Hypermobility 112: The Vagus Nerve

Leslie N Russek, PT, DPT, PhD, OCS
Clarkson University

Who Am I?

- Professor Emeritus, Physical Therapy, Clarkson University.
- Staff PT, St. Lawrence Health System, Potsdam NY.
  - Clinical specialties: hypermobility, chronic pain, fibromyalgia, headaches, temporomandibular disorders
- Facilitator of the North America Allied Health Professionals ECHO
- Member of:
  - The Allied Health Working Group of the International Consortium of Ehlers-Danlos Syndromes and Hypermobility Spectrum Disorders
  - The National Academy of Sciences, Engineering and Medicine Committee on Selected Heritable Connective Tissue Disorders and Disability.
- Author of ”Chronic Pain” chapter in *Physical Rehabilitation* textbook for PT students
- Lrussek@Clarkson.edu
- https://webspace.clarkson.edu/~lrussek/
- I do free weekly Zoom lectures for people with HSD (see website)

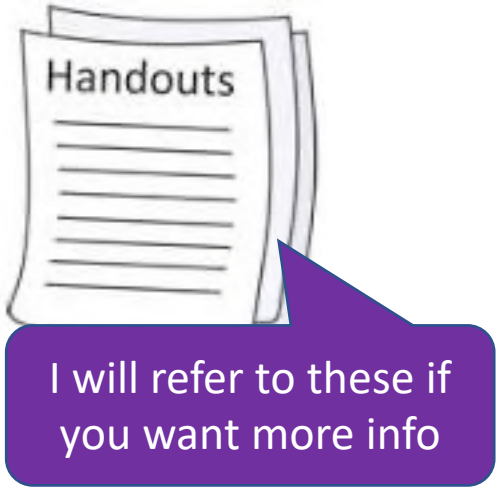
I do not have any conflicts of interest to report

Hypermobility Lecture Series Schedule

I will refer to these if you want more info

- HSD 101: Basics of HSD/hEDS and self-care
- HSD 102: POTS and POTS self-care, basics of MCAS
- HSD 103: Pain management in HSD/hEDS
- HSD 104: Safe exercise selection and progression with HSD/hEDS
- HSD 105: Posture and joint protection
- HSD 106: Gut issues in HSD/hEDS, POTS, MCAS
- HSD 107: Fatigue in HSD/hEDS and POTS
- HSD 108: Headaches, migraines, & TMJ pain associated with HSD, POTS and MCAS
- HSD 109: Breathing disorders in HSD
- HSD 110: Lumbar instability
- HSD 111: Conservative management of cervical instability
- HSD 112: The vagus nerve
- HSD 113: The role of fascia

Relevant Handouts Available



- https://webspace.clarkson.edu/~lrussek/research.html
- **Self-Care Strategies**
  - Breathing. Breathing incorrectly can increase pain sensitivity, headaches, jaw pain, and more.
  - Heart-rate variability biofeedback. Biofeedback to increase activation of your parasympathetic nervous system can help quiet sensitive nerves and decrease pain.
  - Sleep Hygiene and Positioning. Sleep posture and sleep hygiene strategies.
  - Sleep Checklist. Sleep is critical to good health. This checklist of sleep promoting strategies can make sure you don't overlook any options.

- **Pain Management**
  - Pain self-care plan. Create a pain self-care plan to improve your pain management.
  - Pain flare management plan - PDF version. Create a flare management plan so you know what works when you have a flare.
  - Free chronic pain management apps for teens
  - Chronic pain management app. Cognitive behavioral approaches to pain management. Contact Dr. Russek if you are interested in 6 weeks free access: Lrussek@clarkson.edu

Disclaimers

The information in this presentation is for general purposes, only, and may or may not apply to your situation.
Check with your health care provider
before starting any new treatment approach
to ensure that it is appropriate and safe for YOU.
I cannot provide personal diagnostic or treatment guidance.

Scientific evidence about the vagus nerve is evolving rapidly.
This lecture attempts to use the most current available research.
I suggest many products that may be helpful. I do not have any financial interest in any. I am familiar with some, but some are new to me.

Objectives

By the end of this session, participants should be able to:

1. Describe the function of the vagus nerve (VN)
2. List some of the health consequences of vagus nerve dysfunction
3. Describe the basic concepts of 'Polyvagal Theory'
4. Describe how heart rate variability (HRV) can measure VN activity
5. Identify strategies for activating the vagus nerve
   - Relaxation strategies: e.g., slow breathing, chanting, ear massage, singing, etc.
   - Exercises: Aerobic exercise, The Basic Exercise
   - Transcutaneous electrical stimulation (vagus nerve stimulation – VNS)

Approach to Management of HSD

Assist patient in identifying and managing systemic comorbidities: education, treatment and/or referral

Decrease central, peripheral, and autonomic pain sensitization

Educate for correct posture and joint alignment, body mechanics, joint protection, appropriate use of splints and braces

Proprioceptive and motor control training, with training to relax muscles that are guarding

↓

Stabilization, strengthening, muscle flexibility, aerobic conditioning

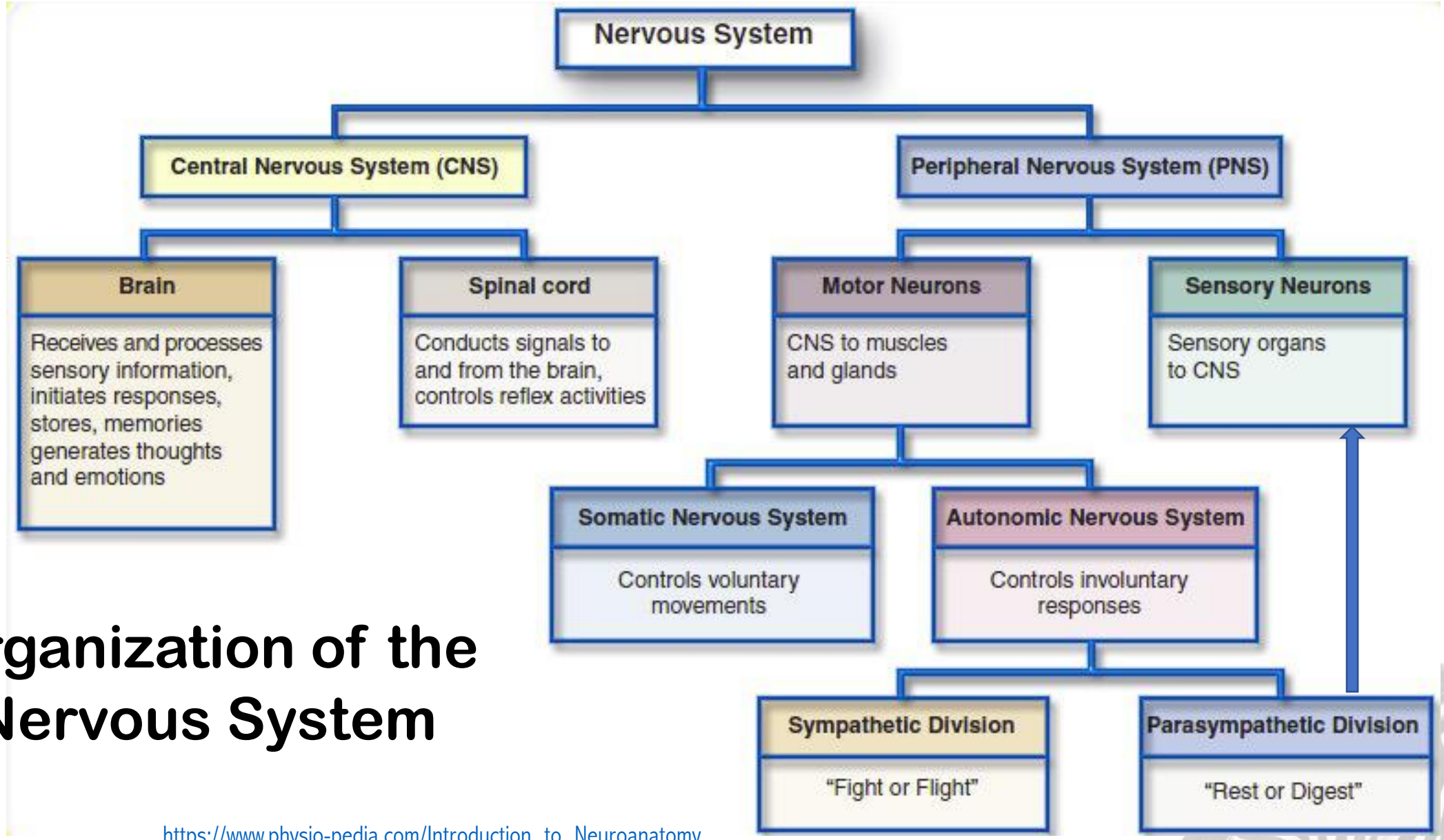
↓

Integration of proper alignment & movement into function

↓

Education about flare management

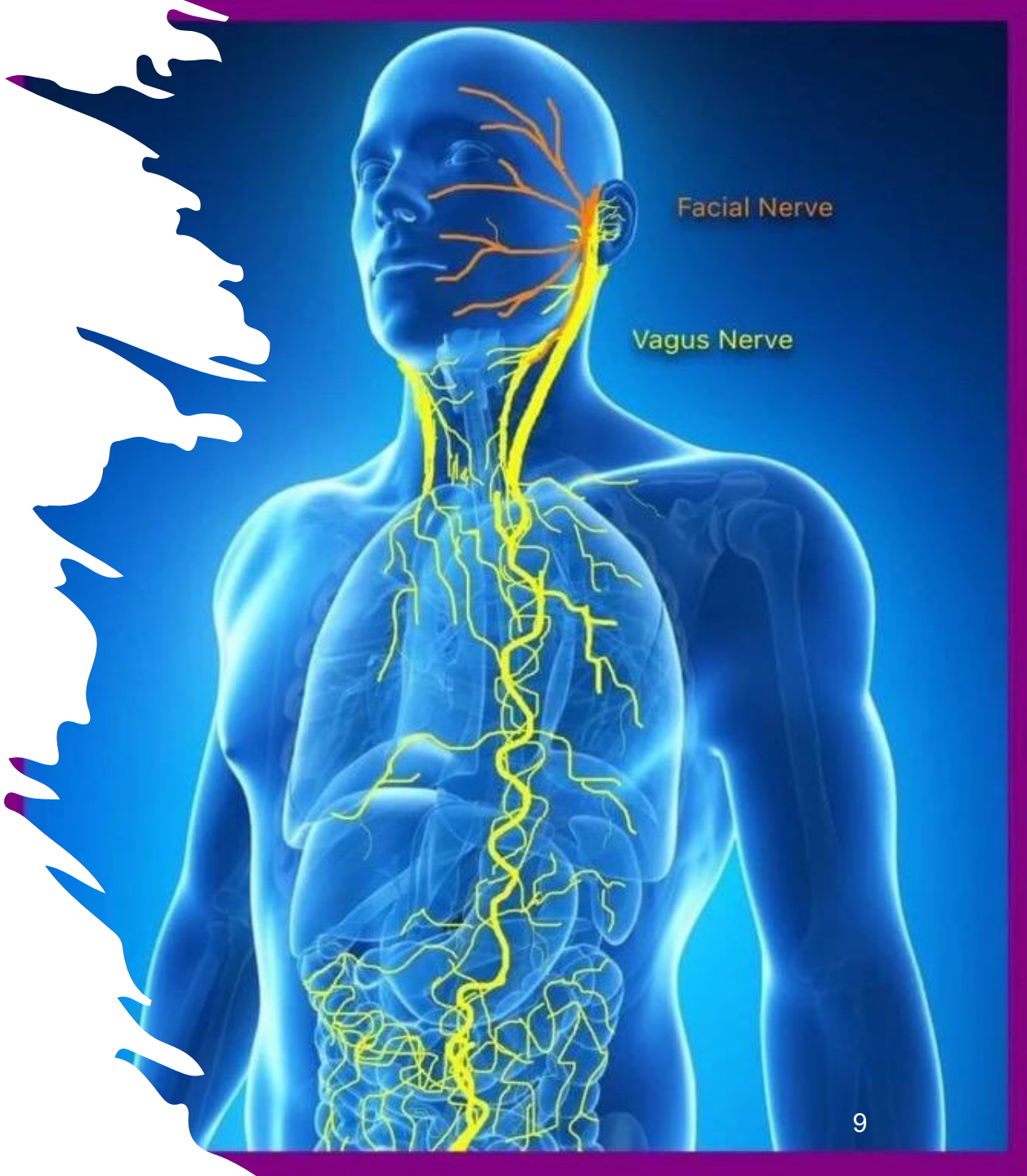
Organization of the Nervous System



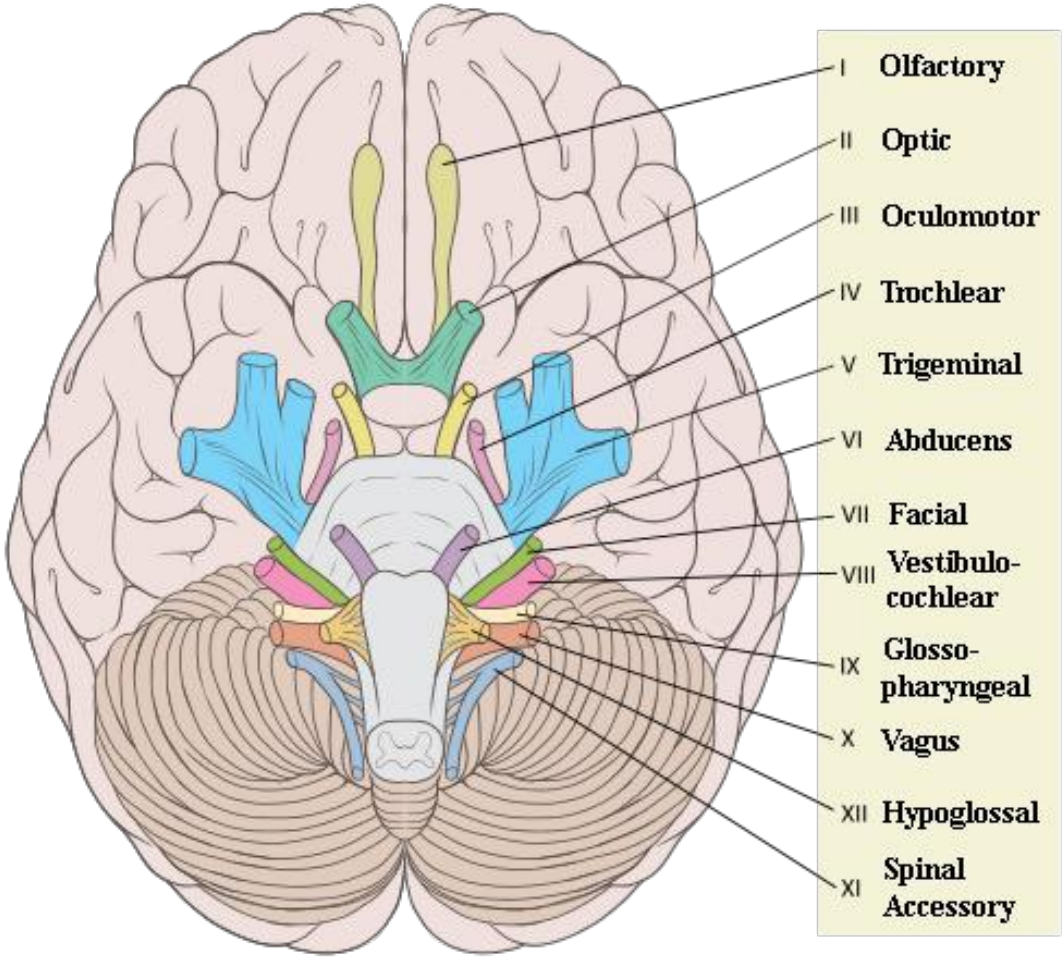
https://www.physio-pedia.com/Introduction_to_Neuroanatomy

The Vagabond

- The Vagus Nerve (VN) is a cranial nerve: it comes directly from the brain
- It is the longest cranial nerve in the body: the “vagabond” or ”traveler”
- It is the primary controller of parasympathetic function, hence of autonomic function

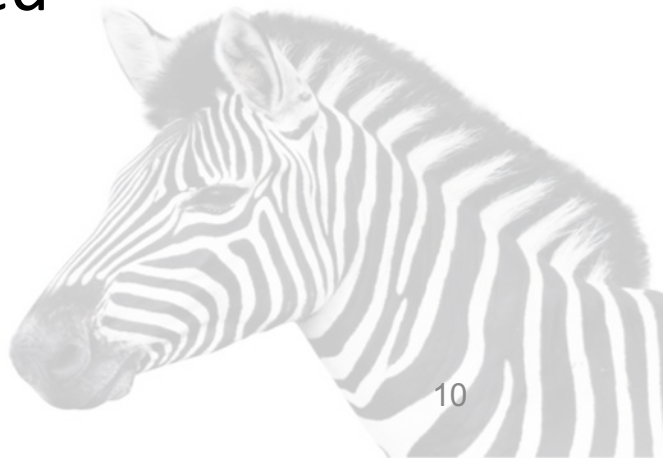


Cranial Nerves



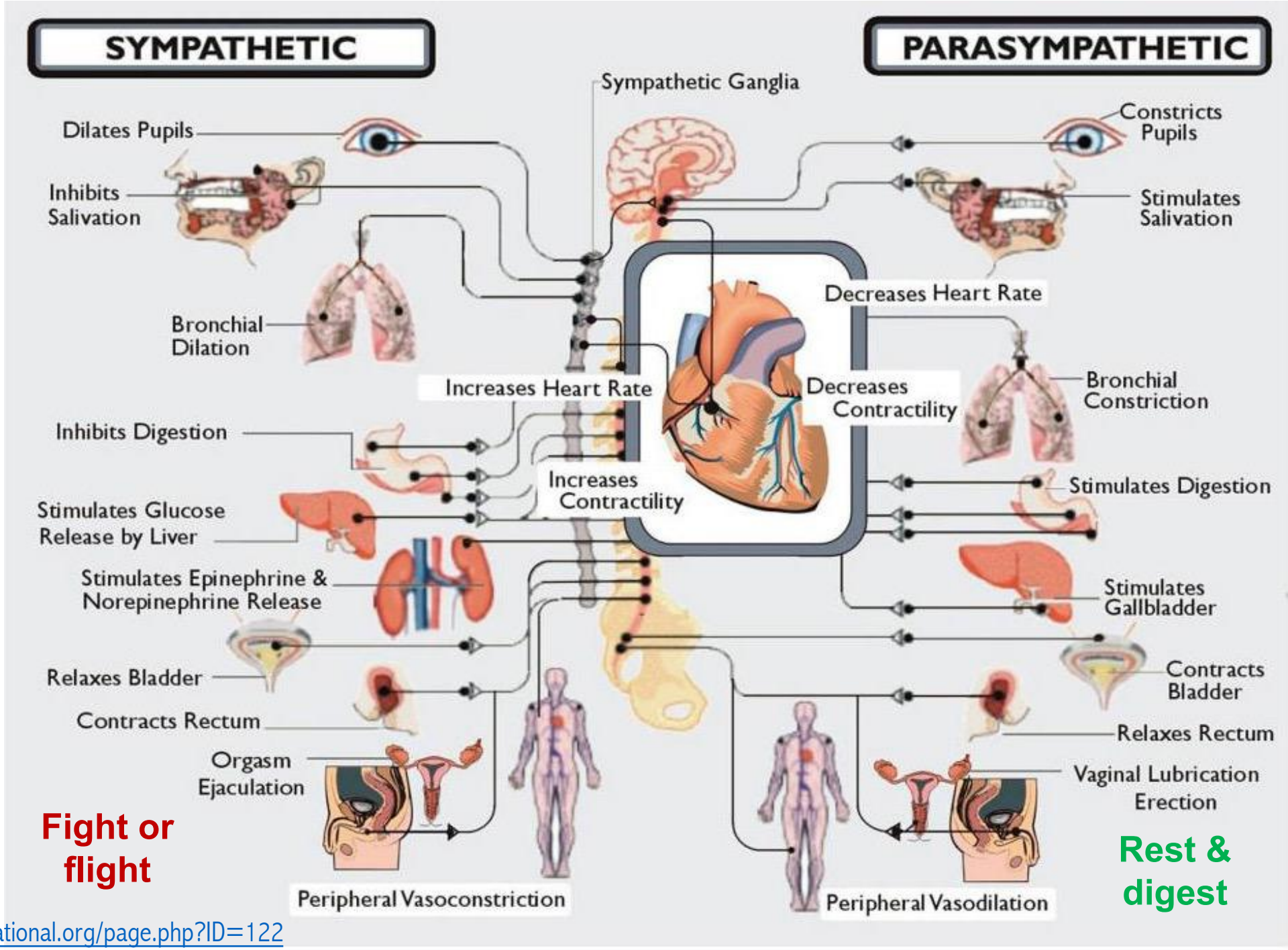
View from the bottom
https://www.vestib.com/CN-anatomy.html

- Cranial nerves (CN) come directly from the brain (not the spinal cord)
- Upper cervical instability can compress or stretch them
- CN III, VII, IX, X are most commonly affected



The Autonomic Nervous System

It is not actually a binary system as shown here



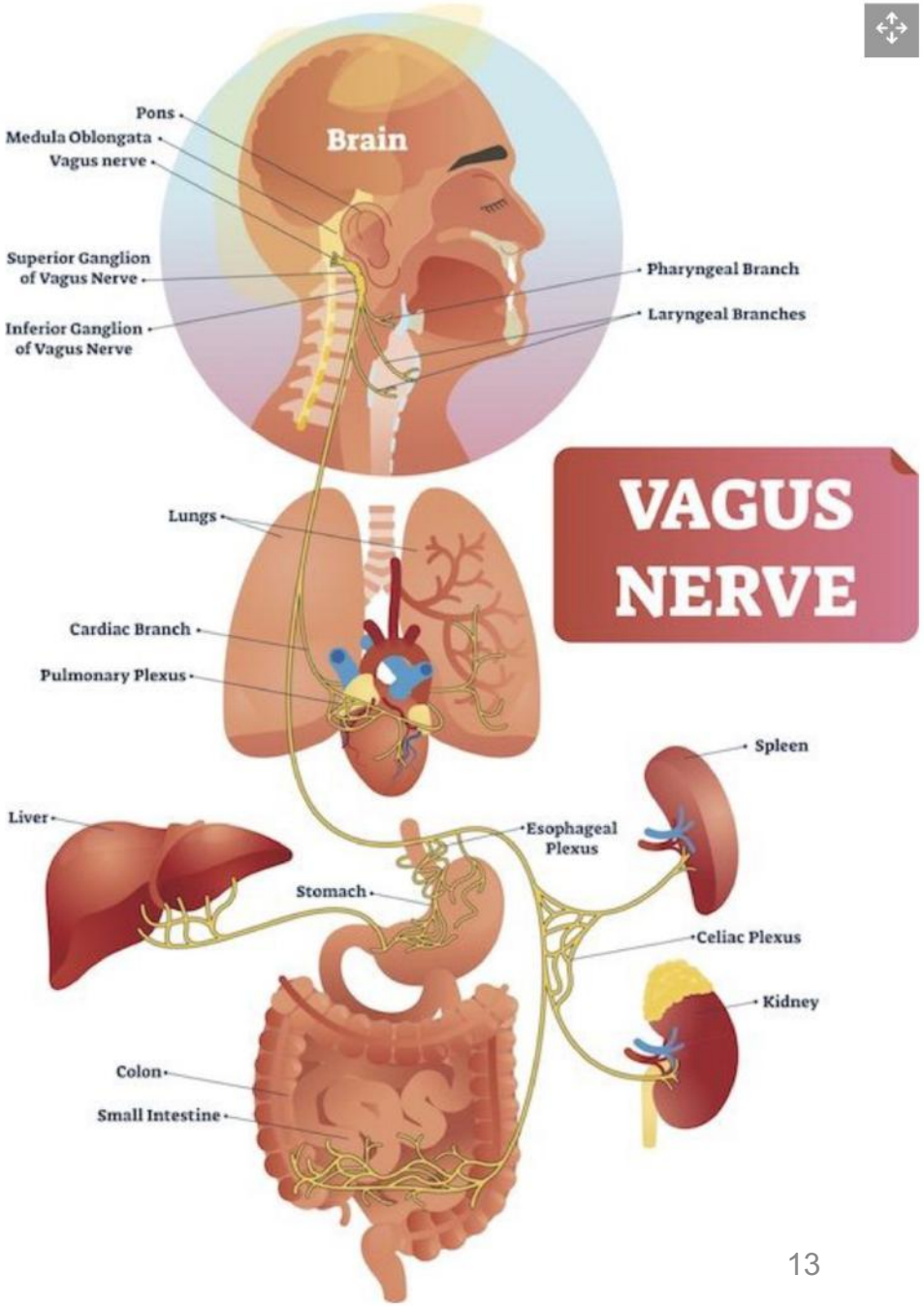
http://www.dysautonomiainternational.org/page.php?ID=122

Sympathetic vs. Parasympathetic

- There is normally a balance between the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS)
- The PNS drives the SNS
- Pain shifts the balance towards the SNS (and SNS increases pain)
  - SNS provides an emergency response to pain The hypothalamic-pituitary-adrenal axis (HPA) provides a slower response via release of cortisol
  - This is beneficial as response to acute pain/stress, but maladaptive as a response to chronic pain/stress
- The VN normally controls/decreases inflammation and cortisol

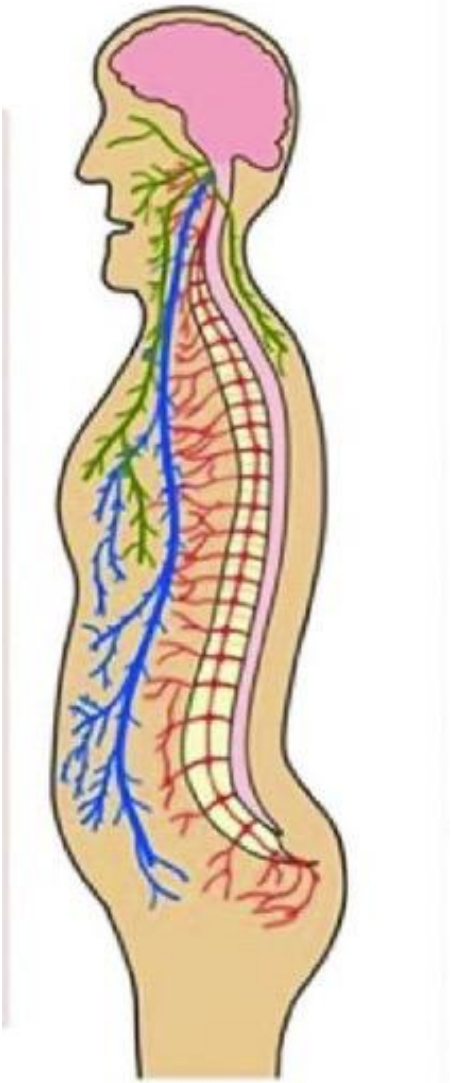
VN Anatomy/Function

- Cranial nerve: from brain via the skull
- Serves some structures in the head and throat, and most organs in the chest and abdominal regions
  - R VN controls most cardiac function
- Functions
  - Sensory: skin of outer ear, throat, heart and abdominal organs
  - Special sense: contributes to taste
  - Motor: some muscles of mouth and throat
  - Parasympathetic: trachea, lungs, gut, heart



picture from: https://www.livescience.com/vagus-nerve.html

Dorsal and Ventral Vagus Nerves

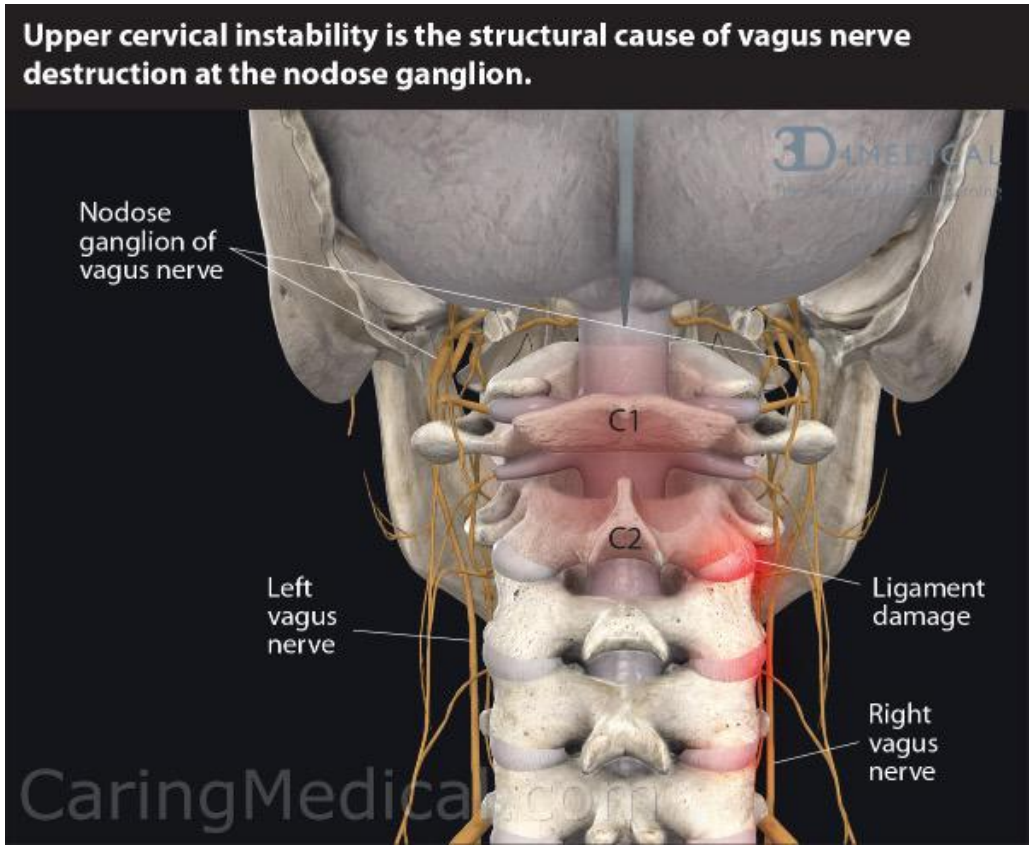


- The right VN becomes the posterior (dorsal) branch and the left becomes the anterior (ventral) branch
  - Dorsal serves the gut and abdominal organs (primitive)
  - Ventral serves the heart, lungs, and vocal cords (only in animals that rear live young).
  - The ventral VN modulates the dorsal VN. When the ventral VN is underactive, the dorsal VN leads to a 'freeze' state

Porges, 2021; Porges, 2022

VN and Cervical Instability

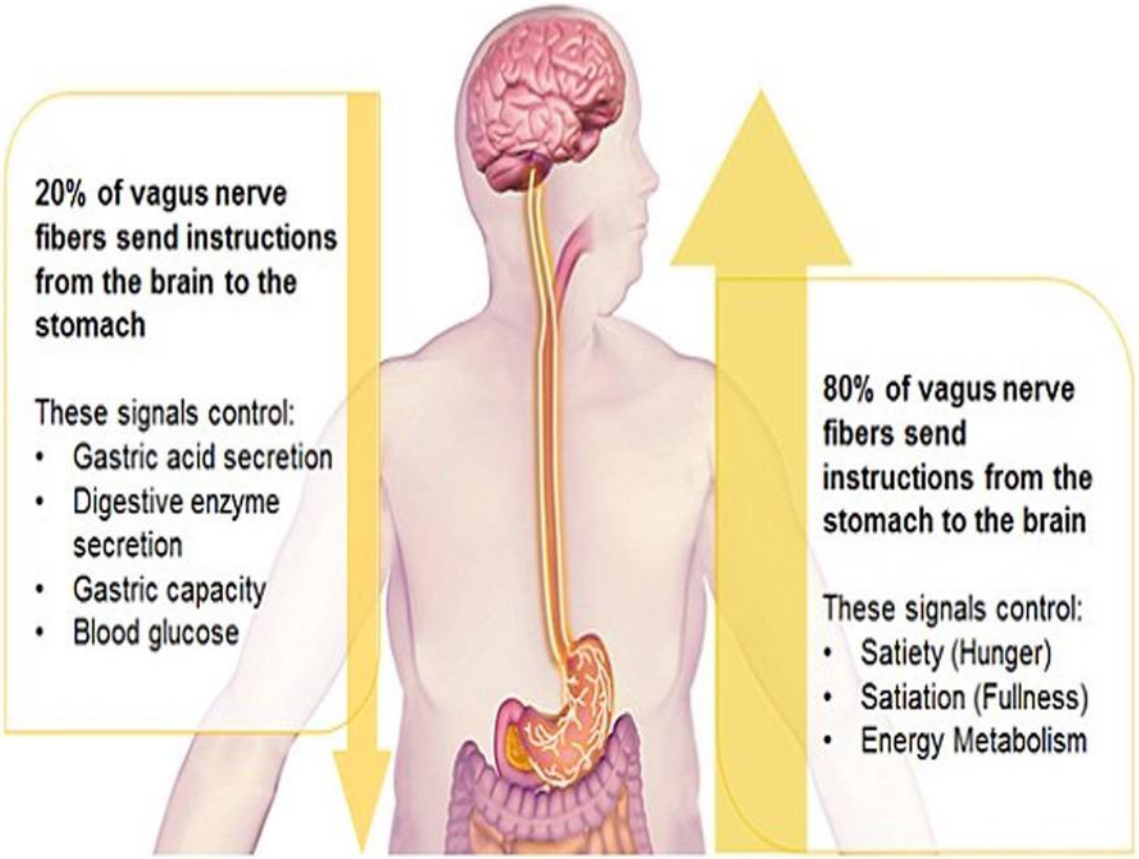
Upper Cervical Instability



https://www.caringmedical.com/prolotherapy-news/vagus-nerve-compression-cervical-spine/

- The VN travels very close to the top cervical vertebrae, C1 & C2
- Cervical instability likely compresses the VN, decreasing its activity
- This leads to increased SNS activity and may aggravate POTS
- It may also contribute to vaso-vagal syncope

VN: An Information Superhighway



- Vagus nerve controls digestion, heart rate, immune function, mood and voice via the parasympathetic nervous system
- 80% of VN fibers communicate from the gut to the brain, telling the brain how the body is doing
- Sympathetic and parasympathetic activity are inversely related
- Vagus nerve function is disrupted in POTS (Anjum, 2018)

Conditions Involving VN Dysfunction

- Dysautonomia, POTS, orthostatic intolerance
- Epilepsy
- Rheumatoid arthritis and some other immune/autoimmune conditions
- Atherosclerosis, hypertension
- Crohn's disease, gastroparesis, constipation, irritable bowel
- Migraine and other chronic pain conditions involving central sensitization
- Post-traumatic stress disorder, depression
- Diabetes, obesity
- Fainting (vasovagal syncope)
- May contribute to some cancers
- It may be involved in long COVID

(Gitler, 2022; Wang, 2022)

Gut-Brain Interaction

HSD163: The Gut in HSD/POTS/MCAD

- "Functional gastrointestinal disorders" (FGD/FGID) have been renamed "**disorders of gut-brain interaction**" (DGBI) (Settembre, 2022)
- The bi-directional communication between the gut and central nervous system (brain)
- Mechanisms:
  - Vagus nerve sends signals between brain and gut
  - Immune system (organs, white blood cells, antibodies, chemicals that protect you from foreign invaders)
  - Endocrine system (set of glands that make & release hormones into blood to contro)
  - Bacterial metabolites from the gut can pass through the blood-brain-barrier
- May be disrupted in multiple sclerosis, Alzheimer's, Parkinson's, depression and mood disorders

(Rutsch, 2020)

VN and POTS

- The VN drives the parasympathetic branch of the autonomic nervous system
- When the VN is not functioning well, dysautonomia results
  - Probably neuropathic POTS
- VN activity is decreased in chronic fatigue syndrome/myalgic encephalitis (CFS/ME) and does not rebound after exercise
- We don’t yet know how to use this to improve management of POTS
- Except: aerobic physical exercise is one of the best ways to normalize VN activity

VN and Chronic Fatigue Syndrome

- People with dysautonomia/CFS are not able to regulate autonomic function during exercise
- Poor parasympathetic function is reflected in:
  - Higher resting heart rate (HRR)
  - Slower drop in HR after exercise
  - Lower HR variability (HRV)

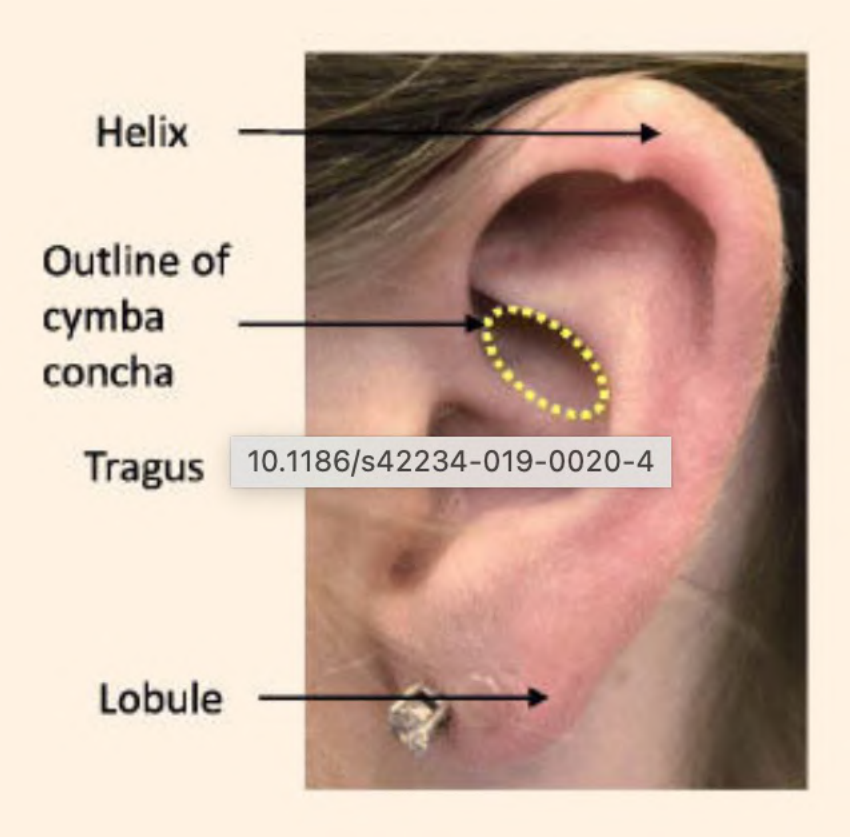
(Gourine, 2018; Ladlow, 2021)

- If severe fatigue after exercise is associated with failure of the parasympathetic nervous system to reactivate, can we activate it manually?
  - Proposed strategies to activate the vagus nerve/parasympathetic system
    - Do a 'cool-down' after exercise (Parks, 2022)
    - Slow, diaphragmatic breathing, left nostril breathing (Pal, 2014)

VN and Chronic Migraine

- VN afferents (sensory fibers) connect to portions of the brain involved in migraine (locus coeruleus and raphe nuclei)
  - These regions of the brain regulate noradrenaline and serotonin in other parts of the brain.
- VN stimulation: 30 minutes, 3x/week for 4 weeks (1 Hz, continuous) to left cymba concha
- Decreased number of migraine days and pain intensity
- Research showed change in brain connectivity

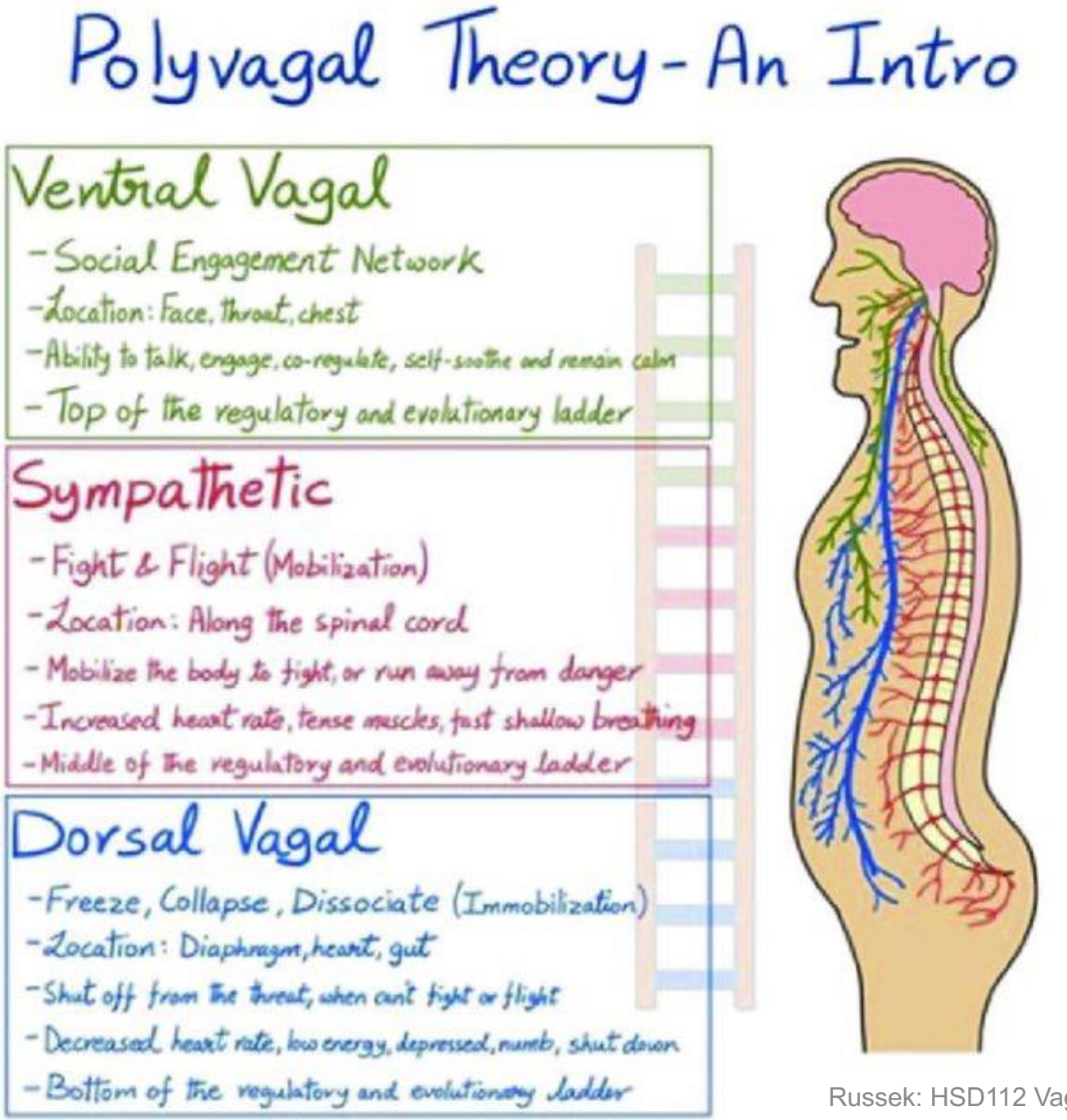
(Huong, 2023)



VN and MCAS

- Mast cell activity influences nerve function, including the VN
- The VN stimulates anti-inflammatory activity, which influences mast cells
- VN directly connects to mast cells, e.g., in the gut, airways, etc. (Forsythe, 2015)
- Research does not yet show how to use this connection for MCAS.

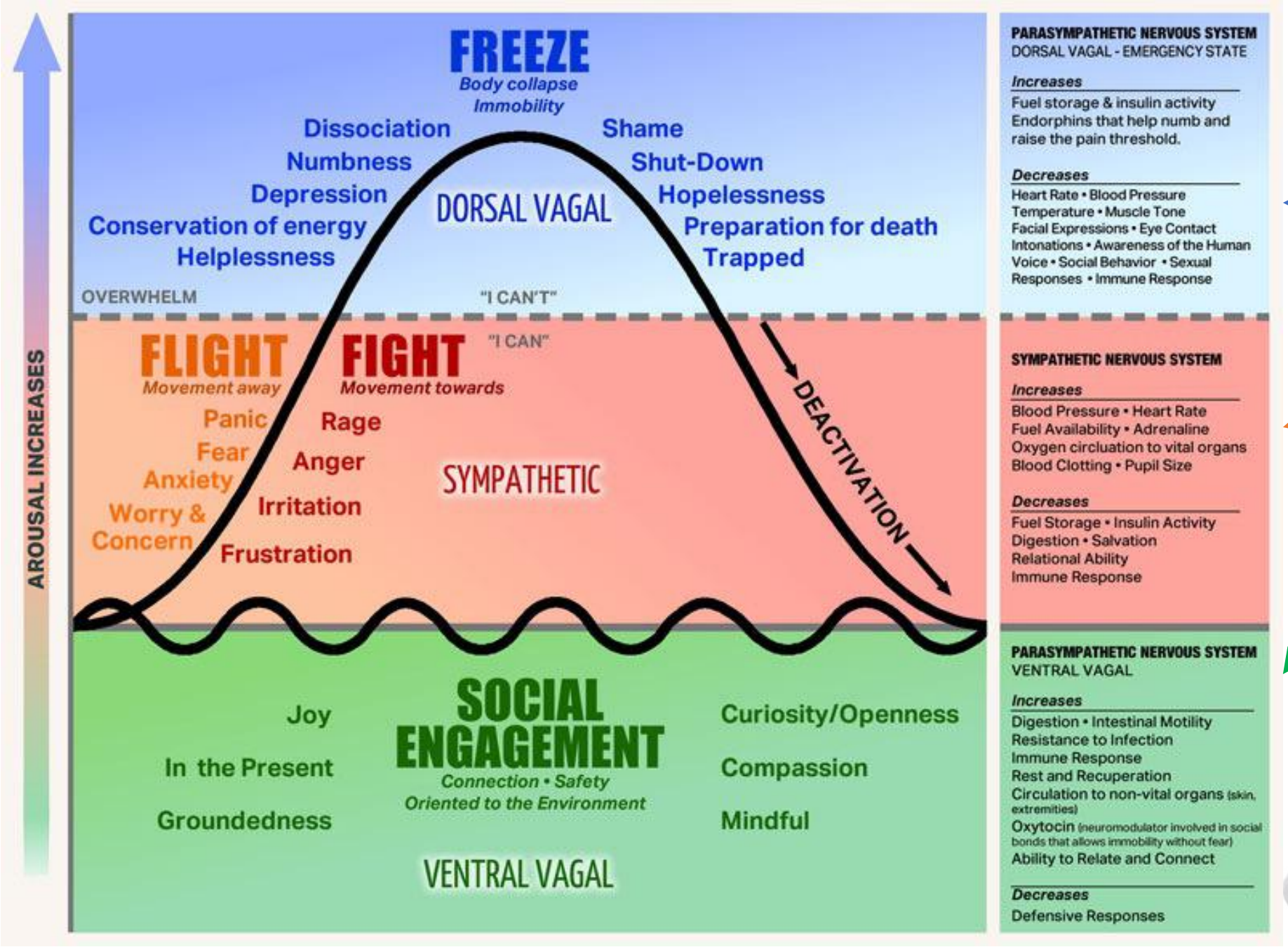
Polyvagal Theory



- We previously thought that the autonomic system was binary: sympathetic and parasympathetic.
- We now know that there are 2 parts to the parasympathetic system, hence "polyvagal"
- There is limited research supporting polyvagal theory

Porges, 2021; Porges, 2022

Diagram: Ayan Mukherjee -therapyillustrated.com



Parasympathetic: Dorsal vagal

Sympathetic

Parasympathetic: Ventral vagal

https://themovementparadigm.com/how-to-map-your-own-nervous-sytem-the-polyvagal-theory/

VN and Feelings of Safety

- HSD, POTS and MCAS may all compromise feelings of safety
  - Feeling out of control
  - Not knowing why you have specific symptoms
  - Feeling like your body is vulnerable to injury
- Feelings of danger can trigger:
  - Sympathetic (fight or flight) response
  - Dorsal vagal (freeze) response
- Interventions should always be implemented slowly, carefully, with time to adapt and feel comfortable

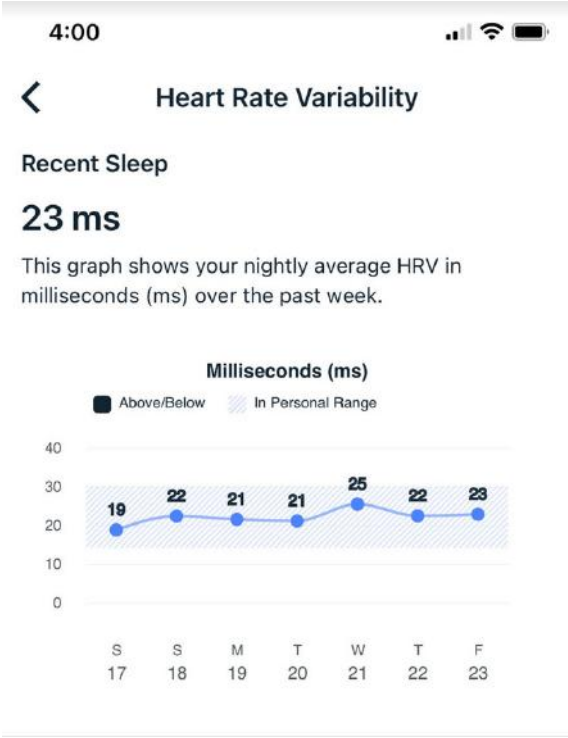
Questions?

Measuring VN activity

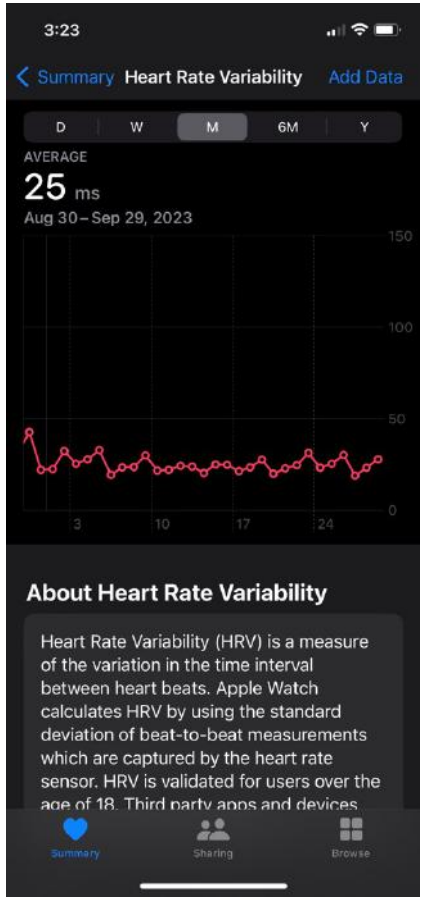
HR Variability Biofeedback

- "Heart rate variability" is a measure of PNS function (Gitler, 2022)
  - Higher HRV indicates higher parasympathetic function (good)
  - There are HRV biofeedback apps that use your smartphone camera to measure HRV: Smartscan™ is free and gives real-time feedback
  - Juva™ uses facial scans to measure HRV
  - Dedicated HRV biofeedback devices: Inner Balance™
- Resting HR also reflects PNS function, but depends on other things as well
  - HR response after exercise (parasympathetic recovery) reflects PNS function
- Tilt table test (same test as for POTS)

Many Wearables Track HRV

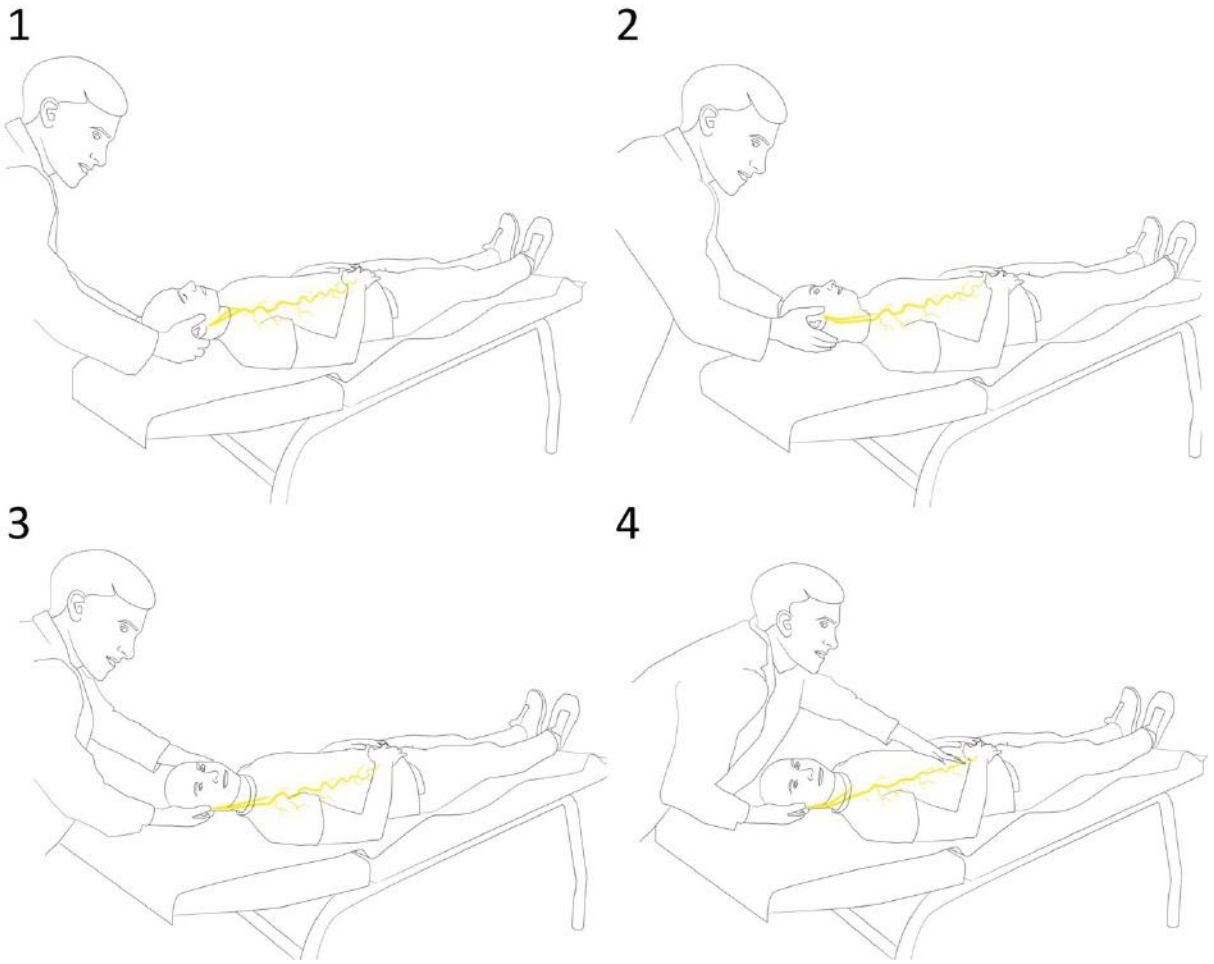


Fitbit↑ AppleWatch→



- You can use daily HRV to judge your daily resilience
  - If your HRV is higher than usual, your body is more resilient, and you can challenge yourself more
  - If your HRV is lower than usual, your body is stressed, and you should be more cautious

FYI: Vagus Neurodynamic Test

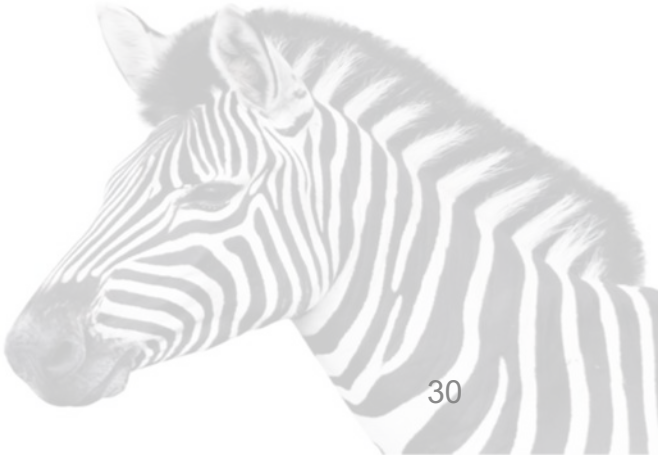


1. Starting position with upper cervical spine in flexion.
2. Contralateral lateral flexion.
3. Ipsilateral neck rotation.
4. End position, with gentle movements of the upper abdomen caudally and cranially as discrimination maneuverers.
5. (+) finding is mechanical allodynia in ipsilateral suboccipital region (predicts autonomic symptoms)
6. Causes HR decrease 8-12 BPM

(Carta, 2021)

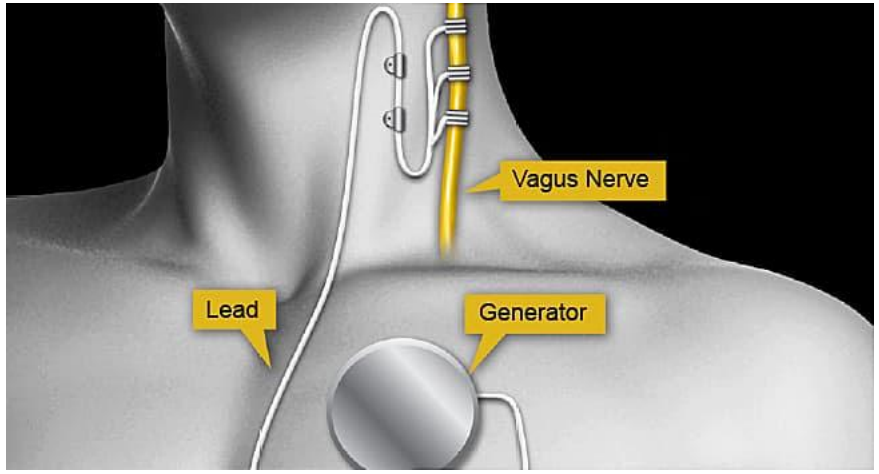
Activating the Vagus Nerve

- Electrical stimulation
- Stress reduction
  - Slow breathing, chanting, laughter
  - Mindfulness meditation
  - Relaxation biofeedback
  - Awe, exposure to nature, positive emotions, forgiveness
- Exercise
  - General (e.g., aerobic exercise, yoga, Pilates, etc.)
  - Vagus nerve specific
- Nutrition



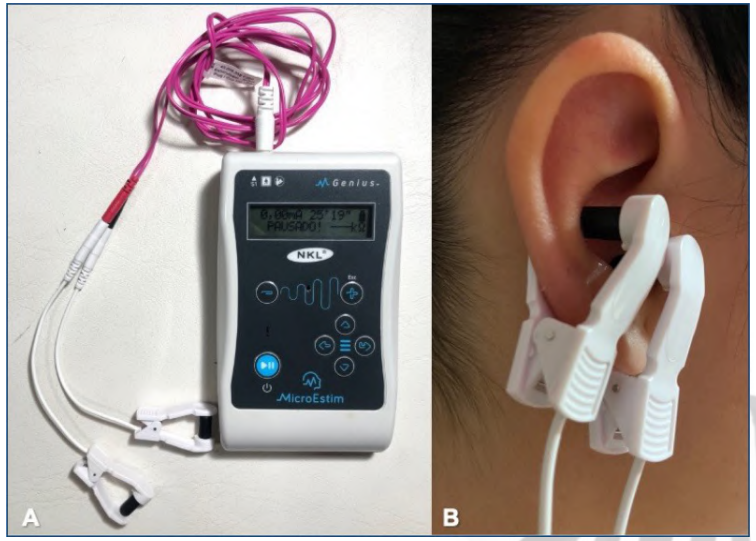
Stimulating the VN at the Neck

- Implanted electrical VN stimulators
  - For intractable epilepsy or depression
  - Chronic inflammatory conditions: RA, Crohn's, asthma, fibromyalgia
- Transcutaneous electrical VN stimulators
  - For migraine/headaches
  - GammaCore™ available by prescription
  - Truvaga™ available for purchase
- Cervical VN stimulation has good research support.



Stimulating the VN at the Ear

- Transcutaneous auricular VN stimulators (taVNS)
  - Also percutaneous aVNS using a small needle in the ear (Sant'Anna, 2023)
- Research shows benefit for: (Wang, 2022)
  - Pain/inflammation
  - Atrial fibrillation
  - Constipation & abdominal pain
  - Depression, anxiety, insomnia
  - Migraine
- Can use custom ear electrodes or clamp electrodes: LEFT cymba concha
- Parameters: (Wang, 2022)
  - "The pulse widths, 100 μs, 200 μs, 250 μs, 200–300 μs, 300 μs, 450 μs, and 1000 μs, are often used during clinical research. The frequencies include 1 Hz, 1.5 Hz, 8 Hz, 20 Hz, 25 Hz, and 30 Hz. The intensities used in clinical research include 130 μA, 0 μA–600 μA, 0.1 mA5mA, 0.1 mA–10 mA, 0.25 mA–10 mA, 0.5 mA, 1 mA, 1.5 mA–3 mA, 4 mA–6 mA, 5 mA, 8 mA, 10 mA–50 mA, tingling threshold, pain threshold, or the threshold of maximum tolerable level." (Wang, 2022)
  - That means – we don't know what parameters are best.
- No… I cannot recommend a specific device to purchase



Auricular Stimulation Electrodes

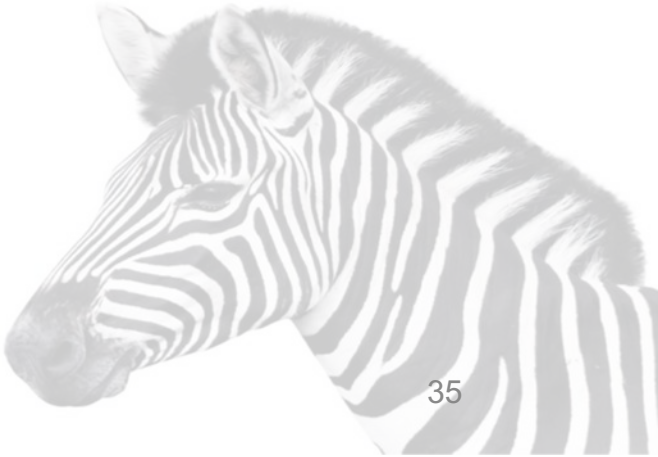
- Get electrodes designed for stimulating the ear
- Get electrode gel
- Use a TENS machine that has appropriate settings:
  - Pulse width 200-300 microseconds (usually 200us)
  - Frequency 5-30 Hz (usually 25Hz)
  - Intensity just below uncomfortable
  - 15-30 minutes

Safety of Electrical VN Stimulation

- Implanted electrodes are relatively high risk
- Transcutaneous VN stimulation is much safer
  - Cervical stimulation is considered safe (Lendvai, 2018)
  - Ear (auricular) stimulation is very safe (Kim, 2022)

“Low Tech” Approaches with Research

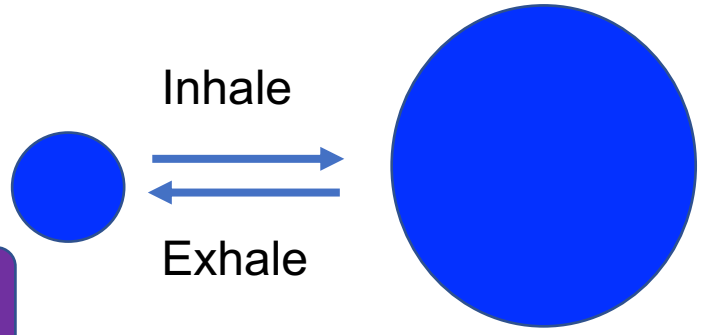
- Relaxation training
  - Slow breathing, chanting, laughter
  - Mindfulness meditation
  - Heart rate variability (HRV) biofeedback
- Exercise
  - Aerobic exercise (if not harmful/threatening)
  - Muscle stretching (in people who were tight), strength training
  - Yoga
- Nutrition
  - Omega-3 fatty acids
  - Probiotics
- Other
  - Massage: ear, abdominal, neck
  - Cold water facial immersion Yuen, 2017



Slow Breathing Practice

HSD109: Breathing

Breathing



- **Slow breathing**
  - Research is very strong that slow breathing improves VN activity (Laborde, 2022)
  - https://youtu.be/PzwTAf2YLh4 has a 2-minute practice
  - Apple Watch & Fitbit also have slow breathing functions
- **"365 Breathing"** (Andre, 2019)
  - **3** times per day
  - Breath **6** times/minute = 5 seconds in, 5 seconds out
  - For **5** minutes

- It is normal to feel a little light-headed or 'air-hungry' at first
  - Don't try to breathe quite so slowly if these symptoms are distressing
- It may take several weeks for the nervous system to reset

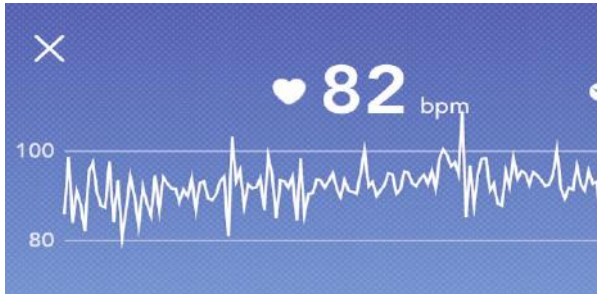
Biofeedback

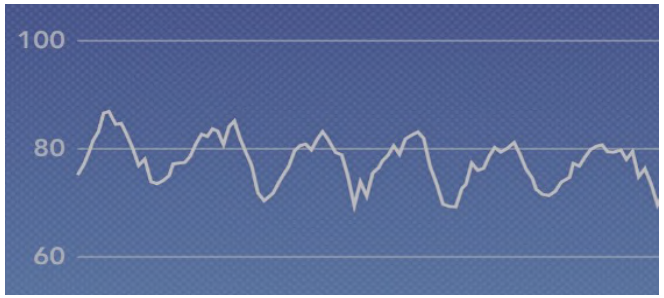
HRV Biofeedback

HSD103: Pain

- More information about biofeedback is available at: https://www.mayoclinic.org/tests-procedures/biofeedback/about/pac-20384664
- HRV biofeedback provides feedback on vagus nerve activity (Gitler, 2022)
  - A smartphone with camera/flash can do HRV biofeedback, many apps available
    - StressScan™ has real-time feedback
    - Juva™ uses facial imaging to track HRV (https://www.juvahealth.com)
  - You can purchase a dedicated biofeedback unit with ear clip: more features
    - Inner Balance™
- Biofeedback apps also for breathing (diaphragmatic or slow)

Stressed





Relaxed

Humming, Chanting, Singing

- How we think it works:
  - The vagus nerve serves the vocal cords and throat; vibration may stimulate those nerves
- Evidence:
  - Chanting OM creates similar brain activation changes as seen with VNS
  - Deactivates the limbic system (decreases anxiety)
  - An ‘ssssss’ sound does not have the same effects
- https://youtu.be/QSAvPgqQ2L0

Kalyani, 2011; Inbaraj, 2022

Yoga and Polyvagal Theory

- Yoga is a form of neural exercise
  - Increases Heart Rate Variability and ventral vagal activity
- The mind-body connection is important
  - The sense of calm
- Controlled breathing is important
  - Chanting may also be helpful
- Slow, full body movements might improve VN mobility and health

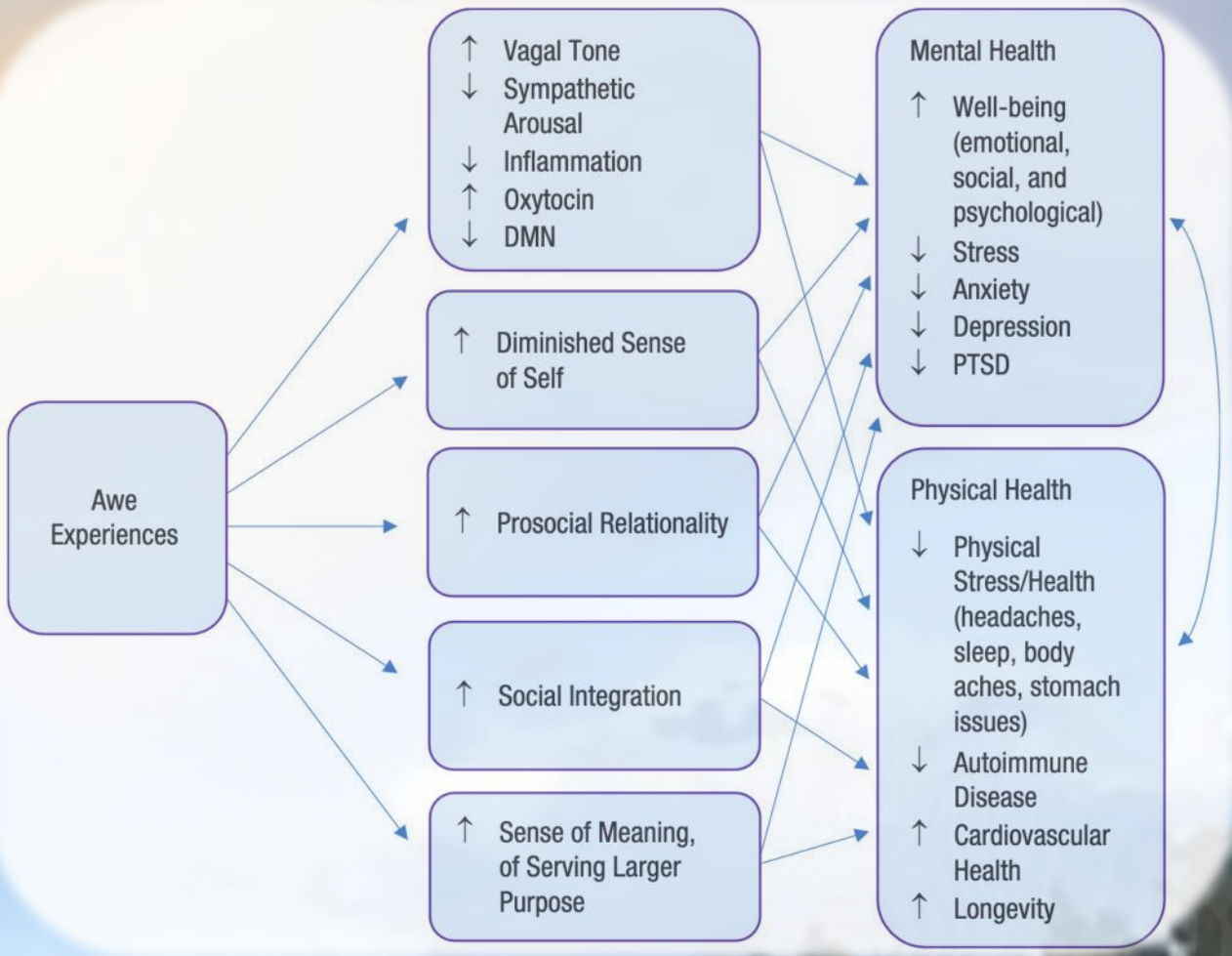
Sullivan, 2018

- Pilates uses many similar approaches

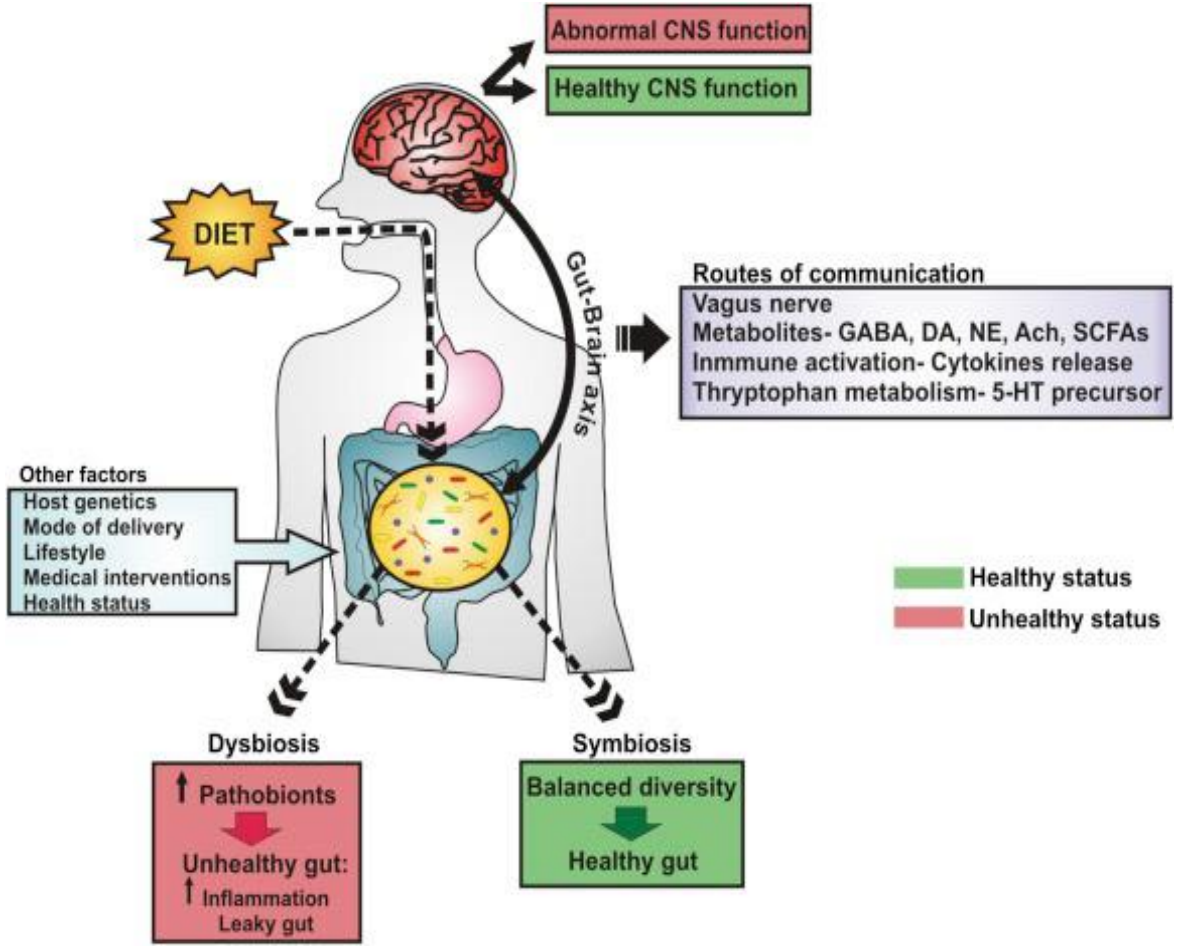
Psychological Approaches

- Listening to Mozart's music
- Positive emotions, 'loving-kindness' meditation, forgiveness
- Exposure to nature
- Experiencing positive awe
- Spirituality

(Monroy, 2023)



Role of Diet in VN Function



- Our diet influences our gut microbiome
- Gut microbiome communicates with the brain via the VN and circulating metabolites
- Diet influences brain function, and can lead to neuroinflammation and pain
- VN activation can decrease gut inflammation and leakiness

(Oriach, 2016; Bonaz, 2018)

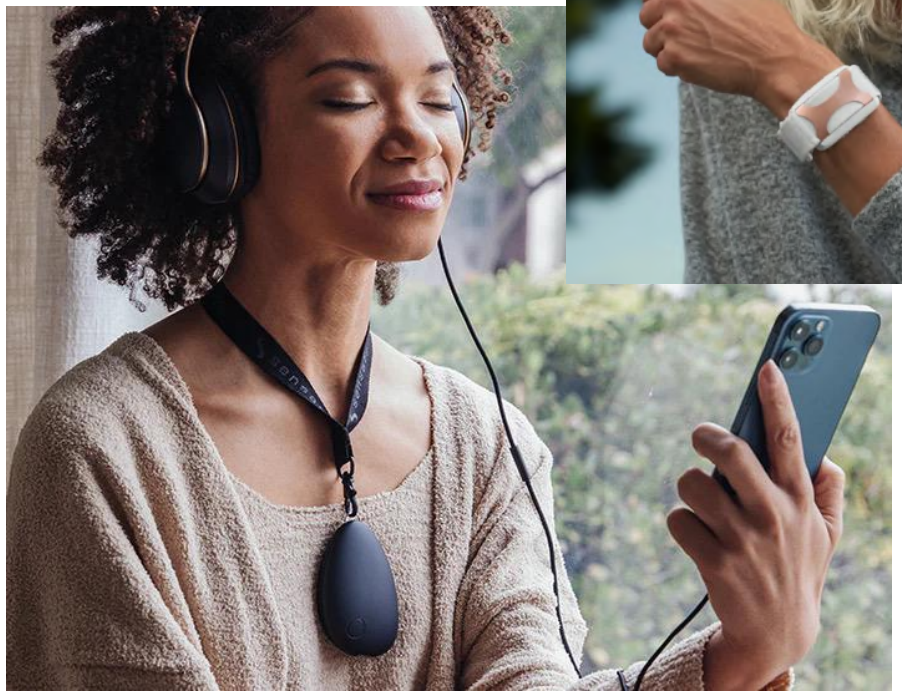
Other “Low Tech” Approaches

These ‘low tech’ approaches have little or no research support, but are likely harmless to try

- Specific VN mobility exercises
  - Zebras should be cautious about neck rotation
- Relaxation with salivation, think of sucking on a lemon
- Sleeping on R side

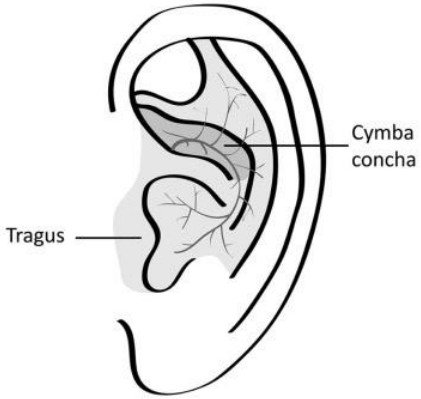
https://sass.uottawa.ca/sites/sass.uottawa.ca/files/how_to_stimulate_your_vagus_nerve_for_better_mental_health_1.pdf

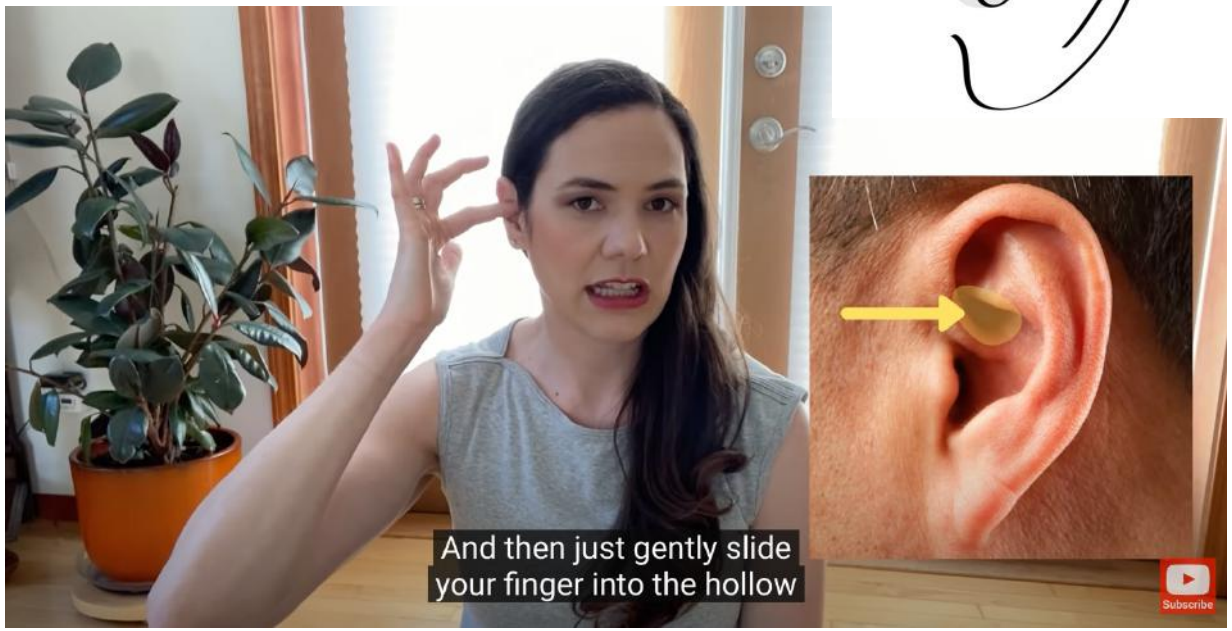
Vibration



- Research is limited for vibration
- Sensate™:
  - https://www.getsensate.com/pages/meet-sensate
- Apollo Neuro™ :
  - https://apolloneuro.com
- These companies report research supporting benefits of improved HRV, sleep, relaxation, but not directly relating to VN

Ear Massage





- Research is limited for ear massage
- How we think it works:
  - The vagus nerve supplies sensory nerves to a portion of the ear pinna (flap)
  - Sensory stimulation of this section of skin provides input to the vagus nerve
  - We think that massage can also stimulate the nerve more gently
  - https://youtu.be/LnV3Q2xIb1U

Listening to Special/Filtered Sounds

- How we think it works:
  - Activates VN through the hearing system, which is sensitive to sounds of threat and danger
  - Creators report research evidence, I could not find confirmation
- “Dreampad” pillow
- “Safe and Sound Protocol”
- https://integratedlistening.com/ssp-safe-sound-protocol/

Vagus Nerve “Exercises”

- The Basic Exercise for activating the VN
- Do it lying down (less chance of pulling on your neck/head)
- **Caution if you have unstable shoulders**, or use pillows to support elbows/shoulders
- YouTube video:
  - https://youtu.be/-cbC2Tto2UM
- **Caution if you have cervical instability:** some exercises (e.g., lizard or salamander)
- Exercises proposed by Stanly Rosenberg, PT (2017)

Summary

- The VN is important for function in many ways
  - Controlling the ‘rest and digest’ organs
  - Managing inflammation, pain, recovery from exercise
  - Communicating from our gut to our brain: “gut feelings”
  - It may also contribute to ‘freeze’ states in trauma, depression, etc.
- There are many ways to improve VN function
  - Low tech: e.g., slow diaphragmatic breathing, chanting, biofeedback, etc.
  - Vagus nerve electrical stimulation (VNS) not widely available, but research and technology changing very fast
- We may be able to ‘hack’ our VN function to improve health

Caution!

- The VN is definitely important
- But much of what you read about the VN on the internet or in popular books might not be correct
- Many approaches may be harmless to try, but be cautious

Resources

- Natural Techniques handout: https://hypnosistrainingacademy.com/what-does-the-vagus-nerve-do/

Books:

- Stanly Rosenberg: *Accessing the Healing Power of the Vagus Nerve: Self-Help Exercises for Anxiety, Depression, Trauma, and Autism* (2017)
- Stephen Porges: *Polyvagal Safety: Attachment, Communication, Self-Regulation* (2021)
- Stephen Porges: *The Pocket Guide to The Polyvagal Theory* (2017)

Web Resources

- Porges brief interview: https://youtu.be/ec3AUMDjtKQ
- Longer and simpler explanation: https://youtu.be/OeokFxnhGQo
- Web site with Polyvagal Theory resources: https://integratedlistening.com/science-of-feeling-safe/
- Good overview of self-care strategies: https://sass.uottawa.ca/sites/sass.uottawa.ca/files/how_to_stimulate_your_vagus_nerve_for_better_mental_health_1.pdf
- YouTube ear self-massage: https://youtu.be/LnV3Q2xIb1U
- ”The Basic Exercise” by Rosenberg: https://youtu.be/-cbC2Tto2UM
- Additional exercises (require neck movement, so do not do if you have neck instability): https://youtu.be/L1HCG3BGK8I
- https://www.rewiretherapy.net/vtp-240-official (looks good, but costs $ and I haven’t tried it)
- Andre C. Proper Breathing Brings Better Health. Scientific American. Jan, 2019. Available at: https://www.scientificamerican.com/article/proper-breathing-brings-better-health/ (popular science article)
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Thank You!

Questions?