mind READER

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NEWSLETTER FOR ALUMNI OF THE IU COGNITIVE SCIENCE PROGRAM • COLLEGE OF ARTS & SCIENCES ALUMNI ASSOCIATION

DIRECTOR'S PERSPECTIVE

Interdisciplinary work, exciting revelations

So far, this year has not borne witness to spaceships carrying people to Jupiter, as Arthur Clark envisioned in his 1982 book *2010*. However, we have seen technological developments in cognitive science that seem comparably magical from a 1982 perspective.

Goldstone

We have computer systems that can identify speech, handwriting, faces, and patterns at impressive levels of accuracy. They can play chess as well as any human being. We can measure *in vivo* neural activity over an entire brain at millimeter and millisecond resolutions (albeit not with the same device). Tens of millions of devices are connected to a global network of knowledge known as the World Wide Web.

The members of the Cognitive Science Program at IU are involved in all of these efforts, and many more.

Despite a skittish economy, we have tenaciously continued our collective pursuit of a fuller understanding of minds and other intelligent systems. Over the last year, several new expansions and initiatives have materialized. We have elected 10 new faculty members to be part of the Cognitive Science program: Johan Bollen, Nathaniel Brown, Joshua Danish, Kris Hauser, Chien-Jer Charles Lin, Rachael Holt, S. Lee Hong, Adam Maltese, Selma Sabanovic, and Thomas Schoenemann. Our total number of Cognitive Science faculty members now stands at 79. In the last year, these faculty members have won Nobel Prizes in Economics (Elinor Ostrom), been elected to the American Academy of Arts and Sciences (Douglas Hofstadter and Ellen Ketterson) and the American Philosophical Society (Douglas Hofstadter), assumed leadership roles as President of the Society for Philosophy and Psychology (Colin Allen), and brought in millions of dollars of grants to support research and teaching at Indiana University.

Our number of stand-alone Cognitive Science PhD candidates has risen steadily to its current highest level ever of 16. Another 66 students are pursuing dual degrees in areas such as psychology, computer science, linguistics, and philosophy.

In addition to formal courses, faculty and students interact in several self-organized reading groups (Cog-X, Apophenia, Brains, the Robotics Reading Group, and the Spackled Group for Animal Behavior, among others).

Despite the relatively small number of Cognitive Science undergraduate majors — 31 at last count — the program's undergraduates have created a vibrant and active intellectual community.

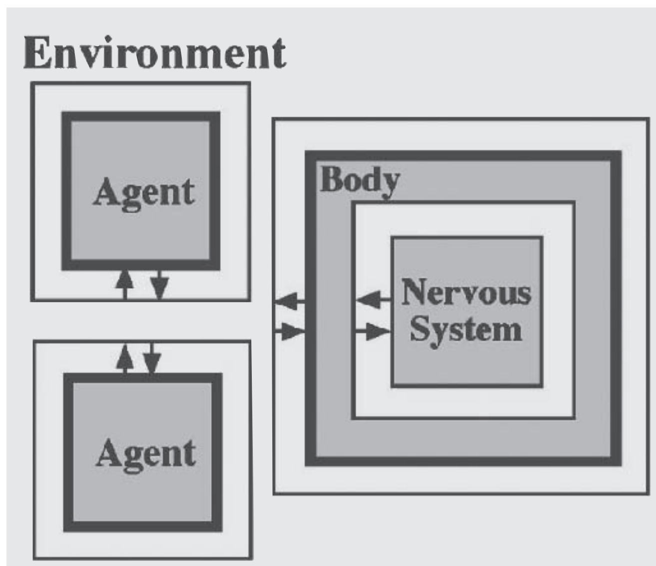

Fig. 1: A schematic of the major interactions embodied in our "Dynamics of brain-body-environment interaction in behavior and cognition" IGERT award. Every agent contains a nervous system that interacts with a body that interacts with an environment that critically consists of other agents with the same interactions.

Last year, they organized and hosted the First Annual Midwest Undergraduate Cognitive Science Conference. Special thanks to the lead organizers: Nicole Beckage, Jaimie Murdock, and Jordan Thevenow-Harrison. Inspired by the success of that first event, the Student Organization for Cognitive Sciences (SOCS) is organizing its second annual conference for April 11–12, 2010.

In addition to this ambitious conference, SOCS meets weekly for discussions, hosts a monthly dinner faculty, organizes showings and discussions of movies related to cognitive science, and runs a blog on related issues.

The undergraduate students also maintain a major Web portal, linked from the program's home page. A site for undergraduates around the world interested in cognitive science, it includes a continually updated set of links on graduate programs, journals, podcasts of lectures, a list of research groups, and news stories related to the field. Even more

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'FARGonauts' create computer microworlds

by Douglas Hofstadter

The Fluid Analogies Research Group (FARG) was launched roughly 30 years ago with the Seek-Whence, Jumbo, and Copycat projects, the goals of which were — and still are — to make accurate computational models of the most fundamental mechanisms of human thought. Since that long ago day, a fair number of other projects have been added to the list.

What all the FARG projects have in common is their continued focus on two profound and totally inseparable issues: 1) What is a concept?; and 2) How does analogical thinking take place?

The philosophy behind our vision of thinking is that the crucial task of brains is, figuratively speaking, to "put their fingers on the essence of the situations facing them", and that this is done by what we call "high-level perception." That means that FARGonauts (as we, with deliberate humor, call ourselves) see a smooth continuum running from, at the lower end, the recognition of the color red, to the recognition of a red apple on a brown table, to the recognition of breakfast on a countertop, to the recognition of a mess in the back seat of our car, to the recognition of a mess in a friend's romantic relationship, to the recognition of the vast web of implications of a friend's potential divorce, to the recognition of the profound irony of the fact that the surgeon is now dying of the very disease that she herself cured so many times in her life, and so forth and so on.

Needless to say, the latter examples get closer and closer to the "high end" of the spectrum of high-level perception.

Our belief is that this kind of "seeing" (which obviously transcends any traditional sensory modality) is the core of human thought, and that it is carried out by the mechanisms of analogy-making. We very deliberately avoid saying "analogical reasoning" because to us that extremely standard, traditional expression is loaded with all sorts of unwanted and misleading connotations.

To us, the making of analogies means nothing more and nothing less than recognizing in something before us — not necessarily before our *eyes*, however — what it most centrally "is." This means making a link between two mental structures, one being the imperfect, crude representation that we have (so far) built up of this situation, and the other being a pre-stored mental representation of a situation from our past (or, just as often, a pre-stored mental representation of a known concept). We do not draw any distinction between a memory of *one* event or situation, and a memory of a *number* of similar situations (*i.e.*, a concept). In fact, we see a memory of one event or situation as constituting every bit as much a genuine concept as is the blurry superposition of 100 similar situations.

In short, the FARG philosophy is that *analogy-making is the core of cognition.* Analogy-making brings all of our concepts into existence, it continually broadens them and deepens them and sharpens them over our lifetimes, and thanks to analogy-making, we recognize new situations as being "instances," in a sense, of old situations. Thus we see analogy-making as happening in a brain many times per second.

We study this remarkably subtle and ubiquitous mechanism of cognition by looking at how it works in tiny microworlds that we design specifically to bring out its deepest, subtlest, most elusive aspects.

Hofstadter

FARG microworlds range in scope, including these examples:

- Copycat alphabetic microdomain: "If *abc* changes to *abd,* then what does *xyz* change to?"
- Seek-Whence numerical microdomain: "What is the most likely pattern in the infinite sequence of integers that starts out '2, 1, 2, 2, 2, 2, 2, 3, 2, ...'?"
- Letter Spirit artistic-style microdomain: This involves trying to understand the abstract "spirit" of gridfonts — the 26 lowercase letters of the alphabet, a relatively small grid of vertical, horizontal, and diagonal straight-line strokes, all designed by a human being with the goal of creating a uniform artistic style
- Phaeaco Bongard-problems microdomain: Designed by Russian computer scientist M. Ya. Bongard, in the 1970s, this is a set of 100 visual pattern-recognition puzzles that are remarkably subtle, delightful, and playful. Phaeaco carries out the vision at many levels of abstraction in order to solve such puzzles, sometimes doing well and sometimes flopping hilariously
- Geometric-creativity microdomain of George: A program that tries to discover new concepts and to make new hypotheses in the domain of triangle geometry in the Euclidean plane.

This list gets across the flavor of our many FARG projects.

The group staunchly believes in using microworlds to study cognition, and the ideas behind the models are informed by many sources, ranging from biological metaphors (the brain is like an ant colony, thinking is like the parallel activity of enzymes in a single cell), to brain research, to the study of error-making, to the careful study of words and their halos, to the observation of our own smallish acts of creativity in various areas of life, to the study of how analogies have pervaded the greatest creative leaps made by physicists and mathematicians.

All FARG computer models are based on the idea that thinking is an extremely parallel, emergent phenomenon, as opposed to some kind of set of precise computational rules for manipulating abstract meaning-bearing symbols. In other words, we don't see thinking as any kind of "logic" or "reasoning," but as a kind of churning, swarming activity in which thousands (if not millions) of microscopic and myopic entities carry out tiny "subcognitive" acts all at the same time, not knowing of each other's existence, and often contradicting each other and working at cross-purposes.

Out of such a random hubbub comes a collective behavior in which connections are made at many levels of sophistication, and larger and larger perceptual structures are gradually built up under the guidance of "pressures" that have been evoked by the situation. None of this activity is

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Face-to-face with a neuroimage

"I never forget a face, but in your case I'll be glad to make an exception."

— Groucho Marx

Marx's quip is intriguing, since we cannot "forget" or "unlearn" a face no matter how hard we might try to do so. As well as letting us know who someone is, the face also serves as an important communication tool.

Our ability to interact with others in daily life — a skill known as social cognition — relies on reading what others are thinking or intending to do. In addition to what those we come in contact with say and do, social cognition relies on the expressions of the face, hands, and body to provide information. Often the true message comes *not* from the spoken word, but from non-verbal signals.

So, we read others effortlessly. But we're not always right; cultural differences also exist. And that is what makes life interesting. Unfortunately, there are a number of disorders, such as autism or schizophrenia, where social cognition is severely hampered. The underlying basis for these difficulties is poorly understood.

Aina Puce has been studying how human brains perceive and recognize faces for about 15 years. Her social cognition studies use different methods for analyzing human brain function.

Puce

The research aims to uncover how our brains read the non-verbal signals of others.

Puce became a faculty member in IU's Psychological and Brain Sciences department in September 2008 and is director of the Imaging Research Facility (IRF) at IU Bloomington. A self-professed "nerd," she gets very excited about all things technological and has spent her time at IU upgrading and adding to the IRF's facilities.

She supervised a major upgrade of the IRF's 3T MRI scanner in February 2009. The state-of-the-art MRI scanner can image brain structure, function, and blood flow. Puce also added two new laboratories to the IRF's core. One lab allows brain function to be studied by two methods, known as high-density electroencephalography (EEG) and transcranial magnetic stimulation (TMS). EEG allows electrical brain activity to be recorded with high temporal resolution (millisecond accuracy) so that neural source modeling studies can be performed. Researchers chart the paths information takes in the active brain. TMS allows the brain to be non-invasively stimulated, making it possible to probe active brain structures while the subject performs a task. When used with brain activation identified in functional MRI studies, TMS is a powerful tool not before available at IU.

In fall 2009, Puce offered a new graduate course, Neurophysiological Techniques: Theory and Methods. Graduate students from Psychological and Brain Sciencs, Cognitive Science, and Neuroscience experienced high-density EEG and TMS firsthand.

The current research in Puce's social neuroscience laboratory focuses on several different areas. First, the lab is investigating how the brain integrates non-verbal information from multiple senses – a necessity for everyday social interaction where the eyes, ears and other senses blend incoming input in a seamless manner. Another area of investigation centers on how the brain interprets changes in another's social attention (as signaled by changes in eye gaze direction) and how this influences how emotions are read, e.g. if they are directed at us as opposed to another individual. A third area of investigation compares human non-verbal behavior to that of other species.

Puce has used EEG methods since the mid-1980s, and functional MRI since the early-1990, and she is passionate about making sure that students understand the methods and right reasons for using them. She was delighted to come to IU as our interdisciplinary philosophy for practicing science sits comfortably with her own interdisciplinary research program and ideas. She is currently an editor (Cognitive Neuroscience section) for the international journal *Neuroimage*, and has served as a member and chair of the *Perception and Cognition Study* section. She is also an active member of the *Organization for Human Brain Mapping* and has served on its Council.

Director

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impressively, it also houses an undergraduate-led journal, *Indiana Undergraduate Journal of Cognitive Science*. Undergraduate students at Indiana University serve as the executive editor (the current editor is Brenden Sewall), associate editors, and board of reviewers. Four journal issues have been published. They are freely available online.

At the graduate level, our biggest piece of good news is that our National Science Foundation proposal for Integrative Graduate Education and Research Traineeship (IGERT) was funded.

This graduate-training initiative was one of only 18 funded out of more than 400 proposals.

IGERT focuses on the role that the interaction of an agent's body, its brain, and the environment plays in the production of behavior and cognition. The principal investigator for this training program is Randall Beer (see his profile on page 4), and the inaugural cohort of six graduate students has already begun training: Skyler Place, Jennifer Trueblood, Richard Veale, Paul Williams, Thomas Wisdom, and Carlos Zednik.

When fully ramped up, this program will provide $30,000-per-year fellowships for nine graduate students annually. The core motivation for this training initiative, entitled "The Dynamics of Brain-Body-Environment Interaction in Behavior and Cognition," is to not only decompose systems into their parts, but to put these parts back together again to show how they interact to form a functioning and adaptive whole.It contrasts with the dominant approach in science, which consists of breaking things down into smaller and smaller components.

Our graduate students will receive training in a variety of methods, including computational simulations, mathematical analysis, experimental methods, and neuroscience. The systems that they will study span many levels, from individual neurons, to neural circuits, to developing infants, to groups of people forming organizations. The four main areas of research covered by the program are: brain dynamics and connectivity, self-organization of individual behavior, processes of change, and self-organization of group behavior.

As part of this IGERT, we are collaborating with the Department of Psychological and Brain Sciences and the Program in Neuroscience to form a partnership with IU Northwest. The goal is to increase recruitment of underrepresented groups to psychology, neuroscience, and cognitive science. The plan is to bring students and faculty from IU Northwest to Bloomington to tour labs, visit classes, and initiate collaborations. Reciprocally, faculty from IU Bloomington will visit IU Northwest.

As the above initiatives exemplify, student and faculty cognitive scientists here at IU are acting a lot like the agents shown in Fig. 1 on the cover. As individuals, we are an integral part of the natural world we are trying to understand. To understand how people are enmeshed with their world, collectively we have found it necessary to interact with each other across disciplinary boundaries. The result of our grounded cognition (about cognition itself) and rich connections to each other is the establishment of a dynamic, flexible, and creative program. The rest of the stories in this newsletter document the exciting dynamics of brain-body-environment interactions in behavior and cognitive scientists. — *Robert Goldstone, director, IU Cognitive Science Program*

Frictionless brains

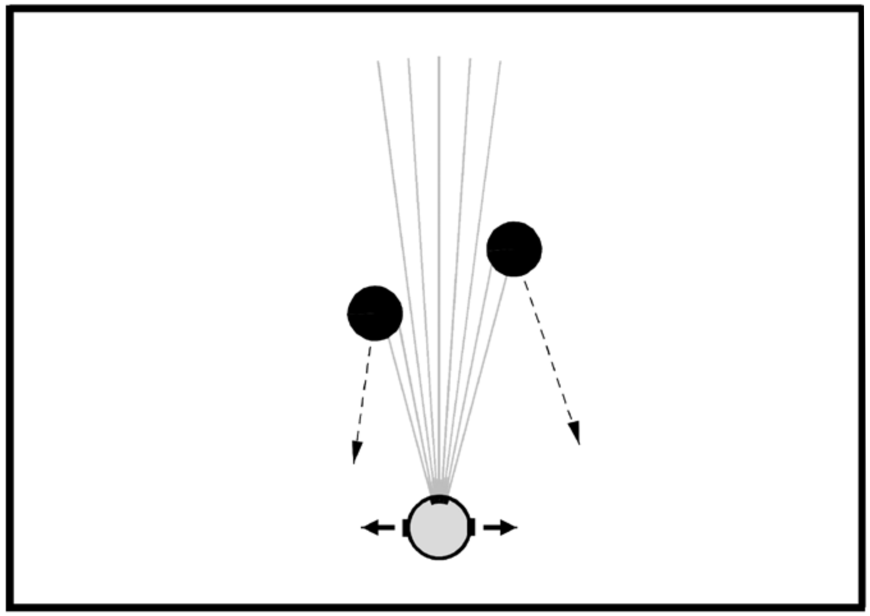
Randall Beer's work — now at the forefront of a new movement in the field of cognitive science — simulates brain-body-environment systems to decode even simple behaviors.

How is sophisticated behavior produced? Investigations of this question typically center on the brain, with the body relegated to a kind of puppet whose only job is to dance faithfully to the tune of the nervous system on the stage of the environment.

There is, of course, no question that neural activity plays a central role in the generation of behavior. But it is becoming increasingly clear that bodies and environments themselves have their own intrinsic dynamics, which continuously shape and are shaped by their interaction with the brain.

Beer

For the past 20 years, the main focus of Professor Randall Beer's research has been on exploring how behavior arises from such coupled brain-body-environment systems, primarily through the evolution and analysis of computer simulations of such systems.



This figure illustrates an evolved agent that must catch multiple objects, a task that involves selective attention, memory, and prediction.

An evolutionary algorithm is a search technique loosely based on biological evolution. A search begins with an initially random population of individuals representing potential solutions to some problem. Each individual is assigned a fitness based on the quality of his or her performance on the given task.

Individuals are then selected to serve as parents for the next generation with a probability related to fitness. From the selected parents, a new generation of children is produced with random, small modifications made to a parent or swapped portions of two parents. Once a new population has been constructed in this manner, the entire process repeats until the population converges on highly fit individuals.

"The key feature of evolutionary algorithms is that they allow us to explore the full range of possible solutions to a problem without being overly biased by our own intuitions about the form a solution must take," Beer says.

So how does this work? Consider a simple behavior like walking. A model body with legs, joints, muscles, etc., is connected via sensors and effectors to an evolvable model nervous system. A natural way to calculate walking performance is to measure the forward distance traveled by the body in a given length of time. Most random agents in the initial population cannot move forward at all because, for example, they do not put their feet down or they do not swing their legs in a coordinated way. But some will move forward a tiny amount, and some will move forward a bit more. This is the kind of difference that an evolutionary process can amplify until, after hundreds or thousands of generations, the population is full of extremely efficient walking agents.

Somewhat surprisingly, this evolutionary approach can also be applied to behaviors that are much more complicated than walking. For example, agents have been evolved that can learn to associate different smells with the edibility of food. In recent years, Beer has been focusing on what he calls "minimally-cognitive behavior," the simplest behavior that raises issues of genuine cognitive interest. Toward that end, he and his students have evolved agents that can perceive opportunities for action in their environment, remember the locations of objects that are temporarily lost sight of, visually discriminate between different objects based on their properties (e.g., shape) and relations (e.g., smaller-than), and interact selectively with one of a group of objects in their field of view. "It is really quite remarkable that these simple agents can exhibit such a range of seemingly sophisticated behavior," says Beer.

Most recently, Beer and graduate student Paul Williams have been exploring the evolution of referential communication, in which one agent communicates information about a distant target to another agent. This work was inspired by the honeybee waggle dance. When a foraging bee finds a resource (e.g., a source of nectar or water), it returns to the hive and recruits other bees by performing a dance that encodes the direction and distance of that resource. The recruited bees then fly off to collect the resource and transport it back to the hive. In the model, one agent (the sender) knows the location of a target that another agent (the receiver) cannot perceive. After interacting with the sender, the receiver must move to and stop at the invisible target. Beer and Williams found that a variety of different communication strategies evolved depending on how the motion of the sender was constrained.

Beyond demonstrating that it can be done, what is the point of evolving all of these model agents?

For Beer, the evolution is just the first step. The main focus of his work is trying to understand how these evolved agents work. Using the mathematical tools of dynamical systems theory and information theory, Beer and his students explore such questions as, "What common features are shared by the best-performing agents?" and "How are the evolved solutions spread across neural activity, properties of the body and the environment?"

Just as Galileo's study of such idealized situations as frictionless planes eventually led to Newton's laws of motion, Beer hopes that his study of "frictionless brains" (and bodies and environments) will likewise lead to insights into natural organisms. "For us," he says, "these evolved model agents are theoretical warm-up exercises for tackling the much more complicated brain-body-environment systems that biological evolution has produced."

Beer's work is just part of a much larger movement toward situated, embodied, and

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Putting your mind into Google™


Jones

As former President Bill Clinton made clear, inferring meaning from language can be a slippery operation to define. Meaning is simultaneously the most obvious feature of language (we can all do it rapidly and automatically), and the most mysterious aspect to study.

In his laboratory, IU Cognitive Science Professor Michael Jones studies how the human brain learns meaning from statistical experience with language, how this knowledge is represented, and how it is used to compute meaning in context.

"Although semantics are intuitively obvious to humans, attempts to emulate this knowledge with artificially intelligent systems has met with continued failure," Jones notes. "Tasks which are trivially easy for infants to learn are still beyond the capability of even the most sophisticated computer algorithms."

The obvious solution for Jones: If humans are so good at computing meaning, let's study and model human semantic cognition, and try to build these models into machine systems that deal with information retrieval. "The human mind has been 'designed' to efficiently compute meaning from language and to deal with massive amounts of semantic data," Jones says. "A better understanding of human semantic cognition can lead to better machine systems to deal with linguistic information."

The interdisciplinary nature of the Cognitive Science Program was a huge draw to Jones, whose approach has always integrated computational modeling with human experimentation.

His graduate work was jointly in cognitive psychology and high-performance computing, and his postdoctoral work at the University of Colorado's Institute of Cognitive Science focused on integration across computing science, psychology, and education. His "BEAGLE" model, recently published in *Psychological Review*, simulates how the human brain averages signals to efficiently learn and use meaning from experience with language, and has already been used as a knowledge representation in a variety of practical systems, from information retrieval to medical diagnosis.

Jones' modeling work has recently attracted the attention of Google Inc. Google has funded his research to integrate human and machine models of semantic representation.

When you enter Google search terms, the system must rapidly determine the semantic relevance of every possible document on the Web to the query, and return a ranked list. Although the exact methods used by search engines are trade secrets, it is clear that they are well beyond keyword matching and instead rely on sophisticated statistical models to represent the meanings of documents.

However, Google is not human, and must guess how the meaning of a Web page lines up with what the human user is searching for. While human semantic representations are built through a lifetime of language experience and perceptual interaction, Google's semantic representation is based only on statistical counts of how words are used in contexts. Hence, Google is working with an impoverished representation of meaning because it has not had the same richness of information as has the human user, nor does it learn things in the same way.

Jones' work with Google is paving the way to perceptually grounded information-retrieval systems based on research with human-embodied cognition. Sensorimotor information is an inherent part of the organization of human semantic memory, but much of this information cannot be learned from statistics in language — it must be learned from multisensory experience. This line of research will help systems like Google know how things look, feel, and taste, as well as how words are used in language.

"With computers and portable devices now able to see and hear their environments, we must be ready with computational models to integrate multisensory information into a better representation of knowledge," says Jones. "Binding together these sources of information is tricky, but not impossible — humans do it every day."

In addition to knowledge representation, Jones' research models the way that humans apply implicit knowledge across a large amount of linguistic experience. A massive amount of unrealized knowledge on the Internet is distributed across many documents rather than located in any specific one.

"It depends on what the meaning of the word 'is' is."

— Bill Clinton, Grand Jury Testimony

While search engines are based on a model of retrieving a particular document that may contain the information you are searching for, humans are able to retrieve abstracted knowledge rather than memory for a particular instance; this is particularly useful when the knowledge must be inferred across multiple data sources. Cognitive models will have a place in the future of the so-called Semantic Web, and there is great potential for discovery of yet unrealized knowledge from large text sources.

Jones' computational models also afford application to clinically relevant issues. The Indiana *Center for Translational Sciences Initiative* (CTSI) recently awarded Jones and Andrew Saykin, of the IU School of Medicine, a grant to model the process of memory degradation in Alzheimer's disease. While it is straightforward to study the loss of episodic memory with aging (e.g., misplacing keys, forgetting names), semantic memory has been much more difficult to quantify.

However, Jones' semantic models are now showing promise at detecting patterns of semantic behavior that are characteristic of early stage Alzheimer's disease as much as 10 to 15 years before the disease is typically diagnosed. Earlier detection can lead to earlier pharmacological treatment, preserving memory much longer, and potentially saving billions in healthcare costs.

Continuing IU's strong tradition of cognitive modeling, Jones is careful to learn lessons from the field's founders. He was recently invited to speak on new directions for cognitive modeling at the NSF Future of Cognitive Science Workshop. His advice for the future was to look at past patterns. Hence the title of his talk: "Putting the blood, sweat, and tears back into cognitive modeling," a recasting of a classic paper by IU Distinguished Scholar of Psychological and Brain Sciences William K. Estes on the future of mathematical psychology. Estes published that paper the same year that Jones was born.

One year out: Chris Honey, PhD'09

Cognitive Science attracts those who like to think across the boundaries of academic disciplines, and work in the field is unusually wide-ranging, but even scientists and students in the field can be surprised to look back and discover how far their intellectual journey has taken them.

Chris Honey, PhD'09, entered IU's graduate program with undergraduate majors in Math and English Lit, and ended up writing a dissertation that combined ideas from network theory and neuroscience. "When I started out, I was thinking about the human brain as a kind of computer," he said. "But as I learned more about the biological nuts and bolts, I started to see the brain from a new perspective: as something more like a rainforest, in which proteins are interacting with one another inside of neurons, and neurons and gial cells are tangled up in local circuits, and all these brain regions are coupled by communication highways made out of nerves. The parallel activity of all of these structures gives rise to our computational abilities, and to our perceptual world. What could be more fascinating?"A basic step in understanding this fascinating system is to determine which parts of the brain are connected to one another.

CHARTING A NEW MAP

When Honey entered graduate school in 2004, surprisingly little was known about the macroscopic connectivity of the human brain. In his graduate work — conducted under the mentorship of Professor Olaf Sporns and in collaboration with Swiss neuroimaging experts — Honey attempted to compile a rough draft of how thousands of different regions of the brain are interconnected. The goal: to build something like a highway map of the brain.

Honey and co-researchers collected data to construct brain networks using diffusion spectrum imaging, a novel neuroimaging technique that infers the orientation of nerve fibers in the brain via their effect on the motion of nearby water particles. After looking at the first drafts of the connection map, Honey and his collaborators noticed that the anatomical patterns could also predict which regions of the brain would tend to cooperate and interact in the course of ongoing brain function.

When these brain networks were published in 2008 in the open access journal *PLoS Biology,* they made a splash, receiving coverage from international news organizations including the *New York Times*. In his time at IU, Honey also published articles in the journals *Proceedings of the National Academies of Sciences*, *Journal of Neuroscience*, and *Human Brain Mapping*, among others.

"What you learn in the classroom is important. But what is indispensable, and what made a real difference to my grad school experience, is what you learn in conversation with professors and colleagues, in the hallways of your department, at departmental colloquia, at conferences and at summer schools," Honey said. "Coming from a quantitative background, I would never have been able to contribute to this successful neuroscience collaboration without all of the financial and intellectual support I received at IU."

LEARNING TO LOVE TEACHING

Honey received funding to attend the Complex Systems Summer School at the Santa Fe Institute in 2005 as well as a Computational Neuroscience Training Program at the Marine Biological Laboratory on Cape Cod in 2007. He also had the chance to network and to discuss science at conferences in San Diego, Minneapolis, Washington, D.C., Memphis, and Chicago, and was able to present his brain mapping work to a broad audience at the Human Brain Mapping meeting in Melbourne in 2008.

Chris Honey, PhD'09

"I'm surprised by how far I have come, how much I learned since I walked in the door at IU."

— Chris Honey, PhD'09

When not taking classes and analyzing data, Honey organized a neuroscience reading group, which attracted attendees from the departments of psychology, cognitive science, informatics, and physics and from IU's Biocomplexity Institute. He financed his work through a combination of grant funding, supplemental research funding, and work as a teaching assistant and undergraduate instructor. "My semester of teaching was a valuable learning experience, though I should add that neither I nor the students would have learned half as much if I had not taken a compulsory class in teaching methodology beforehand!"

After graduating in 2009 with a double major in cognitive science and psychology, Honey took up a postdoctoral research post in the Psychology Department at Princeton University, where he is analyzing electrophysiological signals recorded from the surface of the human brain.

"I am really excited about this next project. And looking back, I'm surprised by how far I have come, how much I learned since I walked in the door at IU," Honey said. "The atmosphere on campus really stands out in my memory. There are so many smart people across the Cognitive Science Program who work with open doors and who are keen to discuss ideas day and night. The attitude at research seminars was always positive, inquisitive and collegial. Possibly that's just a product of the natural curiosity of cognitive scientists, but it's definitely something that I found at IU."


Allen


Beer


Brown


Gershkoff-Stowe


Hagar


Kuebler


Moss


Ostrom


Scheutz


Schiffrin


E. Smith


L. Smith


Todd


Yeager

Awards, publications, & research

In May 2009, **Colin Allen** received a $400,000 grant from the National Endowment for the Humanities for "InPhO @ Work: Providing Integrated Access to Philosophy." He gave the presidential address at the 2009 conference of the Society for Philosophy and Psychology. In July 2009, he was the featured speaker and panelist at the Adelaide Festival of Ideas, in Australia. In October 2009 Allen served as Ida Cordelia Beam Visiting Distinguished Professor at the University of Iowa.

Randall Beer is principal investigator for the $3.1 million, five-year grant that Indiana University cognitive scientists received from the National Science Foundation to create and employ innovative methods for training future scientists.

Assistant Professor **Joshua Brown** received a two-year $684,000 grant from the National Institutes of Health. The grant is for a project aimed at understanding how certain parts of the brain learn to predict the outcome of one's actions.

The National Science Foundation awarded $467,000 to Associate Professor **Lisa Gershkoff-Stowe** to study the word-retrieval processes of young children and the nature of the mechanisms that underlie their development.

Chancellor's Professor and Director of IU's Cognitive Science Program **Robert Goldstone** received a grant for $1.1 million in September 2009. The National Science Foundation award supports Goldstone's work with Dr. Sam Day on the transfer of perceptually grounded scientific principles.

Assistant Professor **Amit Hagar** received a $222,000 NSF Scholar's Award for 2010. This grant will be used to study the notion of minimal length (spatial discreteness and/or finite measurement resolution) in modern physics.

College of Arts and Sciences Distinguished Professor of Cognitive Science **Douglas Hofstadter** was elected a member of the American Academy of Arts and Sciences in April 2009. Hofstadter was also elected a member of the American Philosophical Society.

Professor **Larry Moss** gave an invited lecture in December 2009 at the Amsterdam Colloquium, one of the main conferences in the area of natural language semantics. His lecture focused on his work in natural logic, an attempt to rethink the relation of logic and language.

Elinor Ostrom, Arthur F. Bentley Professor of Political Science, Professor of Public and Environmental Affairs, Co-Director of the Workshop in Political Theory and Policy Analysis, and a member of the Cognitive Science Program, was named the co-recipient of the 2009 Nobel Prize for Economics. She is one of only 64 people and the first woman to receive the award.

Professors **Matthias Scheutz** and **Larry Moss** and Assistant Professor **Sandra Kuebler** are among the organizers of the 4th North American Summer School in Logic, Language, and Information, to be held in Bloomington in June 2010. The school will offer a number of courses of cognitive science interest. For additional information please visit www.indiana.edu/~nassli.

Luther Dana Waterman Professor **Richard Shiffrin** won the 2009 Henry R. Besch, Jr. Promotion of Excellence Award. This award is given by the Indiana University Alliance of Distinguished and Titled Professors, and recognizes outstanding service at Indiana University.

Chancellor's Professor **Eliot R. Smith** was appointed instructor for one of the five courses offered in the two-week intensive Summer Institute for Social Psychology (SISP) held in Evanston, Ill., in July 2009. This program, funded by the NSF, is held every two years and attracts a highly select group of approximately 75 graduate students from the U.S. and abroad.

Chancellor's Professor **Linda Smith** was awarded the 2009 IU Office of Women's Affairs Distinguished Scholar Award.

Professor **Peter Todd** and researchers at the Max Planck Institute for Human Development in Berlin are enjoying wide media coverage for their new study on diet complexity, published in 2010 in the online journal Appetite. Their study was featured in an *L.A. Times* article.

Professor **Larry Yeager** was one of the top five winners in a competition hosted by Culture Lab, a science news blog from *New Scientist*. The competition involved creating the cleverest way to incorporate a line from the 150th anniversary special edition of Charles Darwin's *On the Origin of Species*.

Find out more about our faculty members at **www.cogs.indiana.edu**.

Q&A: Alumna leads businesses, governments in 'going green'

This quarter, *Mind Reader* caught up with alumna Claire Tramm, BS'06, who has emerged as a leader in sustainability since completing degrees in cognitive science, psychology, and political science, as well as a certificate in management from IU's Liberal Arts and Management Program.

Still in her early years as a professional, Tramm has already helped develop sustainability plans and lead implementation of cost-saving green initiatives at several Fortune 500 companies; she's also done extensive modeling and research for several major reports on energy efficiency and the economic impacts of climate change policies while working for McKinsey & Company, a management consulting firm. These days, Tramm is leading implementation of the Chicago Climate Action Plan. She works to ensure a ready workforce for green jobs in the Chicago area while on loan to the Civic Consulting Alliance.

Claire Tramm, BS'06

***Mind Reader:** You certainly sound like a consummate interdisciplinarian. Did that have anything to do with why you chose to major in cognitive science?*

Claire Tramm: It definitely did. I knew I wanted to be part of a program that encouraged interdisciplinary study — something I'm a huge believer in — of a very rich, important, and quickly developing topic area like the human brain. It turned out that my studies in cognitive science would become the beginning of a much larger journey into the study of human behavior and decision-making at many levels.

***MR:** I understand you received a Cognitive Science Undergraduate Research Grant for work on mate choice. Tell me more about it.*

Tramm: I actually became interested in evolutionary psychology and how people make mate choice decisions during a tutorial called "Psychology of Gender" while at Oxford my junior year. When I returned to IU, all of the seniors were in this fantastic CogSci Senior Seminar class with Professor Peter Todd, who was also very interested in the topic and had just come to Indiana from Berlin's Adaptive Behavior and Cognition Research Group. That group was involved in collecting the largest speed-dating data set ever amassed, including biometric, stated preferences, personality measures, you name it, so it presented a great opportunity for me to get involved with research in the area. We inserted another measure, which allowed me to investigate whether people can accurately assess whether other people are romantically interested in them. The biggest thrill of the entire experience was giving a research talk on the study's results at the Human Behavior and Evolution Society Conference. As it turns out, we're actually only slightly better than chance — with no group above 60 percent accuracy — at assessing, at least in a speed-dating context, whether other people like us or not, regardless of gender or age. It really is a wonder people ever find each other at all!

***MR:** Sounds like you really made the most of the Cognitive Science Program's offerings. Tell me — how did you find your way from doing speed dating research to working at a top-tier consulting firm?*

Tramm: [Chuckling] That's a very good question. I think one of the common threads between the two is that I enjoy working on fundamental, complex problems involving human decision-making. Most of the work I do now is very action-oriented, which means at the end of the day, a person or group has to make a big decision that will drive policy and/or business forward in the immediate future. I really enjoy helping direct and inform the decision-making process and seeing the impact of my work.

***MR:** You've focused on applying your leadership skills to work related to sustainability and climate change. How did you become so passionate about this particular topic?*

Tramm: I believe that, in addition to seeking a measure of personal joy and fulfillment, one should devote one's life's work to solving a problem in the world and, in so doing, leave it a better place for having been a part of it. The way I see it, the first priority should be making sure we have a livable home for our own and future generations of humans; all our other problems will become irrelevant if we don't solve that one.

***MR:** I'm sure Abraham Maslow would agree with you. Do you see any connection between cognitive science and preventing climate change?*

Tramm: Absolutely. In order to prevent climate change, we must do many things, one of which is unlocking the mystery of how to change people's mindsets and behaviors. I've had several experiences where I've had to use my cognitive science and psychology background to analyze how people make decisions about, for example, their investment in energy efficiency, their adoption of paperless communication options, or their investment in fuel-efficient vehicles. If we can help businesses and policymakers design strategic changes in those decision architectures by using our understanding of human decision-making, we will encourage people to make more environmentally responsible decisions without requiring a high level of cognizance on everyone's part. I've heard *Nudge* (by Richard H. Thaler and Cass R. Sunstein) is a great book on this topic but haven't had a chance to read it yet.

***MR:** So have you ever actually been able to change the decision architecture on one of these issues?*

Tramm: Yes, and I can tell you that it's easier said than done. However, as an additional incentive, there are huge cost-saving and customer-satisfaction opportunities out there if you can get it right. I was able to help one

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Student Notes

Undergraduate awards

- **Kate Sanders** was named a Cox Research Scholar in 2009.
- **Jaime Murdock** and **Jordan Thevenow-Harrison**, BS'08, received the 2009 Cognitive Science Program Outstanding Contribution Award.
- **Nicole Beckage** received the 2009 Cognitive Science Program Outstanding Research Award.
- **Brenden Sewell** received the 2009 Cognitive Science Program Outstanding Achievement Award.

Undergraduate Summer Scholarships

The following undergraduate students received the 2009 Cognitive Science Program Undergraduate Summer Scholarship:

- **Damian Fricker**, BS student
- **Jaimie Murdock**, BS student
- **Emily Cahill**, BS student
- **Nicole Beckage**, BA student
- **Margaret Brumbaugh**, BS'09

Graduate student awards

- **Ronaldo Vigo**, PhD'08 and **Georg Theiner**, PhD'08 received the 2009 Cognitive Science Program PhD Outstanding Dissertation Award.
- **Ryan Jessup**, PhD'08 received the 2009 Cognitive Science Program PhD Student Research Achievement Award.
- **Paul Williams** received the 2009 Cognitive Science Program Outstanding Teaching Award.
- **Gabriel Recchia** received a 2010 College of Arts & Sciences travel award for $300. Gabriel also received honorable mention in the 2009 NSF Graduate Research Scholarship competition.
- **Sunah Kim** received a 2009 Society for Neuroscience (SFN) Graduate Student Travel Award. This award is offered to honor outstanding graduate researchers.
- **Lisa Cantrell** received a National Science Foundation Graduate Fellowship and a Tinker Foundation Grant for research in Latin American, both in 2009.

2009–2010 Supplemental Research Awards

The following PhD students received the 2009–2010 Cognitive Science Program Supplemental Research Award:Brain Sciences

- **Andy Somogyi**, Cognitive Science Program and Department of Physics
- **Chi-hsin Chen**, Cognitive Science Program and School of Speech and Hearing
- **Drew Hendrickson**, Cognitive Science Program and Department of Psychological and Brain Sciences
- **Gabriel Recchia**, Cognitive Science Program
- **Joe Houpt**, Cognitive Science Program and Department of Psychological and Brain Sciences
- **Seth Frey**, Cognitive Science Program

2009 PhD dissertations

Joe Anderson
Walking to Reach: Information Variables and Control Strategies for Nested Actions
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Geoffrey Bingham (chair); Chen Yu (co-chair); Thomas Busey; Rowan Candy

George Chadderdon
A Neurocomputational Model of the Functional Role of Dopamine in Stimulus-Response Task Learning and Performance
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Olaf Sporns (chair); James Townsend; Peter Todd; Joshua Brown

Joshua Goldberg
When, Not Where: A Dynamical Field Theory of Infant Gaze
PhD School of Informatics and Computing/ Cognitive Science Program
Committee: Michael Gasser (co-chair); Linda Smith (co-chair); Susan Jones; Robert Port; Gregor Schoner, John Spence

Christopher Honey
Fluctuations and Flows in Large-Scale Brain Networks
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Olaf Sporns (chair); James Townsend; Robert Goldstone; John Beggs

Vsevolod Kapatsinski
The Architecture of Grammar in Artificial Grammar Learning: Formal Biases in the Acquisition of Morphophonology and the Nature of the Learning Task
PhD Linguistics/Cognitive Science Program
Committee: Kenneth DeJong (chair); David Pisoni (co-chair); Robert Port; Linda Smith

Eric Dimperio
A Dynamic Model of Planning Behaviors in Multi-stage Risky Decision Tasks
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Jerome Busemeyer (chair); John Kruschke (co-chair); Robert Goldstone; Matthias Scheutz

Rima Hanania
Selective Attention and Attention Shifting in Preschool Children
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Linda Smith (chair); Lisa Gershkoff-Stowe (co-chair); Robert Goldstone; Susan Jones

Sungkyoung Lee
Understanding Available Resources during TV Message Processing: Audio/Video Redundancy, Emotion, Structural Complexity, and Motivated Cognition
PhD Telecommunications/Cognitive Science Program
Committee: Annie Lang (chair); Thomas James (co-chair); Julia Fox; Robert Potter

Angela Nelson
Examining the Co-evolution of Knowledge and Event Memory
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Richard Shiffrin (chair); Robert Goldstone (co-chair); Karin James; Thomas Busey

Stephen Denton
Exploring Active Learning in a Bayesian Framework
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: John Kruschke (chair); Jerome Busemeyer (co-chair); Michael Jones; Peter Todd

Young Lim Lee
Metric Shape can be Perceived Accurately and Used Both for Object Recognition and Visually Guided Action
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Geoffrey Bingham (chair); Thomas Busey (co-chair); Thomas James; Andrew Hanson

(list continued on page 10)

[Cognitive Science scrapbook 2009]

Clockwise from above: **a)** Recipients of the Cognitive Science Program Undergraduate Awards, from left to right: Emily Cahill, Damian Fricker, Brenden Sewell, Nicole Beckage, Jordan Thevenow-Harrison, and Jaimie Murdock; **b)** Graduate student Robert Bowers presents on the Pleo Dinosaur research project during the Robotics Open House; **c)** Cramer, the humanoid robot, was a popular research display during the 2009 Cognitive Science Program Robotics Open House, held at Eigenmann Hall; **d)** Graduate student Carlos Zednik (left) congratulates Paul Williams, recipient of the 2009 Cognitive Science Outstanding Teaching Award; and **e)** Graduate Award winners for 2009 were, from left to right: Ryan Jessup, Ronaldo Vigo and Georg Theiner.

PhD dissertations

(continued from page 9)

Krystal Klein
Vocabulary Acquisition via Cross-Situational Statistical Learning
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Richard Shiffrin (chair); Chen Yu (co-chair); Karin James; Linda Smith

Francisco Lara-Dammer
Modeling Human Discoverativity in Geometry
PhD School of Informatics and Computing/ Cognitive Science Program
Committee: Douglas Hofstadter (chair); David Leake (co-chair); Michael Gasser; Larry Moss

Alfredo Pereira
Development of Systematic Object Viewpoint Selection during Active Object Manipulation from Late Infancy to Early Childhood
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Linda Smith (chair); Karin James; Chen Yu; Susan Jones

Abhijit Mahabal
Seqsee: A Concept-centered Architecture for Sequence
PhD School of Informatics and Computing/ Cognitive Science Program
Committee: Douglas Hofstadter (chair); Robert Goldstone; David Leake; Michael Gasser

Bethany Schneider
Learning to 'See through the Noise:' A Training Study on the Development of Fingerprint Expertise
PhD Psychological and Brain Sciences/Cognitive Science Program
Committee: Thomas Busey (chair); T. Rowan Candy; Jason Gold; Robert Goldstone; Thomas James

Tramm

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of my clients save hundreds of millions of dollars a year in printing, paper, and postage costs for financial communications by defaulting customers to e-delivery whenever legally possible and then using every customer touch point to force a decision on e-delivery and not-so-subtly encourage customers to consent. Basically, we just made "doing the right thing" the path of least resistance for the customer.

***Mind Reader:** That sounds like a very effective approach. Any thoughts about returning to cognitive science research again one day?*

Tramm: I'd love to do research on pathways and effects of hormones like Oxytocin, which are believed to play a big role in long-term pair bonding. I'd also like to do work on revealing what organizational development and management can learn from neurological development. For right now, though, I'm really focused on helping policymakers and businesses optimize the response to climate change and capitalize on the many opportunities a greener economy presents. I'm still deciding where to go to graduate school and what exactly to go for, but I'll keep you posted as things develop!

FARGonauts

(continued from page 3)

seen as being deterministic; rather, our models are all pervaded by randomness or "stochasticity," to use a fancier term for the same idea.

Each run of any FARG program will be different from the next run, even if the program is facing exactly the same situation. The pathway it follows will be totally different, if looked at on the most fine-grained level, although if one steps back from the trees to see the forest — that is, if one looks only at the very high-level (coarse-grained) behavior of the program — it may be that two runs are completely identical at that level of description. (Notice that observing and describing a program's high-level behavior is in itself an act of very high-level perception.)

As we have moved from FARG's early days, 30 or more years ago, into our more "mature" phase, we have come to be increasingly focused on having our models be able to look at their own (forest-level, not tree-level!) behavior. In other words, we've felt an increasing need to have our programs' own behavior become part of the microdomain that models perceive and "think about." This is a very difficult challenge, and although we have been working hard at it for at least a decade or more now, we are still only at the very beginning.

One last word. Although we FARGonauts devise, implement, test, and revise computer models of thought processes, we do not consider ourselves to be carrying out artificial-intelligence research. The reason for this is that we are only trying to understand what human minds do; we build our models not in order to make computers "smarter" but in order to understand more clearly the huge gulf that lies between computers in their standard incarnations and human minds. Many AI researchers want to make programs that avoid errors like the plague, we are interested in precisely the opposite. We are delighted when our programs make clumsy, stupid errors. We rejoice in such "fluidity." Indeed, we want our programs to be able to be confused, blurry, totally lost, and frustrated. We hope, one day, that our programs might have just the barest glimmerings of a sense of humor, and in the midst of their own confused flailings, would be able to recognize how pathetic are their efforts, and to laugh at themselves. That would be a happy day for us FARGonauts.

FARGonauts like Hofstadter, above with Program Director Robert Goldstone, want their programs to exhibit traits simlar to human minds — "to be able to be confused, blurry, totally lost, and frustrated."

Frictionless brains

(continued from page 4)

dynamical approaches that is currently taking place within cognitive science, psychology, neuroscience, robotics, and philosophy of mind. This emerging new perspective requires new training experience for graduate students.

In order to meet this need, Beer, along with co-PIs Rob Goldstone, Linda Smith, and Olaf Sporns, directs a new $3 million training grant from the National Science Foundation's Integrative Graduate Education and Research Traineeship (IGERT) program, "The Dynamics of Brain-Body-Environment Systems in Behavior and Cognition." The program offers new courses in situated, embodied, and dynamical cognitive science; a professional development seminar; summer research internships; an annual research showcase; and a colloquium series offering extended opportunities for trainees to interact with visting speakers.

"Our goal is to train doctoral students to think across traditional levels of analysis in the cognitive, behavioral, and brain sciences," Beer says.

Learn more about Beer's work with the National Science Foundation IGERT project at: **igert.cogs.indiana.edu**

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