Temporal Dynamics of Learning Center
A National Science Foundation Science of Learning Center
November 2014

Why are we here in Washington, DC?

We wish to share the progress of an innovative National Science Foundation (NSF) supported program - the Science of Learning Center (SLC) - and how the Temporal Dynamics of Learning Center (TDLC) specifically fulfills the SLC program objectives to:

- Create a new Science of Learning - which will help create a new science of teaching.
- Create a new scientific organizational structure to promote cooperation between labs - which helps solve problems more efficiently.
- Create an environment where students/trainees have unique *interdisciplinary* research training.
- Translate research into practical tools and technologies for the classroom.
- Translate research into interventions that teach social skills to children with cognitive or learning deficits.

As the SLC program sunsets in 2016, we encourage elected officials, Congressional committee members, and agency leadership to continue support for this type of research, training and translation programming in the future. The NSF initial investment in this group of researchers and students/trainees has grown beyond expectation, has yielded tremendous breakthroughs and benefits, and needs to build on this success!

What is the NSF Science of Learning Centers Program?

The goals of the SLCs are to advance the frontiers of all the sciences of learning through integrated research; to connect the research to specific scientific, technological, educational, and workforce challenges; to enable research communities to capitalize on new opportunities and discoveries; and to respond to new challenges. Centers are supported through large-scale ($4-5M/year), long-term (10 years) Center awards that created the intellectual, organizational and physical infrastructure needed for long-term advancement of the Science of Learning research.

What is the Temporal Dynamics of Learning Center?

TDLC is the largest of the six SLCs, with 42 faculty in 18 institutions in 4 countries. Center personnel also include 30 post-doctoral candidates, 66 graduate students, 32 undergraduate students, and 42 K-12 educators.

Our focus is on the role of *time and timing in learning*, from the scale of how brain cells connect at the 10-millisecond scale to optimizing students' memory for facts at the yearlong scale. We aim to use our understandings of these processes to inform K-12 educational practice. To do so, we created a new collaborative research structure, the network of networks, to transform the practice of science.

Answering questions about the role of time and timing in learning cannot emerge from a single line of inquiry, so TDLC's research model has been collaborative and interdisciplinary from the beginning. TDLC is a community of scientists who break down disciplinary and institutional barriers in pursuit of a common set of research questions. Researchers focus on each set of issues from multiple perspectives, and synchronize their research by running parallel experiments in animal, human, and theoretical models.

TDLC Institutional Partners

University of California, San Diego Rutgers University University of California, Berkeley Vanderbilt University

Affiliated Institutions

Brown University	University at Buffalo SUNY	Carnegie Mellon University
New York University	University of Colorado, Boulder	The Children's Hospital of Philadelphia
University of Pittsburgh	University of Queensland	The Salk Institute
San Diego State University	University College London	Virginia Commonwealth University
University of Victoria		

Future Scientific Challenges for Education and Engineering

In the domains of biological and machine learning, TDLC contributes to understanding and advances in:

- How organisms adapt to the temporal dynamics of the world.
- How the timing of interactions among memory systems integrates memories.
- The timing of interactions between teachers and students, and how that contributes (or not) to the learning.
- How to train perceptual expertise.
- Techniques for motor control in robots, and understanding motor control in humans and other animals.
- Organization of learning at a deep level towards human-like relatively autonomous learning capabilities (learning algorithms for deep architectures).
- Human-machine interfaces and learning (AI, robotics).
- Training young investigators in cross-disciplinary sciences/education required for complex problem solving.

Contributing to the National Research Agenda

TDLC is uniquely positioned to tackle the challenges that the BRAIN Initiative will address. The BRAIN Initiative's overarching goal is to integrate scientific research across scales and disciplines to understand how the brain works, a type of approach that we have done very effectively for almost a decade through our 18 academic institution member research and training collaboration across the US, and in Canada, England and Australia. With investigators in the fields of Machine Learning, Molecular Genetics, Mathematics, Psychology, Biology, Brain Imaging, Cognitive Science, Neuroscience, Robotics, Biophysics, Computer Science, Electrical Engineering, Bioengineering, and Computational Models of Learning and Education, we have tremendous capacity to problem-solve and to train the next generation of young scientists.

Scientific Discovery Leads to Economic Growth and Innovation

Despite science funding challenges, the last several years have been tremendously productive time for neuroscience discoveries. Major advances across disciplines made possible through publicly funded research are leading to new tools, new knowledge, and greater understanding of brain-body function. TDLC is uniquely situated to address tough research questions and develop innovative technologies and tools to address them through the emphasis on integrative and interdisciplinary research. Training the next generation of scientists through innovative and interactive experiences with science, industry, education professionals and the general public, and increasing the diversity of Center students and faculty is foundational for future economic growth and technological innovation.

- TDLC offers a unique business-training environment for students and junior scientists.
- TDLC develops new tools, technologies and therapeutics for classroom and lifelong learning, for laboratory research, and for industry and entertainment.
- TDLC works with biotechnology startups and established companies to function as incubator and research and development laboratories in unique private-public sector partnerships.
- TDLC researchers launch new technology companies and non-profits as spinoffs from Center research.

Why Support these Programs in the Future?

TDLC research, training and translation efforts contribute to:

- Advancing scientific discovery in ways that only occur at the scale of research supported by center-level funding.
- Training the next generation of young investigators in vigorous interdisciplinary sciences and STEM education.
- Increasing student and faculty diversity, which is essential for optimizing teaching and learning.
- Developing of new tools, technologies and approaches to education.
- Transferring tools to the classroom, via direct interactions with K-12 students, teachers and administrators.
- Developing research and teaching tools to study socially situated neuroscience for the BRAIN Initiative.
- Approaches to Big Data that include developing tools and a data-sharing infrastructure to encourage cross-lab innovation.
- Public-Private partnerships that support basic research and training and promote economic growth.
- Growth of the Science of Learning Center model internationally - new Centers and efforts have been initiated in Australia, England, France, China, Singapore, Brazil, Canada; these efforts confirm that continuing to provide strong investments in the Science of Learning will ensure the United States remains competitive.