises in the book — *simulation projects take a long time to complete!*

Your *Emergent* neural network project and a final paper describing your project are due on the first day of finals. The paper should be 10-15 pages (double spaced, excluding figures), and should contain a concise introduction to the psychological issue or phenomenon, a justification of your general approach to modeling it, methods, results, and a concluding discussion (about the significance of your results, what you might do to improve your model, etc.). Network diagrams and graphs of significant results should be included. However, do not include excessive or redundant figures; the text should provide a clear interpretation and justification of all figures.

Because Emergent provides the facilities to create an integrated documentation file that is part of your Emergent neural network project, this paper should actually be included as the documentation file in the Emergent project you turn in.

NOTE: For each day that the final paper is late, 5% will be deducted from your final paper grade.

Final Project Schedule

Deadline	**Assignment**
First Day of Class!	Project topic 1
September 24	Project topic 2
October 1	Project proposal (1 page summary of your question of interest and proposed approach to explore this question through simulations)
October 14-17	Meeting w/instructor about project
November 26-December 5	Presentation of project to class
December 11	Final paper and project due

Class Participation: Productive participation in class discussion is encouraged to help you get the most out of this course. You are expected to read the text chapters the week they are assigned and to come to class prepared to actively participate in discussion.

Disability. Students requesting academic accommodations based on a disability are required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP when adequate documentation is filed. Please be sure the letter is delivered to me (or to the TA) as early in the semester as possible. DSP is open Monday-Friday, 8:30-5:00. The office is in the Student Union 301 and their phone is (213) 740 – 0776.

Academic Integrity Standards
The rules governing dishonesty in the current *University of Southern California Faculty Handbook* and also listed in the 2013-2014 *SCAMPUS*, under University Governance, will be maintained and enforced. Information about academic integrity violations and recommended penalties can be found in *SCAMPUS*.

The minimum penalty for cheating on an exam will be a score of zero on that exam. Particularly gross academic dishonesty on an exam, such as obtaining a copy of the exam beforehand, will result in an F for the course and may result in suspension or expulsion from the University. Cheating on a homework assignment will result in a zero on that assignment and repeated cheating on homework assignments will result in an F for the course.

Plagiarism on any of the class papers will result in a zero for the paper. Particularly gross academic dishonesty, such as turning in a paper done by another (such as a purchased paper) will result in an F for the course. According to the University guidelines plagiarism is defined as: (a) The submission of material authored by another person but represented as the student's work, (b) the submission of material subjected to editorial revision by another person that results in substantive changes in content or major alteration of writing style, (c) the improper acknowledgement of sources in essays or papers. If you use the words or ideas of another you must properly acknowledge the source. If you use a direct quote then you must indicate the source and page number, using APA style. Even if you paraphrase someone's ideas you must still acknowledge the source, using APA style.

You should also be aware that it is considered academic dishonesty to use a paper or project in more than one course without both instructors' permission. The recommended penalty for this is an F in the course.

This description is not intended to be exhaustive. You are expected to be familiar with the relevant parts of the student conduct code.

CLASS SCHEDULE

Week	**Readings and Topic**
August 27	**Chapter 1: Introduction and Overview** (I suggest you read Chapter 5: Brain Areas in the textbook)
	Aisa, B., Mingus, B., O'Reilly, R. (2008). The emergent neural modeling system. *Neural Networks* O'Reilly, R. (2006). Biologically based computational models of high-level cognition. *Science, 314(6), 91-94.*
September 3	**Chapter 2: Individual neurons**
	Overview chapters on Blackboard. Chapters 1 and 2.
September 10	**Chapter 3: Networks of neurons**
	Jordan, M. I. (1986). An introduction to linear algebra in parallel distributed processing. In D. E. Rumelhart, J. L. McClelland, and The PDP Research Group (Eds.), *Parallel Distributed Processing: Explorations in the*

	Microstructure of Cognition. Volume 1: Foundations. Cambridge, MA: MIT Press.
September 17	**Chapter 4: Learning mechanisms**
	Part II -- Cognitive Neuroscience *(lectures, student project development and presentations)*
September 24	**Chapter 5: Brain Areas**
	Work on AX Tutorial on how to build a network model
October 1	**Chapter 6: Perception and Attention**
October 8	**Chapter 7: Motor Control and Reinforcement Learning**
October 15	**Chapter 8: Learning and Memory**
October 22	**Attitudes** Monroe, B. M., & Read, S. J. (2008). A General Connectionist Model of Attitudes and Attitude Change: The ACS (Attitudes as Constraint Satisfaction) Model. *Psychological Review, 115*, 733–759. Read, S. J., & Monroe, B. M. (revision requested). *Modeling Cognitive Dissonance using A Recurrent Neural Network Model with Learning.* Cunningham, W. A., Zelazo, P. D. (2007) Attitudes and evaluations: a social cognitive neuroscience perspective. *Trends in Cognitive Sciences, 11*, 97-104. ***Work on designing and building a simple neural network model of an attitudinal phenomena***
October 29	**Chapter 9: Language**
November 5	**Event Perception** Reynolds, J. R., Zacks, J. M., Braver, T. S. (2007). A Computational Model of Event Segmentation From Perceptual Prediction. *Cognitive Science, 31*, 613–643. [on Blackboard] Kurby, C. A., & Zacks, J. M. (2007). Segmentation in the perception and memory of events. *Trends in Cognitive Sciences. 12,* 72-79. [on Blackboard] Hanson, C., & Hanson, S. J. (1996). Development of Schemata during Event parsing: Neisser's Perceptual Cycle as a Recurrent Connectionist Network.

	Journal of Cognitive Neuroscience, *8*, 119-134. [on Blackboard] ***Continue work on attitude model***
November 12	**Chapter 10: Executive Function:** Class Presentation Braver, T. S., Barch, D. M., & Cohen, J. D. (1999). Cognition and Control in Schizophrenia: A Computational Model of Dopamine and Prefrontal Function. *Biological Psychiatry*, *313*, 312-328. [on Blackboard] Cohen, J. D., Braver, T. S., & O'Reilly (1996). A computational approach to prefrontal cortex, cognitive control and schizophrenia: recent developments and current challenges. *Philosophical Transactions of the Royal Society, 351*, 1515-1527. [on Blackboard]
November 19	**Emotion:** Class Presentations Thagard, P., & Aubie, B. (2008). Emotional consciousness: A neural model of how cognitive appraisal and somatic perception interact to produce qualitative experience. *Consciousness and Cognition 17*, 811–834. [on Blackboard] Nerb, J. (2007). Exploring the dynamics of the appraisal emotion relationship: A constraint satisfaction model of the appraisal process, *Cognition and Emotion*, 21, 1382-1413. [on Blackboard] Litt, A., Eliasmith, C., Thagard, P., (2008). Neural affective decision theory: Choices, brains, and emotions. *Cognitive Systems Research, 9*, 252–273. [on Blackboard]
November 26	**Personality and Motivation:** Read, S. J., Monroe, B. M., Brownstein, A. L., Yang, Y., Chopra, G., & Miller, L. C. (2010). A Neural Network Model of the Structure and Dynamics of Human Personality. *Psychological Review.* [on Blackboard] **Class Presentations**
December 3	**Class Presentations**
December 11	**Final paper/project due**