brain+cognitive sciences news

Spring 2007

BCS RESEARCHERS FIND SYNERGIES BETWEEN BASIC SCIENCE AND REAL-WORLD PROBLEM SOLVING

Since its inception, the Department of Brain and Cognitive Sciences has focused on basic research with the objective of driving fundamental advances in human knowledge. While this long tradition of basic science continues to underlie the work done in BCS, a new trend is emerging with an incresing number of labs finding opportunities to direct their research to practical issues.

While BCS researchers say they are seeing a blurring of the boundaries between research and application, they are quick to advocate a continuing role for basic science. Although national initiatives such as the war against cancer lead to funding for basic research in molecular mechanisms, "in order to reach applications such as cures for cancer, you need to do a lot of basic research first," says Tomaso Poggio. "I think it's true that more funding these days is short-term and pursues applications in a short timeframe. I don't think that's very good if that becomes the dominant way of funding. Basic research has to have a long-term perspective."

Corporate-funded research, for instance, that demands fast solutions is quite different from the university model of basic research, which searches broadly for knowledge rather than quick fixes. "Basic science forces you to think about the deep structure of the problem and its underlying mechanisms," says Pawan Sinha. "A solution that appears to accomplish the right thing without understanding underlying mechanisms hasn't really solved the problem."

In many cases, however, BCS researchers are finding that there is a synergy between fundamental and applied knowledge. A number of faculty are actively engaged in studying opportunities that range from improved diagnosis and treatment of neurological diseases and disorders to the coupling of brain science and engineering to devise better ways to process photographic images, understand brain circuits and treat autistic individuals.

Photo: Donna Coveney

Professors Sinha (top) and Poggio lead research programs that combine basic science and engineering applications.

Among the researchers whose work may lead to medical breakthroughs is Li-Huei Tsai. Tsai, has found that despite substantial loss of brain cells in mice, environmental enrichment coupled with elevated histone acetylation helped the mice recall tasks and other behaviors they had learned weeks before.

Mark Bear hopes that by blocking a single brain chemical, many of the psychiatric and neurological disabilities associated with a primary cause of mental retardation could be treated. He is focusing on changes in the brain and body that result from a single mutated gene and lead to the loss of fragile X retardation protein (FMRP).

Mriganka Sur's lab studies genes involved in synaptic development and plasticity that may be particularly relevant to autism, which manifests itself in the first three years of life—a period of intense neuronal growth and paring involving many genes regulated by activity and experience.

Computers can usually out-compute the human brain, but the brain easily performs tasks such as visual object recognition, which is challenging for computers. Sinha and Poggio are among the researchers whose work could lead to computers becoming more adept at certain tasks.

Poggio's work straddles computer science and mathematics on one side,

Continued inside . . .

BIDWELL LECTURER DESCRIBES NEW CENTER FOR PSYCHIATRIC DISORDERS

On April 13, Edward Scolnick presented the 2007 Bidwell Lecture to a full house in the BCS auditorium. Scolnick spoke primarily about the mission of the newly created Stanley Center for Psychiatric Research at the Broad Institute, of which he is the Director, and of the links between neuroscience research and the Center's work on psychiatric diseases. Scolnick noted that a number of BCS faculty are already involved in collaborative projects with the Stanley Center and predicted that there would be much more to come as work to identify and develop treatments for psychiatric disorders progresses.

NEWS FROM THE BENCH

Of Sleep and Memories

Memories of our life stories may be reinforced while we sleep according to Matt Wilson. As reported in the online edition of *Nature Neuroscience*, Wilson and a colleague looked at what happens in rats' brains when they dream about the mazes they ran while they were awake.

In an earlier paper, Wilson had showed that rats formed complex memories for sequences of events experienced while they were awake, and that these memories were replayed while they slept--perhaps reflecting the animal equivalent of dreaming. Because these replayed memories were detected in the hippocampus, the memory center of the brain, the researchers were not able to determine whether they were accompanied by the type of sensory

Continued on back page . . .

Massachusetts Institute of Technology

If you would like to be put on the newsletter mailing list, or have information you would like to have published, please contact:

Judith Rauchwarger
Human Resources Administrator
jrauch@mit.edu

BCS Alumni Please Keep In Touch

Denise Heintze
Academic Administrator
heintze@mit.edu

A MESSAGE FROM THE DEPARTMENT HEAD

Mriganka Sur

Much has happened in BCS since I last wrote this column nearly a year ago. Following our move into Building 46 in 2005, the pace of our activities - in faculty recruitment, research, teaching and training - has picked up even more. With much that I could write about, I will focus on a few highlights from the last twelve months.

BCS has already welcomed four new faculty members into Building 46. With these additions, the number of our primary faculty appointments stands at 36, up from 28 only five years ago. This remarkable growth is more than matched by the remarkable quality of the faculty that we have attracted in each of the Department's tracks.

BCS must maintain an environment in which our faculty, students and staff can reach their full potential.

In late 2005, Emery Brown, who studies dynamics of information processing, joined the computation group in BCS. Emery's presence has had immediate impact on research interactions between laboratories and on our teaching. In spring 2006, Li-Huei Tsai, a molecular neuroscientist and Howard Hughes Investigator who studies brain development and disease, started her lab in the Picower Institute. In fall 2006, Ki Ann Goosens, a systems neuroscientist who studies neural mechanisms of fear and anxiety, joined the McGovern Institute. And in summer 2006, Rebecca Saxe, who studies social neuroscience, formally joined the cognitive science group as a faculty member—though as a former graduate student of the Department and, later, as a Harvard Fellow, she has been a familiar presence in BCS for many years.

The academic mission of the Department continues to evolve with a number of exciting new developments. In the past year, Elly Nedivi was named Undergraduate Officer, taking over from Molly Potter whose tenure in this position was highlighted by a tremendous broadening and strengthening of the Course 9 curriculum. Our majors, now numbering over 160, have doubled in the past 10 years under Molly's guidance. BCS owes Molly a huge debt of gratitude for her unparalleled leadership of the undergraduate program.

In a development that will have a profound effect on BCS for years to come, the Task Force on the Undergraduate Educational Commons recommended that 9.01, Introduction to Neuroscience, currently taught by Mark Bear and Sebastian Seung, be included in the revised General Institute Requirements for all undergraduates. As one of the courses that fulfill the life sciences requirement, it is obvious that enrollment in 9.01 will grow dramatically. When combined with the popularity of 9.00, Introduction to Cognitive Science, now taught by John Gabrieli, we are confident that these two flagship courses will attract many new Course 9 majors, adding further impetus to our undergraduate program.

I will close with some thoughts on issues that I see affecting the Department over the coming years. As the Department grows, with increasing faculty appointments and expansion of the undergraduate and graduate programs, we need to continually develop our vision for the future.

I see four areas as forming the core of our strategic plan. First and foremost, we need to maintain our uncompromising stance on excellence: our faculty, students, and staff must be outstanding, regardless of their field, and BCS must maintain an environment in which they reach their full potential.

Second, we should evaluate not only the broad fields of neuroscience and cognitive science but also our tracks and specific sub-fields, asking where MIT can excel, what areas we need to represent, and where we might target our faculty appointments. I have set up a strategic planning committee consisting of Morgan Sheng (molecular neuroscience), Matt Wilson (systems neuroscience), Sebastian Seung (computation) and Nancy Kanwisher (cognitive science) to help the Department frame its strategic mission. As well, the McGovern and Picower Institutes are partners in the process.

Third, we need to actively reach out and link our research in new and creative ways to other parts of MIT. Neuroscience and cognitive science have the potential to shape, and be shaped by, many elements of engineering and science. Just as the human genome project has created new tools for discovering and analyzing gene function, emerging technologies and ideas in a variety of fields will impact our work.

Fourth, we need to develop and enhance the synergy between basic science and its applications. Basic science, our core strength, drives advances that lead to applications, ranging from image processing systems to therapeutics (see lead story in this newsletter). As our knowledge of the brain increases, we can envision rational ways to understand and treat brain disorders and diseases. In turn, brain disorders provide unexpected insights into brain function. Furthermore, as federal funding for research stays flat or even declines, we need to consider ways in which we might leverage advances in basic research, funded from traditional sources such as NIH and NSF, to develop and direct its application, with the support of funding from those with a stake in the outcomes.

AWARDS AND HONORS

FACULTY

Earl Miller won the Mathilde Solowey Award in the Neurosciences from the NIH.

Pawan Sinha received the Troland award from the National Academy of Sciences.

Josh Tenenbaum was elected to membership in the Society of Experimental Psychologists, and received their Young Investigator Award. Josh was also named Distinguished Lecturer at the University of Edinburgh, Division of Informatics, and the University of British Columbia, Institute for Computing, Information, and Cognitive Systems.

STUDENTS

Graduate Student Charles Kemp received an honorable mention for the Outstanding Student Paper Award at the 2006 Neural Information Processing Systems conference, for his paper titled "Combining Causal and Similarity-based Reasoning."

SURVIVING THE SPACE CHALLENGE: THREE LIVE TO TELL THE TALE

Although considerable effort was made to design laboratory spaces in the brain and cognitive sciences complex to meet the specific needs of the occupants, those who arrived after programming was complete faced a number of interesting challenges in matching the physical plant with their research objectives.

BCS researchers Ki Goosens, Christopher Moore and John Gabrieli all arrived at MIT within the past four years, and immediately embarked on the daunting task of setting up their own laboratories, in some cases for the first time ever.

When Goosens first looked at the space that had been assigned to her, she realized that she was in for some significant renovation work. "What I really wanted was lots of small rooms," she said, but what she got was a few big, spaces.

For Goosens, the challenges of a first faculty position were compounded by the fact that she was given temporary space on a different floor. She did not want to take delivery of a lot of bulky equipment and then have to move it and set it up again. Her conditioning system for rats involved "a lot of wiring and small pieces linked to computers and control boxes. There are centrifuges and other pieces that have to be balanced by a technician." What is more, Goosens was concerned that the timeline for renovations would slip, causing more problems.

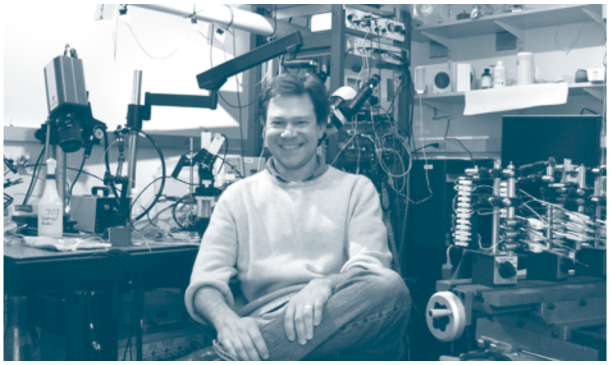
"I had a theory but it was hard to get data because I never had my own lab."

Despite her fears, Goosens gambled and won. She decided to do one big move into her permanent space and she now has two central rooms, one as a main laboratory and one for molecular biological work, plus three testing rooms for animal behaviors and a small pair of rooms for animal testing.

"The renovations went better than I expected," Goosens says. "I'm surprised they got as much of it done as quickly as they did." Six months later, her lab is up and running, although she is still awaiting the installation of a few items.

When John Gabrieli arrived at MIT in summer 2005, there was already a plan in place for the space his laboratory would occupy. Fortunately, there were few changes needed. "The space was so nice, it was easy to fit into what had been planned," he said.

But in his role as director of the Martinos Imaging Center, it was a different story. Gabrieli had to set up the working components of the imaging equipment that, some feared, would not work properly in a building built across train tracks.



There's no place like lab; Chris Moore in his self–designed recording room.

First experiences confirmed the challenges that needed to be overcome. "We had to knock down a wall to get the machine in," he said, and the room had to be shielded so that the powerful magnet didn't affect passersby. But there is now a 3 Tesla machine for humans and large primates in place, plus a 9.4 Tesla machine for use with small animals, primarily rodents. A third bay is being saved for a future machine.

Christopher Moore was thrust into the strange situation of having to design two labs at once—one in E25, BCS's former home, and one in the new brain and cognitive sciences complex. Even though he did not have the benefit of living with his first lab before designing the second, he says he is pleased with the outcome. "I got a little bit lucky. We wasted some space, but not too badly."

One room of the second floor lab is divided up into three areas devoted to the intensive computer analysis that follows the collection of data from optical imaging and fMRI. Another is a wet lab for preparation for recording electrophysiological signals, histology and anatomical development. A third room—Moore's favorite—is a workshop with a milling machine that can make three-dimensional mock-ups out of almost any material for use in animal experiments.

Moore hopes to build computational models of the brain that predict how information will flow in circuits in the human cortex. He has created the first computation model of the brain that takes blood flow into account. His unconventional theory (it was last put forth by Aristotle) is that blood flow carries information in the brain. "It's very cool," Moore said. "I never thought it would work. I had a theory, but it was hard to get the empirical data because I never had my own lab and never had access to the right toys."

BASIC SCIENCE TACKLES REAL-WORLD PROBLEMS

Continued from front page . . .

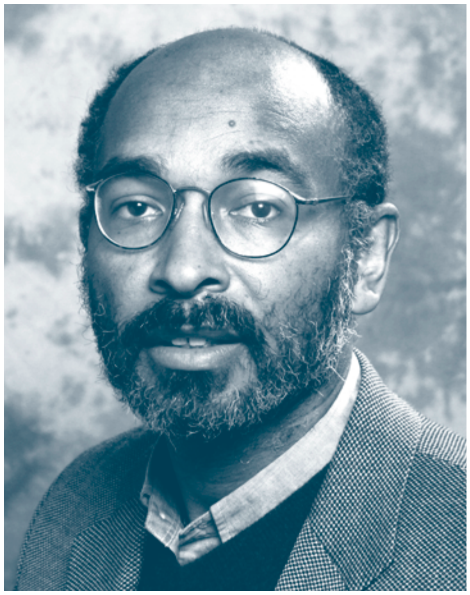
neuroscience on the other. He has developed a computer model designed to mimic the way the brain processes visual information. It performs as well as humans on categorization tasks and could lead, ultimately, to better artificial vision systems. "Basic science is the goal of the research we are doing, but in this case basic research in neuroscience of the visual system had the surprising side-effect of also providing a specific blueprint for a computer vision system with practical applications," Poggio said.

Sinha examines the nature of information that the brain uses for recognizing important classes of objects such as faces. Especially interesting are impoverished images such as highly blurred photographs. Analyzing such stimuli promises to provide insights about what aspects of image information is critical for recognition. The lab's research involves work with a population of children in India who have gained sight after several years of blindness. Studies of the time-course of visual skill development in these children provide valuable clues for the lab's ongoing efforts to computationally model the acquisition of object concepts by the human brain.

Sinha does not see a clear divide between applications-oriented science and basic science—when approaching a problem, he does not question whether it is a basic science problem or an application-oriented problem. "If we want to understand how certain aspects of vision work, we are acknowledging that in everyday life, these aspects of vision are important because they relate to real-world tasks," he says. "It would be hard to pigeonhole my work into either one of these two categories. Some of the most interesting questions in basic science are interesting because they have interesting applications behind them."

FACULTY PROFILE: EMERY BROWN

Even in a community as rich in talents as BCS, Emery Brown is noted, with quiet awe, for the ease with which he is able to turn an interest into a deep area of expertise. With his various professional hats - neuroscientist, practicing anesthesiologist, and master of all things statistical - Emery is many things, just don't call him a renaissance man. "I don't know about that," he laughs. "Let's just say I'm a person with a lot of interests."



Emery was born and raised in central Florida, the third son of mathematics teachers – a background that that has been a continuing influence among he and his siblings. However, he took an unlikely detour; the impetus in this case being the Spanish language records that his brother used to play "over and over" as they were growing up. An interest was kindled and thus it was that Emery, as a Harvard undergraduate with medical school aspirations, ended up majoring in romance languages - at least temporarily.

"It was impossible not to develop a deep interest in the questions of neuroscience."

It was some time in his sophomore year that Emery realized he was more interested in linguistics than literature and so, after a brief flirtation with economics he changed emphasis again, becoming an applied mathematics major. A year in Grenoble, France provided a dual opportunity – to obtain a stronger basis in mathwhile polishing his fluency in French.

Following his undergraduate education, Emery was accepted into the MD/PhD program at Harvard, finishing the latter degree in 1988. He decided to specialize in anesthesiology during his third year rotations; a coincidental return to the department that had sponsored his undergraduate thesis. His dissertation was on the statistics of circadian rhythms which formed the initial basis for his research at MGH where he began work following medical school.

His interest in circadian rhythms began to wane after a few years however. "It was very unrelated to what I was doing in medicine," explains Emery and by the early 1990s, he was "systematically looking for something new to study." It was about this time that he read a paper in *Science* on place cells by BCS Professor Matt Wilson. Inspired, Emery dedicated the second half of a year-long statistics seminar he was teaching to problems in neuroscience. A happy coincidence whereby some of Wilson's lab members contacted Harvard looking for help with data analysis resulted in a first collaboration and, after taking the Computational Neuroscience course at MBL, Emery was hooked. "It was impossible not to develop a deep interest in the questions of neuroscience," he says.

Looking back on what seems a dramatic change in research direction, Emery credits his medical training. "Medicine takes away the fear of delving into new things because there is so much change. New procedures, new protocols – you always have to keep up."

Today, Emery's research focuses on understanding what happens to the brain while anesthetized. Recording simultaneously using EEG and fMRI, he is able to monitor changes in brain activity as more and more drug is administered. Emery also maintains a number of collaborative projects with fellow BCS faculty members Chris Moore, Elly Nedivi, Mriganka Sur, Ann Graybiel, Dick Wurtman and, of course, Matt Wilson. Among his other professional activities is co-directing the Neuroinformatics course at MBL in the summer and he continues to practice as an anesthesiologist, working one day a week in the operating room at MGH.

Such a schedule would seem to leave little time for anything else but Emery is careful to save time for family and fun. He travels with his wife and two children to Spain at least once a year to visit his wife's family. His participation in sports these days is mostly motivated by his children's interests. "I dusted off my skis a few years ago," he says. "I don't think I would have done that if they weren't into it." Emery also keeps fit by riding his bike or running to work as often as he can.

When asked what he would like to achieve while at MIT, Emery pauses only briefly before answering. What follows is an impassioned and reasoned advocacy for statistical rigor in science. "We're in an age where we can measure more things and measure them better," he says. "This is one of the things that is really driving science right now. The problem is that individual experiments can generate multiple terabytes of data and if we don't have the basic principles in place to approach analysis problems of this scale, we may fail to make progress as fast as we could."

His other scientific passion is understanding general anesthesia. "We have delivered anesthesia for more than 160 years in the United States and we still have no idea how it works," he notes. Many of the BCS collaborations that Emery maintains are focused on putting together a systems neuroscience paradigm for studying general anesthesia. Although general anesthesia is a neuroscience question, it is not yet being studied as such. Emery is trying to change that!

NEW BEGINNINGS

Professor John Gabrieli and Research Scientist Susan Whitfield Gabrieli welcomed their first child, daughter Christina Sophia Grace November 20.

MIBR Financial Officer Donna Wells and husband Chris are the proud parents of son Richard John Wells, born January 22, 2007.

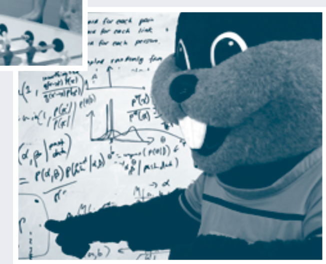
Postdoctoral Associate Nadine Gaab married Stanford University Postdoctoral Fellow Ozan Alkan in Cambridge on November 2nd, 2006.

Recent doctoral graduate Corey Harwell and his wife Lynn have a new daughter, their first. Noor Harwell was born in December, 2006.

HOLIDAY PARTY

The BCS/Picower/McGovern holiday party was a tremendous success bringing together all the people of Building 46 for and evening of food, drink, and celebration. With over 400 in attendance, it was the biggest event since the building dedication.

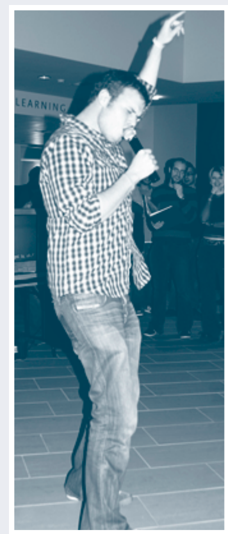
Tim the Beaver came for the party, but stayed for the science and foosball.



The highlight of the evening was a rousing performance by the fabluous Santa–hat clad BCS Graduate Band (and friends).

MC Sue Corkin kept the evening on track.

Photos: Eric Bersak

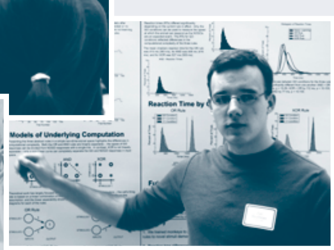


The karaoke was a big hit too.

INTERVIEW DAY

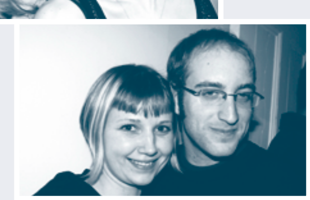
Interview Day brought 50 candidates for the graduate program to Cambridge for an intensive schedule of meetings, lab tours, and presentations.

The current graduate students put on an impressive display of more than 30 posters.



Of course there was plenty of food . . .

. . . and a big party to close out the day.



NEWS FROM THE BENCH

Continued from front page . . .

experience that we associate with dreams - in particular, the presence of visual imagery.

In the latest experiment, by recording brain activity simultaneously in the hippocampus and the visual cortex, Wilson was able to demonstrate that replayed memories did, in fact, contain the visual images that were present during the running experience.

Miller Lab Identifies Dual Attention Mechanisms

A paper by Professor Earl Miller and Graduate Student Timothy Buschman provides evidence that two different regions--the prefrontal cortex and the parietal cortex—are each responsible for originating a different mode of attention. In the March 30 issue of *Science*, the researchers also reported for the first time that activity in the two regions operate at different frequencies depending on whether the attention is based on sensory input or on experience and memory.

Using an innovative technique, Miller and Buschman conducted a series of experiments in which monkeys were engaged in different kinds of visual tasks. The researchers looked simultaneously at the prefrontal cortex and the parietal cortex allowing, for the first time, a direct comparison of the activity in these regions. The results support the idea that in the bottom-up mode, sensory cortical areas like the parietal cortex direct our eyes toward the stimulus. When we purposefully look for something, the prefrontal cortex seems to originate and coordinate attention.

"Taken together, these data suggest two modes of operation: When a stimulus pops out, a bottom-up, fast target selection occurs first in the posterior visual cortex; while in search mode, a top-down, longer latency target selection is reflected first in the prefrontal cortex," Miller said. "To our knowledge, these are the first direct demonstrations that these areas may have different contributions to these different modes of attention."

Time Takes Note of Project Prakash

How does the human brain learn to see? If the brain is deprived of visual input early in life, can it later learn to see at all? Pawan Sinha's lab is exploring those questions by studying some unique patients - people who were born blind, or blinded very young, and later had their sight restored.

Doctors have long believed that children who were blind during a "critical period" early in life had little hope of learning how to see even if vision were later restored, so they were reluctant to offer potentially risky surgical treatments such as cataract removal to children older than 5 or 6. However, in a recent case study, it was found that a woman who had her vision restored at the age of 12 performed almost normally on a battery of high-level vision tests when they studied her at the age of 32. The results appeared in a recent issue of *Psychological Science*. The new research "shows that the brain is still malleable" in older children, says Sinha. This knowledge could benefit thousands of blind children around the world, particularly in developing nations, who were previously thought to be too old to receive eye treatment.

The research was carried out in conjunction with Project Prakash ("light" in Sanskrit). This NSF funded initiative begun by Sinha is, first, a humanitarian mission to help bring eye care to those in India who have never had access to advanced medical resources. The project has attracted a lot of media attention including an extensive article in the February 23rd issue of *Time*.

The Genetics of Schizophrenia

Gene mutations governing a key brain enzyme make people susceptible to schizophrenia and may be targeted in future treatments for the psychiatric illness, according to Susumu Tonegawa.

The National Institute for Mental Health estimates that 51 million people worldwide suffer from schizophrenia. Although 80 percent of schizophrenia cases appear to be inherited, the specific genetic components underlying individuals' susceptibility and pathology are largely unknown. The work, involving scientists from Tonegawa's lab and Japan's RIKEN Brain Science Institute, was reported in a recent issue of the *Proceedings of the National Academy of Sciences*.

brain+cognitive sciences

Massachusetts Institute of Technology
46-2005
77 Massachusetts Ave.
Cambridge, MA 02139

NON PROFIT ORG.
U.S. Postage
Paid
Cambridge, MA
Permit No. 54016