The vagus nerve is the longest of 12 pairs of nerves that originate in the brain, serving as the brain’s central command in the fight against stress, inflammation, and toxicity. The vagus helps regulate our “fight or flight” response, digestion, detoxification, various aspects of heart rate, and blood pressure. Recent research indicates it also regulates our immune system and provides us with a neurological infrastructure that determines many of our emotional responses, enabling us to empathize with, bond with, communicate with, and relate to others.

Called “the wandering nerve,” the vagus is the longest nerve in the body. It begins at the brainstem, located near the base of the skull, and has branches that travel down each side of the neck and extend throughout the body. It actually consists of nerve pairs: One nerve sends information, and the other nerve receives. An underactive or underdeveloped vagus nerve is now thought to be one of the major contributors to symptoms of autism. The vagus nerve is part of what is called the autonomic nerve system, which automatically regulates the functions our mind does not consciously control.
Working independently of our conscious mind, the autonomic nerve system controls functions essential to survival. It consists of two components: the parasympathetic and sympathetic nerve systems. The parasympathetic system is responsible for stimulation that occurs when the body is at rest, especially after eating—including sexual arousal, salivation, tears, and digestion. The sympathetic nerve system is responsible for stimulating activities associated with the fight-or-flight response to perceived danger. The vagus nerve is part of the parasympathetic nerve system and inhibits the flight-or-fight response. It contains 80 to 90 percent of the body’s sensory neurons (also called afferent neurons), which provide information to the central nerve system and brain from organs and other parts of the body.

The Polyvagal Theory of Autopilot

University of Illinois researcher Stephen Porges proposed a polyvagal theory that explains how our autonomic nerve system actually consists of three overlapping nerve systems that can independently control autonomic functions, which evolutionarily developed over millions of years.

Porges identifies our three nerve systems as:

Myelinated vagus. When we are not threatened, we use our most evolved mammalian nerve system, which Porges refers to as the myelinated vagus. This system evolved to inhibit the more primitive nerve systems and enable high-functioning mammals to support social behavior. This social behavior includes determining friend from foe, evaluating whether the environment is safe, and communicating with a social group. The vagus nerve is part of what is also called the parasympathetic nerve system.

The sympathetic nerve system. When we are in a lifethreatening situation that the parasympathetic system cannot address, the body automatically overrides it and uses the sympathetic nerve system to trigger adrenal glands to secrete the hormone cortisol, which causes the classic flight-or-fight response to a scary situation.
The non-myelinated vagus. If we cannot escape the threat, the body triggers the most primitive nerve system, which Porges refers to as the non-myelinated vagus. The non-myelinated vagus is theorized to come from a turtlelike ancestor, and causes us literally to be paralyzed with fear and possibly faint, just as a turtle’s head and limbs contract into its shell when it is threatened, or when an opossum plays dead.

In sensory processing disorders (SPD) like autism, the vagus nerve does not strongly enough signal the body to perform autonomic functions. If it does not do its job, then the more primitive parasympathetic nerve system dominates, resulting in a chronic flight-or-fight response by the body. This has many consequences, and can result in symptoms, behaviors, and health issues frequently associated with SPD.

For more primitive non-mammalian animals, such as reptiles, Dr. Porges proposes that they do not experience emotions such as empathy and love. These emotions are what enables social animals to live in social groups, to pay attention to social cues, to communicate, to bond, to work together, and to nurture and raise offspring. The vagus nerve provides the neurological support needed for living in a social group. It also regulates breathing, heart rate, and digestive activity when the body is in a relaxed state. The vagus nerve overrides the sympathetic nerve system’s propensity to flee from close proximity to other creatures.

Porges says:

If you study trauma you realize that people who are traumatized often don’t like to be in public places because noise or sounds bother them and they have great difficulty extracting human voice from background activity. Well, that’s the same thing with autism. Over 60 percent of autistic individuals have auditory hyper-sensitivity. And they suffer from what is often viewed as another paradox, and that is they’re hypersensitive to sound but have great difficulty in extracting human voice. And this becomes explained between autism and trauma. You’ll see the same thing in depression, schizophrenia; all these disorders have both an underlying state regulation disorder, an underlying flatness of affective tone on the face, an underlying lack of proximity in their voice— and they also tend to be represented in a different autonomic state, meaning they tend to have higher heart rates and less vagal activity.

In the head, the vagus nerve affects how well we hear. The auricular branch of the vagus interacts with the ear, and the pharyngeal branch interacts with the ear, larynx, and palate of the mouth, carrying sensory and motor information. It also controls how eyes focus and attend to
other people and works in conjunction with oxytocin receptors in the brain, which stimulate feelings of bonding, attraction, and love.

The vagus regulates heartbeat, lung expansion, and digestion, and stimulates the production of digestive and anti-stress enzymes and hormones (such as acetylcholine, vasopressin, and oxytocin). Interestingly, the vagus nerve uses the neurotransmitter acetylcholine. The vagus nerve manages the complex processes in the digestive tract, including signaling muscles in the stomach to contract and push food into the small intestine and to secrete substances that properly digest food, including pepsin and intrinsic factor.

**Connecting with the Cerebellum and Higher Brain**

Signals from the human body are delivered from the initial receptors of touch, sight, smell, pressure sense, and balance to the spinal nerve roots and on to the spinal cord, where they are delivered to the lower part of the brain, called the cerebellum. These important signals feed the brain and develop its response to the environment based on the information they convey.

The cerebellum coordinates movement and controls all impulses, including thought. The signals are transmitted to the brain cortex (the outer layer of neural tissue in humans), which increases the frequency of firing, keeping the brain viable and healthy. Without this stimulation the brain loses its ability to actively control basic functions, regulating everything from breathing to pain.

It is a malfunctioning brainstem, where the vagus nerve originates, which causes many symptoms of sensory processing disorder. When the cortex receives insufficient input from the cerebellum, it becomes incapable of properly controlling the brainstem functions. When the vagus nerve is underactive, it results in an uncontrolled overactive midbrain, which creates imbalances in cranial nerve function. These imbalances in turn can cause sensory distortions such as photophobia (sensitivity to light), dizziness, inner ear pressure and sound distortion, problems with sleep, digestion difficulties, heart arrhythmias, and systemic pain and fatigue. The vagus nerve inhibits overexcitement; when it is not functioning properly, the midbrain over-fires. Also, mercury poisoning can block the action of acetylcholine, which the vagus nerve uses to transmit signals to other parts of the body.

**Frequently Asked Questions**
Viva Vagus! What Happens in the Vagus Nerve Affects Every Part of Our Lives

Written by Susan Bennett
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**Why do individuals with autism spin?** Spinning stimulates the vagus nerve, which helps regulate balance. It can actually be therapeutic and help someone with autism to become better oriented. Spinning can help to mature the balance system, which is the master integrator for all other senses in the body.

**Why do individuals with autism flap their hands?** This activity also stimulates and regulates the vagus nerve. The sensory feedback we receive from our extremities helps to orient us in space and tells us where our body ends and the rest of the world begins. In autism, individuals who do not receive enough sensory feedback from their extremities (proprioceptive feedback) have difficulty with their sense of identity and how they are oriented in space. It’s the reason mothers intuitively tightly swaddle their infants in blankets—the vagus nerve system is not mature, and the gentle pressure helps to stimulate the vagus nerve, which triggers the release of calming neurotransmitters, putting the child at ease.

**Why do individuals with autism have difficulty understanding language and language delays?** Listening is actually a motor act and involves tensing muscles in the middle ear. The middle ear muscles are regulated by the facial nerve, a nerve that also regulates eyelid lifting. When you are interested in what someone is saying, you lift your eyelids and simultaneously your middle ear muscles tense. Now you are prepared to hear their voice, even in noisy environments. In some individuals on the spectrum, the muscle tone in the ear is not sufficient to block out background noises, making it both hard to hear and look at someone. Also, recent research indicates that there is a time lag in auditory processing in some individuals with autism so the sounds come in after the visual images, and the person speaking appears to be out of sync, with the words not matching what they see.

**Why do individuals with autism have difficulty making eye contact?** The neural system controlling spontaneous eye gaze is turned off. This newer, social-engagement system can only be expressed when the nerve system detects the environment as safe. You can’t make eye contact in flight-or-fight mode.

**Why do some autistic individuals speak with unusual modulation of the voice and enunciation?** The vagus helps to modulate the larynx and muscles used for speech.
Why do individuals on the spectrum often lack animation in their faces, especially the level of the nose and above? The vagus nerve triggers animation in the facial muscles.

Why does auditory integration training work so well for many individuals on the spectrum? Auditory integration training stimulates the vagus nerve through the ear, increasing muscle tone that is normally stimulated directly through the vagus nerve.

What helps stimulate the vagus nerve to function more optimally? Deep breathing exercises, meditation, aerobic exercise (brisk walking, bicycling, running jogging), martial arts training, tap dancing, auditory integration training, interactive metronome therapy, drumming, oxygen therapies (hyperbaric oxygen), spinning, cranial sacral massage, and chiropractic adjustments. Relaxed, positive social interactions with friendly people who like the person and whom the person trusts also help.

Why do half of autistic individuals improve in level of functioning when they have a fever? The mechanism that spikes a fever switches on metabolic systems in the body normally switched on by a fully functional vagus nerve.

Why is the immune system frequently depressed in individuals with autism, subjecting them to many infections? The vagus nerve stimulates the immune system to fight off infections. Why do individuals with autism often have high levels of toxins and heavy metals? The vagus nerve stimulates the body to detoxify.

Why is there a deficiency in B-12 in most individuals within the autism spectrum? The vagus nerve stimulates the production of intrinsic factor in the small intestine, which the body needs to make B-12.

What nutritional support can help protect and repair the vagus nerve? Viruses tend to activate when exposed to excessive levels of sugar and carbohydrates. Foods and supplements that support neurological repair, such as coconut oil and milk, sunflower lecithin, phosphatidyl serine, and choline, may also help.
What can I do to calm an overactive sympathetic nerve system that’s keeping my child in fight-or-flight mode? Reduce external stressors, provide a calm, safe environment, and use humor to address potentially stressful situations. There are also supplements that can lower levels of cortisol. Taking steps to identify and rid the body of infections will also help to calm down the parasympathetic nerve system.

Why do meditation and relaxation techniques help? Deep breathing stimulates the vagus nerve connections in the lung area. So, for example, if you regularly and deeply breathe in through your nose and expand your lungs, then hold in your breath for two seconds and release it through your mouth, you can immediately lower your blood pressure. The vagus nerve produces calm and feelings of well-being—the opposite of the sympathetic fight-or-flight response. Vagal tone is measured by tracking how the heart rate speeds up and slows down during breathing. Increased vagal tone stimulates better social feelings, which in turn stimulates better vagal tone in a virtuous cycle. In one study, meditators had increased vagal tone after nine weeks, which correlated with positive emotions.

Are there mainstream therapies being developed to improve the function of the vagus nerve? Pharmaceutical companies are currently sinking millions of dollars into research in this area to develop both drugs and devices to help stimulate the vagus nerve. Preliminary studies have indicated that vagal nerve stimulation (VNS) therapy currently used to reduce pharmacoresistant seizures in epilepsy may improve neurocognitive performance in individuals with autism, as well as alleviate depression in individuals with untreatable depression. The therapy is a surgical solution, in which a pacemaker-like device is implanted in the body to continually stimulate the vagus nerve. In the journal Epilepsy Behavior, researcher Y.D. Park reported a study with 59 autistic patients and six with Landau-Kleffner syndrome (epileptic aphasia). Improvements were reported in all areas of quality of life monitored, particularly alertness (76 percent at 12 months). But better standardized and long-term studies are required to assess the results better.

I’m personally not recommending an invasive surgery, but the concept of stimulating the vagus shows great promise.