# Cognitive Science

Department Website: https://voices.uchicago.edu/cognitivescience (https://voices.uchicago.edu/cognitivescience/)

## Program of Study

Cognitive science explores the nature of cognitive processes such as perception, reasoning, memory, attention, language, decision making, emotion, motor control, and problem solving. The goal of cognitive science, stated simply, is to understand how minds work, in humans, animals, and machines. Cognitive science emerged in the latter part of the 20th century at the intersection of computer science, linguistics, philosophy, psychology, and neuroscience, and is an inherently interdisciplinary endeavor, drawing on tools and ideas from the social sciences, the physical and biological sciences, and the humanities. Topics of research include (but are not limited to) cognitive development, cognitive processing, judgment and decision making, language and communication, the neurological bases of cognition, perception, and memory, philosophy of mind, and artificial intelligence. A defining feature of cognitive science is its emphasis on integration among fields, for a truly interdisciplinary study of the mind. Students will be trained in formal methods of analysis and modeling that are common in majors in the physical and biological sciences, but often absent from majors in the humanities and social sciences; at the same time, students will also be trained in the advanced reasoning skills that define humanistic inquiry, but are often absent from more technical or applied majors.

The undergraduate major in Cognitive Science at the University of Chicago is designed to embody this interdisciplinary approach to the study of the mind and brain. Students gain broad knowledge of the field by taking courses in each of the five main disciplinary areas—computer science, linguistics, philosophy, psychology, and neuroscience—and then develop further focus and depth of understanding by taking additional courses in two of these disciplinary areas. Students will form key technical foundations through a Formal Foundations requirement, and will gain critical training in integrating interdisciplinary perspectives through the two core foundational courses: COGS 20001 Mind, Brain and Meaning and COGS 20002 Cognitive Models. A distinguishing feature of the Cognitive Science major at the University of Chicago is the centrality of the humanistic component of the study of the mind: starting immediately with the foundational course sequence, questions about what it *means* to learn, communicate, and think will be assigned equal significance to, and asked alongside, questions about what it *is* to learn, communicate, and think. Training emphasizes both engagement with the principal theories of mind and the evidence that bears on choices between them, and development of the conceptual and practical skills needed for understanding and conducting theoretical and empirical work in the field.

Students who are majoring in Cognitive Science may visit the Department of Cognitive Science homepage (https://voices.uchicago.edu/cognitivescience/) at voices.uchicago.edu/cognitivescience (https://voices.uchicago.edu/cognitivescience/) to learn about events and resources on and off campus and for links to information on employment opportunities.

## Program Requirements

Students majoring in Cognitive Science will receive the degree of bachelor of arts. To qualify for the BA, students must minimally satisfy the general education requirements and take an additional 15 required courses for the major, which fall into four categories: **Introductory Courses**, which engage students with the core questions, intellectual history, and analytical methods that unify cognitive scientific research (200 units); **Formal Foundations Courses**, which give students the analytical tools to explore different strands of contemporary cognitive scientific research (200 units); **Core Discipline Courses**, which provide breadth and depth in the five core disciplines (900 units); and **Extra-Disciplinary Courses**, which engage students with cognitive scientific work in areas beyond the core disciplines (200 units). These courses and their pedagogical roles in the major are described in more detail below.

Note that some courses may be used to satisfy different requirements; but no single course may be "double counted" towards satisfaction of two requirements. For example, a student who takes PHIL 20100 Introduction to Logic may count it either towards satisfaction of the Formal Foundations requirement or towards satisfaction of the Philosophy Core Discipline requirement, but not both.

## Introductory Courses

There are two introductory courses in the Cognitive Science major, COGS 20001 Mind, Brain and Meaning and COGS 20002 Cognitive Models, which serve two purposes. First, they introduce students to the empirical questions, theoretical concepts, and analytical methodologies that led to the emergence of cognitive science as a distinct field of study and continue to drive contemporary research. Second, they will highlight the ways that these issues manifest in the core disciplines of cognitive science—philosophy, psychology, linguistics, computer science, and neuroscience—and the ways that progress on central questions about the nature of the mind have been informed by interactions, conversations, and collaborations across the disciplines. Ideally, both courses will normally be co-taught by faculty from different fields, with the dual goal of providing substantive disciplinary expertise in more than one area, and of manifesting, in the classroom, the kind of interdisciplinarity that defines the field.

## Formal Foundations Courses

The Cognitive Science major requires students to develop expertise in the formal analytical methods used in the field. The specific formal skills that will be most useful to individual students depend on their particular areas of interest, so students are free to select any two courses from an approved set of options from a range of courses in mathematics, computer science, statistics, and logic. Though not formally required, experience with the equivalent of one course in calculus is highly recommended, as expertise in this area is required for many of the Core Discipline courses. (NOTE: Calculus I-II may be used to satisfy the Formal Foundations requirement only if the courses are not used to satisfy the general education requirement in the mathematical sciences.)

The following list provides examples of courses that could be used to satisfy the Formal Foundations requirement, but it is meant to be illustrative only and is not exhaustive. Students may petition for approval of a course not on this list as satisfaction of the Formal Foundations requirement by submitting a proposal and rationale to the Director of the Cognitive Science Program.

**Cognitive Science Formal Foundations Courses**

| | | |
|---|---|---|
| CHDV 39301 | Qualitative Research Methods | 100 |
| CMSC 12100 | Computer Science with Applications I | 100 |
| CMSC 12200 | Computer Science with Applications II | 100 |
| CMSC 14100 | Introduction to Computer Science I | 100 |
| CMSC 14200 | Introduction to Computer Science II | 100 |
| CMSC 14300 | Systems Programming I | 100 |
| CMSC 14400 | Systems Programming II | 100 |
| CMSC 15100 | Introduction to Computer Science I | 100 |
| CMSC 15200 | Introduction to Computer Science II | 100 |
| CMSC 15400 | Introduction to Computer Systems | 100 |
| CMSC 25300 | Mathematical Foundations of Machine Learning | 100 |
| CMSC 27100 | Discrete Mathematics | 100 |
| LING 21020 | Formal Foundations of Linguistics | 100 |
| LING 22500 | Quantitative Research Methods in Linguistics | 100 |
| MATH 13100 | Elem Functions and Calculus I (or higher) | 100 |
| MATH 13200 | Elem Functions and Calculus II (or higher) | 100 |
| MATH 19620 | Linear Algebra | 100 |
| MATH 27700 | Mathematical Logic I | 100 |
| MATH 28000 | Introduction to Formal Languages | 100 |
| PHIL 20100 | Introduction to Logic | 100 |
| PSYC 20200 | Psychological Research Methods | 100 |
| PSYC 20250 | Introduction to Statistical Concepts and Methods | 100 |
| STAT 24400 | Statistical Theory and Methods I | 100 |
| STAT 24500 | Statistical Theory and Methods II | 100 |
| STAT 27410 | Introduction to Bayesian Data Analysis | 100 |

## Core Discipline Courses

The core disciplines of cognitive science are computer science, linguistics, philosophy, psychology, and neuroscience. The Core Discipline requirements are designed to strike a balance between breadth and depth in the core disciplines, while also allowing students a great deal of freedom to construct an individualized plan of study that best matches their interests in cognitive science. Students in the Cognitive Science major must take:

- **Five Core Discipline breadth courses:** one approved course in each of the five core disciplines
- **Four Core Discipline depth courses:** two additional courses in two of the core disciplines

Approved electives from each of the five core disciplines are listed below; students may, in addition, request approval of a course that is not on this list by submitting a proposal and rationale to the Director of the Cognitive Science Program.

**Cognitive Science Core Discipline Courses: Computer Science**

| | | |
|---|---|---|
| CMSC 13600 | Introduction to Data Engineering | 100 |
| CMSC 14100 | Introduction to Computer Science I | 100 |
| CMSC 14200 | Introduction to Computer Science II | 100 |
| CMSC 14300 | Systems Programming I | 100 |
| CMSC 14400 | Systems Programming II | 100 |

| | | |
|---|---|---|
| CMSC 15100 | Introduction to Computer Science I | 100 |
| CMSC 15200 | Introduction to Computer Science II | 100 |
| CMSC 15400 | Introduction to Computer Systems | 100 |
| CMSC 20600 | Introduction to Robotics | 100 |
| CMSC 21800 | Data Science for Computer Scientists | 100 |
| CMSC 23900 | Data Visualization | 100 |
| CMSC 25300 | Mathematical Foundations of Machine Learning | 100 |
| CMSC 25400 | Machine Learning | 100 |
| CMSC 25500 | Introduction to Neural Networks | 100 |
| CMSC 25700 | Natural Language Processing | 100 |

**Cognitive Science Core Discipline Courses: Linguistics**

| | | |
|---|---|---|
| LING 20101 | Introduction to Phonetics and Phonology | 100 |
| LING 20201 | Introduction to Syntax | 100 |
| LING 20301 | Introduction to Semantics and Pragmatics | 100 |
| LING 21020 | Formal Foundations of Linguistics | 100 |
| LING 27010 | Psycholinguistics | 100 |
| LING 28610 | Undergraduate Computational Linguistics | 100 |

**Cognitive Science Core Discipline Courses: Philosophy**

| | | |
|---|---|---|
| PHIL 20100 | Introduction to Logic | 100 |
| PHIL 22960 | Bayesian Epistemology | 100 |
| PHIL 23000 | Introduction to Metaphysics and Epistemology | 100 |
| PHIL 23501 | Philosophy of Mind | 100 |
| PHIL 24010 | Meaning and Reference | 100 |
| PHIL 26000 | History of Philosophy II: Medieval and Early Modern Philosophy | 100 |

**Cognitive Science Core Discipline Courses: Psychology**

| | | |
|---|---|---|
| PSYC 20400 | Cognitive Psychology | 100 |
| PSYC 20500 | Developmental Psychology | 100 |
| PSYC 20700 | Sensation and Perception | 100 |
| PSYC 21510 | Neuroscience of Communication | 100 |
| PSYC 23200 | Introduction to Language Acquisition | 100 |
| PSYC 23820 | Attention and Working Memory in the Mind and Brain | 100 |
| PSYC 25101 | The Psychology of Decision Making | 100 |
| PSYC 28990 | Constructing consciousness: How do we go from matter to mind? | 100 |

**Cognitive Science Core Discipline Courses: Neuroscience**

| | | |
|---|---|---|
| NSCI 20101 | Foundations of Neuroscience | 100 |
| NSCI 20130 | Systems Neuroscience | 100 |
| NSCI 21000 | Social Neuroscience | 100 |
| NSCI 21015 | Biological Psychology | 100 |
| NSCI 21625 | Cognitive Neuroscience in Humans and Rodents | 100 |
| NSCI 21750 | Ethics through a Neurobiological Lens | 100 |
| NSCI 22010 | Neuroscience of Consciousness | 100 |
| NSCI 23700 | Methods in Computational Neuroscience | 100 |

## Extra-Disciplinary Courses

The Extra-Disciplinary requirement ensures that students also engage with cognitive scientific work outside the core disciplines, in areas such as music, anthropology, religion, economics, and political science, and so are exposed to the full breadth of the interdisciplinary study of the mind. Students in the major must take a total of two Extra-Disciplinary courses.

A partial list of courses that could be used to satisfy the Extra-Disciplinary requirement is provided below; as above, students may also request approval of courses not included in this list, or courses from other fields, by submitting a proposal and rationale to the Director of the Cognitive Science Program.

**Cognitive Science Extra-Disciplinary Courses**

| | | |
|---|---|---|
| ANTH 21355 | Remembering: An Anthropological Approach | 100 |
| ANTH 24321 | Psychological Anthropology | 100 |
| ASTR 23000 | Cosmos and Conscience: Looking for Ourselves Elsewhere | 100 |
| BPRO 28400 | Thinking Psychoanalytically: From the Sciences to the Arts | 100 |
| BUSN 20710 | Behavioral Economics | 100 |
| ENGL 12720 | Inventing Consciousness: Literature, Philosophy, Psychology | 100 |
| CHDV 20703 | Literacy, Language, and Education | 100 |
| CHDV 22580 | Child Development in the Classroom | 100 |
| CHDV 23100 | Human Language and Interaction | 100 |
| CHDV 27950 | Evolution and Economics of Human Behavior | 100 |
| MUSI 20719 | Music and Mind | 100 |
| MUSI 43720 | Music and Affect | 100 |
| PLSC 24210 | Politicizing the Passions: Emotions and Collective Action | 100 |
| RLST 23750 | The End of Metaphysics and the Future of Philosophy | 100 |

## Summary of Requirements for the BA in Cognitive Science

| | |
|---|---|
| COGS 20001 Mind, Brain and Meaning | 100 |
| COGS 20002 Cognitive Models | 100 |
| Two Formal Foundations Courses | 200 |
| Five Core Discipline breadth courses | 500 |
| Four Core Discipline depth courses | 400 |
| Two Extra-Disciplinary courses | 200 |
| Total Units | 1500 |

## Grading

All courses used to satisfy requirements for the major must be taken for quality grades. With consent of the instructor, nonmajors may take COGS courses for P/F grading.

## Honors

Students wishing to receive a BA in Cognitive Science with honors must carry out an independent research project that culminates in an honors thesis. Any student who has maintained a 3.25 or better overall GPA and a 3.5 or better GPA in courses that count towards the major may apply to receive a degree with honors; the deadline for application is the end of the fifth week of the third quarter before the student graduates, canonically Autumn Quarter of the fourth year. Applications must include a research proposal of no more than three pages, which explains the project and its significance, documents the student's preparation for the work, and has been approved by a faculty advisor or advisors. Students are strongly encouraged to identify co-advisors from distinct disciplines. The thesis must be submitted by the fifth week of the quarter in which the student plans to graduate.

This program may accept an honors thesis or project used to satisfy the same requirement in another major with the consent of both program directors. Students should consult with the relevant program directors by the earliest BA proposal deadline, or by the end of their third year if neither program publishes a deadline. The P (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/BA_Double_Major_0.pdf)etition to use a Single Bachelor's Paper for Two Majors (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/BA_Double_Major_0.pdf) form, to be signed by both program directors, must be completed and returned to the College adviser by the end of Autumn Quarter of the student's year of graduation.

## Cognitive Science Courses

**COGS 20001. Mind, Brain and Meaning. 100 Units.**
What is the relationship between physical processes in the brain and body and the processes of thought and consciousness that constitute our mental life? Philosophers and others have puzzled over this question for millennia. Many have concluded it to be intractable. In recent decades, the field of cognitive science--encompassing philosophy, psychology, neuroscience, computer science, linguistics, and other disciplines--has proposed a new form of answer. The driving idea is that the interaction of the mental and the physical may be understood via a third level of analysis: that of the computational. This course offers a critical introduction to the elements of this approach, and surveys some of the alternative models and theories that fall within it. Readings are drawn from a range of historical and contemporary sources in philosophy, psychology, linguistics, and computer science. (B) (II)
Instructor(s): J. Bridges; L. Kay; C. Kennedy Terms Offered: Autumn
Equivalent Course(s): PHIL 36520, NSCI 22520, PSYC 36520, LING 26520, PSYC 26520, LING 36520, PHIL 26520

**COGS 20002. Cognitive Models. 100 Units.**
A foundational principle of cognitive science is that the workings of cognitive systems--whether biological, mechanical, or digital--can be productively represented by the operation of formal computational models. This course provides a survey of popular modeling frameworks (such as Bayesian rational agents, connectionist networks, dynamical systems, etc.), as well as the cognitive phenomena that these models have been used to simulate. We will discuss the theoretical commitments of these models, assess strengths and weaknesses of each framework for addressing different types of cognitive questions, and analyze the implications of these models' successes and failures for our understanding of the mind.
Instructor(s): Yu Ji, Eugene Terms Offered: Spring
Equivalent Course(s): LING 30002, LING 20002

**COGS 20100. Perspectives on large language models: computational, cognitive, social. 100 Units.**
In this interdisciplinary course, students will delve into the multifaceted world of large language models (LLMs), investigating their computational, cognitive, and social dimensions. The course covers an array of topics, such as the history and evolution of LLMs, computational underpinnings like neural networks and training methodologies, cognitive aspects of human-like language understanding, communication, and creativity, as well as crucial ethical and social considerations, encompassing fairness, transparency, trustworthiness, and privacy. Through both lectures and discussions, we will examine the scientific and practical applications and limitations of LLMs across diverse domains and contemplate the future prospects and challenges LLMs pose for science, technology, and society. Through critical discourse, hands-on exercises, and case studies, our goal is to foster a comprehensive understanding of LLMs, empowering students to critically assess these models and contribute to ongoing dialogues regarding their broader implications. Prior experience in computer science or cognitive science is beneficial but not mandatory. Note: this course primarily focuses on cultivating reflective thinking about LLMs, rather than programming or implementation. Students with programming skills are, however, encouraged to utilize them to facilitate their learning.
Instructor(s): Eugene Yu Ji Terms Offered: Autumn
Equivalent Course(s): LING 20110

**COGS 21720. Sociophonetics. 100 Units.**
Variation is a ubiquitous feature of speech, yet most variations observed are non-random. This course will examine this type of structured heterogeneity (Weinreich et al. 1968) from the point of view of sociophonetics. We will focus on the interrelationships between phonetic/phonological form and social factors such as speaking style and the background of the speaker, with a particular interest in explaining the origins and transmission of linguistic change. Our goals will be to (a) acquire the phonetic and phonological foundation necessary to conduct sociophonetic research through practical exercises; (b) survey new sociolinguistic research that addresses issues in phonetic and phonological theories; and (c) locate and explain phonetic variation in its social context while drawing on current approaches to the relationship between language and society. This course will give students hands-on experience with designing and conducting experiments. As part of the empirical foundation of this course, we will focus on sociophonetic variation across Chicago neighborhoods. For a final project, students are required to conduct a small-scale study investigating a research question of relevance to sociophonetic research. LING 20101 or graduate student standing.
Instructor(s): Alan Yu Terms Offered: Winter
Equivalent Course(s): COGS 31720, CHST 21720, LING 21720, LING 31720

**COGS 24001. Prediction in Language Comprehension. 100 Units.**
Language tends to follow predictable patterns, from what sounds and words are about to be uttered, to what grammatical structures are likely, to be used to what broader implications are about to be suggested, and more. One prevailing hypothesis is that the human mind can take advantage of this predictability to help maintain the rapid pace of language comprehension. This course will explore critical questions surrounding the nature of prediction processes during language comprehension. What do people predict? How are their predictions constrained? How can we study the inherently internal process(es) of prediction? What are the consequences of prediction? Perhaps most importantly, what do the answers to these questions suggest about the mechanisms and computations of prediction? Readings will primarily consist of contemporary articles from peer-reviewed journals, and class meetings will be a mix of lectures and student-led discussions.
Instructor(s): Melinh Lai Terms Offered: Spring
Equivalent Course(s): LING 24001

**COGS 27010. Psycholinguistics. 100 Units.**
This is a survey course in the psychology of language. We will focus on issues related to language comprehension, language production, and language acquisition. The course will also train students on how to read primary literature and conduct original research studies.
Instructor(s): Ming Xiang (Autumn), Monica Do (Spring) Terms Offered: Autumn Spring
Equivalent Course(s): LING 27010, PSYC 27010