

## Science of Learning Center Comes to UC San Diego

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Gary Cottrell, a Computer Science and Engineering professor from UCSD's Jacobs School of Engineering, is the driving force behind the founding of The Temporal Dynamics of Learning Center as well as a participating researcher.

A better understanding of how humans learn could lead to improved teaching techniques and, along the way, alter the trajectories of countless human lives. Thanks to a National Science Foundation (NSF) grant for \$3.5 million, with the possibility of an additional \$32 million over the next decade, a UC San Diego-based interdisciplinary team of scientists and educators is poised to clarify the importance of time in learning.

The center - called The Temporal Dynamics of Learning Center - will benefit from major participation from scientists at Vanderbilt University, Rutgers University at Newark, and other U.S. and international institutions.

When you learn new facts, interact with colleagues and teachers, experiment with new gadgets, or engage in countless other learning activities, timing plays a role in the functioning of your neurons, in the communication between and within sensory systems, and in the interactions between different regions of your brain. The success or failure of attempts to communicate using gestures, expressions and verbal language also depends on timing.

Gary Cottrell, a Computer Science and Engineering professor from UCSD's Jacobs School of Engineering, is the driving force behind the founding of the center as well as a participating researcher. Cottrell recruited over forty researchers from across the United States, Canada, and Australia to participate in the effort.

An artist's conception of the "network of networks" structure that defines the new learning center.

The NSF's Science of Learning Centers program offers awards for large-scale, long-term centers that will extend the frontiers of knowledge on learning of all types and create the intellectual, organizational, and physical infrastructure needed for the long-term advancement of learning research.

"It was a monumental task putting this together," Cottrell said, "but when we started talking about our plans, people just came out of the woodwork to join in. It was a group effort," Cottrell said.

Cottrell will direct The Temporal Dynamics of Learning Center in concert with Andrea Chiba, a professor at the Cognitive Science department and an affiliate of the Graduate Program in Neurosciences at UCSD and with Terry Sejnowski, who is the head of the Computational Neurobiology Laboratory at the Salk Institute for Biological Studies and a professor of Biology at UCSD.

"Our approach to organizing research at the center is unique. We have created four research networks, made up of interdisciplinary teams to study the same questions using differing methods, skills, and expertise. We have explicitly *not* created groups that will just meet and tell each other about their research," explained Cottrell. "Rather, we will work across disciplines to synchronize our research on various aspects of time and

timing in learning to develop a more comprehensive, multidisciplinary science focused on the temporal dynamics of learning, from the laboratory to the classroom."

The award is for \$3.5 million for the first two years. The NSF, with input from peer reviewers, will then decide whether to fund an additional \$12 million over the next three years. The grant could then be renewed for another \$20 million over the following five years.

Only four other Science of Learning Centers have been funded in recent years. The NSF is, however, in the process of funding two new centers: one will be dedicated to understanding spatial aspects of learning and the other will focus on vision and learning.

At UCSD and the relevant partner institutions, the four networks of The Temporal Dynamics of Learning Center will collaborate to form a "network of networks" structure that could revolutionize the way in which collaborative scientific research is performed.

RUBI, a social robot that currently teaches numbers, colors and other basic concepts to kids at the UCSD Early Childhood Education Center - and the scientists who created her - are part of The Temporal Dynamics of Learning Center.

The researchers are asking questions that cross the boundaries of traditional fields of learning research. In an attempt to achieve results that will extend beyond academia, questions are being developed through ongoing dialogue with educators. The researchers hope to improve teacher understanding of the scientific research pertaining to the dynamics of learning. In addition, the researchers aim to collaborate with teachers to understand the dynamics of how students are taught in the classroom. Through this process of outreach and "inreach" -- bringing teachers into the laboratory -- the center's researchers hope to ensure that their work will be relevant to the real world of the classroom.

The Temporal Dynamics of Learning Center will integrate its research and educational mission through the Education Outreach Center that will be co-directed by Paula Tallal from Rutgers University at Newark and Terry Sejnowski from the Salk Institute for Biological Studies.

The name of the center, when combined with its official slogan, highlights the dual research and education missions: The Temporal Dynamics of Learning Center: Better Learning through the Advancement of the Science of Time (TLC: BLAST).

The Preuss School -- a middle school and high school on the UCSD campus that provides intensive college prep education for motivated low-income students (Dr. Doris Alvarez, principal ) -- will serve as a "living lab" for appropriate research projects, such as testing new ideas concerning how and when new material should be presented to students.

UCSD's Student Educational Advancement office, whose primary mission is to motivate and prepare educationally disadvantaged and first-generation college students for college success and graduate school, is another outreach partner.

"Timing is everything. It's been a neglected area that we think can really be exploited to help us understand some of the basic ways in which information is integrated in our brains across a variety of timescales. I think we could transform the way that research is actually done by understanding in a real classroom setting how children interact with teachers and use that to help inform our science," said Terry Sejnowski.

"Attempting to understand the temporal dynamics underlying effective learning and memory is an enormous undertaking that will require synchronization of research across multiple disciplines and research models," said Andrea Chiba. "For example, the structure of our center will allow us to carry out similar experiments,

simultaneously, in humans, animal models, and computational models. The San Diego Supercomputer Center will provide us with the cyberinfrastructure necessary to embark on such a large scale collaborative endeavor."

The scientists who are part of this new multidisciplinary center hail from a variety of fields, including machine learning, psychology, cognitive science, neuroscience, molecular genetics, biophysics, mathematics, and education.

"Creating a Science of Learning Center with our colleagues from Rutgers and from Vanderbilt is really an exciting development that is consistent with the mission and vision for this campus. We have the number one neuroscience program in the country. We have the San Diego Supercomputer Center which is unique in being able to handle the large data sets that will be generated by basic research. It will be a wonderful multidisciplinary center," said UCSD Chancellor Marye Anne Fox.

The four networks that will make up The Temporal Dynamics Learning Center are the:

-- **Sensory Motor Learning Network:** Researchers will study the fine temporal dynamics of synaptic learning and motor learning. The network leader is Dan Feldman, professor of Biology and Neuroscience at UCSD.

-- **Interacting Memory Systems Network:** Scientists will focus on the timing of interactions among memory systems. The network leader is Andrea Chiba, professor of Cognitive Science and Neuroscience at UCSD.

-- **Perceptual Expertise Network:** Investigators will study the time course of how representations come online in perceptual expertise, such as face processing. The network leaders are Isabel Gauthier and Tom Palmeri from the Psychology Department at Vanderbilt University.

-- **Social Interaction Network:** Researchers will study how time affects interactions between children and adults in educational settings. Insights on learning may be passed on to RUBI, a social robot that currently teaches numbers, colors and other basic concepts to kids at the UCSD Early Childhood Education Center. The network leader is Javier Movellan, director of the Machine Perception Lab at UCSD's Institute for Neural Computation, located in the California Institute for Telecommunications and Information Technology (Calit2) on the La Jolla campus.

The inspiration for the network-of-networks model came from the success of an interdisciplinary, multi-institution research group called the Perceptual Expertise Network (PEN) which Cottrell and Gauthier helped to create five years ago. Perceptual expertise relates to our ability to rapidly categorize objects such as faces at the individual level. PEN researchers have studied whether face expertise is a special skill or an extension of more general expertise learning, such as that exhibited by a discerning judge at a dog show. During the five years of PEN's existence, collaborations among researchers in the PEN network expanded exponentially, rapidly moving the science of perceptual expertise forward.

Like the Perceptual Expertise Network, the impact of The Temporal Dynamics of Learning Center is expected to be greater than the sum of its parts. The researchers working within the new network of networks are expected to develop, among other things, cross cutting resources that should be available and useful to various scientific and educational communities. The resulting resources are expected to include the:

-- Motion Capture Facility, led by Emo Todorov of the Cognitive Science department at UCSD, and Howard Poizner of UCSD's Institute for Neural Computation. The Facility will be housed in the Calit2 building and will be used to capture the fine scale timing of interactions between teacher and students in one-on-one teaching contexts. Analyses of these interactions will serve as a model for RUBI, the preschool-teaching social robot.

-- Brain Dynamics Facility, led by Scott Makeig, director of UCSD's Swartz Center for Computational Neuroscience. This facility is expected to provide the state-of-the-art algorithms and hardware necessary for simultaneous EEG (electroencephalography) and fMRI (functional magnetic resonance imaging) measurements.

The simultaneous use of EEG and fMRI technologies in the same person - a long-standing scientific goal and technical challenge - would provide high resolution, simultaneous information on both the timing and localization of brain activity that could yield insights on the process of learning.

-- Data Sharing Facility led by Reagan Moore of the San Diego Supercomputer Center and Mark Appelbaum of the Psychology department at UCSD. The facility will provide scalable, cutting-edge analytical capacity for the large-scale data mining that will be critical to the interdisciplinary and collaborative nature of the new research collective. This facility may also serve as a data-sharing model for other interdisciplinary communities.

Center-affiliated researchers will be aiming to enhance and disseminate existing research-based learning initiatives, such as the language and reading intervention products, FastForWord; a face and emotion recognition training system for autistic children called Let's Face It; the robotic preschool teacher, RUBI; as well as develop new translational research initiatives.

The center's goals will be enhanced by the participation of corporate partners, including the Scientific Learning Corporation and Jensen Learning Corporation, both K-12 education companies. The Science Network -- a non-profit, online TV network developed by Roger Bingham, a researcher affiliated with UCSD and the Salk Institute for Biological Studies - is expected to grow to disseminate information from the center and may be used as a vehicle to educate the public and policy makers in order to inject science into the discussion of education reform.

In addition to advancing the basic science of learning and teaching, The Temporal Dynamics of Learning Center has the long-term goal of understanding how to more effectively and efficiently translate this science from the research laboratory into the classroom.

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