Temporal Dynamics of Learning Center

TDLC NEWS

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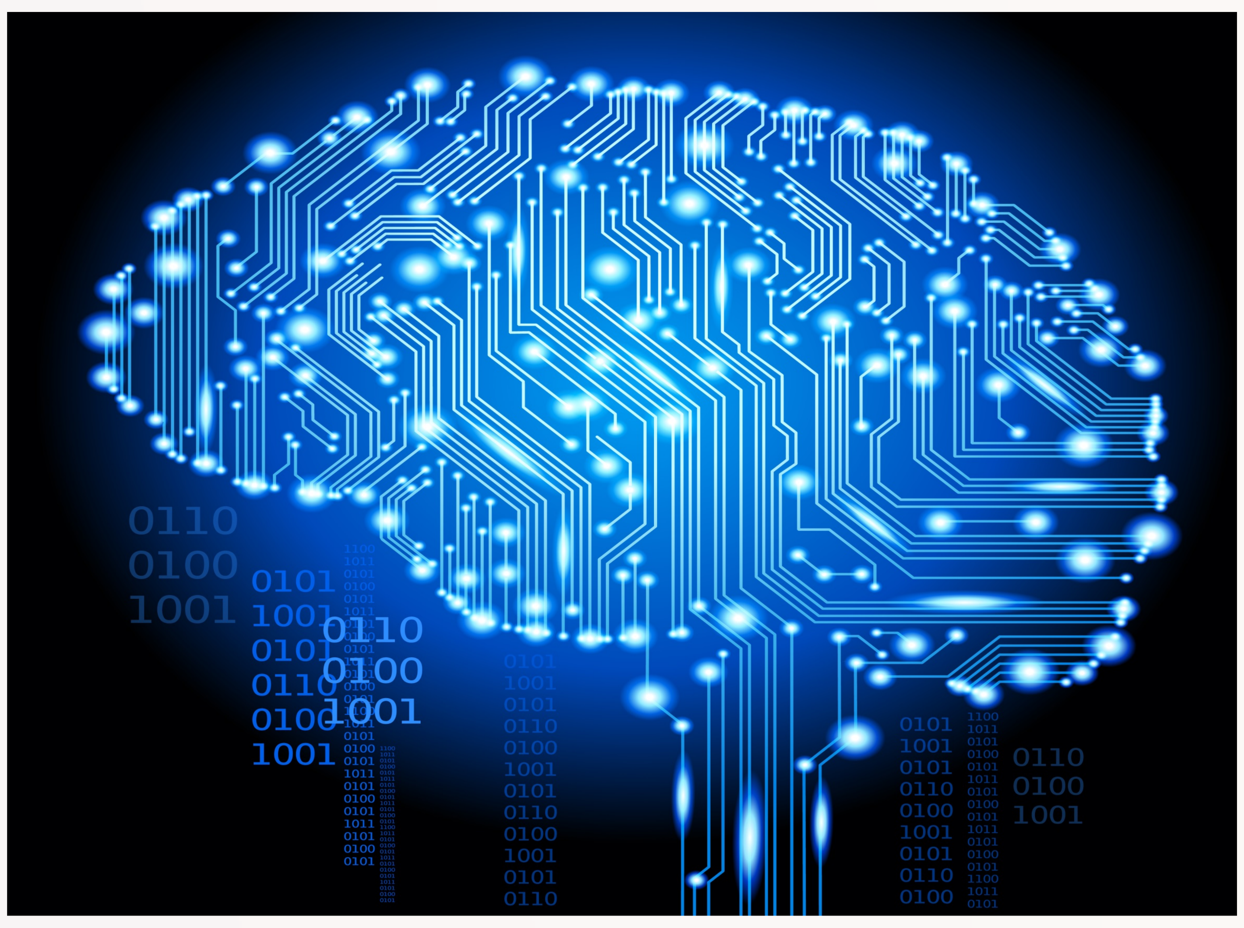
Building a Better Science of Learning: It's About Time!



TDLC Develops Innovative Network-of-Network Organization

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 science disciplines include:

- Machine Learning
- Psychology
- Cognitive Science
- Biophysics
- Computer Science
- Molecular Genetics
- Biology
- Neuroscience
- Electrical Engineering
- Computational models of learning and education
- Mathematics
- Brain Imaging
- Robotics
- Bioengineering

TDLC is organized as a network of networks to focus on four major aspects of learning: Sensori-Motor Learning, Interactive Memory Systems, Perceptual Expertise, and Social Interaction Systems. Each network is composed of multiple PIs, often from different partner institutions, and there are crosscutting resources available to researchers in all the networks: Brain dynamics, data sharing and motion capture facilities, and an education and outreach center. The TDLC collaborative multi-disciplinary model effectively and efficiently builds relationships between researchers, educators, students and the general public in order to generate new, transformational ideas.

Worldwide Interdisciplinary Team

> Over 40 Principal Investigators
> More than 150 Trainees – undergraduate through post-doc
> At 18 partner research institutions
> Located in four countries (U.S., Canada, London, Australia)

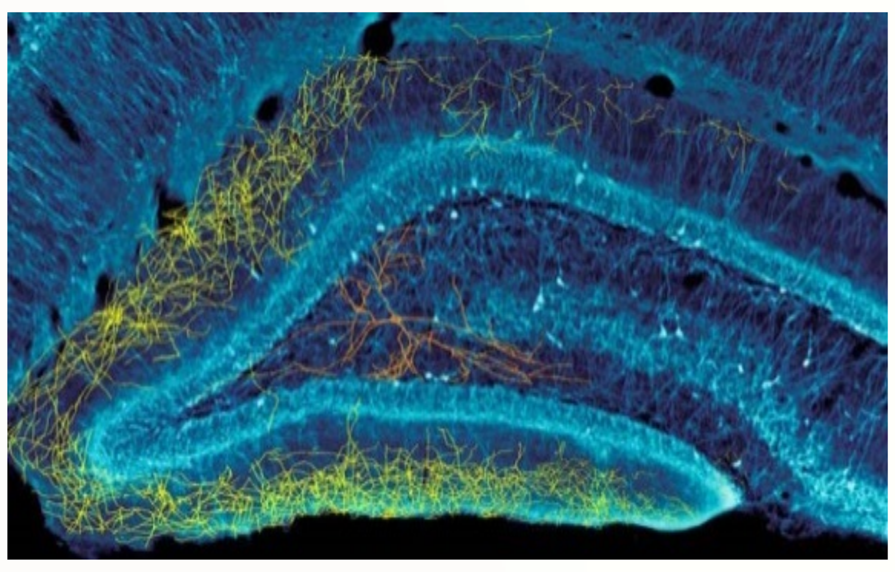
Translation

Education is a well-developed discipline with a lengthy history. Neuroscience and computation are younger fields that are rapidly growing. At TDLC, we are dedicated to the integration of neuroscience and computation into educational theory and practice, and ultimately, translation of research findings into innovative technologies and programs such as:

- Creating groundbreaking computer games to help autistic children read faces (The Let's Face It! and FaceMaze programs).
- Developing robots to help in schools: RUBI, a social robot, has taught colors and shapes to preschoolers using California standards.
- Robot baby, Diego-San, may aid in therapy sessions with special needs children one day.
- Writing computer models that can schedule students' study sessions for optimal learning.
- Inventing adaptive tutoring systems that respond to the user's facial expressions.
- Developing cognitive and literacy skills training (FastForword) that can improve students' basic writing skills.
- Creating a system for improving students' memory for vocabulary words.
- Understanding the role of group musical training in learning and development.

Our Mission

As one of six Science of Learning Centers funded by the National Science Foundation, our mission is to create a new science of the temporal dynamics of learning in which we achieve an integrated understanding of the role of time and timing in learning, across multiple scales, brain systems, and social systems. We aim to use this understanding 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.



Brain image provided by TDLC investigator Dr. Gyorgy Buzsaki

Questions We Ask

Timing is critical for learning at every level, from learning the precise temporal patterns of speech sounds, to learning appropriate sequences of movements, to optimal training and instructional schedules for learning, to interpreting the streams of social signals that reinforce learning in the classroom or the boardroom. TDLC initiatives address fundamental research questions such as:

- *How is temporal information about the world learned and how do the temporal dynamics of the world influence learning?*
- *How do the intrinsic temporal dynamic properties of brain cells and circuits facilitate and/or constrain learning and behavior?*
- *How can the temporal features of learning be used to enhance education?*
- *What are the best theoretical ways to conceive the temporal dynamics of learning in the brain and between brains?*
- *What are the temporal structures for body movements and sampling the environment and how are they learned?*

A Sampler of Innovative Research and Findings

- An activated brain state, as measured by cortical EEG, is essential for accurate encoding of sensory temporal patterns in both the auditory and visual modalities.
- Lower levels of (fast oscillatory activity) gamma power in the resting cortical EEG of an infant may predict early childhood language or attentional problems. This knowledge spurred the creation of early interventions for specific language impairments.
- The ability of a child (playing in a Gamelan musical percussion group) to temporally synchronize with an external source correlates significantly with established measures of attentional performance.
- By examining children playing group music in an instrumental setting, The SIMPHONY Project is one of the first longitudinal studies of its kind to study the effect of musical training on brain development.
- aMEG (anatomically constrained magnetoencephalograpy) demonstrates a "contralateral ear to hemisphere advantage" for auditory processing in real time, confirming physiologically what has been hypothesized for decades, based on dichotic listening behavioral studies.
- Temporal coordination in and between brain regions (temporal synchronicity) may improve the fidelity of information transfer.
- Human cortical theta oscillations during free exploration encode space and predict subsequent memory and language.
- The frequency of an individual's oscillatory activity (measured by cortical EEG) prior to the presentation of a stimulus, predicts their later memory for that stimulus.
- Neurogenesis (birth of neurons in the hippocampus) binds new memories together on short timescales (minutes to days) while providing a code for separating events that occur farther apart in time (weeks to months).
- Computational links have been forged between thermodynamics and prediction, showing that in order to be energy-efficient, an organism must be predictive.
- The brain's visual perception system can automatically guide our decision-making through affective valence perception.
- During face recognition, the first two places we look at are around the nose, with the eyes being the third fixation.
- Scientists are attempting to develop robots trained to "read" a student's facial expressions in order to improve intelligent tutoring systems.
- Scientists are exploring whether training autistic children to become "face experts" will improve their social skills.
- Researchers hope to use Brain-Computer Interfaces (BCIs) and other non-invasive interventions to help individuals with motor-sensory learning impairments.
- MuJoCo: A new physics engine for model-based control is being released for public use. This will facilitate the testing and development of numerous optimal control applications, including new discoveries in motor control.

Diversity, Outreach & Education

TDLC is committed to enhancing student education with innovative and interactive experiences with science, industry and education professionals and the general public, and increasing the diversity of our Center and the scientific community. The Center offers opportunities such as:

- The Educator Network
- Summer Fellows Institute
- Annual FaceCamp
- TDLC Distinguished Educator Advisory Panel
- Small Grant Program
- Fellows Lecture Series and Retreat
- iSLC Conference
- Summer TDLC Research Lab Internship Programs
- Language Training Programs
- Research Experience for Undergraduates Site Program
- Gamelan Project at The Museum School
- Research for Tomorrow
- The Preuss School Internship
- UCSD Neuroscience Outreach Group

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"Life passes in milliseconds, but what we learn in those milliseconds changes us for life."

Dr. Gary Cottrell, TDLC Director