Cognitive Science thrives at IU

The goal of Indiana University’s Cognitive Science Program is simple to state, but challenging to attain.

We seek an understanding of minds and other intelligent systems. This mission inherently involves interdisciplinary collaboration, and so we focus our efforts to function as a distributed network (we are not a “center” for cognitive science) of research that spans anthropology, computer science, education, information science, linguistics, neuroscience, philosophy, and psychology among many other fields.

We encourage scholarly research that contacts more than one of these fields. The interdisciplinarity of cognitive science is a strength because it fosters cross-fertilization, but also because it can provide converging constraints on a theory of mind that no field could provide by itself. Also, from a practical perspective, advances in educational reforms, automatic object recognition, user interface design, the treatment of neurologically impaired patients, machine translation, computerized speech production and recognition, real-world robotics, and information-search techniques will only be achieved by cooperation across the contributing fields of cognitive science. Approaches from single perspectives, no matter how insightful, cannot hope to meet these challenges by acting in isolation.

A final motivation for integrating the insights from many traditional disciplines is that it serves as an antidote for the increasing specialization of science and alienation of scientists. We have gone from an era when the only major scientific journals were Nature and Science to an era with specialized journals such as Journal of Contaminant Hydrology and Journal of Shoulder and Elbow Surgery, each an umbrella outlet for several distinct sub-specializations.

The image of increasingly specialized sciences has been emphatically painted by John Horgan. He argues that the age of fundamental scientific theorizing and discoveries has passed, and that all that is left to be done is refining the details of theories already laid down by the likes of Einstein, Darwin, and Newton. In contrast to this vision, many cognitive scientists have chosen to reverse this trend toward increasing specialization. They have instead pursued principles that govern any intelligent, adaptive system, whether it consists of neurons, integrated circuits, or collections of agents.

We are in good company in this enterprise. Many of the most noteworthy advances of science have involved finding deep principles shared by superficially dissimilar phenomena. Finding biological laws that govern the appearance of both snails and humans, physical laws that govern both electromagnetic and gravitational acceleration, and psychological laws that underlie transfer of learning across species and stimuli are undeniably important enterprises.

Preserving this interdisciplinary environment will be challenging. There is danger of cognitive science becoming dominated by psychology, both locally at IU as well as nationally. Monitoring the diversity of our program and the field is critical if we wish to take advantage of the synergistic potential of multiple perspectives on minds.

I would like to highlight two additional challenges. First, we need to better integrate basic research and applications, for the mutual benefit of each. Application without basic research is ad hoc and hard to translate to new situations. Basic research without application misses opportunities to become more sophisticated by considering the richness of the real world.

Second, we need to promote research that employs powerful formal methods, but formal precision is not sufficient. Formalism without substance is mere symbol-pushing (I am reminded of Saul Gorn’s quip that a formalist is somebody who can’t understand a theory unless it is meaningless). We must also promote research that challenges our thinking about thought. Cognitive science has a tradition of flouting tradition that we should continue to honor so long as it breathes new life into our field. In a nutshell, we need to find a way to keep the rigor, but not the mortis.

This is the inaugural edition of the Mind Reader newsletter. Its contents attest to the vitality of our program.

We are home to 75 faculty members (most of whom have primary appointments in other departments), 64 graduate students pursuing joint degrees, 13 graduate students pursuing stand-alone cognitive science degrees, and 36 undergraduate majors. Some of our internationally recognized specialties include: agent-environment interaction, analogy, animal behavior, artificial life, concepts and categorization, cognitive development, cognitive neuroscience, collective behavior, complex systems, language computation, dynamical systems, embodied cognition, evolution and adaptation, judgment and decision making, learning science, machine learning, mathematical and computational models of thought, robotics, social networks, and vision science.

Special interest groups affiliated with our program include Cog-X (general topics related to cognitive science), the Robotics Reading Group, Developmental Brownbag, Logic Lunch, Cognitive Lunch, the Minds and Machines series, the Mind Reader Group, the Embodied Cognition Group, and Spackle (focusing on animal cognition). We recently collaborated with (continued on page 2)
Kuebler’s research: from trees to computer programs

Assistant Professor of Linguistics Sandra Kuebler specializes in computational linguistics. An inherently interdisciplinary field of research, her field is situated between linguistics, computer science, cognitive science, information science, and psychology. Research in the specialty ranges from theory to design of applications in all areas where computers interact with natural language.

Kuebler’s research focuses on the syntactic level of linguistic description. One of her main areas of interest is syntactic parsing.

Most researchers in parsing concentrate on one specific algorithm and on the Penn Treebank, the major resource for syntactically annotated data in English. Since the Penn Treebank is based on the Wall Street Journal, more critical researchers feel that research in parsing has turned into “Wall Street Science.” Parsers are optimized to that specific type of language and the annotation scheme of the Penn Treebank. The vast differences in parser performance between different languages and annotation schemes are mostly ignored.

A more thorough investigation of these properties led not only to improved parsing algorithms but also to clearer understanding of which decisions in the annotation scheme have an influence on parsing. Since the annotation of a treebank is very costly in terms of time and labor, the design of syntactic annotation schemes has far reaching consequences, especially since there is a trend to adopt the Penn Treebank annotation scheme for different languages with only minor modifications.

German is an ideal language for this type of research since there exist three treebanks annotated in two very different schemes. Kuebler started research on comparing German treebanks.

Her research sparked an increased interest in parsing German and in comparing the two syntactic annotation schemes, culminating in the Workshop on Parsing German at the Annual Conference of the Association for Computational Linguistics in 2008, which Kuebler co-organized. Results from the workshop may lead to a complete reinterpretation of parsing results in the last decade.

Another direction in parsing that Kuebler is pursuing is dependency parsing. She is presently working on a book on the topic with Joakim Nivre and Ryan MacDonald. It will be the first in the new Synthesis Series on Human Language Technology by Morgan & Claypool. All three authors were also involved in the organization of the 2007 shared task force on multilingual dependency parsing of the Conference on Computational Language Learning.

While most of Kuebler’s research on parsing is fundamental, there are also applications that incorporate this technology. At present, Kuebler, Markus Dickinson, and Ken de Jong are collaborating with the Terre Haute-based InfraWare in a project funded by the Indiana 21st Century Research and Technology Fund. One project goal is to improve the output of an automatic speech recognizer in the medical domain by applying constraints given by the document structure and by inserting punctuation.

Kuebler also collaborates with Matthias Scheutz, director of the IU Human Robot Interaction Laboratory. Studies show that when humans encounter a robot with a speech interface, they expect the robot to be able to have full human-language understanding capabilities. This means, among other things, that the analysis of speech directed at a robot must be analyzed in real time, thus making the standard sequential natural language processing architecture impractical.

Scheutz and Kuebler are working on an architecture in which all the required natural language modules work incrementally so that partial analyses can be passed to the next level before the sentence is completely analyzed. While this may give the best results in terms of accuracy, it (continued on page 3)

Director
(continued from page 1)

several campus units on conferences as diverse as: Artificial Life, the International Conference on Development and Learning, Decisions and Games, the International Conference of the Learning Sciences, Computers and Philosophy, and the International Conference on the Teaching of Mathematical Modeling and Applications, as well as numerous smaller workshops.

Our faculty has received prestigious awards and federal grants from agencies including the National Science Foundation, National Institute of Health, National Endowment for the Humanities, Department of Education, Department of Justice, DARPA, Office of the Air Force, the McDonnell Foundation, and the MacArthur Foundation, among many others.

Our undergraduate students produce an undergraduate journal of cognitive science (http://cogs.indiana.edu/icoSci), which receives, reviews, edits, and publishes manuscripts from around the world. In 2008, we offered nine undergraduate courses and seven graduate courses, from basic courses to advanced topics such as Autonomous Robotics and Galois Theory Visualized.

All of these activities are a natural result of our inherent interest in our own minds. It may seem strange that we should spend so much effort trying to understand the very thing that we know most directly, at least according to René Descartes. However, for many of us in the Cognitive Science Program, the simultaneous familiarity and mystery of minds makes them the most prized intellectual quarry of all. We are goaded by T.S. Eliot’s exhortation: “We shall not cease from exploration and the end of all our exploring will be to arrive where we started and know the place for the first time.” — Robert Goldstone

Resources:
6. Kudos to Nubil Muhammad Mohd Kasa for coming up with our newsletter’s clever name.
Cognitive Science is ‘InPho’ a treat

Philosophers live and die by the word. So, the more than 12 million words in the online Stanford Encyclopedia of Philosophy proved a very tempting target for Professor Colin Allen, a philosopher with a background in artificial intelligence.

With initial funding from IU’s New Frontiers in the Arts & Humanities Program and a grant from the National Endowment for the Humanities, Allen started the Indiana Philosophy Ontology “InPhO” project (http://inpho.cogs.indiana.edu). Allen has worked closely with graduate and undergraduate students on the InPhO team to build a system that mines the Stanford Encyclopedia for connections between key words and thinkers, and automatically infers a hierarchical representation or “ontology” of philosophical ideas.

Because the Stanford Encyclopedia is continually being expanded and updated, the software system has to be flexible enough to keep track of its moving target. The result is a dynamically changing database that has several practical applications, including a way to navigate and search for information about philosophical topics, and a tool for the editors of the encyclopedia that provides software-generated suggestions for cross-referencing the articles. Other applications are in the pipeline, including a visual interface for navigating the entire discipline of philosophy.

Allen came to IU from Texas A&M University in 2004, and has a split appointment: 50 percent in the Cognitive Science program and 50 percent in the Department of History and Philosophy of Science. He also has adjunct appointments in the Department of Philosophy and IU’s Center for the Integrative Study of Animal Behavior.

“I immediately felt right at home at IU,” he says. “The interdisciplinary atmosphere in the Cognitive Science program was something I’d always dreamed of. As a graduate student at UCLA, and then as a faculty member at Texas A&M University, I always had to start and run my own interdisciplinary groups. But at IU, I stepped right into the very vibrant cognitive science scene: “cog lunch” every Wednesday, colloquium talks on Mondays, and a number of lab groups such as the Friday developmental seminar. All have been very welcoming.”

Allen hasn’t just settled for what he found at IU. Right after arriving, he started a new group for faculty and students to meet and discuss the latest work in animal cognition, the area in which Allen’s own scholarly work is best known. The so-called “spackled” group has become a regular fixture with meetings roughly every other week during the academic year.

“The name’s a bit of a joke,” Allen concedes. “It stands for something like ‘seminar for philosophy of animal cognition, knowledge, learning, evolution, and development,’ but we liked the idea that we were filling a gap in cognitive science so we filled in the long title after we came up with the name ‘spackled.’” The group attracts graduate students and faculty from psychology, philosophy, informatics, history and philosophy of science, and biology, expanding the outreach of the Cognitive Science program at IU.

In his capacity as director of undergraduate studies for the program, Allen also is concerned with campus outreach to undergraduates. “Unfortunately, most students at IU haven’t heard of cognitive science, and so it never occurs to them to consider it as a major,” he says. “The students we do get are excellent — among the best at IU — but we need to find new ways to let others know that cognitive science might be the major they’ve been searching for.”

Allen teaches the undergraduate and graduate courses on the philosophical foundations of cognitive science, Q240 and Q540, which are required for majors and minors at the bachelors and doctoral levels. The undergraduate course regularly nets one or two new majors whenever Allen teaches it, but, he says, “We’d like to reach potential students even before they’ve looked at the schedule of classes and noticed the Cognitive Science courses.”

In addition to his work with the undergraduate program, Allen has also been recognized at the University level for his work with graduate students, receiving 2008 Faculty Mentor of the Year Award from IU’s Graduate and Professional Students Organization. “That was great!”, says Allen. “It really meant a lot to me to get an award that was initiated and chosen by the students.”

Allen credits the exceptional graduate students at IU for much of what he has been able to accomplish these past four years. “Without the graduate students there would have been no InPhO project,” he says. “They took some vague ideas I had about data mining the Stanford Encyclopedia, and provided the technical expertise that allowed us to write some compelling grant proposals and carry out the project.” It’s not just the InPhO project that has benefited from Allen’s work with graduate students; he credits them with having sparked one of the most productive periods of his career in terms of his recent and forthcoming publications and talks.

This fall sees the publication of Allen’s latest book, Moral Machines: Teaching Robots Right from Wrong from Oxford University Press, written with coauthor Wendell Wallach of Yale University’s Bioethics Center. “I have no idea what the reaction will be to the book,” he says. “We generate more questions than answers. But it’s a really important topic. Computers and machines are everywhere, making decisions that affect our lives in everything from credit card purchase approvals to military robots. How do humans manage, sometimes at least, to make ethical decisions, and how much advanced artificial intelligence is needed to ensure these machines make ethical decisions? Cognitive science is the central discipline for answering these questions.”

With fingers in many pies, some of Allen’s colleagues and students secretly believe that he is a robot — a view that is held even more strongly by the students who have attempted but failed to outpace him on bicycle rides through the hills around Bloomington. As any philosopher should, Allen chooses his words carefully. “It’s always good when I can I teach the students a thing or two,” he says.
Music science and the ‘Informatics Philharmonic’

Associate Professor Christopher Raphael’s first love was the oboe, and to this day he continues to play enthusiastically, if not as well as he likes to think he once did.

At 17, he won the San Francisco Symphony’s Young Artist Competition and appeared as soloist with that orchestra. Following his serious musical studies at Northwestern, he held a fellowship at the Boston University Tanglewood Institute and played in a wide array of professional ensembles in California.

A fork in the road led him to graduate studies in applied mathematics at Brown University. But it wasn’t long before his attention returned to music, blending with the perspective of the scientist. Since coming to IU from the Mathematics Department at the University of Massachusetts, Amherst, he has made the music-research connection official as the head of the Music Informatics Program in the School of Informatics.

His longest standing research project studies musical accompaniment systems, a project which continues to flourish here at IU. “Even in a top music school like IU’s Jacobs School of Music, most performance-oriented students will complete their studies at IU never having soloed with an orchestra, even though the solo literature is the main focus of their studies.”

Raphael thinks this is nearly tragic, since the experience of playing as a soloist is a profoundly rewarding one, as well as a vehicle for musical growth. Armed with both a deep understanding of what a musician wants and needs, as well as technical expertise in pattern recognition and statistical machine learning, he began a long journey to create the orchestra that so many deserving would-be soloists have been missing — out of software.

His orchestra is now composed of nearly 100,000 lines of C-code written entirely by himself. The approach divides a task into three separate parts, which run as unique “threads” in the program. The “listen” thread is responsible for hearing the soloist, accomplished using the hidden Markov model technology so successful in speech recognition. In essence, this thread performs an ongoing match between the incoming audio from the soloist and a musical score inside the computer. What comes out is a running commentary on the soloist’s playing that identifies times at which the various notes occur.

These times are fed into a prediction engine that forms a continually evolving estimate of how the musical timing will unfold. In this “predict” thread, the learning accomplished by live musicians during rehearsal is mirrored by a machine-learning assimilation of the rehearsal data. In this way the system’s predictions are influenced both by the soloist’s real-time actions as well as by what has been learned during rehearsal. “Really,” says Raphael, “there is only rehearsal with my orchestra — if the musician wants to give a different name to the final rehearsal where no one is allowed to stop, that is okay, but the program’s musical agenda remains the same.” Finally the “play” thread connects the trail of breadcrumbs created by the predict thread with audio re-synthesized from an actual recording.

Raphael has been working with Jacobs School violin faculty member Mimi Zweig and many of her students on a wide array of standard repertoire including concerti of Beethoven, Sibelius, Mozart, Wieniawski, among many others. The “Informatics Philharmonic,” as Zweig calls it, has been used in a variety of teaching settings — one student even used the program in her solo recital. “Most of the students I work with are overwhelmingly positive about the orchestra,” Raphael says. He believes the research will continue to attract attention and gain acceptance in the Jacobs School. “Students feel thrilled and empowered by the experience and never seem to want to leave my lab.”

The research is not all about the music of the past, though. A musical accompaniment system makes possible new music that would be unplayable by traditional means. The computer is capable of nearly unlimited virtuosity when it comes to playing fast notes and complex rhythms. Works by several composers have been written explicitly for Raphael’s accompaniment system to make use of this untapped potential. Raphael and Swiss composer Jan Beran recently released a recording on the Vienna Modern Masters label of works for oboe and computer-controlled pianos including Winter (formerly known as Winter 7-II). The piece was named for the complex interplay between simultaneous groups of 7 and 11, nearly unplayable by humans.

Of course, Raphael admits that there are important aspects of musicianship where his system lags significantly behind humans. While many think of musical expression as simply a matter of taste, Raphael asserts that the worst of computer-generated music suggests otherwise. In musical phrasing there are basic aspects of inflection and emphasis where, Raphael believes, one may speak of “correctness,” though this notion is rather difficult to capture numerically.

Raphael’s most recent focus has been on this area, partly due to the importance of musical expression to accompaniment systems, and partly to the intrinsic interest of trying to understand something so simple for the human yet so far out the computer’s reach.

Progress has been aided by a recent National Science Foundation grant, which included a Bosendorfer reproducing piano. This piano captures the precise motion of keys, hammers, and pedals and facilitates a scientific study of how musicians breathe life into otherwise sterile and meaningless notes. The piano will be shared with IU’s new Brazilian piano virtuoso, Arnaldo Cohen, who is eager to participate in Raphael’s research. In addition to its value as a piece of research equipment, Raphael wants the piano to be used as a musical instrument.

Raphael says this is a terrific time to be working in what he terms “music science.”

“The area is wide open,” he said, “and most of the best ideas haven’t been thought of yet.” — CHRISTOPHER RAPHAEL
Social robots at work and home – Are you ready?

While the 20th century was the century of the digital computer, an increasing number of experts predict that the 21st century will be the century of robots and human-robot interaction.1 But what does it mean to interact with a robot, you might ask? Aren’t robots machines that are programmed to autonomously perform tedious jobs in industrial manufacturing? Yes and no.

Clearly, the density of robots per capita drastically increases each year in industrialized nations.2 But this is not to say that most of these robots are industrial robots, though this was still true a decade ago. The current robotics landscape is different. In 2004, for the first time, social robots such as service robots, entertainment robots, and robotic companions, outnumbered industrial robots, and this trend will continue at an even faster rate according to a recent UN survey.3 Social robots go wherever their owners take them (or wherever they end up going on their own!).

And while industrial robots look very much like machines — think huge robotic arms in car factories — social robots are often purposefully modeled after living creatures (from dogs to humans), giving them a lifelike appearance. Social robots are also typically mobile and can move autonomously around their environments (like a robotic vacuum cleaner, for example). In short, social robots are different, and they are slowly but surely becoming part of our society.

At the IUB Human-Robot Interaction (HRI) Laboratory in the Cognitive Science Program, researchers embraced the possibility of future human-robot societies. A team started investigating the principles and mechanisms that will allow future robots to interact with humans in typical human environments and in natural ways.

However, there are many challenges that must be met to enable autonomous human-like robots. For example, imagine a robot that assists you at home with your daily chores. Wouldn’t it be nice if you could talk to the robot as you might communicate with a human household helper? Yet, no robot that can currently handle even the typical language interactions of a three-year-old.

Or imagine an office robot that delivers mail and other office materials, and can be asked to bring coffee and snacks. Should this robot do so everything you tell it to do, or should there be limits to its obedience (for example, when you tell it to spill coffee over your office mate’s files)? Right now, no robot exists that can base judgment on general moral and ethical principles in conjunction with pre-programmed directives (a la Asimov).

And finally, imagine a robotic nutrition consultant designed to help you make good lifestyle choices on a daily basis — does its appearance have an influence on how seriously you consider its recommendations? Currently, we do not understand how robot appearance and behavior have an influence on how seriously you consider its recommendations?

Under the leadership of its director Professor Matthias Scheutz, IU’s HRI researchers are pursuing projects in all of the above-mentioned areas: natural language interactions, robot autonomy and decision-making, and human mental models of robots. For example, a Multi-University Research Initiative (MURI) funded by the Office of Naval Research and led by IU, with teams from Arizona State University, the University of Notre Dame, and Stanford University, attempts to investigate the ways humans working together exchange information in natural language in order to achieve common goals.

Researchers on the MURI team are developing models of human natural language interactions that are subsequently implemented and tested on robots like the humanoid CRAMER (pictured). Their goal is to be able to achieve robust natural language understanding on robots for limited domains (such as search-and-rescue missions in disaster zones) by 2012.

For robot autonomy, IU’s researchers investigate the extent to which autonomy based on a robot’s independent decision-making and action affects the performance of a mixed human-robot team while being subjectively acceptable to the human team leader. Results from experiments where the robot could (and at times did) ignore human commands in critical situations in an effort to pursue activities that would help achieve the team goal show that subjects found the autonomous robot more cooperative, helpful, and capable.

A third project at IU’s HRI lab investigates people’s perceptions of social presence in robots during a sequence of different interactions, where the robot functions as a survey taker as well as an observer of human task performance. The results show an interesting gender difference in the subjects’ perception of the robot: males view the robot as more human-like than females. As a result, their task performance on a difficult task (like performing mathematical calculations) is more impacted by the robot’s presence than that of females (an effect known from human experiments as “social inhibition,” a mark of human agency).

What is unique about the HRI lab at IU, compared to other national and international research laboratories that pursue research in human-robot interaction, is that robots serve a dual role: they are used to study human cognition and develop “embodied” computational models of cognitive processes that can elucidate principles and mechanisms of cognition, thus serving a distinct role in the cognitive science community; and they are used to evaluate the developed models and control algorithms in typical interaction tasks with humans to confirm that the proposed algorithms will lead to more natural human-robot interactions, thus enabling the technology for the deployment of future robots.

The HRI lab serves an important role in the teaching mission of the Cognitive Science Program, from introductory courses where simple robots are used to illustrate basic embodied cognition, to project courses where undergraduates get involved in original research, to graduate courses where students develop their own sophisticated robotic models and control algorithms as part of their semester projects.

Models of human natural language interactions are being tested on humanoid robots like CRAMER (at right) to increase natural language understanding for purposes such as search-and-rescue missions.

Resources:
2. In Japan, for example, there are 295 industrial robots per 10000 manufacturing workers. See http://spectrum.ieee.org/dec08/7012.
Exploring the complexity and networks of the brain

It comes as no surprise to the readers of this newsletter that the functioning of the human mind is tied to the activity of neurons in the human brain. Activity in the brain is now mapped with greater accuracy by using tools of cognitive and systems neuroscience, and thousands of publications have appeared in recent years that have attempted to relate brain activity patterns to mental and cognitive phenomena. However, despite the significant progress of neuroscience in recent years to unravel neural mechanisms of brain function in great detail, we still lack a good understanding of the complexity and network attributes of whole nervous systems.

Work in the laboratory of Professor Olaf Sporns targets this issue in two ways. By approaching brain function from a network perspective, Sporns and his collaborators have gained insight into how brains are organized to efficiently integrate and process information. And by studying the dynamic interactions between brain, body and environment, Sporns' work has suggested new ways in which embodiment can be used to generate and shape information in the brain.

What are brain networks? Ultimately, brain networks are rooted in neuroanatomy, the intricate meshwork of a million billion connections that link nerve cells within the brain — mapping all of these connections one-by-one would be a daunting exercise and is still well beyond our technical capabilities.

But thanks to non-invasive brain imaging techniques we can now collect data sets from individual human brains. From this data, we can reconstruct whole brain networks at a resolution of about 1,000 nodes per brain. Each node in such a network corresponds to a fairly large chunk of the brain, but it is possible to gain significant insights about how brain networks are organized even at this rough scale.

Together with an international team of imaging researchers, Sporns recently set out to map the connections within human cerebral cortex [see illustration]. This study led to several unexpected insights. The cortex is organized into a set of modules, possibly arranged in a hierarchical cluster structure, which are interconnected by a small set of hub regions. These hubs are highly connected and central, and some of them are found in regions of the cortex that have previously been associated with high-level processing and multimodal integration. The most conspicuous hub is located in a part of the cortex close to the central midline, about which relatively little is known.

Some studies indicate that this most central hub (the core of the brain) is involved in self-monitoring, visuo-spatial imagery, episodic memory retrieval, and perhaps even consciousness. Overall, the modularity of the cortex forms the basis for a type of small-world architecture which is also found in a wide range of non-neural complex systems.

But brain anatomy is a rather lifeless subject — what about patterns of activity in the brain? How are these dynamic patterns shaped by physical connections, the “wires” of the brain?

To investigate this question, Sporns uses computational models of brain dynamics as well as empirical studies of dynamic patterns in the human brain. The anatomical networks described previously can be used as a coupling matrix for a computational model of a dynamic neural system. In other words, the structural couplings observed in a human brain can be used to inform a computational model that can reproduce brain activity patterns. These simulated brain patterns can then be compared to actual brain recordings from individual human participants.

Ultimately, this work may allow the construction of a global brain model that can be used to gain a better understanding of and allow predictions about brain processes that are otherwise hard to measure or observe.

So far, we’ve gone from static brain networks to dynamic patterns of neural activity — but can we really gain a complete understanding of cognition by looking only at the brain? Dr. Sporns doesn’t think so. Embodiment is a necessary ingredient in any theoretical framework directed at understanding how the human brain gives rise to the mind. Embodiment is often forgotten and neglected in standard neuroscientific practice, in part because of methodological difficulties, but also because the prevalence of reductionist approaches has tended to block complementary system-based accounts.

Brain networks do not operate in isolation of the body within which they reside and the environment within which the body operates. Every time neural outputs result in the displacement of our sensors and a reconfiguration of our motor apparatus, the result is a change in neural inputs, which in turn impacts neural information processing. This simple realization led Sporns and his collaborators to suggest that embodiment can have measurable impact on information flow into, out of, and within the brain. This has led to the development of new ways to quantitatively measure how much information is gained by coordinated embodied activity. Ultimately, such measures may guide the design of fully embodied cognitive agents, simulated or real.

An overarching theme in Sporns’ work is that the complexity of the brain is irreducible, but can be captured at various levels by extracting functional principles of organization.

These principles can be instantiated and explored in computational models that range from simulations of neurons and brains to embodied agents and robots. Over the years, undergraduate and graduate students have carried forward work in Sporns’ lab — among them, Jonathan Zwi, Teresa Pegors, Dan Bulwinkle, Jeremy Karnowski, Jeff Alstott, Will Alexander, George Chadderdon and Chris Honey, whose contributions have been absolutely essential.

“So far,” says Sporns, “we’ve only caught a glimpse of how the networks of the brain give rise to the mind. There is much still to do, and many surprises and insights undoubtedly are still ahead.”
Professors Randall Beer and Matthias Scheutz hosted IU’s robotics laboratory open house event on April 25, 2008, with press coverage from WFIU and the Herald Times.

Professor Colin Allen was elected president of the Society for Philosophy and Psychology for 2008–09. He also received the 2008 Faculty Mentor Award. The GPSO established this award to recognize and generate appreciation for faculty members who are outstanding mentors to graduate and professional students.

Professor Peter Todd organized an international program in cooperation with the Max Planck Institute for the study of judgment and decision-making. This program funds graduate students to visit IU for research, and hosts annual summer school events.

Assistant Professor Karin James, Professor Linda Smith, and Professor Susan Jones received over $1 million grant money from the National Institute of Health and National Institute of Child Health and Human Development. The study is titled Children's Actions and Object Recognition. The study will seek to understand the role of developmental changes in self-generated action on objects in the development of visual object representations and recognition.

Assistant Professor Thomas James received the 2008 Randolph Blake Early Career Award. Vanderbilt University established this award to recognized exemplary alumni from the school’s program in psychological sciences. Recipients received a plaque, a $500 award and an invitation to give a colloquium.

The College of Arts & Sciences Alumni Association Board honored IU Cognitive Scientist Olaf Sporns with the 2008 Distinguished Faculty Award at a banquet held on Nov. 7.

Professor Eliot R. Smith received the Society for Personality and Social Psychology 2008 Service Award for Contributions on Behalf of Personality-Social Psychology, for contributions to founding the NSF-funded Summer Institute in Social Psychology. He was also named IU’s Classes of the War Years Chancellor’s Professor of Psychological and Brain Sciences for 2008.

Associate Professor Jonathan A. Plucker was recognized as one of 40 outstanding alumni under the age of 40 from The University of Connecticut. He will be featured in the Fall/Winter edition of the university’s alumni magazine scheduled for publication in November 2008.

Professor Larry Yaeger’s artificial life research was recently featured in the “Future Intelligence” episode of the “NextWorld” series on the Discovery Channel in August 2008.

Professor Jerome Busemeyer was awarded a new three-year NSF grant. The grant will be used to develop and empirically test quantum models of decision-making.

Associate Professor Sasha Barab and Assistant Professor Melissa Gresalfi were awarded a $1.8 million award from the MacArthur Foundation as part of the digital media and learning initiative. The grant, entitled “Scaling Out Virtual Worlds: Growing a 21st Century Curriculum,” is intended to scale a current curriculum development project called Quest Atlantis. The purpose of the grant is to support wide-scale change in media literacy in countries around the world.

Associate Professor Jonathan W. Mills was among 20 international musicians chosen to perform at the Different Skies Electronic Music Festival and Concert at Arcosanti, Arizona, in September 2008. One of Jonathan’s compositions, titled “The Fire Balloons,” from his newest CD Ylla was chosen to be performed and was streamed worldwide over Internet radio.

Associate Professor Hamid Ekbia authored “Artificial Dreams: The Quest for Non-Biological Intelligence,” published April 2008 by the Cambridge University Press. The book is a critique of artificial intelligence from the perspective of cognitive science.

Professor Larry Moss organized the “Decisions and Games” workshop at Indiana University in May 2008. He would like to thank Cognitive Science for their support during the event. Moss also published articles in several journals and in the online Stanford Encyclopedia of Philosophy, the Handbook of the Philosophy of Information, and the Handbook of Spatial Logics.

Find out more about what’s on the minds of our faculty members at www.cogs.indiana.edu.
Melissa Troyer, BS'08, graduated from Indiana University in 2008 with majors in linguistics, psychology, French, and cognitive science. While a student at IU, Troyer was very involved in extra-curricular activities, such as the IU Timmy Foundation and the Indiana Memorial Union Board, extra-extra-curricular activities, such as performing as the drummer in a rock band with the group “The N170s,” and also some academic activities, such as coursework and research.

The rigorous, interdisciplinary training she received while at IU prepared her to ask research questions about human cognition and language using multiple approaches, and Troyer attributes many of her current academic aspirations to the experiences afforded by IU Cognitive Science. She is currently a PhD candidate in the department of Brain and Cognitive Sciences at the Massachusetts Institute of Technology and hopes to one day become a professor, eventually leading her own research group.

Courses in cognitive science allowed Troyer to collaborate with students from diverse backgrounds. For instance, in How Language Works she collaborated with a classmate (who she says was much more competent in computational science) to complete a project that implemented unsupervised grammar learning, extracting hierarchical information from a large corpus of data and eventually generating novel sentences on its own. She says this kind of cross-disciplinary research was one of the most exciting features of the program and one of the primary reasons she decided to continue her academic career in the field of cognitive science.

Apart from coursework, Troyer spent much of her time at IU engaged in other scholarly activities. Her work in David Pisoni’s Speech Research Laboratory (SRL) taught her how to be an effective researcher and showed her that a career in academia is where her passion lies. In the SRL, she had the opportunity to collaborate on many projects with other researchers and finally completed a senior honors thesis investigating cross-modal speech. Specifically, she investigated how visual perception can modify the auditory perception of speech signals.

Previous studies have shown that when presented with incongruous audio and visual signals, participants often combine the two to form a “fused” percept (for instance, seeing lips form “back” and simultaneously hearing “lack” may lead to the perception of “black”). Troyer investigated the effects of temporal asynchrony on this kind of perception. Interestingly, she found that even when asynchronous, audio-visually incongruous items were not perceived as “fused” in a perceptual task, the same items were more likely to be reported as synchronous (happening at the same time) in an asynchrony detection task if participants had previously been exposed to them in the perceptual task. These findings indicate that even when conflicting auditory and visual stimuli are not completely fused perceptually, some lower-level integration may be leading participants to judge them as temporally synchronous.

In her time at IU, Troyer also worked as a computer programmer in Dr. Thomas Busey’s lab, which investigates visual perception and expertise using EEG (electroencephalogram). Her work focused on designing teaching tools to be used in undergraduate psychology courses, including statistics software and a “Virtual EEG” application. In Virtual EEG, students are able to design, run, and analyze their own EEG studies in minutes using previously recorded brain responses (from a large number of subjects) to a large dataset of pictures. Students can group the pictures into categories and look for significant differences in the electrophysiological data at 32 electrode sites. So far, this teaching tool has been extremely effective when used in an undergraduate research methods course, allowing students to think critically about designing an experiment and analyzing real data.

In addition to giving Troyer the opportunity to refine her research skills, IU’s Cognitive Science Program allowed Troyer to develop another skill integral to a career in academia — teaching. In her sophomore and junior years, she served as an undergraduate teaching assistant for a math and logic in cognitive science course taught by Ruth Eberle, who is also the program’s director of technology. Having had many engaging and thought-provoking teachers over the years, Troyer was thrilled to have the opportunity to lead discussion sections composed of a class of her peers. Through the guidance of professors in the department, Troyer was thus able to hone her teaching skills (and hopes to use them next year when she tackles her first graduate assistantship at MIT).

When she graduated from IU, Troyer won two national fellowships, the National Science Defense and Engineering Graduate Fellowship from the Department of Defense and the Graduate Research Fellowship from the National Science Foundation that would fund her for five years at the graduate school of her choice. She chose to attend MIT, where she is currently a first-year graduate student in the Brain and Cognitive Sciences program studying language processing in Ted Gibson’s lab. Troyer’s research interests are motivated by questions about how people cope with ambiguity in language and how ambiguity in language is resolved. In particular, she is interested in how prosodic, lexical, and discourse factors, as well as the interaction of such factors, might contribute to ambiguity resolution. She is currently investigating these questions at MIT using behavioral methods as (continued on page 9)
2008 PhD dissertations

Ronaldo Vigo
Mathematical Principles of Boolean Concept Learning
PhD Cognitive Science Program
Committee: Colin Allen (co-chair); John Kruschke (co-chair); Robert Goldstone; Robert Nosofsky; James Townsend

Georg Theiner
From Extended Minds to Group Minds: Rethinking the Boundaries of the Mental
PhD Philosophy/Cognitive Science Program
Committee: Robert Goldstone (co-chair); Tim O'Connor (co-chair); Frederick Schmitt; Jonathan Weinberg

Michael Roberts
Human Collective Behavior: Complex systems properties of self-organizations, coordination, and emergent
PhD Psychological & Brain Science/Cognitive Science Program
Committee: Robert Goldstone (chair); Elinor Ostrom; Eliot Smith; Peter Todd

Shakila Shayan
Emergence of Roles in English Canonical Transitive Construction
PhD Computer Science/Cognitive Science Program
Committee: Michael Gasser (co-chair); Lisa Gershkoff-Stowe (co-chair); David Leake; Robert Goldstone; Linda Smith

Ryan Jessup
Neural correlates of the behavioral differences between descriptive & experiential choice: An examination combining computational modeling with fMRI
PhD Psychological & Brain Science/Cognitive Science Program
Committee: Jerome Busemeyer (chair); Joshua Brown; Olaf Sporns; Peter Todd

Franklin Bergert
Using response time to distinguish between lexicographic and linear models of decision making
PhD Philosophy/Cognitive Science Program
Committee: Robert Nosofsky (chair); John Kruschke; Peter Todd; James Townsend

Troyer
(continued from page 8)
well as collaborating with Dr. Gina Kuperberg's EEG lab in the psychology department at Tufts University.

Already having a few months of graduate study under her belt, Troyer can say with certainty that she is very happy to have found an area of study that makes her rather OK with putting in 20-hour days if necessary. Troyer knows that committing one's life to research can be a pretty daunting prospect, but having the academic freedom (in addition to the responsibility) to study what one sincerely cares about is a nice way to start off one's adult life. Troyer considers herself lucky to have been a part of the IU Cognitive Science community, and she is grateful to the wonderful mentors that helped her elucidate her life's goal of learning something about cognition and communicating it to the scientific community.
When the mind meets media

On the night on Nov. 4, Barack Obama addressed the country for the first time as the president-elect. Audiences were excited, inspired, relieved, worried — or disappointed. This historical moment occurred in Chicago's Grant Park, but, to most American people, everything happened on television.

Switch the channel. Of all the sudden, you are carried away by Carrie, in the romantic and dramatic Sex and the City. Switch again. You are in exotic Nicaragua looking for a house with HGTV's House Hunters International. Another switch. Now, the local campaign ad tells you to vote “no” on issue 6. Switch, switch, switch, and switch: a tearjerker, Corona beer, "vote yes on issue 6," and how-to make-a-pumpkin-pie.

Hundreds of channels. 24/7. This, however, represents only a sliver of our media-saturated world. How does this crazy mediated world affect us? We are holding the remote control, but are we in control?

These questions always made Zheng Wang, PhD’07, curious when she was a journalist in Beijing, China, for a prime-time news program with hundreds of millions of viewers. So, planning to take two years to understand media effects and then return to her news production work in Beijing, she arrived in Bloomington as a master's degree student in the Department of Telecommunications in 2001.

Six years later, her search for answers had led her to even more questions and also to a joint PhD in mass communication and cognitive science. “After exploring many approaches during the first two years of my graduate education, I was fascinated by psychological and cognitive approaches,” Wang said. “It seems that my questions are always finally reduced to: what are the processes in the media audiences’ minds that lead to the various media effects? The media effects are numerous and changeable, but the underlying psychological processes are fundamental and generalizable.”

Wang seeks to understand these fundamentals. For example, media effect theories say that the more a person watches violent TV, the more aggressive she becomes. So, what happens in the “black box” of our minds between watching TV and being aggressive? For example, researchers found negative news gets people's attention.

FUEL FOR A CURIOUS BRAIN

The Cognitive Science Program offered Wang the most exciting time in her journey. “I developed a secret notation habit when reading or taking notes which I still love today: I sketch a lighting bulb in the margins when my mind sparks,” she said. She drew thousands of them during her years in the Cognitive Science program—during lectures, seminars, readings, lab meetings, and discussion (or debates) with professors or fellow students.

“The interdisciplinary environment truly promotes the exchange of ideas among various research specializations and paradigms. I was so fortunate to have the top-notch professors from different areas. They removed boundaries between traditional fields, stimulated me with fresh insights, cultivated my curiosity, taught me how to ask questions as a good scientist, and trained me how to look for answers using sophisticated methods.”

In the interview, Wang paused and drew a big bulb shedding abundant light on a piece of scratch paper. She summarized her four years in the program, “My brain was constantly turned on.”

While a student, she worked intensively in the psychophysiological research lab in the Institute of Communication Research (ICR). Thanks to the tutelage of professors Annie Lang, Julia Fox, and Robert Potter, she mastered theoretical knowledge and skills of psychophysiological measures and applied them to investigate the real time responses of audiences. During her study of the real-time interaction between mediated information and media users, she came to appreciate the beauty and importance of dynamic mathematical modeling. She joined the Decision Lab directed by Professor Jerome Bussemeyer, where she received training with dynamic-system theories and mathematical modeling tools.

One result of this training is her dynamic stochastic model of channel changing behavior, called ChaCha. This model tries to predict the type of behaviors described in the first paragraphs: how long do you watch the election victory address, and if you switch channels, do you go for the tearjerker, Carrie’s sex and love, the pumpkin pie, or jump back to Obama after zapping around. This ChaCha model integrates a reinforcement model of learning what is shown on each channel, a diffusion model of attention to determine the time spent on a given channel, and a ratio of strength model to choose among channels. She developed and tested this model using real-time channel viewing and choice data, and is extending it to general variety seeking in media use. This highly original approach is pioneering in media research.

Wang’s dissertation was recognized as Dissertation of the Year by the Cognitive Science Program and named as The Best Information System by the International Communication Association in 2008. Her work further developed an integrative and dynamic model of channel-changing behavior and its underlying motivational processing. She conducted two experiments, during which she collected real-time data indicative of emotional, cognitive, and channel choice responses, using continuous self-report, physiological (heart rate, skin conductance, zygomatic and corrugator electromyography), and behavioral measures. A second order linear stochastic difference model with delayed media content input effects was used to reveal how viewers’ channel-changing behaviors could be predicted by the interactions between channel content and viewers’ motivational features.

JOURNEY OF QUESTIONS

Has she found all the answers now? She seems amused by this question. “One answer leads to another deeper question. There is, simply, no end of this journey. It is like the Babushka doll. You know, the Russian nested doll? You open one doll, and find another inside.”

She picked a notebook from the bookshelf, showing the author a quote she copied down on its first page. The passage by Bernt Olsén encourages (or comforts) her: “We have not succeeded in answering all our problems. The answers we have found only serve to raise a whole set of new questions. In some ways we feel we are as confused as ever, but we believe we are confused on a higher level and about more important things.”

“When this is all we are doing, isn’t it the most critical task to ask the good questions and use the appropriate tools to look for answers so they lead you to good questions again?” Wang said. “I’m so thankful that the Cognitive Science program trained me on these. My Babushka-doll journey is always exciting.”

Now, her journey continues at the Ohio State University, where she took an assistant professorship in 2007. Last year, she set up her own psychophysiological research lab. The Media and Cognitive Science lab has attracted both graduate and undergraduate students who, like Wang while she was at IU, are fascinated by how media interact with our minds.
Clockwise from above: a) Recipients of the Cognitive Science Program Undergraduate awards, from left to right: Jairime Murdock, Melissa Troyer, Alexander Burkhard, Patrick Mundy, Director of Cognitive Science Program Robert Goldstone, Jordan Thevenow-Harrison and Jamie Murdock; b) Graduate Award-winners for 2008 were David Landy (pictured) and Zheng Wang (photo on page 10); c) Faculty members and students enjoyed the 2008 Annual Summer Picnic for Interdisciplinary Cognitive Science held at the Stone Age Institute. Professors Larry Yaege and Peter Todd were among picnic attendees; d & e) Guests marvel at research displays during the 2008 Cognitive Science Program Robotics Open House, held at Eigenmann Hall.; f) Program Director Robert Goldstone discussed the program’s progress during the 2008 Awards Reception.

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