Computational Cognitive Neuroscience (Psych 4175/5175)

T/Th 11:00 - 12:15, Spring 2006
Muenzinger D156 (Labs in Muenzinger E-311, Clipr Seuss XTerminal Room)
Class Web Site: `http://psych.colorado.edu/~oreilly/cogsim.html`

	Professor	**Teaching Assistant**
Name:	Randy O'Reilly	Philip Branning
Office:	Muenzinger D-251C	Muenzinger D-313D
Phone:	303-492-0054	
Email:	oreilly@psych.colorado.edu	philip.branning@colorado.edu
Office Hours:	Monday 3-4	TBD

Lab Sections: 101: Weds 2-3:50. 102: Thurs 9-10:50 Muenzinger E-311, Clipr Seuss XTerminal Room

Goals: How does the brain secrete the mind? This course will introduce you to the ideas and methods in computational cognitive neuroscience that have been applied to answering this question. Specifically, we focus on simulating cognitive and perceptual processes using neural network models. These models provide a bridge between behavioral and biological levels of analysis. 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 (self-organizing and error-driven), which all networks of neurons require to perform any reasonably complex task. We will examine a range of cognitive phenomena within this framework, including attention, memory, language, and higher-level cognition. The overarching goal is to use simulations to help us to understand how our neurons give rise to our thoughts.

Prerequisites: The formal prerequisite courses for this course are: PSYC 1001 (intro), 2145 (cognitive), 2012 (bio), and 3101 (stats), which provide basic background in cognitive psychology and neurobiology that will be useful for the course. In addition to these formal prerequisites, students who have a sincere interest and/or additional background in cognitive psychology, neuroscience, and/or computers (or their relationships) will find this course more engaging. While the models we will be using are mathematically based, 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: O'Reilly, R. C. and Munakata, Y. (2000). *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simultating the Brain*. Cambridge, MA: MIT Press.

Lab: There is a weekly two-hour lab session that is supervised by the teaching assistant, where students obtain in-depth hands-on experience with 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 scenarious to understand what aspects of the brain's biology are important for producing specific cognitive 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 (to be worked on during the lab sessions). You should be able to do most, hopefully all, of the required homework during these lab sessions.

Evaluation: Your grade will be based on three 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 or the TA's box on the date shown in the schedule. Although you will be working on these exercises in the labs, 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 `cogsim-teach@grey.colorado.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!* The following timeline is designed to ensure that you make progress on your project (5 of the 30 points for the project will come from simply making each of the 5 deadlines before the final due date) and that you receive feedback on it before turning in the final version.

Deadline	**Assignment**
Today!	Project topic 1
Mar 9	Project topic 2
Mar 16	Project proposal (1 page summary of your question of interest and proposed approach to explore this question through simulations)
Apr 4 - 6	Meeting w/instructor about project
Apr 25 - May 2	Presentation of project to class
May 5	Final paper

In your presentation to the class, you are expected to have substantive, if not final, results to discuss. Presentations should clearly motivate the psychological issue or phenomenon and your approach to it, in addition to a summary of the methods and results.

A final paper describing your project is due on the last day of classes. This 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. NOTE: For each day that the final paper is late, 5% will be deducted from your final paper grade.

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. You can also communicate about any course-related topics as a group by emailing cogsim@grey.colorado.edu.

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.

Grading Policy: Grades are not curved; they are based on percentages:

97-100	A+	87-89	B+	77-79	C+	67-69	D+
93-96	A	83-86	B	73-76	C	63-66	D
90-92	A-	80-82	B-	70-72	C-	60-62	D-

Simulation Pragmatics: To run the simulations, you need to take the following steps:

- Login to the machine using your identikey account.
- Start the X11 application, which is in Applications/Utilities/X11 in the Finder.
- Start the leabra++ application in Applications/CogNeuroSims/leabra++.
- You can drag these items into the dock to make them show up there next time.
- Note: when you quit, you may need to click in the leabra++ shell terminal window, and hit Return before it will actually quit..

If you want to work on your own machine

You can also download the software (from http://psych.colorado.edu/~oreilly/cecn_download.html) to run on your own machines. Most major platforms are supported: Linux, Mac, Windows, Sun, SGI, HP.

Schedule

Wk	Date	Tuesday	Ch	Due	Date	Thursday	Ch	Due	Due Fri
1	17 Jan 06	**Introduction**	**1**	Top1	19 Jan 06	**Neurons**	**2**	RR1	
2	24 Jan 06	Neurons	2	RR2	26 Jan 06	**Networks**	**3**		
3	31 Jan 06	Networks	3	HW2	2 Feb 06	Networks	3	RR3	
4	7 Feb 06	Networks	3		9 Feb 06	**Model Learning**	**4**		HW3
5	14 Feb 06	Model Learning	4	RR4	16 Feb 06	**Task Learning**	**5**		HW4
6	21 Feb 06	Task Learning	5	RR5	23 Feb 06	**Combo Learning**	**6**		
7	28 Feb 06	Temporal Learning	6	RR6	2 Mar 06	Temporal Learning	6	RR6	HW5
8	7 Mar 06	**Large Scale Org**	**7**	RR7	9 Mar 06	**Perception**	**8**	Top2	HW6
9	14 Mar 06	Perception	8	RR8	16 Mar 06	Perception	8	Prop	
10	21 Mar 06	**Memory**	**9**		23 Mar 06	Memory	9	RR9	HW8
11	28 Mar 06	*Spring Break (no class)*			30 Mar 06	*Spring Break (no class)*			
12	4 Apr 06	Memory	9	Meet	6 Apr 06	**Language**	**10**	HW9 Meet	
13	11 Apr 06	Language	10	RR10	13 Apr 06	Language	10		
14	18 Apr 06	**Higher Level Cognition**	**11**	HW10	20 Apr 06	Higher Level Cognition	11	RR11	
15	25 Apr 06	**Student Presentations**			27 Apr 06	Student Presentations			
16	2 May 06	Student Presentations			4 May 06	**Grand Finale**	**12**	RR12	Paper

Ch = Chapter in text to read, **Due** = Materials due in class (**HW** = homework, **RR** = reading reaction), **Top** = Paper topic, **Prop** = Final project proposal, **Meet** = Meet with instructor this week to discuss proposals. **Paper** = Final papers due by 5:00pm in professor's offi ce or mailbox.

This table shows the questions that can be skipped in your write-ups. You should still step through these exercises as you go through the chapter. (In some cases, this will be useful for subsequent questions.)

Ch	Undergrads Skip	Grads Skip	Ch	Undergrads Skip	Grads Skip
2	2.2b, 2.3c, 2.5c, 2.8b	–	3	3.4, 3.6, 3.8, 3.11d,e, 3.12, 3.14	3.4, 3.12, 3.14
4	4.4, 4.5, 4.7c,d	–	5	5.5b	5.5b
6	6.3, 6.4, 6.5b,c	6.4	8	8.5, 8.7c, 8.8, 8.13	8.13
9	9.3, 9.8, 9.12, 9.15, 9.16	9.3, 9.12, 9.15, 9.16	10	10.2b, 10.8, 10.9	–
11	11.5	–			

Please provide the following on your **student information card**:

a. your name as it appears on our class registration list
b. the name you use if different from your first name (such as middle name or nickname)
c. email address and phone number
d. year and major
e. where you are from (city, state/province, country if outside of U.S.)
f. hobbies or interests
g. any relevant interests/background aside from the course prerequisites
h. what you hope to get out of this course

On the back of your card, try a first-pass description of a possible final project topic (or topics). What aspects of brain-behavior relations would you be interested in exploring through simulations? Why?