Systems Neuroscience: Syllabus

Course Materials: Research Papers listed below

(NO TEXTBOOK)

Instructor: Avinash D Singh Bala, Ph.D.
Email: avinash@uoregon.edu

CLASS TIME (PAC 30): 1400-1450 Mon/Wed/Fri
OFFICE HOURS: 228B Huestis Hall
- Tue 1300-1500
- Other days /times by appointment

Links:
- Blackboard
- Course CRN; Academic Deadlines etc.
- UO Libraries
- Backup site for course document access (if blackboard is down)

I. Contents
   I. Contents
   II. Notice to Students with Disabilities
   III. Introduction
   IV. Reading
   V. Key Questions
   VI. Where can you find the Research Articles listed?

NOTE: The electronic version of this document is available on blackboard as a PDF file, and underlined phrases are functional hyperlinks.

II. Notice to Students with Disabilities

   The University of Oregon is working to create inclusive learning environments. If there are aspects of the instruction or design of this course that result in barriers to your participation, please let me know as early as possible, in person or via email. You may also wish to contact Accessible Education Services in 164 Oregon Hall, by phone at (541) 346-1155 or uaec@uoregon.edu. I welcome the chance to help you learn, and will work with you to help make it a good learning opportunity and experience.
III. Introduction

The goal of systems neuroscience is to decipher the neuronal codes that produce perception and behavior. We will examine four very different neural systems: binaural hearing, binocular vision, echolocation, and electrorception. Different though they may be, these systems have in common the fact that they all require the comparison of information received by different parts of the body (e.g., left eye vs right eye) or at different points in time (e.g., sonar-pulse and echo return). Our goal is to identify general principles of this comparative process and see how they are differentially implemented to achieve various perceptual and behavioral goals. In addition, there is a general question that lurks behind all of these topics: How does behavioral performance compare with the performance of individual neurons? This all-encompassing topic is explored in the last segment of the course.

You are expected to have a working knowledge of basic physics, neuroanatomy, and neurophysiology. Basic neuroscience or neurobiology textbooks should be consulted to brush up on fundamental neuroscience concepts. Textbooks for brushing up basic knowledge:

- Fred Delcomyn, Foundations of Neurobiology
- Gary Matthews, Neurobiology: Molecules, Cells, Systems
- Eric Kandel, Principles of Neural Science

The course is taught from the primary literature (reading list below; all papers available online) and has a lecture/discussion format. The lectures are designed to give you background information and an organizational framework of each of the four topics. You are expected to have read the papers ahead of time. The "Key Questions” listed below will give you an idea of the aspects of each of the papers to which you should attend. You should attempt to answer these questions before we discuss them in class. During class, you will be called upon to provide details, interpretations, and criticisms regarding the papers. In this manner, I hope to help you to arrive at an overall picture of each topic.

Details about grading, assignments, deadlines etc. can be found in a document called 'Grading&Assignments_Final_Sysneuro1401..pdf”, which is also available in the Course Documents folder on Blackboard.

IV. Reading

I. Comparing the two ears: Computation of binaural time disparities and spatial hearing.


A. Coding of monaural phase

B. Computation of binaural phase difference

D. An alternative to the Jeffress Model?

II. Comparing two points in time: Computation of target range in echolocating bats


A. Phase Sensitivity

B. Phase sensitivity & Hyperacuity

III. Comparing the two eyes: computation of retinal disparities and stereoscopic vision


C. Cumming BG, Parker AJ. 2000. Local disparity not perceived depth is signaled by binocular neurons in cortical area V1 of the macaque. *J. Neurosci.* **20:**4758-4767.

IV. Comparing body surfaces: Jamming avoidance response in weakly electric fishes


V. Comparing neuronal responses and behavioral performance

A. Somatosensory Thresholds

B. Visual Motion


V. Key Questions

**SYSTEMS NEUROSCIENCE: NEURONS, NETWORKS AND BEHAVIOR**

I Comparing the two ears: Computation of binaural time disparities and spatial hearing

1. Explain the concept of phase locking. Explain the construction of period histograms and the concepts of vector strength and mean phase angle. What happens to the mean phase angle if you change the stimulus frequency and what does such an experiment tell us?
2. Explain the delay-line and coincidence detector model of binaural phase computation. How does this mechanism give rise to phase-ambiguity?
3. How is phase-ambiguity solved theoretically and how does the owl’s auditory system implement this solution?
4. Compare and contrast the manner in which the barn owl and small mammals (e.g., guinea pigs, gerbils) represent auditory space. Include a description of the place-code strategy and the rate code strategy.
5. Why is the dependence of best ITD on neuronal best frequency an important part of McAlpine group’s argument on how small-headed mammals use their ITD-sensitive neurons

II Comparing two points in time: Computation of target range in echolocating bats

1. Application of cross-correlation principles: Imagine that you are a molecular biologist. You are faced with the following sequence of nucleotides, N(s): 5’GATCATTGAGTATTACGTTAGCAGCTAGGCCCATTGAGTAGTTTAAGCCGAT3’. You want to know whether the following probe sequence, P(s), is complementary to any part or parts of N(s) and where the complementary region(s) might be. P(s): 3’GTAACTCATC5’
   a. Write a set of specific instructions of the type that you might give to a computer to solve this problem. Remember, Watson-Crick pairing means G/C bind and A/T bind. (i.e., GxC=1; AxT=1; all other products = 0)
2. Simmons and colleagues (1990, *J. Comp. Physiol.* 167:589-616) taught bats to discriminate between jittering and stationary targets, and plotted the number of errors the bats made as a function of the size of the jitter. Their paper shows that the bats have problems distinguishing between jittering and non-jittering targets at a jitter of around 30 microseconds. Why is the bat making errors at this jitter and how do the authors interpret this result? Why is it so controversial?
3. Explain the control that argues in favor of the involvement of phase.
III Comparing the two eyes: computation of retinal disparities and stereoscopic vision

1. What is the equivalent of ITD in stereopsis, and how does this parameter encode depth?
2. Derive the relationship between binocular disparity and the distance off of the horopter. What happens to this relationship if the location of the horopter is changed?
3. What is the difference in the response of cells that are selective for relative and absolute disparities? To which of these disparities are cells in the primate V1 tuned (Trotter et al., 1992)? Explain the results that lead you to your conclusion.

IV Comparing body surfaces: Jamming avoidance response in weakly electric fishes

1. How did Heiligenberg and colleagues demonstrate that the weakly electric fish, *Eigenmannia*, performed the JAR without benefit of an efference copy (a copy of its own EOD)?
2. What physical cues does the fish need to determine whether its EOD frequency is higher or lower than a neighboring fish? What does it mean that the fish “reads” the sense of rotation in the phase/amplitude plane (Lissajous figure)?
3. Explain the methods by which Carr, Heiligenberg, and Rose (1986 *J. Neurosci.* 6:107-119) determined the minimal detectable time differences between two patches of the body surface. How did this compare to neuronal performance?
4. How are the cues represented in the nervous system and how are they combined to produce the neurons that can tell the difference in frequency between a fish’s own EOD and that of its neighbor?

V Comparing neuronal responses and behavioral performance

1. What is the basic idea behind signal detection theory and how does it alter our basic ideas about perceptual thresholds? What does the quantity $d'$ represent?
2. How did Johansson and Vallbo measure behavioral (psychophysical) and neuronal detection thresholds?
3. In other systems, sensory neurons may perform at, above, or below behavioral thresholds. What do Johansson and Vallbo conclude about the relationship between behavioral performance and neuronal sensitivity of human somatosensory receptors?
4. List some factors which, in your mind, would enhance the validity of comparing neuronal responses to behavioral responses.
5. Detail one example where behavioral thresholds are seemingly determined by the performance of single neurons, and one example where single neurons are unable to explain behavioral performance. What would you describe as the advantages and disadvantages of either process?
6. What is the evidence that perception is based on the contributions of a relatively small number of specialized (for detecting visual motion) neurons?
VI. Where can you find the Research Articles listed?

All papers listed are available online, and can be accessed via the hyperlinks at the end of each citation. Most can be found by searching at the main UO library search engine: just type the entire title. However, please remember that the Library’s subscription to journals can only be accessed while you are on the UO campus, or are connected to the university via VPN. Off campus access is detailed here.
I. Contents

I. Contents ........................................................................................................................................ 1
II. Notice to Students with Disabilities ................................................................................................. 2
III. Grade Components .......................................................................................................................... 2
IV. TESTS (60%) ..................................................................................................................................... 2
V. Student Groups ................................................................................................................................... 3
VI. Study Group Responses (15%) ........................................................................................................... 4
VII. Paper Summaries (10%) .................................................................................................................. 4
VIII. News Article Analysis (BI-461 only; 15%) .................................................................................... 4
IX. Self-study report (BI-561 only; 15%) ................................................................................................. 5
X. Submitting Assignments .................................................................................................................... 5

NOTE: The electronic version of this document is available on blackboard as a PDF file, and many underlined phrases are functional hyperlinks.
II. Notice to Students with Disabilities

The University of Oregon is working to create inclusive learning environments. If there are aspects of the instruction or design of this course that result in barriers to your participation, please let me know as soon as possible, in person or via email. You may also wish to contact Accessible Education Services in 164 Oregon Hall at (541) 346-1155 or uoaec@uoregon.edu.

III. Grade Components

Table 1

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>#</th>
<th>461</th>
<th>561</th>
<th>WHEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes</td>
<td>5 (best of 7)</td>
<td>15</td>
<td>15</td>
<td>10/8; 10/20; 10/31; 11/12; 11/24; (+2 online in Oct &amp; Nov)*</td>
</tr>
<tr>
<td>Midterm</td>
<td>1</td>
<td>20</td>
<td>20</td>
<td>Nov 03</td>
</tr>
<tr>
<td>Final</td>
<td>1</td>
<td>25</td>
<td>25</td>
<td>Wed 12/10 (1445 h)</td>
</tr>
<tr>
<td>Study group responses (SGR)</td>
<td>5</td>
<td>15</td>
<td>15</td>
<td>Oct 4, 18, Nov 1, 15, 29</td>
</tr>
<tr>
<td>Paper Summaries</td>
<td>10 (best)</td>
<td>10</td>
<td>10</td>
<td>Day Paper discussed in Class</td>
</tr>
<tr>
<td>News analysis</td>
<td>1</td>
<td>15</td>
<td>-</td>
<td>12/1*</td>
</tr>
<tr>
<td>Self-study</td>
<td>1</td>
<td>--</td>
<td>15</td>
<td>12/1*</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Extra credit (Max)</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

* To Be Finalized in first lecture with input from class

Assignment / Exam dates not in Table 1

<table>
<thead>
<tr>
<th>Day, Date</th>
<th>Time</th>
<th>Assignment due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thu, Oct 2</td>
<td>2359</td>
<td>Enroll in Study Groups</td>
</tr>
<tr>
<td>Sun, Oct 19</td>
<td>2359</td>
<td>1. BI 461 – News Analysis Topic&lt;br&gt;2. Copies of News &amp; Reference of Research article</td>
</tr>
<tr>
<td>Mon, Nov 03</td>
<td>1400</td>
<td>MID-TERM</td>
</tr>
<tr>
<td>Sun, Nov 30</td>
<td>2359</td>
<td>BI-461 News analysis Report</td>
</tr>
<tr>
<td>Sun, Nov 30</td>
<td>2359</td>
<td>BI-561 Self-study report</td>
</tr>
<tr>
<td>Wed, Dec 10</td>
<td>14:45</td>
<td>Final Exam</td>
</tr>
</tbody>
</table>

IV. TESTS (60%)

QUZZES: (15%)
- First 10 minutes of class on designated dates (see Table above)
- Quick, non-cumulative reviews of materials since last quiz
- Short answer questions
- 5 quizzes on designated days, 6th & 7th will be online towards end of Oct & Nov
- 5 highest scoring will count
Short quizzes will be given in the first 10 minutes of class some days (see the course schedule). The quizzes are designed to serve as quick reviews of recently covered materials as well as to help you keep up with the reading assignments. Quizzes will contain 3 to 10 short answer questions that pertain to the most recently presented lecture material. Questions will occasionally be drawn from readings that have been assigned but may not yet have been discussed in the lectures; however, these questions will be of a more general nature and should be easily answerable. Of the 7 quizzes, the 2 with the lowest scores will be dropped, with the total score of the remaining 5 yielding 15% of the final grade. No make-up quizzes will be offered; if you miss a quiz, that grade will be one of the two that will be dropped. 5 Quizzes will be in-class; the remaining two will be online quizzes administered through Blackboard. The final quiz will be offered just prior to exam week, and will give people a chance to make up a missing quiz or to improve their quiz score. **NOTE:** Some of the quiz questions will require calculation. If you need calculators, please bring them along. You may NOT use calculators that are part of your computer, PDA, or smartphone, or mobile phone.

**EXAMS: (Midterm - 20%; Final 25%)**
- Two exams
  - Midterm (20%)
  - Final (25%)
- Midterm designed to be completed in 45 minutes
- Final 1 hr 15 min (but you will have 2 hrs to finish it)

Exams will test conceptual understanding, not just information. The exams will be part multiple choice, part fill-in-the-blank/match the information and part short answer/short essay. The Final will emphasize materials covered in class since the midterm, and only conceptual questions about pre-midterm material. As with the quiz instructions, if you need calculators for calculations, please bring one with you. **No make-up exams will be given without a valid, excused absence!** If unforeseen circumstances during the term prevent you from taking an exam, notify the instructor immediately. Allowable excused absences are executive orders/ court orders, medical emergencies and athletic events such as away games for student athletes. All such occasions must be accompanied by official documentation. Make-up exams may be essay-type. **NOTE: Academic Honesty:** As an Instructor, I am required to report any instances of academic dishonesty. Please do not attempt to cheat in any way during exams - instructors do not have any other option.

**V. Student Groups**

You will need to form groups of 3 people each for Study Group Responses (below). Since the course material is primary research papers, studying as a group can be very helpful. You will get time in class to meet people and decide on study group members during the first day of term, and you can send me a list by email.
VI. Study Group Responses (15%)

- 5 total SGRs
- One every 2 weeks except for mid-term week
- Work with study group members on problems
- Mainly conceptual problems
- Only online, and you will have at least a week to work on the problems
- Due before midnight Sunday night 23:59:59)

VII. Paper Summaries (10%)

Paper summaries comprise a report on any 10 of the papers listed above as part of the curriculum. Acceptable summaries: Handwritten on template; typewritten on template; highlighted PDF; scan of highlighted and annotated prints, write-up. The summary should make it obvious that you read the paper completely and thoroughly – particularly the methods and the results. You can submit reports on more than 10 articles; the best 10 will be counted. Report on any article is due the day it is discussed in class. You may hand me a hard-copy at start of class, or email it to me prior to start of class. No late submissions will be counted, since there are enough extra articles to make up for a couple missed ones

VIII. News Article Analysis (BI-461 only:15%)

This will be an individual assignment.

1. Find an appropriate topic (deadline for submitting topic: Oct 19th, 23:59:59)
   - Pick a news item from 2013/14 that discusses research related to Systems Neuroscience
   - Find the original research article
   - Submit a brief (max 1 page) write-up defending the choice of topic. It must be based on research in System Neuroscience, be of sufficient general interest, and based on an empirical research article (not a review, abstract, poster, or talk)

2. Write a well-researched, comprehensive report on the primary research article, and analyze the way in which that research was presented to the lay public (or the lay scientific community). It must be obvious to the reader that you have a good grasp of the findings of the paper and were able to analyze the original research and the news article in a thoughtful manner [Blackboard submission deadline 2359h, Mon. Dec 1st]
   - Describe the original research article, critically examining the methods, findings, interpretation, and the reason it made it into the news
   - Was the research important or interesting enough to make its inclusion in the news appropriate?
   - Then, analyze the original news article, and examine how the research was portrayed in the news article.
• Was the research appropriately presented? Did the researchers or the news writer do a fair job of presenting the pluses and minuses of the research?

• All scientific papers highlight the possible flaws or gaps in the results being presented. This is one of the fundamental hallmarks of scientific writing: to give extraordinary weight to any argument that may disprove any findings or interpretations. This is usually in the 'Discussion' section, and is almost always glossed over in any press coverage. Did the news article make any effort to present alternative theory or data?

• The final report should be 6-8 pages (11-12 pt font; 1.5 or double spaced; 1.5 inch left margin, other 1 inch margins). After running your report through Safe Assign, you must submit it via Blackboard (folder: Assignments) by 2359h, Mon, Dec 1st).

Templates will be available on Blackboard

NOTE: Academic Honesty: Plagiarism is regarded as academic misconduct, and also needs to be reported. In order to make your job simpler, 'SafeAssign' will be available to all, and you are required to run your News Analysis Report through it.

IX. Self–study report (BI–561 only; 15%)

Students enrolled in BI-561 are expected to complete a self-study project which can take one of a few forms. Students enrolled in BI561 will meet the instructor later in the 1st week of class to discuss options, which in the past have included:
  - Analyze a Systems Neuroscience topic not covered in class
  - Write a Research Proposal based on Systems Neuroscience or related topic based on your interests

X. Submitting Assignments

Electronic submission:
  - Blackboard where appropriate
  - If blackboard is not online
    - Email to avinash@uoregon.edu or scientist.brain@gmail.com

Hard copies:
  - Mail slot labeled ‘SINGH’ in Biology office (77, Klamath Hall) before 5 pm (office closes at 5 pm)
  - Mail Slot labeled ‘SINGH’ in Hallway opposite 222 Huestis Hall before 5 pm (building dooris locked at 5 pm)
  - Turn it in before class
<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Lecture Topic</th>
</tr>
</thead>
</table>
| Mon   | Sep 29  | Course Intro                                      | Papers  
| Wed   | Oct 1   | I. Binaural Hearing                               | A       
| Fri   | Oct 3   | I. Binaural Hearing                               | A/B     
| Mon   | Oct 6   | I. Binaural Hearing                               | B/C     
| Wed   | Oct 8   | I. Binaural Hearing                               | B/C     
| Fri   | Oct 10  | I. Binaural Hearing                               | C       
| Mon   | Oct 13  | I. Binaural Hearing                               | D       
| Wed   | Oct 15  | I. Binaural Hearing                               | D       
| Fri   | Oct 17  | II. Echolocation                                  |         
| Mon   | Oct 20  | II. Echolocation                                  | A       
| Wed   | Oct 22  | II. Echolocation                                  | A/B     
| Fri   | Oct 24  | II. Echolocation                                  | A/B     
| Mon   | Oct 27  | II. Echolocation                                  | B       
| Wed   | Oct 29  | IV. E-fish Jamming Avoidance Response             | A       
| Fri   | Oct 31  | IV. E-fish Jamming Avoidance Response             | A       
| Mon   | Nov 03  | MID-TERM                                          |         
| Wed   | Nov 05  | IV. E-fish Jamming Avoidance Response             | A       
| Fri   | Nov 07  | IV. E-fish Jamming Avoidance Response             | A       
| Mon   | Nov 10  | IV. E-fish Jamming Avoidance Response             | A       
| Wed   | Nov 12  | III. Depth Perception                             | A       
| Fri   | Nov 14  | III. Depth Perception                             | A       
| Mon   | Nov 17  | III. Depth Perception                             | A       
| Wed   | Nov 19  | III. Depth Perception                             | A/B     
| Fri   | Nov 21  | III. Depth Perception                             | B/C     
| Mon   | Nov 24  | III. Depth Perception                             | B/C     
| Wed   | Nov 26  | V. Neurons vs Behavior                            | A       
| Fri   | Nov 28  | NO LECTURE – Thanksgiving Break                   |         
| Mon   | Dec 01  | V. Neurons vs Behavior                            | B       
| Wed   | Dec 03  | V. Neurons vs Behavior                            | B       
| Fri   | Dec 05  | V. Neurons vs Behavior                            | B       
| Wed   | Dec 10  | FINAL                                             | Wed     |