AS.050 (COGNITIVE SCIENCE)

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.

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 reciprocal 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.

AS.050.116. Visual Cognition. 3 Credits.
How do humans make sense of the visual world around them? This course will provide an introductory overview of current research, methods, and theories in visual cognition. We will draw upon topics in cognitive psychology, cognitive neuroscience, cognitive neuropsychology, and artificial intelligence.

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.

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 augment this course. It is highly recommended that students with less extensive computational and mathematical experience register for this lab.

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 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.

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.

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.

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

AS.050.223. 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.

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 or human language in neuro-typical and impaired individuals.
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.
Area: Writing Intensive
AS.050.102 OR AS.050.105 OR AS.050.203 OR AS.080.203

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).
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.

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.
AS.050.107 OR AS.050.102 or AS.050.240 or instructor's permission.

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.
AS.050.102 OR AS.050.240 or equivalent/see instructor.

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.

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: 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.
AS.050.101 OR AS.050.339 OR AS.200.132 OR AS.050.105 OR Instructor's Permission.

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.
AS.050.102 OR AS.050.240 OR AS.050.317 OR AS.050.320 OR AS.050.325 or instructor's permission.

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.

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.
(AS.050.240 OR AS.050.320 OR AS.050.325) AND (AS.050.102 OR AS.050.206)
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. (AS.050.240 OR AS.050.320 OR AS.050.325) AND (AS.050.348 OR AS.050.102 OR AS.050.206)

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 human-like 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.050.353. Applying Cognitive Neuroscience to Artificial Intelligence Part II. 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.

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.

AS.050.102 OR AS.050.320 OR AS.050.325 or instructor permission.

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. (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.

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.

Prerequisite(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).
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.
AS.050.102 OR AS.050.202

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.

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 (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.
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.

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).
AS.110.106 OR AS.110.108

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.
AS.050.203 OR AS.080.203 OR AS.050.202 or equivalent.

AS.050.500. Practicum in Language Disorders- Community Based Learning. 2 Credits.
This course provides the opportunity to learn about adult aphasias, 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.
A- or Better in AS.050.105 OR AS.050.203 OR AS.080.203 OR AS.050.311 or instructor’s permission. You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.050.503. Research in Cognitive Science/Sophomores. 1 - 3 Credits.

AS.050.504. Research Cognitive Science-Freshmen. 1 - 3 Credits.
Permission Required. You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

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

AS.050.506. Readings Cognitive Science-Sophomores. 1 - 3 Credits.
Permission Required. You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.050.507. Research in Cognitive Science/Sophomores. 1 - 3 Credits.

AS.050.508. Research Cognitive Science - Sophomores. 1 - 3 Credits.
Permission Required. You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > 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/. AS.990.500


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. 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.

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 lexical representations of meaning.

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.050.625. 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.

**AS.050.626. Foundations of Cognitive Science.**
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: Writing Intensive

**AS.050.632. Developmental Cognitive Neuroscience.**
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.**
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 or human language in neuro-typical and impaired individuals. Also listed as AS.050.236.

**AS.050.639. Cognitive Development.**
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.

**AS.050.649. Second Language Acquisition.**
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.050.653. Applying Cognitive Neuroscience to Artificial Intelligence Part II.**
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.
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 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.

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, 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).

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

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.

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.