

Computational Cognitive Neuroscience (Psych 4175/5175)

T/Th 11:00 - 12:15, Fall 2003

Muenzinger E114 (Labs in Muenzinger E-311, Clipr Seuss XTerminal Room)

Class Web Site: <http://psych.colorado.edu/~munakata/teaching/ccn03/>

| | Professor | Teaching Assistant |
|----------------------|----------------------------|---------------------------|
| Name: | Yuko Munakata | Seth Herd |
| Office: | Muenzinger D-251D | Muenzinger D260-G |
| Phone: | 735-5499 | 492-5394 |
| Email: | munakata@colorado.edu | seth.herd@colorado.edu |
| Office Hours: | M 1:00-2:00, Tu 12:15-1:15 | Wed 4-5, Th 12:30-1:30 |

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 tend to find this course more engaging if they have an interest and/or additional background in cognitive psychology, neuroscience, philosophy of mind, computers, and/or relationships among any of these areas. The models we will use 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: O'Reilly, R. C. and Munakata, Y. (2000). *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain*. Cambridge, MA: MIT Press.

Lab: There is a weekly two-hour lab session that is supervised by the teaching assistant, where you will 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 scenarios to understand what aspects of the brain's biology are important for producing specific cognitive phenomena. You will also damage some models and observe the effects, to help understand the behaviors observed in patients following brain damage. 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 consist of the following:

| | |
|----------------------|-----|
| Simulation exercises | 40% |
| Reading reactions | 20% |
| Final project | 30% |
| Class participation | 10% |

Simulation Exercises: The simulation exercises are interspersed throughout the text. You should answer all of the exercise questions for each chapter, aside from the ones noted, turning them in in class 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 what 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 ccn-teach@grey.colorado.edu, prior to the class meeting when they are due.

Final Project: Your 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 |
| Oct 21 | Project topic 2 |
| Oct 28 | Project proposal (1 page summary of your question of interest and proposed approach to explore this question through simulations) |
| Nov 3 - Nov 7 | Meeting w/instructor about project |
| Dec 2-9 | Presentation of project to class |
| Dec 12 | 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 ccn-all@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 (just once).

Getting your account

- go to <http://plus.colorado.edu>
- click Log-On
- enter CUID & PIN and click Submit
- click "E-mail & Passwords" on the left of the screen
- scroll down and select "Specialty Accounts"
- validate for accounts by entering CUID and PIN again
- click "Make account on samiam"

After accepting User Responsibilities, students will input a password of their choice, and the account will usually be made in the next 5 minutes.

Setting up your simulation files

- login (either to samiam or the local system)
- at the console prompt, type "`cp ~oreillyr/setup_sims .`"
- then type "`./setup_sims`"
- you will see a bunch of messages – don't worry about "no match"
- From here on out, you can run simulations by typing "`cd sims`", then "`leabra++`". In the little PDP++ window that comes up, click on `.projects/Open_in/root`, then click on the chapter and the project name.

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 | 26 Aug 03 | Introduction | 1 | Top1 | 28 Aug 03 | Neurons | 2 | RR1 | |
| 2 | 2 Sep 03 | Neurons | 2 | RR2 | 4 Sep 03 | Networks | 3 | | |
| 3 | 9 Sep 03 | Networks | 3 | HW2 | 11 Sep 03 | Networks | 3 | RR3 | |
| 4 | 16 Sep 03 | Networks | 3 | | 18 Sep 03 | Model Learning | 4 | | HW3 |
| 5 | 23 Sep 03 | Model Learning | 4 | RR4 | 25 Sep 03 | Task Learning | 5 | | HW4 |
| 6 | 30 Sep 03 | Task Learning | 5 | RR5 | 2 Oct 03 | <i>Fall Break (no class)</i> | | | |
| 7 | 7 Oct 03 | Combo Learning | 6 | | 9 Oct 03 | Temporal Learning | 6 | RR6 | HW5 |
| 8 | 14 Oct 03 | Temporal Learning | 6 | | 16 Oct 03 | Large Scale Org | 7 | RR7 | HW6 |
| 9 | 21 Oct 03 | Perception | 8 | Top2 | 23 Oct 03 | Perception | 8 | RR8 | |
| 10 | 28 Oct 03 | Perception | 8 | Prop | 30 Oct 03 | Memory | 9 | | HW8 |
| 11 | 4 Nov 03 | Memory | 9 | RR9 Meet | 6 Nov 03 | Memory | 9 | Meet | |
| 12 | 11 Nov 03 | Language | 10 | HW9 | 13 Nov 03 | Language | 10 | RR10 | |
| 13 | 18 Nov 03 | Language | 10 | | 20 Nov 03 | Higher Level Cognition | 11 | | HW10 |
| 14 | 25 Nov 03 | Higher Level Cognition | 11 | RR11 | 27 Nov 03 | <i>Thanksgiving (no class)</i> | | | |
| 15 | 2 Dec 03 | Student Presentations | | | 4 Dec 03 | Student Presentations | | | |
| 16 | 9 Dec 03 | Student Presentations | | | 11 Dec 03 | 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 office 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 |
|----|--------------------------------------|-----------------------------|
| 2 | 2.3c, 2.5c, 2.8b | 2.5c |
| 3 | 3.7a,b, 3.8a, 3.14c,d,e | 3.14c,d,e |
| 4 | 4.4a,b,c,d,e, 4.5a,b, 4.7c,d | 4.7c,d |
| 5 | 5.5b | 5.5b |
| 6 | 6.4, 6.5b,c | 6.4 |
| 8 | 8.5, 8.7c, 8.13 | 8.13 |
| 9 | 9.3, 9.10a,b, 9.12, 9.15a,b, 9.16a,b | 9.3, 9.12, 9.15a,b, 9.16a,b |
| 10 | 10.2b, 10.8, 10.9a,b | 10.8 |

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

- your name as it appears on our class registration list
- the name you use if different from your first name (such as middle name or nickname)
- email address and phone number
- year and major
- where you are from (city, state/province, country if outside of U.S.)
- hobbies or interests
- any relevant interests/background aside from the course prerequisites
- 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?