

MSU's Cognitive Science Program Wins IGERT Grant from NSF

In the fall of 2001, the National Science Foundation awarded Michigan State University's Cognitive Science Program the prestigious Integrative Graduate Education and Research Traineeship (IGERT) grant. The Cognitive Science Program, another of MSU's nationally-recognized programs on the cutting edge of interdisciplinary studies, is one of only about 20 programs from all disciplines and universities across the country that received an IGERT grant this year.

Worth \$2.5 million over five years, the IGERT grant is part of a recent NSF initiative to support multi-disciplinary education in the sciences and engineering and thus to prepare graduate students for the changing workplace of the future. According to the National Science Foundation (<http://nsf.gov/igert>), "The (IGERT) program is intended to catalyze a cultural change in graduate education, for students, faculty, and universities, by establishing new, innovative models for graduate education in a fertile environment for collaborative research that transcends traditional disciplinary boundaries." This grant is dedicated entirely to graduate student training. It funds graduate student stipends, equipment, research, and travel, thereby freeing graduate students to focus on their scholarship and professional development.

The study of sequential decision-making, how to combine information from the environment and information from memory to make desirable decisions in the present moment, is a core research theme for the faculty and graduate students associated with the IGERT grant at MSU. Such decisions by humans, animals, and intelligent machines rely on a series of earlier, related choices which help them select the present course of action. How does this decision-making process work, particularly when the outcome is uncertain? Integrating their research on humans, animals and intelligent machines, faculty and graduate students from the various disciplines involved in the IGERT grant use this general focus as a framework for their individual studies about the nature of decision-making. This framework sets up an environment in which each project holds implications for and provides new approaches to the others.

To facilitate the open exchange of ideas under the project's framework, principal investigators and graduate students meet regularly in open discussions. Each week, students and faculty from a different lab give a short presentation about their work, discoveries, and any problems that have arisen. Coming together in this organized fashion allows for direct feedback from the researchers in other disciplines as well as collaborative brainstorming and problem-solving. Dan Gajewski, a second-year graduate student in Psychology, points out, "Each discipline tends to

develop its own way of talking about and thinking through problems that overlap with other disciplines. One benefit of coming together is that we have the opportunity to learn the language and processes of other disciplines. This, in turn, opens us up to looking at our projects in ways that we otherwise might not. Working together with people in different fields allows for a fresh give-and-take of ideas and offers new ways of approaching research questions."



How do people direct their gaze when searching for objects? Psychology graduate students Dan Gajewski and Monica Castelhana demonstrate the eye-tracking machine that records eye movement patterns.

Dr. John Henderson, Director of the Cognitive Science Program, explains that work under the IGERT grant takes place on several different levels. "On one level, we are each in our own labs doing our own research under the project framework. On another level, we study questions in our labs that are motivated directly by what's going on in the other IGERT labs. We generate questions and ideas with each other as an outgrowth of the interaction of the various fields. Then, we come back together to share our results. This kind of give and take leads to new approaches and insights. Finally, there's a third level where people from different departments share lab space and work together in the same physical environment. The IGERT grant makes such close collaboration possible."

The history of MSU's IGERT grant is closely connected to the history of the Cognitive Science Program, which started at MSU approximately five years ago. According to Dr. Henderson, numerous people on campus were interested in interdisciplinary work related to information processing in machines, humans, and other animals, but there was no formal

recognition or mechanism for bringing these scholars from various departments together. This made it difficult to connect with potential collaborators. Beginning with a short symposium, the interest in working across disciplines developed into the creation of a new program. With the support of the Provost's Office and Deans from the College of Arts and Letters, the College of Social Science, the College of Natural Science, The College of Engineering, and the College of Communication Arts and Sciences, the graduate program in Cognitive Science allowed for cohesion among the interested faculty and immediately led to research collaborations.

One such collaboration among Psychology, Computer Science, and Zoology faculty resulted in a Knowledge and Distributive Intelligence (KDI) Grant from the National Science Foundation, a grant which laid the groundwork for the current IGERT grant. Working under the KDI grant, researchers in the Cognitive Science Program studied sequential decision-making and realized that such interdisciplinary collaboration would provide a good framework for graduate student training. The IGERT grant proposal grew from this realization. Five principal investigators set up the research plan: Dr. Fred Dyer (Zoology), Dr. Fernanda Ferreira (Psychology/Linguistics), Dr. Tom Getty (Zoology), Dr. John Henderson (Psychology), and Dr. Sridhar Mahadevan (Computer Science and Engineering). In addition to the principal researchers, the grant allows for participation by the more than 30 other faculty members in the Cognitive Science Program.

Within each discipline, a variety of labs conduct research on sequential decision-making. The results are then brought to the larger group. Some psychology graduate students working under the IGERT grant focus on gaze control in humans—how do people move their eyes appropriately to pick up information needed for the tasks in which they are engaged? Every complex task or activity requires that a person directs his or her eyes to certain locations; people do so automatically, many times per second. The visual information is rapidly processed in the brain and used to make complex decisions such that the person looks at the right place at the right time. People aren't consciously aware of these sequential decisions, but they are happening all the time. For example, when a woman walks into a room, she knows she is in an office and that she should look for an object like a telephone on the desk, and not on the floor or chair. In a split second, using visual information and memory, she has already made a number of decisions about where to direct her eyes in the scene. This process becomes more complicated in activities such as driving, yet the same visual control system makes it possible.

In the lab, researchers measure a person's gaze patterns in milliseconds using visual eye-tracking technology. Computers can map out where people look in a given situation and then can provide data for understanding how gaze control works. One graduate student, Monica Castelhana, studies how much visual information a person can remember and use in the long term from a single glimpse. If a person looks briefly at something and then looks away, how much information will that person remember later? In the lab, she presents subjects with photos of different scenes and asks them to do different things like identify objects or search for one specific object. One group is told to memorize and another is not. The eye-tracker shows where people look when trying to memorize, compared to where people look when searching for a target object. Castelhana has found scene context can be used to quickly direct the eyes to the search object. In addition, Castelhana has found that both groups remember objects similarly, provided they looked at those objects originally. This occurs even though only one group is actually trying to memorize, an important finding for understanding the nature of visual memory. It also suggests that incidental visual processing results in strong memory representations.

In a related project, psychology graduate student Dan Gajewski examines visual control in the short term. Dan presents subjects with two scenes and asks if they are similar or different. He then tracks their eye movement to see where the subjects look as they compare the pictures. Dan finds that the subjects don't notice the difference until they look directly at the differing area in the scene's two versions. This finding calls into question the belief that people see the entire scene at once. Instead, the visual map has more or less detail based on where the person's attentional focus lies. Not only does this provide information about why and how people hold different things in their memory; it also points to the way in which attention and gaze are controlled sequentially as they interact with the visual world.

Under principal investigator Dr. Fred Dyer, Professor of Zoology, IGERT graduate students in zoology focus on the



When reading or listening to sentences, people re-order ambiguous words or structures. "If we can learn how humans do this, we can apply that knowledge to advancements in computer technologies."

**--Dr. Fernanda Ferreira,
Professor of Psychology
and Linguistics**

sequential decisions that bees make while navigating to and from the hive in their search for food. How do honeybees use landmarks to pinpoint food? How do they use visual attention to best find the food and return to it later? While bees may use a circuitous route to find food, they are able to take a direct path back to the hive. How do they know how to do this? To explore questions like these, the researchers have set up a one-way system of small tubes leading to and from a tented area containing a food source. A surveillance camera traces the movement patterns of the bees as they zero in on the food. Next, a software program translates the images into diagrams which the researchers then use to determine how the bees find

meetings. “All of my research questions have been motivated or affected by the people in different fields. I may not have come up with some of my ideas otherwise. Working under the IGERT grant is very helpful for integrating with other disciplines and understanding the angles from which other fields see similar issues.” The nature of this training grant has also given him a more versatile education that he will take with him outside MSU. “Usually, during the thesis or dissertation, a person learns the techniques specific to that project. Unless you were going to continue to work with bees in your career, you’d have to start all over learning techniques for a new area of study. With the IGERT grant, you can learn a



To understand how bees use visual cues to remember where to find a food source, Frank Bartlett manipulates different landmarks in a tented area and graphs bees' flight patterns.

their way. They control for smell and other outside factors so that the bees use only the visual cues around them. Once the bees learn where the food hole is, the researchers add certain complications, such as changing the food hole or shifting the navigating landmarks around the food hole. Using the charts, they can study patterns of how long it takes a bee to realize the change, how it learns the food's new location, how important a role landmarks play, and which landmarks a bee chooses. One goal of these experiments is to create computational models which can accurately replicate bee behavior and visual cognition. Such models can lend insight into how bees and humans decide what visual cues are important and how their brains advance toward optimal navigation.

Zoology doctoral student Frank Bartlett is one of the graduate students working on the bee project under the IGERT grant. He emphasizes the importance of coming together with the other fields in such formats as the weekly IGERT

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lot of different research techniques to take with you outside MSU. Working with the other cognitive science fields, I have learned *how* to learn and ask different types of research questions, as well as come up with new procedures more easily. It allows me to be more flexible in my approaches and facilitates the kind of learning I will continue throughout my career.”

The IGERT researchers in Computer Science and Engineering connect their own studies of intelligent machines (robots) with the evidence gained from humans and animals. For example, when a robot moves around or looks around, it faces the same kind of gaze control issues with its artificial vision system that humans would when directing attention to the right place at the right time. Memory and cognition allow humans to quickly focus on the needed information; they know not to waste time looking for people on the ceiling, for instance. Learning how people and animals do this can

translate into creating new systems for intelligent machines; likewise, work on artificial intelligence can provide insight into human and animal visual control.

Graduate students in Computer Science and Engineering, working with Dr. Aude Oliva, Assistant Professor in Psychology and Computer Science, use data generated by humans and animals to create algorithms that match the ideas discovered in these other disciplines. With such information, they then try to understand underlying factors of visual attention and to simulate the same process in a computer. According to Silviu Minut, a doctoral student in computer science and one of the original graduate students who worked on the KDI grant, "People know from prior knowledge how to look for a specific object and then make decisions based on that stimulus. They have an operational map based on memory that helps them to learn, for example, how best to drive from one place to another. Can we build this kind of memory to seek out and recognize an object in a cluttered environment (such as a lab), in as few steps (visual fixations) as possible?" Silviu worked on this question for his Master's thesis and was able to "train" a computer to build this kind of memory such that its visual fixations decreased as it learned to recognize and seek out a specific object. The IGERT grant allows for continuation of this work. "We can't guarantee that human/animal gaze control and artificial vision systems work in the same way, but enough parallels exist that all three areas benefit from conversations with each other."

The IGERT group in Psycholinguistics examines the decisions adults continually make as they use language in real time—how to choose the right vocabulary words, how to recall the grammar and syntax, how to speak appropriately based on perceptions of audience and situation, etc. As adults, people already have a memory base that assists in these decisions, but even when spoken input is clear, ambiguities exist which necessitate decision-making on the part of the listener. For example, a listener might "fix" an incorrect or ambiguous sentence by backtracking and remaking its structure and meaning.

One area of study involves disfluencies, sounds like "um" or "ah" that punctuate spoken sentences. Dr. Fernanda Ferreira, Professor of Psychology and Linguistics, explains, "Listeners have a familiarity with these interruptions; they expect the 'ums' and pauses and incorporate them into the meaning of the sentence. We've found that listeners know a disfluency will precede a heavy or long phrase or clause; these interruptions become an informational cue for a person's language system. In the past, others have seen disfluencies as junk that listeners filter out. We see them as information that listeners use to make better sense of the sentence's meaning. The sequential decision-making approach has helped us to see this process in a new way."

In the lab, subjects listen to sentences which contain instructions about how to move objects in the immediate environment. People's eye movements are monitored with an

eyetracker while they listen and manipulate objects. In other experiments, people read sentences while their eye movements are monitored. This allows the researchers to see what letters and words the subjects look at, how long, and if they look backward to fix an "off" sentence. "Such word ordering and decision making," explains Dr. Ferreira, "is a challenge no machine can do. If we can learn how humans do these things, we can apply that knowledge not only to our continuing study of human behavior but also to advancements in computer technologies."

The collaborative learning that takes place under MSU's IGERT grant continually benefits graduate student research. As Monica Castelhana explains, "The collaborations and new ideas that can result are amazing. You might go to a conference or your department might host a speaker but the

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ORIGINAL PRINCIPAL INVESTIGATORS FOR THE IGERT GRANT

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Zoology

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Psychology and Linguistics

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Dr. John Henderson

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Dr. Sridhar Mahadevan

Computer Science and Engineering

For more information on the
MSU IGERT grant, see
<http://www.cogsci.msu.edu/IGERT>

For more information about
MSU's Cognitive Science Program
and its affiliated departments, see
<http://www.cogsci.msu.edu>.

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In CHM, the first two years of a student's experience is spent in lecture and small group classroom learning. During their third and fourth years, students train in hospitals and clinics to gain practical experience. The MSU community-based approach to medical training uses several satellite campuses in which students work during the latter part of their education. These include campuses in the Upper Peninsula, Saginaw, Grand Rapids, Kalamazoo and Lansing. Students spend each day taking patient histories, giving physical exams, and developing their general skills. Since 80% to 90% of successful diagnosis is contained in a patient's history, this training is invaluable. Friedhoff explains, "We are able to engage a patient in conversation in a way that helps us make a diagnosis and that helps the patient feel heard. In addition, we're trained in such a way that we think about the bio-psycho-social aspects of the diagnosis. With the biological aspect we look at what is going wrong inside the mechanics of

their physiology, and with the psycho-social element we look at their life and their mind." In addition, students in the Upper Peninsula campus are dispatched for an eight-week experience in rural family practice outside the hospital environment. This component of medical education is unique to both CHM and the Rural Physician Program. For Friedhoff this has been one of the greatest benefits of her training. It affords an opportunity to interact through a more personal relationship with the member of the community in which a student is assigned.

According to Friedhoff, the process by which students choose a medical college affects what the student is searching for in a training experience. She notes that because the various medical programs each have their own "personality," it was important to search for one in which her social science skills would be considered an asset to the program. CHM's broad-based approach to teaching has made this possible. ❖

RESPONSIBLE CONDUCT OF RESEARCH

SCHEDULE OF PRESENTATIONS

RESPONSIBILITY TO THE INSTITUTION:

Safety and Security in the Academic Workplace

Thursday, January 23, 2003
6:00-8:30 PM

Room 104, Kellogg Center
Robert J. Ceru, M.Sc.
Terry A. May, Ph.D.

RESPONSIBILITY TO THE

SUBJECTS OF RESEARCH: Humans

Tuesday, February 11, 2003
6:00-8:30 PM

Conference 62, Kellogg Center
David E. Wright, Ph.D.

RESPONSIBILITY FOR OBJECTIVITY:

Conflicts of Interest

Tuesday, February 25, 2003
6:00-8:30 PM

Room 103, Kellogg Center
Terry A. May, Ph.D.
David E. Wright, Ph.D.

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interaction is limited due to time. Here, we continually interact with and inspire each other in our projects. The greater exposure we have here with other students and professors who are experts in their fields allows us to deepen our understanding of the subject matter and to follow through with research questions."

Dr. Ferreira notes that the IGERT grant facilitates leadership training for graduate students. "Because the graduate students supervise the undergraduate students working with them, they gain knowledge that will help them run their own labs once they leave MSU. Also, because they have access to resources, they get experience writing proposals and requests for travel money. This helps prepare them for future grant and proposal writing in their careers."

The IGERT grant will also help MSU's Cognitive Science Program develop in the future. "This is really just the

beginning," states Dr. Henderson. "From this base we can now expand as a pre-eminent cognitive science program, leading to more funding, additional graduate students, and better research. We are very excited about the possibilities that lay ahead."

Graduate School Dean Karen Klomparens is also excited about the IGERT grant. "The interdisciplinary nature of the educational process that is the foundation for an IGERT grant is the future of much of doctoral education in the sciences and engineering, broadly defined. I am proud of our faculty and graduate students who participate in the IGERT. I'm sure they will have many interesting lessons to share at the end of five years, not only in the research areas, but also in terms of how research can be conducted successfully across disciplinary lines, language/terminology, and methods." ❖