Cognitive Science

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The mission of the Cognitive Science Program is to advance the study of minds and brains, real or artificial, in all their aspects, through research and teaching. This interdisciplinary field, encompassing the fields of psychology, linguistics, computer science, philosophy, anthropology, and neuroscience, provides excellent preparation for life in the age of information. The program aims to instill in students a solid grasp of the intellectual problems, frameworks, and methodologies currently available; to provide experience exploring these through guided research; and to foster the desire to create and disseminate new knowledge. With this foundation, students are well prepared for a wide variety of careers at the interfaces of technology, minds, brains, and behavior, and for graduate study in Cognitive Science or any of the contributing disciplines.

We offer undergraduate B.A. and B.S. degrees in Cognitive Science, an undergraduate minor, and a graduate certificate. A Cognitive Science major is easy to combine with a second major in the humanities, natural sciences, social sciences, or computer science.

Professors. Kiri Lee, PHD (Harvard University); Barbara C. Malt, PHD (Stanford University); Hector Munoz-Avila, PHD (Technische Universität Kaiserslautern); Padraig O'Seaghdha, PHD (University of Toronto); Dominic J. Packer, PHD (University of Toronto)

Associate Professors. Catherine M. Arrington, PHD (Michigan State University); Amanda C. Brandon, PHD (University of Michigan); Jeffrey D. Heflin, PHD (University of Maryland, College Park); Almut Hupbach, PHD (Universitat Trier)

Assistant Professor. Nancy B. Carlisle, PHD (Vanderbilt University, Peabody College)

B.A. IN COGNITIVE SCIENCE

The B.A. in Cognitive Science requires a minimum of 14 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science. They also complete a course in research methods or tools. Students then pursue their individual interests by completing at least five electives from across three tracks. A capstone integration occurs in the required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

Collateral Requirements

<table>
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<td>CSE 001</td>
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<tr>
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<td>Survey of Computer Science</td>
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<td>Fundamentals of Programming</td>
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B.S. IN COGNITIVE SCIENCE

The B.S.in Cognitive Science entails additional courses beyond those in the B.A. to provide both additional breadth and depth. It requires a minimum of 20 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science, math, and social science. They also complete two courses in research methods or tools and at least one semester of supervised research. Students then pursue their individual interests by choosing a concentration area from among three tracks and completing at least six electives with a minimum of four in the concentration area. A capstone integration occurs in the required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

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<tr>
<td>or MATH 051</td>
<td>Survey of Calculus I</td>
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<tr>
<td>or MATH 075 &amp; MATH 076</td>
<td>Calculus I, Part A and Calculus I, Part B</td>
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<tr>
<td>CSE 140</td>
<td>Foundations of Discrete Structures and Algorithms</td>
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<td>PSYC 001</td>
<td>Introduction to Psychology</td>
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Cognitive Science

or ECO 001 Principles of Economics
or ANTH 011 Cultural Diversity and Human Nature

Two courses in research methods and tools.

For Artificial Intelligence and Formal Models Concentration:
CSE 160 Introduction to Data Science
& MATH 231 Probability and Statistics
or ECO 045 Statistical Methods

For all other concentrations:
PSYC 201 Research Methods and Data Analysis I
& PSYC 202 and Research Methods and Data Analysis II

Introductory Course
COGS 007 Introduction to Cognitive Science 4

Disciplinary Core Course
16
COGS/PSYC 117 Cognitive Psychology
COGS/PSYC 176 Cognitive Neuroscience
COGS/PHIL 250 Philosophy of Mind
COGS/CSE 327 Artificial Intelligence Theory and Practice
COGS 183 or COGS 184 Cognitive Neuroscience Recitation

Concentrations 18-24
Choose six electives from the concentration lists, at least four of them from within the same concentration. The lists are the same for the B.A. and the B.S. Requirements specific to each concentration for the B.S. are as follows:

Artificial Intelligence and Formal Models
CSE 017 Programming and Data Structures

Cognition, Culture, and Meaning
COGS 140 Introduction to Linguistics

Cognitive Neuroscience
BIOS 121 Biology Core III: Integrative & Comparative Biology 2

Research Experience 3
COGS 161 Supervised Research 4 - 2-4

Senior Project
6-8
COGS 301 or COGS 302 Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution

Total Credits 46-56

1 Collateral courses may count toward CAS distribution requirements where applicable.
2 BIOS 121 Biology Core III: Integrative & Comparative Biology pre-reqs: any CHM course that fulfills the pre-requisite for BIOS 041, plus BIOS 041 Biology Core I: Cellular and Molecular and BIOS 042 Biology Core I: Cellular and Molecular Lab. These are not part of the major but can count toward CAS Natural Science distribution.
3 Students are encouraged to take the required research credits beginning in the second year or even earlier. At least two semesters of relevant research experience (minimum 4 credits) are required for B.S. students prior to enrolling in COGS 391 Honors Thesis in Cognitive Science: Proposal and COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis for their senior project.
4 May be repeated for credit.

MAJOR ELECTIVES

Artificial Intelligence and Formal Models
CSE 017 Programming and Data Structures
CSE 042 Game Design
CSE 140 Foundations of Discrete Structures and Algorithms

CSE 262 Programming Languages
CSE 318 Introduction to the Theory of Computation
CSE 326 Fundamentals of Machine Learning
CSE 331 User Interface Systems and Techniques
CSE 335 Topics on Intelligent Decision Support Systems
CSE 337 Reinforcement Learning
CSE 347 Data Mining
CSE 348 AI Game Programming
CSE 360 Introduction to Mobile Robotics
CSE 428 Semantic Web Topics
CSE 431 Intelligent Agents

Cognition, Culture, and Meaning
ANTH 376 Culture and the Individual
COGS/ANTH/MLL 140 Introduction to Linguistics
COMM 385 Seminar in Communication Issues
CSE 252 Computers, the Internet, and Society
PHIL 128 Philosophy Of Science
PHIL 135 Modern Philosophy
PHIL 139 Contemporary Philosophy
PHIL 220 Ways of Knowing
PHIL 228 Topics in the Philosophy of Science
PHIL 260 Making Sense of Words
PSYC 307 Higher Order Cognition
PSYC 313 Person Perception
PSYC 314 Social Cognition
PSYC 320 Psychology of Language
PSYC/HS/MS 344 Health Care Reasoning and Decision Making
PSYC 351 Children's Thinking
PSYC/ES 357 Psychology of Environmental Issues
PSYC 358 Inside the Infant Mind
PSYC 362 Cognition in Practice & Policy
PSYC/GS 365 Human Development in Cross-Cultural Perspective
PSYC 384 Self and Identity
SOC/JOUR 135 Human Communication

Cognitive Neuroscience
ANTH 012 Human Evolution and Prehistory
ANTH 145 Human Evolution
BIOS 121 Biology Core III: Integrative & Comparative Biology
BIOS 276 Central Nervous System and Behavior
BIOS 277 Experimental Neuroscience Laboratory
BIOS 365 Neurobiology of Sensory Systems
BIOS 366 Diseases of the Nervous System
BIOS 382 Endocrinology of Behavior
BIOS 385 Synapses, Plasticity and Learning
BIOS 386 Genes and the Brain
PSYC 012 Introduction to Human Neuroscience
ELECTIVES

the home department.

The Graduate Certificate requires four courses from the list below.

The certificate will appear on the student's transcript after submission

Individuals should contact the Director of the Cognitive Science

relevant to those working in technology-related fields.

welcome to undertake the certificate.

with sufficient background to complete the coursework are also

available to both enrolled and

external students.

The certificate may be especially

INTERDISCIPLINARY

The graduate certificate provides the opportunity to develop an

perspective on human and machine intelligence.

It is available to both enrolled and

students.

Students in Lehigh University graduate degree programs such as

course and major electives, with at least two of these being

Disciplinary Core Courses

Total Credits 16-20

PROGRAM HONORS

Mayors seeking to graduate with honors in cognitive science must

have a 3.30 GPA in the major, a 3.30 GPA overall, and complete a

high quality senior thesis with enrollment in COGS 391 Honors Thesis

in Cognitive Science: Proposal and COGS 392 Honors Thesis in

Cognitive-Science: Project Execution and Thesis. Theses submitted

for honors will be evaluated by a committee of at least three cognitive

science faculty.

GRADUATE CERTIFICATE IN COGNITIVE SCIENCE

The undergraduate minor in Cognitive Science requires five courses:

COGS 007 Introduction to Cognitive Science 4

Four additional courses selected from among the major's core

courses and major electives, with at least two of these being

Disciplinary Core Courses

Total Credits 12-16

MINOR IN COGNITIVE SCIENCE

The undergraduate minor in Cognitive Science requires five courses:

COGS 007 Introduction to Cognitive Science 4

Four additional courses selected from among the major's core

courses and major electives, with at least two of these being

Disciplinary Core Courses

Total Credits 12-16

ELECTIVES

Computer Science

CSE 327  Artificial Intelligence Theory and Practice
CSE 331  User Interface Systems and Techniques
CSE 332  Multimedia Design and Development
CSE 335  Topics on Intelligent Decision Support Systems
CSE 348  AI Game Programming
CSE 409  Theory of Computation
CSE 426  Fundamentals of Machine Learning
CSE 428  Semantic Web Topics
CSE 431  Intelligent Agents
CSE 435  Topics on Intelligent Decision Support Systems
CSE 437  Reinforcement Learning and Markov Decision Processes
CSE 447  Data Mining
CSE 460  Mobile Robotics

Psychology

PSYC 307  Higher Order Cognition
PSYC 313  Person Perception
PSYC 314  Social Cognition
PSYC 316  The Talking World: Psychology and Neuroscience of Speaking
PSYC 320  Psychology of Language
PSYC/HMS 344  Health Care Reasoning and Decision Making
PSYC 347  Cognitive Neuroscience of Memory
PSYC 351  Children's Thinking
PSYC 355  Seminar in Cognitive Neuroscience
PSYC 358  Inside the Infant Mind
PSYC 362  Cognition in Practice & Policy
PSYC 377  Attention and Attentional Failures
PSYC 402  Developmental Psychology
PSYC 403  Cognitive Psychology
PSYC 406  Social Cognition
PSYC 433  Cognitive Neuroscience Techniques
PSYC 448  Seminar in Psychology of Language
PSYC 464  Naive Realism in Social Judgement
PSYC 476  Seminar In Cognition
PSYC/COGS 478  Ontological Psychology
PSYC 480  Seminar in Cognitive Development

Philosophy

PHIL/COGS 250  Philosophy of Mind
PHIL 260  Making Sense of Words

Sociology and Anthropology

ANTH 376  Culture and the Individual

Total Credits 0

Note: These particular 200-level courses may be taken by graduate
students.

Courses

COGS 007 Introduction to Cognitive Science 4 Credits

What is a mind? How is the mind related to the brain? Could we make
an artificial mind? Issues concerning knowledge representation and
intelligence in minds and computers as investigated by psychologists,
philosophers, linguists, neuroscientists, and researchers in artificial
intelligence.

COGS 117 (PSYC 117) Cognitive Psychology 4 Credits

The architecture and dynamics of the human mind: How we acquire
knowledge through perception, represent and activate it in memory,
and use it to communicate, make decisions, solve problems, and
reason creatively. May not be taken pass/fail.

Prerequisites: PSYC 001 or COGS 007

Attribute/Distribution: SS

COGS 127 (CSE 127) Survey of Artificial Intelligence 3 Credits

An introduction to artificial intelligence (AI) intended for non-majors. AI
concepts, systems, and history. Credit will not be given for both CSE/ COGS 127 and CSE/COGS 327.

Prerequisites: CSE 002 or CSE 004 or CSE 007

COGS 140 (ANTH 140, MLL 140) Introduction to Linguistics 4 Credits

Relationship between language and mind; formal properties of
language; language and society; how languages change over time.
May not be taken pass/fail.

Attribute/Distribution: SS

COGS 161 Supervised Research 1-3 Credits

Research under the direct supervision of a faculty member in the
cognitive science program. Students must arrange the particular
project with a faculty member before enrolling. Consent of program
director required.

Repeat Status: Course may be repeated.

Attribute/Distribution: ND
COGS 176 (PSYC 176) Cognitive Neuroscience 4 Credits
Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory, and thought; neural network (connectionist) models of mental processes. May not be taken pass/fail.
Prerequisites: CSE/COGS 017 and CSE/COGS 007
Attribute/Distribution: NS

COGS 183 (PSYC 183) Cognitive Psychology Recitation 1 Credit
Research, discussion, and analysis of topics in cognitive psychology.
Prerequisites: PSYC 117 or COGS 117
Can be taken Concurrently: PSYC 117, COGS 117

COGS 184 (PSYC 184) Cognitive Neuroscience Recitation 1 Credit
Research, discussion, and analysis of topics in cognitive neuroscience.
Prerequisites: PSYC 176 or COGS 176
Can be taken Concurrently: PSYC 176, COGS 176

COGS 194 Special Topics in Cognitive Science 2-4 Credits
Topics vary from semester to semester. Topics are addressed at an intermediate level. Previous course work in cognitive science and consent of faculty sponsor is required.
Repeat Status: Course may be repeated.

COGS 250 (PHIL 250) Philosophy of Mind 4 Credits
An exploration of the mind-body problem. Are the body and mind distinct substances (dualism); or is there only body (materialism); or only mind (idealism)? Other views to be considered include behaviorism (the view that behavior can be explained without recourse to mental states), and the view that the mind is a complex computer.
Attribute/Distribution: HU

COGS 300 Apprentice Teaching 1-4 Credits

COGS 301 Senior Project in Cognitive Science: Proposal 1-3 Credits
For students not intending to apply for program Honors. Background reading and preparation of a short written proposal are conducted in the first semester in consultation with a faculty adviser. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.

COGS 302 Senior Project in Cognitive Science: Execution 1-3 Credits
For students not intending to apply for program Honors. Execution of the project is conducted in the second semester in consultation with a faculty adviser. A presentation will be given at the end of the semester. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.
Prerequisites: COGS 301

COGS 327 (CSE 327) Artificial Intelligence Theory and Practice 3 Credits
Detailed analysis of a broad range of artificial intelligence (AI) algorithms and systems. Problem solving, knowledge representation, reasoning, planning, uncertainty and machine learning. Applications of AI to areas such as natural language processing, vision, and robotics. Credit will not be given for both CSE/COGS 127 and CSE/COGS 327.
Prerequisites: CSE 017 and CSE 140

COGS 361 Independent Research 2-4 Credits
Independent research in cognitive science with a faculty advisor. Students must arrange the particular project with a faculty advisor before enrolling. Consent of program director required.
Repeat Status: Course may be repeated.
Attribute/Distribution: ND

COGS 391 Honors Thesis in Cognitive Science: Proposal 1-4 Credits
For students with 3.3 or higher major and overall GPA by the spring of the junior year, who want to undertake a project with the potential for program Honors. Literature review and preparation of a written proposal are conducted in the first semester in consultation with a faculty adviser. An oral presentation will be given at end of the semester. Students must enroll for four credits which may be split between co-advisers. Consent of program director and project adviser required.

COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis 1-4 Credits
For students with 3.3 or higher major and overall GPA by the spring of the junior year. Project execution and preparation of the written report is conducted in the second semester. An oral presentation will be given at the end of the semester. Theses will be evaluated for Honors by three cognitive science faculty. Students must enroll for a total of four credits which may be split between co-advisers. Consent of program director and project adviser required.
Prerequisites: COGS 391

COGS 394 Special Topics in Cognitive Science 3-4 Credits
Topics vary from semester to semester. Topics are presented at an advanced level.
Repeat Status: Course may be repeated.

COGS 399 Senior Project in Cognitive Science: Thesis 1-3 Credits
Research during senior year culminating in senior thesis advised by a member of the Cognitive Science faculty. Execution and written report of project proposed and approved in COGS 301. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Theses submitted for honors will be evaluated by a committee of at least three cognitive science faculty. Prerequisite: COGS 301 and consent of the program director.
Repeat Status: Course may be repeated.
Prerequisites: COGS 301

COGS 405 Individual Study in Cognitive Science 1-6 Credits
Study of a topic not covered in regular course offerings. By arrangement with a consulting faculty member. Consent of program director required.
Repeat Status: Course may be repeated.

COGS 423 (PSYC 423) Foundations of Cognitive Science 3 Credits
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

COGS 478 (PSYC 478) Ontological Psychology 3 Credits
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.