Stanford | MEDICINE

Tass Lab

It's one of nature's most impressive marvels. Always at work, the human nervous system is capable of processing incredibly complex information, allowing us to respond to a remarkable range of stimuli. Sadly, when things go awry, the impact can be devastating.

Disorders such as stroke or Parkinson's disease ravage nerves, potentially robbing patients of basic abilities such as speech, vision, and movement. Parkinson's disease advances unpredictably, diminishing capabilities, while stroke attacks suddenly, depleting the brain of necessary oxygen and inflicting immediate damage. Although usually less devastating, tinnitus also falls under the umbrella of debilitating nerve disorders. Fifteen percent of Americans suffer from the constant sound of ringing, whooshing, buzzing, or popping in their ears, with no outside stimulus. Until now, few treatments have proven to make a difference in the quality of life for those afflicted with these disorders.

While seemingly unrelated, Parkinson's disease, tinnitus, and the symptoms seen in the aftermath of stroke are all believed to have a similar root cause. Developing tools and techniques that have the potential to radically alter the impact of these diseases could bring about lasting life change for millions of people. The benefits of such treatments could also extend to those who struggle with other diseases such as epilepsy and psychiatric issues such as obsessive-compulsive disorder.

Targeting the underlying cause

In a healthy nervous system, information travels through relatively weakly connected, desynchronized neuronal networks. However, many brain disorders, including Parkinson's disease, problems with movement, epilepsy, tinnitus, and stroke damage are characterized by overly synchronized neuronal networks.

Stanford's Peter Tass, MD, PhD, is determined to make headway against these disorders, using his unique expertise to weigh every possibility for new therapies and cures. A professor of neurosurgery, physician, and computational neuroscientist with extensive translational experience, Dr. Tass has already developed FDA and CE-mark approved Medtech stimulation devices that he uses in his extensive and ongoing research. These devices are continuously modified and improved as a result of this research.

Since March 2017, when he was recruited from his position as director of the Institute of Neuroscience and Medicine—Neuromodulation at Juelich Research Center in Germany, Dr. Tass has been working side-by-side with Stanford's world-renowned teams of scientists and physicians to bring about widespread and lasting impact to nervous system disorders. Currently, his lab is targeting abnormally synchronized nerves, coaxing them to unlearn their connectivity and return to normal function.

COORDINATED RESET HAS THE POTENTIAL TO TREAT:

- **Parkinson's disease and other movement disorders**
- **Stroke-related damage**
- **Epilepsy**
- **Tinnitus**
- **Psychiatric diseases such as Obsessive-Compulsive Disorder (OCD) and Attention-Deficit/ Hyperactivity Disorder (ADHD)**

BY THE NUMBERS:

- **60,000 Americans are diagnosed with Parkinson's disease every year**
- **800,000 Americans suffer strokes every year**
- **Tinnitus affects 15 percent of Americans; 20 million cases per year are characterized as burdensome and chronic; 2 million cases nationwide are classified as debilitating**
- **Obsessive-Compulsive Disorder affects 1 in 40 adults in the U.S. and 1 in 100 children.**
- **Estimates of American children suffering from ADHD range from 5 in 100 to 11 in 100.**

Novel approach

Dr. Tass has pioneered the concept of coordinated reset (CR), a promising therapy for a vast array of brain disorders. The goal is to counteract maladaptive connectivity by stimulating nerves and loosening their synchronization, thereby alleviating symptoms.

CR stimulation uses high-frequency stimuli in a patterned sequence to desynchronize maladaptively synchronized neural networks, facilitating the spontaneous rewiring of brain circuitry. This appears to cause synapses, which connect neurons, to normalize, effectively restoring proper function. Ultimately, the "unlearning" is so significant that the neurons are not able to maladaptively synchronize again.

"This is not just a symptom-suppression while stimulation is on; it has a curative and restorative component. Therapeutic effects persist after cessation of stimulation," Dr. Tass said. This is unlike other deep brain stimulation (DBS) or vibratory treatment options, where the benefits fade as the treatment concludes.

CR can be delivered with different stimulation modalities, either through electrodes implanted in the brain or non-invasively through sensory stimuli such as gentle vibrations applied to the fingertips. Or, in the case of tinnitus, by exposing the patient to varying auditory tones.

Advancing new frontiers

During medical school, Dr. Tass found himself on the forefront of an entirely new field of medicine: one characterized by the study of self-organization processes. "To me, it was intriguing how many subsystems in the body perform a well-coordinated action, adapt to changes of the environment, and interact with psychological processes," he said.

He was drawn to the beauty of the well-orchestrated complexity in healthy bodies and its alterations in disease states but came to realize that traditional medical studies were incapable of fully addressing such complex systems. As a result, upon completion of his medical training, Dr. Tass took on the additional challenge of studying mathematics and earned a doctorate in physics. He turned his focus to topics typically confined to a mathematics or engineering classroom, including nonlinear dynamics, statistical physics, self-organization, pattern formation, oscillations, and synchronization, and applied those concepts to the human body.

"From the very beginning, it was my goal to use self-organization principles for therapeutic purposes, to develop subtle interventions that induce significant therapeutic effects," Dr. Tass said. "This approach enables the brain to undergo sustained, healthy changes of activity and synaptic connectivity. In other words, the brain unlearns its abnormal behavior—activity and synaptic connectivity—through the use of specially designed stimulus patterns that have been developed employing dynamic self-organization and plasticity principles."

Tangible results

What is particularly exciting about Dr. Tass's work is that his ideas have moved beyond theory; he is producing dramatic results. Having laid the groundwork with his development and study of computational models that use nonlinear dynamics and statistical physics, Dr. Tass has progressed to successful pre-clinical work and is now seeing impressive results in initial clinical trials.

"The effects of standard deep brain stimulation vanish when the stimulation is turned off, while the effects of CR stimulation persist," Dr. Tass said. "Accordingly, we do not need to stimulate permanently. As predicted computationally, we can also deliver CR stimulation by means of noninvasive stimulus modalities—by sensory means—such as vibrotactile and acoustic stimuli. Hence, it is our goal to develop non-invasive CR therapies that induce sustained effects and require only a few hours' stimulation delivered regularly or occasionally."

Current studies, conducted by Dr. Tass's team, use DBS either generated via an implanted brain pacemaker or by a noninvasive vibrotactile device that delivers vibratory stimuli to a patient's fingertips. Only a few hours of mild, non-painful stimulation have been found to substantially improve gait and hand movements in late-stage Parkinson's patients, and, remarkably, the effects remain a month after treatment. The success of the noninvasive approach to stimulation is mirrored in Dr.Tass's work with DBS, which has been proven to extend the positive effects of the stimulation long after it has ceased. This is remarkable because without his algorithm for stimulation, the positive effects of DBS were only experienced during stimulation. It is likely that this advance will reduce the incidence of side effects in patients receiving this treatment.

Promise of new therapies on the horizon

As research into neurological disorders continues to accelerate and smash through the barriers of what's known, there are more reasons than ever for hope. Thanks to Stanford Medicine's comprehensive approach and teams such as Dr. Tass's, we offer unparalleled care at all levels, from advancing the most cutting-edge and creative research, to expert physicians who are passionate about their patients' well-being, to centers where patients can get support and learn disease management skills.

At Stanford Medicine, we are on the cusp of exciting new models of treatment and therapy for Parkinson's disease, stroke, and tinnitus. Dr. Tass's lab is uniquely poised to take on this tremendous challenge. With his uncommon expertise in medicine, physics, and computational modeling, he is able to provide experimentally testable predictions that guide him and his team as they design new study protocols and dosage regimens.

Furthermore, Dr. Tass's Neuromodulation lab, which is located in Stanford's Neuroscience Health Center, has begun to perform real-time electroencephalogram analysis to assess stimulation effects and perfectly optimize stimuli, tailoring therapy for individual patients as they are being treated.

"The mathematics and physics of neural plasticity and self-organization are gorgeous. However, what is most exciting and rewarding for me is seeing that these beautiful principles actually work in patients and help them significantly."

Peter A. Tass, MD, PhD
Professor of Neurosurgery

As these capabilities merge, Dr. Tass is bringing together the finest minds and the most creative innovations to bring an end to devastating nerve disorders.

Join Us

The three disorders the Tass Lab is currently focused on—stroke, Parkinson's disease, and tinnitus—affect millions of Americans and cost the economy billions of dollars every year. Dr. Tass and the team of experts at Stanford Medicine are rapidly advancing what we know about these diseases, with the intention of translating that research and applying it to other brain disorders, significantly altering the course of modern medicine.

Stanford researchers are staring down these life-altering diseases with optimism and hope. We have innovative programs that pair patients with researchers—world-class minds exhaustively working on these challenges—and advanced technologies that allow our physicians and scientists to best understand these disorders so we can zero in on improving health.

What is needed is the support of generous philanthropic partners to drive our work forward. Please join us in bringing hope and healing to those awaiting our medical breakthroughs.

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