Self -Regulation: Chiropractic and Vagal Tone

Roadmap

- regulation and Cardiac Vagal Tone, some definitions
- understanding the influence of the Parasympathetic and Sympathetic Nervous Systems on the heart
- the functional overlap between Vagal regulation of the heart and Vagal innervation of musculature involved in sucking, swallowing and breathing
- models linking Vagal Tone to regulatory capacities
- influencing Vagal Tone: Chiropractic and manual therapy studies, behavioural strategies
- Heart Rate Variability (HRV): Indexing Vagal Tone
- the Vagal Brake….allowing our mind/bodies to engage, disengage and re-engage to challenges
- what does it mean for us in clinical practice? And for our personal flourishing?

Vagal Tone and Self-Regulation

The Dunedin Study

A Gradient of Childhood Self-Control Predicts Health, Wealth and Public Safety.

Self Regulation

'Self-regulation is the ability to manage your emotions and behavior in accordance with the demands of the situation. It includes being able to resist highly emotional reactions to upsetting stimuli, to calm yourself down when you get upset, to adjust to a change in expectations and to handle frustration without an outburst. It is a set of skills that enables children, as they mature, to direct their own behavior towards a goal, despite the unpredictability of the world and our own feelings.'

https://childmind.org/article/can-help-kids-self-regulation/

Cardiac Vagal Tone

- also referred to as 'vagal tone', 'vagal activity' or 'parasympathetic activity'
- reflects the activity of the Vagus nerve regulating cardiac functioning (Vagus nerve has an *inhibitory* influence on the sino-atrial node of the heart.)
- the parasympathetic influence on the heart via the Vagus can be non-invasively measured by Heart Rate Variability. Cardiac Vagal control is reflected in several specific parameters of HRV.
- has been positively associated with a broad range of regulatory functions including:
  - regulation of visceral function
  - regulation of feeding/ingestive behaviours
  - immunomodulatory properties
  - emotional regulation
  - attention and other parameters of cognition
  - social regulation

Factors Influencing Vagal Tone

- **Stable biological factors** eg age, gender, ethnicity, genetics
- **Transient biological characteristics** eg weight loss, circadian rhythms, body position, hormones, breathing
- **Behavioural strategies** eg nutrition, exercise, water immersion, body temperature reduction, sleeping habits, relaxation methods, cognitive methods, praying, media entertainment, music
- **Social environment** eg contact with humans and animals
- **Physical environment** eg aromas, lights sounds, temperature, electromagnetic fields, outdoor environment, altitude
- **Somatic Interventions and stimulation methods** eg Vagus Nerve Stimulation, pharmacologic factors

Laborde S, Mosely E, Mertgen A . A unifying conceptual framework of factors associated to cardiac vagal control. Heliyon. Vol 4, Issue 12, Dec 2018

Diet, Exercise and Stress Reduction and Cardiac Vagal Tone

Diet:

- "People can easily influence cardiac vagal control (CVC) when taking care of their diet"
- Certain foods contribute to increasing CVC: eg pistachio nuts, soy oil, yoghurt enriched with bioactive components, leafy green vegetables, fatty fish
- CVC recovery after a stressful event can be increased by chocolate enriched with gamma-aminobutyric acid
- high alcohol consumption reduces CVC, moderate alcohol consumption can enhance CVC
- omega three supplementation, DHA-rich fish oil, Vitamin B12, magnesium increase CVC
- vegetarians were found to have higher CVC
- acute fasting (representing a stressor) lowers CVC, whilst long term caloric restriction increases CVC

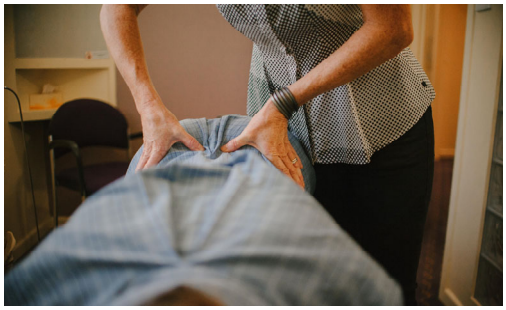
Exercise:

- CVC drops *during* exercise and then after a certain time begins to rise again - this action of vagal reactivation illustrates the health of the vagal system
- moderate aerobic training increases CVC - athletes and physically active individuals display higher resting CVC
- exercising in the natural environment increases CVC

Stress Reduction

- cognitive reappraisal and cognitive behavioural therapy positively influence CVC,
- acupuncture, hypnosis, left nostril breathing, massage, meditation, mindfulness training, reiki, slow paced breathing, and yoga increase CVC
- lavender oil, cedrol oil, Yasmin tea enhance CVC
- owning a pet, going for a walk with a dog, patting and talking to a dog all increase CVC

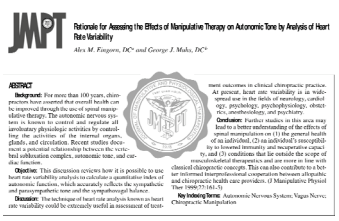
Laborde S, Mosely E, Mertgen A . A unifying conceptual framework of factors associated to cardiac vagal control. Heliyon. Vol 4, Issue 12, Dec 2018.



Chiropractic Care and Vagal Tone

Why measure HRV?

- general health of an individual
- an individual's susceptibility to lowered immunity and recuperative capacity
- conditions that lie outside the scope of musculoskeletal therapeutics



JMPT

Rationale for Assessing the Effects of Manipulative Therapy on Autonomic Tone by Analysis of Heart Rate Variability

Alex M. Eingorn, DC and George J. Muhs, DC**

ABSTRACT

Background: For more than 100 years, chiropractors have asserted that overall health can be improved through the use of spinal manipulative therapy. The autonomic nervous system is known to control and regulate all involuntary physiologic activities by controlling the activities of the internal organs, glands, and circulation. Recent studies document a potential relationship between the vertebral subluxation complex, autonomic tone, and cardiac function.

Objective: This discussion reviews how it is possible to use heart rate variability analysis to calculate a quantitative index of autonomic function, which accurately reflects the sympathetic and parasympathetic tone and the sympathovagal balance.

Discussion: The technique of heart rate analysis known as heart rate variability could be extremely useful in assessment of treatment outcomes in clinical chiropractic practice. At present, heart rate variability is in widespread use in the fields of neurology, cardiology, psychology, psychophysiology, obstetrics, anesthesiology, and psychiatry.

Conclusion: Further studies in this area may lead to a better understanding of the effects of spinal manipulation on (1) the general health of an individual, (2) an individual's susceptibility to lowered immunity and recuperative capacity, and (3) conditions that lie outside the scope of musculoskeletal therapeutics and are more in line with classical chiropractic concepts. This can also contribute to a better informed interprofessional cooperation between allopathic and chiropractic health care providers. (J Manipulative Physiol Ther 1999;57:161-3)

Key Indexing Terms: Autonomic Nervous System; Vagus Nerve; Chiropractic Manipulation

Eingorn AM, Muhs GJ. Journal of Manipulative and Physiological Therapeutics Volume 22 • Number 3 • March/April 1999

In a Nutshell

- in manual therapy literature autonomically mediated responses following spinal manipulative therapy (SMT) have been well established
- a variety of outcome measures have been used to determine autonomic activity after manipulation, including skin blood flow indexes, blood pressure changes, pupillary light reflex and heart rate variability (HRV)
- there is strong evidence that HRV is a good marker of autonomic activity. Different studies cite changes in different HRV parameters.
- the literature suggests that changes in autonomic modulation as a result of SMT may depend on the segment mobilised/manipulated. Cervical manipulation is associated with increased parasympathetic responses (vestibular mechanisms need also to be considered here). Thoracic manipulation is associated with increased sympathetic activity. Lumbosacral manipulation would seem to effect the parasympathetic nervous system. Cranial techniques tend to stimulate a parasympathetic response.
- relaxation promoted by myofascial techniques facilitates the parasympathetic response
- observed modulation of HRV following SMT in some studies may depend on whether the patient is pain-free, perhaps reflecting the interactions between the Autonomic Nervous System and Nociceptive system on multiple levels - brainstem, forebrain, peripheral, dorsal horn.

Borges B, Bortolazzo G, Netto H. Effects of spinal manipulation and myofascial techniques on heart rate variability: a systematic review. Journal of Bodywork and Movement Therapies. 22 (2018) 203-208.

Stimulating the Vagus Naturally….

- slow breathing exercises
- chanting
- music therapy
- listening to Mozart's music
- positive emotions and social connections
- mindfulness practice
- practising forgiveness
- aerobic exercise
- stretching
- resistance training
- yoga
- omega 3 fatty acids
- probiotics
- fasting
- massage
- cold water facial immersion
- gag reflex
- sleeping on the right side

Yuen A, Sander J. Can natural ways to stimulate the Vagus nerve improve seizure control? Epilepsy and Behaviour. 67 (2017) pp105-110.

Modulating Vagal Tone through Electrical Stimulation

- the large number of Vagal afferents has led to it being investigated as a therapeutic pathway for influencing brain activity via electrical stimulation - this stimulation may be performed along different sites in the Vagus pathway with varying levels of invasiveness
- human studies have observed effects in epilepsy, depression, pain - (especially cluster headache and migraine) following electrical stimulation of the Vagus.
- central projections of the Auricular Branch of the Vagus (ABVN) include to: the Nucleus of the Solitary Tract, the Spinal Trigeminal Nucleus, Dorsal Raphe, Locus Coeruleus, the Parabrachial Nucleus, Amygdala and Nucleus Accumbens.

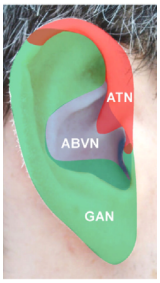


Fig 1. ABVN -Auricular branch of the Vagus
ATN - Auriculotemporal nerve
GAN - Great Auricular nerve

Murray AR, Atkinson L, Mahadi MK, Deuchars SA, Deuchars J. The strange case of the ear and the heart: the Auricular Vagus Nerve and its influence on cardiac control. Autonomic Neuroscience: Basic and Clinical 199(2016) 48-53.

Neurovisceral Integration Model: Brain-Body Connection and the Vagus

Brain structures associated with control of heart rate: 'The Central Autonomic Network'

Solid black arrows indicate efferent pathways to the heart, including right vagus nerve (PNS) and stellate ganglion (SNS) inputs to the SA node. Dotted gray arrows indicate afferent pathways to medullary structures via aortic baroreceptor signals carried through the vagus. Dashed black arrows indicate bidirectional connections.

Structures within the Central Autonomic Network include:

AMB, nucleus ambiguus; **BF,** basal forebrain; **BLA,** baso-lateral amygdala; **CeA,** central nucleus of the amygdala; **CVLM,** caudal ventrolateral medullary neurons; **DVMN,** dorsal vagal motor nuclei; **Hyp**, hypothalamus (lateral and paraventricular); **IML,** intermediolateral cell column of the spinal cord; **LC,** locus coeruleus; **NTS,** nucleus of the solitary tract; **PAG,** periaqueductal gray; **PBN**, parabrachial nucluei; **PFC,** prefrontal cortex; **PGi,** nucleus paragigantocellularis; **RVLM,** rostral ventrolateral medullary neurons

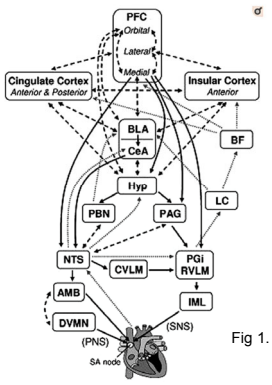


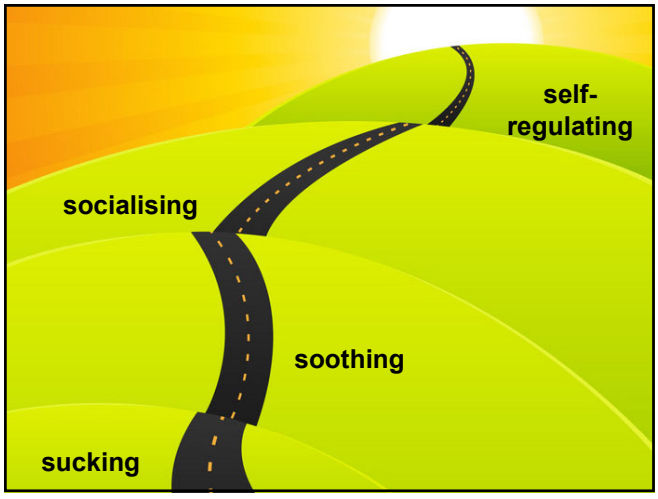
Fig 1.

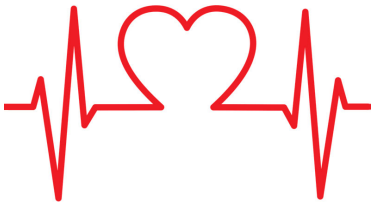
Park G, Thayer J. From the heart to the mind: cardiac vagal tone modulates top-down and bottom-up visual perception and attention to emotional stimuli . Front. Psychol. 2014; 5: 248.

Neonatal Cardiac Vagal Tone influences the development of other regulatory systems.

- cardiac vagal tone, measured by heart rate variability, is a brainstem-controlled pacemaker that supports other regulatory functions
- the contribution of cardiac vagal tone from the third trimester of pregnancy to the development of emotional, attentional and cognitive regulation marks the vagal system as an important foundation for the child's later capacity to manage stress, orient, focus attention and flexibly adapt to the environment

Feldman R, The development of regulatory functions from birth to 5 years: insights from premature infants. Child Devel





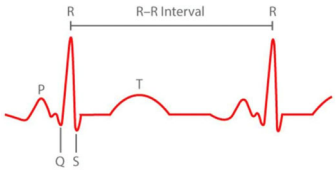
Heart Rate Variability

HRV:
An index of mental and physical wellbeing

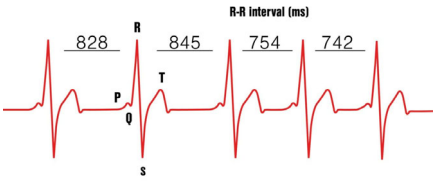
- a useful non invasive tool
- high HRV associated with better glucose regulation, better HPA axis function, reduced inflammation, reduced risk for stroke, cardiovascular disease…and all cause mortality
- associated with greater levels of emotional regulation, greater performances of cognitive tasks involving attention, working memory and inhibitory control
- low HRV is associated with affective disorders including depression and anxiety.

Smith R, Thayer J, Khalsa S, Lane R. The hierarchical basis of neurovisceral integration. Neuroscience and Biobehavioural Reviews. Vol 75. April 2017. pp 274-296

What is Heart Rate Variability?



A Healthy Heart is Not a Metronome



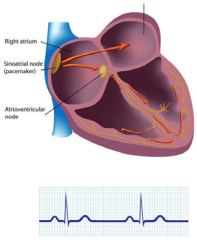
Influences on the Heart

- Parasympathetic Nervous System
- Sympathetic Nervous System
- Circadian rhythms, hormones, core temperature, thoracic anatomy, flow dynamics.

Shaffer F, Mc Craty R, Zen C. A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. Frontiers in Psychology. Sept 2014. Vol 5. Article 1040: 1-19.

Parasympathetic and Sympathetic Systems Influence the Heart on Different Time Scales

- at rest the Parasympathetic and Sympathetic Nervous systems tonically influence the heart. The Vagal (Parasympathetic) effects are dominant. This results in an average heart rate of around 75 beats per minute.
- the Parasympathetic and Sympathetic Systems operate on different timescales: Vagal stimulation to the heart acts very quickly on the Sinoatrial pacemaker to **slow** the heart, whereas the heart's response to Sympathetic stimulation (to speed the heart) is much less immediate.
- the Vagal Brake: engaging, dis-engaging, re-engaging to challenge



Shaffer F, Mc Craty R, Zerr C. A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. Frontiers in Psychology. Sept 2014. Vol 5. Article 1040: 1-19.

Vagal tone is reflected in several HRV parameters

Consider:

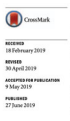
- for *the **time domain***, the root mean square of successive differences between adjacent normal RR intervals (RMSSD), and the percentage of successive normal RR intervals differing more than 50 milliseconds (pNN50)
- for the ***frequency domain,*** high frequency (HF) reflects cardiac vagal control

Laborde S, Mosley E, Mertgen A. Vagal Tank Theory: the three Rs of cardiac Vagal control functioning - resting, reactivity and recovery. Front Neurosci. 2018 July, 12:458

Respiratory Sinus Arrhythmia (RSA): the variation in the heart rate due to breathing

- the main source of variability within the heart beat
- Vagal cardioinhibitory fibres fire with a breathing pattern called Respiratory Sinus Arrhythmia
- during *inhalation*, vagal tone *reduces*
- during *exhalation,* vagal tone *increases*
- RSA may enhance the efficiency of pulmonary gas exchange
- reflects activity of myelinated Vagal fibres

Journal of Breath Research



PAPER

The brain's resonance with breathing—decelerated breathing synchronizes heart rate and slow cortical potentials

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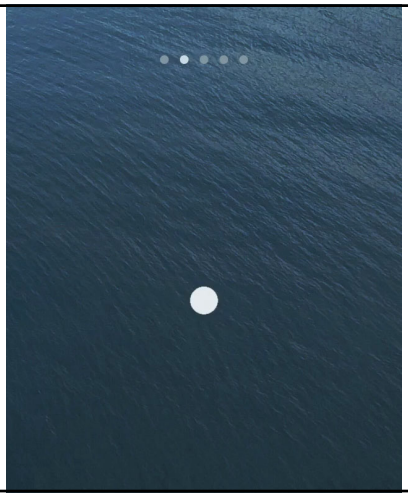
Keywords: paced breathing, slow cortical potentials, heart rate variability

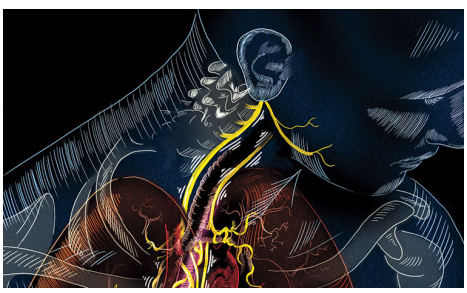
Abstract
Numerous methods for enhancing consciousness and well-being emphasize the role of breathing. For the first time, we have investigated the link between body rhythms and slow cortical brain dynamics during paced breathing. We present physiological data from 37 participants who performed paced breathing sessions with respiration rates (RRs) from 6 to 14 s/cycle (with 7 min for each task). Measures of respiration, heart rate variability (HRV) and 64-channel electroencephalogram (EEG) as well as subjective ratings were recorded and compared with each other. Both the respiratory sinus arrhythmia of the HRV and the slow cortical potentials (SCPs) of the EEG correlated with the respiration cycle. The highest correlations were observed at a RR of 10 s/cycle for the SCPs. A strong positive voltage deflection during inhalation is followed by a negative variation during exhalation. This decelerated breathing rhythm matches the frequency of baroreceptor sensitivity, leading to synchronization between breathing, HRV, baroreceptors and the brain. Subjectively, participants rated this RR as the most relaxing one. This study demonstrates the importance of the effect of speed of breathing on brain dynamics, which might help in understanding the role of breathing in mental health.

Paced decelerated breathing at the ‘resonance frequency’ increases Vagal Tone

- breathing at 6 breaths per minute (0.1Hz) - ‘the resonance frequency’ or ‘cardiac coherence’ maximises Heart Rate Variability
- resonance frequency breathing synchronizes multiple physiological systems
- paced breathing has a modulatory effect on the cardiovascular system (other studies suggest this occurs is through activating and strengthening the baro-reflex)
- decelerated breathing at 6 breaths per minute strongly influences brain dynamics (slow cortical potentials)
- subjectively, this pace is described by research participants as ‘most calming’

Hinterberger T, Walter N, Doliwa C, Loew T. The brain’s resonance with breathing - decelerated breathing synchronizes heart rate and slow cortical potentials. J. Breath Res 13(2019)





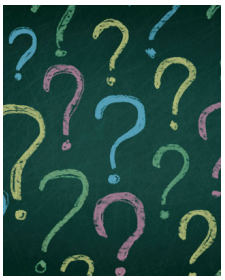
Polyvagal Theory

Stephen Porges

Professor of Psychiatry
Behavioural Neuroscientist
Researcher

The Vagal Paradox

- Porges's early research showed high vagal tone (measured by Heart Rate Variability) in neonates was a sensitive index for good health outcomes
- High vagal tone in neonates had previously been associated with poor outcomes, including bradycardia

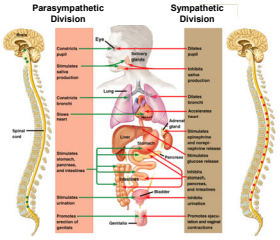


Tenets of Polyvagal Theory

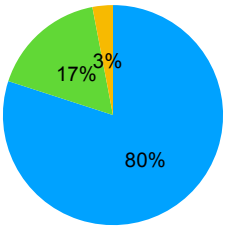
- the Vagus is part of a larger integrative system that relies on vast interoceptive information (gut feel)
- the Autonomic Nervous System in mammals evolved to support complex social and emotional behaviours
- a myelinated Vagus nerve originating from the Nucleus Ambiguus evolved to regulate the heart
- the Vagus acts like a 'brake' on the heart - this braking action is reflected by increases in measures of cardiac vagal tone
- this myelinated Vagus displays a respiratory rhythm (Respiratory Sinus Arrhythmia)
- the myelinated Vagus is neurophysiologically linked to the facial muscles involved in expressivity and receptivity

Revisiting the Autonomic Nervous System

- the Autonomic Nervous System responds to internal needs and external challenges in the environment
- the traditional view conceptualises a model based on 'paired antagonism' between parasympathetic and sympathetic divisions
- it is a bidirectional system receiving vast amounts of afferent information



Vagus Nerve Composition

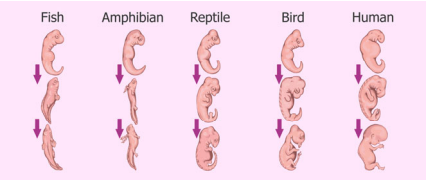


- Vagal Afferents (sensory somatic and visceral fibres)
- Unmyelinated Vagal Efferents (motor fibres)
- Myelinated Vagal Efferents (motor fibres)

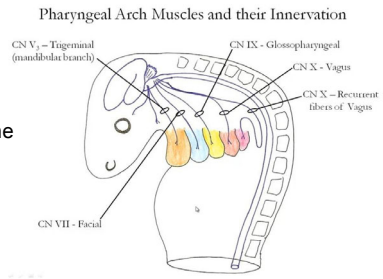
Regulating Fuel Supply

Sensory Information → **Behaviour**

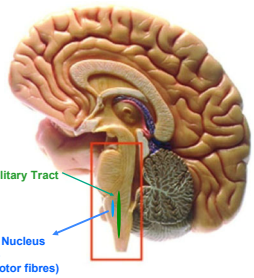
In mammals the muscles that control facial expression, sucking, swallowing, breathing, listening and vocalisation emerge from the embryological branchial arches (pharyngeal arches). They are innervated by a group of cranial nerves
(V, VII, IX, X and XI) called
Special Visceral Efferents.



Autonomic support for muscles derived from the primitive gill arches is regulated by the myelinated Vagus.

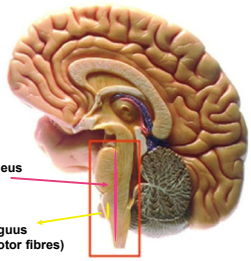


Older Unmyelinated Parasympathetic Circuit



*regulation of sub-diaphragmatic organs in mammals

New Mammalian Myelinated Parasympathetic Circuit



*regulation of supra-diaphragmatic organs in mammals

Hierarchical Model of Autonomic Nervous System Control

In safe and prosocial environments the activity in the older circuits is regulated by the newer myelinated vagus.

Myelinated Vagus
(Supradiaphragmatic Organs in mammals)
Prosocial, Calm
Contexts
Social Engagement
behaviours

↓

Sympathetic Nervous System
Dangerous Situations
Mobilisation behaviours
Fight/Flight

↓

Unmyelinated Vagus
(Subdiaphragmatic Organs in mammals)
Severe threat
Shutdown behaviours
Freeze, syncope, 'blending in'
dissociation

The Social Engagement System

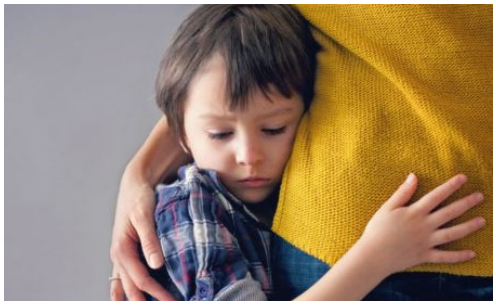
Cranial Nerves V, VII, IX, X, XI and the Vagal Brake.
A Unique Face-Voice-Heart Connection

Face-Voice-Heart Connections

- Mammal evolution coincides with a separation of vagal pathways. The newer myelinated vagal pathway shifted ventrally to the Nucleus Ambiguus, away from the phylogenetically older and unmyelinated vagal fibres in the Dorsal Motor Nucleus
- The newer pathway resulted in an anatomical and neurophysiological linkage between the neural regulation of the heart via the myelinated vagus and the special visceral efferent (cranial nerve) pathways that regulate the striated muscles of the face head and neck. This linkage between brainstem motor systems that are responsible for cardiovascular functions and those regulating the function of the head, face and neck form an integrated "Social Engagement System"
- The Social Engagement System includes the muscles of facial expression, the middle ear muscles (eg extracting human voice from background sounds), muscles of mastication (chewing, sucking), laryngeal and pharyngeal muscles (vocalising, swallowing, breathing) and muscles for head turning and tilting (social gesturing and orientation)
- The face-voice-heart connection provided us with an ability to convey physiological state via facial expression and intonation of voice

All Ears

As vertebrates evolved from reptiles to mammals, the structures at the end of the mandible that define the middle ear bones became detached….



Safety and Physiological State

Understanding Neuroception

Feeling Safe

- connecting is a biological imperative - when the Social Engagement System is stimulated, the individual responds both behaviourally and physiologically
- requires a unique set of cues to the nervous system that are not equivalent to physical safety or the removal of threat - safety is not merely about removing danger, but the active presentation of certain features that our nervous system craves
- when the environment is perceived as stable and safe the vagal brake slows the heart facilitating general attention to the environment, relaxation and social engagement behaviours.
- safe states are prerequisite for optimal social behaviour…and for accessing higher brain areas allowing for creativity and generative behaviour

Porges S. Making the world safe for our children: down regulating defence and up-regulating social engagement to 'optimize' the human experience. Children Australia. 2015 .Vol 40. No 2 pp 114-123.

Adverse Childhood Experiences (ACEs) change the threshold for 'feeling safe'

- Physical abuse
- Sexual abuse
- Emotional abuse
- Physical neglect
- Emotional neglect
- Exposure to domestic violence
- Household substance abuse
- Household mental illness
- Parental separation or divorce
- Incarcerated household member

Increasing Vagal Tone Everyday in Practice

- chiropractic adjustments/manual therapy and other interventions
- behavioural strategies/environmental considerations and caregiving practices
- optimising the Social Engagement System