Temporal Dynamics of Learning Center

NSF Highlights 2018

Internship program taps into the talents of autistic youth

Interns conduct an interactive showcase of their research and resulting video games to the campus and local community. Photo by Erik Jepsen/UC San Diego Publications

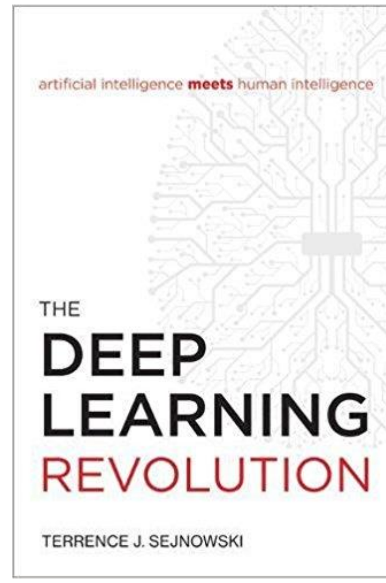
Outcome: A new internship program at UC San Diego taps into the talents of autistic youth to develop therapeutic video games. Dr. Leanne Chukoskie, a neuroscientist at UC San Diego, designed a paid summer internship program for people with Autism Spectrum Disorder (ASD). With support from the San Diego Foundation and the Legler Benbough Foundation, she established the program through the Power of Neurogaming Center (PoNG) at UC San Diego's Qualcomm Institute. The eight-week program is mutually beneficial - Dr. Chukoskie gains the students' coding talent, and interns improve their social skills by working in creative groups and making professional connections. The 25 interns, grouped in teams, develop "neurogames" or video games that are sensor-enabled and designed to improve or test different cognitive or motor functions such as attention and balance. The interns use Unity, a cutting-edge software development platform, to create games that use eye-tracking technology, balance boards, and EEG (electroencephalogram) sensors to allow participants to connect to the game and improve motor skills and focus. (The video games, which use eye movement to train attention, are based on research performed through the Temporal Dynamics of Learning Center, funded by the National Science Foundation).

Impact/benefits: Young adults with ASD have a very low rate of employment, due to factors such as challenges in social communication and social interaction. They often experience social anxiety and a preference for routine which makes it difficult during job interviews and in communicating their skills and making big life transitions. But those on the spectrum have many talents that can be extremely beneficial to the community, especially in technical fields such as computer science and video game programming. In the case of the PoNG program, interns have already contributed five new sensor-enabled video games for training and assessment. Some of the games include a team player space game that eyes eye tracking from both participants and an Android game designed to help seniors get more exercise and practice navigation skills in safe environment. In turn, students leave the summer internship program with new knowledge, programming skills, and connections, and find themselves one step closer to future employment.

Background/Explanation: Currently, relatively little is known about the most efficient and effective ways to support young adults with ASD to obtain and maintain employment. "It's hard to be under the stigma of Autism Spectrum Disorder. I'm awkward, I admit that," shares Chris Rosenbaum, one of the RADLab interns. Like Chris, the other interns are aware of their challenges. But they are also aware of their talents. Chris quickly adds, "We're capable of doing great work!" Dr. Chukoskie sums it up, "The goal of this program is to shine a light on this community, demonstrate that this is the tech talent companies have been missing. These people have a lot to give."

More:
Tapping Untapped Talent: Internship program taps into the talents of autistic youth - UC San Diego News Center, 10/18
Neuroscientist sees video games as a tool to help youth with autism **-** The San Diego Union-Tribune, 7/19/18

The Deep Learning Revolution
*Artificial intelligence **meets** human intelligence*
by Dr. Terrence J. Sejnowski (The MIT Press)



Outcome:
In his soon-to-be released book, *The Deep Learning Revolution*, Dr. Terrence Sejnowski describes the way deep learning is changing our lives and transforming our economy. The book, available October 9, 2018, explains the history and people who have led the deep learning revolution, how the field is evolving, and where it is heading. He devotes one chapter to his research funded by the National Science Foundation through its Science of Learning Center, the Temporal Dynamics of Learning Center (TDLC). TDLC emphasized machine learning and brain learning, two areas that are converging. Examples of research by TDLC include the automatic recognition of facial expressions, social robots for classrooms, and learning how to learn. These advances are being supercharged with deep learning and could soon lead to personalized tutors.

Impact/benefits:
Deep learning is reshaping the world in which we live – affecting everything from the automotive industry (driverless cars) to medicine and healthcare (e.g. computer-aided detection and diagnosis). Other common applications include Google Translate, Alexa, face recognition, voice-activated intelligent assistants, and image recognition. Deep Learning will impact most industries as well as those who work in those industries and use those products. Because deep learning surrounds us every day, and its influence will only increase with time, *The Deep Learning Revolution* is key in helping us understand what our future might hold.

Explanation:
Deep learning involves building artificial neural networks which attempt to mimic the way human brains sort and process information. As these learning algorithms are exposed to new data, they are able to adapt. The models learn from previous computations to produce reliable, repeatable decisions and results. Dr. Sejnowski is one of the pioneers of deep learning. In the 1980s, he was part of a small group of researchers who helped develop this new model of artificial intelligence. It is fitting that such a central figure in the field writes a book to explain the history, the incredible advances that have come out of the field, and where deep learning is headed. What might come next? Dr. Sejnowski gives us crucial insight into our deep learning future.


Social Robots for Classrooms: Children interact with TDLC’s RUBI (Robot Using Bayesian Inference)

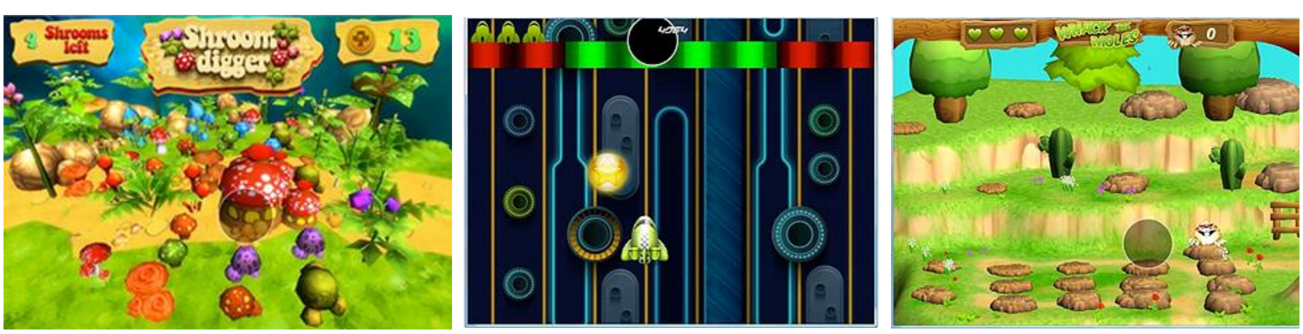
Therapeutic Games for Improving Low-Level Attention

Outcome: The ability to orient and focus one's attention appropriately is an important ingredient for effective learning. Dr. Jeanne Townsend and Dr. Leanne Chukoskie saw the need to take research findings about attention and to translate them into effective, affordable and readily available interventions. Through their new company, BrainLeap Technologies, they have created interventions in the form of fun games, aimed at improving attention. These games, using eye movements, gradually shape behavior using visual and auditory feedback provided in real time. They are designed to improve the speed, accuracy and control of eye movement, and in doing so they improve the speed, accuracy and control of attention. Townsend and Chukoskie are currently working to take these games from the lab and into homes and schools, to improve attentional skill and increase classroom readiness.

Impact/benefits: A major challenge in training attention and motor skills such as eye movement is the amount of time required and the necessity for frequent practice. It is difficult, if not impossible, to administer frequent and lengthy training in a laboratory or clinic. But the BrainLeap game system was designed for use at home or in school, which allows for greater flexibility and ease of use, and more hours of distributed training.

Background/Explanation: Research has shown that eye movement and attention are tightly linked and share much of the same brain circuitry. Attention is difficult to measure because it cannot be observed directly. It can only be measured by observing the way it affects our information processing, learning and memory. But eye movements can be observed and are easy to measure. Past studies have shown that saccadic eye movements – fast orienting eye movements – can be used as a sensitive, non-invasive measure of attention and motor planning. By understanding how eye movement and attention work together, Drs. Townsend and Chukoskie have developed therapeutic games that use eye movement to train attention. All of the games are played using an eye tracker that follows the user's eyes. The games train different principles of eye movement and attention control such as fast and accurate shifts, inhibitory control, increasing field-of-view, fixation control, fast visual search, and looking ahead to improve and encourage movement planning.

The BrainLeap games include: Shroom Digger (left), Space Race (middle), Whack the Moles (right)



Shroom Digger: The player must fix gaze on the mushroom houses to explode them. Looking away causes the house to shrink. This game trains gaze fixation control, sustained attention focus, and fast visual search.

Space Race: Players must look ahead of the ship to move it through the green gates and pick up stars for bonus points. Crashing into a red gate causes a lost ship. This game trains fast attention, gaze shifts, and eye movement control.

Whack the Moles: Cartoon moles emerge from their holes or descend with parachutes from the sky. Some are to be 'whacked' by fixed gaze and others are to be avoided. This game trains rapid, accurate shifts and inhibitory control of attention and gaze.

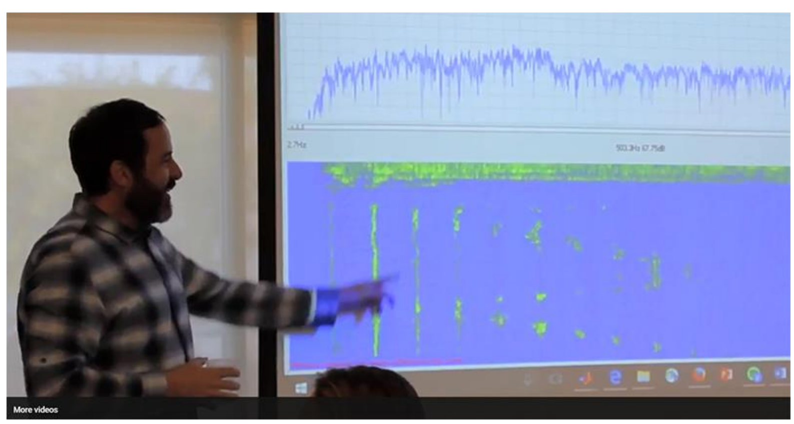
Chukoskie, L., Westerfield, M., Townsend, J. (2017) "A Novel Approach to Training Attention and Gaze in ASD: A Feasibility and Efficacy Pilot Study". *Developmental Neurobiology*. doi: 10.1002/dneu.22563

The Role of Music in Science Education

Outcome: *Listening to Waves* is an educational program that seeks to engage youth in STEM by teaching them the science of waves through the creation of electronic sounds and musical instruments. An upshot of Dr. Minces' and Dr. Khalil's TDLC work investigating the role of music in education, is that it is now supported by the EHR division of the National Science Foundation. Since its inception, Listening to Waves has served more than 1300 students, largely from low SES populations.

Impact/benefits: The goal of the *Listening to Waves* program is to increase student engagement with science. In the *Listening to Waves* program, students learn the science of waves and signal processing through making electronic music and acoustic musical instruments, expanding their horizons through career awareness activities and media. At the end of this program, sound making objects created are presented individually as a public art-science-show and collectively in a music concert in which the different aspects of waves are visualized. In this way, not only the participants of the program but the whole community are invited to appreciate the rich physical world embedded in music. In addition, Victor and Alex aim to understand how their program influences students' perception of the relevance of science in their lives and the perception of themselves as scientists.

Background/Explanation: An important problem in science education is that students often do not perceive the topics covered in school as relevant to their everyday lives. Therefore, it is important to understand what learning experiences can be meaningful for the students and how these experiences can influence their lives and their relationship with science. Victor Minces and Alexander Khalil realized that music is a ubiquitous interest in adolescent populations, and that there are numerous connections between music and science. They decided to create a K-12 science of music education program to increase student engagement with science.



Note: The *Listening to Waves* program developed from work at the Temporal Dynamics of Learning Center (TDLC). The program was recently awarded an NSF grant (Innovative Technologies for Students and Teachers, ITEST), for $1.1 Million, starting July 2017.

V. Minces, A. Khalil, I. Oved, C. Challen, A. Chiba (2016). Listening to Waves: Using computer tools to learn science through making music. EDULEARN16 Proceedings, pp. 3844-3852.

Media Coverage:

http://www.cbs8.com/clip/12621316/students-learn-physics-through-musical-sound

Very high density EEG elucidates spatiotemporal aspects of early visual processing

Outcome: TDLC's Marlene Behrmann and Michael Tarr at Carnegie Mellon University (with Pulkit Grover, Shawn Kelly, and Amanda Robinson as lead author) showed that whereas standard human EEG systems based on spatial Nyquist estimates suggest that 20-30 mm electrode spacing suffices to capture neural signals on the scalp, “super-Nyquist” density EEG (“SND”) with Nyquist density (“ND”) arrays can capture neural signals, especially in the high frequency range, with greater accuracy (see Figure 1a for montage of 128 electrodes 14mm apart; 1b classification accuracy from 6-way analysis of the possible stimuli; and 1c for the left/right visual field stimuli of medium).

Impact/benefits: That we obtain better classification accuracy in the temporal and frequency domains provides a proof of concept for the development of super-Nyquist systems and offers the possibility of examining temporal dynamics in cortex in a noninvasive fashion. Such systems might also serve to diagnose various disorders including migraine, sleep and concussion. Also, because EEG less expensive and easier to implement than the similarly time-precise method of magnetoencephalography (MEG) or of functional MRI, there is the possibility that the high-density EEG systems might be exploited in underserviced areas.

Background/Explanation: Relative to functional magnetic resonance imaging (fMRI) and, to a lesser extent, MEG, EEG signals are believed to yield relatively low spatial resolution. This is thought to be due to the disproportionate decay of high-spatial frequencies (which carry high resolution information) during volume conduction from electrical sources in the brain to electrodes on the scalp. At the same time, the concrete limits of EEG’s spatial resolution are not well understood, and a critical question remains unanswered: does increasing the density of EEG electrodes enable the extraction of high-resolution spatial information? This study provided an answer to this question through an experiment designed to test whether, in human early visual cortex, high-density EEG can capture higher-resolution spatial neural information as compared to present-day, standard low-density systems. We demonstrated that this is indeed the case. As a non-invasive neuroimaging method that is almost unrivalled in its temporal precision, high-density electroencephalography (EEG) is extremely useful in studying neural signals, their representation and temporal dynamics.

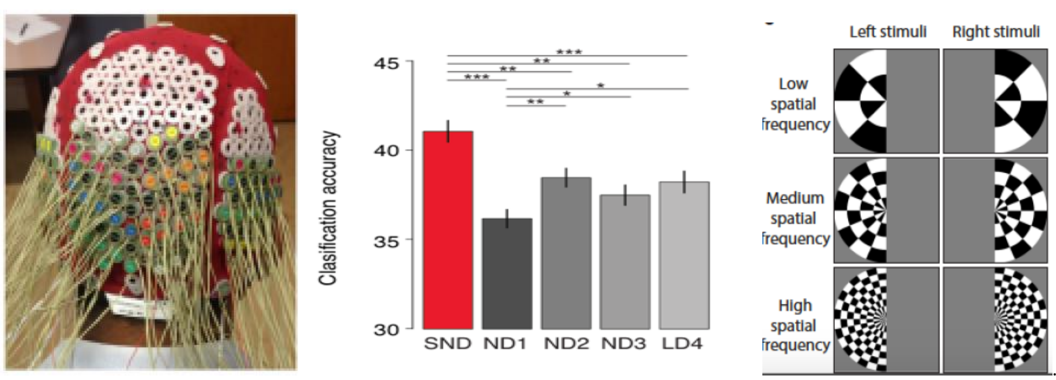


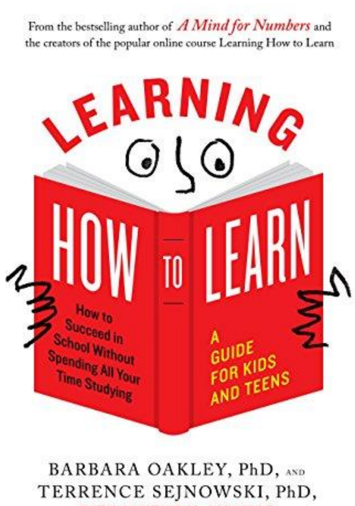
Fig. 1: a. SND-EEG with 128 electrodes over occipital & temporal cortex; b. SND-EEG (red) and ND classification accuracy; c. Visual stimuli: position (left/right visual field) x spatial frequency (low, medium, high) (Robinson et al., 2017)

Massive Open Online Courses:
Learning How to Learn **and** ***Mindshift***

Outcome: The new Mindshift course is already on the list of the top 50 MOOCS! This MOOC provides important mental tools and practical insights from science so that participants can learn how to learn and change effectively. Because of the success of their MOOCS (Learning How to Learn and Mindshift), Drs. Sejnowski and Oakley wanted to broaden access to this important knowledge. They began writing a "Learning How to Learn" book for kids and teens, to be available in August 2018. In addition, they are working on a *Learning How to Learn* MOOC for children, sponsored by Arizona State University and due out in Fall 2018, as well as a version of the adult *Learning How to Learn* in Chinese.

Impact/benefits: Mindshift is designed for any age or stage, teaching essentials such as how to work with mentors, the secrets of avoiding career and life ruts, and how to learn and change effectively even in maturity. By offering this invaluable information, Drs. Sejnowski and Oakley can help countless people in their education and life goals. In addition, offering a Learning How to Learn book for kids and teens will help a younger group acquire invaluable techniques for learning so that they can benefit early in their education.

Background/Explanation: Drs. Terry Sejnowski and Barbara Oakley's extremely popular Massive open online course (MOOC) for Coursera called "*Learning How to Learn*," is currently the most popular MOOC from major universities around the world. The course teaches participants invaluable learning techniques used by experts in many disciplines. Participants learn about the how the brain uses two very different learning modes and how it encapsulates ("chunks") information, as well as learning about illusions of learning, memory techniques, dealing with procrastination, and best practices. In April 2017, Drs. Sejnowski and Oakley launched a companion course, "*Mindshift: Break Through Obstacles to Learning and Discover Your Hidden Potential*." This new course is designed to "help boost your career and life in today's fast-paced learning environment." It is offered for any age or stage in life, to teach essentials -- things like how to work with mentors, and the secrets to avoiding career or life ruts. Drs. Sejnowski and Oakley provide mental tools and practical insights from science about how to learn and change effectively even in maturity.



CARTE Academy for Children on the Autism Spectrum

Outcome: In the fall of 2017, the Centre for Autism Research, Technology, and Education (CARTE) at the University of Victoria launched a new (FREE) monthly series of half-day camps for children on the autism spectrum. CARTE Academy recently received a generous grant of $10,000 from the Ames Family Foundation to support exciting new programs in pottery making and photography.

Impact/benefits: This 3-session format allows the CARTE activity programmers to build progressive lessons in chemistry and biology, rhythm and music, arts and crafts and social-emotion skills. The activities are fun and educational, and in a setting that allows campers a better chance to develop friendships with other campers and camp staff.

Background/Explanation: In 2017, CARTE decided to offer a monthly series of free half-day camps for children on the autism spectrum. The camps are run by CARTE Director Dr. Jim Tanaka from the Department of Psychology and student volunteers who are passionate about learning, playing, community building, and supporting children on the autism spectrum and their families.

Photos: Dr. Jim Tanaka playing a ukulele with fellow camper; Callie (camp staff) with camper

Additional information about CARTE: http://web.uvic.ca/~carte/