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Sensory Substitution to Regain Vision and Balance

NONINVASIVE NEUROMODULATION OF THE CENTRAL NERVOUS SYSTEM

So many illnesses are caused by central nervous system damage. Can a new method of noninvasive brain stimulation treat or cure disease. Welcome to the Clinician's Roundtable on ReachMD. I am your host, Dr. Bruce Bloom, joining me to discuss noninvasive neuromodulation of the central nervous system is senior scientist, Yuri Danilov, Ph.D. of the Tactile Communication and Neurorehabilitation Laboratory in the Department of Orthopedics and Rehabilitation Medicine and the Department of Biomedical Engineering at the University of Wisconsin-Madison.

DR. BRUCE BLOOM:

Dr. Danilov, welcome to ReachMD.

DR. YURI DANILOV:

Thank you Bruce.

DR. BRUCE BLOOM:

So, you and your team have been working on a technology that goes all the way back 20 or 30 years. Tell us about how this all started.

DR. YURI DANILOV:

Well, it started actually in the end of 60s when Dr. Paul Bach-y-Rita came up with idea that brain is actually flexible and capable to changes. In the end of 60s, it was the heresy that nobody believed and now 40 years later you can hear brain positivity everywhere from cellular and molecular biology to behavioral and psychology, so it's now major concept how the brain works, so they started 40 years ago and approved his idea that Dr. Paul Bach-y-Rita developed the concept of sensory substitution, so replace one missing sensory channel with another if having normal natural input to the brain. So, that's how he came up to replace any as a matter of fact any sensory system with tactile sensations. So, for 30 years he developed the system for blind people and help people to see through the skin, and then in 1968, he published first paper when he designed a mechanical chair that allowed the blind subject to see from the output of video camera that even recognize the human faces. Later in 1998, it was designed first electrotactile stimulation of the tongue

system that was much portable and was capable to repeat the results that developed in 60s and even move it much further and right now the current models of the electrotactile visual substitution system allowed the people to recognize a letter, charts, navigate in the street, in the room to see the objective even draw and read the letters and numbers.

DR. BRUCE BLOOM:

So when they are doing the sensory substitution, are you seeing that they are actually seeing. They are just not using their eyes to see. That's what really going on.

DR. YURI DANILOV:

Bruce, you are provoking me on the really long answer, but I tried to be a little brief. So, I was visual neuroscientist for about 30 years, and one day, that Paul first time suggested to me to study vision through the tongue. My natural reaction was what and right now 10 years later I am traveling around the globe and convincing my former colleagues that it is vision through the tongue, but look itself if you agree <_____> read materials that are published on the web about the blind subject behavior you can see that they presenting the natural visually guided behavior from one side. From another side, we have evidence from fMRI and pad research that during the after training with this device, people activating almost all visual areas of the brain. So, from one side you have visual guided behavior. From another you have visual brain activated to analyze this information. What it is if it is not vision? We probably don't have in the vocabulary another word for that, but before that the only word that described the process is a vision instead the visual information going not through the eye, but through the tongue.

DR. BRUCE BLOOM:

And so what you are saying is this visual information comes in through the tongue and instead of just going to the spots in the brain the tongue normally innervates, it is also lighting up the parts of the brain that the eyes would normally innervate even though the patient is blind.

DR. YURI DANILOV:

Exactly, it means that the brain used full capacity of visual analysis mechanisms that disperse any visual areas to analyze information from the tongue. That's the most mysterious part of all this research because it happened almost immediately. So somehow the brain knows how to switch information and where to send it for analysis.

DR. BRUCE BLOOM:

And is this true in patients that were seeing and then became blind or is this actually true for patients, who had never had any sight through their eyes.

DR. YURI DANILOV:

Well, it's working equally well on congenitally blind people and people, who lost their vision later. Of course, the people who already had their visual experiences much more easy to work with imaging technician because I can give you example so when we just started the

first experiment and I showed patient doughnut, let's say draw it on the wall and people, who already have a visual experience they usually can identify it as a doughnut let's say, but people who were congenitally blind have to touch it physically by hand before they realize that it's a doughnut.

DR. BRUCE BLOOM:

And so now you switched your focus from vision substitution to treating other diseases of the brain using technology that started in this vision substitution. So tell us a little about what's going on with that.

DR. YURI DANILOV:

Well during the study of the sensory substitution our next step of the vision was balance and we started to develop vestibular substitution system to see if concept is working. I have to work equally well on the balance affected patients, and as a matter of fact in the last 8 eight years, we moved from the very simple model like people, who have peripheral vestibular loss because of toxic reaction of antibiotics. So, it was scientifically very clean model when the people lost just peripheral sensory cells, but brain structure was intact, and when we got the first success there, we moved forward to people with central balance disorder and figured out that it is working equally well and then we did the next step we started to look in a population, who had a balance disorder as a secondary to something else like traumatic brain injury, stroke, Parkinson, and multiple sclerosis, and we have a very positive preliminary data and very inspiring experimental results showing that we can help with this population as well. So, then we ask our questions what actually we are doing and looks like what our technology doing is universal brain stimulator. It is not specialized under one specific target. It is not specialized under one specific brain structure. Instead of that it created pretty dispersed stimulation that helped the brain be more sensitive to other rehabilitation therapies. For example, if we are working with balance affected patient and we train them to stand still or walk straight and even at the same time we will stimulate the tongue we will create opportunity to improve the functions that related to balance and walking. If we are talking about the Parkinson patient, if we will stimulate the tongue and simultaneously will do exercise on the hand, we will improve circuitry responsible for hand control and so on and so on. So that is combination of the engineering reports that the very sophisticated device training regimen that is absolutely necessary because you know the major principal that the brain uses to lose it. So we have to use an exercise function that is missing or malfunctioning together with tongue stimulation. Then, we will get the positive effect.

DR. BRUCE BLOOM:

If you have just tuned in, you are listening to the Clinician's Roundtable on ReachMD, The Channel for Medical Professionals. I am your host, Dr. Bruce Bloom, and joining me to discuss noninvasive neuromodulation of the central nervous system is senior scientist, Yuri Danilov, Ph.D., of the Tactile Communication and Neurorehabilitation Laboratory at the University of Wisconsin-Madison.

So, you're saying that it's a combination of this electrical stimulation of the tongue. At the same time, people are doing physical therapy and other kinds of manual training and those 2 things done together help each other to cure these diseases.

DR. YURI DANILOV:

Yes, indeed. The interesting phenomenon happening right now in neurorehabilitation science more and more people understand that it is not very good to treat brain without body or do rehabilitation of the body without brain. So the brain and body have to both simultaneously interactively recover and this is very interesting that exactly what we are observing the best effect we can see when you combine brain stimulation with physical therapy.

DR. BRUCE BLOOM:

So what you think is going on with the electrical stimulation of the brain from a physiological and anatomical basis in the brain. What's happening when you are stimulating the tongue?

DR. YURI DANILOV:

When we are stimulating the tongue, we produce massive spike trains that is coming from the tip of the tongue through 2 cranial nerves, trigeminal and facial to the central structure of the brain system <_____> and trigeminal nuclear complex. During this summer, we have very good evidence on the fMRI imaging recording showing that after 5 days of selenium therapy, the human brain showing long-lasting changes and activity in the dorsal part of the brainstem and the pons and the medulla it's lower part that interface was a spinal cord and cerebellum. All three centers deeply involved in the movement control. So as a first step that's what we verified already, it is activation of these 3 structures. What's happening in the next step is much more, let's say undiscovered because let's say trigeminal nuclear complex directly linked to the thalamus and the so called trigeminal thalamic pathway. So activity from the nuclear go through the trigeminal thalamic pathway to the thalamus and that's how we see it might <_____> we did Parkinson patient for example because it's a direct projection from nuclear activity in the brainstem to the thalamus. It may suggest a small fragment of the anatomy. If you open anatomy book, you can see how deeply the structures trigeminal nuclear <_____> and vestibular nuclear complex involved in the many, many aspects of the brain function starting from cognitive function to endocrine release, balance control, autonomic responses, and so on.

DR. BRUCE BLOOM:

Now when you do this treatment to the patients, does it only last during the time of the treatment or does it endure beyond the treatment and what kind of cumulative effect does it have?

DR. YURI DANILOV:

Well, it's actually excellent question because the major striking results of this therapy that it is not only working when device in the mouth, but effects continue after device is removed from the mouth. As the patient experienced at least in the beginning **11:05** <_____> therapy experienced long-lasting effects that continue from 1 to 2 hours up to 24 hours after first training session and in the patients that we have observed so far and so far around the globe we have few hundred patients, who already tried this therapy, the pattern is approximately the same for the people, who have a balance disorder especially peripheral and central, it's cumulative effect. The first patient that we started to work with in 2004, she was completely recovered after 2-1/2 years of therapy and we have about 5 patients like her with completely different vestibular disorders, but after couple of years of therapy they completely recovered and they don't need the device anymore. Other people like traumatic brain injury patients, it's only patients I personally worked with was using device about 2 years and he still progressively recovered. So, may be it took another few years until we will go to plateau. So, we definitely have a cumulative effect of this therapy.

DR. BRUCE BLOOM:

I would like to thank my guest, senior scientist, Yuri Danilov, Ph.D., of the Tactile Communication and Neurorehabilitation Laboratory in the Department of Orthopedics and Rehabilitation Medicine and the Department of Biomedical Engineering at the University of Wisconsin-Madison joining me to discuss noninvasive neuromodulation of the central nervous system.

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