Vagus Nerve Stimulation Holds Promise for Treating Addiction

Vagus nerve stimulation inhibits drug-seeking behavior in lab rats, study finds

Posted Jan 24, 2017

Vagus nerve stimulation (VNS) therapy involves implanting a small device that sends a mild electric pulse through the vagus nerve.

Source: Alila Medical Media/Shutterstock

Vagus nerve stimulation (VNS) therapy may help addicts overcome substance abuse via the extinction of conditioned drug-seeking behaviors, according to a groundbreaking preclinical study.

The new report, “Vagus Nerve Stimulation Reduces Cocaine Seeking and Alters Plasticity in the Extinction Network,” was published in the January issue of Learning and Memory.
Although this is an animal study, the researchers believe their findings could eventually be applied to people who struggle with drug addiction or substance abuse disorders. VNS therapy has already been approved by the FDA as a treatment for certain illnesses, including clinical depression, epilepsy, and inflammation.

This new research adds to a growing body of evidence on the benefits of VNS therapy. For example, a February 2016 study found that VNS therapy improved functional connectivity of the default mode network which reduced symptoms of Major Depressive Disorders (MDD).

Additionally, a July 2016 study by neuroscientists and immunology experts found that VNS therapy inhibited “the inflammatory reflex” by blocking the production of pro-inflammatory cytokines. This research was the first human study designed to reduce symptoms of rheumatoid arthritis by triggering a chain reaction that reduced cytokine levels and inflammation.

For the new January 2017 study on breaking the behavioral cycles of addiction, researchers at the University of Texas at Dallas School of Behavioral and Brain Sciences found that lab rats who had become addicted to cocaine significantly reduced their drug-seeking behavior when they were treated with VNS therapy.

The researchers found that VNS therapy triggered changes in synaptic plasticity between the prefrontal cortex and the amygdala in cocaine-addicted lab rats. Through a complex process, VNS appeared to facilitate "extinction learning" of drug-seeking behaviors by reducing cravings and encoding new reward behaviors in place of those previously associated with pushing a lever to receive a hit of cocaine.

As you can see by scrolling down this early anatomical drawing below, the vagus nerve is very long; hence its colloquial name as the "wandering nerve."
Vagus means "wandering" in Latin. The vagus nerve is known as the "wandering nerve" because it has multiple branches that diverge from two thick stems rooted in the cerebellum (Latin for "little brain") and brainstem that wander to the lowest viscera of your abdomen touching your heart and most major organs along the way. The vagus nerves is a central player in the "gut-brain axis."

In 1921, a Nobel-Prize winning German physiologist, Otto Loewi, discovered that stimulating the vagus nerve caused a reduction in heart rate by triggering the release of a substance he coined Vagusstoff (German for "Vagus Substance"). The “vagus substance” was later identified as acetylcholine and became the first neurotransmitter ever identified by scientists.

Vagusstoff (acetylcholine) is like a tranquilizer that you can self-administer simply by taking slow, deep diaphragmatic breaths. Consciously tapping into the power of your vagus nerve can create a state of inner calm while reducing stress and taming your inflammation reflex at a neurobiological level.

The vagus nerve is the prime component of the parasympathetic nervous system which regulates the “rest-and-digest” or "tend-and-befriend" responses. On the flip side, to maintain homeostasis, the sympathetic nervous system drives the “fight-or-flight” response.

Healthy vagal tone is indicated by a slight increase of heart rate when you inhale, and a decrease of heart rate when you exhale. A higher vagal tone index is linked to positive emotions and psychological homeostasis, which can create an upward spiral of well-being. Conversely, a low vagal tone index is associated with free-floating anxiety, stress, inflammation, and depression—which can create a downward spiral of well-being.
Vagus Nerve Stimulation May Reduce Drug Cravings Via Synaptic Plasticity

The latest cutting-edge research on VNS therapy shows that stimulating the vagus nerve with a mild electric current can reduce drug cravings by altering the functional connectivity between the prefrontal cortex (PFC) and the basolateral amygdala (BLA). The researchers used immunohistochemistry to measure changes in the PFC and the BLA, which work together to regulate cue learning and extinction.

Typically, drug and alcohol use disorders cause changes to the PFC and other brain regions that impair addicts' inhibitory control over drug-seeking behaviors. In order to make hardwired addictive patterns of behavior extinct, the UT Dallas researchers found that it's necessary to break the paired bonding between drug-associated cues and the delivery of the reward during the extinction learning phase that fuels addiction.

In a statement to University of Texas at Dallas released today, senior author of this study, Sven Kroener, summed up his team's findings:

"We are studying extinction learning and how vagus nerve stimulation can help subjects learn a new behavior that is opposed to an existing, maladaptive behavior like drug taking. When a subject is addicted to a drug, extinction is a method to help them re-learn behaviors—so they are able to take different actions.

Extinction of fearful memories and extinction of drug-seeking memories relies on the same substrate in the brain. In our experiments, VNS facilitates both the extinction learning and reduces the relapse response as well.

This approach really has the potential to become a therapy during rehab where people do this kind of exposure therapy, where they look at the stimuli that used to trigger their craving, while they are abstaining in a safe situation. The VNS treatment might reinforce that abstinence, eventually weaning them off the drug-related behavior and protecting them better from the cravings."

Kroener and his UT Dallas colleagues are VNS trailblazers. They are also researching how vagus nerve stimulation can help treat post-traumatic stress disorder (PTSD), anxiety, tinnitus, and help people recover from paralysis after a stroke. Hopefully, their latest findings on the potential application of VNS-therapy to treat addiction will move into human clinical trials soon.
Stay tuned for more state-of-the-art research on vagus nerve stimulation therapy. To read other *Psychology Today* blog posts I've written on the vagus nerve click here.

References

