PROGRAM IN SYMBOLIC SYSTEMS

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Consulting Faculty: Mary Dalrymple (Linguistics), Jerry Hobbs (Linguistics), Bernardo Huberman (Applied Physics), Ronald Kaplan (Linguistics), John R. Koza (Medicine, Electrical Engineering), Patrick Langley

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Computer systems, robots, and people are all examples of symbolic systems, agents that use language to represent the world around them so as to communicate and generally act intelligently. The notions of symbol, representation, information, and action are at the heart of the study of symbolic systems. This common core of notions arises in a variety of fields including artificial intelligence, computer science, cognitive psychology, linguistics, philosophy, and symbolic logic. In recent decades, though, a new discipline has begun to emerge from research collaborations across these traditional disciplines, addressing questions such as: In what ways are computers and computer languages like humans and their languages? How can the interaction between humans and computers be made easier and more productive? What would it take to build a computer that thinks?

The Symbolic Systems Program (SSP) offers an opportunity to focus on these issues. Majors take courses in the departments of Computer Science, Linguistics, Philosophy, and Psychology, as well as courses designed specifically for the program. The goal is to prepare students with the vocabulary, theoretical background, and technical skills to understand and participate in contemporary interdisciplinary research into questions about language, information, and intelligence, both human and machine. The curriculum offers traditional humanistic approaches to these questions as well as training in contemporary developments in the science and technology of computation.

A degree in Symbolic Systems prepares students for advanced training in the interdisciplinary study of language and information, or for postgraduate study in any of the contributing disciplines. It is also excellent preparation for employment immediately after graduation.

UNDERGRADUATE PROGRAMS

BACHELOR OF SCIENCE

The program leads to a B.S. in Symbolic Systems. The curriculum provides students with a core of concepts and techniques from computer science, linguistics, logic, philosophy, and cognitive psychology, drawing on faculty and courses from various departments.

Symbolic Systems majors must complete a core of required courses plus a concentration consisting of five additional courses. All major courses are to be taken for letter grades unless an approved course is offered satisfactory/no credit only. The core requirements are:

1. Cognition:
   a) Psychology 40, Introduction to Cognitive Psychology
   b) One Psychology course from: 30, Introduction to Perception; 50, Introduction to Human Neuropsychology; 131, Language and Thought; 132, Language Processing; 141, Cognitive Development

2. Computation and Artificial Intelligence:
   a) Computer Science 103B, Discrete Structures, *or* Computer Science 103X, Discrete Structures (Accelerated)
   b) Computer Science 106B, Programming Abstractions, *or* 106X, Programming Methodology and Abstractions
   c) Computer Science 121, Introduction to Artificial Intelligence, *or*
      221 Artificial Intelligence: Principles and Techniques

3. Philosophical Foundations:
   a) Philosophy 80, Mind, Matter, and Meaning
   b) One Philosophy course from: 181, Philosophy of Language; 184, Theory of Knowledge; 186, Philosophy of Mind; 189 Philosophical Applications of Cognitive Science

4. Language:
   a) Linguistics 120, Introduction to Syntax
   b) Linguistics 130A, Introduction to Linguistics Meaning, *or* 130B, Introduction to Lexical Semantics, *or* 230A, Introduction to Semantics and Pragmatics

5. Logic:
   a) Philosophy 160A, First Order Logic
   b) Philosophy 160B, Computability and Logic; *or* Computer Science 154, Introduction to Automata and Complexity Theory

6. Mathematics: one approved course on a mathematical topic other than calculus.

7. Senior Seminar: Symbolic Systems 201 or an approved interdisciplinary seminar.

Students select concentrations from the list below *or* design others in consultation with their advisers.

Applied Logic
Artificial Intelligence
Cognition
Computer Music
Education and Learning
Human-Computer Interaction
Natural Language
Neural Systems
Philosophical Foundations
Rationality

MINORS

Students may minor in Symbolic Systems by completing either item '1' or '2' below.

1. One course in each of the specified core areas (please note that several of these courses have prerequisites):
   a) Artificial Intelligence: Computer Science 121 or 221
   b) Computer Science: Comp. Sci. 103B, or 103X
   c) Linguistics: Ling. 120, 130A or 130B
   d) Logic: Philosophy 159 or 160A, or Computer Science 154
   e) Philosophy: Phil. 80, 181, 184, 186, or 189
   f) Psychology: Psych. 30, 40, 50, 131, 132, or 141

2. Symbolic Systems 100, plus an interdisciplinary SSP concentration listed in the program booklet (available from the program office, or on the SSP Web page, http://www.stanford.edu/dept/symbol/). To qualify, the selection of courses used for the minor must be interdisciplinary, that is, it must either include courses from at least three departments, or include more than one course from each of two departments.

DIRECTED RESEARCH, SENIOR HONORS, AND COTERMINAL DEGREES

The program strongly encourages all SSP majors to gain experience in directed research by participating in faculty research or by pursuing independent study. Several avenues are offered.

1. Summer Internships: students work on SSP-related faculty research projects.
2. Independent Study: under faculty supervision, students work on independent projects. For course credit they may enroll in Symbolic Systems 196.
3. Senior Honors: under faculty supervision, students pursue extended research projects and complete a senior honors dissertation.

Contact SSP for more information on any of these options. In addition, the Undergraduate Research Opportunities office on campus offers numerous grants and scholarships supporting student research projects at all levels.

Many SSP majors also complete coterminal M.S. or A.M. degrees in affiliated departments. The Department of Philosophy offers a special Symbolic Systems track for interdisciplinary graduate level work.

COURSES

100. Introduction to Cognitive Science—The history, foundations, and accomplishments of the cognitive sciences, including presentations by leading Stanford researchers in artificial intelligence, linguistics, philosophy, and psychology. Overview of the issues addressed in the Symbolic Systems major.
4 units, Spr (Beaver)

115. Spoken Language Understanding Systems—Review of spoken language technology. Speech recognition, language modeling, and language understanding algorithms. Voice application development process. Usability issues and the design of voice user interfaces for dialog systems.
4 units, Win (Cohen)

145. Cognition and Computer Use—How complex cognitive processes (e.g., learning, spatial reasoning, problem solving, and language) inform the design of systems and interfaces for scientific, educational, and commercial applications. Important low level "ergonomic" phenomena, e.g., perception, attention, and motor skills. Student project examines thesis issues in a real world setting of their choosing. Attention to commonly overlooked populations, e.g., the elderly, people with special cognitive needs (e.g., dyslexics), and children. Limited enrollment. Prerequisite: consent of instructor.
4 units, Win (Shrager)

CORE

30. Introduction to Perception—(Enroll in Psychology 30.)
3 units, Aut (Heeger)

40. Introduction to Cognitive Psychology—(Enroll in Psychology 40.)
4 units, Win (Spieler)

50. Introduction to Human Neuropsychology—(Enroll in Psychology 50.)
4 units, Win (Gabrieli)

80. Mind, Matter, and Meaning—(Enroll in Philosophy 80.) (WIM)
5 units, Win (Lawlor)

103B. Discrete Structures—(Enroll in Computer Science 103B.)
3 units, Win, Spr (Johnson)

103X. Discrete Structures (Accelerated)—(Enroll in Computer Science 103X.)
4 units, Win (Dill, Mitchell)

106B. Programming Abstractions—(Enroll in Computer Science 106B.)
5 units, Aut (Staff)
Win (Plummer)
Spr (Zelenski)

106X. Programming Methodology and Abstractions (Accelerated)—(Enroll in Computer Science 106X.)
5 units, Aut (Staff)
Win (Plummer)
Spr (Zelenski)

120. Introduction to Syntax—(Enroll in Linguistics 120.)
4 units, Aut (Sag, Sells)

121. Introduction to Artificial Intelligence—(Enroll in Computer Science 121.)
3 units, Win (Manning)

130A. Introduction to Linguistic Meaning
4 units (Staff) not given 2000-01

130B. Introduction to Lexical Semantics—(Enroll in Linguistics 130B.)
4 units, Win (Levin)

131. Language and Thought—(Enroll in Psychology 131.)
4 units, Aut (Clark)

132. Language Processing—(Enroll in Psychology 132.)
4 units, Win (Griffin)

141. Cognitive Development—(Enroll in Psychology 141.)
3 units, Spr (Johnson)

154. Introduction to Automata and Complexity Theory—(Enroll in Computer Science 154.)
4 units, Win (Staff)
Spr (Motwani)

160A. First-Order Logic—(Enroll in Philosophy 160A.)
4 units, Win (Mints)

160B. Computability and Logic—(Enroll in Philosophy 160B.)
4 units Spr (Mints)

181. Philosophy of Language—(Enroll in Philosophy 181.)
4 units, Win (Crimmins)

184. Theory of Knowledge—(Enroll in Philosophy 184.)
4 units, Spr (Lawlor)

186. Philosophy of Mind—(Enroll in Philosophy 186.)
4 units, Win (Maguire)

201. Senior Seminar—Core seminar for program majors. Integrates themes from core course work with contemporary cross-disciplinary research in learning, computation, and formal systems.
2 units, Spr (Davies)

221. Artificial Intelligence: Principles and Techniques—(Enroll in Computer Science 221.)
4 units, Aut (Koller)

230A. Introduction to Semantics and Pragmatics—(Enroll in Linguistics 230A.)
4 units, Win (Beaver)

RESEARCH

190. Senior Honors Tutorial—Under the supervision of the honors faculty adviser, students work on their senior honors project.
1-5 units, any quarter (Staff)

191. Senior Honors Seminar—Under the leadership of the Symbolic Systems program coordinator, students meet, discuss, and present their honors project.
2 units, Win, Spr (Davies)

196. Independent Study—Independent work under the supervision of a faculty member.
1-15 units, any quarter (Staff)

AFFILIATED DEPARTMENT OFFERINGS

Listed below are a sample of other courses, some of which can be used as part of the student's concentration (see SSP booklet), or may be of special interest to SSP majors. The list is not exhaustive. Students should consult course listings in the related departments for additional courses and information.

COMMUNICATION

169. Computers and Interfaces: Psychological and Social Issues
5 units, Win (Nass)

172/272. Psychological Processing
5 units (Reeves) not given 2000-01

COMPUTER SCIENCE

99C. Stanford Introductory Seminar: Computers—Fact and Fiction
3 units (Koller) not given 2000-01

99F. Stanford Introductory Seminar: Paradox—Bug or Feature?
3 units, Win (Pratt)

99G. Stanford Introductory Seminar: The Two Cultures—Bridging the Gap
3 units, Aut (Roberts, Saldivar)

99P. Stanford Introductory Seminar: Smart Computers and other Technological Opportunities
3 units (McCarthy) not given 2000-01

147. Introduction to Human-Computer Interaction Design
3-4 units, Aut (Winograd)

148. Introductory Computer Graphics
3 units, Aut (Staff)

193H. Human-Computer Interface Tools
3 units, Aut (Staff)

193L. Programming in LISP
3 units (McCarthy)

201. Computers, Ethics, and Social Responsibility
4 units, Win (Roberts)

224N. Natural Language Processing
3 units, Spr (Manning)

228. Probabilistic Models in Artificial Intelligence
3 units, Win (Koller)

229. Statistical Learning
3 units, Win (Bregler)

247A. Human-Computer Interaction: Interaction Design Studio
3-4 units, Aut, Win, Spr (Staff)

247B. Contextual and Organizational Issues in Human-Computer Interaction
3-4 units, Spr (Hinds)

323. Common Sense Reasoning in Logic
3 units, Aut (McCarthy)

377. Topics in Human-Computer Interaction
3-4 units, Aut, Win, Spr

378. Phenomenological Foundations of Cognition, Language, and Computation
3-4 units, Win (Winograd)

426. Genetic Algorithms and Genetic Programming
3 units, Spr (Koza)

547. Human-Computer Interaction Seminar
1 unit, Aut, Win, Spr (Winograd)

EDUCATION

106. Interactive Media in Education
3-5 units, Sum (Walker)

224. Information Technology in the Classroom
3 units, Win (Walker)

295. Learning and Cognition in Activity
3 units, Spr (Greeno)

LINGUISTICS

17Q. Stanford Introductory Seminar: Slips of the Tongue
3 units, Win (Zwicky)

44N. Stanford Introductory Seminar: Living with Two Languages
3 units, Spr (E. Clark)

105. Phonetics
4 units, Win (Reetz)

110. Introduction to Phonetics and Phonology
4 units, Spr (Leben)

124. Introduction to Formal Universal Grammer
4 units, Aut (Bresnan)

138. Introduction to Computational Linguistics
4 units, Aut (Kay)

140. Language Acquisition I
4 units, Aut (E. Clark)

221A. Foundations of English Grammar
4 units, Win (Sag)

237. Natural Language Processing
4 units (Manning)

240. Language Acquisition I
4 units, Aut (E. Clark)

PHILOSOPHY

12N. Stanford Introductory Seminar: Gödel's Theorem, Minds, and Machines
3 units, Aut (Feferman)

14N. Stanford Introductory Seminar: Time and Meaning
3 units, Win (Strevens)

159. Basic Concepts in Mathematical Logic
4 units, Aut (Barker-Plummer)

162. Philosophy of Mathematics
4 units, Win (Feferman)

164. Central Topics in the Philosophy of Science: Theory and Evidence
4 units, Aut (Strevens)

169. Intensional Logic
4 units, Spr (van Benthem)

194C. Self-Deception
4 units, Win (Lawlor)

PSYCHOLOGY

6N. Stanford Introductory Seminar: Remembering and Misre-membering
3 units, Win (Tversky)

15Q. Stanford Introductory Seminar: Mind—A Historical View
3 units, Aut (Hastorf)

20. Introduction to Brain and Behavior
3 units, Aut (R. Fernald)

112. Research Methods in Cognitive Psychology
5 units, Aut (Spieler)

134. Seminar on Language and Deception
3 units, Win (H. Clark)

205. Foundations of Cognition
1-3 units, Aut (Tenenbaum)

219. Graduate Seminar on Selected Topics in Cognition
1-3 units, Aut (Tversky)

221. Applied Vision and Image Systems
1-3 units, Win (Wandell)

227. Semniar on Language Processing
3 units, Spr (Griffin)