

# Cognitive Science

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## Core Faculty

Kate Arrington, Ph.D. (Psychology); Mark Bickhard, Ph.D. (Philosophy and Psychology); Amanda Brandone, Ph.D. (Psychology); Nancy Carlisle, Ph.D. (Psychology); Jeffrey Heflin, Ph.D. (Computer Science and Engineering); Almut Hupbach, Ph.D. (Psychology); Kiri Lee, Ph.D. (Modern Languages and Literatures); Barbara Malt, Ph.D. (Psychology); Jesseca Marsh, Ph.D. (Psychology); Hector Munoz-Avila, Ph.D. (Computer Science and Engineering); Padraig O'Seaghda, Ph.D. (Psychology); Dominic Packer, Ph.D. (Psychology); and Aladdin Yaqub, Ph.D. (Philosophy)

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 in technology, human thought and behavior, or their interaction, and for graduate studies in Cognitive Science or any of the contributing disciplines.

We offer an undergraduate major in Cognitive Science, an undergraduate minor, a graduate 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.

**Professor.** Hector Munoz-Avila, PHD (Technische Universitat Kaiserslautern)

**Associate Professors.** Jeffrey D. Heflin, PHD (University of Maryland College Park); Padraig G O'Seaghda, PHD (University of Toronto)

## B.A. IN COGNITIVE SCIENCE

The B.A. with a major in Cognitive Science requires a minimum of 13 courses. All majors take COGS 007, an introduction to cognitive science, core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science and math. They also complete a course in research methods or tools. Students then pursue their individual interests by completing at least five electives from 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 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

CSE 001	Breadth of Computing
or CSE 012	Survey of Computer Science
CSE 002	Fundamentals of Programming
MATH 021	Calculus I

or MATH 051 Survey of Calculus I

One course in research methods and tools from the following: PSYC 110 Statistical Analysis of Behavioral Data; PSYC 210 Experimental Research Methods and Laboratory (pre-requisite PSYC 110); ECO 045 Statistical Methods; SOAN 111 Research Methods and Data Analysis; CSE 160 Introduction to Data Science; BIOS 130 Biostatistics

## Introductory Course

COGS 007 Introduction to Cognitive Science

## Disciplinary Core Courses

COGS/PSYC 117 Cognitive Psychology

COGS/PSYC 176 Cognitive Neuroscience

COGS/PHIL 250 Philosophy of Mind

COGS/CSE 327 Artificial Intelligence Theory and Practice

## Major Electives

Select a minimum of five electives, with at least one course from each of the three tracks.

## Senior Project

COGS 301 & COGS 302 Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution

or

COGS 391 & COGS 392 Honors Thesis in Cognitive Science: Proposal and Honors Thesis in Cognitive Science: Project Execution and Thesis

## 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

PHIL/MATH 114 Symbolic Logic

PHIL/MATH 214 Topics in Philosophical Logic

PHIL 265 Philosophy of Mathematics

PHIL/MATH 303 Mathematical Logic

MATH 304 Axiomatic Set Theory

MATH 329 Computability Theory

### Cognition, Culture, and Meaning

ANTH 376 Culture and the Individual

COGS/ANTH/MLL 140 Introduction to Linguistics

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/HMS 344	Health Care Reasoning and Decision Making
PSYC 351	Children's Thinking
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
PSYC 316	The Talking World: Psychology and Neuroscience of Speaking
PSYC 347	Cognitive Neuroscience of Memory
PSYC 355	Seminar in Cognitive Neuroscience
PSYC 369	Memory Under Construction
PSYC 377	Attention and Attentional Failures
PSYC 433	Cognitive Neuroscience Techniques

**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		12-16
Total Credits		16-20

**PROGRAM HONORS**

Majors 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.

**FOR GRADUATE STUDENTS**

There are two concentrations in Cognitive Science available for post-baccalaureate students: a Graduate Minor and a Graduate Certificate. The minor is intended for students currently enrolled in a degree-granting graduate program at Lehigh University. The certificate is intended for non-degree students.

**Graduate Minor in Cognitive Science**

The minor gives students enrolled in Lehigh University graduate degree programs, such as computer science, psychology, and

educational technology, an opportunity to develop expertise at the intersection of information processing by humans and intelligent machines. Graduate students are encouraged to participate, with the approval of an advisor in their major program, by contacting the Director of the Cognitive Science Program. On completion of the program, the Director of the Cognitive Science Program will issue a letter to the student certifying that or she has met the requirements of the minor.

The Graduate Minor requires five graduate level courses.

**Required**

COGS/PSYC 423	Foundations of Cognitive Science	3
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**Electives**

Four electives from the list below (or approved substitutions). At least two of the four electives must be taken outside the student's home department. Special topics courses with a cognitive science emphasis may also count toward the minor, with the approval of the Cognitive Science Program Director. Courses taken toward the minor may also fulfill requirements of the student's major program, with the approval of the major department.

CSE 331	User Interface Systems and Techniques
CSE 348	AI Game Programming
CSE 409	Theory of Computation
CSE 426	Pattern Recognition
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
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

Total Credits		15-19
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**Graduate Certificate in Cognitive Science**

This concentration is intended for people working in technology-related businesses and other qualified individuals with an interest in cognitive science. It provides non-degree post-baccalaureate students with an interdisciplinary perspective on human and machine intelligence.

The Graduate Certificate requires four graduate level courses: the core course COGS/PSYC 423 and three electives. At least two of the three electives must be at the 400-level, and the three electives must be spread over at least two departments.

COGS 423	Foundations of Cognitive Science	3
Three electives from the list below.		9-12

**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 426	Pattern Recognition
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
<b>Psychology</b>	
PSYC 307	Higher Order Cognition
PSYC 313	Person Perception
PSYC 314	Social Cognition
PSYC 317	Psychology of Emotion
PSYC 320	Psychology of Language
PSYC 321	Language Development
PSYC 347	Cognitive Neuroscience of Memory
PSYC 351	Children's Thinking
PSYC 358	Inside the Infant Mind
PSYC 362	Cognition in Practice & Policy
PSYC 365	Human Development in Cross-Cultural Perspective
PSYC 369	Memory Under Construction
PSYC 377	Attention and Attentional Failures
PSYC 402	Developmental Psychology
PSYC 403	Cognitive Psychology
PSYC 406	Social Cognition
PSYC 443	Seminar In Language Acquisition
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
<b>Philosophy</b> <sup>1</sup>	
PHIL/COGS 250	Philosophy of Mind
PHIL 260	Making Sense of Words
<b>Sociology and Anthropology</b>	
ANTH 376	Culture and the Individual
Total Credits	12-15

<sup>1</sup> 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 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:** PSYC 001 or COGS 007

**Attribute/Distribution:** NS

#### **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. Must have completed one HU-designated course in Philosophy at 100-level or higher.

**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. 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 poster presentation will be given at the end of the semester. Consent of program director and project adviser required.

**Prerequisite:** COGS 301 and consent of the program director.

**Prerequisites:** COGS 301

#### **COGS 327 (CSE 327) Artificial Intelligence Theory and Practice 3 Credits**

Introduction to the field of artificial intelligence: Problem solving, knowledge representation, reasoning, planning and machine learning. Use of AI systems or languages. Advanced topics such as natural language processing, vision, robotics, and uncertainty. CSE 261 is recommended.

**Prerequisites:** (CSE 001 and CSE 002) or CSE 017

#### **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 GPA overall and in major by the spring of the junior year, who want to undertake a research project with the potential to result in 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. 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 GPA overall and in major by the spring of the junior year, who want to undertake a research project with the potential to result in program Honors. Project execution and preparation of the written report is conducted in the second semester in consultation with a faculty adviser. An oral presentation will be given at the end of the semester. Theses will be evaluated for Honors by three cognitive science faculty.

**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.