

## The Vagus Nerve

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Your body's levels of stress hormones are regulated by the **autonomic nervous system** (ANS). The ANS has two components that balance each other, the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS).

- The SNS turns up your nervous system. It helps us handle what we perceive to be emergencies and is in charge of the flight-or-fight response.
- The PNS turns down the nervous system and helps us to be calm. It promotes relaxation, rest, sleep, and drowsiness by slowing our heart rate, slowing our breathing, constricts the pupils of our eyes, increases the production of saliva in our mouth, and so forth.

The **vagus nerve** is the nerve that comes from the brain and controls the parasympathetic nervous system, which controls your relaxation response. And this nervous system uses the neurotransmitter, acetylcholine. If your brain cannot communicate with your diaphragm via the release of acetylcholine from the vagus nerve (for example, impaired by botulinum toxin), then you will stop breathing and die.

### History of the VNS

The vagus nerve is known as the "wandering nerve" because it has multiple branches that diverge from two thick stems rooted in the cerebellum and brainstem that wander to the lowest viscera of your abdomen touching your heart and most major organs along the way. Vagus means "wandering" in Latin (the words vagabond, vague, and vagrant are all derived from the same Latin root).

In 1921, a German physiologist named 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 a few deep diaphragmatic breaths with long exhales. Consciously tapping into the power of your vagus nerve can create a state of inner-calm while taming your inflammation reflex.

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.

### How to Activate the Vagus Nerve on Your Own

To practice deep diaphragmatic breathing, inhale through your nose and exhale through your mouth. Remember to (Sears):

- Breathe more slowly.
- Breathe more deeply, from the belly.
- Exhale a little longer than you inhale.

You can proceed as follows: take a breath (expanding your diaphragm) to the count of five, pause for a second, then breathe out slowly through a small hole in your mouth. While at rest most people take about 10 to 14 breaths per minute (Sears). Ideally, reduce your breathing to 5 to 7 times per minute. Exhaling through your mouth instead of nose makes your breathing a conscious process, not a subconscious one.

As you do this, your muscles will relax, dropping your worries and anxieties. The oxygen supply to your body's cells increases and this helps produce endorphins, the body's feel-good hormones. Tibetan monks have been practicing this to modulate the effects of stress for decades. They don't practice these ancient techniques to improve their memory, fight depression, lower blood pressure, or heart rate, or boost their immune systems, but that all happens with deep diaphragmatic breathing!

## **Benefits: Brain, Inflammation, Pain and Positive Emotions**

### **1. Brain**

Acetylcholine is responsible for learning and memory. It also creates a calming and relaxing response, which is used by vagus nerve to send messages of peace and relaxation throughout the body. Research has also linked the vagus nerve to improved neurogenesis, increased BDNF output (brain-derived neurotrophic factor is like super fertilizer for your brain cells) and repair of brain tissue, and to actual regeneration throughout the body (Koopman, Okano, Tracy). For example, Tracy and Okano have found that stem cells are directly connected to the vagus nerve. Activating the vagus nerve can stimulate stem cells to produce new cells and repair and rebuild your own organs.

There are many ways to activate the vagus nerve and turn on the relaxation response. When you take a deep breath and relax and expand your diaphragm, your vagus system is stimulated, you instantly turn on the parasympathetic nervous system, your cortisol levels are reduced, and your brain heals.

### **2. Inflammation**

Research has found that acetylcholine is a major brake on inflammation in the body (Sloan). In other words, stimulating your vagus nerve sends acetylcholine throughout your body, not only relaxing the body but also turning down the fires of inflammation which are related to the negative effects from stress (Sloan).

### **3. Vagus for Pain and Inflammation**

Inflammatory responses play a central role in the development and persistence of many diseases and can lead to debilitating chronic pain. In many cases, inflammation is your

body's response to stress. Therefore, reducing "fight-or-flight" responses in the nervous system and lowering biological markers for stress can also reduce inflammation.

Typically, doctors prescribe medications to combat inflammation. However, there's growing evidence that another way to combat inflammation is by engaging the vagus nerve and improving "vagal tone." This can be achieved through daily habits such as Tai Chi, Ai Chi, Yoga and Meditation—or in more extreme cases of inflammation, such as rheumatoid arthritis (RA)—by using an implanted device for vagus nerve stimulation (VNS).

An international team of researchers from Amsterdam and the United States conducted a clinical trial which demonstrates that stimulating the vagus nerve with a small implanted device significantly reduced inflammation and improved outcomes for patients with rheumatoid arthritis by inhibiting cytokine production.

RA is a chronic inflammatory disease that affects approximately 1.3 million people in the United States and costs tens of billions of dollars to treat each year, according to the researchers. The neuroscientists and immunology experts involved in this study used state-of-the-art technology to map the neural circuitry that regulates inflammation. In one circuit—termed "the inflammatory reflex"—action potentials transmitted in the vagus nerve inhibit the production of pro-inflammatory cytokines.

The July 2016 study, "Vagus Nerve Stimulation Inhibits Cytokine Production and Attenuates Disease Severity in Rheumatoid Arthritis," appears online in the *Proceedings of the National Academy of Sciences* (PNAS) and was published in a later print issue.

This is the first human study designed to reduce symptoms of rheumatoid arthritis by stimulating the vagus nerve with a small implanted device which triggered a chain reaction that reduced cytokine levels and inflammation. Although this study focused on rheumatoid arthritis, the trial's results may have implications for patients suffering from other inflammatory diseases, including Parkinson's, Crohn's, and Alzheimer's.

In a statement, Paul-Peter Tak, the international principal investigator and lead author of the paper from the Division of Clinical Immunology & Rheumatology of the Academic Medical Center at the University of Amsterdam, said, "*This is the first study to evaluate whether stimulating the inflammatory reflex directly with an implanted electronic device can treat RA in humans. We have previously shown that targeting the inflammatory reflex may reduce inflammation in animal models and in vitro models of RA . . . which might be relevant for other immune-mediated inflammatory diseases as well.*"

These findings suggest a new approach to fighting diseases that are currently treated with relatively expensive drugs that have a host of side effects. VNS gives healthcare providers a potentially more effective way to improve the lives of people suffering from chronic inflammatory diseases.

#### ***4. Healthy Vagal Tone Is Part of a Feedback Loop Linked to Positive Emotions***

Healthy vagal tone is indicated by a slight increase of heart rate when you inhale, and a decrease of heart rate when you exhale. Deep diaphragmatic breathing—with a long, slow exhale—is key to stimulating the vagus nerve and slowing heart rate and blood pressure, especially in times of anxiety.

A higher vagal tone index is linked to physical and psychological well-being. Conversely, a low vagal tone index is associated with inflammation, depression, negative moods, loneliness, heart attacks, and stroke (Bergland).

A 2010 study, "How Positive Emotions Build Physical Health: Perceived Positive Social Connections Account for the Upward Spiral Between Positive Emotions and Vagal Tone," was published in *Psychological Science*. For this research, Barbara Fredrickson and Bethany Kok of the University of North Carolina at Chapel Hill focused on the vagus nerve and discovered that a high vagal tone index was part of a feedback loop between positive emotions, physical health, and positive social connections.

Their research suggests that positive emotions, robust social connections, and physical health influence one another in a self-sustaining upward spiral dynamic and feedback loop that scientists are just beginning to understand.

For this experiment, Frederickson and Kok used a Loving-Kindness Meditation (LKM) technique to help participants become better at self-generating positive emotions. However, they also found that simply reflecting on positive social connections and working to improve close-knit human bonds also caused improvements in vagal tone.

In 2014, a *Psychology Today* post, How Does the Vagus Nerve Convey Gut Instincts to the Brain? said "*based on findings by researchers in Switzerland who identified how the vagus nerve conveys "gut feelings" of anxiety and fear to the brain. Clinical and experimental studies indicate that stress and depression are associated with the up-regulation of the immune system, including increased production of pro-inflammatory cytokines*".

When administered to patients or laboratory animals, cytokines have been found to induce typical symptoms of depression. Therefore some cases of low mood, low energy, and lack of motivation may be due to elevated levels of cytokine proteins.

## **Conclusion: Deep Diaphragmatic Breathing Is a Potent Drug-Free Alternative for Treating Inflammation**

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