

# COGNITIVE SCIENCE

<https://cogsci.jhu.edu/>

Cognitive science is the study of the human mind and brain, focusing on how the mind represents and manipulates knowledge and how mental representations and processes are realized in the brain. Conceiving of the mind as an abstract computing device instantiated in the brain, cognitive scientists endeavor to understand the mental computations underlying cognitive functioning and how these computations are implemented by neural tissue. Cognitive science has emerged at the interface of several disciplines. Central among these are cognitive psychology, linguistics, and portions of computer science and artificial intelligence; other important components derive from work in the neurosciences, philosophy, and anthropology. This diverse ancestry has brought into cognitive science several different perspectives and methodologies. Cognitive scientists endeavor to unite such varieties of perspectives around the central goal of characterizing the structure of human intellectual functioning. It is this common object of inquiry that integrates traditionally separate disciplines into the unified field of cognitive science.

Programs in cognitive science at Johns Hopkins University reflect the interdisciplinary nature of the subject, requiring the student to approach the study of the mind/brain from several different investigative perspectives. Programs in cognitive science draw on courses offered by several other departments as well.

## Facilities

The department is located in Krieger Hall. Laboratory and office space is provided for graduate students. The department's research facilities are provided by the following laboratories (<https://cogsci.jhu.edu/research-areas/labs/>):

- Cognitive and Brain Sciences Lab (Rapp)
- Cognitive Neuroscience Lab (McCloskey)
- Cognitive Neuroscience and Machine Learning Lab (Bonner)
- Computational Cognitive Neuroscience (Isik)
- Computational Cognition, Vision, & Learning (CCVL) Research Group (Yuille)
- Computational Linguistics Lab (Smolensky)
- Kocab Lab - new!
- Language Acquisition Lab (Legendre)
- Language and Cognition Lab (Landau)
- Phonetics/Phonology Lab (Wilson)
- Semantics Lab (Rawlins)
- Integrated Experimental/Theoretical Grammar Research (IGERT) Lab and Library (Smolensky)

Department members also conduct research in the F.M. Kirby Center for Functional Brain Imaging at the Kennedy Krieger Institute and in other laboratories at Johns Hopkins School of Medicine.

## Programs

- Cognitive Science, Bachelor of Arts (<https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/cognitive-science/cognitive-science-bachelor-arts/>)

- Cognitive Science, Master of Arts (<https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/cognitive-science/cognitive-science-master-art/>)
- Cognitive Science, PhD (<https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/cognitive-science/cognitive-science-phd/>)
- Linguistics, Minor (<https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/cognitive-science/linguistics-minor/>)

For current course information and registration go to <https://sis.jhu.edu/classes/>

## Courses

### AS.050.102. Language and Mind. 3 Credits.

Introductory course dealing with theory, methods, and current research topics in the study of language as a component of the mind. What it is to "know" a language: components of linguistic knowledge (phonetics, phonology, morphology, syntax, semantics) and the course of language acquisition. How linguistic knowledge is put to use: language and the brain and linguistic processing in various domains.

Area: Natural Sciences, Social and Behavioral Sciences

### AS.050.105. Introduction to Cognitive Neuropsychology. 3 Credits.

When the brain is damaged or fails to develop normally, even the most basic cognitive abilities (such as the ability to understand words, or perceive objects) may be disrupted, often in remarkable ways. This course explores a wide range of cognitive deficits, focusing on what these deficits can tell us about how the normal brain works. Topics include brain anatomy and causes of brain damage, reading and spelling deficits, unilateral spatial neglect, hemispheric disconnection, cortical plasticity, and visual perception of location and orientation. Students read primary sources: journal articles that report deficits and discuss their implications.

Area: Natural Sciences, Social and Behavioral Sciences

### AS.050.116. Visual Cognition. 3 Credits.

How do humans make sense of the visual world around them? This course will provide an introductory survey of current research, methods, and theories in visual cognition. We will draw upon topics in cognitive psychology, cognitive neuroscience, cognitive neuropsychology, and artificial intelligence.

Area: Natural Sciences, Social and Behavioral Sciences

### AS.050.135. Speech & Voice. 3 Credits.

Course on human speech production and perception, covering topics including anatomy and physiology of the vocal tract, phonetic analysis, language acquisition and impairments, and speech technologies.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.202. Introduction to Computational Cognitive Science. 3 Credits.**

How does the mind work? Cognitive science addresses this question from a multidisciplinary perspective, drawing upon methods and ideas from psychology, neurophysiology, neuroscience, philosophy, linguistics, and computer science. Within this framework, computational cognitive science has two related goals. The first is to create computational models of human cognition, computer programs that simulate certain aspects of the mind. The second is to understand how to produce intelligent behavior in machines, taking cues from humans. The computational frameworks we will discuss include symbolic structured representations, probabilistic inference and artificial neural networks, as applied to concept learning, language and vision. While this class does not have formal prerequisites, some programming experience (e.g., AS 250.205 Introduction to Computing or equivalent) and mathematical preparation (e.g., AS.110.107 Calculus II or equivalent) are essential. An optional, hands-on lab (AS.050.212) is offered to supplement this course. It is highly recommended that students with less extensive computational and mathematical experience register for this lab.

Area: Quantitative and Mathematical Sciences

**AS.050.203. Neuroscience: Cognitive. 3 Credits.**

This course surveys theory and research concerning how mental processes are carried out by the human brain. Currently a wide range of methods of probing the functioning brain are yielding insights into the nature of the relation between mental and neural events. Emphasis will be placed on developing an understanding of both the physiological bases of the techniques and the issues involved in relating measures of brain activity to cognitive functioning. Methods surveyed include electrophysiological recording techniques such as EEG, ERP, single/multiple unit recording and MEG; functional imaging techniques such as PET and fMRI; and methods that involve lesioning or disrupting neural activity such as cortical stimulation, animal lesion studies, and the study of brain-damaged individuals. Also offered as AS.050.603. It's strongly recommended that students have background in one of the following courses: AS.050.105 OR AS.200.141.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.206. Bilingualism. 3 Credits.**

Do children get confused when they grow up exposed to more than one language? Is it possible to forget one's native language? Are the first and second language processed in different areas of the brain? How does brain damage impact the different languages of a polyglot? Does knowing a second language affect non-linguistic cognitive processing? This course will address questions such as these through an exploration of mental and neural processes underlying bilingual and multilingual language processing. Also offered as AS.050.606.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.212. Introduction to Computational Cognitive Science Lab. 0.5 Credits.**

This course is a hands-on lab supplement for AS.050.202 Introduction to Computational Cognitive Science. While this lab is optional, it is highly recommended to students with less extensive computational and mathematical experience.

**Corequisite(s):** Must be registered for AS.050.202 in order to register for this optional lab.

**AS.050.233. Lost in Space: How Humans Learn, Think, and Talk About the World Around Us. 3 Credits.**

The ability to perceive, navigate, and explain space around us is essential in our everyday life: every day humans find their favorite coffee mug, make their way to work, hang their coat, and give directions to dinner guests with relative ease. How is this assorted set of tasks accomplished? How does the human mind structure the space around us and recognize the spatial relations between various objects? What happens when this ability is impaired? This course will attempt to answer these questions by sampling key concepts, theories, and experimental findings from a diverse set of disciplines, including neuroscience, psychology, and linguistics. We will get an overview of spatial cognition from multiple perspectives and draw analogies between different research paradigms.

Area: Social and Behavioral Sciences

**AS.050.236. Neurolinguistics. 3 Credits.**

This course provides an introductory survey of the cognitive neuroscience of language – a multidisciplinary field in the intersection of Linguistics, Psycholinguistics, and Neuroscience. We will explore current research on the neural bases of the perception, production, and acquisition of human language in neuro-typical and impaired individuals.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.244. Cognitive Neuroscience Lab. 3 Credits.**

This course aims to provide a deeper understanding of cognitive neuroscience methods and theory through a series of labs and active learning activities. Example labs include building psychophysical experiments, exploring the brain using MRI images and developing artificial neural networks. Emphasis will be placed on developing a scientific mindset in approaching problems. This course is a hands-on supplement for AS.050.203 Neuroscience: Cognitive. It is required that students have background in AS.050.203.

**Prerequisite(s):** AS.050.203

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.311. Written Language: Normal Processing and Disorders. 3 Credits.**

This course surveys both the historical development of written language as well as current cognitive theories that account for the manner in which the written language is represented and processed by readers/writers of a language. Issues regarding the relationship between the written and spoken language, the neural bases of written language, the acquisition of written language skills, as well as acquired and developmental disorders of reading and writing will be examined.

**Prerequisite(s):** AS.050.102 OR AS.050.105 OR AS.050.203 OR AS.080.203

Area: Natural Sciences, Social and Behavioral Sciences

Writing Intensive

**AS.050.312. Cognitive Neuroimaging Methods in High-Level Vision. 3 Credits.**

This course is an advanced seminar and research practicum course. It will provide the opportunity to learn about fMRI methods used in the field of vision science and for students to have hands-on experience to develop, design and analyze a research study on topics in the cognitive neuroscience field of high-level vision. In the first part of the course students will read recent fMRI journal papers and learn about common fMRI designs and analysis methods; in the second part of the course students will conduct a research study to address a research question developed from readings. Students are expected to write a paper in a short journal article format at the end of the course and to present their results in front of the class. Research topics will vary but with special focus on topics in high-level visual processing.

**Prerequisite(s):** AS.050.105 OR AS.050.116 OR AS.050.203 OR AS.050.315 OR AS.050.332 OR AS.200.110

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.315. Cognitive Neuropsychology of Visual Perception: The Malfunctioning Visual Brain. 3 Credits.**

When we think about our ability to see, we tend to think about our eyes, but in fact vision happens mostly in the brain. This course explores the remarkable perceptual deficits that occur when the visual regions of the brain are damaged or fail to develop normally, focusing on what these perceptual malfunctions tell us about normal visual perception. Topics include visual system anatomy and physiology; functional specialization in the lower visual system as revealed by cerebral achromatopsia (color blindness resulting from brain damage) and akinetopsia (impaired motion perception); cortical plasticity in the visual system; spatial deficits in perception and action; and the implications of high-level visual deficits, including prosopagnosia (impaired face recognition), Charles Bonnet syndrome (complex visual hallucinations in blind areas of the visual field), blindsight (accurate responding to visual stimuli despite apparent inability to see them), and aphantasia (lack of visual imagery).

**Prerequisite(s):** AS.050.105 OR AS.050.203 OR AS.080.203 OR AS.050.101 OR AS.200.110 OR AS.200.211 or instructor's permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.317. Semantics I. 3 Credits.**

This is an introduction to the study of meaning in natural language. We address the conceptual and empirical issues in semantic theory and introduce some formal machinery that has been developed to deal with such problems. After discussing foundational questions, we turn to formal semantics and pragmatics, as well as their interfaces with syntax and the lexicon. Specific topics include presupposition, type-driven composition, quantification, lexical aspect, argument structure, and lexical representations of meaning.

**Prerequisite(s):** AS.050.107 OR AS.050.102 or AS.050.240 or instructor's permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.320. Syntax I. 3 Credits.**

Introduces the basic methods and means of analysis used in contemporary syntax investigations, practicing with data from different languages. Also offered as AS.050.620.

**Prerequisite(s):** AS.050.102 OR AS.050.240 or equivalent/see instructor.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.325. Phonology I. 3 Credits.**

An introduction to the basic principles underlying the mental representation and manipulation of language sounds and their relation to human perception and vocal articulation: how units of sound are both decomposable into elementary features and combined to form larger structures like syllables and words. The role of rules and constraints in a formal theory of phonological competence and in accounting for the range of variation among the world's languages. Also offered as AS.050.625.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.326. Foundations of Cognitive Science. 3 Credits.**

This course explores general issues and methodologies in cognitive science through the reading of classic works (from Plato and Kant through Skinner and Turing) and recent research articles to begin construction of a coherent picture of many seemingly divergent perspectives on the mind/brain. Recent brain-based computational models serve to focus discussion. Also offered as AS.050.626.

Recommended Course Background: at least one course at the 300-level or higher in cognitive science, computer science, neuroscience, philosophy, or psychology.

Area: Natural Sciences, Social and Behavioral Sciences

Writing Intensive

**AS.050.332. Developmental Cognitive Neuroscience. 3 Credits.**

In-depth examination of the current literature on cognitive development in the context of developmental cognitive neuroscience. Please see course prerequisites. Meets with AS.050.632.

**Prerequisite(s):** AS.050.101 OR AS.050.339 OR AS.200.132 OR AS.050.105 OR Instructor's Permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.333. Psycholinguistics. 3 Credits.**

This course provides a broad survey of current research on language processing in adult native speakers and language learners. Topics include speech perception, word recognition, and sentence production and comprehension. We will discuss the nature of representations that are being constructed in real-time language use, as well as how the mental procedures for constructing linguistic representations could be studied by various behavioral and physiological measures. Also offered as AS.050.633.

**Prerequisite(s):** AS.050.102 OR AS.050.240 OR AS.050.317 OR AS.050.320 OR AS.050.325 or instructor's permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.337. Reading the Mind: Computational Cognitive Neuroscience of Vision. 3 Credits.**

Recent advancements in neuroscience, computational cognitive science and machine learning have led to new possibilities for understanding the mind and brain. With the current neural network modelling and artificial intelligence (AI) techniques, scientists are able to decode neural representation to understand one's internal mental state. In this course, we will discuss how to utilize the latest technologies, including voxel-wise encoding models, convolutional neural networks (CNNs), generative adversarial networks (GANs) and transformers, to model neural representations with a focus on vision. Students will read latest primary research articles and gain hands-on neural modelling experience. Also offered as AS.050.637

**Prerequisite(s):** (AS.050.202 OR AS.250.205 OR AS.050.372) AND (AS.050.105 OR AS.050.116 OR AS.050.203) or equivalent with instructor permission.

Area: Natural Sciences, Quantitative and Mathematical Sciences

**AS.050.339. Cognitive Development. 3 Credits.**

This is a survey course in developmental psychology designed for individuals with some basic background in psychology or cognitive science, but little or none in development. The course is strongly theoretically oriented, with emphasis on issues of nature, and development psychology as well as relevant empirical evidence. The principle focus will be early development, i.e., from conception through middle childhood. The course is organized topically, covering biological and prenatal development, perceptual and cognitive development, the nature and development of intelligence, and language learning. Also offered as AS.050.639.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.348. First Language Acquisition. 3 Credits.**

This course provides an introduction to the fields of first and bilingual language acquisition by looking at questions such as the following: Can the grammar of a native language be learned solely on the basis of noticing statistical correlations among words? How does native language acquisition explain — or is explained by — the universal properties, shared by all languages, of words and grammars? How does being exposed to multiple languages from birth affect language acquisition and what happens when a child is not exposed to any language early in life? This is the first part of a two-part course sequence on first and second language acquisition.

**Prerequisite(s):** (AS.050.240 OR AS.050.320 OR AS.050.325) OR (AS.050.102 OR AS.050.206)

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.349. Second Language Acquisition. 3 Credits.**

First language acquisition is natural and seemingly effortless. The situation is reversed when one tries to learn another language. This course discusses in what ways first and second language acquisition (SLA) differ and how individual differences of the learners as well as external factors contribute to the variability observed in rates and ultimate proficiency of second language learning in children and adults. We will discuss such topics as Universal Grammar access in early and late SLA, first language influence, critical periods, possibility of native-like attainment, and language attrition. Also offered as AS.050.649.

**Prerequisite(s):** AS.050.102 OR AS.050.206 OR AS.050.320 OR AS.050.325 OR AS.050.348

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.353. Cognitive Science in Artificial Intelligence. 3 Credits.**

As a myriad of artificial intelligence enabled autonomous systems enter into our lives and change how we live, we must ask: can we trust these systems? In this course we will take a human-centered perspective on assured autonomy and identify why and how insights from human perception and cognition can guide solutions for reliable, resilient, and robust autonomous systems. We will address bias, ethics, explainability, and safety by focusing on specific case studies from autonomous vehicles, cybersecurity, healthcare, fashion, law enforcement, and military systems. Students will apply learned material to a semester-long group research project on a topic of their choice. Also offered as AS.050.653.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.358. Language & Thought. 3 Credits.**

Have you ever wondered about the relationships between language and thought? Philosophers, linguists, psychologists, evolutionary theorists and cognitive scientists have too and this course will survey the current thinking on this matter. Classical papers such as those by Whorf and Sapir, more recent philosophical papers by people such as Fodor and Dennett, and recent empirical work by linguists and psycholinguists on the relationship between language and thinking in development and in adults will be covered. Discussions will focus on the theoretically possible relationships between language and thought and the empirical data that speak to these. Juniors and seniors only. Freshmen and sophomores by permission of instructor only.

**Prerequisite(s):** AS.050.102 OR AS.050.320 OR AS.050.325 or instructor permission.

Area: Humanities, Natural Sciences, Social and Behavioral Sciences

**AS.050.360. Computational Psycholinguistics. 3 Credits.**

How do we understand and produce sentences in a language we speak? How do we acquire the knowledge that underlies this ability? Computational psycholinguistics seeks to address these questions using a combination of two approaches: computational models, which aim to replicate the processes that take place in the human mind; and human experiments, which are designed to test those models. The perspective we will take in this class is that the models and experimental paradigms do not only advance our understanding of the cognitive science, but can also help us advance artificial intelligence and language technologies.

While computational psycholinguistics spans all levels of linguistic structure, from speech to discourse, our focus in this class will be at the level of the sentence (syntax and semantics). The course will assume familiarity with programming and computational modeling frameworks in cognitive science, as covered by Introduction to Computational Cognitive Science or equivalent. Also offered as AS.050.660. An optional, hands-on lab (AS.050.361) is offered to supplement this course. It is highly recommended that students with less extensive computational and mathematical experience register for this lab.

**Prerequisite(s):** (AS.050.102 OR AS.050.240 OR AS.050.317 OR AS.050.320) AND (AS.050.202 OR EN.601.465) or Instructor Permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.361. Computational Psycholinguistics Lab. 0.5 Credits.**

This course is an optional hands-on lab supplement for Computational Psycholinguistics. While this lab is optional, it is highly recommended to students with less extensive computational and mathematical experience.

**Corequisite(s):** Must be registered for AS.050.360 or AS.050.660 in order to register for this optional lab.

**AS.050.365. Cracking the code: Theory and modeling of information coding in neural activity. 3 Credits.**

One of the most foundational concepts in neuroscience is the idea that neural activity encodes information about an animal's sensory environment and internal mental states. This idea is closely connected to the concept of mental representation in cognitive science and philosophy, whereby the mind is proposed to contain internal symbols that represent things in the external world. There have been many fascinating discoveries about how neural signals encode information, but we are still far from a comprehensive theory of neural representation. Recent major developments in neuroscience and machine learning have opened up a new world of possibilities for investigating the underlying principles of information coding in the brains of humans and other animals. In this course, we will discuss primary research articles on neural representation and information processing, and students will implement computational analyses that address issues in these domains. We will mostly focus on vision as a system that illustrates broader principles of information processing in the human brain. The reading material will include work from philosophy, neuroimaging, electrophysiology, and computational modeling. The topics covered include mental and neural representation, neural tuning, population coding, information theory, encoding and decoding models, dimensionality reduction, computational models, deep learning, and other applications of machine learning in neuroscience. Enrollment is limited to Juniors and Seniors. While this class does not have formal prerequisites, programming experience (e.g., AS.250.205 Introduction to Computing) and mathematical preparation (e.g., AS.110.107 Calculus II) are essential. It is also highly recommended that students have previously taken introductory courses in cognitive or systems neuroscience (e.g., AS.050.203 Neuroscience: Cognitive) and machine learning or neural network modeling (e.g., AS.050.372 Foundations of Neural Network Theory).

Area: Natural Sciences, Quantitative and Mathematical Sciences

**AS.050.370. Mathematical Models of Language. 3 Credits.**

This course will be devoted to the study of formal systems that have proven useful in the cognitive science of language. We will discuss a wide range of mathematical structures and techniques and demonstrate their applications in theories of grammatical competence and performance. A major goal of this course is bringing students to a point where they can evaluate the strengths and weaknesses of existing formal theories of cognitive capacities, as well as profitably engage in such formalization, constructing precise and coherent definitions and rigorous proofs. Also offered as AS.050.670.

**Prerequisite(s):** AS.050.102 OR AS.050.202

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.371. Bayesian Inference. 3 Credits.**

This course introduces techniques for computational modeling of aspects of human cognition, including perception, categorization, and induction. Possible topics include maximum likelihood and Bayesian inference, structured statistical models (including hierarchical and graphical models), nonparametric models. The course emphasizes the close connections among data analysis, theory development, and modeling, with examples drawn from language and vision. Also offered as AS.050.671.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.372. Foundations of Neural Network Theory. 4 Credits.**

Introduction to continuous mathematics for cognitive science, with applications to biological and cognitive network models: real and complex numbers, differential and integral multi-variable calculus, linear algebra, dynamical systems, numerical optimization. Recommended course background in Calculus I. This is a basic-level course not appropriate for students with significant math background. tudents who have completed both Calc III (AS.110.202 or AS.110.211) and Linear Algebra (AS.110.201 or AS.110.212 or EN.553.291) or an equivalent combination may not register. Also offered as AS.050.672.

**Prerequisite(s):** Students who have completed both (AS.110.202 OR AS.110.211) AND (AS.110.201 OR AS.110.212 OR EN.553.291) or an equivalent combination may not register.

Area: Natural Sciences, Quantitative and Mathematical Sciences

**AS.050.375. Probabilistic Models of the Visual Cortex. 3 Credits.**

The course gives an introduction to computational models of the mammalian visual cortex. It covers topics in low-, mid-, and high-level vision. It briefly discusses the relevant evidence from anatomy, electrophysiology, imaging (e.g., fMRI), and psychophysics. It concentrates on mathematical modeling of these phenomena taking into account recent progress in probabilistic models of computer vision and developments in machine learning, such as deep networks. Also offered as EN.601.485. Required Background: Calculus I and experience in a programming language (Python preferred).

**Prerequisite(s):** Students who have taken EN.601.485/EN.601.685 are not eligible to take AS.050.375.;AS.110.106 OR AS.110.108

Area: Quantitative and Mathematical Sciences

**AS.050.383. Computational Social Cognition. 3 Credits.**

Humans are a fundamentally social species with amazing capabilities beyond that of any other biological or artificial system. Yet the cognitive and neural computations underlying our vast social abilities are largely unknown. Advances in machine learning and naturalistic neuroscience paradigms are revolutionizing the way cognitive scientists study social cognition. This course will explore new research in computational social cognition, drawing from topics in development, artificial intelligence, and cognitive neuroscience. Our goal is to understand the motivation, methodology and implications of recent research. The class will be heavily focused on social vision, but will also explore other aspects of social cognition including theory of mind and moral reasoning. This is a discussion-based class that will consist primarily of reading and discussing primary research articles, as well as student-led presentations. While there will not be any hands-on computational exercises, a background in both cognitive neuroscience and computational methods are important to understanding the readings and other course material.

**Prerequisite(s):** AS.050.203 AND AS.050.202 or equivalent.

Area: Natural Sciences, Quantitative and Mathematical Sciences

**AS.050.500. Practicum in Language Disorders- Community Based Learning. 2 Credits.**

This course provides the opportunity to learn about adult aphasia, language disorders which are one of the most common consequences of stroke. You will receive training in supportive communication techniques and work as a communication partner with an individual with aphasia for two hours per week. Three class meetings for orientation and reading assignments will be held on campus; training and practicum will be conducted at a local aphasia support center. Independent mode of transportation required. Co-listed as AS.080.505 in Neuroscience. Find out more about the practicum site at <https://www.leagueforpeople.org/scale>.

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.;A- or Better in AS.050.105 OR AS.050.203 OR AS.050.311 or instructor's permission.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.510. Cognitive Science Internship. 1 Credit.**

For internships in cognitive science-related fields. Graded S/U only. Student cannot receive credit for paid internships. A Cognitive Science faculty sponsor is required and must be named in the Independent Academic Work form. Please read the relevant independent academic work FAQ. KSAS primary majors, visit <https://advising.jhu.edu/research-internships-and-independent-study/>. WSE primary majors, visit <https://engineering.jhu.edu/advising/advising-questions/>.

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.

**AS.050.514. Research Cognitive Science - Juniors. 1 - 3 Credits.**

Permission Required,

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.

**AS.050.515. Readings in Cognitive Science. 1 - 3 Credits.**

Assigned readings on current topics in cognitive science. Instructor approval required. Letter-graded.

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.

**AS.050.550. Undergraduate Teaching Practicum in Cognitive Science. 1 - 3 Credits.**

By invitation, qualified students may serve as undergraduate Teaching Assistants for cognitive science courses and receive credit. This practicum is graded S/U. Each section instructor will determine TA responsibilities based upon departmental policy. Students who accept an invitation, should forward that invitation to the Director of Undergraduate Studies (Dr. Colin Wilson) and make a request in SIS to add the instructor's teaching practicum section. Dr. Wilson will approve requests in SIS. Students may not both receive credit and be paid for the same undergraduate teaching position. This course may not be used toward cognitive science major degree requirements.

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.

**AS.050.599. Research in Cognitive Science. 1 - 3 Credits.**

Research current topics in cognitive science. Instructor approval required. Graded S/U.

**Prerequisite(s):** You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.

**AS.050.603. Intro to Cognitive Neuroscience. 3 Credits.**

This course surveys theory and research concerning how mental processes are carried out by the human brain. Currently a wide range of methods of probing the functioning brain are yielding insights into the nature of the relation between mental and neural events. Emphasis will be placed on developing an understanding of both the physiological bases of the techniques and the issues involved in relating measures of brain activity to cognitive functioning. Methods surveyed include electrophysiological recording techniques such as EEG, ERP, single/multiple unit recording and MEG; functional imaging techniques such as PET and fMRI; and methods that involve lesioning or disrupting neural activity such as cortical stimulation, animal lesion studies, and the study of brain-damaged individuals. Also offered as AS.050.203.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.606. Intro to Bilingualism. 3 Credits.**

Do children get confused when they grow up exposed to more than one language? Is it possible to forget one's native language? Are the first and second language processed in different areas of the brain? How does brain damage impact the different languages of a polyglot? Does knowing a second language affect non-linguistic cognitive processing? This course will address questions such as these through an exploration of mental and neural processes underlying bilingual and multilingual language processing. Also listed as AS.050.206.

**AS.050.612. Cognitive Neuroimaging Methods in High-Level Vision. 3 Credits.**

This course is an advanced seminar and research practicum course. It will provide the opportunity to learn about fMRI methods used in the field of vision science and for students to have hands-on experience to develop, design and analyze a research study on topics in the cognitive neuroscience field of high-level vision. In the first part of the course students will read recent fMRI journal papers and learn about common fMRI designs and analysis methods; in the second part of the course students will conduct a research study to address a research question developed from readings. Students are expected to write a paper in a short journal article format at the end of the course and to present their results in front of the class. Research topics will vary but with special focus on topics in high-level visual processing. Cross-listed with Neuroscience and Psychology.

**AS.050.617. Semantics I. 3 Credits.**

Also offered as AS.050.317. This is an introduction to the study of meaning in natural language. We address the conceptual and empirical issues in semantic theory and introduce some formal machinery that has been developed to deal with such problems. After discussing foundational questions, we turn to formal semantics and pragmatics, as well as their interfaces with syntax and the lexicon. Specific topics include presupposition, type-driven composition, quantification, lexical aspect, argument structure, and lexical representations of meaning.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.620. Syntax I. 3 Credits.**

Introduces the basic methods and means of analysis used in contemporary syntax investigations, practicing with data from different languages. Also offered as AS.050.320.

**AS.050.625. Phonology I. 3 Credits.**

An introduction to the basic principles underlying the mental representation and manipulation of language sounds and their relation to human perception and vocal articulation: how units of sound are both decomposable into elementary features and combined to form larger structures like syllables and words. The role of rules and constraints in a formal theory of phonological competence and in accounting for the range of variation among the world's languages. Also offered as AS.050.325.

Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.626. Foundations of Cognitive Science. 3 Credits.**

Also offered as AS.050.326. This course explores general issues and methodologies in cognitive science through the reading of classic works (from Plato and Kant through Skinner and Turing) and recent research articles to begin construction of a coherent picture of many seemingly divergent perspectives on the mind/brain. Recent brain-based computational models serve to focus discussion. Also offered as AS.050.326.

Area: Natural Sciences, Social and Behavioral Sciences

Writing Intensive

**AS.050.632. Developmental Cognitive Neuroscience. 3 Credits.**

In-depth examination of the current literature on cognitive development in the context of developmental cognitive neuroscience. Meets with AS.050.332.

**AS.050.633. Psycholinguistics. 3 Credits.**

Also offered as AS.050.333. This course provides a broad survey of current research on language processing in adult native speakers and language learners. Topics include speech perception, word recognition, and sentence production and comprehension. We will discuss the nature of representations that are being constructed in real-time language use, as well as how the mental procedures for constructing linguistic representations could be studied by various behavioral and physiological measures.

**AS.050.636. Intro to Neurolinguistics. 3 Credits.**

This course provides an introductory survey of the cognitive neuroscience of language – a multidisciplinary field in the intersection of Linguistics, Psycholinguistics, and Neuroscience. We will explore current research on the neural bases of the perception, production, and acquisition of human language in neuro-typical and impaired individuals. Also listed as AS.050.236.

**AS.050.637. Reading the Mind: Computational Cognitive Neuroscience of Vision. 3 Credits.**

Recent advancements in neuroscience, computational cognitive science and machine learning have led to new possibilities for understanding the mind and brain. With the current neural network modelling and artificial intelligence (AI) techniques, scientists are able to decode neural representation to understand one's internal mental state. In this course, we will discuss how to utilize the latest technologies, including voxel-wise encoding models, convolutional neural networks (CNNs), generative adversarial networks (GANs) and transformers, to model neural representations with a focus on vision. Students will read latest primary research articles and gain hands-on neural modelling experience. Recommended course background: At least one course in each cognitive neuroscience and introduction to computing. Also offered as AS.050.373

**AS.050.639. Cognitive Development. 3 Credits.**

Also offered as AS.050.339. This is a survey course in developmental psychology designed for individuals with some basic background in psychology or cognitive science, but little or none in development. The course is strongly theoretically oriented, with emphasis on issues of nature, and development psychology as well as relevant empirical evidence. The principle focus will be early development, i.e., from conception through middle childhood. The course is organized topically, covering biological and prenatal development, perceptual and cognitive development, the nature and development of intelligence, and language learning.

**AS.050.648. First Language Acquisition. 3 Credits.**

This course provides an introduction to the fields of first and bilingual language acquisition by looking at questions such as the following: Can the grammar of a native language be learned solely on the basis of noticing statistical correlations among words? How does native language acquisition explain – or is explained by – the universal properties, shared by all languages, of words and grammars? How does being exposed to multiple languages from birth affect language acquisition and what happens when a child is not exposed to any language early in life? This is the first part of a two-part course sequence on first and second language acquisition.

**AS.050.649. Second Language Acquisition. 3 Credits.**

First language acquisition is natural and seemingly effortless. The situation is reversed when one tries to learn another language. This course discusses in what ways first and second language acquisition (SLA) differ and how individual differences of the learners as well as external factors contribute to the variability observed in rates and ultimate proficiency of second language learning in children and adults. We will discuss such topics as Universal Grammar access in early and late SLA, first language influence, critical periods, possibility of native-like attainment, and language attrition. Recommended background in at least one of the following: AS.050.102 Language and Mind, AS.050.606 Bilingualism, AS.050.620 Syntax I, AS.050.625 Phonology I, AS.050.648 First Language Acquisition, or equivalent. Recommended background in at least one prior linguistics course.

**AS.050.653. Cognitive Science in Artificial Intelligence. 3 Credits.**

As a myriad of artificial intelligence enabled autonomous systems enter into our lives and change how we live, we must ask: can we trust these systems? In this course we will take a human-centered perspective on assured autonomy and identify why and how insights from human perception and cognition can guide solutions for reliable, resilient, and robust autonomous systems. We will address bias, ethics, explainability, and safety by focusing on specific case studies from autonomous vehicles, cybersecurity, healthcare, fashion, law enforcement, and military systems. Students will apply learned material to a semester-long group research project on a topic of their choice. Also offered as AS.050.353.

**AS.050.658. Language & Thought. 3 Credits.**

Have you ever wondered about the relationships between language and thought? Philosophers, linguists, psychologists, evolutionary theorists and cognitive scientists have too and this course will survey the current thinking on this matter. Classical papers such as those by Whorf and Sapir, more recent philosophical papers by people such as Fodor and Dennett, and recent empirical work by linguists and psycholinguists on the relationship between language and thinking in development and in adults will be covered. Discussions will focus on the theoretically possible relationships between language and thought and the empirical data that speak to these.

**AS.050.660. Computational Psycholinguistics. 3 Credits.**

How do we understand and produce sentences in a language we speak? How do we acquire the knowledge that underlies this ability? Computational psycholinguistics seeks to address these questions using a combination of two approaches: computational models, which aim to replicate the processes that take place in the human mind; and human experiments, which are designed to test those models. The perspective we will take in this class is that the models and experimental paradigms do not only advance our understanding of the cognitive science, but can also help us advance artificial intelligence and language technologies. While computational psycholinguistics spans all levels of linguistic structure, from speech to discourse, our focus in this class will be at the level of the sentence (syntax and semantics). The course will assume familiarity with programming and computational modeling frameworks in cognitive science, as covered by Introduction to Computational Cognitive Science or equivalent. Also offered as AS.050.360. An optional, hands-on lab (AS.050.361) is offered to supplement this course. It is highly recommended that students with less extensive computational and mathematical experience register for this lab.

**AS.050.665. Cracking the code: Theory and modeling of information coding in neural activity. 3 Credits.**

One of the most foundational concepts in neuroscience is the idea that neural activity encodes information about an animal's sensory environment and internal mental states. This idea is closely connected to the concept of mental representation in cognitive science and philosophy, whereby the mind is proposed to contain internal symbols that represent things in the external world. There have been many fascinating discoveries about how neural signals encode information, but we are still far from a comprehensive theory of neural representation. Recent major developments in neuroscience and machine learning have opened up a new world of possibilities for investigating the underlying principles of information coding in the brains of humans and other animals. In this course, we will discuss primary research articles on neural representation and information processing, and students will implement computational analyses that address issues in these domains. We will mostly focus on vision as a system that illustrates broader principles of information processing in the human brain. The reading material will include work from philosophy, neuroimaging, electrophysiology, and computational modeling. The topics covered include mental and neural representation, neural tuning, population coding, information theory, encoding and decoding models, dimensionality reduction, computational models, deep learning, and other applications of machine learning in neuroscience. Enrollment is limited to Juniors and Seniors. While this class does not have formal prerequisites, programming experience (e.g., AS.250.205 Introduction to Computing) and mathematical preparation (e.g., AS.110.107 Calculus II) are essential. It is also highly recommended that students have previously taken introductory courses in cognitive or systems neuroscience (e.g., AS.050.203 Neuroscience: Cognitive) and machine learning or neural network modeling (e.g., AS.050.372 Foundations of Neural Network Theory).

**AS.050.670. Mathematical Models of Language. 3 Credits.**

This course will be devoted to the study of formal systems that have proven useful in the cognitive science of language. We will discuss a wide range of mathematical structures and techniques and demonstrate their applications in theories of grammatical competence and performance. A major goal of this course is bringing students to a point where they can evaluate the strengths and weaknesses of existing formal theories of cognitive capacities, as well as profitably engage in such formalization, constructing precise and coherent definitions and rigorous proofs. Recommended background in language and mind or computational cognitive science. Also offered as AS.050.370  
Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.671. Bayesian Inference. 3 Credits.**

Also offered as AS.050.371. This course introduces techniques for computational modeling of aspects of human cognition, including perception, categorization, and induction. Possible topics include maximum likelihood and Bayesian inference, structured statistical models (including hierarchical and graphical models), nonparametric models. The course emphasizes the close connections among data analysis, theory development, and modeling, with examples drawn from language and vision.  
Area: Natural Sciences, Social and Behavioral Sciences

**AS.050.672. Foundations of Neural Network Theory. 4 Credits.**

Introduction to continuous mathematics for cognitive science, with applications to biological and cognitive network models: real and complex numbers, differential and integral multi-variable calculus, linear algebra, dynamical systems, numerical optimization. Recommended course background in Calculus I. This is a basic-level course not appropriate for students with significant math background. Students who have completed both Calc III and Linear Algebra or an equivalent combination may not register. Also offered as AS.050.372.

**AS.050.675. Probabilistic Models of the Visual Cortex. 3 Credits.**

The course gives an introduction to computational models of the mammalian visual cortex. It covers topics in low-, mid-, and high-level vision. It briefly discusses the relevant evidence from anatomy, electrophysiology, imaging (e.g., fMRI), and psychophysics. It concentrates on mathematical modeling of these phenomena taking into account recent progress in probabilistic models of computer vision and developments in machine learning, such as deep networks. Also offered as EN.601.685. Required Background: Calculus I and experience in a programming language (Python preferred).

**Prerequisite(s):** Students who have taken EN.601.485/EN.601.685 are not eligible to take AS.050.675.

**AS.050.683. Computational Social Cognition. 3 Credits.**

Humans are a fundamentally social species with amazing capabilities beyond that of any other biological or artificial system. Yet the cognitive and neural computations underlying our vast social abilities are largely unknown. Advances in machine learning and naturalistic neuroscience paradigms are revolutionizing the way cognitive scientists study social cognition. This course will explore new research in computational social cognition, drawing from topics in development, artificial intelligence, and cognitive neuroscience. Our goal is to understand the motivation, methodology and implications of recent research. The class will be heavily focused on social vision, but will also explore other aspects of social cognition including theory of mind and moral reasoning. This is a discussion-based class that will consist primarily of reading and discussing primary research articles, as well as student-led presentations. While there will not be any hands-on computational exercises, a background in both cognitive neuroscience and computational methods are important to understanding the readings and other course material.

**AS.050.800. Directed Readings in Cognitive Science. 1 - 10 Credits.**

Directed readings on current topics in cognitive science. Instructor approval required.

**AS.050.801. Research Seminar in Cognitive Neuropsychology. 2 Credits.**

Participants in this graduate seminar will read and discuss current research articles in cognitive neuropsychology of vision or language, and present their own research.

**AS.050.802. Research Seminar in Cognitive Processes. 2 Credits.**

Permission required. Current issues and ongoing research on human cognition are discussed.

**AS.050.806. Research Seminar in Cognitive Neuroscience and Machine Learning. 2 Credits.**

Participants in this seminar will read and discuss current research articles in the fields of cognitive neuroscience, computational neuroscience, machine learning, and artificial intelligence. The seminar will focus on research that provides insights into the representations and algorithms of the human brain, with an emphasis on vision and natural semantic understanding.

**AS.050.809. Research Seminar in Computational Cognitive Science. 1.5 Credits.**

This seminar is on computational models for vision and its interaction with language. For Cognitive Science, computational models, like Deep Nets, offer the possibility of developing computational theories which can be tested on natural, or realistically synthetic images. But Deep Nets by themselves are unable to capture the richness and flexibility of human perception, so we will discuss other classes of model with more compositional structure and ability to represent the physical properties of the 3D world. These will be related to, and motivated by, behavioral and electrophysiological experiments.

**AS.050.811. Research Seminar in Language & Cognition. 1.5 Credits.**

A specialized research seminar for individuals researching language acquisition, cognitive development and the interface between language and cognition. Students must actively carry out empirical or theoretical research in these areas. Permission required.

**AS.050.812. Research Seminar in Computational Cognitive Neuroscience. 1.5 Credits.**

This seminar will discuss papers and ongoing research in the areas of computational cognitive neuroscience, with a focus on different areas of visual and social perception.

**AS.050.814. Research Seminar in Computer Vision. 2 Credits.**

This seminar is based on topics in computational vision with the option of attending additional subgroup meetings on specific topics.

**AS.050.817. Research Seminar in Semantics. 2 Credits.**

A critical analysis of current issues and debates in natural language semantics. Discussion of on-going research. Permission required.

**AS.050.818. Research Seminar: AcqLab Meeting. 3 Credits.**

Participants in this graduate seminar will read and discuss current research articles in language development and present their own research. Permission required.

**AS.050.819. Research Seminar in Psycholinguistics. 2 Credits.**

Discussion of current computational and experimental research on human language processing.

**AS.050.822. Research Seminar Syntax. 3 Credits.**

A critical analysis of current issues and debates in theoretical syntax. Discussion of on-going research.

**AS.050.826. Research Seminar in Formal Approaches to Cognitive Science. 2 Credits.**

Readings and research presentations on varying topics in mathematics, computation, and formal linguistics with bearing on cognitive science.

**AS.050.827. Research Seminar in Language Acquisition. 3 Credits.**

Focus is on current research in acquisition of syntax.

**AS.050.829. Research Seminar on Formal Theory in Cognitive Science. 2 Credits.**

Topics range from mathematical analysis of neural networks to computational studies of linguistic structure. Focus is ongoing research and current literature.

**AS.050.830. Seminar on Special Topics. 3 Credits.**

This seminar will focus on Special Topics of current interest in Cognitive Science and reflect the breath of expertise in the department.

**AS.050.839. Research in Cognitive Science. 1 - 20 Credits.**

Current topics in any area of cognitive science, including language and vision, with discussion of recent developments in theory, experimental study, and computational modeling.

**AS.050.849. Teaching Practicum. 3 - 9 Credits.**

Permission required. Essential for Teaching Assistants.

**AS.050.850. Current Advances in Cognitive Science. 1 Credit.**

Introduces advanced research topics in cognitive science to graduate students through a series of speakers and discussions.

**AS.050.860. Professional Seminar in Cognitive Science. 0.5 Credits.**

Instructor permission required. Addresses professional issues such as research ethics, success on the job market and in an academic career, teaching and mentoring and differing professional standards in the sub-disciplines of cognitive science.

## Cross Listed Courses

### Computer Science

#### EN.601.769. Events Semantics in Theory and Practice. 3 Credits.

This course explores selected topics in the nature of event representations from the perspective of cognitive science, computer science, linguistics, and philosophy. These fields have developed a rich array of scientific theories about the representation of events, and how humans make inferences about them – we investigate how (and if) such theories could be applied to current research topics and tasks in computational semantics such as inference from text, automated summarization, veridicality assessment, and so on. In addition to classic articles dealing with formal semantic theories, the course considers available machine-readable corpora, ontologies, and related resources that bear on event structure, such as WordNet, PropBank, FrameNet, etc.. The course is aimed to marry theory with practice: students with either a computational or linguistic background are encouraged to participate. [Applications]

#### EN.601.783. Vision as Bayesian Inference. 3 Credits.

This is an advanced course on computer vision from a probabilistic and machine learning perspective. It covers techniques such as linear and non-linear filtering, geometry, energy function methods, markov random fields, conditional random fields, graphical models, probabilistic grammars, and deep neural networks. These are illustrated on a set of vision problems ranging from image segmentation, semantic segmentation, depth estimation, object recognition, object parsing, scene parsing, action recognition, and text captioning. [Analysis or Applications] Required course background: calculus, linear algebra (AS.110.201 or equiv.), probability and statistics (AS.550.311 or equiv.), and the ability to program in Python and C++.

### First Year Seminars

#### AS.001.146. FYS: Nature, Nurture, Cognition. 3 Credits.

Using both seminal and contemporary readings as a foundation, we will explore the foundations of cognition and how they support human cognitive development, focusing on how 'nature' and 'nurture' collaborate to shape development of the human mind. This semester, we will read at least three, and possibly four books, along with supplementary readings, as appropriate. Our focus will be on understanding the roles of nature and nurture in the context of typical and atypical development, including an understanding of how knowledge about objects, language, number, and other minds all emerge during human development, from infancy to adulthood, in typically and atypically developing individuals.

Area: Humanities, Social and Behavioral Sciences

#### AS.001.189. FYS: Language, Advertising, and Propaganda. 3 Credits.

Advertising pervades our culture; interactions with advertising are an unavoidable fact of modern life. This class uses tools from linguistics and cognitive science to analyze these interactions, and understand the impact of advertising on its viewers. A central theme is to treat ads as communicative acts, and explore the consequences – what can theories of communication (from linguistics, psychology, and philosophy) tell us about ads? How do ads use central features of human cognition to accomplish their aims? Do ads manipulate, and if so, how successfully? The theories of communication we explore include Gricean pragmatics, theories of speech acts, linguistic theories of presuppositions, and more. Students will collect, analyze, and discuss advertisements in all mediums.

Area: Humanities, Social and Behavioral Sciences

### Music

#### AS.376.371. Introduction to Music Cognition. 3 Credits.

What underlies our aesthetic response to music? How and why are we able to identify certain sounds as music? To what extent are music and natural language similar? What is it about music that evokes such powerful emotions such as happiness and sadness? What is unique to musical creativity? Examining such questions from cognitive science, neuroscience, psychology, and philosophical perspectives, this course explores relevant research and theory in the emerging domain of music perception and cognition. Students will complete a final research paper on the topic of their choice that integrates the course material.

Area: Natural Sciences, Social and Behavioral Sciences

#### AS.376.372. Topics in Music Cognition. 3 Credits.

This course explores the similarities and differences between music and language, the effects of musical training on cognitive development, and the expressive power of music, with an introduction to music and its role in film. We will read relevant research and theory on these topics from cognitive science, neuroscience, psychology, musicology, and philosophical perspectives.

Area: Natural Sciences, Social and Behavioral Sciences

### Psychological & Brain Sciences

#### AS.200.313. Models of Mind and Brain. 3 Credits.

This is a seminar surveying computational approaches to understanding mental and neural processes, including sensory and conceptual representation, categorization, learning and memory. The course will also develop familiarity with computational tools such as numerical simulation, linear transformation and data visualization. Enrollment limited to Juniors and Seniors. Recommended Course Background: AS.110.106 / Calculus I OR AS.110.108 Calculus I, AS.050.101 / Cognition OR AS.200.211 / Sensation & Perception OR AS.080.105 / Introduction to Neuroscience OR other introductory coursework in cognitive & neural sciences. Some basic experience with computer programming (any language) is recommended, although not required.

Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences

For current faculty and contact information go to <http://cogsci.jhu.edu/> people (<http://cogsci.jhu.edu/people/>)