COGNITIVE SCIENCE

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FACULTY ASSOCIATED WITH THE PROGRAM IN COGNITIVE SCIENCE

Professors  Woo-kyoung Ahn (Psychology), Stephen Anderson (Linguistics), Amy Arnsten (School of Medicine), John Bargh (Psychology), Paul Bloom (Chair) (Psychology), Hal Blumenfeld (School of Medicine), Marvin Chun (Psychology), Michael Della Rocca (Philosophy), Ravi Dhar (School of Management), Julie Dorsey (Computer Science), Carol Fowler (Adjunct) (Psychology), Robert Frank (Linguistics), David Gelernter (Computer Science), Tamar Gendler (Philosophy), Laurence Horn (Linguistics), Marcia Johnson (Psychology), Dan Kahan (Law School), Frank Keil (Psychology, Linguistics), Joshua Knobe (Philosophy), Gregory McCarthy (Psychology), Drew McDermott (Computer Science), Nathan Novemsky (School of Management, Psychology), Rhea Paul (School of Medicine), Kenneth Pugh (School of Medicine), Ian Quinn (Music), Holly Rushmeier (Computer Science), Brian Scholl (Psychology), Sun-Joo Shin (Philosophy), Zoltán Szabó (Philosophy), Fred Volkmar (School of Medicine), Xiao-Jing Wang (School of Medicine), David Watts (Anthropology), Bruce Wexler (School of Medicine), Karen Wynn (Psychology), Raffaella Zanuttini (Linguistics), Steven Zucker (Computer Science, Biomedical Engineering)

Associate Professors  Keith Chen (School of Management), Daeyeol Lee (School of Medicine), James Mazer (School of Medicine), Kevin Pelphrey (School of Medicine), Maria Piñango (Linguistics), Laurie Santos (Psychology), Brian Scassellati (Computer Science)

Assistant Professors  Daylian Cain (School of Management), Yarrow Dunham (Psychology), June Gruber (Psychology), Gaja Jarosz (Linguistics), Hedy Kober (School of Medicine), George Newman (School of Management), Ève Poudrier (Music), David Rand (Psychology), Gregory Samanez-Larkin (Psychology)

Lecturer  Kathryn Davidson

Cognitive science explores the nature of cognitive processes such as perception, reasoning, memory, attention, language, decision making, imagery, motor control, and problem solving. The goal of cognitive science, stated simply, is to understand how the mind works. Cognitive science is an inherently interdisciplinary endeavor, drawing on tools and ideas from fields such as psychology, computer science, linguistics, philosophy, economics, and neuroscience. Approaches include empirical studies of the ontogenetic and phylogenetic development of cognitive abilities, experimental work on cognitive processing in adults, attempts to understand perception and cognition based on patterns of breakdown in pathology, computational and robotic research that strives to simulate aspects of cognition and behavior, neuroscientific investigations of the neural bases of cognition using neural recording and brain scanning, and the development of philosophical theories of the nature of mind.

Introductory course  An introductory survey course, CGSC 110, is normally taken by the end of the fall term of the sophomore year and prior to admission to the major.

The major for the Classes of 2014 and 2015  Students in the Class of 2014 must fulfill the requirements of the Cognitive Science major that were in place when they entered the major, as described in previous editions of this bulletin (http://www.yale.edu/primer/bulletin/archivedpdfs/YCPS). Students in the Class of 2015 may also fulfill the requirements of the major that were in place when they entered it. Alternatively, students in the Class of 2015 may fulfill the requirements for the major as described below for the Class of 2016 and subsequent classes.

Requirements of the major for the Class of 2016 and subsequent classes  Fourteen term courses, for a total of thirteen course credits, are required for the major, including the introductory course and the senior requirement. Each major program must include the elements described below. The particular selection of courses must be approved by the director of undergraduate studies in order to assure overall coherence.

A breadth requirement introduces students to the subfields of cognitive science. Each student is required to take a course from four of the following six areas:

1. Computer science: CPSC 201
2. Economics and decision making: ECON 159, PSYC 553
4. Neuroscience: CGSC 201, MCDB 320, PSYC 160, 270
5. Philosophy: PHIL 126, 181, 269, 270, 271
6. Psychology: PSYC 110, 140, 304

Students also fulfill a depth requirement by completing six courses that focus on a specific topic or area in cognitive science. The depth courses must be chosen from at least two disciplines, and are typically drawn from the six cognitive science subfields. It may be possible to draw depth courses from other fields when necessary to explore the student’s focal topic, in consultation with the director of undergraduate studies. All six depth courses must be at the intermediate or advanced level; for most disciplines, courses numbered 300 or
above fulfill the requirement. With permission of the director of undergraduate studies, up to one directed reading or research course may count toward the depth requirement.

Because formal techniques are fundamental to cognitive science, one skills course is required, preferably prior to the senior year. Courses that fulfill the skills requirement include CPSC 112, 202, LING 224, PSYC 200, and 270. Other courses may fulfill this requirement with permission of the director of undergraduate studies. No course may be used to fulfill more than one requirement for the major.

In the junior year, students are required to take CGSC 395, a half-credit colloquium in which majors discuss current issues and research in cognitive science and select a senior essay topic.

Senior requirement In the senior year, students take CGSC 491, a half-credit capstone course in which the senior essay is written. Students in the course meet regularly with one another and with the faculty to discuss current work in cognitive science and their own developing research projects.

Credit/D/Fail courses Courses taken Credit/D/Fail may not be counted toward the requirements of the major, except with permission of the director of undergraduate studies.

Application to the major Students can apply to enter the major at any point after the freshman year. Applications must be made in writing to the director of undergraduate studies. Applications must include (a) an official or unofficial transcript of work at Yale, (b) a brief statement of purpose, which indicates academic interests and expected focus within the areas of the Cognitive Science major, and (c) a list of the six upper-level courses that the student plans to take as part of the research focus. Application forms and answers to frequently asked questions are available on the program’s Web site (http://www.yale.edu/cogsci/info_undergrad.html).

REQUIREMENTS OF THE MAJOR

Prerequisite CGSC 110
Number of courses 14 term courses, for a total of 13 course credits (incl prereq and senior req)
Specific course required CGSC 395
Distribution of courses 1 course each in 4 of 6 subfields, as specified; 6 courses in a specific topic or area, as specified; 1 skills course, as specified
Senior requirement Senior essay (CGSC 491)

Introductory Courses

CGSC 110a / PSYC 130a, Introduction to Cognitive Science  Brian Scholl
An introduction to the interdisciplinary study of how the mind works. Discussion of tools, theories, and assumptions from psychology, computer science, neuroscience, linguistics, and philosophy.  so

*CGSC 201a / PSYC 120a, Brain and Thought: An Introduction to the Human Brain  Amy Arnsten
An introduction to human brain anatomy, physiology, and function, designed for neuroscience-related majors but accessible to nonscience majors. Focus on basic concepts of neural function and on brain mechanisms underlying perception, memory, and higher cognitive abilities, and how these are altered in neurological and neuropsychiatric disorders.  sc

*CGSC 215b / LING 215b, Sign Languages and the Mind  Kathryn Zaremba
Analysis of sign languages at different levels of linguistic structure, such as phonology, morphology, syntax, and semantics. Related aspects of cognition in the visual modality, including working memory, the neural bases for sign language, and deafness and language development. Ways in which perspectives from manual/visual language study can inform general theories of linguistic structure, plasticity, and domain generality in cognitive science.  so

CGSC 216b / LING 116b, Cognitive Science of Language  Robert Frank
The study of language from the perspective of cognitive science. Exploration of mental structures that underlie the human ability to learn and process language, drawing on studies of normal and atypical language development and processing, brain imaging, neuropsychology, and computational modeling. Innate linguistic structure vs. determination by experience and culture; the relation between linguistic and nonlinguistic cognition in the domains of decision making, social cognition, and musical cognition; the degree to which language shapes perceptions of color, number, space, and gender.  so

Advanced Courses

CGSC 304a / PSYC 304a, The Mental Lives of Babies and Animals  Karen Wynn
Interdisciplinary exploration of the cognitive, social, and emotional capacities of creatures lacking language and culture. The extent to which our complex psychology is unique to mature humans; the relative richness of a mental life without language or culture. Some attention to particular human populations such as children with autism and adults with language disorders.  so

*CGSC 343a / MUSI 343a, Music Cognition  Ian Quinn
A survey of historical and current approaches to questions about the perception and cognition of music. Topics include psychoacoustics; the cognitive neuroscience of music; relationships between music and language; the nature of musical knowledge; and debates about aesthetics, evolutionary psychology, and musical universals. Prerequisite: MUSI 110 or familiarity with music notation.  so
*CGSC 390a, Junior Seminar in Cognitive Science  Kathryn Zaremba
Discussion of historically important papers in cognitive science. Topics are varied and reflect student interests. Some attention to planning for the senior project. Intended for juniors in the Cognitive Science major.

*CGSC 425b / PSYC 425b, Social Perception  Brian Scholl
Connections between visual perception, among the earliest and most basic of human cognitive processes, and social cognition, among the most advanced forms of higher-level cognition. The perception of animacy, agency, and goal-directedness; biological motion; face perception (including the perception of facial attractiveness); gaze processing and social attention; "thin-slicing" and "perceptual stereotypes"; and social and cultural influences on perception.  SO

*CGSC 432a / PHIL 432a, Experimental Philosophy  Joshua Knobe
Overview of research in and critical responses to experimental philosophy, a field in which scientific studies are conducted to examine people's intuitions about philosophical problems. Applications of this method to philosophical questions about morality, language, knowledge, and consciousness.  HU

*CGSC 435b / PHIL 435b, Philosophy for Psychologists  Aaron Norby
Central issues in philosophy of mind and their relations with contemporary psychology. Scientific psychology versus philosophy as the better approach to addressing the questions raised. Prerequisite: PHIL 181 or equivalent.  HU

Courses for Majors

*CGSC 471a and CGSC 472b, Directed Research in Cognitive Science  Joshua Knobe
Research projects for qualified students. The student must be supervised by a member of the Cognitive Science faculty, who sets the requirements and directs the research. To register, a student must submit a written plan of study to the director of undergraduate studies and the faculty supervisor. The normal minimum requirement is a written report of the completed research, but individual faculty members may set alternative equivalent requirements. Only one term may be offered toward the major, with permission of the director of undergraduate studies; two terms may be offered toward the bachelor's degree.

*CGSC 473a and CGSC 474b, Directed Reading in Cognitive Science  Joshua Knobe
Individual study for qualified students who wish to investigate an area of cognitive science not covered in regular courses. The student must be supervised by a member of the Cognitive Science faculty, who sets the requirements and meets regularly with the student. To register, a student must submit a written plan of study to the director of undergraduate studies and the faculty supervisor. The normal minimum requirement is a term paper, but individual faculty members may set alternative equivalent requirements. Only one term may be offered toward the major, with permission of the director of undergraduate studies; two terms may be offered toward the bachelor's degree.

*CGSC 490a, Senior Colloquium  Kathryn Zaremba
A research colloquium leading to the selection of a topic for the senior essay. Students attend regular colloquium presentations by outside scholars. Enrollment limited to Cognitive Science majors in the Classes of 2014 and 2015. ½ Course cr

*CGSC 491b, Senior Project  Kathryn Zaremba
A research colloquium leading to the completion of the senior essay. Students attend regular colloquium presentations. Enrollment limited to Cognitive Science majors. ½ Course cr

Related Courses That May Count toward the Major

*CHLD 350a or b / PSYC 350a or b, Autism and Related Disorders  James McPartland
Weekly seminar focusing on autism and related disorders of socialization. A series of lectures on topics in etiology, diagnosis and assessment, treatment and advocacy, and social neuroscience methods; topics cover infancy through adulthood. Supervised experience in the form of placement in a school, residence, or treatment setting for individuals with autism spectrum disorders. Details about admission to the course are explained at the first course meeting. Prerequisite: an introductory psychology course.  SO

CPSC 112a or b, Introduction to Programming  Daniel Abadi and staff
Development on the computer of programming skills, problem-solving methods, and selected applications. No previous experience with computers necessary.  QR

CPSC 201a or b, Introduction to Computer Science  Dana Angluin
Introduction to the concepts, techniques, and applications of computer science. Topics include computer systems (the design of computers and their languages); theoretical foundations of computing (computability, complexity, algorithm design); and artificial intelligence (the organization of knowledge and its representation for efficient search). Examples stress the importance of different problem-solving methods. After CPSC 112 or equivalent.  QR
Math: Stat/Applied Math

CPSC 202a, Mathematical Tools for Computer Science  James Aspnes
Introduction to formal methods for reasoning and to mathematical techniques basic to computer science. Topics include propositional logic, discrete mathematics, and linear algebra. Emphasis on applications to computer science: recurrences, sorting, graph traversal, Gaussian elimination.  QR
*LING 471G, Advanced Topics in Artificial Intelligence  Barry Nalebuff
An in-depth study of one area of artificial intelligence. Topics vary from year to year. The topic for 2013–2014 is artificial intelligence and philosophy of mind. After CPSC 470 or with permission of instructor.  WR

ECON 159b, Game Theory  Barry Nalebuff
An introduction to game theory and strategic thinking. Ideas such as dominance, backward induction, Nash equilibrium, evolutionary stability, commitment, credibility, asymmetric information, adverse selection, and signaling are applied to games played in class and to examples drawn from economics, politics, the movies, and elsewhere. After introductory microeconomics. No prior knowledge of game theory assumed.  QR, SO

*LING 018b, Acquiring a First Language  Maria Pinango
Current debates and areas of consensus in the field of language acquisition. The logical problem of language acquisition; phonological, morphological, and syntactic milestones; the bootstrapping problem; acquisition under special circumstances; acquiring a second language; language loss. Enrollment limited to freshmen. Preregistration required; see under Freshman Seminar Program.  SO

LING 110aG, Language: Introduction to Linguistics  Ryan Bennett
The goals and methods of linguistics. Basic concepts in phonology, morphology, syntax, and semantics. Techniques of linguistic analysis and construction of linguistic models. Trends in modern linguistics. The relation of linguistics to psychology, logic, and other disciplines.  SO

LING 117aG / PSYC 137a, Language and Mind  Maria Pinango
Knowledge of language as a component of the mind: mental grammars, the nature and subdivisions of linguistic knowledge in connection with the brain. The logical problem of language acquisition. The "universal grammar hypothesis" according to which all humans have an innate ability to acquire language. The connection between language acquisition and general cognitive abilities.  SO

LING 130aG / PSYC 322a, Evolution of Language  Stephen Anderson
The origin and evolution of human language from an interdisciplinary perspective. Topics include the design features of language, the structure of evolutionary theory, elementary molecular genetics and genetic evidence for language evolution, cognitive continuity and discontinuity with other species, hominid evolutionary history, domain specificity and generality of the language faculty, evidence for evolutionary shaping of physical and cognitive structures.

*LING 169bG / PHIL 436bG, Meaning  Laurence Horn and Benjamin George
Analysis of selected classic readings in the study of meaning. Problems of sense and reference, presupposition, speaker intention, semantics of descriptions, names, and natural kinds. Historical tensions concerning the relationship between formal logicalism and ordinary language; debates about the role of context in theories of meaning. Readings from works by Frege, Russell, Strawson, Donnellan, Austin, Grice, Kripke, and Putnam.  SO

LING 220bG / PSYC 318b, General Phonetics  Jelena Krivokapic and Christian DiCanio
Investigation of possible ways to describe the speech sounds of human languages. Acoustics and physiology of speech; computer synthesis of speech; practical exercises in producing and transcribing sounds. (Formerly LING 120)  SO

*LING 224G, Formal Foundations of Linguistic Theories  Robert Frank
Study of formal systems that play an important role in the scientific study of language. Exploration of a range of mathematical structures and techniques; demonstrations of their application in theories of grammatical competence and performance including set theory, graphs and discrete structures, algebras, formal language, and automata theory. Evaluation of strengths and weaknesses of existing formal theories of linguistic knowledge.  QR

LING 227bG / PSYC 327b, Language and Computation  Gaja Jarosz and Tamas Biro
Design and analysis of computational models of language. Topics include finite state tools, computational morphology and phonology, grammar and parsing, lexical semantics, and the use of linguistic models in applied problems. Prerequisite: Prior programming experience or permission of instructor. (Formerly LING 141)  QR, SO

LING 231bG / PSYC 331bG, Neurolinguistics  Maria Pinango
The study of language as a cognitive neuroscience. The interaction between linguistic theory and neurological evidence from brain damage, degenerative diseases (e.g., Alzheimer's disease), mental illness (e.g., schizophrenia), neuroimaging, and neurophysiology. The connection of language as a neurocognitive system to other systems such as memory and music.  SO

LING 232aG, Introduction to Phonological Analysis  Ryan Bennett and Tamas Biro
The structure of sound systems in particular languages. Phonemic and morphophonemic analysis, distinctive-feature theory, formulation of rules, and problems of rule interpretation. Emphasis on problem solving. Prerequisite: LING 220, or a grade of B or above in LING 110. (Formerly LING 132)  SO

*LING 233bG, Phonological Theory  Ryan Bennett
Topics in the architecture of a theory of sound structure. Motivations for replacing a system of ordered rules with a system of ranked constraints. Optimality theory: universals, violability, constraint types and their interactions. Interaction of phonology and morphology,
as well as the relationship of phonological theory to language acquisition and learnability. Opacity, lexical phonology, and serial versions of optimality theory. Prerequisite: LING 232 or permission of instructor. (Formerly LING 135)

**LING 253a**, Syntax I  Raffaella Zanuttini
An introduction to the syntax of natural language. Generative syntactic theory and key theoretical concepts. Syntactic description and argumentation. Topics include the structure of clauses and noun phrases, movement operations, and the notion of parameter. (Formerly LING 135)

**LING 254b**, Syntax II  Robert Frank
Recent developments in the principles and parameters approach to syntactic theory. In-depth exploration of theoretical and empirical issues in long-distance dependencies (island effects, dependency types, movement vs. binding), the character of syntactic structure (constituency, thematic mapping, functional categories), and the architecture of grammatical derivations (logical form, operations for structure building, anaphora). Prerequisite: LING 253.

**LING 263a**, Semantics  Ashwini Deo
Introduction to truth-conditional compositional semantics. Set theory, first- and higher-order logic, and the lambda calculus as they relate to the study of natural language meaning. Some attention to analyzing the meanings of tense/aspect markers, adverbs, and modals.

**LING 280b**, Morphology  Stephen Anderson
The theory of word structure within a formal grammar. Relation to other areas of grammar (syntax, phonology); basic units of word structure; types of morphology (inflection, derivation, compounding). Prerequisites: LING 232 and 253, or permission of instructor.

**LING 361a**, Topics in Syntax: The Mental Lexicon  Maria Piñango
Definitions of lexical knowledge; views of the lexicon as a repository of information vs. a "generative" system; the case of idioms; the lexicon and the grammar-conceptual structure interface; acquisition of the lexicon. (Formerly LING 260)

**MCDB 320a**, Neurobiology  Haig Keshishian and Paul Forscher
The excitability of the nerve cell membrane as a starting point for the study of molecular, cellular, and systems-level mechanisms underlying the generation and control of behavior. After a year of college-level chemistry; a course in physics is strongly recommended.

**PHIL 125**, Introduction to Modern Philosophy from Descartes to Kant  Michael Della Rocca
An introduction to major figures in the history of modern philosophy, with critical reading of works by Descartes, Malabranche, Spinoza, Leibniz, Locke, Berkeley, Hume, and Kant. Intended to be taken in conjunction with PHIL 125 although PHIL 125 is not a prerequisite.

**PHIL 267a**, Mathematical Logic  Sun-Joo Shin
An introduction to the metatheory of first-order logic, up to and including the completeness theorem for the first-order calculus. Introduction to the basic concepts of set theory. Prerequisite: PHIL 115 or permission of instructor.

**PHIL 269b**, The Philosophy of Science  Daniel Greco
Central questions about the nature of scientific theory and practice. Factors that make a discipline a science; how and why scientific theories change over time; interpreting probabilistic claims in science; whether simpler theories are more likely to be true; the laws of nature; whether physics has a special status compared to other sciences; the legitimacy of adaptationist thinking in evolutionary biology.

**PHIL 270b**, Epistemology  Keith DeRose
Introduction to current topics in the theory of knowledge. The analysis of knowledge, justified belief, rationality, certainty, and evidence.

**PHIL 271a / LING 271a**, Philosophy of Language  Zoltán Szabó
An introduction to contemporary philosophy of language, organized around four broad topics: meaning, reference, context, and communication. Introduction to the use of logical notation.

**PHIL 301a**, Causation  Zoltán Szabó
The metaphysics of causation. Topics include what sorts of entities are causes and effects, how causation differs from mere regularity, the causal efficacy of the mind, free will, and natural teleology. Prerequisite: a course in philosophy.

**PHIL 429a**, Problems in Semantics: Quantification  Benjamin George
Topics in the semantics of quantification, with a focus on the expressive power of quantification in natural language. Analysis of quantifiers such as some, every, no, many, fewer, and most; generalizations about and possible universals of quantification in natural language; implications for mathematical and philosophical properties of logics that are suitable for modeling natural language semantics; plural quantification.

**PSYC 110a or b**, Introduction to Psychology  Marvin Chun [F] and Paul Bloom [Sp]
A survey of major psychological approaches to the biological, cognitive, and social bases of behavior.
PSYC 131a, Human Emotion  June Gruber and staff
Introduction to major discoveries in human emotion. Evolutionary theories of anger, love, and disgust; emotion and morality; cultural
and gender differences; emotion and the brain; relation between emotion and thinking; development of emotion; and abnormal
emotions in mental illness.  SO  RP
Psychology: Social Science

PSYC 140a, Developmental Psychology  Frank Keil
An introduction to research and theory on the development of perception, action, emotion, personality, language, and cognition from a
cognitive science perspective. Focus on birth to adolescence in humans and other species. Prerequisite: PSYC 110.  SO
Psychology: Core
Psychology: Social Science

PSYC 150b, Social Psychology  John Bargh
Study of social cognition, attitudes and persuasion, group processes, intergroup processes, prosocial behavior, aggression, and
conformity. Theories, methodology, and applications of social psychology. Prerequisite: PSYC 110.  SO
Psychology: Core
Psychology: Social Science

PSYC 160b, The Human Brain  Gregory McCarthy
Introduction to the neural bases of human psychological function, including social, cognitive, and affective processing. Preparation for
more advanced courses in cognitive and social neuroscience. Topics include memory, reward processing, neuroeconomics, individual
differences, emotion, social inferences, and clinical disorders. Neuroanatomy, neurophysiology, and neuropharmacology are also
introduced.  SC
Psychology: Core
Psychology: Natural Science

PSYC 200b, Statistics  Gregory Samanez-Larkin
Measures of central tendency, variability, association, and the application of probability concepts in determining the significance of
research findings.  QR

*PSYC 270b, Research Methods in Behavioral Neuroscience  Nelson Donegan
Laboratory course in which students design and conduct research to study brain function and behavior. Emphasis on hands-on
participation in behavioral and neuroscience techniques. Prerequisites: PSYC 160 or <170>, and a course in statistics, or with permission
of instructor.  SC
Psychology: Natural Science
Psychology: ResearchMethods

*PSYC 479b, Thinking  Woo-kyoung Ahn
A survey of psychological studies on thinking and reasoning, with discussion of ways to improve thinking skills. Topics include
judgments and decision making, counterfactual reasoning, causal learning, inductive inferences, analogical reasoning, problem solving,
critical thinking, and creativity. First class meeting to be held during course selection period at a time determined by admitted students.
See the syllabus on Classes*v2 (http://classesv2.yale.edu) for application information.  SO