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New approach to Neurorehabilitation: Cranial nerve noninvasive neuromodulation (CN-NINM technology)

Cranial-Nerve Non-Invasive NeuroModulation (CN-NINM) is a primary and complementary multi-targeted rehabilitation therapy that initiates the recovery of multiple damaged or suppressed brain functions that are affected by neurological disorders. CN-NINM was originally developed in our lab to facilitate and enhance the brain's innate ability to reorganize and "normalize" its functional activity during targeted physical and occupational therapy, and thus improve movement control and cognition. It is deployable as a simple, home-based device (portable tongue neurostimulator, PoNSTM) and training regimen following initial patient training in an outpatient clinic. It may be easily combined with all existing rehabilitation therapies, and may reduce or eliminate need for more aggressive invasive procedures or decrease the total medication intake.

CN-NINM uses sequenced patterns of electrical stimulation on the tongue. Our hypothesis is that CN-NINM induces neuroplasticity by noninvasive stimulation of two major cranial nerves: trigeminal, CN-V, and facial, CN-VII. This stimulation excites a natural flow of neural impulses to the brainstem (pons varolli and medulla), and cerebellum via the lingual branch of the cranial nerve (CN-Vc), and chorda tympani branch of CN-VII, to effect changes in the function of these targeted brain structures, extending to corresponding nuclei of the brainstem – at least in the sensory and spinal nuclei of trigeminal nuclei complex and the caudal part of the nucleus tractus solitarius. We postulate that the intensive activation of these structures initiates a sequential cascade of changes in neighboring and/or connected nuclei by direct collateral connections, brainstem interneuron circuitry and/or passive transmission of biochemical compounds in the intercellular space. Combining neurostimulation with a specific set of physical, cognitive and/or mental exercises we can further focus brain rehabilitation and target our effort on recovery of selected functional damage. The result is essentially brain plasticity on demand – a priming or up-regulating of targeted neural structures to develop new functional pathways, which is the goal of neuro-rehabilitation and a primary means of functional normalization and recovery.

CN-NINM represents a synthesis of a new non-invasive brain stimulation technique with applications in physical medicine, cognitive, and affective neurosciences. Our new stimulation method appears promising for treatment of a full spectrum of movement disorders, and for both attention and memory dysfunction associated with traumatic brain injury. The integrated CN-NINM therapy proposed here aims to restore function beyond traditionally expected limits by employing both newly-developed therapeutic mechanisms for progressive physical and cognitive training - while simultaneously applying brain stimulation through a portable neurostimulation device. Based on our previous research and recent pilot data, we believe a rigorous in-clinic CN-NINM training program, followed by regular at-home exercises that will also be performed with CN-NINM, will simultaneously enhance, accelerate, and extend recovery from multiple impairments (e.g. movement, vision, speech, memory, attention, and mood), based on divergent, but deeply interconnected neurophysiological mechanisms.

Biography

Yuri P. Danilov, PhD, Senior Scientist and Neuroscience Director in Tactile Communication and Neuromudulation Laboratory (TCNL), Biomedical Engineering Department, UW-Madison, is a system neuroscientist with over 35 years' experience in research on brain functions and the special senses, including vision, taste, hearing and balance. He is the lead discoverer of the balance retention effect, lead development of the specific training regimens, and continues to identify potential clinical and non-clinical application of neuromodulation and sensory substitution technology. He received the M.S. degree in biophysics, in 1978, from St. Petersburg University in Russia and the Ph.D. degree in neuroscience, in 1984, from the Pavlov Institute of Physiology, USSR Academy of Science. He was Senior Scientist (11/00 – 12/04) and Director of Clinical Research at Wicab, Inc., where as co-inventor oversaw both conceptual development for the BrainPort vision and balance systems. He is a co-inventor the CN-NINM technology and his interest areas are neuroplasticity, neurorehabilitation, enhancement of human performance.

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