New Course Request

Academic Organization and Curriculum Handbook

College: SBS

Course Bulletin Listing: PSYCH - PSYCHOLOGY

Course Prefix:

Course Number: 611

☐ Generic course or decimal subdivision?

A matching course number is found for this course offering unit. If the course is still active, use the Change Course form or select a different number.

Course	Prefix	Decimal	Qtr	Year
611			2	2001

Full Course Title: Introduction to Programming in Behavioral Science

Transcript Title: BehSci Programming

Level: ☑ Undergraduate ☑ Graduate

Credit Hours: 5

Proposed Effective Year: 09

Proposed Effective Term: Autumn Quarter

Course Bulletin

Course Description: Introduction to a high-level programming language in the context of behavioral research. Provides overview of techniques for real-time experimentation and signal processing.

Terms Offered: Quarter(s)

- ☑ Autumn
- ☐ Winter
- ☐ Spring
- ☐ Summer
- ☐ Summer 1
- ☐ Summer 2

Offering Pattern: ☑ This year ☐ Every other year

Distribution of Class Time: 1 x 2.5 Hr Cl

Omit distribution of class time from printing? [x]

Prerequisities: Graduate Standing or permission of instructor

[x] Electronic enforcement of prerequisites?

Exclusion or Limiting Clause:

Repeatable? [ ]

Cross Listed? [ ]

Course part of a sequence? [ ]

Grade Option: (•) Letter ( ) S/U [ ] Progress

[ ] GEC Course

General Course Information Statement:

[ ] Off Campus/Field Experience?

[ ] EM Credit?

[ ] Admission Condition Course?

[ ] Offered in Distance Learning Format?

[ ] Service Learning?

General Information

Subject (CIP) Code: 420801

Subsidy Level: D

If you have questions, please contact Jed Dickhaut @ dickhaut.1@osu.edu.

Expected Section

Size 20

Proposed Number of Sections Per Year 1

☐ Course time less than 1 full term or Workshop

☐ Off-campus offering?

☐ Required on Major(s)

☐ Required on Minor(s)

☑ Elective within Major(s)

List of Major Programs: Psychology

☐ Elective within Minor(s)

☐ Choice of Major(s)

☐ Choice of Minor(s)

☑ A General Elective

State the need and purpose of the course. Indicate how the course relates to the primary goals of the academic unit/school/college/university.

Python, the language taught, is widely used in such research but is not a language taught in existing computer prog. courses at OSU. No existing course provides an introduction to prog. suitable for psych research that is accesible to psych student who lack extensive prior exposure tocomputer prog. This will benifit both grad & undergrads preparing for grad study in psych

Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. Evidence must be given of whether the budget support will come from reallocation of existing resources or from new program funds.

No adjustments are necessary - the course can be accomodated as part of a recently hired faculty member's regular teaching load.

Is approval of this request contingent upon the approval of other course or curricular requests? ○ Yes ◉ No

Please complete and attach the form(s) on the following page before completing the package.

Course Supplement Form

Course Contact Information

Faculty Name	Michael Vasey
Faculty Email	vasey.1@osu.edu
Contact Name	Kevin McCarthy
Contact Dept	Psychology
Contact Email	mccarthy.232@osu.edu
Contact Phone	292-6742

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THE OHIO STATE UNIVERSITY WWW.OSU.EDU

Psychology 611
Introduction to Programming for Behavioral Scientists

Credits: 5
Time Allotment: One session of 2 hours 18 minutes per week.
Audience: Entry-level graduate and advanced undergraduate students.
Prerequisites: None.
Instructor: Simon Dennis or Alexander Petrov

Required Text: How to Think Like a Computer Scientist: Learning with Python. 2nd Edition by Jeffrey Elkner, Allen B. Downey and Chris Meyers, 2008. The text is available free of change online at http://openbookproject.net/thinkCSpy/index.html. We will also be using the pyEPL package and associated manual by Aaron Geller, which is available free of charge at http://pyepl.sourceforge.net.

Acknowledgment: We would like to thank Jeffrey Elkner, Allen B. Downey and Chris Meyers for the work that they have put into the production of the textbook. We would also like to thank Michael Kahana, Aaron Geller and the members, past and present, of the Computational Memory laboratory for their work on the pyEPL system.

Description

Programming is an essential skill for behavioral scientists. Whether you wish to present stimuli to subjects and collect measurements, analyze and plot data or build and test computational models of the underlying processes, being able to program allows you to get the job done just the way you want and on your own time scale. The rigor enforced by programming helps to clarify thinking and often exposes errors in understanding. However, most researchers in the behavioral sciences are interested in how people do things, not how computers do them. Sometimes students don't feel at ease under the tyranny of the command prompt and find the rigid and literal paradigms of programming frustrating and far from intuitive. This course is designed to foster an intimate relationship between student and machine based on understanding and mutual respect.

Objectives

By the end of this course, you should:

1. Understand how programs are used to make computers do useful things
2. Be able to speak the python language
3. Be able to program behavioral experiments
4. Be able to write programs to analyze behavioral data
5. Be able to produce publication-quality graphics
6. Be able to understand and perform signal processing in speech, EEG and image behavioral research

Prerequisites

The course is designed for graduate students with little or no exposure to formal programming languages. Some exposure to statistical techniques is useful but is not necessary. It will be assumed that the student has an active requirement in their home laboratories that will be the subject of the major project (see assessment below). The course is also open to advanced undergraduate students, particularly those who intend to enter graduate school in psychology.

Evaluation

There will be two major components of assessment:

1. In class problem sets (45%)
2. Programming project (55%)
   - Project proposal
   - Code, documentation and unit tests

Problem Sets

Learning programming in lecture format is considered ineffective and inhumane. Consequently, all classes will occur in the laboratory and will primarily involve working through exercises. 5% of the assessment will be assigned to each of these problem sets. These will be marked on a satisfactory, unsatisfactory basis. Attending class and making a genuine effort at completing the exercises will constitute satisfactory performance. If you are unable to attend a given class then you must complete the exercises and submit them electronically through the drop box on Carmen (https://carmen.osu.edu/) by midnight on the Friday of the week of the class in order to receive credit.

Programming Assignment

The remaining 55% of the assessment will involve creating a program to do a task that you need to complete for your own research purposes. This might involve writing experimental code, doing data analysis and/or the creation of graphs of some results, analysis of speech, EEG or image data etc. A one paragraph project proposal will be due mid course and you should consult with the professor to ensure that your proposal is feasible. The final product will include the code, documentation on how to use it and unit tests demonstrating that it works. You will be marked on the clarity, commenting etc of the code, the clarity of the documentation, and the completeness of the unit tests.

Choice of Programming Language

There are a number of languages that could have been chosen on which to base this course. MatLab and R, in particular, are widely used in the behavioral sciences. We have chosen to use the python language (http://www.python.org/). The reasons are as follows:

1) Python has an elegant well designed syntax that incorporates object oriented programming, list and dictionary based data types and functional programming in a simple way.
2) Python is easy to learn. It has an interpreter, so one can start with simple examples and you are freed from the compilation cycle which is confusing for beginners. You can waste a lot of time trying to understand and debug unnecessary bracketing conventions etc.
3) Python promotes and in some cases enforces good programming habits. Indenting is mandatory and it has the literate programming mechanisms that turn comments into HTML documentation. It also has a unit testing framework.
4) Python has all of the components needed by behavioral researchers – an experimental programming laboratory (pyEPL), statistical and signal processing libraries (numpy and scipy) and graphics libraries (matplotlib).
5) It can be used for a wide variety of other tasks as well - it has fully developed web programming modules, regular expression libraries (necessary for doing corpus work) and GUI platforms. These wont be covered in the current course, but it is nice to know they are there should you need to use them in the future. Python also scales well to large applications.
6) There is a large community of users. Based on google document counts the python community is approximately 4 to 5 times bigger than the matlab community, for instance, and includes organizations such as Google and NASA.
7) It is easy to interface to other languages - both high level and low level. So, there are interfaces to

matlab and R (but the reverse is not true). Interfacing to C is done directly - it does not require writing intermediate files (like mex files).
8) There is a free online text (http://openbookproject.net/thinkCSpy/index.xhtml) under the GNU open
document license that has had many contributors and debuggers. The text is also available in hardcopy. There are also many other online resources (e.g. python tutorial http://docs.python.org/tut/tut.html).
9) Python is free and available on all major platforms (linux, OSX and windows). This means that when you leave the university environment either to go home or to start a new job, you will be able to access it wherever you are.

Submitting Assessment

All assessment should be submitted using the Carmen dropbox, https://carmen.osu.edu/ . If you don't know how to login to Carmen or are uncertain how to use the dropbox ask either after class or during my office hours.

Academic Misconduct

Don't be naughty! Sexual, racial, religious or political harassment of any kind will not be tolerated.

All students at the Ohio State University are bound by the Code of Student Conduct (see http://studentaffairs.osu.edu/resource_csc.asp). Suspected violations of the code in this class will be dealt with according to the procedures detailed in that code. Specifically, any alleged cases of misconduct will be referred to the Committee on Academic Misconduct.

Disability Accommodation

If you need an accommodation based on the impact of a disability, you should contact the instructor to arrange an appointment as soon as possible and no later than the end of the second week of classes. At the appointment we can discuss the course format, anticipate your needs, and explore potential accommodations. I rely on the Office for Disability Services for assistance in verifying the need for accommodations and developing accommodations strategies. If you have not previously contacted the Office for Disability Services, I encourage you to do so: http://www.ods.ohio-state.edu , 150 Pomerene Hall, 614-292-3307.

Course Schedule

Week 1: The way of the program, variables, expressions and statements
Reading: Elkner, Downey & Meyers (2008) Chapters 1-2

Week 2: Functions, conditionals and iteration
Reading: Elkner, Downey & Meyers (2008) Chapters 3-6

Week 3: Strings, Lists and Dictionaries
Reading: Elkner, Downey & Meyers (2008) Chapters 7, 9, 12

Week 4: Modules and Files
Reading: Elkner, Downey & Meyers (2008) Chapters 10

Week 5: Classes and Objects
Reading: Elkner, Downey & Meyers (2008) Chapters 13

Week 6: Programming Experiments
Reading: Geller (2006), http://pyepl.sourceforge.net

Week 7: Analyzing Data and Creating Plots

Week 8: Signal Processing (Speech and EEG)
Reading: Vibration Analysis and Theory: Tutorial
(http://www.cage.curtin.edu.au/mechanical/info/vibrations/tutor.htm)
See in particular the section on sampling and aliasing.
Reference: Chatfield, C. (2003). The analysis of time series: An introduction
(6^{th} Ed) -- Particularly Chapter 2, Simple Descriptive Techniques
Reference: Fourier Analysis Made Easy
http://www.complextoreal.com/tutorial.htm (Tutorials 4, 5, 6)

Week 9: Signal Processing (Images)
Reference: Graham, N. (1989). Visual Pattern Analyzers. Oxford UP.
Chapter 2
Reference: Press, W., Teukolsky, S., Vetterling, W., & Flannery, B. (1992).
Numerical Recipes in C: The art of scientific computing (2nd Ed.). Cambridge
UP. Chapters 12 and 13: Fast Fourier Transform and Spectral Applications

Week 10: Project Trouble Shooting

Last updated 2008-06-05

New Course Request

Academic Organization and Curriculum Handbook

College: SBS

Course Bulletin Listing: PSYCH - PSYCHOLOGY

Course Prefix:

Course Number: 618

☐ Generic course or decimal subdivision?

Full Course Title: Introduction to Computational Cognitive Neuroscience

Transcript Title: CompuCogNeuroSci

Level: ☑ Undergraduate ☑ Graduate

Credit Hours: 4

Proposed Effective Year: 09

Proposed Effective Term: Autumn Quarter

Course Bulletin

Course Description: Biologically plausible models of perception, memory, language, and high-levelcognition. Hands-on exercises with a state-of-the-art neural network simulator. Interdiciplinary emphasis

Terms Offered: Quarter(s)

- ☑ Autumn
- ☐ Winter
- ☐ Spring
- ☐ Summer
- ☐ Summer 1
- ☐ Summer 2

Offering Pattern: ☑ This year ☐ Every other year

Distribution of Class Time: 1 x 2.5 Hr Cl

Omit distribution of class time from printing? ☑

Prerequisities: Psych 310 or 312 or graduate standing or permission of instructor. (Psych 612 recommended)

☑ Electronic enforcement of prerequisites?

Exclusion or Limiting Clause: Not open to students with credit for Psych 878 in Winter, 2009

Repeatable? ☐

Cross Listed? ☐

Course part of a sequence? ☐

Grade Option: ◉ Letter ○ S/U ☐ Progress

☐ GEC Course

General Course Information Statement:

☐ Off Campus/Field Experience?

☐ EM Credit?

☐ Admission Condition Course?

☐ Offered in Distance Learning Format?

☐ Service Learning?

General Information

Subject (CIP) Code: 420801 Subsidy Level: D

If you have questions, please contact Jed Dickhaut @ dickhaut.1@osu.edu.

Expected Section Size: 20 Proposed Number of Sections Per Year: 1

☐ Course time less than 1 full term or Workshop

☐ Off-campus offering?

☐ Required on Major(s)

☐ Required on Minor(s)

☑ Elective within Major(s)

List of Major Programs: Psychology

☐ Elective within Minor(s)

☐ Choice of Major(s)

☐ Choice of Minor(s)

☑ A General Elective

State the need and purpose of the course. Indicate how the course relates to the primary goals of the academic unit/school/college/university.

Current trends in cognitive science emphasize computational models. Psych 617 (Neural Network Models in Psychology) emphasizes the algorithmic and mathematical side of such models but no existing course focuses on the neurophysiological basis of such models. The proposed course is meant to fill that gap.

Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. Evidence must be given of whether the budget support will come from reallocation of existing resources or from new program funds.

No adjustments are necessary - the course can be accommodated as part of a recently hired faculty members

Is approval of this request contingent upon the approval of other course or curricular requests? (●) Yes ( ) No

Please complete and attach the form(s) on the following page before completing the package.

Course Supplement Form

Course Contact Information

Faculty Name: Michael Vasey

Faculty Email: vasey.1@osu.edu

Contact Name: Kevin McCarthy

Contact Dept: Psychology

Contact Email: mccarthy.232@osu.edu

Contact Phone: 292-6742

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To: Dr. Richard Petty, Chair
Department of Psychology

From: Randy J. Nelson, Ph.D., & John D. Oberdick, Ph.D., Co-Directors
Neuroscience Graduate Studies Program

Re: Concurrence request for Psychology 618 (Introduction to Computational Cognitive Neuroscience)

Date: 17 February 2009

We have considered the syllabus and goals for the new proposed course, “Introduction to Computational Cognitive Neuroscience”. We are providing this letter of concurrence from our Neuroscience Graduate Studies Program (NGSP) in support of this course. To the best of our knowledge, no existing course at OSU overlaps with the proposed course. Although the course is targeted at graduate students and advanced undergraduate students in psychology, we believe it is also a natural fit for the Cognitive and Computational Neuroscience track of the proposed undergraduate major. We have increasing numbers of students involved in computational neuroscience projects and this course will be very useful in their training. From our perspective, this course will fill an important gap in our students' education and we suspect that students specifically advised by Drs Travers and Terman will benefit from this course. As we expand the computational neurosciences at Ohio State, this course will be important for this expansion. Thus, the NGSP is fully supportive of this course going forward.

From: Bruce W. Weide
To: Kevin Mccarthy;
cc: Kitty Reeves;
Subject: Psych 618
Date: Thursday, February 19, 2009 8:30:47 AM

HI Kevin,

We (CSE) have looked at the proposed Psych 618 and have no objections; you may consider this e-mail documentation of our concurrence.

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Cheers,
-Bruce

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Bruce W. Weide
Professor and Associate Chair
Dept. of Computer Science and Engineering
The Ohio State University
2015 Neil Ave.
Columbus, OH 43210-1277

Phone: 614-292-1517
FAX: 614-292-2911
E-mail: weide.1@osu.edu
Web: http://www.cse.osu.edu/~weide

Psychology 618

Introduction to Computational Cognitive Neuroscience

Proposed Course Syllabus

Course:	PSYCH 618
Call number:	TBA
Credits:	4
Dates:	TBA
Times:	2 hours 18 minutes class time, once per week
Room:	TBA
Prerequisites:	Psych 310 or 312 or graduate standing or permission by instructor. (Psych 612 recommended.)
Websites:	https://carmen.osu.edu
Textbook:	Randall O'Reilly & Yuko Munakata (2000). *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain.* Cambridge, MA: MIT Press.

Course Overview

How does cognition emerge from the brain? This course introduces you to the new and exciting field of Computational Cognitive Neuroscience (CCN) that provides important pieces of the answer to this question. We focus on simulations of cognitive and perceptual processes, using neural network models that bridge the gap between biology and behavior. We adopt the *Leabra* framework of Randy O'Reilly and Yuko Munakata, and use their 2000 book as the main text for the course. We first consider briefly the basic biological and computational properties of individual neurons and networks of neurons, as well as their idealized *Leabra* counterparts. We discuss their role in basic processing mechanisms such as spreading activation, inhibition, and multiple constraint satisfaction. We then discuss learning mechanisms that allow networks of neurons to build internal models of their environments and perform complex tasks. Models illustrating these ideas will be demonstrated in class and explored in homework assignments. We complement the simple demos with a few case studies of full-blown models of various aspects of perception, language, and memory. Finally, we turn to big-picture issues and present (an outline of) a comprehensive connectionist proposal of a cognitive architecture. We discuss how different brain systems (e.g., hippocampus, parietal cortex, frontal cortex) specialize to solve difficult computational tradeoffs. The course introduces the *Emergent* neural network simulator, which will enable you to explore the variety of models that come with the book.

Textbook

The main textbook is *Computational Explorations in Cognitive Neuroscience* (O'Reilly & Munakata, 2000), http://grey.colorado.edu/CompCogNeuro/index.php/CECN
Additional readings are listed in the lecture plan below.

Prerequisites

Undergraduate students need to have taken Psych 310 or Psych 312 or some other advanced course in cognitive psychology. There are no formal prerequisites for graduate students. Psych 612 is recommended but not required. Obviously, prior exposure to neural network models (e.g., Psych 617), mathematical models (e.g., Psych 609), and/or neuroscience (e.g., Psych 313) will be extremely useful, although the present course has little overlap with these courses. While the models we will be using are mathematically based, only algebra and some simple calculus-level concepts are involved. We rely primarily on computer simulations to explore the models and develop intuitions about how they work. Computer programming experience is not required because the models are accessible via a graphical interface. Still, you will be expected to install the *Emergent* simulator on your own and be able to run a few “canned” exercises with selected models.

Teaching Method

Classes will consist of lectures, tutorials, and discussions. There will be many in-class demonstrations. The course will require preparation prior to each class: reading chapters from the textbook, additional readings, and hands-on explorations with *Emergent*.

Emergent Software

Each student should have access to the *Emergent* simulator. It is the successor of PDP++ (the software that came with the book). *Emergent* is open-source and available on all major platforms: Linux, Mac OS X (preferred), and Windows. Precompiled binaries (and C sources) are available for download from http://grey.colorado.edu/emergent/ It is assumed that all graduate students have access to a personal computer and are willing to install the software. Be sure to get version 4.0.17 or later.

Hands-on experience with actual running models is an important part of the course. It is a unique exploratory learning opportunity. The difficulty level will be matched to the average ability of the students in the class. We will begin with very simple exercises and progress to more complex ones depending on your interest and skill. The simulator gives complete control over all aspects of the network and its training environment. It also provides dynamic, colorful visualizations that are an indispensable tool for developing intuitions about how complex cognition can emerge from a network of neurons. To access the simulation exercises, go to
http://grey.colorado.edu/CompCogNeuro/index.php/CECN1_Projects

IMPORTANT: The textbook was written to support PDP++ (the old software), not *Emergent* (the new software we will be using). As such, many of the instructions in the textbook are incorrect, and you need to follow the directions that are contained within the projects that you download. See the above link for more information.

Accommodations for Students with Special Needs

The policy of The Ohio State University is to provide every reasonable, appropriate, and necessary accommodation to qualified disabled students. The University's colleges and academic centers evaluate and judge applications on an individual basis and no categories of disabled individuals are automatically barred from admission. The privacy rights of each disabled person are honored to the fullest extent possible. The University's interest in a students disabilities are only for the purpose of accommodating his/her specific disability, thereby providing an academically qualified disabled student access to programs and activities accorded all other qualified students. Whenever generally accessible facilities do not adequately accommodate a specific disability, the University makes every reasonable accommodation and program or facility adjustment to assure individual access. These policies are fully supported and practiced in this class.

If you have a disability documented with the Office of Disability Services (http://www.ods.ohio-state.edu, 150 Pomerene Hall, 614-292-3307), please contact Dr. Petrov privately (petrov.11@osu.edu, 200B Lazenby Hall, 614-247-2734) by the end of the second week of classes so that any accommodations can be made.

Evaluation

Your grade will depend on four components in the following proportions:

Model explorations	50%
Class participation	10%
Final paper	40%

Grades are based on absolute cutoffs: A=90-100%, B=80-89%, C=70-79%, D=60-69%.

Model explorations: The textbook comes with a large number of pre-built neural network models that illustrate key principles and phenomena. Every week, you will explore these pre-built models and document your explorations by answering questions from the textbook. The Course Calendar lists which exercises to do for each chapter. You should write up all assigned simulation exercises for each chapter and upload them to the corresponding Carmen dropbox. The acceptable formats are MS Word (.doc or .docx), plain text (.txt), PDF, HTML, or RTF. Note that the model exploration report for each chapter must be in a separate file and dropped in a separate dropbox, prior to the date specified in the Calendar section of the syllabus. Late submissions will be penalized 1%

for each day after the due date. Reports submitted by email, slipped under the door, etc. will not be graded and do not bring any points. Teamwork on these explorations is encouraged, but you must write your reports *individually*. We want to see that each individual person understands the material, and so this should be evident in your writing. It is best to write down results and first drafts of answers as you work through the simulations; they can sometimes take a while and you do not want to have to run them repeatedly.

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 discuss the issues and answer questions. Attendance is required.

Final paper: 40 percent of your grade are based on a final paper. It must be uploaded to the "Final Paper" dropbox on the Carmen website by 11:59 pm on Monday, ?/??. It must be 8-12 pages long (double-spaced, 12-pt font, excluding figures) and be submitted in one of the acceptable file formats. Late penalty 5% per day. For the final paper, you can either (a) use simulations to examine some psychological phenomenon of interest to you or (b) do a literature search and write a review that compares a neural network model to another model (neural network or otherwise) in light of some behavioral, neuropsychological and/or neurophysiological data. I expect (and recommend) that most of you will choose option (b), but the more challenging option (a) is available too. If you choose (a), *do not be overly ambitious* – relatively simple but thoughtful work is preferred to a complicated half-baked mess. Do not be misled by the relative simplicity or running the canned exercises in the book. Developing a simulation from scratch takes a long time. See the tutorial
http://grey.colorado.edu/emergent/index.php/Build_your_own_network

Literature review (option b) will require more reading and integration of scientific articles. While this does not involve you in actual simulations, it does require in-depth understanding of publishable research on connectionist modeling. You will have to compare at least two published models and how they differentially account for your phenomenon of interest. One (or both) of these models must be a neural network model. The minimum review that can still bring you 40% towards your grade would take some of the models in the textbook and compare it against the original publication of the same model. For example, the Leabra implementation of the triangular model presented in Section 10.3 in the book (Figure 10.5) can be compared against the original backprop implementation of Plaut & Shallice (1993). Your review paper should contain a concise introduction to the psychological issue or phenomenon and outline the principle(s) instantiated by the two models. It should contain methods, results, and a concluding discussion of the significance of the results, how the models can be improved, etc.

By Sunday, ?/??, you should upload on Carmen a one-page proposal for your final paper. This proposal should specify whether you plan to do (a) a simulation or (b) a literature review. It should also contain a summary of your question of interest, your proposed approach to explore this question through simulation (a) or the two models you propose to compare (b). This one-page proposal is worth 5% toward the 40% allocation for the final paper. Your proposal must be approved by the instructor as a prerequisite for the final paper. Unapproved papers will not be graded and do not bring any points.

Academic Ethics

All students enrolled in OSU courses are bound by the Code of Student Conduct (http://studentaffairs.osu.edu/resource_csc.asp). Suspected violations of the Code will be dealt with according to the procedures detailed in the Code. Specifically, any alleged cases of misconduct will be referred to the Committee on Academic Misconduct.

Course Calendar

1. **Introduction and overview. Neurons (I).**

   Getting started. The appeal of Parallel Distributed Processing (PDP). Overview of the course. Overview of *Leabra*. Overview of the Emergent simulator. A network in action: constraint satisfaction. Jets-and-Sharks model (aka Cats-and-Dogs model, Sect. 3.6.4). Necker cube model (Sect. 3.6.5). The neuron as a detector.

   Readings:

   - Chapter 1 in O'Reilly & Munakata (2000, henceforth O&M).
   - O'Reilly, R. C. (1998). Six principles for biologically-based computational models of cortical cognition. *Trends in Cognitive Sciences, 2*, 455-462. http://psych.colorado.edu/~oreilly/pubs-abstr.html#OReilly98
   - McClelland, J. L., Rumelhart, D. E., & Hinton, G. E. (1986). The appeal of parallel distributed processing. In D. Rumelhart & J. McClelland (Eds.) *Parallel Distributed Processing, Vol. 1: Foundations*. Cambridge, MA, MIT Press. (Available on Carmen.)
   - Skim through O&M Chapter 2. Must read only the summary (Sect.2.10).

   Explorations: There is no written assignment this week but you should obtain the textbook, install the Emergent simulator and go through the tutorial: http://grey.colorado.edu/emergent/index.php/Getting_Started

2. **Neurons (II) and Networks**

   Point-neuron activation function (Box 2.2 in O&M, p. 49). Biology of the neuron. Cortical networks. Localist vs. distributed representations. Feedforward and recurrent networks. NetTalk demo. Pattern completion. Inhibition and its k-winner-takes-all (kWTA) approximation. Constraint satisfaction. Jets-and-Sharks and Necker-cube models revisited.

   Readings:

   - O'Reilly, R. C. (1998), *TiCS, 2*, 455-462 – see full citation above
   - Skim through O&M Chapters 2 and 3. Read all summaries and boxes carefully. You will need Sections 2.6.3, 3.6.4, and 3.6.5 for the assigned model explorations.
   - [Optional] Sejnowski, T. J. & Rosenberg, C. R. (1987). Parallel networks that learn to pronounce English text. *Complex Systems, 1*, 145-168. (PDF reprint and audio file nettalk-audio-demo.mp3 available on Carmen.)

   Explorations (6%): Exercises 2.7, 2.9, 3.6, 3.15, and 3.16, **due ?/??**, 11:59 pm.

3. Hebbian Model Learning

Learning in neural networks. Hebbian vs. error-driven learning: what is the difference? Biological mechanisms of learning. Computational objectives of learning. Conditional PCA. Self-organizing learning. Explorations of Hebbian (Sect. 4.6) and self-organizing learning (Sect. 4.8.1).

Readings:

- O&M Chapter 4. Feel free to skip all mathematical derivations, as well as the technicalities of renormalization and contrast enhancement (Sect. 4.7).
- [Completely optional] Kandel, E. (2001). The molecular biology of memory storage: A dialogue between genes and synapses. *Science, 294,* 1030-1038. (Based on Eric Kandel's acceptance speech for the 2000 Nobel Prize for Medicine. PDF available on Carmen.)

Explorations (6%): Ex. 4.3 and 4.6. **Due ?/??**, 11:59 pm.

4. Applications of Hebbian Learning

Learning self-organizing maps in primary visual cortex (Sect. 8.3). Learning semantic representations from word co-occurrences (Sect. 10.6).

Readings:

- O&M Sections 4.5, 4.8, 8.3, and 10.6.
- [Optional] Olshausen, B. A. & Field, D. J. (1996). Emergence of simple-cell receptive field properties by learning a sparse code for natural images. *Nature, 381*, 607-609. (PDF reprint available on Carmen.)

Explorations (6%): Ex. 8.1, 8.2 and 8.3. **Due ?/??**, 11:59 pm.

5. Error-Driven Task Learning. Combined Hebbian+Task Learning

Learning of arbitrary input-output mappings. XOR problem. Delta rule and its generalizations. The GeneRec learning algorithm computes error from activation differences. Functional pros and cons of Hebbian and error-driven learning. The advantages of combining them. Inductive biases. Generalization.

Readings:

- Skim through O&M Chapters 5 and 6, up to Sect. 6.4 inclusive. Feel free to skip all mathematical derivations. Make sure to read Sections 5.8, 5.10, 6.2, 6.8, and Box 6.1.

Explorations (7%): Exercises 5,1, 5.2, 5.3, 5.5, and 6.2, **due ?/??**, 11:59 pm.

6. Invariant Object Recognition

Dorsal and ventral visual streams. Invariant object recognition: the problem. Structural vs. image-based approaches. The binding problem. A simple model of object recognition.

Readings:

- O&M Chapter 8, Section 8.4.

- [Optional] Riesenhuber, M. & Poggio, T. (1999). Hierarchical Models of Object Recognition in Cortex. *Nature Neuroscience, 2*, 1019-1025. (PDF available on Carmen.)
- [Optional] Hummel, J. E. (2001). Complementary solutions to the binding problem in vision: Implications for shape perception and object recognition. *Visual Cognition, 8*, 489-517. (PDF available on Carmen.)

Model explorations (6%): Exercises 8.4 and 8.6. **Due ?/??**, 11:59 pm.

7. Selective Attention

A simple model of spatial attention (Sect. 8.5). An integrated model (Sect. 8.6).

Readings:

- O&M Chapter 8, Sections 8.5 and 8.6.
- [Optional] Mozer, M. C. & Sitton, M. (1998). Computational Modeling of Spatial Attention. In H. Pashler (Ed.), *Attention* (pp. 341-393). Philadelphia, PA: Psychology Press. (Contact Dr. Petrov for a hard copy.)

One-page proposal for final paper, **due ?/??**, 11:59 pm.
Explorations (6%): Exercises 8.8, 8.9, and 18.10, **due ?/??**, 11:59 pm.

8. Complementary Learning Systems

Memory is not unitary. Weight-based vs. activation-based memories. AB-AC learning. Catastrophic interference. Role of the medial temporal lobe. Amnesia. Functional tradeoffs and the need for complementary learning systems.

Readings:

- O&M Chapter 9.
- [Optional] McClelland, J. L., McNaughton, B. L., & O'Reilly, R. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review, 102*, 419-457. [http://psych.colorado.edu/~oreilly/pubs-abstr.html #McClellandMcNaughtonOReilly95](http://psych.colorado.edu/~oreilly/pubs-abstr.html#McClellandMcNaughtonOReilly95)

Explorations (6%): Exercises 9.2, 9.4 (competition for extra credit!), and 9.7. **Due ?/??**, 11:59 pm.

9. Tripartite Cognitive Architecture

Cognitive architecture: A big idea of science. Tripartite functional organization of the brain. Prefrontal cortex. Working memory (Sect. 9.5). Stroop model (Sect. 11.3). Basal ganglia: reinforcement learning, gating.

Readings:

- O&M Chapter 7 and Sections 9.5, 11.1, 11.2, 11.3, and 11.7.
- [Optional] O'Reilly, R.C., Braver, T. S. & Cohen, J. D. (1999). A Biologically Based Computational Model of Working Memory. In A. Miyake & P. Shah (Eds.) *Models of Working Memory: Mechanisms of Active Maintenance and Executive Control* (pp. 375-411). New York:

Cambridge University Press. http://psych.colorado.edu/~oreilly/pubs-abstr.html#OReillyBraverCohen99

- [Optional] Anderson, J. R. & Lebiere, C. L. (2003). The Newell test for a theory of cognition. *Behavioral & Brain Sciences*, *26*, 587-637. http://act-r.psy.cmu.edu/publications/pubinfo.php?id=507

Explorations (7%): Exercises 9.9, 9.11, 11.2, and 11.3. **Due ?/??**, 11:59 pm

10. Advanced Topics. Conclusions
Higher-level cognition in neural networks. Final discussion.

Readings:

- O&M Chapter 12 and Sections 11.5, 11.6, and 11.7.
- O'Reilly, R. C. (2006). Biologically Based Computational Models of High-Level Cognition. *Science*, *314*, 91-94. http://psych.colorado.edu/~oreilly/pubs-abstr.html#OReilly06
- [Optional] Rougier, N. P., Noelle, D., Braver, T. S., Cohen, J. D. & O'Reilly, R. C. (2005). Prefrontal Cortex and the Flexibility of Cognitive Control: Rules Without Symbols. *Proceedings of the National Academy of Sciences*, *102*, 7338-7343. http://psych.colorado.edu/~oreilly/pubs-abstr.html#RougierEtAl05

F. Final Paper Due ?/??, 11:59 pm

The above calendar is subject to change at the discretion of the instructor, depending on the rate of progress through the material, student interest in alternative topics, and/or scheduling constraints. The model exploration assignments are also subject to change; you will be notified at least five days in advance for any changes in the assignments.

Finally, welcome to the course. I hope that you will enjoy the class and learn valuable information and skills. I look forward to seeing you on ?/??.

Alex Petrov

psy618-proposed-syllabus.doc, last updated 7 Jan 2009