Committee on Computational Neuroscience

Graduate Student Handbook

2016 - 2017

Contents

Organization of the University of Chicago

The University of Chicago is a private university that is organized into four graduate divisions, four collegiate divisions and seven professional schools, one of which is the Pritzker School of Medicine. The four graduate divisions are the Humanities Division, the Social Sciences Division, the Physical Sciences Division and the Biological Sciences Division. They are responsible for graduate education. Undergraduate education occurs within the College of the University of Chicago, which includes the Humanities Collegiate Division, the Social Sciences Collegiate Division, the Physical Sciences Collegiate Division and the Biological Science Collegiate Division,

The President of the University of Chicago is Robert Zimmer, who was formerly a professor in the mathematics department. The Provost of the University of Chicago is Eric D. Isaacs, who is a professor in the Department of Physics. The organization of the University is unusual in that the medical school is not physically separate from the rest of the university and one individual, Dr. Kenneth Polonsky, serves as Dean of the Biological Sciences Division and the Pritzker School of Medicine and is responsible for both graduate and medical education. Dr. Jocelyn Malamy is the Master of the Biological Sciences Collegiate Division.

The Division of the Biological Sciences offers Ph.D. degrees in ~20 disciplines, each of which is administered by a graduate program. Some degrees are offered by basic science departments and some are offered by committees. Departments are academic units that hire faculty and have laboratory space. Each faculty at the University has a primary appointment in a department. Some, but not all, departments have graduate programs. For example, the Department of Neurobiology does not have a graduate program. Committees are interdepartmental units that include faculty from several different departments. They offer training in areas of biology that involve several different sub-disciplines. The Committee on Evolutionary Biology, for example, brings together faculty from Anthropology, Ecology and Evolution, Geophysical Sciences, Organismal Biology and Anatomy, as well as several other departments in the University and the Field Museum of Natural History.

Since the Biological Sciences Division has a large number of graduate programs, the majority have been grouped together into units called Clusters that bring together related programs. Each Cluster has an administrator who handles student matters for the cluster. Some of the Clusters have a core curriculum that is required for students in all of the programs in the cluster, and many Clusters sponsor events such as retreats.

The Neuroscience Cluster

The Neuroscience Cluster includes the three graduate programs at the University of Chicago that are closely related to neuroscience. Two of the programs are committees and one is a track within a department. The two committees are the Committee on Neurobiology (chaired by Ruth Anne Eatock) and the Committee on Computational Neuroscience (chaired by David Freedman). The Integrative Neuroscience Program (chaired by Brian Prendergast) is a track within the Department of Psychology. Thus, students in Neurobiology and Computational Neuroscience receive degrees from the Committee on Neurobiology or from the Committee on Computational Neuroscience, respectively; students in Integrative Neuroscience receive a degree from the Department of Psychology. The Cluster sponsors a three-quarter core sequence of courses, an annual retreat, and a seminar series for talks from more advanced students in the three programs.

One advantage of the Cluster is that it allows students to choose a training option that best suits their interests and backgrounds. Individual faculty can belong to one, two or three of the programs. Thus, a student can work with a specific faculty member and have several degree options. Generally speaking, Neurobiology is a good choice for students with a strong interest in cellular, molecular or developmental biology. Computational Neuroscience is a good choice for students' interests in systems neuroscience, particularly with an emphasis on quantitative approaches, theoretical neuroscience, and for students with a strong quantitative background. Integrative Neuroscience is a good choice for students with a strong interest in behavior. Many of the faculty have students from more than one program in their lab at a given time.

A second advantage of the Cluster is that regardless of his or her interests, each student will be exposed to students and faculty working in all of the major areas of neuroscience. A student interested in molecular neurobiology may not take courses in cognitive neuroscience, but will be exposed to this area through contact with students, seminars, retreats, etc.

In addition to the three graduate programs (which grant Ph.D. degrees), the Cluster also houses a number of graduate training programs. These offer structured experiences for students interested in the study of drug abuse or translational neuroscience, but do not grant degrees in these areas. Students enrolled in any of the degree programs can participate in either the drug abuse or translational neuroscience training programs.

A student must select one of the three graduate programs upon entering the University. It is possible to switch from one program to another after entering the University. This is easy to do in the first year, but becomes more difficult in later years.

The Committee on Computational Neuroscience

The Committee (Graduate Program) on Computational Neuroscience was founded in 2001 and started with two students. There are currently 37 CNS faculty, and 26 Ph.D. students. All of the faculty of CNS can be found at http://neuroscience.uchicago.edu. The faculty chair (director) of the CNS Graduate Program is David Freedman. Dr. Freedman's email address is dfreedman@uchicago.edu and his phone number is 773-834-5186 (4-5186 from a campus phone). His office is in room P-419 in the Grossman Neuroscience Institute, located in the Medical Center. Feel free to get in touch with Dr. Freedman at any time.

Staff

The Neuroscience Cluster refers to both the Computational Neuroscience and Neurobiology Graduate programs. The cluster has an Administrative Director, Elena Rizzo, whose office is in room P-400 in The Grossman Neuroscience Institute. Her phone number is 773-795-3849 and her e-mail is erizzo@uchicago.edu. The administrative director is responsible for recruiting graduate students, registering graduate students, handling any paperwork related to graduate degrees, and organizing Cluster events such as the annual retreat. Sharon Montgomery is the administrative assistant for the Committee whose office is also located in room P-400 in the Grossman Neuroscience Institute. Her phone number is 773-702-6371 and e-mail is smontgomery2@bsd.uchicago.edu. She is responsible for scheduling speakers for the seminar series and other administrative matters directly related to the Committees on Computational Neuroscience and Neurobiology.

Since all of the faculty in the Committee have primary appointments in a department, you are likely to interact with administrators in the home department of your thesis advisor. This will happen if you are being supported by a grant to your thesis advisor since that grant will probably be administered through the home department.

Faculty

The current faculty members of the Committee are listed in Table 1 below. You can do your thesis research with any of the active faculty. Notice that the table also lists five faculty in the Department of Biomedical Engineering at IIT. You can do laboratory rotations or do your thesis research with any of these faculty, and you can actually do your thesis research with a University of Chicago faculty member who is not a member of the Committee. If you do your thesis work with someone who is not a member of the Committee, a member of your Committee would serve as your official advisor. It is usually not difficult to work out arrangements of this sort.

Table 1 - Faculty in the Committee on Computational Neuroscience including members in the Department of Biomedical Engineering, IIT

Yali Amit (Statistics) -- Computer vision

Konstantinos Arfanakis (Biomedical Engineering, IIT) -- Neuroengineering

Edward Awh (Psychology) – Cognitive neuroscience of attention and memory

David Biron (Physics) -- Neuroethology of *C. Elegans*

Sliman Bensmaia (Organismal Biology & Anatomy) – Somatosensory system

Nicolas Brunel (Statistics) – Theoretical neuroscience and modeling

Stephanie Cacioppo (Psychiatry) – Social and Cognitive Neuroscience

Jack Cowan (Mathematics) -- Theoretical neuroscience

Jean Decety (Psychology) - Affective and cognitive neuroscience - Developmental neuroscience

Jennifer Derwent (Biomedical Engineering, IIT) -- Retinal biology

Ruth Anne Eatock (Neurobiology) -- Sensory signaling by hair cells and neurons in the inner ear

David Freedman (Neurobiology) – Visual, Cognitive, and Computational Neuroscience

Jay Goldberg (Neurobiology, Pharmacology and Physiology) - - Vestibular system

John Goldsmith (Linguistics) -- Computational linguistics

Melina Hale (Organismal Biology and Anatomy) -- Motor control in zebra fish

Dorothy Hanck (Medicine) -- Voltage gated ion channels

Christian Hansel (Neurobiology) - Learning and memory mechanisms in neural circuits

Nicholas Hatsopoulos (Organismal Biology and Anatomy) -- Primate motor cortex; motor control & neural prosthetics

Derek Kamper (Biomedical Engineering, IIT; Rehabilitation Institute of Chicago) -- Recovery from stroke

Narayan “Bobby” Kasthuri (Argonne National Laboratories and Neurobiology) – Neural circuits and connectomics

Leslie Kay (Psychology) -- Physiology and behavior of olfactory system

Richard Kraig (Neurology) -- Protection against neurological disease

Sarah London (Psychology) - Genomic and social effects on development of neural circuits that control behavior

Jason MacLean (Neurobiology) -- Neuronal dynamics

Daniel Margoliash (Organismal Biology and Anatomy) -- Neuroethology; bird song

John H. Maunsell (Neurobiology) – Neuronal mechanisms of vision and attention

Martha McClintock (Psychology) -- Olfactory behavior

David Mogul (Biomedical Engineering, IIT) -- Epilepsy

Howard Nusbaum (Psychology) -- Speech perception

Leslie Osborne (Neurobiology) -- Computational & physiological mechanisms of sensory-motor processing

Stephanie Palmer (Organismal Biology and Anatomy)—Theoretical neuroscience of Prediction

Eduardo Perozo (Pediatrics) -- Ion channel biophysics

Joel Pokorny (Ophthalmology and Visual Science) -- Visual psychophysics; color perception

Brian Prendergast (Psychology) - Biological rhythms in behavior, behavioral neuroendocrinology, psychoneuroimmunology

Steven Shevell (Psychology) -- Color perception

Murray Sherman (Neurobiology) -- Physiology of the thalamus

V. Leo Towle (Neurology) -- Epilepsy; neuroprosthetics

Philip Troyk (Biomedical Engineering, IIT) -- Visual neuroprosthetics & electrical stimulation

Wim van Drongelen (Pediatrics) -- Epilepsy

Edward Vogel (Psychology) – Cognitive neuroscience of attention and memory

Wei Wei (Neurobiology) - Development and function of the neural circuits in the retina

Xiaoxi Zhuang (Neurobiology) - Dopamine signaling and basal ganglia function in motivated behaviors

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Curriculum

The curriculum for the Computational Neuroscience program involves coursework, passing a preliminary examination, passing a thesis defense examination, completing a thesis, and participating in Committee activities such as the seminar series, student talks, and the Neuroscience Cluster Retreat.

(1) Required courses. Students in the program are required to complete a set of required courses (Table 2). These are the three Cluster core courses (Cellular Neurobiology, Survey of Systems Neuroscience, and Behavioral Neuroscience) two computational neuroscience courses (Methods in Computational Neuroscience, Computational Approaches to Cognitive Neuroscience), and three biological mathematics courses (Mathematics Methods for the Biological Sciences I & II, and Signal Analysis and Modeling for Neuroscientists). Students who have some background in differential equations and linear algebra may place out of taking Mathematics Methods for the Biological Sciences I & II and instead should take two elective courses. In addition, all students are required to take at least one course in the Theoretical Neuroscience sequence (Single neuron dynamics and computation, Network dynamics and computation, or Statistics and Information Theory).

Students who have a background in the area of one of the required courses can normally receive permission to place out of these courses from the Committee Chairman. Students in the M.D./Ph.D. program normally can substitute the medical school neurobiology course for the Cellular Neurobiology and Survey in Systems Neuroscience courses.

(2)

Table 2			
	Autumn Quarter	Winter Quarter	Spring Quarter
Year 1	Cellular Neurobiology Survey in Systems Neuroscience Math. Method for Bio. I Theoretical Neuro. I Elective/lab rotation	Behavioral Neuroscience Methods in Comp. Neuroscience Math. Methods for Bio. II or Theoretical Neuro. II Elective/lab rotation	Cognitive Neuroscience Signal Anal. & Model. for Neuroscientists or Theoretical Neuro. III Elective/lab rotation Ethics
Year 2	TA	TA	

Elective courses. Students can take courses related to their interests from any appropriate department within the University or from the Department of Biomedical Engineering, IIT. They should discuss their interests with the Committee Chair or their thesis advisor, if they have chosen one. Students wishing to take courses at the Illinois Institute of Technology should contact the cluster administrator to make appropriate arrangements.

(3) Ethics course. All students are required to take the course in the Ethical Conduct of Science that is offered by the Biological Sciences Division. M.D./Ph.D. students should take this course in the spring quarter of their third year; other students will take it in the spring quarter of their first year.

(4) Teaching requirement. Students are required to serve as teaching assistants in two courses without pay. Students register for a divisional course in the quarter of the TA and fill out a certain amount of paperwork to formalize each TA. This requirement is usually fulfilled during year 2 or 3. They are encouraged to work as teaching assistants in computational neuroscience courses or in neurobiology courses in the College or medical school. Students are paid for subsequent TA-ships, although teaching after meeting the requirement is generally discouraged because it takes time away from thesis research.

Seminars and other events. Students are expected to attend the weekly seminars sponsored by the programs in Computational Neuroscience and Neurobiology. These seminars are normally scheduled for Thursdays at noon during Fall, Winter, and Spring quarters. Committee seminars are announced via e-mail on the Synapse mailing list and are posted on the Neuroscience Institute website. Other special workshops and symposia are held from time to time.

Students with similar interests are encouraged to form journal clubs. These involve periodic meetings in which students present journal articles or discuss topics of mutual interest. A journal club that discusses mathematical and theoretical papers is currently meeting regularly. Support for student organized journal clubs for scheduling, room reservations, and refreshments is available from the graduate program.

Attendance at local and national scientific meetings. Students who have begun their research work should present it at scientific meetings on a regular basis. Students who are being supported on the MSTP training grant are entitled to travel expenses of $600 per year. Students who are not on a training grant but do not yet have a thesis advisor may request travel funds from the Committee chairman. If approved, you should request a travel reimbursement form from either the cluster administrator or the CNS secretary after completing the trip in order to be reimbursed for expenses such as plane fares, hotel costs or registration for the meeting. It is necessary to submit receipts for these expenses. Plane tickets can be purchased on-line, but it is important to have a receipt showing that the ticket was paid for, as opposed to a confirmation which does not necessarily have a proof of payment. Travel expenses for students who are working on their thesis research are normally the responsibility of the thesis advisor.

Qualifying Exam (Thesis Proposal). Students should form a thesis committee and prepare a thesis proposal, and defend the proposal no later than the end of their second year. The thesis committee should include the thesis advisor and three additional faculty. Three of the four faculty on the committee should be members of the Committee on Computational Neuroscience. The fourth member can be a University of Chicago faculty member who is not a member of the Committee on Computational Neuroscience, a faculty person from IIT, or a faculty member from another university. The composition of the thesis committee should be approved by the thesis advisor and the chairman of the Committee on Computational Neuroscience.

The doctoral candidate should schedule a preliminary thesis committee meeting to take place before the Spring quarter of the candidate’s second year. The meeting will provide the candidate with an opportunity to meet with the members of the thesis committee and to outline, in an informal presentation, the experiments proposed for the dissertation project. The committee will then have the opportunity to make suggestions about the project and help guide the candidate towards a suitable dissertation.

The candidate is required to write a formal research proposal, in NRSA format suitable for submission to NIH, describing the proposed dissertation project, and will distribute it to his or her thesis committee and to an external evaluator from the Executive Committee of CNS. Instructions on writing a NRSA proposal are available at the NIH website: http://grants.nih.gov/grants/funding/416/phs416.htm.

Only the project description component (including the specific aims page) of the NRSA proposal is required. If all the members of the thesis committee, excluding the Principal Investigator, are assistant professors, a senior faculty member will be appointed as the external evaluator. The oral portion of the qualifying examination will take place before the beginning of the Fall quarter of the candidate's third year and will be attended by the thesis committee and the external evaluator. The oral examination will consist of two parts. First, the candidate will present the proposed work in a formal presentation, during which the evaluators (four thesis committee members and the external evaluator) will ask questions pertaining to the dissertation project. Second, the evaluators will then administer a comprehensive oral exam which can include any topic that was covered in course work or is related to the dissertation project. Each portion of the examination will last 45 minutes.

The qualifying examination will have four possible outcomes:

1. *Unconditional pass***.** If the examination committee determines that the candidate's performance was adequate with no reservation, the candidate will be awarded a pass. In exceptional cases, a high pass will be noted in the student's record.

2. *Conditional pass***.** If the examination committee determines that the candidate's performance was generally adequate, but that he or she revealed some shortcomings in a particular subject matter, the candidate may be required to meet additional requirements put forth by the committee. Examples of additional requirements could include taking one or more courses or writing a paper on an assigned topic before a pass is awarded.

When awarded with a pass, the candidate will be encouraged to edit the research proposal following the committee's suggestions and submit it to the NIH as an NRSA proposal.

3. *Provisional fail***.** If the members of the examination committee determine that the candidate's performance fell short of meeting the standards of the Committee on Computational Neuroscience but deem that the student may be able to meet that standard upon re-examination, the candidate will have the opportunity to be re-examined. This second qualifying examination will take place in the Fall quarter of the candidate's third year. A second provisional fail cannot be awarded.

4. *Terminal fail.* If the members of the examination committee determine that the candidate's performance fell far short of meeting the standards of the Committee on Computational Neuroscience and deem that the student is not likely to be able to meet these

standards upon re-examination, the candidate will be referred to the graduate Dean for termination. Provided that a substantive amount of work was completed in the research domain or that the candidate passed the general knowledge but not the research portion of the exam, a terminal Master's degree may be awarded.

If the student passes the Qualifying Exam, the student is admitted to candidacy for the Ph.D. This is an administrative task completed by the cluster administrator.

Thesis Committee Meetings. The student should meet periodically with the thesis committee, at least annually and sometimes more often. In addition, a thesis committee meeting should be scheduled approximately three weeks before the scheduled thesis defense date. The purpose of this meeting is for the thesis committee to agree that the thesis is suitable for defense. The thesis will generally not be entirely complete at this time, and changes can be made after this meeting or even the thesis defense.

Thesis and thesis defense. Information on the format required for the thesis is available at the University Library website: http://www.lib.uchicago.edu/e/phd/. The thesis is presented at an open seminar on the date of the defense. This seminar would generally be an hour in length, followed by a private oral examination by the thesis committee. If the student is successful in defending the thesis, the committee must sign forms that are available from the cluster administrator. Once the thesis is approved by the thesis committee, two copies are printed on acid free paper, in strict adherence to the University's formatting rules, and presented to the Dissertation Office. Students will become familiar with these rules when the time comes, through the library website and quarterly information sessions presented by the Dissertation Office.

Financial Support

Tuition and stipends will be provided to students who are making satisfactory progress towards their degrees. Although the length required to finish a degree will vary from student to student, a target of five years after beginning the program is desirable. Students who are not making satisfactory progress may not be eligible for continuing support.

The mechanisms by which a student is supported vary, but the most common scenario is that the student is supported by funds from the Biological Sciences Division for their first year, by funds from a training grant (if available) for their second and third years, and by a research grant to their thesis advisor in their last two years. Students are encouraged to apply for their own external funding. This can be in the form of a National Science Foundation predoctoral fellowship. Applications for this fellowship can be made in the autumn quarter of the first or second years in graduate school. Students who have begun their research can apply for an individual National Research Service Award (NRSA) fellowship from the NIH. This requires some preliminary data and, preferably, an abstract of a presentation at a scientific meeting. This application is best submitted after the thesis proposal has been approved because the proposal is done in the form of an NRSA application.

Student Resources

Dissertation. The University of Chicago Dissertation Office serves doctoral students helping them to understand and meet the university-wide requirements for the Ph.D. dissertation. The Dissertation Specialist and her student assistants provide guidance and support with issues related to formatting the dissertation, submitting the dissertation online, and publishing the dissertation through ProQuest UMI Dissertation Publishing. Deadlines and important information relating to formatting are listed on the Dissertation Office webpage (http://phd.lib.uchicago.edu). Prior to submitting your finalized dissertation students are encouraged to submit their text to the Ph.D. office for a draft review. This will significantly reduce the time spent revising later on.

Teaching. The Center for Teaching and Learning (CTL) collaborates with faculty and graduate students, to promote a university culture committed to excellent teaching across departments, emphasizing the importance of attending to student learning as the primary way to improve teaching. The Center offers workshops, seminars, and conferences, which address topics including course and assignment design, teaching with technology, and academic job market preparation. Electronic and bibliographic resources, as well as consultation services, are also available to the University community. Visit the CTL website at http://teaching.uchicago.edu/ to find more information about upcoming events and other services.

Emergency and Crisis. Student Emergency Response Systems are coordinated by the Assistant Director of Student Emergency Response Systems. The Assistant Director oversees and manages the development and implementation of policies and procedures for critical incidents involving students, through the Dean on Call (http://deanoncall.uchicago.edu/), Sexual Assault Dean on Call, and Bias Response Team programs (http://brt.uchicago.edu/). This person is responsible for coordinating the Campus and Student Life response to critical incidents involving students, and plays a crucial front-line role in dealing with students, parents, and staff in representing the Office of Campus and Student Life in interpreting policies, responding to concerns, and handling complex situations. Responsibilities include supervision of the Dean on Call program, which is tasked with handling individual student emergencies, and coordinating responses to special incidents in collaboration with the University of Chicago Police Department.

Emergency and Crisis Contact Information

(773) 702-8762
(773) 834-(HELP) 4357: Dean on Call/Sexual Assault Dean on Call
(773) 702-(HELP) 4357: Bias Response Team
(773) 702-8181 (or 123): University of Chicago Police Department

Student Counseling. The Student Counseling Service provides diagnostic assessments, emergency services, crisis intervention, individual, couples, and/or group psychotherapy, medication management, academic skills counseling, and referral services at little or no cost. For information, see http://counseling.uchicago.edu/

Appendix - Study guide for the Qualifying Oral Examination

Cellular Neuroscience

Passive Properties of Neurons

Be familiar with methods of recording from neurons with *in vivo* and *in vitro* preparations

Understand biophysical parameters of neurons, their units and how they relate to the size and shape of neurons

Be able to draw an equivalent circuit for a membrane and derive the corresponding differential equation

Understand how electrotonic length scales with the size and shape of neurons

Synapses

Know the similarities and differences between the structure of the neuromuscular junction and central chemical synapses.

Know the functional significance of the various ultrastructural features of synapses

Understand the concept of calcium microdomains and how it relates to vesicle release

Understand the basic proteins involved in vesicle release and recycling

Know the major types of neurotransmitters and ligand-gated receptors

Understand the molecular structure of ligand-gated receptors

Understand second messenger systems

Know how synaptic currents interact with the cell's passive membrane to produce PSPs.

Ion Channels

Understand the molecular structure of voltage gated ion channels and how their structure is related to the activation and inactivation processes.

Understand what a voltage clamp apparatus does.

Understand the Hodgkin-Huxley experiments and how data on ion channels behavior is studied in voltage clamp mode.

Understand how single channel events can be visualized using patch clamp electrodes.

Understand the properties of action potentials in axons and dendrites and how they are generated in different kinds of neurons.

Understand how neuronal firing properties are studied and be familiar with the major types of firing patterns.

Be familiar with the major types of sodium, potassium and calcium channels found in neurons.

Understand how the different types of ion channels are distributed in neurons and how they generate the different firing pattern properties of neurons.

Understand how the passive properties, synapses and voltage gated channels are studied in neurons in slice preparations.

Neural Systems

1. Visual perception, the eye, and the retina
2. Receptive fields in lateral geniculate nucleus and primary visual cortex
3. Thalamus and thalamocortical communication
4. Form processing at the somatosensory periphery
5. The tactile perception of vibration
6. Texture processing at the somatosensory periphery
7. Form processing in somatosensory cortex
8. Motion processing in somatosensory cortex
9. Motor and oculomotor systems
10. Basic Neuroanatomy

Understand the major components of vertebrate nervous systems
Understand the developmental processes that lead to the anatomy of the adult nervous system
Understand the organization of the thalamus and the cerebral cortex

11. Neural Systems

Understand the basic organization of the visual, somatosensory system, auditory system, vestibular system, olfactory system, motor system, pathways involving the basal ganglia and pathways involving the cerebellum

Cognitive Neuroscience

<u>Basic Concepts</u>

Understand the three levels of analysis in computational neuroscience: Computational, Algorithmic, and Implementation levels.

Be familiar with the Localist vs. Globalist views of cognitive functioning

Be familiar with the following Brodmann's cortical areas: 1,2,3,4,6,17,18,,20&21 (Inferior temporal area),22 (Wernicke's area),40,41&42 (A1), 44 (Broca's area)

<u>Methods of Cognitive Neuroscience</u>

Be familiar with the various methodologies used in cognitive neuroscience and their relative spatial and temporal resolutions:

1) Cognitive psychological methods used to infer mental representations: percent correct, reaction time

2) Functional imaging: PET, fMRI, optical

3) Electrophysiology/magnetic recording: EEG, ERP, MEG, LFP, single-unit recording

4) Transcranial Magnetic Stimulation

5) Lesioning

6) Genetic knockouts

7) Functional neurosurgery

Understand the Inverse Problem & Dipole modeling in EEG studies

Understand the distinction between hemodynamic responses vs. direct neuronal activity measures

Feature Perception

Be familiar with the basic tuning properties and relative receptive field sizes of VI, V2, V3, V4, V8, MT, & MST

Be able to explain what blindsight is & its possible underlying visual pathways

Understand visual search paradigms and how they are used to infer feature primitives

Be familiar with Achromatopsia & Akinetopsia, Synesthesia

Object Recognition

Be able to draw the “What” vs. “Where” visual pathways

Understand the distinction between Perception for Identification vs. Perception for action

Be familiar with the clinical condition of optic ataxia

Understand how multi-stable perception can be induced via binocular rivalry and how neural activity in inferior temporal cortex relates this phenomenon

Be familiar with invariance, binding, & association problems in computational theories of object recognition

Be familiar with apperceptive, integrative, & associative agnosias & the tests to identify them

Be familiar with Warrington’s 2-stage model of object recognition

Be familiar with the evidence supporting and rejecting the hypothesis that face recognition involves the fusiform face area

Attention

Understand the distinction between spatial, object, & feature attention

Be familiar with the distinction between endogenous vs. exogenous attention

Be familiar with the early- vs. late-selection theories of endogenous attention

Be familiar with the clinical conditions of hemi-neglect & Balint’s syndrome

Understand the Posner’s spatial cueing task and how hemi-neglect patients perform on this task

Be familiar with the N1 & P1 components of the ERP

Be familiar with the attentional control vs. target processing circuits in cortex in the context of the Posner task
Be familiar with the biased competition and feature similarity gain models of attention

Learning

Understand the basic components of Hebbian learning

Be familiar with the basic molecular events underlying long-term potentiation & depression

Understand the distinction between LTP versus ltp

Be familiar with the evidence that LTP is related to learning in the hippocampus

Be familiar with basic neural network learning rules: Unsupervised learning (competitive learning) vs. Supervised error-driven learning

Be familiar with spike-timing dependent potentiation and depression

Memory

Understand the distinction between sensory, short-term, working, & long-term memory

Be familiar with the stages of memory formation: encoding, storage, & retrieval

Be familiar with the Atkinson & Shiffrin Modal Model

Understand why the Serial Position effect occurs
Be able to describe the evidence that the prefrontal cortex is involved in working memory

Understand the distinction between declarative (explicit) vs. non-declarative (implicit) memory

Understand the distinction between episodic vs. semantic memory

Be able to describe the memory deficits of medial temporal damage patients

Be familiar with types of non-declarative memory: procedural, priming, classical conditioning, non-associative memory and the areas of the brain involved in non-declarative memory

Be familiar with memory consolidation and reconsolidation

Motor Control

Be familiar with the motor control hierarchy and its neural basis

Be familiar with the various cortical areas involved in the control of movement
Be familiar with the topography in motor cortex

Understand what cosine tuning of direction in motor cortex is

Understand population vector decoding

Be familiar with the role of premotor and supplementary motor cortex in movement planning

Be familiar with the role of SMA in sequential movement planning and execution

Be familiar with internal model (robotics) & equilibrium point theories of motor control

Executive Function and Prefontal Cortex

Be familiar with the functional anatomy of the prefrontal cortex:

1) Dorsal and ventral lateral prefrontal cortex

2) Anterior cingulate

3) Orbitofrontal cortex

Be familiar with the role of prefrontal cortex in maintenance, temporal organization, & manipulation of working memory.

Be familiar with the role of prefrontal cortex in applying rules for making decisions under different contexts (Earl Miller studies)

Be familiar with the Wisconsin Card Sorting Task

Cerebral Lateralization

Be familiar with the functional asymmetries in normals and corpus callosotomy patients: asymmetries in perception, memory, and spatial judgment

Be familiar with the left hemisphere dominance in language

Be familiar with the cerebral specialization in local versus global processing

Be familiar with the left hemisphere as Interpreter

Methods in Computational Neuroscience

Mathematical foundations Spike train variability
Principle components analysis
Multidimensional scaling
Signal detection theory
Models of receptive fields
Spike triggered average, STRF
Reduced single neuron models
Information theory
Generalized Linear Model
Bootstrapping
Graph theory
Natural image statistics
Efficient/sparse coding
Machine learning
Classification algorithms
Hierarchical model of vision
Analysis of local field potentials

Signal Processing

Basic data acquisition

Understand how electrical signals are recorded

Understand A/D conversion, aliasing, the Nyquist theorem
and the effect of noise on signals

Transforms

Understand the nature or continuous, discrete and fast Fourier transforms
and how they are used

Understand Laplace and *z*-transforms and how they are used

Understand the nature of wavelets and how they are used

Analysis

Understand the properties of signal averaging

Understand time and frequency domain properties of correlation, convolution, and coherence

Filters and control systems

Understand the properties of linear filters and how convolution is used to characterize input/output relationships of filters

Understand the basic properties of linear filters

Understand how systems can be characterized by families of ordinary differential equations, how these are turned into a state space representation of the system, and how to find transfer and frequency response functions for the systems

Understand the nature and use of Bode plots and Nyquist plots

Understand the basic features of feedforward and feedback systems

Spike train analysis

Understand the nature of spikes trains

Understand statistics of spike trains (Poisson process, Poisson distribution)
Understand entropy, information and correlations and how they can be used to analyze spike trains

Non-linear systems

Understand the nonparametric characterization of non-linear systems, including the use of Wiener and Volterra kernels

Understand how phase planes can be used to analyze dynamical systems

Understand stability analysis of fixed points

Understand the nature of bifurcations and major types of bifurcations

Understand the nature of catastrophes

Understand the nature of chaos and of return maps

Understand how reduced models of neuronal firing (integrate and fire, Fitzhugh-Nagumo, Izhikevich) models are formulated and studied

Understand how reduced models of neuronal networks are formulated and studied (Ising spin model, Wilson-Cowan model)