Cognitive Science

Website: http://cogsci.cas.lehigh.edu/ **(**http://cogsci.cas2.lehigh.edu/**)**

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.

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. Students are required to complete a two-semester senior capstone 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. Students can opt out of the capstone project by taking two courses at the 200 level and above from the list of major electives.

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		**7-8**
CSE 007	Introduction to Programming	
or CSE 003 & CSE 004	Introduction to Programming, Part A and Introduction to Programming, Part B	
One course in research methods and tools from the following: PSYC 201 Research Methods and Data Analysis I; PSYC 202 Research Methods and Data Analysis II; ECO 045 Statistical Methods; SOC 211 Research Methods and Data Analysis; CSE 160 Introduction to Data Science; BIOS 130 Biostatistics		
Introductory Course		**4**
COGS 007	Introduction to Cognitive Science	
Disciplinary Core Courses		**15**
COGS/PSYC 117	Cognitive Psychology	
COGS/CSE 127	Survey of Artificial Intelligence	
or COGS/CSE 327	Artificial Intelligence Theory and Practice	
COGS/PSYC 176	Cognitive Neuroscience	
COGS/PHIL 250	Philosophy of Mind	
or COGS/PHIL 251	Philosophical Foundations of Cognitive Science	
Major Electives		**15-20**
Select a minimum of five electives, with at least one course from each of the three tracks.		
Senior Project: Select One of the Following:		**6-8**
Two 200-level or above Major Electives		
COGS 301 & COGS 302	Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution [1]	
COGS 391 & COGS 392	Honors Thesis in Cognitive Science: Proposal and Honors Thesis in Cognitive Science: Project Execution and Thesis [1]	
Total Credits		**47-55**

[1] Credits may be split between two advisors but must total 3 per semester.

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. Students are required to complete a two-semester senior capstone 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. Students can opt out of the capstone project by taking two courses at the 200 level and above from the list of major electives.

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 [1]		
MATH 021	Calculus I	
or MATH 051	Survey of Calculus I	
or MATH 075 & MATH 076	Calculus I, Part A and Calculus I, Part B	
CSE 007	Introduction to Programming	
or CSE 003 & CSE 004	Introduction to Programming, Part A and Introduction to Programming, Part B	
CSE 140	Foundations of Discrete Structures and Algorithms [6]	
or CSE 160	Introduction to Data Science	
PSYC 001	Introduction to Psychology	
or ECO 001	Principles of Economics	
or ANTH 011	Cultural Diversity and Human Nature	
Two courses in research methods and tools.		**6-8**
For Artificial Intelligence and Formal Models Concentration:		
CSE 140 & MATH 231	Foundations of Discrete Structures and Algorithms and Probability and Statistics	
or ECO 045	Statistical Methods	
For all other concentrations:		
PSYC 201 & PSYC 202	Research Methods and Data Analysis I and Research Methods and Data Analysis II	
Introductory Course		**4**
COGS 007	Introduction to Cognitive Science	

Disciplinary Core Course		**16**
COGS/PSYC 117	Cognitive Psychology	
COGS/CSE 127	Survey of Artificial Intelligence [7]	
or COGS/CSE 327	Artificial Intelligence Theory and Practice	
COGS/PSYC 176	Cognitive Neuroscience	
COGS/PHIL 250	Philosophy of Mind	
or COGS/PHIL 251	Philosophical Foundations of Cognitive Science	
COGS 183	Cognitive Psychology Recitation	
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 044	Introduction to Integrative and Comparative Biology [2]	
Research Experience [3]		**2-4**
COGS 161	Supervised Research [4]	
Senior Project: Select one of the following:		**6-8**
Two 200-level or above Major Electives		
COGS 301 & COGS 302	Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution [5]	
COGS 391 & COGS 392	Honors Thesis in Cognitive Science: Proposal and Honors Thesis in Cognitive Science: Project Execution and Thesis [5]	
Total Credits		**52-64**

1

Collateral courses may count toward CAS distribution requirements where applicable.

2

BIOS 044 pre-reqs: any CHM course that fulfills the pre-requisite for BIOS 041, plus BIOS 041 Introduction to Cellular and Molecular Biology and BIOS 042 Introduction to Cellular and Molecular Biology Laboratory. 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.

5

Credits may be split between two advisers but must total 3 per semester (301,302) or 4 per semester (391, 392).

6

Not available in the Artificial Intelligence concentration.

7

This option is not available in the Artificial Intelligence concentration.

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 014	Symbolic Logic
PHIL/MATH 114	Metalogic
PHIL 265	Philosophy of Mathematics
Cognition, Culture, and Meaning	
COGS/ANTH/MLL 140	Introduction to Linguistics
CSE 252	Computers, the Internet, and Society
EDUC 391	Educational Linguistics
JOUR 135	Human Communication
PHIL 128	Philosophy Of Science
PHIL 135	Modern Philosophy
PHIL 139	Contemporary Philosophy
PHIL 220	Epistemology
PHIL 228	Philosophy of Specific Sciences
PHIL 260	Philosophy of Language
PSYC 307	Higher Order Cognition
PSYC 313	Person Perception
PSYC 314	Social Cognition
PSYC/HMS 344	Health Care Reasoning and Decision Making
PSYC 351	Children's Thinking
PSYC/EVST 357	Psychology of Environmental Issues
PSYC 362	Cognition in Practice & Policy
PSYC 384	Self and Identity
SOC 118	Sociology of Culture
SOC 226	Computational Text Analysis
Cognitive Neuroscience	
ANTH 012	Intro to Archaeology and Human Origins
ANTH 145	Human Evolution
BIOS 044	Introduction to Integrative and Comparative Biology
BIOS 276	Central Nervous System and Behavior
BIOS 277	Experimental Neuroscience Laboratory
BIOS 332	Behavioral Neuroanatomy
BIOS 365	Neurobiology of Sensory Systems
BIOS 366	Diseases of the Nervous System
BIOS 382	Endocrinology
BIOS 385	Synapses, Plasticity and Learning
BIOS 386	Genes and the Brain
PSYC 012	Introduction to Human Neuroscience

PSYC 347	Topics in Memory
PSYC 355	Seminar in Cognitive Neuroscience
PSYC 377	Attention and Attentional Failures
PSYC 433	Cognitive Neuroscience Techniques

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 014	Symbolic Logic
PHIL/MATH 114	Metalogic
PHIL/MATH 214	Topics in Philosophical Logic
PHIL 265	Philosophy of Mathematics

Cognition, Culture, and Meaning

COGS/ANTH/MLL 140	Introduction to Linguistics
CSE 252	Computing Ethics
EDUC 391	Educational Linguistics
JOUR 135	Human Communication
PHIL 128	Philosophy Of Science
PHIL 135	Modern Philosophy
PHIL 139	Contemporary Philosophy
PHIL 220	Epistemology
PHIL 228	Philosophy of Specific Sciences
PHIL 260	Philosophy of Language
PSYC 307	Higher Order Cognition
PSYC 313	Person Perception
PSYC 314	Social Cognition
PSYC/HMS 344	Health Care Reasoning and Decision Making
PSYC 351	Children's Thinking
PSYC/EVST 357	Psychology of Environmental Issues
PSYC 362	Cognition in Practice & Policy
PSYC 384	Self and Identity
SOC 118	Sociology of Culture
SOC 226	Computational Text Analysis

Cognitive Neuroscience

ANTH 012	Intro to Archaeology and Human Origins
BIOS 044	Introduction to Integrative and Comparative Biology
ANTH 145	Human Evolution
BIOS 276	Central Nervous System and Behavior
BIOS 277	Experimental Neuroscience Laboratory
BIOS 332	Behavioral Neuroanatomy
BIOS 365	Neurobiology of Sensory Systems
BIOS 366	Diseases of the Nervous System
BIOS 382	Endocrinology
BIOS 385	Synapses, Plasticity and Learning
BIOS 386	Genes and the Brain
PSYC 012	Introduction to Human Neuroscience
PSYC 347	Topics in Memory
PSYC 355	Seminar in Cognitive Neuroscience
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.

GRADUATE CERTIFICATE IN COGNITIVE SCIENCE

The graduate certificate provides the opportunity to develop an interdisciplinary perspective on human and machine intelligence. It is available to both enrolled and external students.

Students in Lehigh University graduate degree programs such as computer science, psychology, and instructional technology are encouraged to participate with the approval of an adviser in their major program. Non-degree, post-baccalaureate individuals with sufficient background to complete the coursework are also welcome to undertake the certificate. The certificate may be especially relevant to those working in technology-related fields. Interested individuals should contact the Director of the Cognitive Science Program. External candidates will also need to apply to the College of Arts and Sciences for non-degree graduate status.

The certificate will appear on the student’s transcript after submission of a signed completion form by the program director.

The Graduate Certificate requires four courses from the list below. At least two of the courses must be at the 400-level, and the four courses must be spread over at least two departments. For Lehigh degree candidates, at least three of the four courses must be outside the home department. The certificate will entail 12-16 credits.

ELECTIVES

Computer Science

CSE 327	Artificial Intelligence Theory and Practice
CSE 331	User Interface Systems and Techniques
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 Precesses
CSE 447	Data Mining

CSE 460	Mobile Robotics
Psychology	
PSYC 307	Higher Order Cognition
PSYC 313	Person Perception
PSYC 314	Social Cognition
PSYC/HMS 344	Health Care Reasoning and Decision Making
PSYC 347	Topics in Memory
PSYC 351	Children's Thinking
PSYC 355	Seminar in Cognitive Neuroscience
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 476	Seminar In Cognition
PSYC/COGS 478	Ontological Psychology
PSYC 480	Seminar in Cognitive Development
Philosophy [1]	
PHIL/COGS 250	Philosophy of Mind
PHIL 260	Philosophy of Language
Sociology and Anthropology	
Total Credits	**0**

[1]

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.
Attribute/Distribution: SW

COGS 091 Special Topics 1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: AL, CC, HE, HU, NW, SS, SW, W

COGS 098 1-4 Credits
Repeat Status: Course may be repeated.

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, SW

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 004 or CSE 007 or CSE 012
Attribute/Distribution: Q

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, SW

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: CC, W

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, NW

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 191 Special Topics 1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: AL, CC, HE, HU, NW, SS, SW, W

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. Student must have completed at least one Philosophy course at the 100-level.
Attribute/Distribution: HE, HU

COGS 251 (PHIL 251) Philosophical Foundations of Cognitive Science 4 Credits
Cognitive Science is the study of aspects of natural and artificial minds: perception, cognition, reasoning, action, and language. Several fields intersect here: artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience. Central issues include: the nature of representation, the boundaries of cognitive science, and consciousness. We will survey the foundational philosophical aspects of these issues within Cognitive Science. Student must have completed at least one Philosophy course at the 100-level, or major in Cognitive Science.
Attribute/Distribution: HE, HU

COGS 291 Special Topics 1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: CC, HU, SS, W

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.
Attribute/Distribution: CC, W

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.
Repeat Status: Course may be repeated.
Prerequisites: COGS 301
Attribute/Distribution: CC, W

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
Attribute/Distribution: Q

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: CC, W

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.
Repeat Status: Course may be repeated.
Attribute/Distribution: CC, W

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.
Repeat Status: Course may be repeated.
Prerequisites: COGS 391
Attribute/Distribution: CC, W

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.
Attribute/Distribution: CC, W

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.