THE AUTONOMIC NERVOUS SYSTEM AND PAIN – WHAT'S THE LINK?

HOW MANY SENSES DO WE HAVE?

HOW MANY SENSES DO WE HAVE?

- The big 5 – vision, hearing, smell, taste and touch

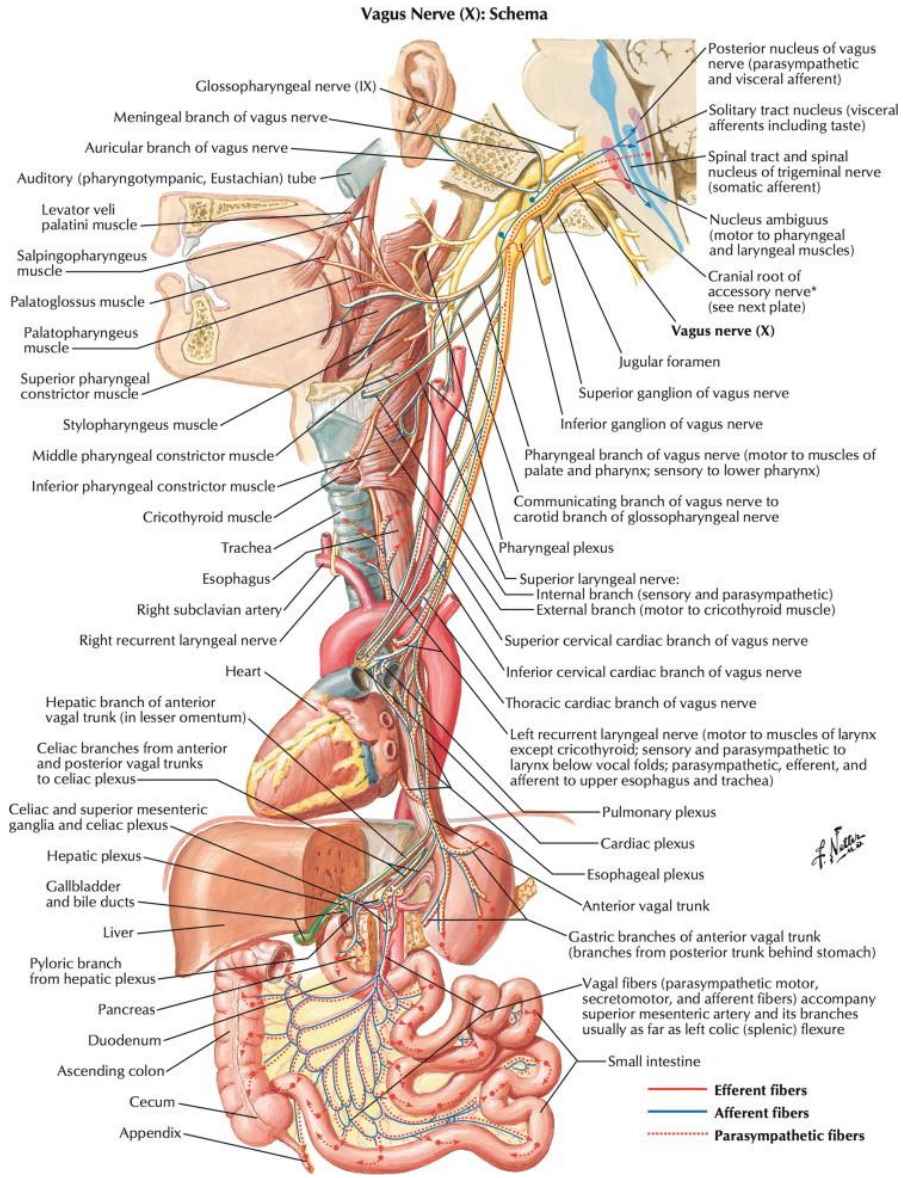
HOW MANY SENSES DO WE HAVE?

- The big 5 – vision, hearing, smell, taste and touch
- INTEROCEPTION
- Balance
- Movement
- Pressure
- Breathing
- Fatigue
- Pain
- Itch
- Temperature
- Appetite
- Expulsion

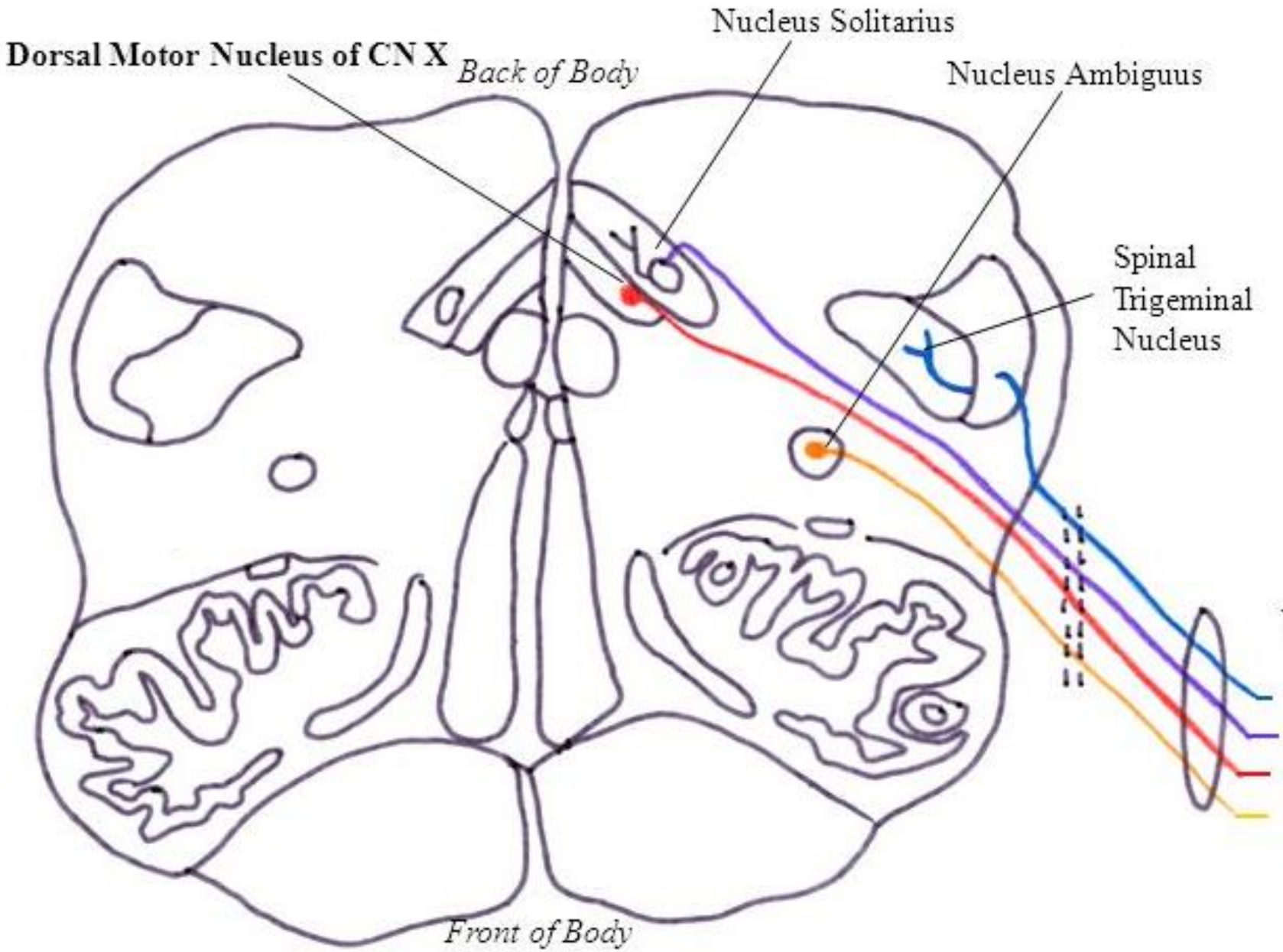
THE VAGUS AND THE POLYVAGAL THEORY

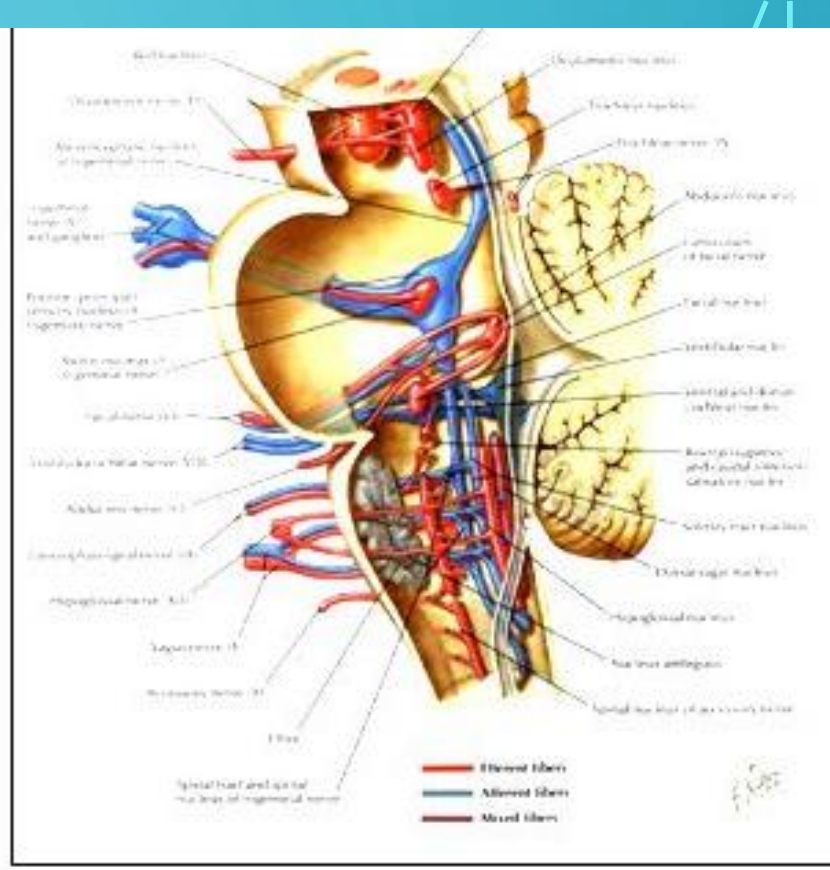
THE VAGUS OR WANDERING NERVE

- Vagabond
- Vague



Vagus Nerve Nuclei Diagram





VAGUS NERVE

- Skin, External Ear
- Viscera, abdomen & thorax
- Viscera, abdomen & thorax
- *Muscles of pharnyx, larnyx, esophagus*

THE EVOLUTION OF THE VAGAL SYSTEM – THE POLYVAGAL THEORY

- **Immobilization**
- Feigning death, behavioural shutdown.
- The most primitive component, shared with most vertebrates.
- Dependent on the oldest branch of the vagus nerve (an unmyelinated portion originating in an area of the brainstem known as the dorsal motor nucleus of the vagus.

THE SYMPATHETIC NERVOUS SYSTEM

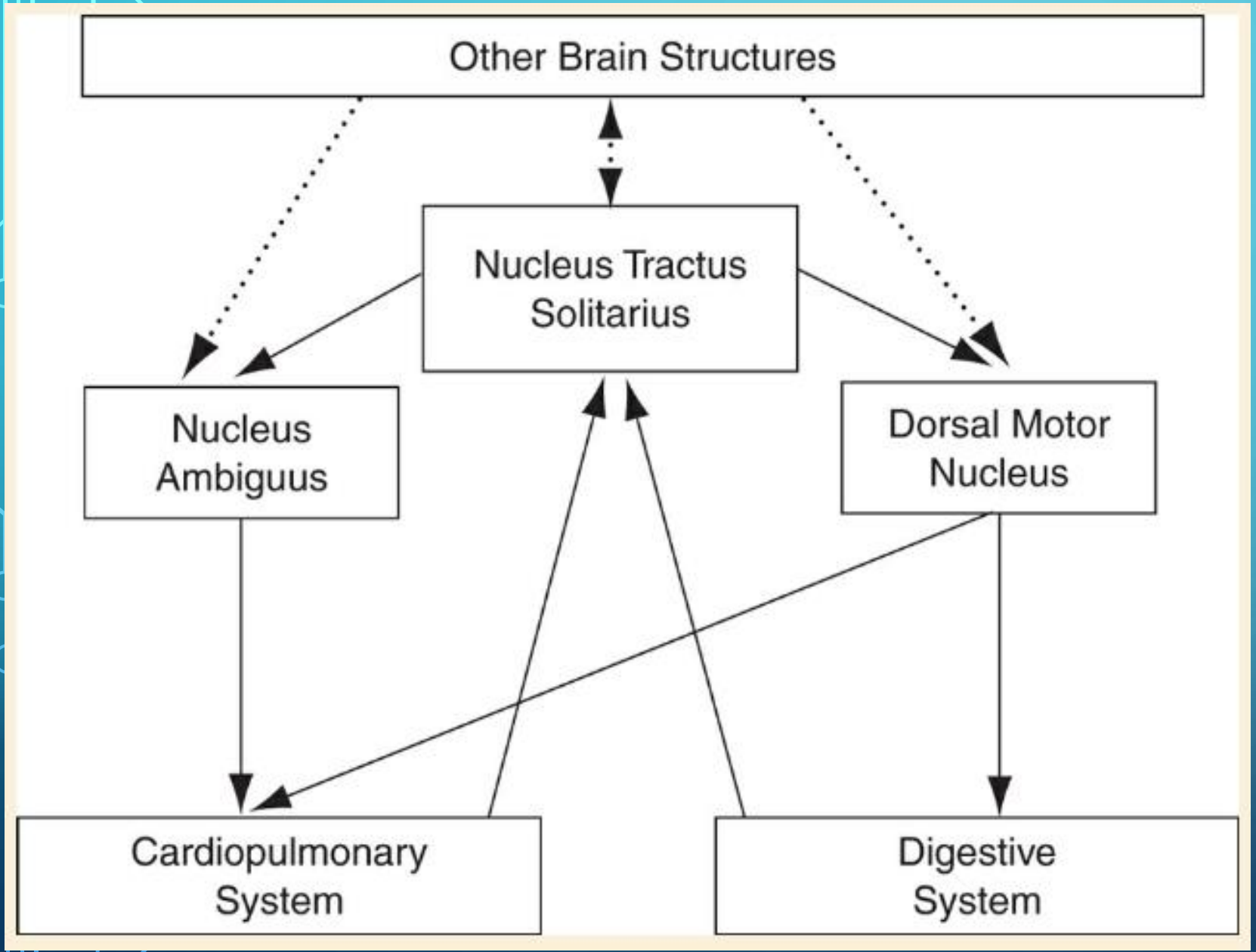
- **Mobilization**
- Fight-or-flight behaviours
- Dependent on the functioning of the sympathetic nervous system, a system associated with increasing metabolic activity and increasing cardiac output (e.g., faster heart rate, greater ability of the heart to contract).

MAMMALIAN EVOLUTION OF THE VAGUS

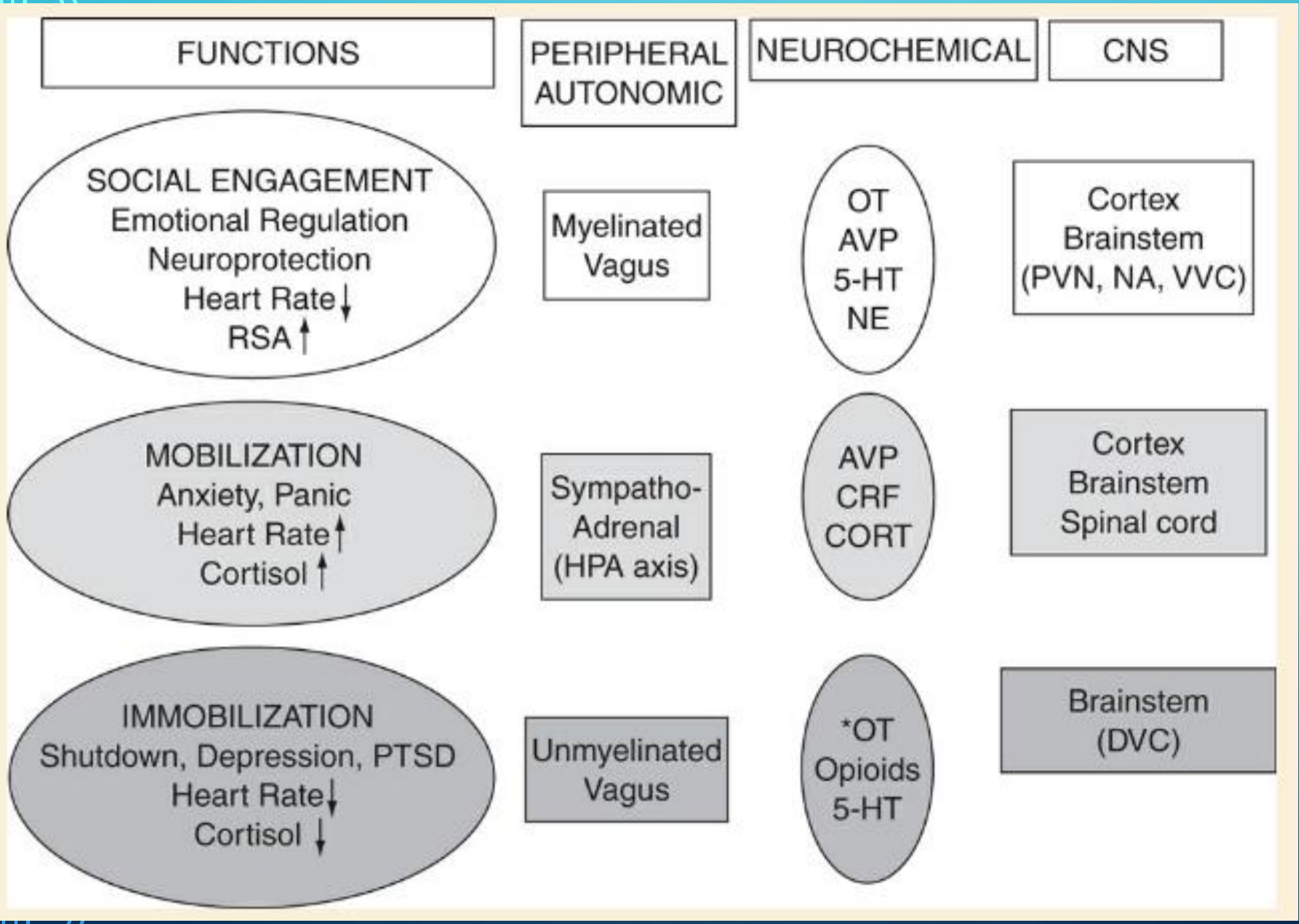
- **Social communication or social engagement**
- Facial expression, vocalization, listening.
- Dependent on the myelinated vagus, which originates in the nucleus ambiguus.
- The myelinated vagus fosters calm behavioural states by inhibiting the influence of the sympathetic nervous system on the heart.

NEUROCEPTION OF SAFETY OR DANGER

- In reptiles, immobilisation and increased vagal tone is default response to danger.
- In mammals this leads to vasovagal response, which can occur in extreme fear or if escape is not possible.
- Sympathetic activation is more adaptive for survival.
- Safety is necessary for prosocial behaviour.



- Brainstem mechanisms providing feedback to cardiopulmonary and digestive systems

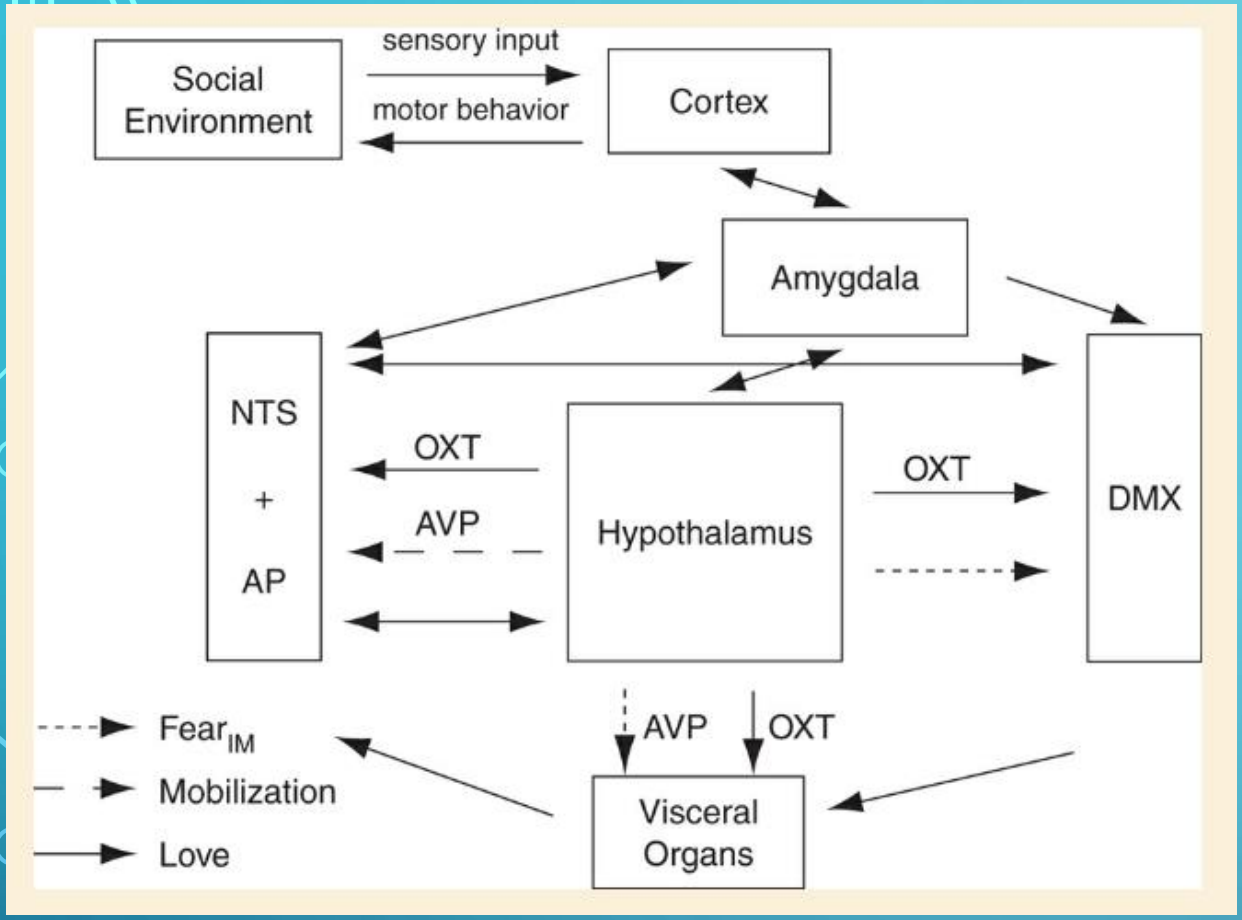

FUNCTIONS
PERIPHERAL AUTONOMIC
NEUROCHEMICAL
CNS
SOCIAL ENGAGEMENT
Emotional Regulation
Neuroprotection
Heart Rate↓
RSA↑
Myelinated Vagus
OT
AVP
5-HT
NE
Cortex
Brainstem
(PVN, NA, VVC)
MOBILIZATION
Anxiety, Panic
Heart Rate↑
Cortisol↑
Sympatho-Adrenal (HPA axis)
AVP
CRF
CORT
Cortex
Brainstem
Spinal cord
IMMOBILIZATION
Shutdown, Depression, PTSD
Heart Rate↓
Cortisol↓
Unmyelinated Vagus
*OT
Opioids
5-HT
Brainstem
(DVC)

SOCIAL ENGAGEMENT

- make eye contact
- vocalize with an appealing inflection and rhythm
- display contingent facial expressions
- modulate the middle-ear muscles to distinguish the human voice from background sounds more efficiently.

VAGAL SUPPRESSION

- the eyelids droop
- the voice loses inflection
- positive facial expressions dwindle
- awareness of the sound of the human voice becomes less acute
- sensitivity to others' social engagement behaviours decreases.



Neural and neuropeptide regulation of the dorsal motor nucleus of the vagus: fear or love?

- Higher brain structures including the amygdala and cortex influence hypothalamic–dorsal vagal complex (DVC) communication.
- The DVC includes sensory nuclei in the nucleus of the solitary tract (NTS) and area postrema (AP) and motor nuclei in the dorsal motor nucleus of the vagus (DMX).
- During perceived danger, when mobilization is adaptive, central vasopressinergic pathways (AVP) communicate between the hypothalamus and both NTS and AP to change the set-point of vagal reflexes to facilitate sympathetic excitation.
- Immobilized fear occurs when fight-or-flight behaviors are not an option. Immobilized fear is fostered by vagal surges from DMX to visceral organs, which are potentiated by systemic AVP.

- Systemic AVP triggers increased DMX output by stimulating visceral afferents via NTS and AP.
- During perceived safety, oxytocin (OXT) is released centrally and systemically to foster an immobilized love response pattern.
- Central OXT limits DMX output to a functional range protecting homeostasis and systemic OXT stimulates visceral organs.
- Small increases in systemic AVP might, either via vagal afferents or direct stimulation of vasopressinergic receptors in AP, trigger central AVP and OXT and promote sexual arousal.

WHAT HAPPENS WHEN NEUROCEPTION OF DANGER IS FAULTY?

- Areas in the temporal cortex that are assumed to inhibit fight, flight, or freeze reactions are not activated in people with autism or schizophrenia, who have difficulty with social engagement.
- In anxiety disorders and depression there's compromised social behaviour; difficulties in regulating heart rate, as reflected in measures of vagal control of the heart and reduced facial expressiveness.
- Maltreated and institutionalized children with reactive attachment disorder tend to be either inhibited (emotionally withdrawn and unresponsive) or uninhibited (indiscriminate in their attachment behaviour
- Both types of behaviour suggest faulty neuroception of the risk in the environment.

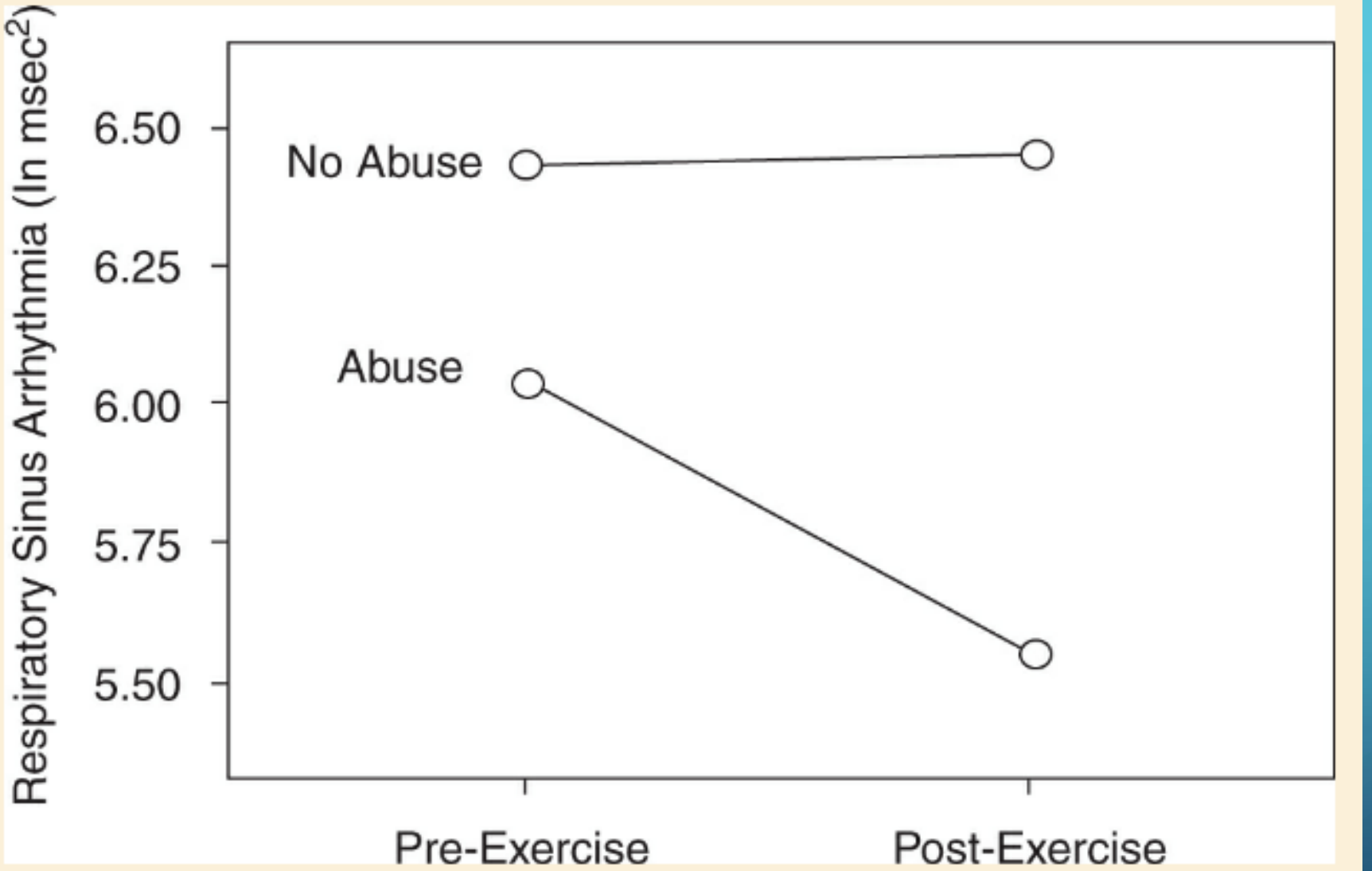
THE VAGUS AND EMOTION

- Vagus innervates branchial arches that have evolved from gill arches.
- Larynx and facial muscles.
- Darwin's study of universal expressions of emotion.

- There are **six universal emotions**!
  - 1. Happiness
  - 2. Surprise
  - 3. Sadness
  - 4. Anger
  - 5. Disgust
  - 6. Fear
- People from all cultures can recognize & understand expressions of these 6 emotions.

VAGAL TONE AND STRESS VULNERABILITY

- Vagal tone from the Nucleus Ambiguus can be measured by RSA
- Preterm neonates have impaired RSA
- Increased RSA associated with more reactivity to environment
- …and ability to self soothe
- The vagal brake allows rapid switching between attachment and disengaging
- Neglect or abuse impact RSA
- Atropine affects ability to maintain attention
- BOTOX can reduce emotional experiences

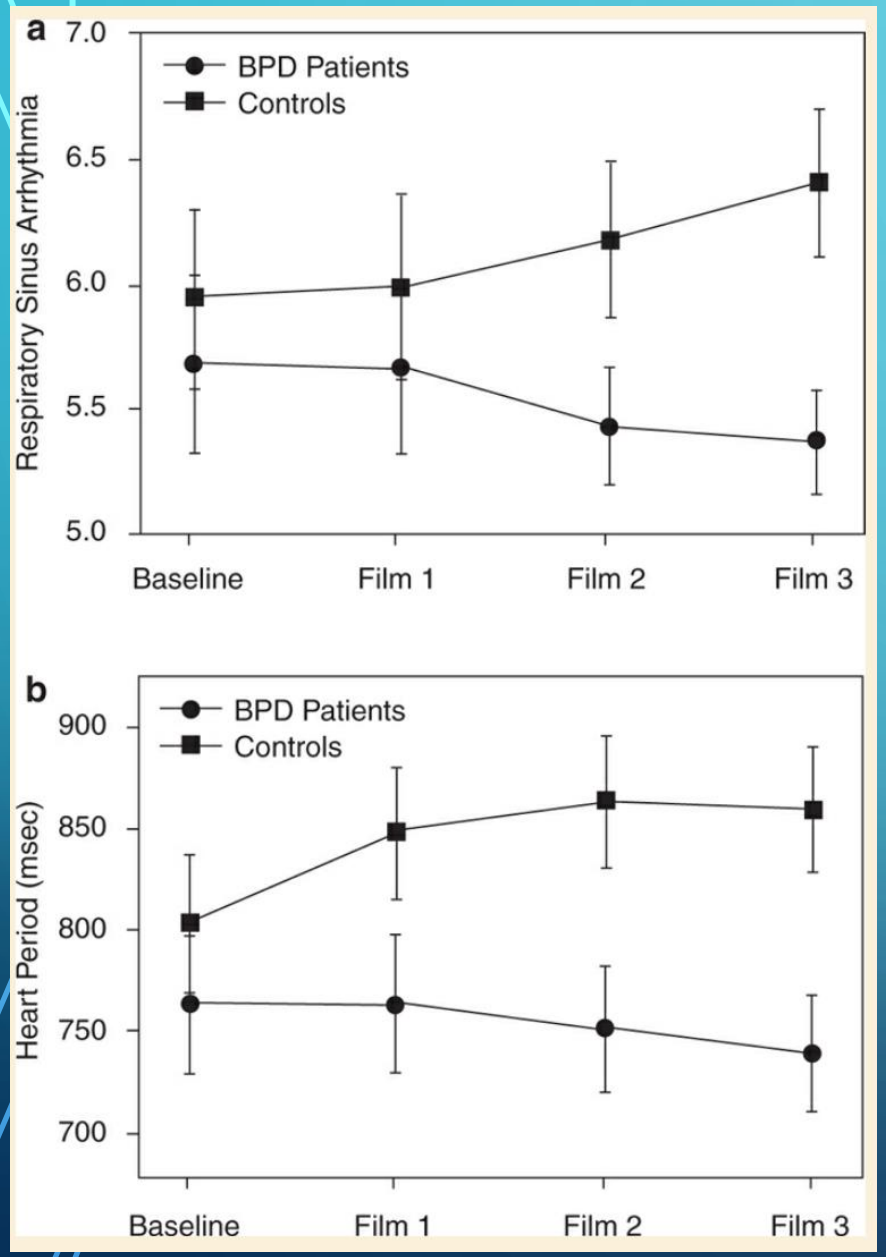


- Heart rate variability reduced with history of abuse.

WHAT IF THE VAGUS IS DYSREGULATED

- May compromise the regulation of visceral organs, such as the gut, heart, and pancreas.
- Involved in the modulation of pain and the regulation of cytokines and the HPA axis.
- The brainstem areas regulating the myelinated vagal system provide both output and input to feedback systems involving other brain structures, leading to difficulty in assessing and experiencing emotions.
- The myelinated vagus may, via direct influence on thymus and direct inhibition of the sympathetic nervous system, trigger a physiologic state that would promote immune function.

BORDERLINE PERSONALITY DISORDER AND EMOTION REGULATION



- Film one – argument mother and child
- Film two – neutral
- Film three – conflict scene father child

GUT FEELINGS

- Neuroception of danger can trigger vagal dysregulation.
- Bidirectional between viscera and emotions and cognition.
- Trauma triggers can cause hypervigilance – sympathetic activation an loss of the vagal brake –
- … or shut down freeze and dissociation.
- Using behaviour to modulate these sensations is helpful …..
- …. But often we make up stories to explain them…

THE LOVE BRIDGE

- Feel forced to stay in uncomfortable state.
- Can feel anger at self.
- A child may act out …
- Wanting and not wanting.
- Comfortable to feel immobilisation without fear.
- I would love to do ……. but my body won't let me.

NOVELTY AND SAFETY

- Difference in response of mammals and reptiles.
- Novelty stimulates communication and moving away from safety of mother.
- Those who are bold have most efficient path back to safety
- Using face to face and vocalisation to keep play safe.
- Developing state regulation.

CHANGES IN VAGAL FUNCTION THAT CAN HELP US FEEL MORE COMFORTABLE

- Prosody
- Ingestion
- Relaxation of facial muscles – especially around the eyes
- Social engagement – muscles in inner ear focus hearing on speech rather than low frequencies – looking out for predators

IMPLICATIONS FOR TREATMENT OF TRAUMA

- PTSD diagnosed by checklist – PCL
- But there are different physiological responses to trauma
- And there is single traumatic event v's repeated trauma and abuse
- Focus on the response rather than the details of the event

WHAT CAN WE DO TO NORMALISE VAGAL FUNCTION?

- Breathing
- Movement
- Rhythmical calming speech or chanting
- Music
- Cold water swimming
- Enhancing safety