

Syllabus

Introduction to the Methods of Computational Neuroscience and Psychology

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Britt Anderson

1 Instructor Information

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2 Course Description

This course is intended for students, undergraduate and graduate, who wish to learn more about computational methods and their application to neuroscience and psychological topics. The particular type of student towards whom the course is directed is a student that has shied away from mathematical and computational courses in the past; thus, while the student has an interest in these techniques, they feel ill-suited, either by training or natural ability, to pursue this interest.

To meet the needs of such students, the course has three large goals. First, we explore how computational techniques have been used in cognitive and neuroscience research so that we can be critical readers of research papers. No more will the words: model, computation, or equation, lead us to skip from introduction to discussion with the simple presumption that everything in between was done properly. Second, we will develop our computational vocabulary. This will help us with our first goal of being critical consumers of computational research, but it will also allow us to be collaborators in computational research. We can do this if we can speak some of the language of the computer scientist and mathematician. This vocabulary is also a pre-requisite for pursuing these techniques beyond this introduction. Third, we will dispel the notion that computational approaches require some special ability or months spent learning some arcane programming language. Anyone who has ever used a spreadsheet to sum a column of numbers is a computer

programmer and nothing beyond that knowledge is necessary to begin to use computational techniques. The use of a spreadsheet also has the benefit that it makes clear and explicit, at every step, what is happening; this is not always true of more conventional computational implementations.

In summary, the goals for the course are to become informed readers of research articles using computational techniques, learn enough mathematical and computational terminology to be active scientific collaborators, and to actually program computational simulations at a rudimentary level.

The more specific objectives of the course are aligned around four mathematical topics each of which is paired with a computational example or cognitive area of application:

differential equations	neuronal voltage
linear algebra	neural networks
probability	neuronal firing
information theory	attention

Table 1: the list of mathematical topics and their paired computational approach or topic

For each row of the table, we will discuss some of the relevant neuroscience or psychology background. We will try and read a pertinent article using the approach. We will review some of the mathematical background and the computational algorithm. Then, we will use spreadsheet software to develop our own implementation of the algorithm.

3 Textbook

I tried my best to find us a textbook for this course, and I failed. Please feel free to make suggestions. My problem was that there is essentially only one textbook on computational approaches to cognitive neuroscience. This is

the book: *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain*. I really like this book, and we will use their chapter 1 for our introduction. However, all the simulations in the book use a particular computational implementation: Emergent. This is a version of the PDP approach. This software is not terribly complicated, but there is a learning curve and I didn't want to spend most of our term learning how to use a piece of software rather than what the software is good for. Also, all the time spent learning any particular software approach may not be valuable, because the student may not be using that language in the future. We want to learn about the techniques generally; then we can pick the computational language in the future that best suits our needs.

There are several good textbooks on computational neuroscience, but they, too, either bind themselves to one particular computer language, or are too high level for us. Two good books are *Theoretical Neuroscience* by Dayan and Abbott (this one is fairly high level) and *Fundamentals of Computational Neuroscience* by Trappenberg (a bit more basic, but reliant on MATLAB).

Therefore, we will be relying on handouts and pdfs. I will try and post as many of these as I can on our course site on UW-ACE.

4 Course Requirements, Expectations, and Grading

4.1 Requirements

There really are no requirements. I have PSYCH261 as a pre-requisite in order to try and prevent us from having to go over too much basic terminology, but I would probably waive this if a student was curious enough to ask. By the same token, any prior calculus, linear algebra, or programming experience will be convenient, but it is not necessary. I really am only looking for people to roll up their sleeves and get their hands dirty. If you want to get anything out of this course you will probably have to work pretty hard, but the pressure to do so, will have to be self-applied. Just because the course is classed as a "seminar" does not mean that it is all about reading and talking. You will have to work to learn anything.

4.2 Expectations

I expect you to attend every class or send me advance notice indicating why you cannot. There will be periodic assignments during the course. You must complete all assignments. If you complete a reasonable effort at every assignment than you will pass. I hope to use much of our class time for group discussion and small projects.

4.3 Grading

Graduate students have to meet all the obligations of the undergraduates and in addition they will have to present a paper in class. The paper will be selected by the graduate student from a published source. The paper should use, or in some way rely on, a computational technique. The student will present the paper, and the technique and then guide the class's discussion on the pros and cons of the approach used.

The other components of the grade will come from the classroom assignments and, potentially, a final project. No midterms or finals are projected at this time.

5 Accommodations for Students with Disabilities

The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

6 UW-ACE

I will be trying to use UW-ACE for everything. We have a course web page where all readings and assignments will be posted. Drop boxes in the course web page will be used for you to submit your assignments. A discussion forum on our course web page will be there for the discussion of topics that you think other students might be able to answer for you, or that you think other students will be interested in my comments.

Some of the assignments will have templates of spreadsheets that you can work from as a starting point. These will be located in a folder in the Contents tab of the UW-ACE page.

I will be attempting to use the grade book option of UW-ACE to keep you informed of your performance on the assignments.

7 Communications

7.1 Discussion Forum

As discussed above, this is for items of general interest.

7.2 Email

Please email me through the UW-ACE page. It is good for both of us if our academic correspondence goes through ACE. This gives us both a record of what was sent and went. Because of this I will only answer email inquiries about the course through the UW-ACE site. You should verify that UW-ACE forwards your email, or that you check the course site regularly.

7.3 Other

In general, email is not a very good communication media for anything but simple inquiries. If you have a deep question, or personal issue, please come by and see me. My office hours are listed above. If you come by and my door is open, please feel free to knock and see if I am busy. I am also happy to schedule a time for an appointment and my office extension is available if you want to check on my availability before walking over to PAS.

8 Academic Integrity, Academic Offenses, Grievance, and Appeals

To protect course integrity, as well as to provide appropriate guidance to students, course outlines in the Faculty of Arts incorporate the following note on avoidance of academic offenses:

Academic Integrity: in order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about 'rules' for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 - Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals, <http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>

9 Concerns About the Instructor - Informal Stage

We in the Psychology Department take great pride in the high quality of our program and our instructors. Though infrequent, we know that students occasionally find themselves in situations of conflict with their instructors over course policies or grade assessments. If such a conflict arises, the Associate Chair for Undergraduate Affairs (Dr. Colin Ellard) is available for consultation and to mediate a resolution between the student and instructor. Dr. Ellard's contact information is as follows:

Email: cellard@uwaterloo.ca
Ph 519-888- 4567 ext 36852

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. See Policy 70 and 71 below for further details.

10 The Official Course Outline

If there is a discrepancy between the hard copy outline and the outline posted on UW-ACE, the outline on UW-ACE will be deemed the official version. Outlines on UW-ACE may change as instructors develop a course, but they become final as of the first class meeting for the term.