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:

- Cognitive and Brain Sciences Lab (Rapp)
- Cognitive Neuroscience Lab (McCloskey)
- Cognitive Neuroscience and Machine Learning Lab (Bonner)
- Computational Cognitive Neuroscience (Isik)
- Computational Linguistics Lab (Smolensky)
- 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

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**


For current course information and registration go to [https://sis.jhu.edu/classes/](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 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.050.107. Freshman Seminar: Language and Advertising. 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: 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.050.121. Freshman Seminar: Theory of Mind and the Science of “Mindreading”. 3 Credits.
Fundamental to nearly all of human social behavior – including the use of language, the development of complex societies and cultures, pretending and storytelling – is the understanding that others have their own thoughts, beliefs, and intentions guiding their behavior. This capacity for “mindreading” is known as theory of mind. This course will explore what it means to have a theory of mind. Are humans born with a theory of mind? Does theory of mind interact with other aspects of cognition? How and why did theory of mind evolve in humans? Are humans unique amongst animals in having a theory of mind? The course will examine basic concepts of the mind and intention in philosophy and psychology, and review research from psychology, cognitive science, and neuroscience on topics including the development of theory of mind in children, the relationship between language and theory of mind, neurological correlates of theory of mind, links between theory of mind and autism, and theory of mind in non-human animals.
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, neuropsychology, 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. It’s strongly recommended that students have background in one of the following courses: AS.050.101 OR 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 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.050.236. 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.050.240. World of Language. 3 Credits.
This hands-on course exposes students to the fascinating variety – and uniformity – to be found among the world’s 6000 languages through group lectures on a variety of topics as well as actual linguistic fieldwork conducted in small groups with a native speaker of a language unknown to the participants. This course is a good preparation for upper-division linguistics courses.
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
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 akiognosia (impaired motion perception); cortical plasticity in the visual system; spatial deficits in perception and action; and the implications of high-level visual defects, 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.
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.050.339. 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.
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 second 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? Does the same cognitive mechanism guide language learning in children and adults? What factors account for individual differences in ease and ultimate attainment when a second language is learned later in life? Is it possible to become indistinguishable from a native speaker in a foreign language? What changes take place in the brain when a new language is learned? Also offered as AS.050.648.
Prerequisite(s): (AS.050.240 OR AS.050.320 OR AS.050.325) AND (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.
Prerequisite(s): (AS.050.240 OR AS.050.320 OR AS.050.325) AND (AS.050.348 OR AS.050.102 OR AS.050.206)
Area: Natural Sciences, Social and Behavioral Sciences

AS.050.352. Applying Cognitive Neuroscience to Artificial Intelligence Part I. 3 Credits.
As a result of greater computing power and Big Data, artificial intelligence (AI) is rapidly improving for well-defined tasks and narrow intelligence. Moreover, it has entered all industries in a myriad of ways. But will AI ever have human-like general intelligence? What does humanlike general intelligence even mean? Why should we even care? This course is designed to answer these complex questions by giving students working knowledge of the underlying principles and mechanisms of human behavior and cognition, and how they may be applied to solving current and rising industry challenges. Key topics to be addressed will include vision, audition, language, learning, emotion and social cognition, creativity, and consciousness. Each topic addressed will cover latest advancements within cognitive neuroscience, with relevant applied case studies. Students will apply learned topics to a final group research project on the topic of their choice.
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 psychologists 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 optional 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. Students who have completed both Calc III and Linear Algebra or an equivalent combination may not register. Also offered as AS.050.672.
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. Required Background: Calculus I and experience in a programming language (Python preferred).
Prerequisite(s): AS.110.106 OR AS.110.108
Area: Natural Sciences, 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 naturalistic neuroscience paradigms and machine learning are revolutionizing the way cognitive scientists study social cognition. This course will explore new research in computational social cognition, drawing from topics in cognitive neuroscience, development, and artificial intelligence. 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.
Prerequisite(s): AS.050.203 OR AS.080.203 OR AS.050.202 or equivalent.
Area: Natural Sciences, Quantitative and Mathematical Sciences

AS.050.501. Readings in Cognitive Science/Freshmen. 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 &gt; Online Forms.

AS.050.502. Readings in Cognitive Science-Freshmen. 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 &gt; Online Forms.

AS.050.503. Research in Cognitive Science/Freshmen. 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 &gt; Online Forms.

AS.050.504. Research Cognitive Science-Freshmen. 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 &gt; Online Forms.

AS.050.505. Readings in Cognitive Science/Sophomores. 1 - 3 Credits.
Research current topics in cognitive science.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration &gt; Online Forms.

AS.050.506. Readings Cognitive Science-Sophomores. 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 &gt; Online Forms.

AS.050.507. Research in Cognitive Science/Sophomores. 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 &gt; Online Forms.

AS.050.508. Research Cognitive Science - Sophomores. 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 &gt; Online Forms.

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): AS.990.500

AS.050.511. Readings in Cognitive Science/Juniors. 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 &gt; Online Forms.
AS.050.512. Readings 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.050.513. Research in Cognitive Science - Juniors. 1 - 3 Credits. 
Research current topics in cognitive science. Instructor approval required. 
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration & Online Forms.

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 - Seniors. 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.050.516. Readings Cognitive Science - Senior. 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.050.517. Research in Cognitive Science - Seniors. 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.050.518. Research Cognitive Science - Seniors. 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.050.519. Research Cognitive Science. 0 - 3 Credits. 
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. 
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. 
Area: Natural Sciences, Social and Behavioral Sciences

AS.050.606. Intro to Bilingualism. 
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.050.617. Semantics I. 
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 representational meaning. 
Area: Natural Sciences, Social and Behavioral Sciences

AS.050.620. Syntax I. 
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.050.622. Semantics II. 
Co-taught with AS.050.322. This course extends the material in AS.050.317 to cover advanced but central topics in semantic and pragmatic theory, focusing on intensional semantics (especially possible world semantics and situation semantics). Empirical domains of interest in this class include modality, tense, grammatical aspect, conditionals, attitude and speech reports, questions, and free choice phenomena. Three core theoretical issues addressed in this class are the nature of a compositional account of the above intensional phenomena, the representations of possibilities involved, and the role of the syntax/semantics/pragmatics interface in such an account. 
Prerequisite(s): AS.050.617. 
Area: Natural Sciences, Social and Behavioral Sciences

AS.050.625. Phonology I. 
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

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. 
Area: Natural Sciences, Social and Behavioral Sciences 
Writing Intensive

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

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.
This course provides an introduction to the fields of first and second 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? Does the same cognitive mechanism guide language learning in children and adults? What factors account for individual differences in ease and ultimate attainment when a second language is learned later in life? Is it possible to become indistinguishable from a native speaker in a foreign language? What changes take place in the brain when a new language is learned? Recommended background: An introductory course in a linguistic course such as world of language, phonology, or syntax as well as a linguistics course such as language and mind or bilingualism. Also offered as AS.050.348.

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 AS.050.102 Language and Mind, AS.050.348 Language Acquisition, AS.050.206 Bilingualism or equivalent. Also offered as AS.050.349.

AS.050.652. Applying Cognitive Neuroscience to Artificial Intelligence Part I.
As a result of greater computing power and Big Data, artificial intelligence (AI) is rapidly improving for well-defined tasks and narrow intelligence. Moreover, it has entered all industries in a myriad of ways. But will AI ever have human-like general intelligence? What does humanlike general intelligence even mean? Why should we even care? This course is designed to answer these complex questions by giving students working knowledge of the underlying principles and mechanisms of human behavior and cognition, and how they may be applied to solving current and rising industry challenges. Key topics to be addressed will include vision, audition, language, learning, emotion and social cognition, creativity, and consciousness. Each topic addressed will cover latest advancements within cognitive neuroscience, with relevant applied case studies. Students will apply learned topics to a final group research project on the topic of their choice.

AS.050.658. Language & Thought.
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.
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.
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, neuromaging, 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).

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.
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.
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.

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 modelling 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 AS.050.375.

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 naturalistic neuroscience paradigms and machine learning are revolutionizing the way cognitive scientists study social cognition. This course will explore new research in computational social cognition, drawing from topics in cognitive neuroscience, development, and artificial intelligence. 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. Also offered as AS.050.383.

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

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

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

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.

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.
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.

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


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

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

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

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.
Focus is on current research in acquisition of syntax.

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

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.
Permission required. Essential for Teaching Assistants.

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 orApplications] Required course background: calculus, linear algebra (AS.110.201 or equiv), probability and statistics (AS.553.311 or equiv), and the ability to program in Python and C++. Background in computer vision (EN.601.461/661) and machine learning (EN.601.475) suggested but not required.

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
Neuroscience
AS.080.320. The Auditory System. 3 Credits.
This course will cover the neuroanatomy and neurophysiology of the human auditory system from the ear to the brain. Behavioral, electrophysiological, and neuroimaging methods for assessing peripheral and central auditory function will be discussed. Acquired and developmental disorders of auditory function will be reviewed using clinical case studies.
Pre requisite(s): AS.080.305 OR AS.080.203 OR AS.050.203 OR AS.200.141 OR AS.020.312 or instructor permission.
Area: Natural 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. 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. Experience with at least one programming language is strongly recommended.
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/)