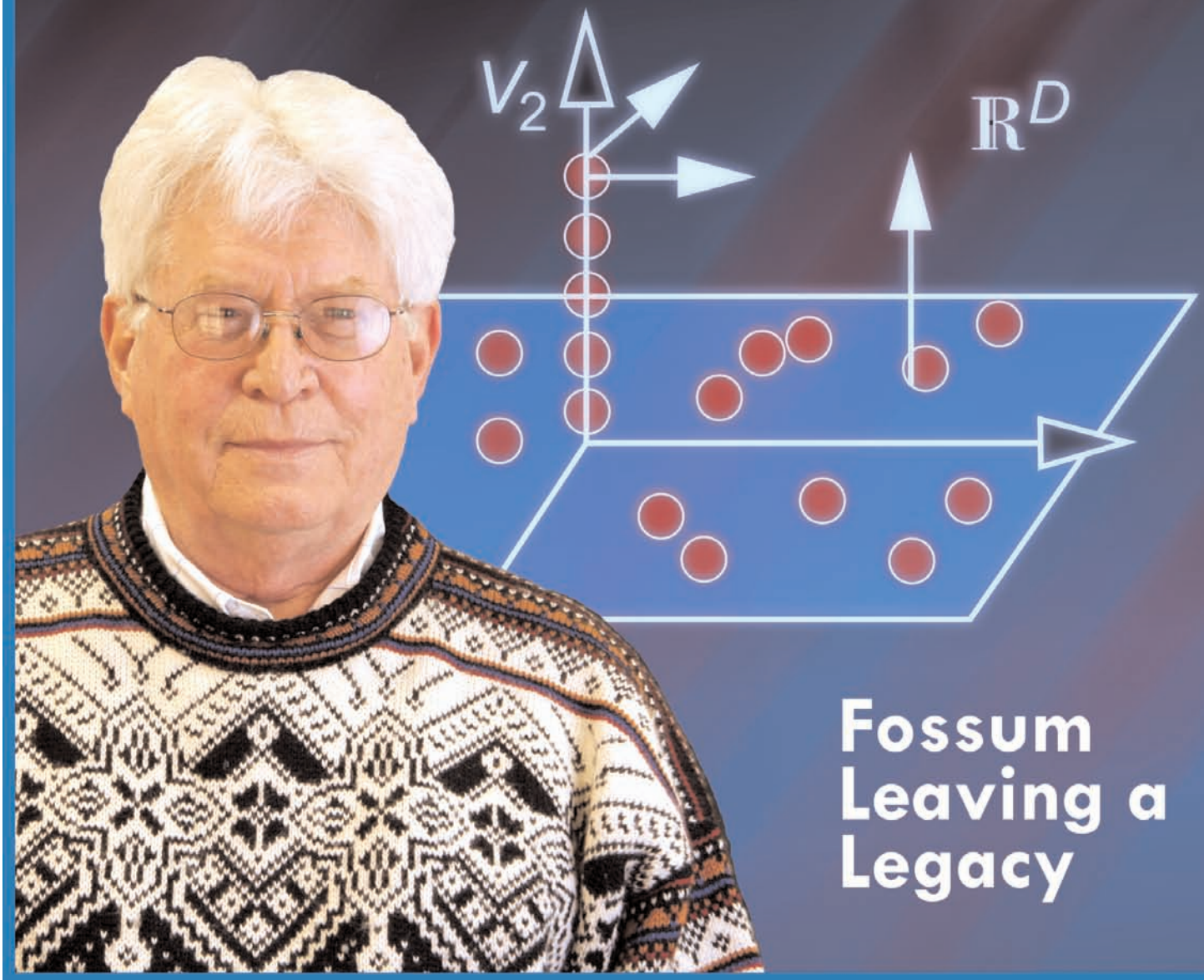
SYNERGY

BECKMAN INSTITUTE FOR ADVANCED SCIENCE AND TECHNOLOGY

ISSUE 9 · SPRING 2008



Fossum Leaving a Legacy

Beckman Fellow and neuroeconomist Ming Hsu was featured in a PBS show that explored factors like moral decision-making and risk aversion that play prominent roles in our economic choices. *Page 4*

The Paul C. Lauterbur Memorial Symposium brought together Magnetic Resonance Imaging (MRI) pioneers and researchers from across the country to honor the late Nobel Laureate. *Page 7*

Ranxiao Frances Wang, who uses Beckman's immersive virtual reality environment known as the Cube to study human cognition and perception, is our faculty profile. *Page 8*

BECKMAN INSTITUTE AT THE UNIVERSITY OF ILLINOIS

Fossum Leaving Legacy

The value of giving back is something ingrained in Robert Fossum. Growing up with the Lutheran ideals and Norwegian heritage that imbue so much of the small-town tapestry of rural Minnesota, he learned the importance of giving for its own sake.

So it's not surprising that he and his wife established the Robert and Robin Fossum Distinguished Lecture Series at the Beckman Institute, or that they have been content to let others choose the visiting lecturers for it. But this year's lecture was different.

"I'm turning 70 on May 1 and I'm retiring on the 15th of May, so this time Robin asked if we could have a lecture around the 1st of May and she said she knew exactly who she wanted to get," Robert Fossum said.

Fossum's choice for speaker was fitting: a world-renowned mathematician and physicist from Harvard named Arthur Jaffe whose many honors include being past president of the American Mathematical Society (AMS). The Lecture Series has had speakers from top-level Microsoft executives to nationally-known cognitive scientists, but the choice of an imminent mathematician was a personal one for Fossum. He is retiring after a long career that saw him make major contributions to the Illinois Department of Mathematics and to the field of mathematics through his research and work with AMS.

Fossum grew up in Northfield, Minnesota, famous for thwarting a daring 1876 bank robbery that spelled the beginning of the end for the James gang, and for being home to two well-respected small colleges. His father ran the school's bookstore at St. Olaf's College and his uncle was chair of the college's physics department.

"It was very intellectually stimulating," Fossum said of his childhood environment. "The bookstore at that time was in the St. Olaf College library building and he had keys to every place there, so I would go up there on Saturdays with him and go back into stacks of the library. It wasn't like it is today with security; I had total access to everything in that library."

It was there that Fossum began exploring his intellectual and scientific interests. A master key to the physics building courtesy of his uncle helped him unlock the door to applications.

"I had access to the machine shop and the classrooms and all of the laboratories," he said. "I probably didn't make the best use of it, but my friends and I around '55 or '56 used the physics lab to make rockets."

Using the machine shop's lathe, some pipe, and some homemade gunpowder, Fossum and his high school buddies began their own rocket program.

"One of the guys was a chemist and he would make gunpowder and we'd fill these things with gunpowder and an old flash bulb that we had broken the glass out of and stand a ways away, connect to the battery, and watch these things go aloft," Fossum said with a laugh. "Nowadays we would be declared terrorists."

Fossum's scientifically adventurous sprit didn't end there: he earned a Ph.D. in Mathematics from Michigan before joining the faculty at Illinois in 1964. It was early in his career here that Fossum learned about the Fulbright Scholar program, an international exchange program that allows American faculty members to teach and learn abroad. Both sets of his grandparents were born in Norway, so he applied for and was accepted for a year teaching at the University of Oslo.

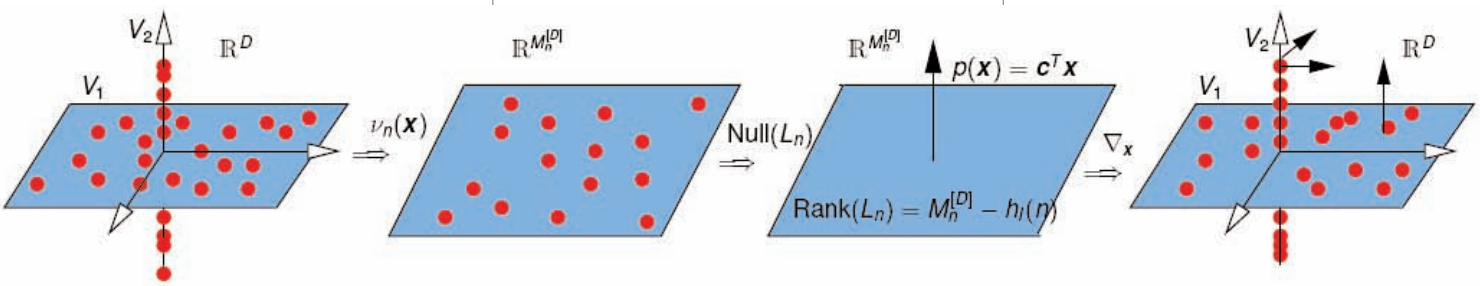
"They asked me to stay another year as a visiting professor and I told them I would stay another year as a janitor," Fossum said. "The advantage was I got to meet a lot of people, not just in Norway but all over Europe."

Fossum's European adventure continued off and on for the next decade – taking leaves of absence without pay from Illinois – and included faculty positions in Denmark and France as well as Norway. The experience benefitted not only Fossum but also the University of Illinois and the field of mathematics.

"I think all of these contacts are what really made my career," he said. "It was well worth it because I was bringing back ideas to our campus too. I would come back and lecture and give seminars on the material that I learned."

A few years later those contacts also helped Fossum in his efforts to expand the American Mathematical Society into a truly international organization while serving as its secretary for a decade. Sheldon Katz, Chairman of the Illinois Department of Mathematics, said Fossum's tenure as secretary from 1989 to 1999 was important because of the part he played while AMS's publishing services operations were being doubled and Web-based services were introduced.

"He was an important player in the profession," Katz said. "The Secretary is one of the most important leadership positions in the Society and critical for continuity – Robert was only the eighth Secretary in the 120-year history of the AMS. Throughout his service to the Society, he liked to take risks while pursuing enormous benefits. In a similar vein, he currently chairs the math department's newly formed Online Committee, a policy and oversight committee for our online offerings."



Hybrid models as algebraic sets. Image courtesy Robert M. Fossum.

Through his European contacts, Fossum began turning AMS meetings into international events.

"The American Mathematical Society is the largest professional organization for research mathematicians," Fossum said. "The contacts I had were very important. I knew all the important people in Europe to discuss this with so there were no problems with doors being opened," he said.

Fossum also knew the value of sound diplomacy.

"We had members all over the world so why shouldn't we have meetings in Germany, for instance," he said. "But we couldn't just walk into Germany and have a meeting because the Germans have a mathematical society. So what I did was arrange for the host country's mathematical society to have a joint meeting that was sponsored.

"Of course I was always very careful about saying this is a collaborative thing, let's do it together. That was very important. Now there are probably four a year, one with Mexico, in China, Australia, India, worldwide. I started that and I'm really proud of it."

Fossum's research interests are in algebraic groups, classical invariant theory, and applications of geometry and algebra to computer vision. He lists a paper called *Vector bundles over spheres are algebraic* as his favorite and a book titled *The Divisor Class Group of a Krull Domain* as a text he's most proud of because it became a main reference in the area of commutative rings and ideal class groups.

> "I came over to Beckman in 2000 and I think it has completely changed my point of view on the importance of interdisciplinary work."
>
> – Robert Fossum

At Beckman, Fossum is a member of the Image Formation and Processing group, where he works with researchers Tom Huang and Yi Ma, contributing mathematics to projects involving topics like face recognition and segmentation and clustering of images.

"One of the ways that mathematics gets involved is in describing things using algebraic equations," Fossum said. "Another way is to try and find the components of the image that satisfy certain equations. You're telling this (face recognition) software what to look for and one of the things it is looking for is these equations. I'm not a programmer but I can say look for these equations and the graduate students are very good programmers so they say 'I know how to do that.'"

Even though Fossum came to Beckman later in his academic career, he said it has been a great learning experience.

"Until I came to Beckman I had been considered a pure mathematician and the work that I was doing was definitely not influenced by any engineering applications," he said. "So I think that it's really opened up my own eyes to the way mathematics can help solve engineering problems and, on the other hand, many mathematics problems that arise from engineering problems can be solved. I came over to Beckman in 2000 and I think it has completely changed my point of view on the importance of interdisciplinary work."

In a recent brush with fame Robert was photographed with actor Keanu Reeves. Image courtesy Robert M. Fossum.

Even though he is retiring, Fossum still hopes to keep working at his office at Beckman and he and his wife plan on continuing to fund the lecture series. He said the Robert and Robin Fossum Distinguished Lecture Series grew out of a discussion with Institute Director Pierre Wiltzius about Fossum's desire to give something back to Beckman.

"I was really appreciative of being able to come over to Beckman," he said. "I think I'm the first mathematician who has had a full appointment here. I was really proud of that. We give this money and we plan to continue on giving this money because I think it's important for the Institute. It brings people here who maybe wouldn't normally come."

The Fossums have a second home on five wooded acres in northern Wisconsin, near his father's boyhood home, but Robert doesn't plan on complete retirement just yet. He wants to continue working on projects, while his wife Robin continues to serve as a Senior Regional Director of Gift Development for the University of Illinois Foundation.

"Most of what she does is stewardship," Robert said. "I grew up in the Lutheran Church and I can remember one of the things they taught was stewardship. Officers practice stewardship and part of that is thanking people all the time, even for the smallest, smallest gift because you never know when that is going to multiply."

While he doesn't mind being thanked, Fossum said he and his wife fund the lecture series for other reasons.

"I don't need to have my back scratched," he said. "I give money for something like this because I think it's valuable."

The Fossums keep framed posters, signed by the speaker, of each of the series' lectures in their home. It's safe to say the poster for Jaffe lecture will have some extra meaning for them.

"I think he'll give a very good lecture," Fossum said. "I'm just very pleased that he's coming because we asked him to come."

***SYNERGY** is a quarterly publication of the External Relations office of the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. Each issue will spotlight the people and science that make the Institute one of the premier facilities for interdisciplinary research in the world.*

Contact information:
Office of External Relations
Beckman Institute
405 N. Mathews, Urbana, IL 61801
www.beckman.uiuc.edu

Editor: Sue Johnson, johnso16@uiuc.edu
Writer: Steve McGaughey, smcgaugh@uiuc.edu

Web & Cover Design: Rick Valentin, rnv123@uiuc.edu

Photo Credits:
Cover image courtesy Robert Fossum.
All other photos by the Beckman Institute unless otherwise noted.

Making The Right Choice: A Coin Flip

Hsu Puts the Brain's DecisionMaking Processes Under the fMRI Spotlight

Ming Hsu likes to present people with tough choices. For example:

• Which of two coins – one that is perfectly balanced or one that has an unknown bias in favor of either heads or tails – would you pick to best enhance your chances in a coin flip? Your answer on this one most likely reflects how you also make certain investment decisions.

• After looking at photos and reading biographies of children living at a real-life children's home in Africa you are asked to decide how to allocate food to them. Don't expect to feel entirely good about your charity, however. Hsu set up the experiment so test subjects have to choose between giving a set number of meals to one child or giving fewer meals, but to more children.

Research participants in Ming Hsu's fMRI moral decision-making study were asked to choose how to allocate food to children living in a home in Africa.

The coin question relates to what is called the Ellsberg Paradox, which has to do with aversion to ambiguity in decision-making, while the children's home dilemma came from an experiment Hsu ran while at Caltech using functional Magnetic Resonance Imaging (fMRI) to study how the brain functions during moral decision-making. As it turns out the odds in the coin flip are the same no matter which one you choose and the children's home gained a lump sum donation for food at study's end. What Hsu gained was insight into how the human brain works when asked to make difficult choices involving primal issues like risk/reward and morality.

Hsu's area of study is neuroeconomics, which is a combination of neuroscience and economics and a subset of behavioral economics. Hsu, who has a Ph.D. in Social Sciences from Caltech, is currently a Beckman Fellow and he will be joining the faculty of the Department of Economics at Illinois in the fall as an assistant professor.

"It's combining neuroscience and economics," Hsu said of his field. "Traditionally economics is formal models of decision-making, and some of it is from real-world data. Behavioral economics is sort of a fusion of psychology and economics, and neuroeconomics brings in neuroscience as well."

Neuroeconomics is a cutting edge field in a discipline, economics, with a history of being slow to adapt to new ideas (using fMRI techniques to study economic decisions is less than a decade old). Nevertheless, and not surprisingly, the idea of looking at the brain as it deliberates questions like how to distribute food to needy children or how to invest one's money has drawn a national spotlight. Hsu's work at Caltech has been written about in the *Wall Street Journal* and was featured in a recent episode of the PBS science show *Curious*, aired nationally on Jan. 24.

That show focused on the experiment run by Hsu and his colleagues at Caltech involving the Canaan's Children's Home in Uganda. Test subjects were put into a headscanning magnet and made donation decisions by pushing one of four colored buttons to move a ball on a screen to one of the donation options. Hsu calls it a distributive justice experiment.

"They have a decision whether to donate more money in total to the kids or to be more equitable in their distribution," Hsu said. "So you can imagine 'I can give 24 meals to one kid or 10 each to two.' In one case you are giving more in the sum and then the second case you are being more equitable and you are giving to more kids, but the total is less."

Hsu said they varied the donations so that there was a tension between being equitable and donating the largest amount possible to the children.

"We can vary these numbers to see what your aversion to inequity is and see what brain areas are responding to issues of equity and efficiency," he said.

That ability to look at the brain while it processes decisions about issues such as equity and risk is providing new insights not only for economics, but also for neuroscience, psychology, and even philosophy.

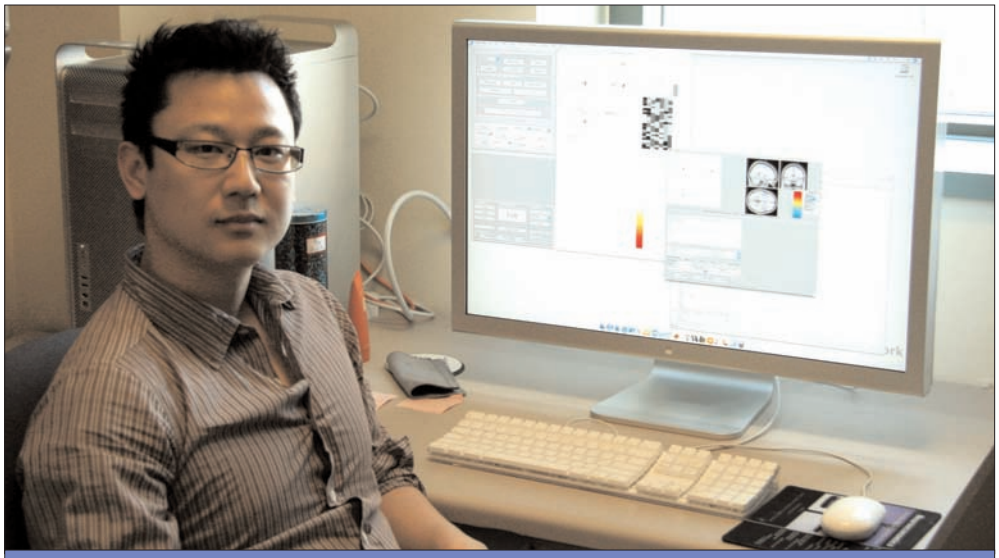
"This is about a very specific subset of moral decisions," Hsu said. "This goes back to a lot of the political philosophers who talk about how we allocate burdens and benefits in a society. In formal terms it's called distributive justice. There are a lot of theories about how we should do this, and our study comes from an economic approach. We study that within the context of individual decision-making."

Neuroeconomics as a branch of behavioral economics investigates biological and neural processes as people make decisions about purchasing, investing, or bargaining. And Ming is a young researcher at the forefront of this developing field. While at Caltech, he was lead author on a paper about the Ellsberg Paradox, *Neural Systems Responding to Degrees of Uncertainty in Human Decision-Making* that was published in *Science* in 2005 and he has done a paper about the experiment with the children's home for *Science* in 2008. Although he uses technology like fMRI and views topics through the lens of neuro-

science, Hsu said his field of neuroeconomics fits within traditional economics.

"Right now what we've done is coming from a very traditional economic perspective," Hsu said. "I think only a really hard-core rational choice economist would be surprised by that. I think it's just filling in the picture. The interesting things are things we never thought about before like the connection between inequity and risk."

Those connections are at the heart of the neuroscience aspect of Hsu's research.



"Behavioral economics is sort of a fusion of psychology and economics, and neuroeconomics brings in neuroscience as well."
— Ming Hsu

The headscanner measured blood flow during both the children's home experiment and the study about the Ellsberg Paradox, illuminating which brain regions are activated when people are asked to make those kinds of decisions.

"We found basically that the classical decision regions are very much involved in this type of decision making," Hsu said. "In the past people haven't really found that. We found in the striatal regions in the dorsal striatum that encode equity and efficiency, the more money you give to these kids and the more equitable it is, the more these regions fire. These regions are the ones that are activated when you get money personally. Rats are happy when cocaine is injected into these regions.

"One of the emotional regions in the brain, the insula, responds to inequities, so the more inequity that the subjects are able to save with their choices, the more this region fires. It's almost as if this region is pushing you toward making the more equitable choice. The difference between subjects' activation of the insula have in other studies been found to correlate with their level of risk-aversion."

Hsu said issues of equity and risk are connected in the brain.

"You can relate equity sensitivity or moral sensitivity to brain function," he said. "Both inequity and risk have very deep theoretical connections. With those you are essentially comparing distribution. If you think of a financial market, it's a distribution of returns that you are worrying about when it comes to risk. With equity you are caring about the distribution of, say, income or education or whatever variable you want to measure in a population."

Any investigation that could shine a light as to why people make economic decisions would, needless to say, be of interest to those concerned with finances and investments. In addition to the *Wall Street Journal* the work of Hsu and his colleagues has been written about in *Forbes* and the *Chicago Tribune*. His initial project using fMRI, which resulted in the paper on the Ellsberg Paradox, had ramifications for financial planning.

"The basic idea is that there are different types of uncertainty in the world," Hsu said. "In classical theory of uncertainty you have some probability distribution over some event, and you use that information. The classic counter argument is the Ellsberg Paradox."

Hsu said most people in the coin flip experiment usually choose the unbiased coin, even though the odds are the same as with a biased coin (again assuming you don't know the bias) as a balanced coin. The Ellsberg Paradox experiment tested what brain regions fired when people were evaluating ambiguous gambles versus risky gambles where the probability is known.

"Most people would prefer to bet on the known fair coin, even though you can say for all objective reasons it's the same as if you chose the biased, unknown coin," Hsu said. "There has been a lot of work in the last 30 years, generalizing this notion to explain this behavioral aversion to what's called ambiguity to real-world phenomenon."

As an example, Hsu pointed to financial investments. Since stocks are seen as riskier than other investments such as government bonds, investors expect high returns – more risk, more reward – but they are more likely to take that risk than, for example, the ambiguity of investing in an unfamiliar country.

"If you are investing in a stock market, would you rather invest in your home country, in U.S. stocks, or would you rather diversify all over the world," Hsu said. "If you diversify all over the world it's a good thing because every banker says you should diversify your portfolio. But of course people don't do that, people invest overwhelmingly in their own country. One of the explanations is that people have this ambiguity aversion and invest in their own country because they feel like they know more about it and they feel like it's just safer, even when it's actually not a good thing to do."

The topics of risk/reward and equity that Hsu explores are intimately related to our brains' evolutionary heritage. Risk/reward factors that have developed in humans and other animals over thousands of years while foraging for food or keeping an eye out for predators are deeply ingrained and play roles in decision-making for all sorts of things. Hsu said studying those factors through fMRI simply adds to our knowledge of how and why people make choices.

"People respond to incentives; I don't think you'll find any kind of behavioral economist or neuroeconomist who will disagree with that," Hsu said. "We know that institutions matter, we know that social behavior matters. It's really about the way that the brain implements (behaviors) and how social institutions change those behaviors. So a lot is filling in a more complete picture of how people actually make decisions."

Hsu believes there is plenty of room to explore these issues at his new home, including in an area that several Beckman psychology researchers focus on: the aging mind.

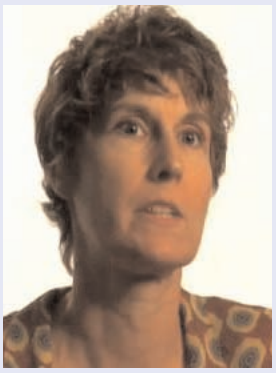
"One of the nice things about the University of Illinois is that there is a very strong aging group here," he said. "When people are saving for retirement those (topics) are things that we know people are extremely biased for in their actual decision-making. I think part of the reason is

that evolution has designed us to just not think about what is going to happen when we're 80 years old.

"So there is a lot of work in what kind of decision processes lead to under-saving by older people and how we can change the framing of the problem to get them to save more and what kind of therapies you can use to get very old people to improve their decision-making."

Despite being a researcher who has yet to start his faculty career, Hsu is already crossing disciplines from psychology to economics to philosophy and earning national recognition.

"These are questions that every notable philosopher has asked since basically the beginning of philosophy," he said. "To the extent that you can bring some new ideas into it, people are interested."



"Christine", one of Ming Hsu's subjects in a moral decision-making experiment. Image courtesy WNET Thirteen.

Experiment Puts Subjects to the Test

The choices required of test subjects in Ming Hsu's moral decision-making experiment were not easy, according to several of the study's subjects. The PBS show *Curious*, produced by WNET Thirteen in New York, followed Hsu and his fellow researchers as they ran test subjects through a headscanner and asked them to make decisions about donating to a children's home. Hsu explains the rationale behind the tough moral dilemma for subjects at the heart of the experiment in this behind-the-scenes clip.

To watch an online version of the *Curious* episode, titled *Mind, Brain, Machine*, click **HERE** or visit http://www.thirteen.org/curious/episodes/watch-the-full-episode-mind-brain-machine/.

Carle Foundation Hospital and the Beckman Institute Launch Fellows Program with Cancer-related Research Focus

In February, Carle Foundation Hospital and the Beckman Institute for Advanced Science and Technology announced an exciting new Fellows program that will provide a young scientist with the opportunity to spend several years conducting cancer-related translational research. The Carle Foundation Hospital – Beckman Institute Fellows Program is intended for a recent Ph.D. who will focus his or her research efforts on engineering biological materials for molecular imaging investigations of cancer.

Beckman Institute Director Pierre Wiltzius said this is the first partnership of its kind with Carle Foundation Hospital.

"The development of this Fellows program is another step toward a great relationship with Carle Foundation Hospital. A relationship that we hope brings about tangible results in cancer-related research." Wiltzius said.

The selected candidate will be appointed for up to three years and will interact with Beckman Institute faculty as well as clinical mentors at the Carle Foundation Hospital. During the term, the Fellow will be allowed the opportunity to fully focus on research. The Fellow will be given access to state-of-the-art facilities and will be provided with staff support to aid their efforts.

"The Carle Foundation Hospital – Beckman Institute Fellows won't have to worry about teaching or administrative responsibilities," Wiltzius said. "This gives recent Ph.D.s the opportunity to immerse themselves in their research and jump-start research programs that we hope yield advances in areas including non-invasive cancer screening and detection."

The ability for the Fellow to have relationships with mentors at Carle Foundation Hospital is also a great advantage of this program.

"Collaboration between practicing physicians and scientists is the key to translational research," said Suzanne Stratton, Ph.D., Vice President of Research at Carle Foundation Hospital. "The only way to develop new medical treatments and diagnostic tools is by close partnership between clinical and research disciplines. The ultimate goal is to improve patient care."

The Carle Foundation Hospital – Beckman Institute Fellows Program will contribute to the Carle Foundation Hospital accomplishing its goals of enhancing relationships with University of Illinois scientists, advancing its translational research program in the area of breast cancer research, and providing an opportunity for its medical staff to collaborate with researchers in the search for breakthrough discoveries that will improve healthcare. The announcement of the selected Fellow will be on Friday, May 16, 2008.

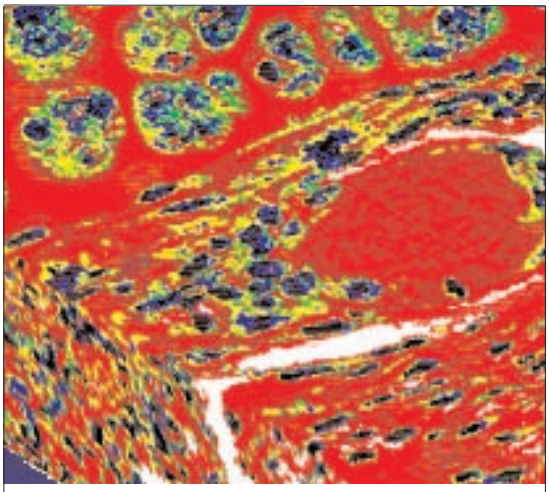


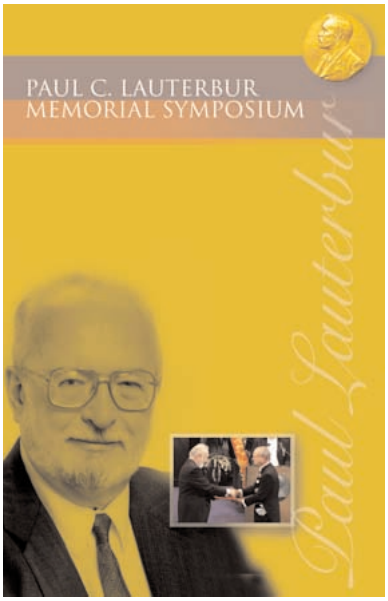
Image courtesy Michael Oelze

"Collaboration between practicing physicians and scientists is the key to translational research. The only way to develop new medical treatments and diagnostic tools is by close partnership between clinical and research disciplines. The ultimate goal is to improve patient care."

– Suzanne Stratton, Vice President of Research at Carle Foundation Hospital

Carle Foundation Hospital

BECKMAN INSTITUTE AT THE UNIVERSITY OF ILLINOIS



Memorial Symposium Honors Lauterbur

Magnetic Resonance Imaging (MRI) pioneers and researchers from across the country gathered in March at the Beckman Institute to honor the late Nobel Laureate Paul C. Lauterbur.

The Paul C. Lauterbur Memorial Symposium brought together nationally-known experts for discussions of historical developments, current status, and future directions in a field that Lauterbur initiated.

The symposium featured four plenary sessions of invited talks and two keynote lectures by leading MRI researchers, as well as two special sessions of talks by some of Lauterbur's former collaborators and students, and a social program honoring his life and achievements.

"Paul's life and career have been a great source of inspiration for so many people, so having the symposium here not only paid tribute to him but also educated a new generation of students and junior researchers. Paul is one of the greatest scientists of the 20th Century. Being a faculty member here, he brought tremendous visibility to the campus."
– Zhi-Pei Liang

Lauterbur and Sir Peter Mansfield won the Nobel Prize for Physiology or Medicine in 2003 for their "seminal discoveries concerning the use of magnetic resonance to visualize different structures. These discoveries have led to the development of modern magnetic resonance imaging, MRI, which represents a breakthrough in medical diagnostics and research."

Lauterbur founded what is now called the Beckman Institute Biomedical Imaging Center (BIC) on campus. BIC Director Art Kramer and fellow Beckman researcher Brad Sutton were on the organizing committee while Beckman Institute Associate Director Van Anderson was a co-chair of the event.

Anderson said it was exciting for Beckman to play host to the Paul C. Lauterbur Memorial Symposium and said the program featured top researchers who provided a glimpse of the history of magnetic resonance imaging and spectroscopy, as well as the state-of-the-art research and the emerging technologies in the field.

Zhi-Pei Liang, a faculty member at Beckman and in the Department of Electrical and Computer Engineering at Illinois, was also a co-chair. Liang was a post-doctoral student under Lauterbur before becoming his colleague on the faculty at Illinois.

"I worked with Paul for 17 years. He was not only a great scientist but also a very humble, gracious, and caring person," Liang said.

Liang said that Lauterbur, who died in March of 2007, inspired many fellow scientists and students over the years.

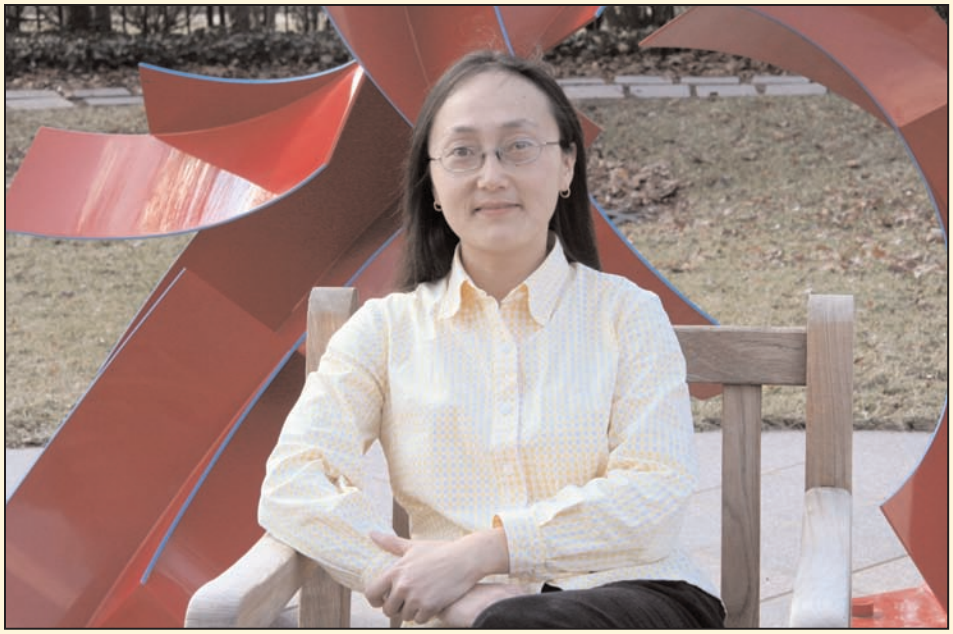
"Paul's life and career have been a great source of inspiration for so many people, so having the symposium here not only paid tribute to him but also educated a new generation of students and junior researchers," Liang said. "Paul is one of the greatest scientists of the 20th Century. Being a faculty member here, he brought tremendous visibility to the campus."

Charles Springer of the Oregon Health and Science University gave a keynote speech "Lauterburian Wit and Wisdom" at the symposium banquet on March 27, 2008.

Zhi-Pei Liang, co-chair for the Paul C. Lauterbur Symposium and former student of Paul's, introduces Elise Lauterbur.

The symposium was sponsored by the Office of the Chancellor, Office of the Provost, Office of the Vice Chancellor for Research, Beckman Institute, Department of Bioengineering, Department of Chemistry, Department of Electrical and Computer Engineering, College of Medicine, and the Olga G. Nalbandov Fund.

FACULTY PROFILE



Wang Pushes Boundaries of Psychology Research

Before the Beckman Institute acquired a state-of-the-art immersive virtual reality environment known as the Cube, the most high tech Ranxiao Frances Wang got in her psychology research was to use a video camera. These days, Wang is treating the Cube like a test pilot does an experimental aircraft.

"She's come up with some of the most innovative projects in the Cube," said Hank Kaczmarksi, Director of Beckman's Integrated Systems Laboratory, which operates the rare, six-sided, 3-D facility. "It's really been exciting working with her. She really pushes the limits of the Cube's capabilities."

Wang is a Professor of Psychology and member of Beckman's Human Perception and Performance group whose research focuses on various aspects of human spatial cognition and visual perception. The Cube, with its ability to create virtual worlds that can simulate everything from swimming sharks to leaves on a tree, is a perfect facility for Wang's expanding research interests.

"I study three-dimensional space and how people move around and understand that," Wang said. "The Cube is really fantastic equipment for that because it creates the kind of environments where I can test different hypotheses. It creates all kinds of things that are impossible to do in real life."

In the past Wang has tested conventional thinking in psychology with projects and papers based on her experiments in the Cube. One paper that she was lead author on, *Spatial updating relies on an egocentric representation of space: effects of the number of objects*, caused a stir when it was published in 2006.

"The findings in that paper were evidence for a new kind of model for how we process information as we move around," Wang said. "The traditional view is that we build maps of the world and then we basically just plod our way around. What we showed is that we don't actually use maps of the world; we build up local ones, egocentric ones, asking 'where is that, relative to me.' We try to calculate coordinates as we move around. It's an online, dynamic system, rather than having a static map."

"It's really been exciting working with her. She really pushes the limits of the Cube's capabilities."
– ISL Director Hank Kaczmarksi on psychology researcher Ranxiao Frances Wang

Wang said her theory was so controversial it took her five years to get it published.

"People just found it really hard to accept," she said. "I think now it's become a very strong candidate for models out there and people are taking it seriously."

Now, with recently earned tenure, Wang is again testing uncharted waters using the Cube as a vessel. In the past her collaborators had all come from psychology; now she is pursuing projects with computer scientists, mathematicians, and even physicists. One upcoming project involves applying her work in spatial cognition and navigation to artificial intelligence.

Intriguingly, she is starting a project exploring quantum mechanics and human consciousness and has pondered the topic of high-dimensional space in collaboration with Beckman researcher George Francis. Using the Cube, Wang is exploring what a four-dimensional world would mean to humans accustomed to merely three.

"What I'm interested in, is how the human mind could comprehend that, can we visualize what that is, can we get a sense of what that means if it was true," she said. "We use the Cube to generate a program that will mimic somebody flying through a four-dimensional world. Our eyes are designed to see three-dimensional objects but we can create a program where everything you see in the scene is something you would see if you were flying through a four-dimensional world.

"Then we use different tasks to see how people respond and learn to make judgments about how things really are when we put them in a four-dimensional world and test if people are really able to generate mental space in four dimensions."

Wang is a native of China who earned a Ph.D. in Computational Cognitive Science from MIT in 1999. She is excited about future projects such as investigating a theory about the mind and quantum mechanics in collaboration with Tony Leggett and Paul Kwiat from the Department of Physics.

"There is a long-lasting mystery about how quantum mechanics works and there is a theory that it actually has some connection with human consciousness," she said. "I don't know where it's going to go; it's one of those very exploratory, high-risk kinds of projects, but fun."

Healing Balm

March 12 – Beckman researcher Jeff Moore and his colleagues are developing self-healing substances that are capable of repairing themselves when damaged. Such self-healing composites would mend themselves when cracked, in much the same way an animal's broken bone heals itself. The difference is that these materials will heal in minutes, rather than months.

The Economist

Can a Computer Have a Sense of Smell?

March 10 – U. of I. chemistry professor and Beckman researcher Kenneth Suslick is working with Stanford professor Paul Rhodes to create a portable sensing device that can sort a host of odors, ultimately to be able to detect toxic material, spoiling food, disease and various degrees of sickness.

San Francisco Chronicle

Combat Helmet That Could Relay Injury Data is Goal of U. of I. Project

March 6 – Kenneth Watkin, a member of the Beckman Institute's Bioimaging Science and Technology group, is leader of a project that is developing communications technology that could, through sensors in a blast helmet, provide real-time blast-injury data to first responders.

U of I News Bureau

Company Working on Marine Uses for Its 'Self-healing' Coating

March 3 – A start-up company that grew out of research into self-healing materials by Beckman Institute faculty members Scott White, Nancy Sottos, Jeff Moore, and their colleagues was the focus of a feature article in Sunday's News-Gazette. White and former Beckman researchers Magnus Andersson and Gerald Wilson are featured in the article.

News-Gazette

Mechanism of Blood Clot Elasticity Revealed In High Definition

February 26 – Blood clots can save lives, staunching blood loss after injury, but they can also kill. Let loose in the bloodstream, a clot can cause a heart attack, stroke or pulmonary embolism. A new study reveals in atomic detail how a blood protein that is a fundamental building block of blood clots gives them their life-enhancing, or life-endangering, properties. The study, conducted at Illinois by Beckman graduate research assistant Eric Lee and Beckman faculty member Klaus Schulten and by researchers at the Mayo College of Medicine, appears in the journal Structure.

Science Daily

Computing and Reaction Simulation

February 15 – The Cell chip used by PlayStation 3 is prized by chemists and physicists because the kinds of calculations required to make high-quality graphics for games are similar to those used to simulate reactions between particles. By using the C programming language to run the chip, Beckman researcher and U. of I. chemistry professor Todd Martinez found he could run calculations 130 times faster than on an ordinary PC. He is now calculating the energy of the electrons in 1,000 atoms, which add up to the size of a small protein.

Agence France-Presse

Pioneering Class Helps Undergraduate Students Explore Their Own Scientific Interests

February 13 – A pilot class at Illinois called "The Chemistry and Biology of Everyday Life" gives students a voice in what they learn and engages them by focusing on their interests. The course was developed by U. of I. chemistry professor and Beckman researcher Yi Lu and Brandy Russell, now a professor at Gustavus Adolphus College in St. Peter, Minn. They hope that the class will encourage more students to continue as science majors.

Chemical & Engineering News

Keeping Your Brain Fit

February 11 – Experts caution that most brain-training products haven't been tested and that what data do exist are still shaky. If improvement of daily living tasks is the goal, "we don't yet have the data to suggest they accomplish that," says Arthur Kramer, a Beckman researcher and U. of I. professor of psychology. "Yes, we have data that says you can get better at certain things with practice. But does it translate to the real world? We don't know yet."

U.S. News & World Report

Self-Repairing Materials

February 11 – Beckman researcher and U. of I. chemistry professor Jeffrey Moore and colleagues are working to develop composite materials such as reinforced plastics that will mend themselves if they get cracked, in much the same way as an animal's broken bone will heal.

The Economist

Tiny Treatments Promise Big Results

February 11 – The potential applications of using nanoparticles to enhance imaging are already being investigated. For example, Amy Oldenburg, a postdoctoral researcher at Illinois's Beckman Institute, and colleagues at the U. of I. and Purdue University, have found that plasmon-resonant gold nanorods provide spectroscopic OCT contrast in removed human breast tumors.

SPIE.org

New Process Makes Nanofibers in Complex Shapes and Unlimited Lengths

January 30 – The continuous fabrication of complex, three-dimensional nanoscale structures and the ability to grow individual nanowires of unlimited length are now possible with a process developed by researchers at the University of Illinois including Beckman affiliate Min-Feng Yu.

U of I News Bureau

Don't Just Stand There, Think

January 24 – An article about the growing research area of embodied cognition includes the work of Illinois psychology professor and Beckman Institute researcher Alejandro Lleras and graduate student Laura Thomas.

Boston Globe

Work of Schulten, TCB Group Spotlighted in Nature Feature

January 17 – A fierce competition involving Beckman Institute researcher Klaus Schulten and his group is at the heart of a Nature magazine feature story about the race to do molecular dynamics simulations at the millisecond scale.

Nature

How to Make a Submarine Disappear

January 17 – Using computer simulations, a group of researchers has determined that

it's possible to build objects that will allow sound waves to slip past undisturbed. If the concept is proved experimentally, it could pave the way not just for military applications such as stealthier submarines but also for auditoriums with less reverberation and perhaps even smoother flights for airplanes. Beckman researcher and U. of I. mechanical engineering professor Nicholas Fang says the research "clearly indicates" that achieving anisotropy is critical to building an acoustic cloaking shell. Although that technology remains challenging, he says, "I am glad to see we now have more tricks to play with sound."

Science Magazine

Cool Solution for Sensitive Biomolecules

January 14 – Beckman researcher and U. of I. chemistry professor Yi Lu and colleagues have designed the first buffer system that maintains the pH independently of temperature. Buffers are used to keep a sample at a particular pH, important for studying sensitive molecules, such as enzymes, that would decompose under acidic or alkaline conditions. But buffered solutions usually change pH at low temperatures, potentially damaging the sample as it is cooled to be studied.

Chemistry World

New York Times Spotlights Conference at Beckman

January 8 – New York Times science reporter Kenneth Chang, who attended a conference held at the Beckman Institute in October commemorating the publication of the first paper explaining the theory of superconductivity, explores the origins of the theory and cites the many U. of I. scientists who have worked in this area of research.

The New York Times

Cell Phones and Driving

January 8 – "The requirements to both listen carefully and respond while on a cell phone creates 'interference' with the task at hand, driving in this case, and our research shows that we have limited cognitive resources to multitask," says Arthur Kramer, Beckman faculty member and director of the Biomedical Imaging Center at Illinois. When demand for our "neural resources" exceeds supply, the result is decreased performance – scanning less attentively for pedestrians, for example, or failing to maintain a lane or speed.

Time magazine

Scientists Seek Cheaper DNA Method

January 8 – A DNA sequencing technique being developed by Beckman researchers Aleksei Aksimentiev and Gregory Timp, involves pushing DNA molecules through tiny pores built into a silicon chip.

United Press International

Genetic Chips

January 3 – Beckman faculty member Oleksii Aksimentiev and colleagues at Illinois are exploring the workings of a human-gene-sequencing chip. Rather than just build chips and doing experiments to see if they work, the researchers use computer simulations to see if their ideas are feasible.

Chicago Tribune

Beckman Researchers Work Featured on January 2008 Nature Photonics Cover

January 3 – The January 2008 issue of Nature Photonics features the work of Beckman faculty member Paul Braun, Beckman Fellow Stephanie Rinne, and their colleague Florencio Garcia-Santamaria. Their paper is entitled "Embedded cavities and waveguides in three-dimensional silicon photonic crystals." It describes how photonic crystals enable the manipulation of light on a scale not previously possible and that controlled fabrication of three-dimensional crystals is proving to be quite a challenge. Their research, using artificial opals and two-photon absorption, shows how it is now possible to create near-infrared waveguides of arbitrary shape. The Nature Photonics cover image was produced in the Beckman Institute's Visualization, Media, and Imaging Lab by ITG 3D Artist Steve Eisenmann.

Photonic Crystal Bends Light Round Corners

December 18 – Beckman researcher and U. of I. materials science and engineering professor Paul Braun and colleagues have pioneered a flexible process for a fabricating 3-D photonic-crystal waveguide by using a focused laser to mark it out.

PhysicsWorld.com

Advance in DNA Sequencing Announced

December 18 – Researchers including Illinois physics professor and Beckman's Aleksei Aksimentiev have demonstrated a strategy for sequencing DNA by driving the molecule back and forth through a nanopore capacitor in a semiconductor chip.

United Press International

DNA Sequencing Using Nanopores: Toward the Genomic Analysis of Cancer

December 14 – A feature article in the Autumn 2007 issue of Chemistry highlights the work of Beckman Institute faculty member Jean-Pierre Leburton and his collaborators in the area of using nanopores to sequence DNA.

Chemistry