UCSD INTERNATIONAL

Cognitive Science Program Development

MARY ET BOYLE, PH. D. – DEPARTMENT OF COGNITIVE SCIENCE – UCSD
general education courses

math
- calc-1
- linear algebra

stats
- intro
- experimental design

comp sci
- intro (C/C++/Java)
- MatLab & quantitative and computational methods

biology
- gen biology

cogsci
- intro to cogsci

gateway course

cogsci core courses

neuro
- neuroanatomy & physiology
- systems neuroscience

ling & dev
- intro to linguistics
- cognitive development
- theory of mind

hci
- design studio
- sensation and perception

modeling
- neural comp
- data analysis

dist cog
- cog ethnography
- distributed cognition
gen ed: calculus I

- Calculus has a pivotal role within social, biological and physical sciences as it helps one to formalize functional relationships between things and provide us solutions to help us optimize our decision making process.

- This course will cover functions, limits, continuity, derivatives, implicit differentiation, related rates, maxima and minima, introduction to definite integral with applications to area and volumes of revolution and elementary trigonometric functions. There will be an emphasis on techniques and applications of integration, polar coordinates, parametric equations, series and infinite sequences, curves in space and vector functions, functions of several variables, and partial derivatives as they relate to the field of cognitive science.

- **Prerequisites:**
  - None.
gen ed: linear algebra

• The mathematics of linear algebra forms the backbone of today’s computational power in image transformation technology used in computer vision, brain imaging and video game applications.

• In this class one will learn the concepts and methods of linear algebra. The topics covered in this class include matrix theory and linear algebra, systems of equations, vector spaces, determinants, eigenvalues, singular value decomposition, and positive definite matrices. Applications to least-squares approximations, stability of differential equations, networks, Fourier transforms, and Markov processes. Assignments and problem sets are implemented using MATLAB.

• **Prerequisites:**
  - This class should be taken in conjunction with QUANTITATIVE COMPUTATIONAL METHODS. (XXXX).
This course is an introduction to the key ideas and concepts in probability and in the principles of data collection, display, and analysis to build a strong foundation for research in Cognitive Science.

Core topics include introductions to probability theory, the theory of point processes, the generalized linear model, Monte Carlo methods, limit theorems, Bernoulli and Poisson processes, Markov chains, Bayesian methods, multivariate methods, time-series analysis, spectral analysis, state-space modeling. Assignments will familiarize the student with modeling and analysis of probabilistic systems, probabilistic models, conditional probability, discrete and continuous random variables, expectation and conditional expectation. There will be a strong emphasis on developing a firm conceptual understanding of the statistical and probability paradigms primarily through analyses of actual experimental data specifically tailored to the cognitive neuroscience computational modeling student.

Prerequisites:
- Class should be taken concurrently with MODELING AND SIMULATION USING MATLAB (XXX).
This class will provide an introduction to using computation to understand real-world phenomena while learning the essential tools to model and simulate innovative ideas in science using MATLAB. Problem-based assignments will focus on applications ranging from machine learning, image processing, optical character recognition, and social science decision modeling cases.

The goal of this class is to introduce the student to data science and to thinking computationally. Course as topics will follow those associated with INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX).

Prerequisites:
- This class should be taken concurrently with INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX).
gen ed: experimental design

- This course provides the Cognitive Science student with the essential tools for organizing data, computing, analyzing experimental data, properly interpreting statistical reports in the literature, and reasoning under uncertain situations.

- This course extends the topics presented in INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX) by introducing tools important for computational modeling such as set theory, combinatorics, automata theory, the Turning Machine model of computation and classic problems of computational complexity. This course will prepare the student in formal reasoning and proof techniques.

- **Prerequisites:**
  - Class should be taken concurrently with INTRODUCTION TO PROGRAMMING (XXXX).
gen ed: introduction to programming

- This class covers the fundamental concepts that underlie all programming languages and provides an introduction to the essential information about algorithms and data structures needed for today’s cutting-edge Cognitive Science applications.
- Students will develop a framework for understanding how to use programming language constructs to effectively design and implement elegant and correct programs. Students will use object-oriented and functional programming techniques to learn how to write composable, robust and reusable code in any language.
- Languages used in this class include C, Java/C++, Lisp/ML, and Ruby.
- **Prerequisites:**
  - No previous programming experience is required.
  - Class should be taken concurrently with EXPERIMENTAL DESIGN (XXXX).
gen ed: general systems biology

• This course will have a special emphasis on human biology and cover topics on evolution, genetics, molecular biology and biotechnology. Special focus will be on mammalian cells, their constituents and their functions. As our understanding of biological systems become more modular we need to examine these systems as discrete functional systems with emergent behavioral properties. This course will challenge the student to design experiments that include computational and simulation methodologies to provide an analysis at the system’s level.

• This class is will challenge the student to ask “how” and “why” questions about cellular mechanisms and functions leading the student to think about disease and potential bioengineering and drug interventions applicable to Cognitive Science.

• Prerequisites:
  • None.
This class is a survey of the current state of Cognitive Science in terms of its triadic interdisciplinary focus of neuroscience, computational modeling and human computer interaction (HCI). Topics associated with the neural foundation of cognitive processes include, perception, sensation, language, attention, motor control, executive function, gesture, social communication, learning and memory. Computational modeling topics include introduction to the visual system and image processing, algorithms used in face recognition and a historical perspective on the perceptron. HCI topics include effective system designs that meet human needs, development of prototype construction and evaluation techniques emerging within HCI today.

Prerequisites:
- GENERAL SYSTEMS BIOLOGY (XXXX).
This course links the study of language to the mind and brain. Students in this class will examine the relationship of language as a primitive human capacity. Topics introduced to the students include natural language categorization such as mental imagery and metaphor; the functional principles of linguistic organization such as iconicity and naturalness; the relationship between language and thought, and discussion on linguistic relativism and conceptual universals.

The goal of this course is to provide a general introduction to the principal subjects and theories associated with Cognitive Linguistics. This course assumes no prior training in linguistics.

**Prerequisites:**
- **INTRODUCTION TO COGNITIVE SCIENCE (XXXX).**
ling/dev: cognitive development

• This course addresses the question of how cognition originates. This course introduces the cognitive science student to the questions about the origins of reality, knowledge, one’s understanding of agents, objects and causality, as well as the problem of other minds.

• Students will perform a literature review on the topic of how the mind develops. They will use data and recent advances on how infants and babies interpret objects, events, people and language that surround them. There will be an emphasis on cognitive and perceptual development from infancy through childhood using current research on cognitive development.

• Prerequisites:
  • INTRODUCTION TO COGNITIVE SCIENCE (XXXX).
ling: language acquisition

- How language is acquired continues to be a hot topic among the world-wide linguistic communities. This course will discuss topics that include language acquisition and development. Students will read critical journal articles on the experimental evidence surrounding the debate on language development as an innate process or built from more general cognitive abilities and influenced by early language exposure. Students will also have the opportunity to discuss if language competence is a defining feature of human cognition.

- **Prerequisites:**
  - *Introduction to Cognitive Science (XXXX).*
This course is a general introduction to psycholinguistics, the study of how individuals comprehend, produce, and acquire language. Psycholinguistics is an interdisciplinary field within cognitive science created by research in neuroscience, philosophy and linguistics. Topics discussed in this course include: what does it mean to know a language? What are the cognitive processes involved in language use? What social rules are associated with language use? What brain mechanisms are active in language use? We will also focus on how language behavior shapes our understanding of the mind and the brain, and how properties of the mind and brain influence human language.

**Prerequisites:**
- Introduction to Cognitive Science (XXXX),
- Introduction to Cognitive Linguistics (XXXX).
ling: how language shapes the mind

• Does language indeed shape the mind? Students in cognitive science are asked to think outside the box and ask themselves how is the mind in fact shaped? Does knowing a second language alter how one thinks? Do people hold different political views or religious ideas based on language, culture and prevailing social norms? More broadly, how does meditation, music, art and language affect cognition? Students will write a critical and extensive literature review addressing mind shaping influences using the latest scientific evidence from cognitive science, linguistics and neuroscience research literature. Students are asked to consider influences in other domains such as policy, business, medicine, academics, athletics and public health.

• **Prerequisites:**
  • INTRODUCTION TO COGNITIVE SCIENCE (XXXX).
ling: neural basis of language

- This course rests at intersection between neuroscience, linguistics and computer science data analyses. Questions in this class include: (a) What are the anatomical and architectural properties of the brain that enables it to learn a language? (b) How is language encoded and is there any cross-talk between modalities (such as synesthesia)? (c) How does the neural organization affect social cognition? (d) Is the nature of thought shaped and constrained by the anatomy of the brain?
- Students in the class will provide a literature review on recent research on the subject matter as well as use models and simulations to gain an understanding of language and the brain.
- **Prerequisites:**
  - Introduction to Cognitive Science (XXXX),
  - Language Acquisition (XXXX),
  - Modeling and Simulation using MATLAB (XXX),
  - Introduction to Programming (XXXX).
d-cog: animal cognition (see johnson)
elective: decision making - morality
elective: language pathology
elective: philosophy of mind
elective: metaphysics and consciousness
Discrete mathematics is a must in the tool box of the innovative and creative cognitive scientist working with data. The topics covered in this class include (a) basic discrete mathematic structure: relations, functions, sets, sequences, partial orders and number systems; (b) basic counting techniques: combinations and permutations; (c) computational algorithmic techniques: information theory, coding theory, graph theory, generating functions and linear programming.

**Prerequisites:**

- INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX),
- MODELING AND SIMULATION USING MATLAB (XXX),
- INTRODUCTION TO PROGRAMMING (XXXX).
modeling: neural computation

- This course provides a robust introduction to a quantitative approach to understanding the brain and its cognitive functions. This class tackles two specific areas relevant to neural computation: (a) using a mathematical description of a neuron understanding how it is able to compute and, (b) model the emergent properties of neural networks to store information. The student will understand and code basic computational methods (for example, biophysical (Hodgkin-Huxley) models of neurons and circuits) for modeling learning and memory, sensory-motor control and vision systems.

- This course will cover issues relevant to neural encoding and decoding techniques, information theory, simplified and biophysical single neuron models, feed-forward and recurrent network models. Class discussion focus is on relevant literature examples of proper application of these techniques. MATLAB is used for class assignments.

- Prerequisites:
  - Introduction to Probability and Statistics (XXXX),
  - Modeling and Simulation Using MATLAB (XXX),
  - Introduction to Programming (XXXX),
  - Neuroanatomy and Physiology (XXXX).
modeling: computational perception & pattern recognition

- The focus of this upper division two semester course will first review experimental paradigms, findings and theories used to evaluate the capabilities and limits of human visual perception. Second, the students will assess how knowledge of human perception can be used to guide machine vision systems. Third, the course will then focus the fundamentals of characterizing and recognizing patterns and features of interest in numerical data. Basic tools and theory for signal understanding problems with applications to user modeling, affect recognition, speech recognition and understanding, computer vision, physiological analysis, and more. Discussions how computer vision systems can perform image analysis and synthesis; face, object and scene perception; texture synthesis, segmentation, and navigation. The student is introduced to various simulation methods. A MATLAB-based project in computational perception is required at the end of the semester.

- **Prerequisites:**
  - Introduction to Probability and Statistics (XXXX),
  - Modeling and Simulation using MATLAB (XXX),
  - Introduction to Programming (XXXX),
  - Modeling: Neural Computation (XXXX).
modeling: neural signal processing

This course extends the signal processing and statistical methods discussed in INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX), and MODELING: NEURAL COMPUTATION (XXXX) to study neural systems and analyze neurophysiological data.

Students in this course will choose a project using MATLAB that involves dynamic analyses of neural encoding, neural spike train decoding, studies of neural receptive field plasticity, algorithms for neural prosthetic control, EEG and MEG source localization.

Prerequisites:
- INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX),
- MODELING AND SIMULATION USING MATLAB (XXX),
- INTRODUCTION TO PROGRAMMING (XXXX),
- MODELING: NEURAL COMPUTATION (XXXX).
modeling: artificial intelligence

• This class uses computational methods to build applications to account for human intelligence and cognition. Classic artificial intelligence paradigms of knowledge representation, expert systems, theorem proving, natural language interfaces, game playing, computer vision, inheritance, constraint propagation, constrained search, statistical inference and rule chaining are introduced. Course topics also include learning paradigms such as genetic algorithms, support-vector machines, boosting and identification trees.

• Concepts in Cognitive Science and Artificial intelligence are developed by the student as they implement programs using pattern matching, data-driven programming, substitution rules, frames, heuristic search, transition networks, neural networks, and evolutionary computation. Students may use MATLAB or LISP in their final projects.

• Prerequisites:
  • INTRODUCTION TO PROBABILITY AND STATISTICS (XXXX),
  • MODELING AND SIMULATION USING MATLAB (XXX),
  • INTRODUCTION TO PROGRAMMING (XXXX),
  • MODELING: NEURAL COMPUTATION (XXXX).
neuro: neuroanatomy & physiology

• The first of three courses that form a rigorous introduction to neuroscience for the cognitive science student. The first part of the course starts with the cellular and molecular biology of neurons and reviews the various mechanisms of neuronal communication. Specific topics covered include an integrated understanding of the biophysics of neurons, with specific emphasis on the electrical properties of neurons (ion channels in excitable membranes, synaptic transmission, and synaptic plasticity). A companion set of computational simulation labs reinforce the student’s understanding of the neuronal biophysical mechanisms to correlate the properties of ionic channels with their physiological functionality.

• The second half of the course focuses anatomy during the development of the central and peripheral nervous systems. Special emphasis will be placed on understanding the topography, descending and ascending spinal cord tracts, cranial nerve nuclei and brainstem organization as well as information flow in the vestibular and cerebellar systems of the human brain. It is recommended to take this class concurrently with METHODS IN COGNITIVE SCIENCE (XXXX).

• Prerequisites:
  • GENERAL SYSTEMS BIOLOGY (XXXX),
  • INTRODUCTION TO COGNITIVE SCIENCE (XXXX)
neuro: methods in cognitive science

• Students enrolled in this class will develop skills need to understand and critique the experimental design, logic and research methods used from current research publications within neuroscience and cognitive science fields. Topics include methods used to study behavior, language, cognition, learning and memory, perception, which include molecular, electrophysiological (cellular and systems levels), functional neuroimaging (fMRI, DTI, EEG), behavioral and computational modeling approaches.
• The course contains of a set of labs intended to provide the students with basic data acquisition and analysis techniques (utilizing MATLAB) for conducting research in cognitive science.
• Prerequisites:
  • General Systems Biology (XXXX),
  • Introduction to Cognitive Science (XXXX)
  • It is recommended to take this class concurrently with Neuroanatomy and Physiology (XXXX).
neuro: systems neuroscience

• This course serves as the second of three rigorous foundational courses for the Cognitive Science student, this course explores the structure and underlying function of the nervous system using a systems approach to the field. The course systematically surveys the anatomical organization and physiological function of nervous systems (with particular attention to the human central nervous system.)

• The overall goal of the class is to prepare the students to read and interpret current literature in neuroscience as it applies to the field of Cognitive Science. The course provides students an understanding of neuronal signaling, plasticity and sensory signal transduction at the molecular, cellular and systems level of analysis.

• Prerequisites:
  • GENERAL SYSTEMS BIOLOGY (XXXX),
  • INTRODUCTION TO COGNITIVE SCIENCE (XXXX),
  • NEUROANATOMY AND PHYSIOLOGY (XXXX)
neuro: cognitive neuroscience

• The third core course looks at how knowledge is represented in the brain. This class builds on the topics presented in NEUROANATOMY AND PHYSIOLOGY (XXXX) and SYSTEMS NEUROSCIENCE (XXXX) courses by extending the student’s anatomical and physiological understanding with formalized theories on the relationships between different brain systems such as: cortex, limbic systems, basal ganglia, thalamus and cerebellum as they pertain to language, learning and memory, habits, motor control, attention, vision and social cognition.

• Students are expected to prepare presentations using journal articles highlighting key findings within cognitive and clinical neuroscience areas.

• Prerequisites:
  • METHODS IN COGNITIVE SCIENCE (XXXX),
  • SYSTEMS NEUROSCIENCE (XXXX),
This course covers topics ranging from the formation of neuronal connections to the role of experience in shaping brain function and structure. Discussion includes the molecular control of neuronal specification, formation of synaptic connections and junctions culminating in the formation of a neuronal circuit and system. The student taking this class will have a good understanding of neural induction pattern formation, cell lineage, neuronal migration, axon guidance, synaptic formation and stabilization, activity-dependent development and the effect of critical periods on the development of behavior and cognition.

**Prerequisites:**
- **NEUROANATOMY AND PHYSIOLOGY (XXXX),**
- **METHODS IN COGNITIVE SCIENCE (XXXX).**
• This course concentrates on typical and atypical child cognitive development within a clinical setting with special attention to discussion on how human developmental processes could and are disrupted. Topics covered in the class include the development of cognitive, perceptual and social skills from infancy through childhood. Developmental disorders discussed include autism, attention deficit hyperactivity disorder (ADHD), developmental coordination disorder (DCD), Down syndrome, dyslexia, dyspraxia, schizophrenia and William’s syndrome.

• Prerequisites:
  • NEUROANATOMY AND PHYSIOLOGY (XXXX),
  • METHODS IN COGNITIVE SCIENCE (XXXX).
At the frontiers of science, this course investigates the potential mechanisms which underlie the changes in cognition which occur during aging within a clinical setting. Topics examined include metabolic dysfunction and associated cognitive impairment, Alzheimer’s disease, Parkinson’s disease, normal pressure hydrocephalus (NPH), stroke and vascular dementia.

Students in the field of cognitive science are in a unique position to study the changes in normative cognition during aging and may be able to develop or design cognitive training intervention techniques to stave off cognitive decline.

This students are expected to be creative and innovative as they use the interdisciplinary tools from the field of cognitive science.

**Prerequisites:**
- NEUROANATOMY AND PHYSIOLOGY (XXXX),
- METHODS IN COGNITIVE SCIENCE (XXXX).
This advanced seminar class will study recent discoveries about the cognitive and neural architectures of working, explicit and implicit memory. The class will have two main areas of study; first, a survey of the mechanisms supporting plasticity in neurons, focusing on how it contributes to learning in several systems. Here we examine cellular forms of associative plasticity such as long-term potentiation and depression relate to associative memory in humans. The second area of study will survey the literature on learning and memory including cognitive and neural organization of memory, mechanisms of remembering and forgetting, and why people sometimes falsely remember events that never happened. The course will discuss cognitive theories and evaluate data from patient and functional neuroimaging studies.

**Prerequisites:**
- **Neuroanatomy and Physiology (XXXX),**
- **Methods in Cognitive Science (XXXX).**
hci: introduction to design studio

- Introduces fundamental methods and principles for designing, implementing, and evaluating user interfaces. Topics: user-centered design, rapid prototyping, experimentation, direct manipulation, cognitive principles, visual design, social software, software tools. Learn by doing: work with a team on a quarter-long design project, supported by lectures, readings, and studios.

- Project-based focus on interaction design process, especially early-stage design and rapid prototyping. Methods used in interaction design including needs analysis, user observation, sketching, concept generation, scenario building, and evaluation.

- Prerequisites:
  - INTRODUCTION TO COGNITIVE SCIENCE (XXXX),
hci: human factors

- Advanced concepts critical to the design of human-technological systems, such as capitalizing upon human capabilities and compensating for human limitations. Topics may include perceptual and motor abilities, human error and cognitive engineering.
- An overview of the tools and techniques used by human factors researchers and practitioners. Topics include task analysis, link analysis, human error in systems, workload analysis, and physiological assessment techniques.
- **Prerequisites:**
  - Introduction to Cognitive Science (XXXX),
hci: interface design

• Concepts and techniques used in constructing interactive web applications. Browser-side web facilities such as HTML5, cascading style sheets, JavaScript, and the document object model. Server-side technologies such as sessions, templates, relational databases, and object-relational mapping. Issues in web security and application scalability. New models of web application deployment.

• Interdisciplinary. User responses to interfaces and design implications of those responses. Theories from different disciplines illustrate cognitive, emotional, and social responses to textual, voice-based, pictorial, metaphoric, conversational, adaptive, agent-based, intelligent, and anthropomorphic interfaces. Group design project applying theory to the design of an interactive interface.

• Prerequisites:
  • Introduction to Cognitive Science (XXXX),
hci: perception
hci: cognitive modeling in design
elective: introduction to computer graphics
elective: creative data visualization

- Techniques and algorithms for creating effective visualizations based on principles from graphic design, visual art, perceptual psychology, and cognitive science. Topics: graphical perception, data and image models, visual encoding, graph and tree layout, color, animation, interaction techniques, automated design.