Topics in Systems Neuroscience
MBHV G6010
Spring 2016
Instructors: Carl Schoonover, Andrew Fink, Sean Escola

(1) The rationale for giving the course, its role in the overall curriculum, and its relationship to any specific departmental major, degree program, specialization, or concentration;

The aim of this course is to provide graduate students in the Ph.D. program in Neuroscience the opportunity to engage deeply with key questions in systems neuroscience under the guidance of researchers actively working in the field. The Neuroscience Ph.D. program offers introductory-level courses for first year graduate students that cover a broad set of topics in the neurosciences, as well as several seminar-style courses in which students may deepen their knowledge and exposure to specific topics within the field. These are generally organized according a particular set of brain regions, sensory modalities or motor functions. The proposed course takes an orthogonal approach in that it is not organized according to brain region/modality/function, but rather according to problem; it will provide a perspective that cuts across brain regions, techniques and experimental/theoretical approaches, focusing on key concepts, questions and hypotheses that are shared across systems neurobiology.

(2) A full description of the content and format of the course (more than the two-sentence Bulletin description);

Topics in Systems Neuroscience is a seminar-style reading course that will offer an in-depth, multi-week discussion of three key concepts within the field, examining them across brain regions, recording modalities, and experimental or computational approaches. Attention will be paid to both the historical background and contemporary views. The three topics are (1) the receptive field, (2) population coding, and (3) the balance of excitation and inhibition. All three present ideas that, in some cases, have been examined since the early 20th century. They represent three potentially simplifying concepts underlying brain function but also contain open questions regarding their relevance to perception, cognition and behavior. The course will introduce these ideas and encourage a critical evaluation of them.

When preparing for the seminar, students will be expected to be formulate answers to the following five questions:

1) What is the question / problem?
2) What is the approach?
3) What is the argument?
4) What is the conclusion?
5) What are the implications?

Each paper will be presented to the group by a student selected at random. He or she will

briefly (<5mn) address questions (1) to (4); the main emphasis of the presentation, and indeed of this seminar, will be on question (5). We will aim to avoid spending significant time examining the details of the experimental or theoretical techniques employed. Instead, while acknowledging that there are always important, sometimes fatal, questions concerning the merits of a specific methodology, the goal of this seminar is to focus on questions in the fifth category; as such, we will prefer to bite a few bullets and take the results at face value in order to engage with the concepts, and to discuss what they would imply if true.

While the answers to (1)-(4) will be fairly straight-forward, (5) is expected to be open-ended, and to serve as a launching-point for conversation with the group. Fruitful avenues might include:

(a) how this study fits into prior knowledge on this question
(b) how this study shapes present-day understanding
(c) what biological mechanism could account for the phenomena described
(d) the scope of the conclusion/model
(e) what advantages/disadvantages the adopted strategy enjoys/suffers in addressing the problem
(f) conceptual problems and open questions

(3) The reading list and weekly syllabus for the course;

TOPIC 1: THE RECEPTIVE FIELD (Weeks 1-4)

BACKGROUND AND HISTORICAL ORIGINS (Week 1)

Hartline HK. *Am J Physiol* (1938)
Kuffler SW. *J Neurophysiol* (1953)
Pitkow X, Meister M. *The Cognitive Neurosciences* (2014)

FORMATION OF RECEPTIVE FIELDS 1 (Week 2)

Olshausen BA, Field DJ. *Nature* (1996)
Yamins D, ..., DiCarlo JJ. *PNAS* (2014) [optional]
Ferster D, Chung S. Wheat H, *Nature* (1996)
Reid RC, Alonso J-M *Nature (*1995)

FORMATION OF RECEPTIVE FIELDS 2 (Week 3)

Lien AD, Scanziani M. *Nat Neurosci* (2013)
Cossell L, … Mrsic-Flogel TD *Nature* (2015)
Bishop textbook introduction to information theory (2006) [optional]

TUNING AND SPATIAL MAPS IN OTHER MODALITIES (Week 4)

Poo C, Isaacson J. *Neuron* (2011)
Knudsen EI, Konishi M. *Science* (1978:200)
Knudsen EI, Konishi M. *Science* (1978:202)
O'Keefe J, Dostrovsky J. *Brain Res* (1971)

TOPIC 2: POPULATION CODING (weeks 5-9)

RECEPTIVE FIELD RECAP / INTRO TO POPULATION CODING (Week 5)

Lettvin JY, ..., Pitt WH. *Proc. Inst. of Radio Engr*. (1959)
Georgopoulos AP, Schwartz AB, Kettner RE. *Science* (1986)

NOISE CORRELATIONS AND THEIR DISCONTENTS (Week 6)

Newsome WT, Britten KH, Movshon J. *Nature* (1989) [optional]
Zohary E, Shadlen MN, Newsome WT. *Nature* (1994)
Averbeck BB, Latham PE, Pouget A. *Nat Neurosci* (2006)

WHAT IS POPULATION CODING GOOD FOR ? (Weeks 7-9)

Primer & lecture on linear discrimination and nonlinear expansion into high-D.
Okun M, Steinmetz NA, … Carandini M, Harris KD. *Nature* (2015)
Perez-Orive J, Mazor O, …, Laurent G. *Science* (2002) [Figures 1 and 2]
Fusi S, Miller EK, Rigotti M. *Current Opinion in Neurobiology* (2016)
Rigotti M, Barak O, … Miller EK, Fusi S. Nature (2014)

TOPIC 3: THE BALANCE OF EXCITATION AND INHIBITION (Weeks 10-13)

BACKGROUND AND HISTORICAL ORIGINS (Week 10)

Gerstein GL, Mandelbrot B. *Biophys J* (1964) [optional]
Softky WR, Koch C. *J Neurosci* (1993) [optional]
Shadlen MN, Newsome WT. *Curr Opin Neurobiol* (1994)
Shadlen MN, Newsome WT. *J Neurosci* (1998) (*only section 1*)

EXPERIMENTAL EVIDENCE (Weeks 11-12)

Primer & lecture on conductance decomposition.
Borg-Graham LJ, Monier C, Fregnac Y. *Nature (*1998)
Wehr M, Zador AM. *Nature* (2003)
Primer on conductance decomposition
Okun M, Lampl I. *Nat Neurosci* (2008)
Poo C, Isaacson J. *Neuron* (2009)

COMPUTATIONAL MODELING (Week 13)

van Vreeswijk C, Sompolinsky H. *Science* (1996)
Renart A, de la Rocha J, …, Harris K. *Science* (2010)