Introduction to Parallel Distributed Processing Models: A *Summer Tutorial Course*

When: Thursdays at 1 PM **Where:** Online and in Singer Hall rm. 222

Instructor:

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<u>This summer tutorial course will utilize GitHub</u>

Overview

The goal of this summer tutorial course is to introduce the basic principles of parallel distributed processing (also known as connectionist or artificial neural-network modeling). For each topic and corresponding lecture, there will be computer simulation exercises in addition to readings. Simulation exercises generally will require you to report the results of simulations you have carried out either in small groups or individually, to analyze these results, and critically to think about some issues raised in the readings. There will also be an opportunity for students to develop a computer simulation of their summer research work that is being carried out in their home research labs.

In general, there are assigned readings for each lecture that are intended to prepare you to participate in class discussion for that day. In addition, there may be optional background readings (marked with "opt.") that serve either as the basis for the lecture, to present an alternative point of view, or simply to make available to you relevant material that we won't have time to cover in class. Optional readings are also an excellent source of ideas for projects.

Readings

There is **<u>no required textbook</u>** for this course. All assigned and optional readings, as well as lecture slides, will be available through GitHub. These will appear as .pdf documents. You can also find other course material such as handouts and simulation exercises on GitHub. The following texts contain some of the course readings and may be useful as general references:

- **PDP1:** Rumelhart, D.E., McClelland, J.L., & the PDP research group (1986). Parallel distributed processing: Explorations in the microstructure of cognition. Volume 1: Foundations. Cambridge, MA: MIT Press.
- **PDP2:** McClelland, J.L., Rumelhart, D.E., & the PDP research group (1986). Parallel distributed processing: Explorations in the microstructure of cognition. Volume 2: Psychological and biological models. Cambridge, MA: MIT Press.
- **PDP Handbook:** McClelland, J.L. and Rumelhart, D.E. (1988). Explorations in parallel distributed processing: A handbook of models, programs, and exercises. Cambridge, MA: MIT Press.
- **MPR:** McLeod, P., Plunkett, K. and Rolls, E.T. (1998). Introduction to Connectionist Modelling of Cognitive Processes. Oxford: Oxford University Press.
- **CCN:** O'Reilly, R.C., Munakata, Y., Frank, M.J., and Hazy, T. (2014). Computational cognitive neuroscience. http://grey.colorado.edu/CompCogNeuro/index.php/CCNBook/Main

Course Goals

This course is designed to introduce you to the connectionist modeling formalism. Specifically, the goals of the course are for you to develop the following knowledge and skills:

(1) An understanding of the basic principles of the PDP approach (through lecture, homework assignments, and the final project).

(2) An understanding of, and appreciate for, how the PDP approach has been used to address many important issues in cognitive development.

(3) The skills to carry out independent computer (PDP) simulations.

(4) The ability to interpret the behavior of PDP models.

(5) The ability to articulate the strengths and weakness of different PDP modeling architectures.

(6) Improve skill in oral and written presentation (through the oral project presentation and written final project report)

(6) Increase facility in designing PDP computer models to address research questions (through the oral project presentation and written final project report) aimed at addressing various issues in cognitive development.

(6) The potential to evaluate different model architectures critically and constructively.

Participation and attendance:

Although attendance is not mandatory in this summer tutorial course—due to the sophisticated nature of the content covered in the course—students are highly encouraged to attend all lectures and to contribute to discussion.

Students will find that the best way to contribute to discussion is to come to class well-prepared, with questions and suggestions based on the assigned readings, previous lectures, and homework assignments. Of course, whether you decide to attend lecture or net—either in person or remotely—is entirely up to you.

Grading

There are no grades, silly. This is a summer tutorial course, for crying out loud.

Simulation Exercises
Simulation Exercise 1
Simulation Exercise 2
Simulation Exercise 3
Simulation Exercise 4
Project Proposal (based on your summer projects with your faculty sponsor)

Other points:

I make the lecture notes available to the class on Moodle three or four days before the lecture. To get the most out of lectures you should read these notes and complete the readings before class on the day for which they are assigned. The lecture notes have "gaps" that will be completed in class – if you miss a class you should obtain the missing information from one of your fellow students. These "gaps" serve to encourage students regularly to attend lecture.

How to do well in this ~~class~~ summer tutorial course:

Completing the simulation exercises and thinking about and synthesizing the content covered in lecture is essential fully to grasp the basic principles of PDP computational modeling. I encourage you actively to engage in discussion during the class; the more discussion we have, the more enjoyable the course will be, and the more we will all learn.

The simulation exercises are designed to achieve two, interrelated aims. First, students will be provided with hands-on experience carrying out computational simulations, which will enable students to discover how and why PDP models succeed and fail in different contexts. Second, these exercises will provide students with the opportunity to engage more deeply with the course content through hands-on simulations. The final project will allow students to design and carry out simulation experiments based on their summer research projects with their faculty sponsor.

Date (week, day, month, date)	Topics	Reading	Assignment
1 Thu. June 10	Overview & basic principles	Rogers, T.T. (2009). Connectionist models. In Squire, L. (Ed.), Encyclopedia of Neuroscience, Volume 3, pp. 75-82. Oxford: Academic Press. Benton, D. T., & Rakison, D. H. (2018). *Computational Modeling and What It Can Tell You About Behavior*. SAGE Publications Ltd.	Simulation Exercise 1 Install Lens
2 Thu. June 17	Lens tutorial & constraint satisfaction	McLeod, P., Plunkett, K. and Rolls, E.T. (1998). The attraction of parallel distributed processing for modelling cognition. MPR, Chapter 2.	Simulation Exercise 2 (due before the next Meeting)
3 Thu. June 24	Hebb and Delta rule & feedforward NN demo in Lens	McClelland, J. L., and Rumelhart, D. E. (1988). The pattern associator. PDP Handbook, Chapter 4 (pp. 83-96).	Simulation Exercise 3 (due before the next meeting)
4 Thu. July 1	Backpropagation	Rumelhart, D. E., Hinton, G. E., & Williams, R. J. (1985). Learning internal representations by error propagation. California Univ San Diego La Jolla Inst for Cognitive Science.	Simulation Exercise 4 (due before the next meeting)

5 Thu. July 8	Simple Recurrent Networks (SRNs) and Fully Recurrent Networks	Elman, J. L. (1990). Finding structure in time. Cognitive Science, 14, 179-211	
6 Thu. July 15	No Meeting		
7 Thu. July 22	Building SRNs and FRNs in Lens in Lens (this is a lab day)		
8 Thu. July 29	Contrastive Hebbian Learning	Hinton, G. E. & Sejnowski, T. J. (1986). Learning and relearning in Boltzmann Machines. PDP1, Chapter 7.	
Thanks for joining me on this journey!			