

Cognitive Science

College of Arts and Sciences Bloomington

Director

Robert L. Goldstone* (Psychological and Brain Sciences)

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Graduate Faculty

(An asterisk [*] denotes membership in the University Graduate School faculty with the endorsement to direct doctoral dissertations.)

Chancellor's Professors

Robert L. Goldstone* (Psychological and Brain Sciences), David B. Pisoni* (Psychological and Brain Sciences), Linda Smith* (Psychological and Brain Sciences)

Chancellor's Professor and Distinguished Professor Psychological and Brain Sciences

Robert Nosofsky*

College Professor and Distinguished Professor of Cognitive Science and Computer Science

Douglas Hofstadter* (Informatics)

Distinguished Professor of Biology and Gender Studies

Ellen D. Ketterson*

Distinguished Professor and Luther Dana Waterman Professor of Psychological and Brain Sciences

Richard M. Shiffrin*

Distinguished Scholar of Psychological and Brain Sciences

William Estes

Oscar R. Ewing Professor of Philosophy

J. Michael Dunn (Emeritus)

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Barbara Jacobs Chair in Education

Thomas M. Duffy*

Rudy Professors

Bennett Bertenthal* (Psychological and Brain Sciences), James T. Townsend* (Psychological and Brain Sciences), Stanley Waserman* (Psychological and Brain Sciences, Sociology, Statistics)

Professors

Colin Allen* (History and Philosophy of Science), Sasha Barab* (Education), Kathleen Bardovi-Harlig* (Second Language Studies), Randall Beer* (Computer Science, Informatics), Geoffrey Bingham* (Psychological and Brain Sciences), Katy Börner* (Information Science), Jerome Busemeyer* (Psychological and Brain Sciences), Thomas Busey* (Psychological and Brain Sciences), Phil Connell* (Speech and Hearing Sciences, Linguistics), Steven Franks* (Linguistics, Slavic Languages and Literature), Judith Gierut* (Speech and Hearing Sciences), Andrew Hanson* (Informatics), Diane Kewley-Port* (Speech and Hearing Sciences), John Kruschke* (Psychological and Brain Sciences), Annie Lang* (Telecommunications), David Leake* (Computer Science), Richard Lesh* (Education), Lawrence Moss* (Mathematics), Timothy O'Connor* (Philosophy), Jonathan Plucker* (Educational Psychology), Robert Port* (Emeritus, Linguistics, Computer Science), Yvonne Rogers* (Library and Information Sciences, Informatics), Kathy Schick* (Anthropology), Martin Siegel* (Education), Elliot R. Smith* (Psychological and Brain Sciences), Olaf Sporns* (Psychological and Brain Sciences, Neuroscience), Erik Stolterman* (Informatics), William Timberlake* (Psychological and Brain Sciences), Peter Todd* (Cognitive Sciences, Informatics), Nicholas Toth* (Anthropology), Michael W. Trosset* (Statistics), Larry Yaeger* (Informatics)

Associate Professors

Rowan Candy* (Optometry), Kenneth de Jong* (Linguistics), Hamid Ekbia (Library and Information Science, Cognitive Science), Julia Fox* (Telecommunications), Michael Gasser* (Computer Science, Cognitive Science), Lisa Gershkoff-Stowe* (Speech and Hearing Sciences), Jason Gold* (Psychological and Brain Sciences), Eric Isaacson* (Music), Jennifer Lentz* (Speech and Hearing Sciences), Jonathan W. Mills* (Computer Science), John Paolillo* (Library and Information Science), Luiz Pessoa* (Psychological and Brain Sciences), Luis Rocha* (Informatics), Matthias Scheutz* (Cognitive Sciences, Computer Science, Informatics), Jonathan Weinberg* (Philosophy)

Assistant Professors

John M. Beggs* (Physics), Joshua W. Brown* (Psychological and Brain Sciences), Isabelle Darcy (Second Language Studies), Markus Dickinson* (Linguistics) Melissa Gresalfi (Counseling and Educational Psychology), Amit Hagar* (History and Philoso-

phy of Science), Karin Harman James* (Psychological & Brain Sciences), Thomas W. James* (Psychological and Brain Sciences), Michael Jones* (Cognitive Sciences, Psychological and Brain Sciences), Sandra Kuebler* (Linguistics), Sharlene Newman* (Psychological and Brain Sciences), Nicholas Port* (Optometry), Robert Joseph Rydell* (Psychological & Brain Sciences), Chen Yu* (Psychological and Brain Sciences)

Associate Faculty

Arthur F. Bentley Professor

Elinor Ostrom* (Political Science, Public and Environmental Affairs)

Barbara Jacobs Chair in Education

Donald J. Cunningham* (Emeritus)

Chancellor's Professors

James C. Craig* (Psychological and Brain Sciences), Daniel Dinnsen* (Linguistics), Steven Sherman* (Psychological and Brain Sciences)

Chancellor's Professor of Economics and Henry H. H. Remak Professor of West European Studies

Roy Gardner*

John F. Mee Chair of Management

Phillip Podsakoff*

Martha Lea and Bill Armstrong Chair in Teacher Education

Frank K. Lester* (Emeritus)

Robert A. Lucas Chair of Law

Jeffrey Evans Stake*

Rudy Professor

George von Furstenberg* (Emeritus, Economics)

Tanis Chair of History and Philosophy of Science

Elisabeth Lloyd*

Professors

Joyce Alexander* (Education), Curtis Bonk* (Education), Arthur Bradley* (Optometry), J. Clancy Clements* (Linguistics, Spanish and Portuguese), William Corsaro* (Sociology), Ivor K. Davies* (Emeritus, Instructional Systems Technology), Stuart Davis* (Linguistics), Joseph Farley* (Psychological and Brain Sciences), Daniel Friedman* (Computer Science), Preston Garraghty* (Psychological and Brain Sciences), Jeffrey Hart* (Political Science), Beverly Hartford* (Emeritus, Linguistics), Julia Heiman* (Psychological and Brain Sciences), Ed Hirt* (Psychological and Brain Sciences), Marianne Kielian-Gilbert* (Music), Eugene Kintgen* (Emeritus, English), David MacKay* (Emeritus, Business, Geography), Daniel Maki* (Emeritus, Mathematics), Emilia Martins* (Biology), David McCarty* (Philosophy), Eugene McGregor Jr.* (Public and Environmental Affairs, Political Science), Michael McRobbie* (Computer Science, Informatics, Philosophy), Laura Murray* (Speech and Hearing Sciences), Christopher Peebles* (Anthropology), Philip Podsakoff* (Busi-

ness), Paul Purdom* (Computer Science), Charles Reigeluth* (Education), Thomas Schwen* (Emeritus, Education), Robert Sherwood* (Education), Maynard Thompson* (Emeritus, Mathematics), Larry Thibos* (Optometry), Frederick Unverzagt (Medical and Molecular Genetics, Medical Neurobiology), Dirk Van Gucht* (Computer Science), Alessandro Vespignani* (Informatics, Physics, Statistics), James Walker* (Economics), Charles Watson* (Emeritus, Speech and Hearing Sciences, Psychological and Brain Sciences), Arlington Williams II* (Economics), Wayne Winston* (Business)

Associate Professors

Julie Anderson (Speech & Hearing Sciences), Raquel Anderson* (Speech and Hearing Sciences), Eli Blevis* (Informatics), Tom Evans* (Geography), Theodore Frick* (Education), Dennis Groth* (Informatics), Daniel Hickey* (Education), Yoshihisa Kitagawa* (Linguistics), Filippo Menczer* (Computer Science, Informatics), Robert F. Potter* (Telecommunications), Gregory Rawlins* (Computer Science), Dennis Senchuk* (Philosophy, Education), Bruce Solomon* (Mathematics), Frances Trix (Anthropology, Linguistics)

Assistant Professors

Theresa Burnett (Speech and Hearing Sciences), Amy Hackenberg (Mathematics Education), Laura Hurley* (Biology), Kalpana Shankar* (Informatics), David Stringer (Second Language Studies)

Associate Scientists

Erick Janssen* (The Kinsey Institute, Psychological and Brain Sciences), Gary Kidd* (Speech and Hearing Sciences)

Senior Lecturer

Leah Savion (Philosophy)

Graduate Advisor

Associate Professor Michael Gasser*, Computer Science, Lindley Hall 230H, (812) 855-7078

Degrees Offered

Doctor of Philosophy and Joint Doctor of Philosophy in Cognitive Science and Another Discipline

Program Information

The Cognitive Science Program comprises an interdisciplinary research program and a doctoral degree program. Students carry out intensive research projects in state-of-the-art computer-based laboratories. There are two Ph.D. degree options: a standalone Ph.D. in Cognitive Science and a joint Ph.D. in Cognitive Science and another discipline; for example, psychology, computer science, philosophy, linguistics, or speech and hearing sciences. The program is designed to train students in theory development and model building (mathematical, formal, and computer simulation models), in empirical research, and in the development of the conceptual framework and tech-

nical skills for successful careers in research, teaching, business, and government.

Doctor of Philosophy Degree

Admission Requirements

Admission is by approval of the program's graduate admission committee. Applicants should have an undergraduate major in Cognitive Science, Psychology, Computer Science, Philosophy, Linguistics, Biology, or Anthropology; basic computer programming skills; and basic knowledge of mathematics for science, including calculus and statistics. In exceptional cases, the programming or mathematics admission requirements may be waived and satisfied while pursuing graduate study.

Course Requirements

A minimum of 90 credit hours, including the core courses COGS Q520 (3 cr.), COGS Q530 (3 cr.), COGS Q540 (3 cr.), COGS Q550 (3 cr.), COGS Q551 (3 cr.), and COGS Q560 (3 cr.) and selections totaling at least 16 credit hours from offerings listed in the Program in Cognitive Science or cross-listed with other departments, divisions, or programs. A maximum of 6 of these 16 credit hours may come from pure research courses (COGS Q799, COGS Q899, or the equivalent in another department). On the basis of their undergraduate background, students may be exempted from one or more of the core courses other than COGS Q540, which all students must take. Exemption from any core courses requires approval by the director of graduate studies of the program. Students must also register for at least four semesters in the Colloquium Series course COGS Q733. In one of these semesters, the only one for which credit is received, each student will be expected to give a lecture on his or her independent research as a part of the Colloquium Series.

Research Project Requirement

All Cognitive Science stand-alone Ph.D. students are required to complete the Research Project requirement. The project should constitute significant original research done while the student is enrolled in the Ph.D. program. Beginning Fall 2007, all new Ph.D. students must decide on a supervisor and topic for their projects by the end of their first year and submit the Research Project Progress Report to the Cognitive Science Program office. The project must be completed by the end of their second year; at this time they should submit the Completion of the Research Project Form.

Content Specialization

Each student will select a Content Specialization, an area of study that can be approached from the perspectives of the different disciplines within cognitive science. The list of available Content Specializations currently includes Language and Speech, Modeling, Dynamical Systems, Logic, and Human-Computer Interaction, but with the approval of the student's advisory/research committee, any relevant area of cognitive science may fulfill the Content Specialization requirement. Students must complete at least five courses in their specialization, and these courses must be taken in at least two different departments. The Content Specialization should normally

be selected by the end of the student's second year in the program, and the courses selected must be approved by the student's advisory/research committee.

Minor Requirement

Students must complete a minor in another department or program. Courses counting toward the minor may also count toward the student's Content Specialization. The minor should normally be completed by the beginning of the student's fourth year.

Qualifying Examination

Each student is expected to pass a Qualifying Examination, normally by the first semester of the student's third year in the program. If the student fails the exam, it may be retaken once, by the end of the student's third year.

Prior to the qualifying examination, each student will be expected to turn in a Qualifying Examination Petition Form with the signatures of the Director of Graduate Studies and Advisory Committee.

The examination is expected to have a written and an oral component and to demonstrate (1) in-depth knowledge of the student's Content Specialization, (2) knowledge of some other area of Cognitive Science, (3) academic writing competence, and (4) the ability to defend a position in an oral setting.

In consultation with his or her Advisory Committee, the student will agree on the format of the examination. Within these constraints, two broad categories of Qualifying Examinations are possible: (1) Conventional Written Examination or (2) Papers. Details regarding these categories are available from the Director of Graduate Studies, the Graduate Secretary, or his or her Advisory Committee.

Joint Doctor of Philosophy Degree in Cognitive Science and Another Discipline

Admission Requirements

Acceptance into the Joint Cognitive Science Ph.D. program is contingent upon admission into another degree-granting program at Indiana University Bloomington, hereafter referred to as the "originating discipline" or "originating department." Students must apply to the originating department, informing it that they also intend to join the Joint Cognitive Science Ph.D. Program. Students are required to make such a request prior to their qualification exams. There is no separate admission process through the Cognitive Science Program.

Course Requirements

A minimum of 90 credit hours, of which 32 credit hours must be in courses listed or cross-listed in cognitive science, including COGS Q520 (3 cr.), COGS Q530 (3 cr.), COGS Q540 (3 cr.), COGS Q550 (3 cr.), COGS Q551 (3 cr.), COGS Q733: three semesters at 0 credits and one semester at 1 credit when the required colloquium is given by the student, and at least 6 credit

hours of breadth coursework not in the originating discipline and not among the Q-courses or pure research courses such as Q799 and Q899. A Q-course that is not cross-listed in any other unit may satisfy the breadth requirement with the approval of the student's advisory committee. The 32 credit hours may include a maximum of 6 credit hours in pure research courses (COGS Q799, COGS Q899, or the equivalent in originating departments). Strong encouragement is given to interdisciplinary diversification. Note that courses may count toward the requirements of both cognitive science and the originating department.

Tool-Skills Requirement

Statistics PSY K300 or PSY K310 or the equivalent.

Qualifying Examination

There are two options for the qualifying examination: (a) an examination in the originating discipline and a separate comprehensive examination in cognitive science (these may be taken at separate times); or (b) a joint examination covering relevant areas of both the originating discipline and cognitive science, as determined by the advisory committee and with permission of both the originating discipline and the Cognitive Science Program. The cognitive science examination is normally taken after completion of the cognitive science course requirements. The examination may be repeated only once.

Public Colloquium

The student must give a colloquium as part of the COGS Q733 colloquium series advertised at large to the university community, and covering some aspect of the student's research in cognitive science. The research covered may be from any stage of the student's career, including (but not restricted to) the thesis research.

Final Examination

The public and oral defense of the dissertation will be conducted jointly with the student's originating discipline.

Ph.D. Minor in Cognitive Science

Graduate students obtaining a Ph.D. in another discipline may find that that discipline gives them the option of taking a minor in cognitive science. To obtain such a minor, students must satisfy the following requirements: (a) obtain approval from the Cognitive Science Program; and (b) complete COGS Q540; one of the following: COGS Q530, COGS Q560, or COGS Q550; at least two semesters of COGS Q733; and at least 6 other credit hours in cognitive science and/or cross-listed courses not in the originating discipline.

Certificates in Cognitive Science

The Cognitive Science Program is extremely broad, ranging from psychology to business to anthropology to computer science, to name just a few. Students in other disciplines may elect to focus on an area or areas within the broad range of cognitive science. Certificates are open to students upon

request; several different cognitive science certificate programs are described in the following pages. Note that certificates are not required for a joint Ph.D. degree. The student will inform the cognitive science office, the student's cognitive science advisor, and the certificate director of intent to pursue a certificate.

General Requirements for Graduate Area Certificates

1. As soon as the student decides to pursue a certificate, a written proposal must be submitted to the Certificate Director and Director of Graduate Studies giving a detailed course of study. The proposal may be a revised draft of an earlier proposal not approved or an alteration of a previously approved proposal, and may contain a request for a revision of any of the stated requirements.
2. The proposal must be approved by the student's Advisory Committee. The student must file a copy of the approved proposal with the Cognitive Science Program office.
3. The student's advisory/research committee must attest that the approved course of study has been completed successfully. At this time, the University Graduate School will be notified of the certificate completion. Ideally, requirements and course work for certificates should be completed at the time of nomination to candidacy.
4. The certificate is awarded upon completion of requirements 1 through 3 and completion of the joint Ph.D. Achievement of the certificate will be noted on official transcripts.

Graduate Area Certificate in Dynamical Systems in Cognitive Science

Students will develop an understanding of problems introduced by a dynamical perspective on cognitive phenomena and of the theoretical and methodological means of addressing those problems as found in dynamical systems. Each student will apply this understanding and analysis to a content area of their choice including study of perception, cognition, motor behavior, neural networks, language, and development.

Specific Requirements

1. Prerequisites. Students should have taken courses in calculus (two to three semesters) at the very least. In addition, courses in differential equations, linear algebra, and (point set) topology would be helpful.
2. Required course. Students must take COGS Q580 Introduction to Dynamical Systems in Cognitive Science.
3. Additional advanced electives. Students must complete an additional four courses selected from among the following: COGS Q550 Models in Cognitive Science; PSY P651 Perception/Action; HPSC X755 Philosophical Issues in Chaos and Nonlinear Dynamics; LING L541 Phonetics; LING L641 Advanced Phonetics; PHIL P561 Philosophy of Mind; CSCI B551 Element of Artificial Intelligence; CSCI B552 Knowledge-Based Computation; CSCI B553 Biomorph Computation; CSCI B651 Natural Language Processing; CSCI

B652 Computer Models of Symbolic Learning; CSCI B657 Computer Vision; CSCI B659 Topics in Artificial Intelligence; PSY P717 Evolutionary Basis of Learning; PSY P615 Developmental Psychology; COGS Q750 Neural Networks as Models of Cognition; HPSC-X755 Fractals.

4. Qualifying exams. At least one question on dynamical systems must be included on the student's qualifying exams.
5. Dissertation. The student's dissertation must include application of dynamical systems to the specific problem under study.

Graduate Area Certificate in Human-Computer Interaction

Students will demonstrate proficiency in a broad range of courses involving the applied cognitive analysis of human-computer interaction (HCI). The program will emphasize the theoretical and methodological issues associated with designing and evaluating cognitively compatible user interfaces to interactive technologies.

Specific Requirements

1. The student must submit a written proposal to the Advisory Committee giving a detailed course of study. The proposal may be a revised draft of an earlier proposal, or an alteration of a previously approved proposal, and may contain a request for a revision of any of the stated requirements. The proposal must be approved by the Advisory Committee.
2. Students for the Cognitive Science Certificate must complete an additional four courses selected from among the following to ensure courses are taken from at least two departments other than the student's home department:

CSCI A546 User Interface Programming

CSCI B581 Advanced Computer Graphics

CSCI B582 Image Synthesis

CSCI B665/B666 Software Engineering Management/Implementation

CSCI B669 Topics in Database and Information Systems

CSCI B689 Topics in Graphics and Human Computer Interaction

INFO I502 Prototyping

INFO I590 Pervasive and Ubiquitous Computing

INFO I590 HCI Design I

INFO I590 HCI Usability

SLIS S561 User Interface Design for Information Systems

SLIS S637 Information Visualization

S661 Concepts and Contemporary Issues in Human-Computer Interaction

S635 Ontologies

SLIS S566 Digital Libraries

EDUC P544 Applied Cognition and Learning Strategies

CSCI P565-566 Software Engineering I-II

EDUC R685 Human-Computer Interface Design

EDUC P600 Topical Seminar in Learning Cognition and Instruction

EDUC P544 Applied Cognition and Learning Strategies

SPHS S522 Digital Signal Processing

BUS S601 MIS Research Topics in Applications Systems Design

BUS S602 MIS Research Topics in Administration and Technology

TEL T571 Applied Emotional and Cognitive Psychology Theory

TEL T602 Seminar in Processes and Effects: The Information Processing of Media

3. The student's dissertation must address issues related to human-computer interaction. The Cognitive Science Certificate in HCI is awarded upon completion of the above requirements and completion of the requirements for the Ph.D. (either as a joint major in Cognitive Science and a home department, or as a Cognitive Science minor and a major in a home department).

Graduate Area Certificate in Language and Speech

Students will demonstrate proficiency in a broad range of topics that focus on issues related to language and speech. The program of study will emphasize mastery of language structure, language processing, and computational approaches to linguistic analysis. An independent research project exploring some facet of language and speech will be required.

Specific Requirements

1. Students must complete at least five approved graduate courses in the area of language and speech.
2. Courses in language and speech must be taken in at least two different departments.
3. Courses must include at least one dealing with language structure and at least one dealing with language processing or acquisition. Courses in language structure include most linguistics courses, PHIL-P 520, and PHIL-P 720. Courses in processing and acquisition include PSY P623, CSCI B651, and periodic seminars on language-related topics in these departments.
4. Students must demonstrate familiarity with computer modeling of cognitive processes. This requirement can be met through course work (COGS Q580, PSY P556, or various courses in Computer Science including CSCI B551, CSCI B552, CSCI B553, CSCI B651, and CSCI B652) or through a written report of research that includes a computer program written by the student. This report could be a master's or Ph.D. thesis.
5. The student's cognitive science qualifying examination must include at least one section on a topic in language and speech.
6. The student's dissertation must address issues related to language and speech.

Graduate Area Certificate in Logic, Language, and Computation

The area covered by this certificate is applied logic; i.e., logic as applied to information processing. It is an area of research that is of increasing importance in artificial intelligence and computer science. Students will demonstrate their mastery of courses

having to do with symbolic information processing.

Specific Requirements

The requirements include at least 18 credit hours of course work (including research and seminars). At least two courses must be taken outside the student's home department. Each proposal for certification would need to demonstrate both breadth and depth in the general area of logic, language, and computation.

1. Prerequisites. Students should demonstrate mathematical maturity by having taken one or more courses in the following: set theory, discrete mathematics, abstract algebra, linear algebra, topology, and mathematical logic.
2. Students must take PHIL P505 and PHIL P506 Logical Theory I-II or demonstrate equivalent knowledge of completeness for first-order logic, together with the Gödel incompleteness and undecidability results. If students demonstrate knowledge of this material, they may take other courses from the lists of advanced courses given below.
3. Students must select at least two or more advanced courses from a list that includes CSCI B501 Theory of Computing; PHIL P550 Systems of Modal Logic; PHIL P551 Philosophy and the Foundations of Mathematics; PHIL P552 Philosophy of Logic; LING L626 Semantics of Natural Language; LING L640 Quantitative Linguistics; MATH M682 Model Theory; and MATH M583 Set Theory.
4. Students must take a research seminar, either one generally designated as such. Some examples: PHIL P750 Seminar Logic, PHIL P751 Seminar Logic, or MATH M781-782 Selected Topics in Mathematical Logic, or another seminar approved by the Logic Certificate Director.
5. Students will be expected to take active part in the weekly Logic Seminar.
6. The student's dissertation must address issues in the general area of logic, language, and computation.

Graduate Area Certificate in Modeling in Cognitive Science

Students will demonstrate their mastery with a broad selection of courses involving mathematical and computer simulation approaches to modeling, with a specialization in at least one area of modeling, and with a research project involving modeling. The program will emphasize both basic techniques and applications in particular content areas.

Specific Requirements

1. Students must fulfill 18 credit hours of courses in the modeling area. Required course: COGS Q550 Models in Cognitive Science, and at least five additional courses in modeling (15 credits minimum).
2. These courses must demonstrate both breadth and specialization, and a grasp of both methods and applications. The course options given below provide examples of courses currently appropriate to accomplish these goals.

The courses should include at least one course in basic techniques and methods (PSY P605 Introduction to Mathematical Psychology; COGS Q580 Introduction to Dynamic

Systems in Cognitive Science; MATH M447-MATH M448 Mathematical Models and Applications; PHIL P550 Systems of Modal Logic); and at least one course in applications (COGS Q750 Neural Networks as Models of Cognition; CSCI B651 Natural Language Processing; CSCI B652 Computer Models of Symbolic Learning; LING L611 Models of Linguistic Structure; PSY P648 Choice Behavior).

The selected courses must be taken from at least two departments, excluding courses listed only in the Cognitive Science Program. These courses may not include a course whose content consists almost entirely of a research project (such courses and projects are separately covered below).

3. Students must demonstrate a grasp of modeling in research, either through course work (COGS Q689 Computer Simulation Project; PSY P556 Independent Computer Project), or through a written report of research involving modeling (includes master's or Ph.D. projects).
4. The Ph.D. qualifying examination in the Cognitive Science Program must contain at least one section on a modeling-related topic.

Cognitive Science Graduate Courses

COGS G901 Advanced Research (6 cr.)

COGS Q520 Mathematics and Logic for Cognitive Science

(3 cr.) Covers the mathematical backgrounds of contemporary work in cognitive science. Includes basic material on both the symbolic and connectionist approaches: machines, logics, networks, games, and probability.

COGS Q530 Programming Methods in Cognitive Science (3 cr.)

P: Some programming experience. An introduction to computer programming methods for artificial intelligence and computer simulation of cognitive models. Emphasis on the necessary data structures and their applications to cognitive science. Programming projects may be related to state-space search for problem solving and game playing, production systems, and cognitive modeling tasks including memory models and neural simulations.

COGS Q540 Philosophical Foundations of the Cognitive and Information Sciences (3 cr.)

Causal issues: cognitive architecture, physical embodiment, neuroscience, networks, dynamic systems. Semantic issues: meaning, interpretation, representation, information flow. The role of both in language, logic, reasoning, action, perception, learning, categorization, and consciousness. Emphasis on writing, analysis, and exposition.

COGS Q550 Models in Cognitive Science (3 cr.) **P:** Q530 and Q560. An introduction to modeling in various areas of cognitive science, including computer simulation models of complex cognition, models within artificial intelligence, models based on neural mechanisms and networks, and formal and mathematical models in areas such as psychology, linguistics, and philosophy.

COGS Q551 The Brain and Cognition (3 cr.) An introduction to neural mechanisms underlying complex cognition, and a survey of topics in neuroscience related to cognition. It provides a solid background in human biopsychology.

COGS Q560 Experimental Methods in Cognitive Science (3 cr.) Specific goals of this course include: a) an understanding of experimental design and the resources for future studies; b) an understanding of converging measures and programmatic research; c) discussion of current controversies in experimental design; and d) hands-on experience in designing, conducting, and critiquing experiments.

COGS Q570 Behavior-Based Robotics (3 cr.) This course will present an overview of behavior-based robotics and its implications for embodied cognitive science, incorporating results from artificial intelligence, robotics, ethology, and psychology. It will give students an appreciation of the difficulties associated with implementing models on robots and allow them to tackle research questions in groups.

COGS Q580 Introduction to Dynamic Systems in Cognitive Science (3 cr.) Introduction to linear and nonlinear dynamic systems including catastrophe and chaos theory. Main aspects include: a) understanding the basic quantitative theory and techniques of dynamic systems, b) illustration of major concepts and systems behavior with the aid of computer graphics and numerical software, and c) examples from cognitive science.

COGS Q689 Computer Simulation Project (3 cr.) The student will develop and test a computer simulation of some aspect of cognition. The student will produce a working, documented computer program, and a paper describing both the workings of the program and tests of the program (either theoretical tests, tests of the program against data, or both).

COGS Q700 Seminar in Cognitive Science (3 cr.) Intensive study of specific topics in cognitive science. Topics and instructors will change regularly. May be repeated.

COGS Q733 Colloquium Series (0-1 cr.) Three semesters at zero credits and one semester at one credit when the required colloquium is given by the student. The class will meet every week. At some meetings, invited speakers will present colloquia; at others, students will present their own work. Each student will be required to make a presentation at least once during the year the course is taken for credit.

COGS Q750 Neural Networks as Models of Cognition (3 cr.) Topical seminar featuring analysis of models based on neural networks. Will usually feature extensive exploration of one or more examples of models of this type.

COGS Q799 Readings and Research in Cognitive Science (1-6 cr.) Tutorial research and study in specialized topics in cognitive science.

COGS Q899 Dissertation Research (1-12 cr.) Dissertation re-

search in specialized topics in cognitive science.

Cross-Listed Courses

The following courses may be used to satisfy the credit hour requirements of the Cognitive Science Program. Additional courses whose content in a given year is sufficiently relevant to cognitive science (including seminars, new courses, or courses with topical content) may also be used to satisfy the requirements, conditional upon acceptance by the Cognitive Science Program of a petition including justification. For an updated list of cross-listed courses, please see the Cognitive Science website.

Anthropology

ANTH L580 Semiotics and Human Ethnology (2 cr.)

ANTH L840 Ethnolinguistic Seminar (1-2 cr.)

Kelley School of Business

BUS S600 Research Design and Methods in Management Information Systems (3 cr.)

BUS S601 Management Information Systems Research: Topics in Application Systems Development (3 cr.)

BUS S602 Management Information Systems Research: Topics in Administration and Technology (3 cr.)

Computer Science

CSCI B501 Theory of Computing (3 cr.)

CSCI B502 Computational Complexity (3 cr.)

CSCI B510 Introduction to Applied Logic (3 cr.)

CSCI B521 Programming Language Principles (3 cr.)

CSCI B522 Programming Language Foundations (3 cr.)

CSCI B551 Elements of Artificial Intelligence (3 cr.)

CSCI B552 Knowledge-Based Computation (3 cr.)

CSCI B553 Biomorphic Computation (3 cr.)

CSCI B621 Advanced Concepts in Programming Languages (3 cr.)

CSCI B622 Programming Language Type Systems (3 cr.)

CSCI B651 Natural Language Processing (3 cr.)

CSCI B652 Computer Models of Symbolic Learning (3 cr.)

CSCI B657 Computer Vision (3 cr.)

CSCI B659 Topics in Artificial Intelligence (1-6 cr.)

CSCI P515 Specification and Verification (3 cr.)

Economics

ECON E626 Game Theory (3 cr.)

School of Education

EDUC H650 Theory of Knowledge and the Educational Process (3 cr.)

EDUC P530 Instructional Psychology (3 cr.)

EDUC P540 Learning and Cognition in Education (3 cr.)

EDUC P544 Applied Cognition and Learning Strategies (3 cr.)

EDUC P550 Cognition and Semiotics (3 cr.)

EDUC P591 Cognitive Assessment and Intervention (3 cr.)

EDUC P600 Topical Seminar in Learning, Cognition, and Instruction (3 cr.)

EDUC P640 Thinking and Learning in Social Contexts (3 cr.)

EDUC Q610 Science Education Curriculum (3 cr.)

EDUC R542 Instructional Graphics Design (3 cr.)
EDUC R561 Evaluation and Change in the Instructional Development Process (3 cr.)
EDUC R586 Practicum in Instructional Systems Technology (1-3 cr.)
EDUC R611 Instructional Technology Foundations (1 cr.)
EDUC R622 Learning Environments Design (3 cr.)
EDUC R630 Learner Analysis in the Instructional Technology Process (3 cr.)
EDUC R695 Topical Inquiry Seminar in Instructional Systems Technology (3 cr.)
EDUC Y530 Topics in Computer Analysis of Educational Data (1-3 cr.)

Folklore and Ethnomusicology

FOLK F714 Paradigms of Ethnomusicology (3 cr.)
FOLK F722 Colloquium in Theoretical Folklore/Ethnomusicology (3 cr.)
FOLK F738 Psychological Issues in Folklore (3 cr.)

French and Italian

FRIT F576 Introduction to French Phonology (3 cr.)
FRIT F577 Introduction to French Syntax (3 cr.)
FRIT F580 Applied French Linguistics (3 cr.)
FRIT F603-F604 History of the French Language (3 cr.)
FRIT F670 Advanced French Phonology (3 cr.)
FRIT F671 Advanced French Syntax (3 cr.)
FRIT F672 French Dialectology (3 cr.)
FRIT F673 Topics in the Learning and Teaching of French (3 cr.)
FRIT F675 Studies in French Linguistics (3 cr.)
FRIT F676 Structure and Sociolinguistics Aspects of Haitian Creole and Haitian French (3 cr.)
FRIT F677 French Lexicology and Lexicography (3 cr.)
FRIT F678 French Morphology (3 cr.)

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