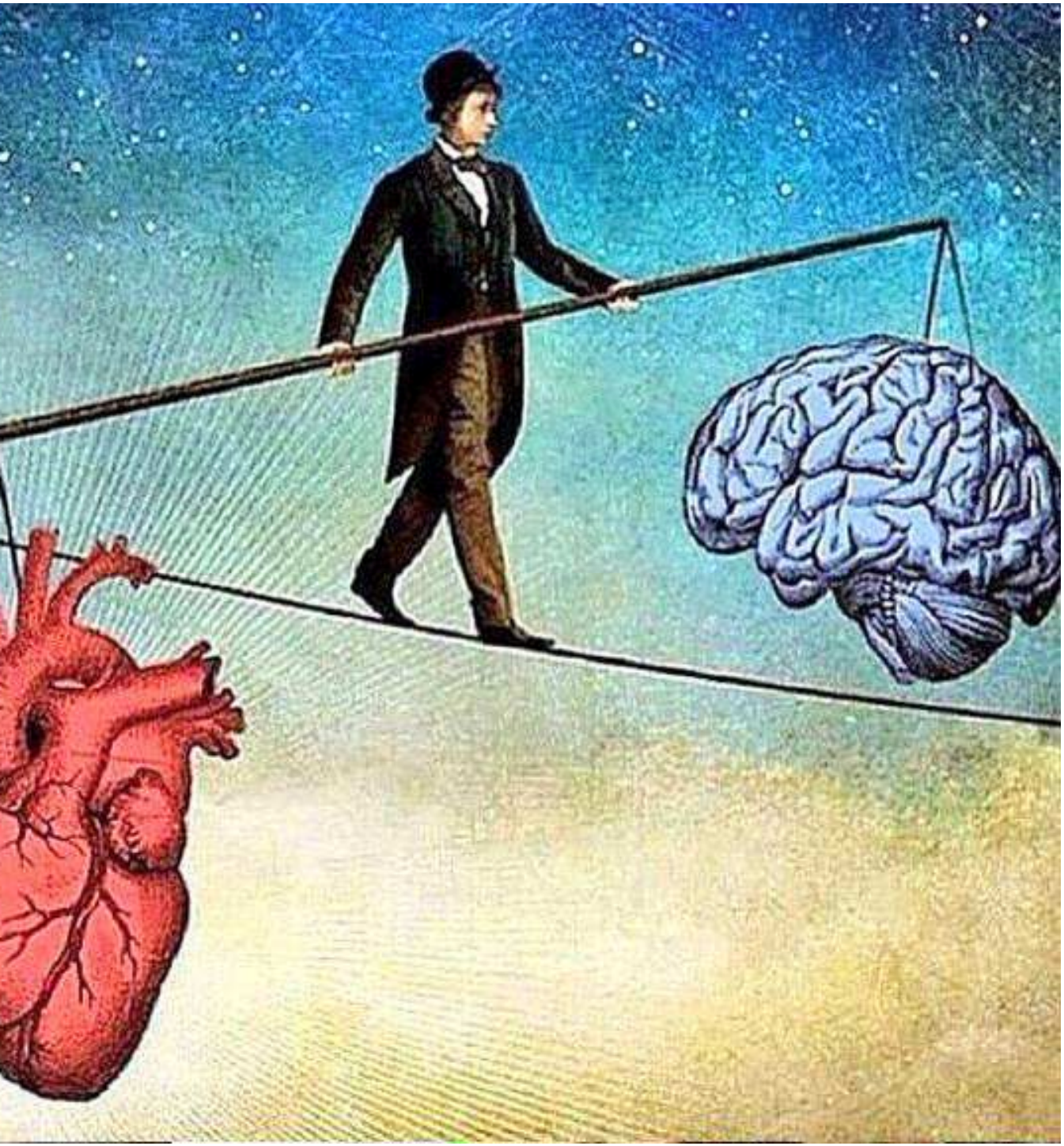


Il linguaggio del cuore

HRV, tono vagale,

disaggio psichico e DC

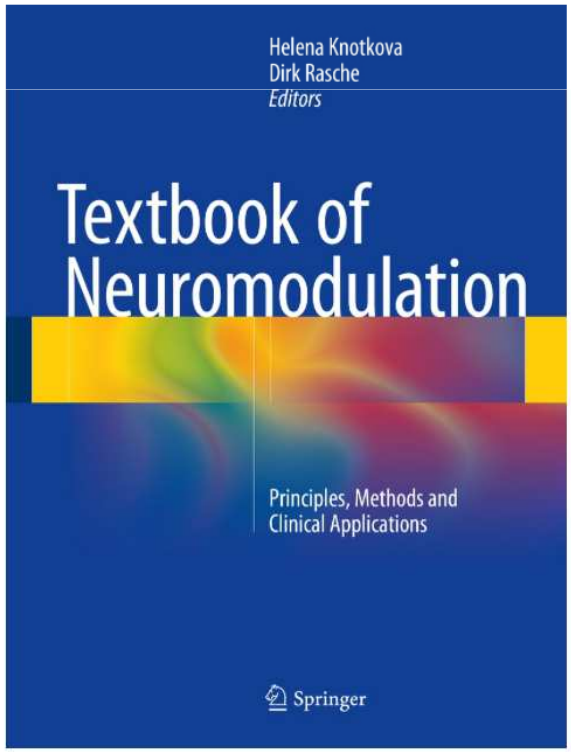
Giancarlo Bazzoni
Alessio Pirino

CERNATEC
Centro per la Ricerca in
Neuromodulazione Auricolare
eTerapie Complementari
. Università di Sassari

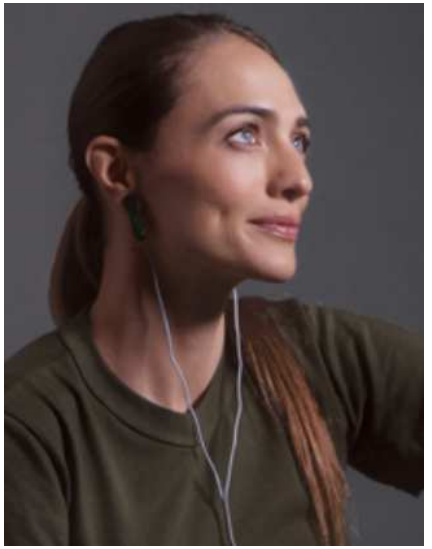
ALGHERO 3-4 Novembre
CONGRESSO NAZIONALE SIRIDA

ll'Auricoloterapia alla Neuromodulazione Auricola

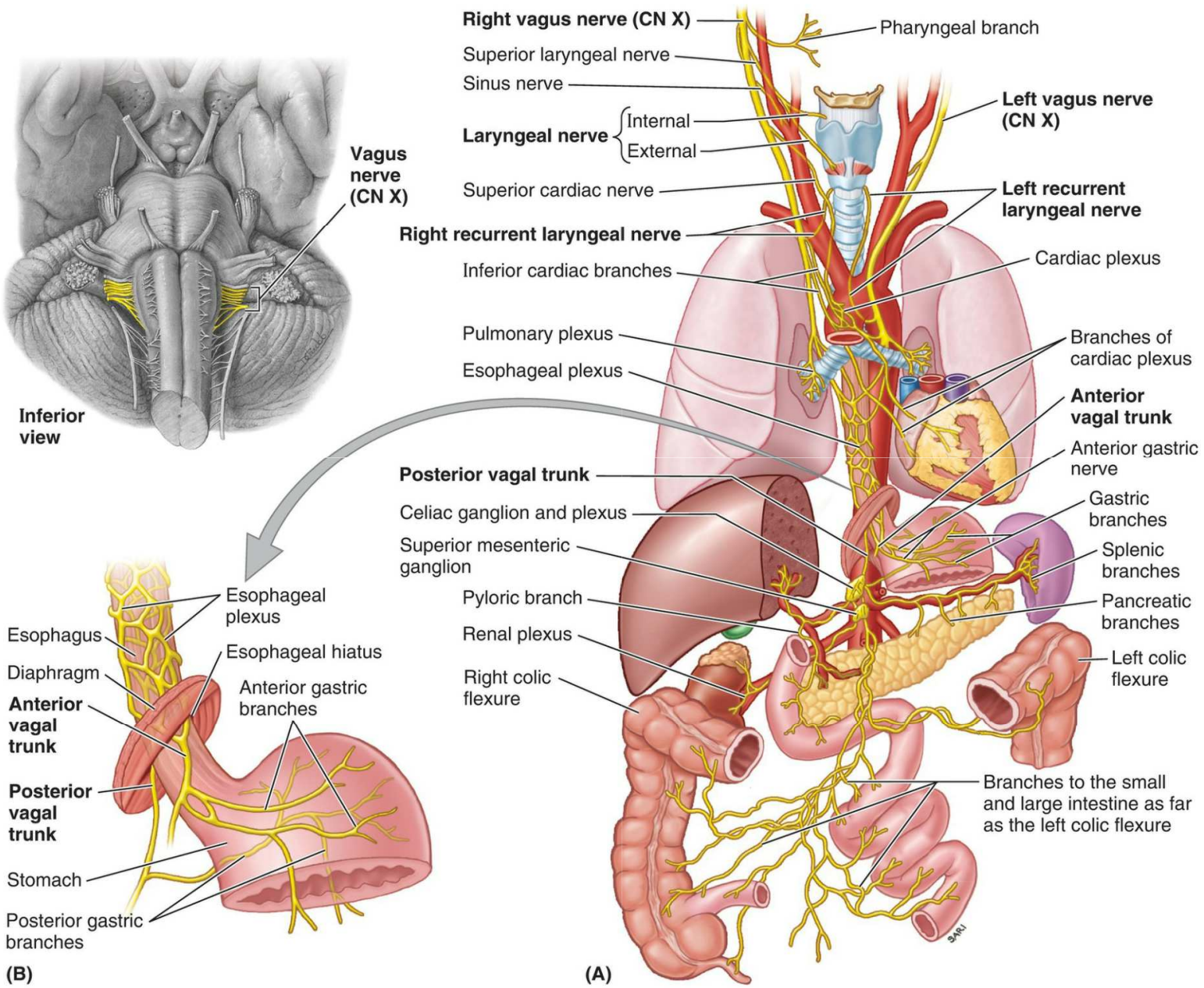
CERNATEC
Centro per la Ricerca in
Neuromodulazione Auricolare e Terap
Complementari
. Università di Sassari



Neuromodulazione Vagale,
Trigeminale e Spinale
Neuromodulazione Auricolare



Nervo pneumogastrico n. vago X paio nervi cranici

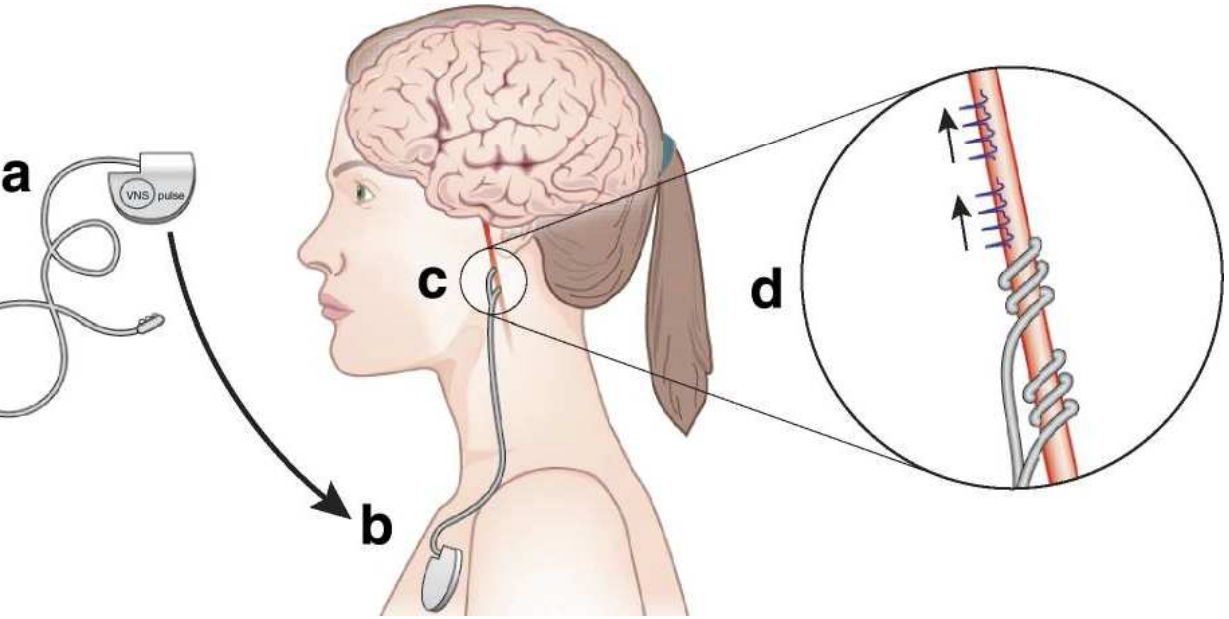


La stimolazione del vago ha un ruolo terapeutico

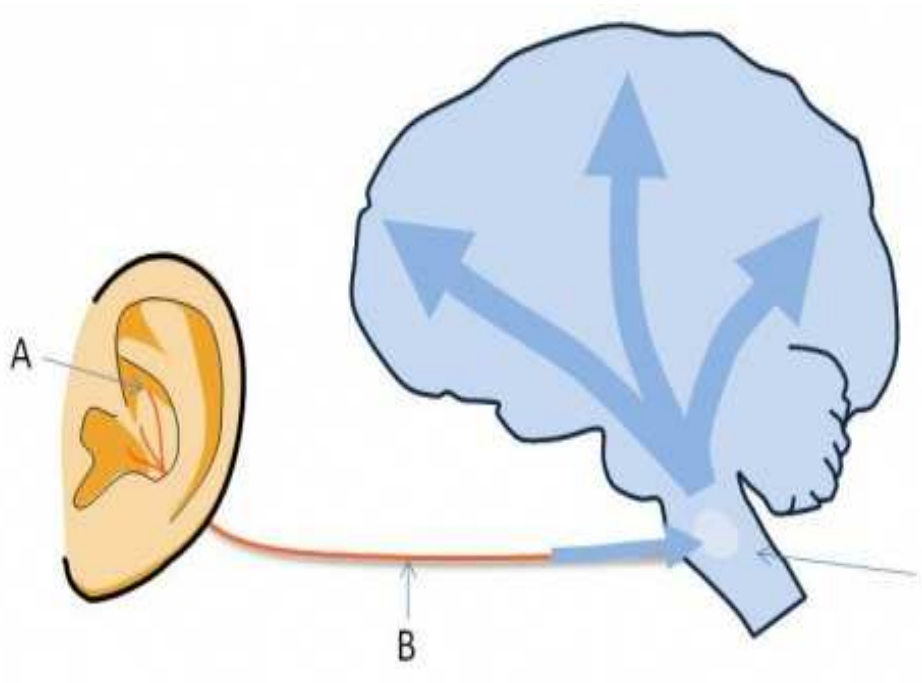
Food and Drug Administration (FDA)

7 → Partial-onset seizures

5 → Chronic recurrent depression

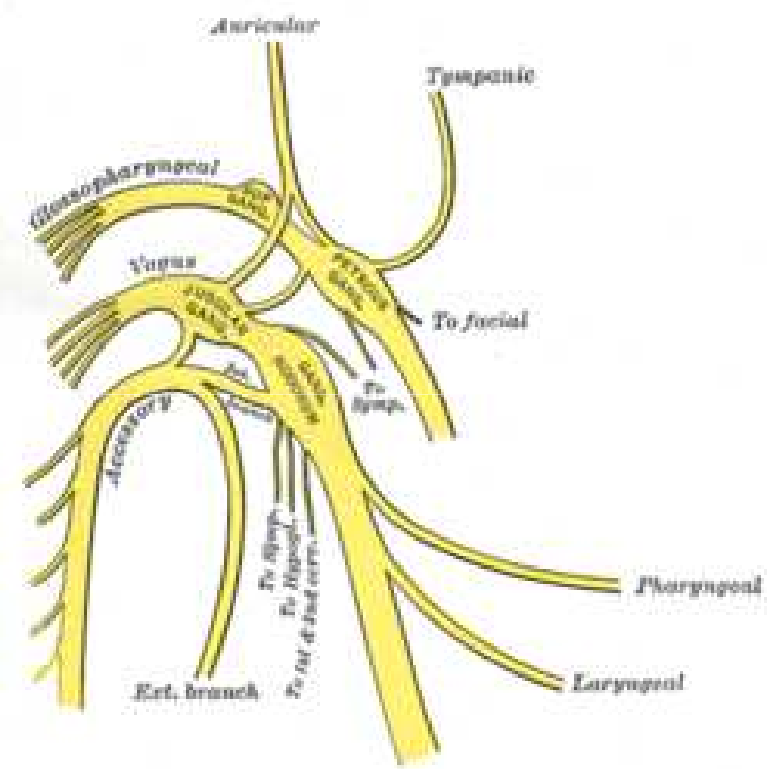


VNS Vagus Nerve Stimulation

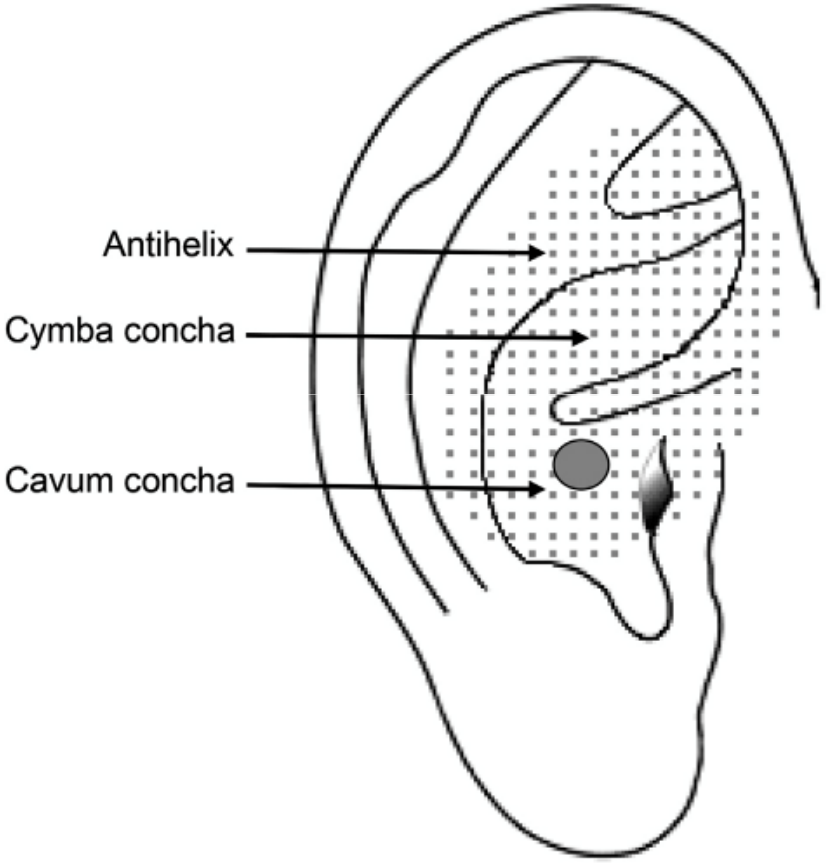


at-VNS Vagus Nerve Stimulation

Il n. vago (X) innerva il padiglione auricolare

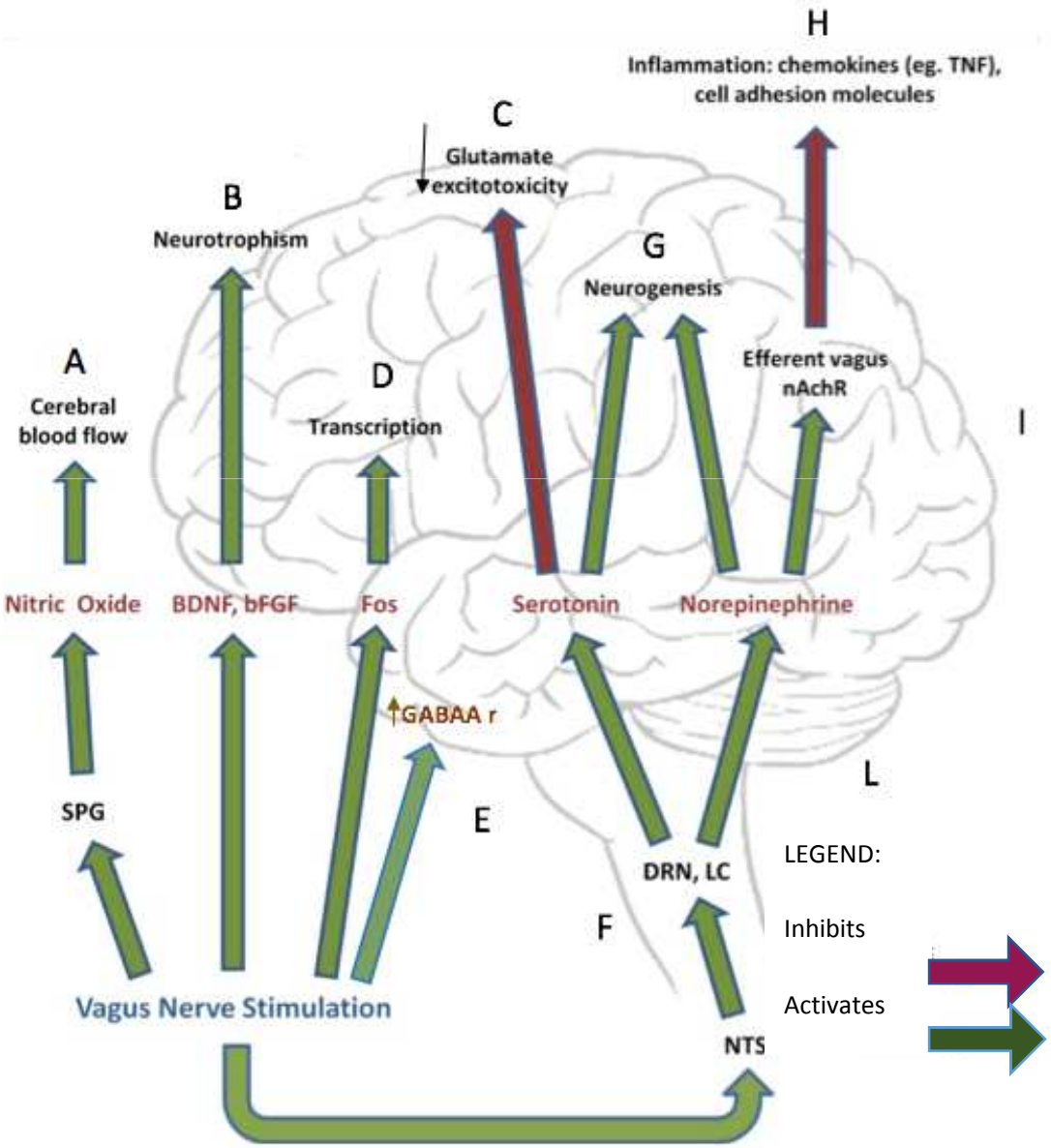


Branca auricolare del nervo vago (ABVN)



Dermatomero vagale

I meccanismi della stimolazione vagale



Abbreviation keys

NTS	Nucleus of the solitary tract
DRN	Dorsal raphe nucleus
LC	Locus coeruleus
SPG	Sphenopalatin ganglion
BDNF	Brain derived neurotrophic factor
bFGF	Brain fibroblast growth factor

A ANTI-EDEMA POST-STROKE EFF
HYPPOCAMPUS NEOCORTEX

B COGNITIVE PROCESSES LEARNI
AND
MEMORY - ANTIDEPRESSANT E
HYPPOCAMPUS NEOCORTEX

C STROKE VOLUME
HYPPOCAMPUS

D NEUROPLASTICITY NEURON SU
AND GROWTH

E ANTI-SEIZURES EFFECT
HYPPOCAMPUS

F MIGRAINE ANTINOCICEPTION
DORSAL RAPHE NUCLEUS
LOCUS COERULEUS

G MEMORY AND MOOD
HYPPOCAMPUS

H ANTIFLAMMATION - IMMUNITY
HYPOTHALAMUS

I METHABOLISM - EATING - SATI
HYPOTHALAMUS

L ANTI DEPRESSANT - ANTI SEIZU
EFFECT
MOOD - ANXIETY
BASOLATERAL AMYGDALA -
PREFRONTAL CORTEX -
HYPPOCAMPUS - LYMBIC
PARALYMBIC SYSTEM

unzioni del sistema vagale già utilizzate in terapia

in fase di studio

Antiepilettica

Antidepressiva

Analgesica

Antinfiammatoria e immunomodulatoria

Modulazione tono simpatico-parasimpatico

Antiedema post stroke

Neuroplasticità cerebrale e neurotrofica

Ansiolitica

Processi cognitivi e memoria

Tinnitus

Antiemicranica

unzioni del sistema vagale già utilizzate in terapia in fase di studio

AZIONE ANTIDEPRESSIVA

rimonprez A, Raedt R et al.

he antidepressant-like effect of vagus nerve imulation is mediated through the locus oeruleus. J PsychiatrRes. 2015

hristmas D, Steele JD et al.

agus nerve stimulation for chronic major epressive disorder: 12-month outcomes in ghly treatment-refractory patients.

Affect Disord. 2013

AZIONE ANTIEPILETTICA

Oliveira TVHF, Francisco AN et al. *The ro of vagus nerve stimulation in refractory epilepsy.* Arq Neuropsiquiatr. 2017

AZIONE ANTINFIAMMATORIA

Pavlov VA, Wang H, Czura CJ, Friedman SG & Tracey KJ

The cholinergic anti-inflammatory pathwa a missing link in neuroimmunomodulation

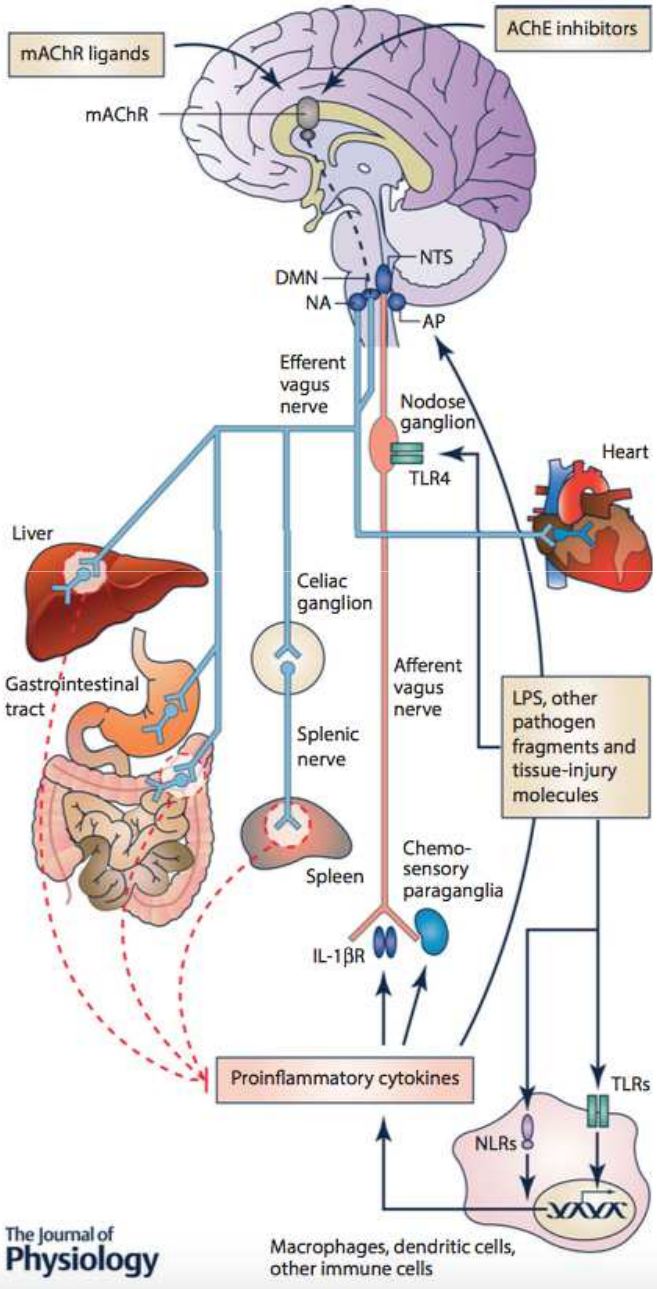
Mol Med 2003

unzioni del sistema vagale già utilizzate in terapia o i

fase di studio

IMMUNOMODULATORIA E ANTINFIAMMATORIA

Pavlov VA & Tracey, *Neural circuitry and immunity*. Immunol Res 2015



The functional anatomy of the inflammatory reflex (according to Pavlov & Tracey, 2015)
AChE, acetylcholinesterase;
AP, area postrema;
DMN, dorsal motor nucleus of the vagus nerve;
LPS, lipopolysaccharide (endotoxin);
mAChR, muscarinic acetylcholine receptor;
NA, nucleus ambiguus;
NLRs, nucleotid e-binding oligomerization domain-like receptors; NTS, nucleus tractus solitarii;
TLR4, Toll-like receptor 4.

unzioni del sistema vagale già utilizzate in terapia o i
fase di studio

AZIONE PARASIMPATICOTONICA SIMPATICOLITICA

---

lancy JA, Mary DA, Witte KK, Greenwood JP, Deuchars SA, Deuchars

Non-invasive vagus nerve stimulation in healthy humans reduces sympathetic nerve

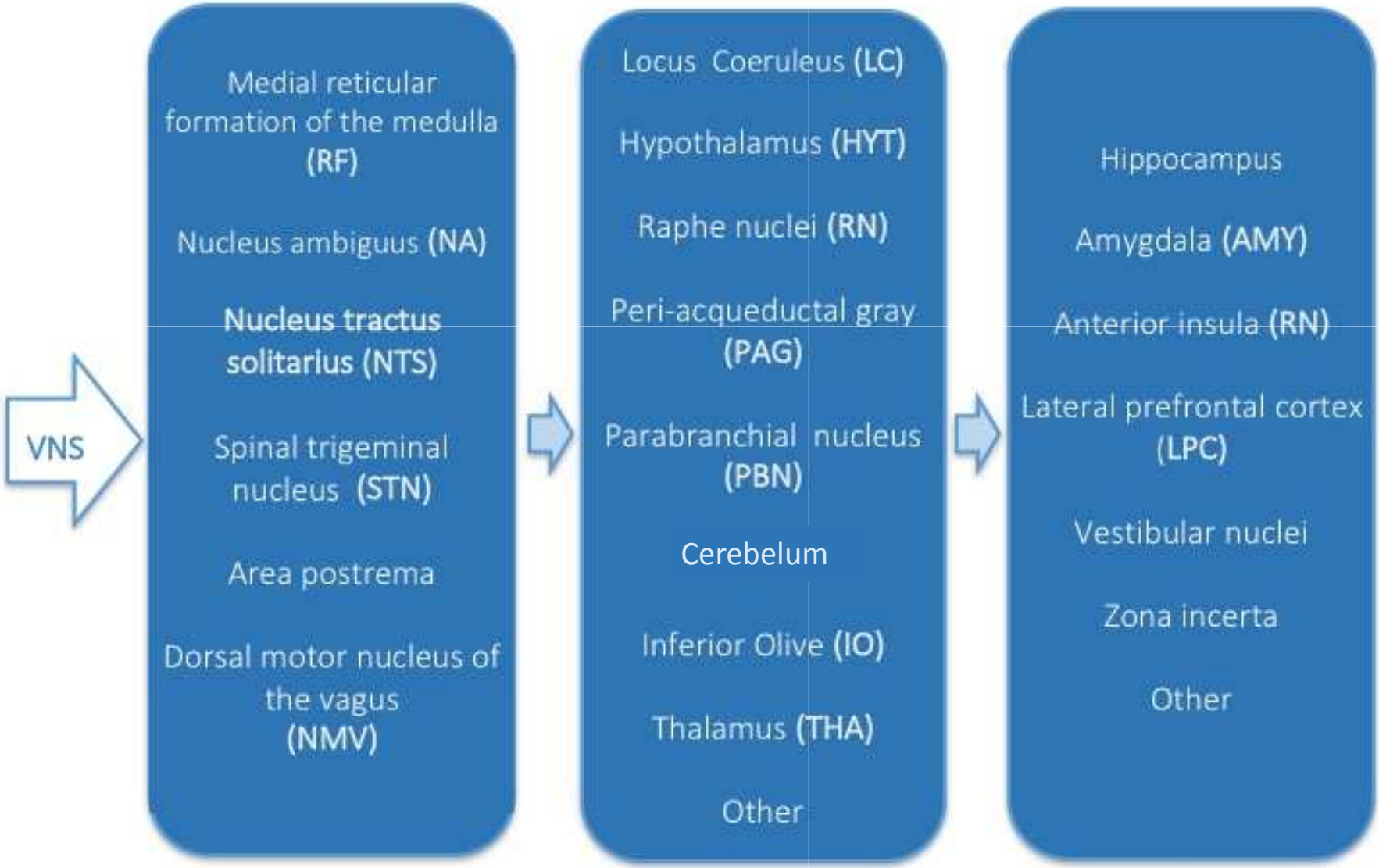
ctivity. *Brain Stimul. 2014*

ikoski J, Lehtimäki J et al.

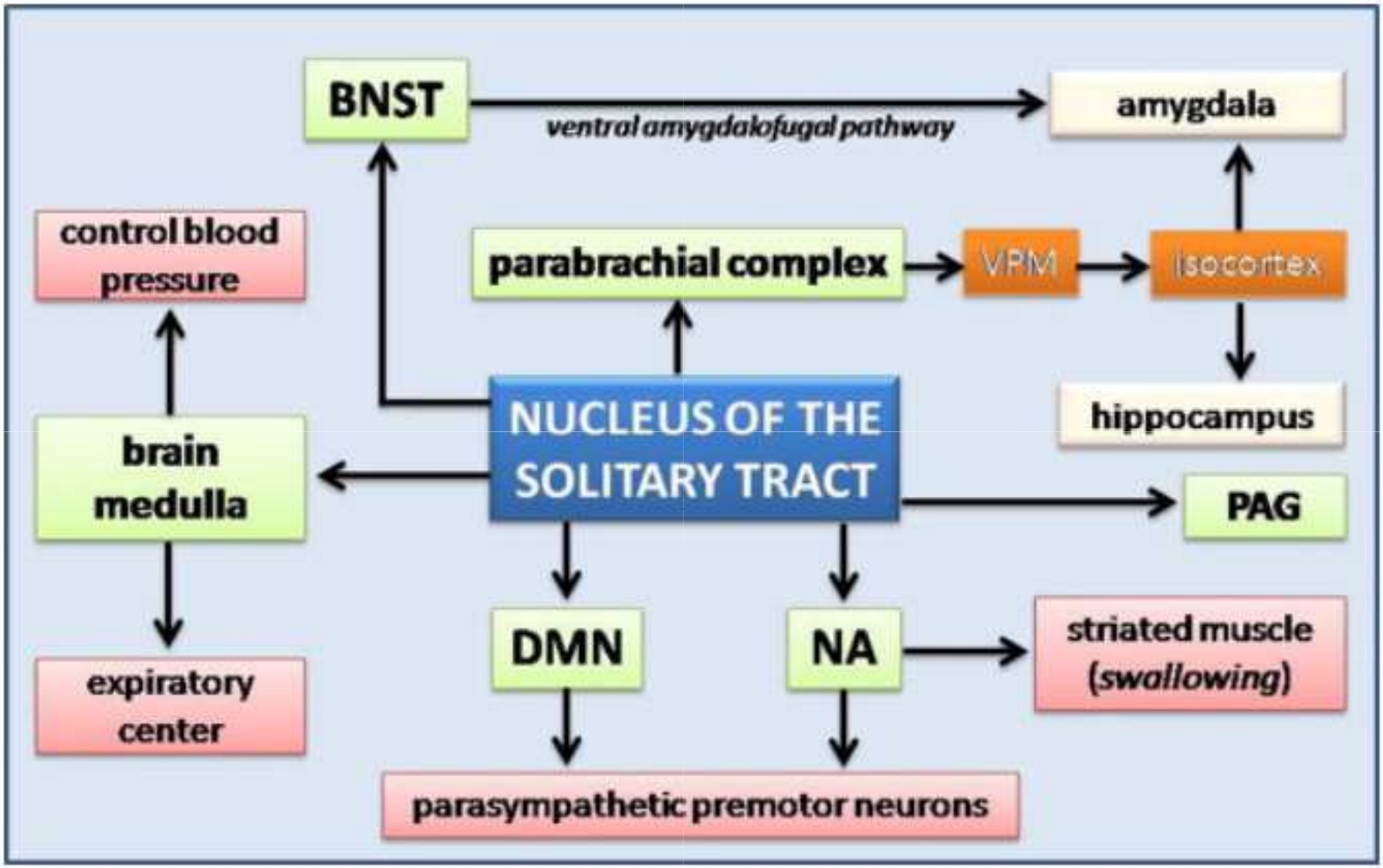
on-invasive vagus nerve stimulation reduces sympathetic preponderance in patients wit

nnitus. *M. Acta Otolaryngol. 2017*

DAL NERVO VAGO AL SISTEMA VAGALE



DAL NERVO VAGO AL SISTEMA VAGALE



Ruffoli R, Giorgi FS et al.
The chemical neuroanatomy of vagus nerve stimulation
J Chem Neuroanat. 2011

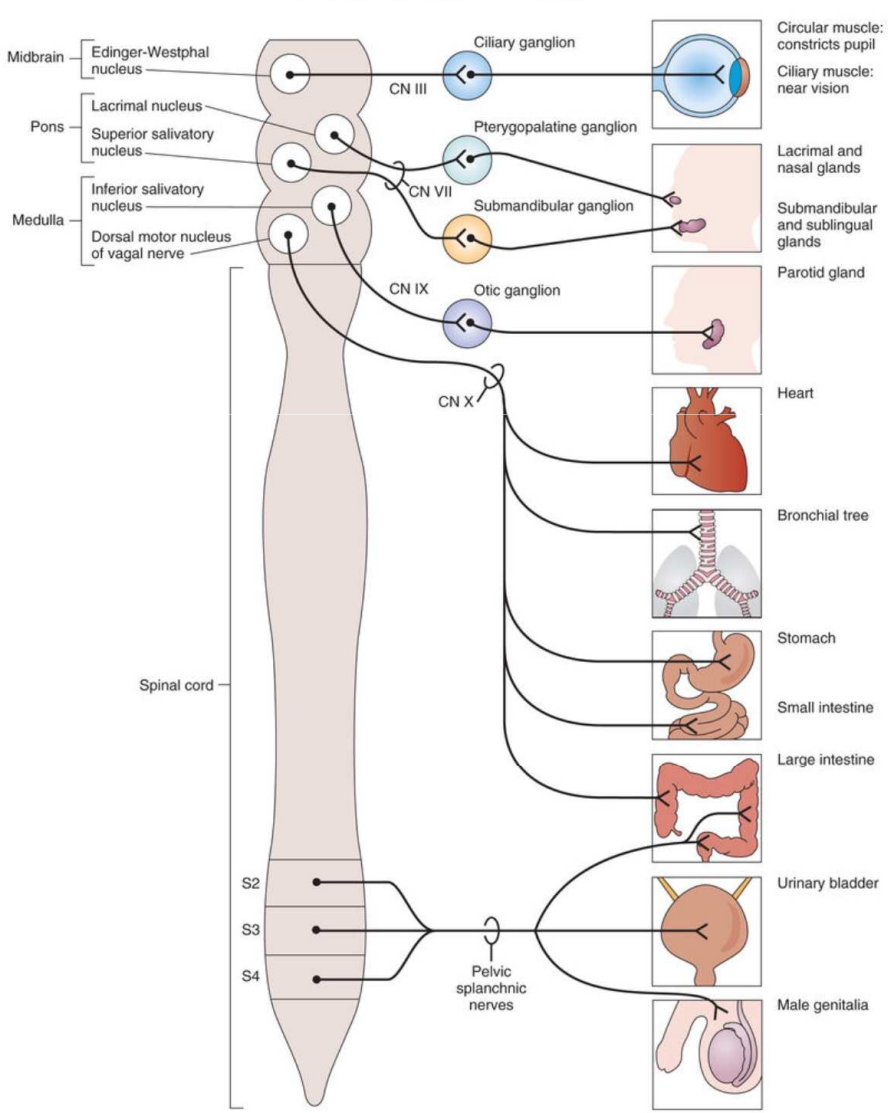
DAL NERVO VAGO AL SISTEMA VAGALE

- Vagal function is associated with:
  - psychological resilience
  - psychophysiological flexibility & response to environmental challenge
  - emotion capacity & social engagement
  - glucose regulation
  - inhibition of hypothalamic-pituitary-adrenal (HPA) axis
  - regulation of immune function
- Chronic decreases reflect impairment of the cholinergic anti-inflammatory reflex →
  - immune dysfunction and inflammation →
  - CVD, diabetes, osteoporosis, arthritis, Alzheimer's disease, periodontal disease, and certain types of cancers as well as declines in muscle strength and increased frailty and disability

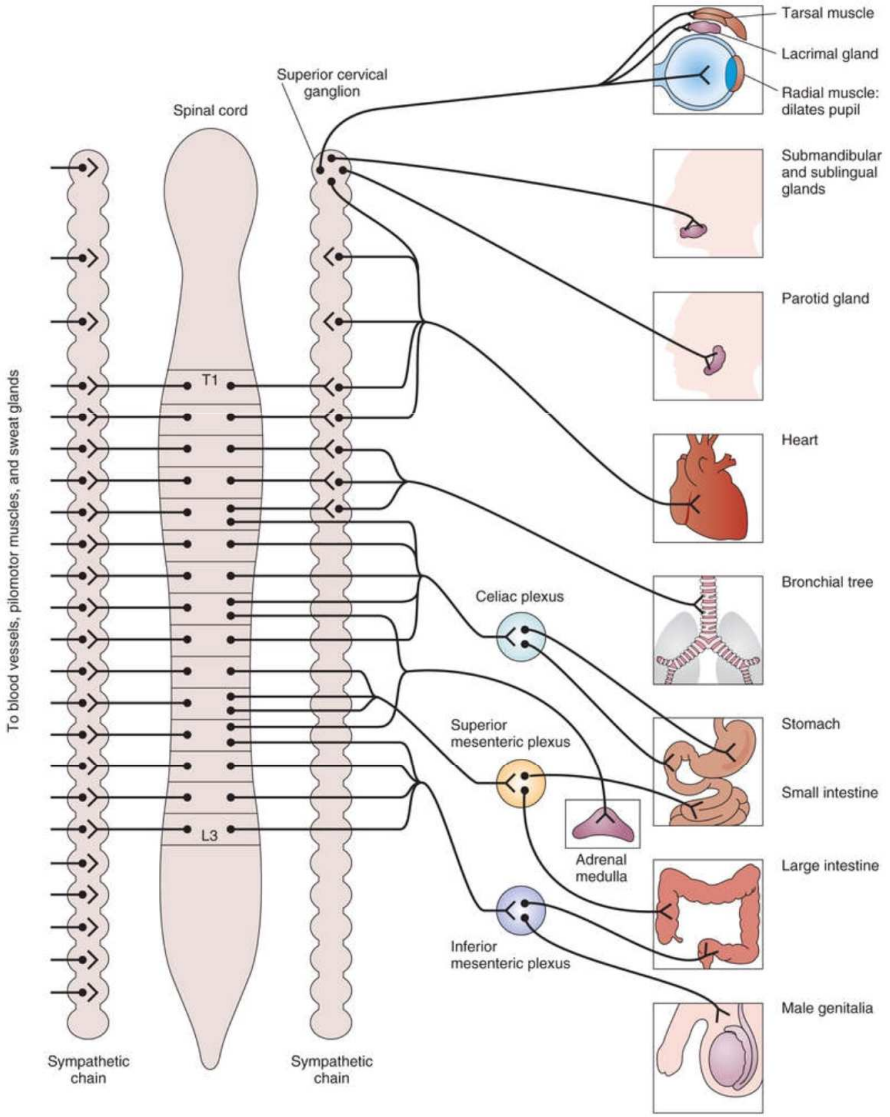
& Quintana, 2013; Thayer & Sternberg, 2006; Thayer et al., 2010; Kashdan & Rottenberg, 2010; Porges (2011); Tracey

ANS SISTEMA NERVOSO NEUROVEGETATIVO AUTONOMO

SISTEMA NERVOSO PARASIMPATICO



SISTEMA NERVOSO SIMPATICO



The neurovisceral integration

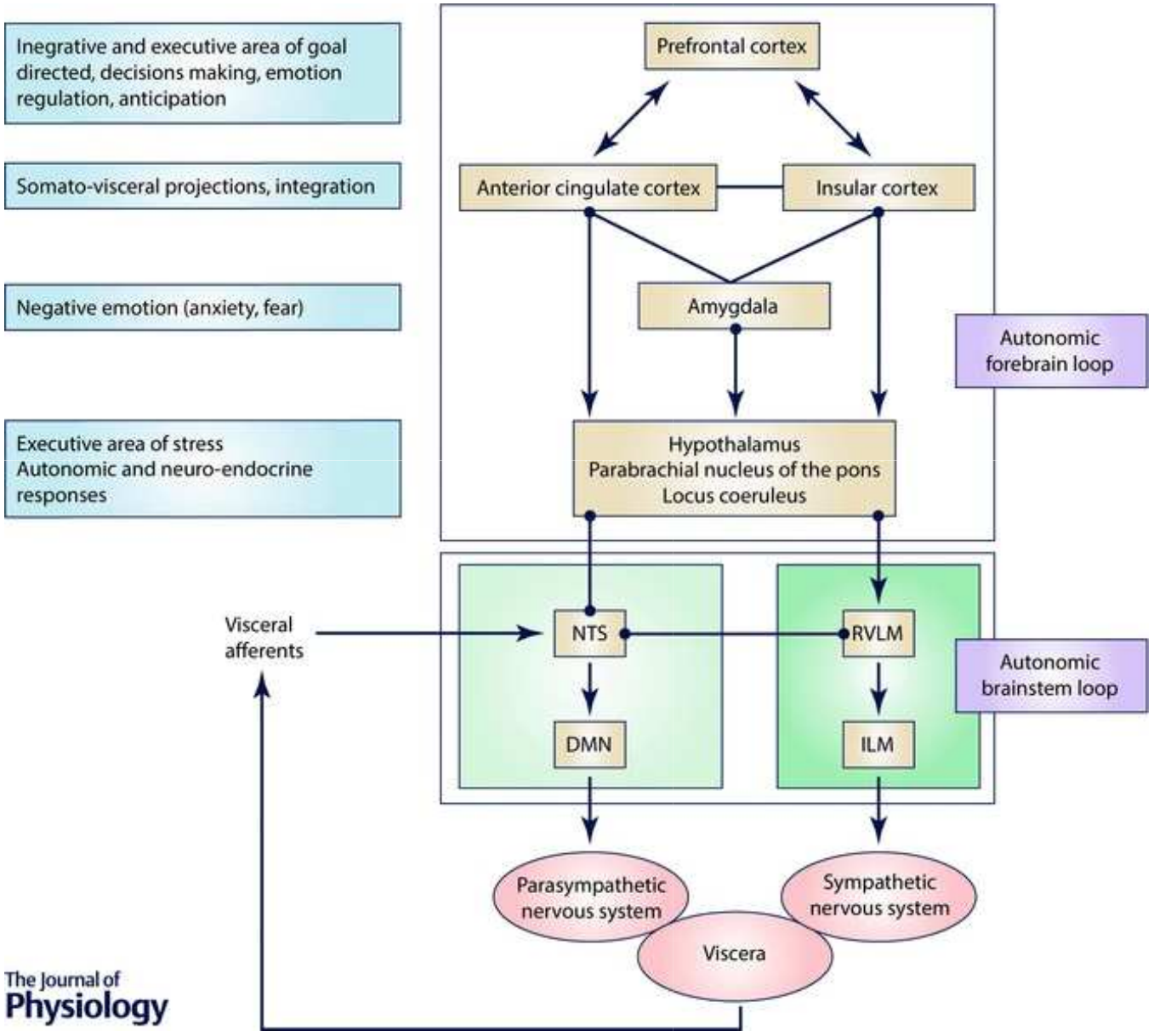
Benarroch EE. ***The central autonomic network****: functional organization, dysfunction, and perspective.* Mayo Clin Proc. 1993

Cersosimo MG, Benarroch EE. ***Central control*** *of autonomic function and involvement in neurodegenerative disorders*. Handb Clin Neurol. 2013

Thayer J. F., Lane R. D. *A model of* ***neurovisceral integration*** *in emotion regulation and dysregulation.* J. Affect. Disord. 2000

Thayer J. F., Hansen A. L., Saus-Rose E., Johnsen B. H. *Heart rate variability, prefrontal neural function and cognitive performance: the* ***neurovisceral integration perspective*** *on self-regulation, adaptation, and health. Ann. Behav. Med.* 2009

CAN CENTRAL AUTONOMIC NETWORK (Thayer & Lane, 2008



AN CENTRAL AUTONOMIC NETWORK: INTERAZIONE CUOR CERVELLO

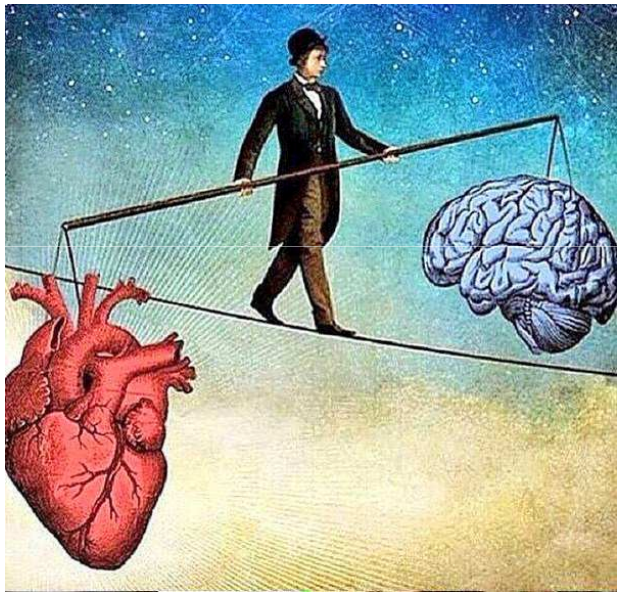
Quando la mente è in uno stato di forte eccitazione, ci aspettiamo che abbia un'influenza immediata sul cuore…..

Quando il cuore viene interessato da questa eccitazione, provoca reazioni a livello cerebrale…..

Attraverso il nervo pneumogastrico…

Si attiva un meccanismo di azione-reazione

C. Darwin The Expression of Emotions in Man and Animals, 1872



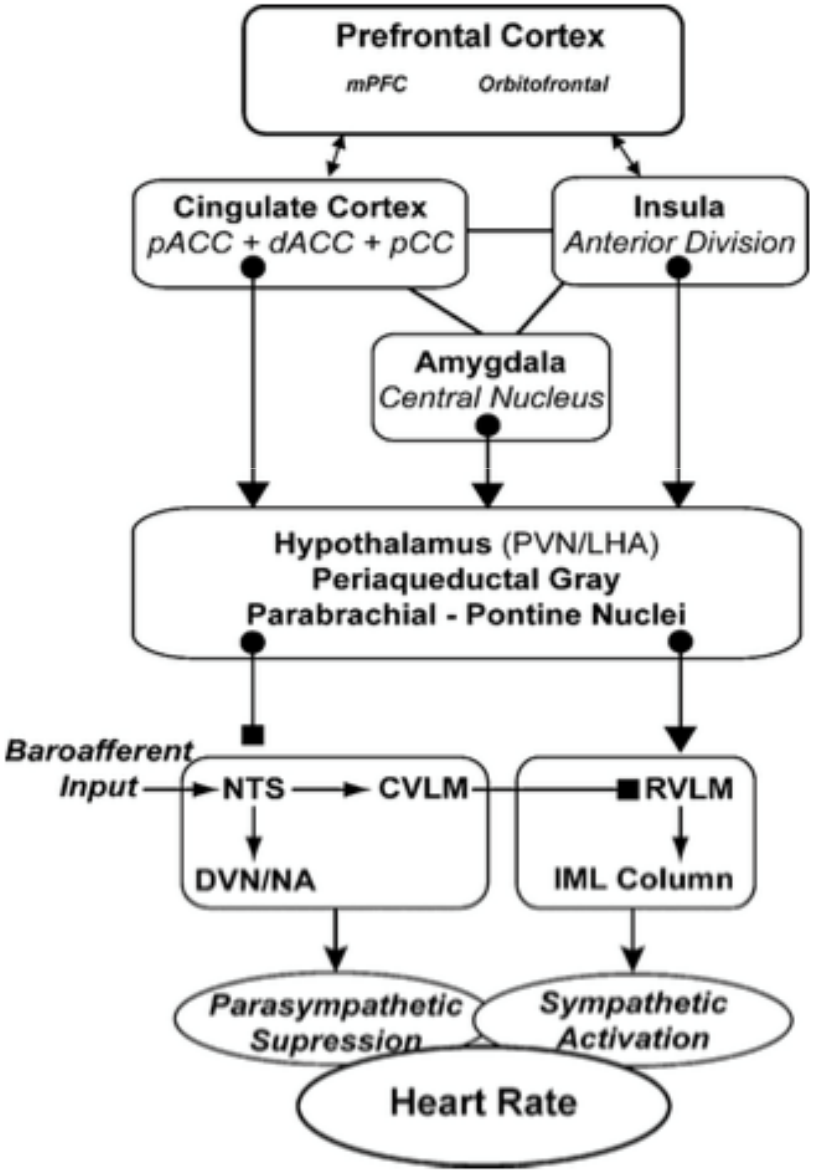
AN CENTRAL AUTONOMIC NETWORK: INTERAZIONE CUOR
CERVELLO

Park G, Thayer JF. *From the heart to the mind: cardiac vagal tone modulates top-down and bottom-up visual perception and attention to emotional stimuli.* *Frontiers in Psychology*, 2014

Thayer J. F., Hansen A. L., Saus-Rose E., Johnsen B. H. *Heart rate variability, prefrontal neural function and cognitive performance the neurovisceral integration perspective on self-regulation*, adaptation, and health. *Ann. Behav. Med.* 2009

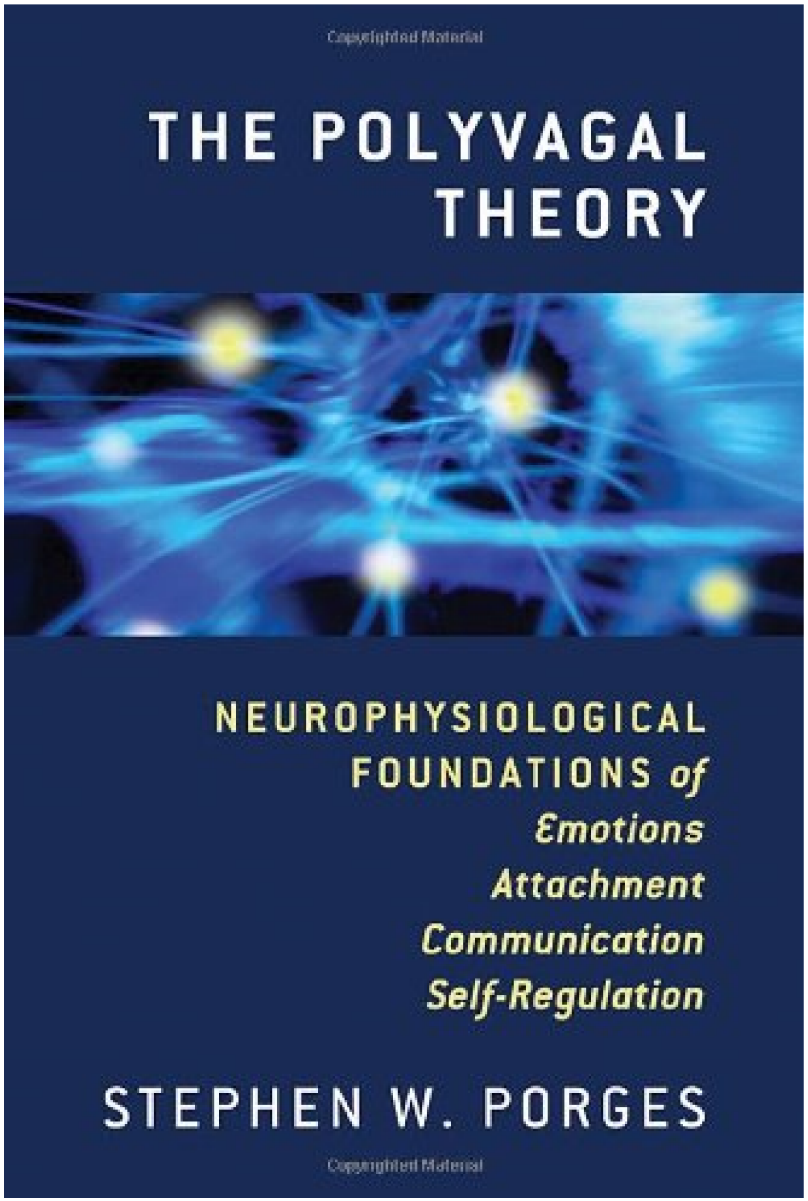
Thayer JF, Lane RD. *Claude Bernard and the heart-brain connection: furtherelaboration of a model of neurovisceral integration*. Neurosci Biobehav Rev. 2009

AN CENTRAL AUTONOMIC NETWORK: INTERAZIONE CUOR CERVELLO



Prefrontal Cortex	medial Prefrontal Cortex **mPFC** Orbitofrontal Cortex **OFC**
Cingulate Cortex	posterior Anterior Cingulate Cortex **pACC** dorsal Anterior Cingulate Cortex **dACC** posterior Cingulate Cortex **pCC**
Insula	Anterior Division of Insula
Amygdala	Central Nucleus **CeA**
Hypothalamus	Paraventricular Nucleus of the Hypothalamus **PVN** Lateral Hypothalamic Area **LHA**
Periacqueductal Gray	
Parabranchial Pontine Nucleus	
Nucleus of Solitary Tract **NTS**	
Caudal Ventrolateral Medullary **CVLM**	
Dorsal Vagal Motor Nucleus **DVN**	
Nucleus Ambiguus **NA**	
Rostral Ventrolateral Medullary **RVLM**	
Intermediolateral Column **IML**	

La Teoria Polivagale The polivagal Theory

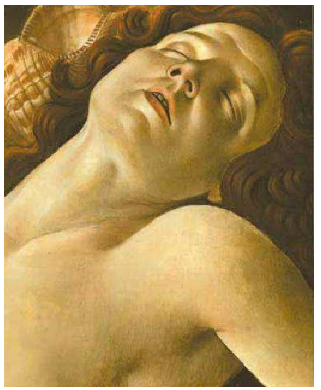


La Teoria Polivagale The polivagal Theory

il SNA è composto da tre circuiti neurali, gerarchicamente organizzati, che regolano l'adattamento dello stato comportamentale e fisiologico in contesti relazionali e sociali sicuri, pericolosi e potenzialmente letali.

Myelinated vagus
Ventral vagal complex
N. Ambiguus NA

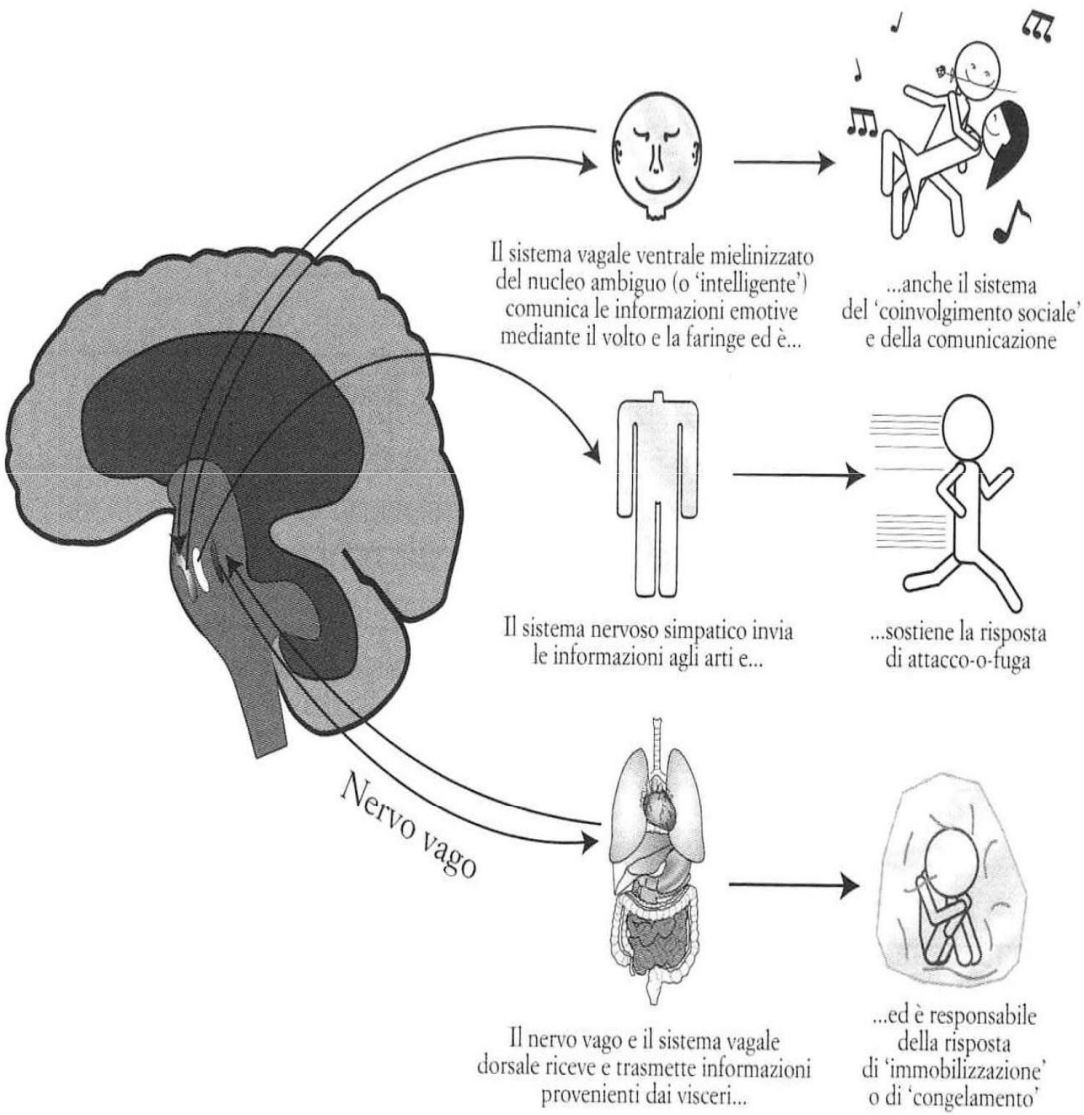
Sympathetic adrenal system



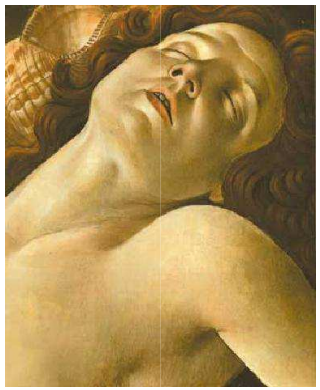
Unmyelinated vagus
Dorsal Motor Nucleus
of Vagus DMN

La Teoria Polivagale The polivagal Theory

S. Porges ha identificato **tre trategie comportamentali dattative**, **filogeneticamente rganizzate**,
iascuna delle quali è collegata ad n circuito neurale distinto che oinvolge il **sistema nervoso utonomo**.



La Teoria Polivagale The polivagal Theory



<u>IMMOBILIZZAZIONE</u>

Morte simulata-blocco dell' azione

Nucleo Motore Dorsale del Vago (DMNX)

Il Complesso Dorso Vagale (DVC) è la branca più antica del Nervo Vago, è presente nei rettili e nei mammiferi, e le sue fibre efferenti non sono mielinizzate. Regola i processi vegetativi e il funzionamento degli organi posti al di sotto del diaframma. Crea uno stato di rallentamento che arriva fino all'immobilizzazione (estrema paura

La Teoria Polivagale The polivagal Theory

MOBILIZZAZIONE

Attacco e fuga

Sistema Nervoso Simpatico

Regola la capacità metabolica e il battito cardiaco per far fronte ad una situazione di pericolo. La sua attivazione porta ad un aumento di PA e di FC, a broncodilatazione, a vasocostrizione e ad un aumento della tensione muscolare, mentre inibisce l'attività del tratto gastro intestinale.

La Teoria Polivagale The polivagal Theory

COMUNICAZIONE O SOCIAL ENGAGEMENT SYSTEM

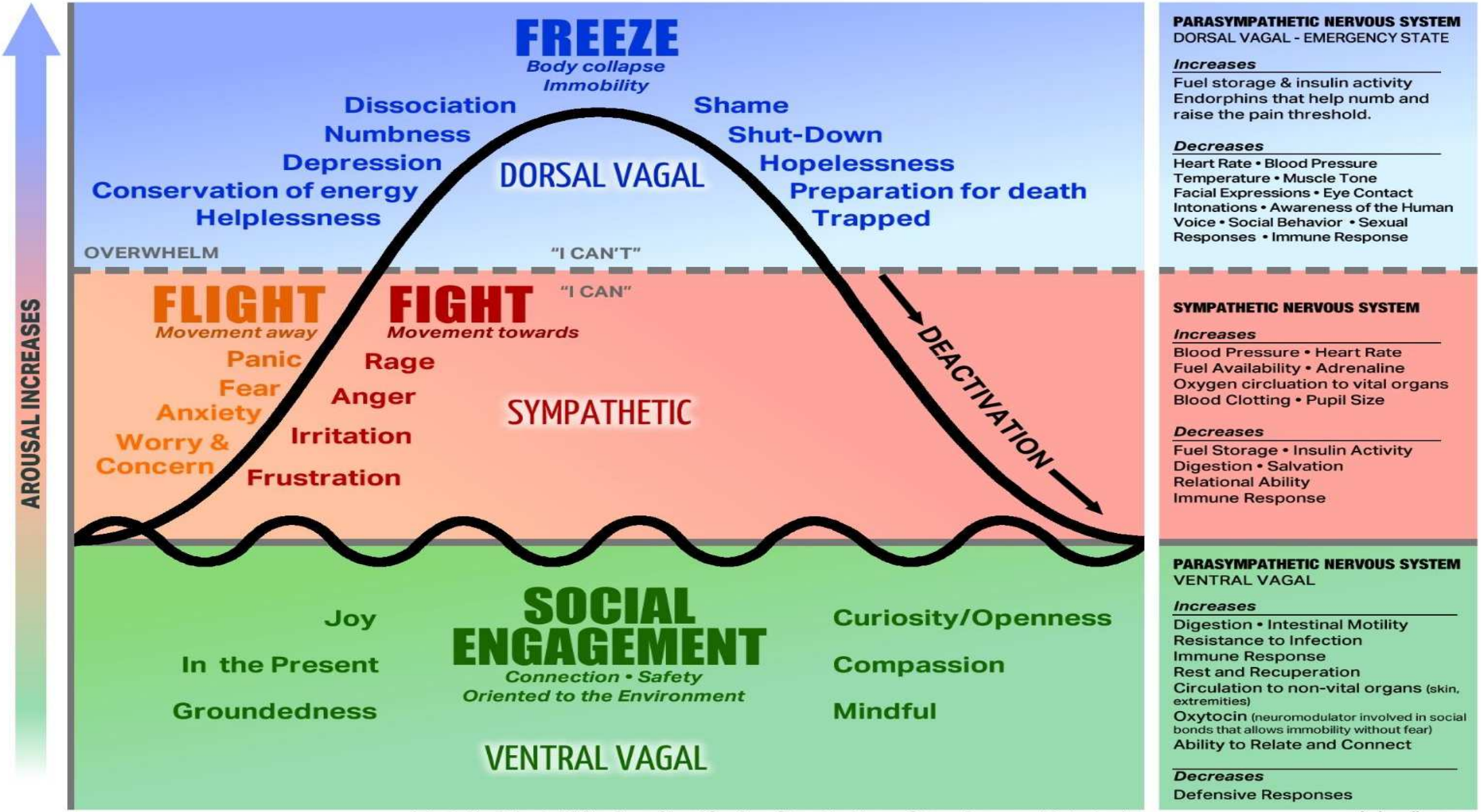
Espressioni facciali, vocalizzazione, ascolto

Complesso Ventro Vagale (VVC)

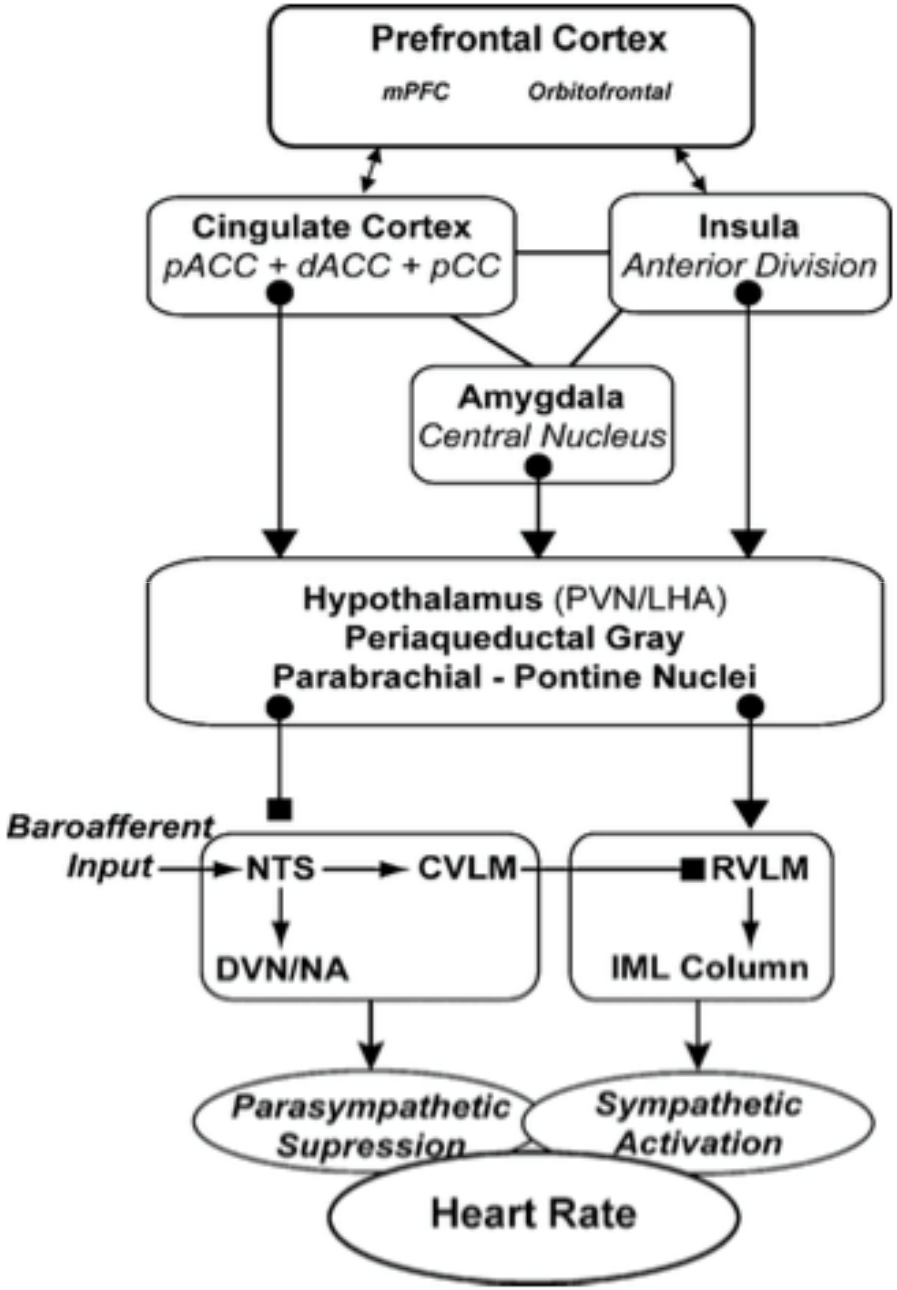
Dipende dal Vago mielinico che origina dal Nucleo Ambiguo ed è presente soltanto nei mammiferi superiori e nell' uomo. Queste fibre contengono un ritmo cardio-respiratorio e rivestono un ruolo fondamentale nei processi di comunicazione **MOBILIZZAZIONE**

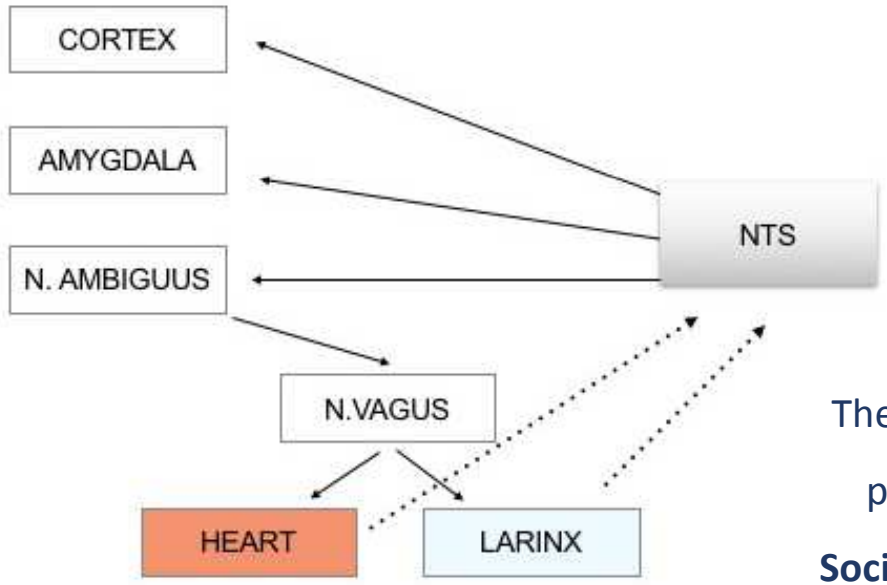
.

La Teoria Polivagale The polivagal Theory



CAN (Thayer & Lane, 2008) - **The Polyvagal Theory** (S. Porge





The neuroanatomical a

physiological bases o

Social Engagement Syst

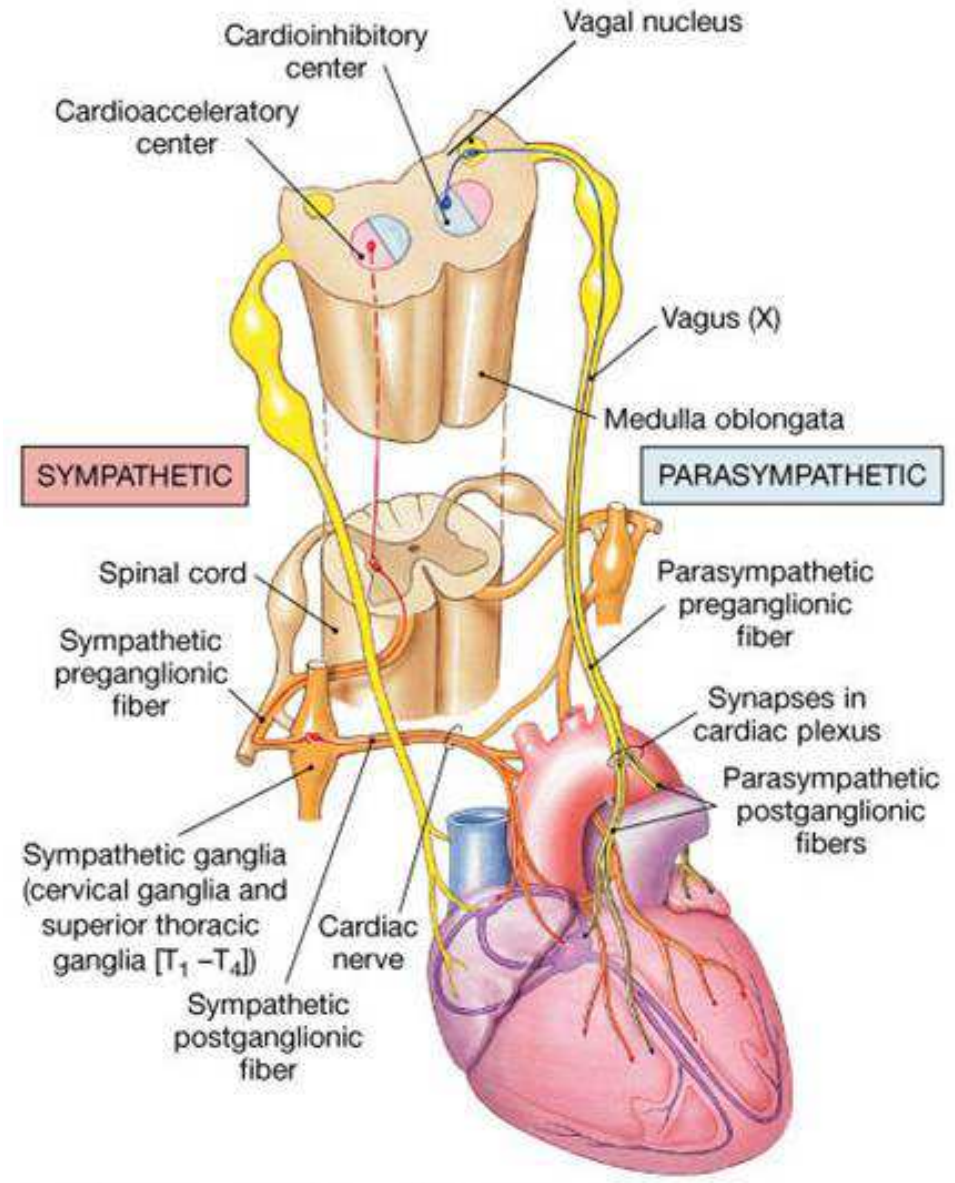
NTROLLO NEURALE DEL CUORE E LATERALIZZAZIO EMISFERICA

Yoon B-W, Morillo CA, Cechetto DF, Hachinski V.
Cerebral hemispheric lateralization in cardiac autonomic control.
Arch Neurol. 1997

Zamrini EY, et al.
Unilateral cerebral inactivation produces differential left/right heart rate responses.
Neurology 1990

Oppenheimer SM, Gelb A et al.
Cardiovascular effects of human insular cortex stimulation.
Neurology. 1992

CONTROLLO NEURALE DEL CUORE



Controllo neurale del cuore

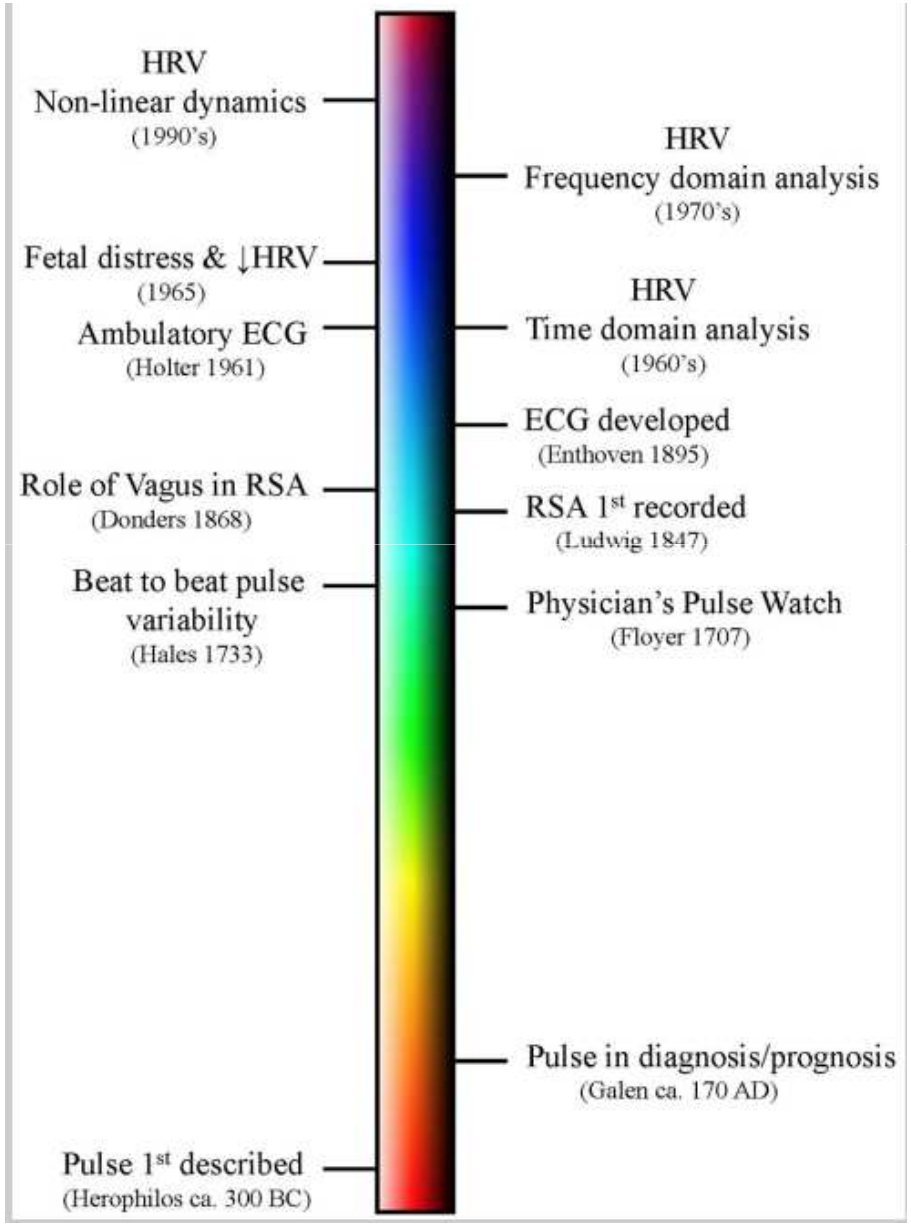
La frequenza a riposo in un soggetto sano è 75 battiti per minuto (bpm).

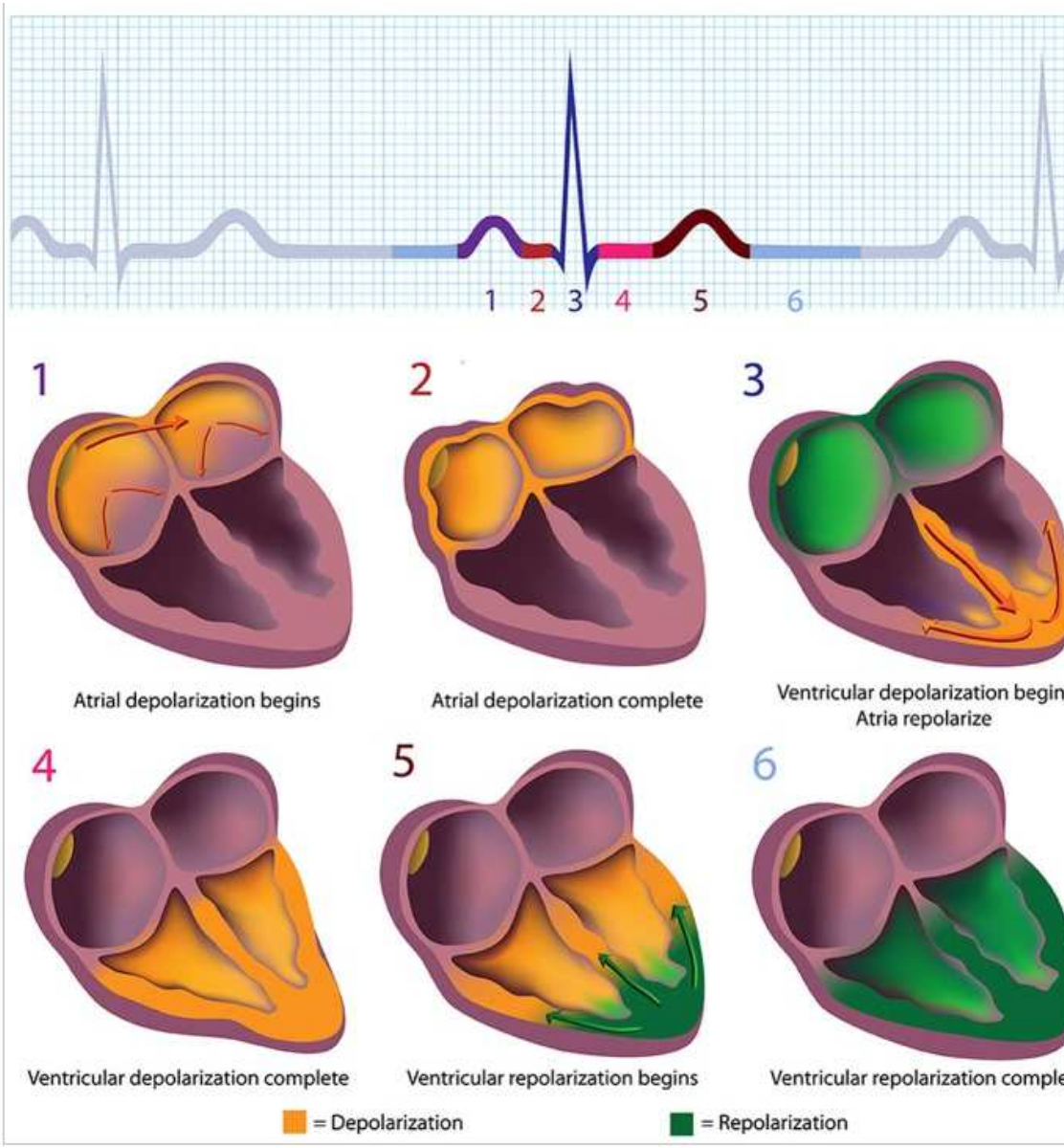
La frequenza intrinseca del nodo SA è 107 bpm (20 anni) e 90 (50 anni) (*Optof, 2000*)

Il parasimpatico esercita un'azione inibente sul nodo SA (riducendo la frequenza di 20-30 bmp per minuto) Heart brake *(Olshansky et al., 2008)*

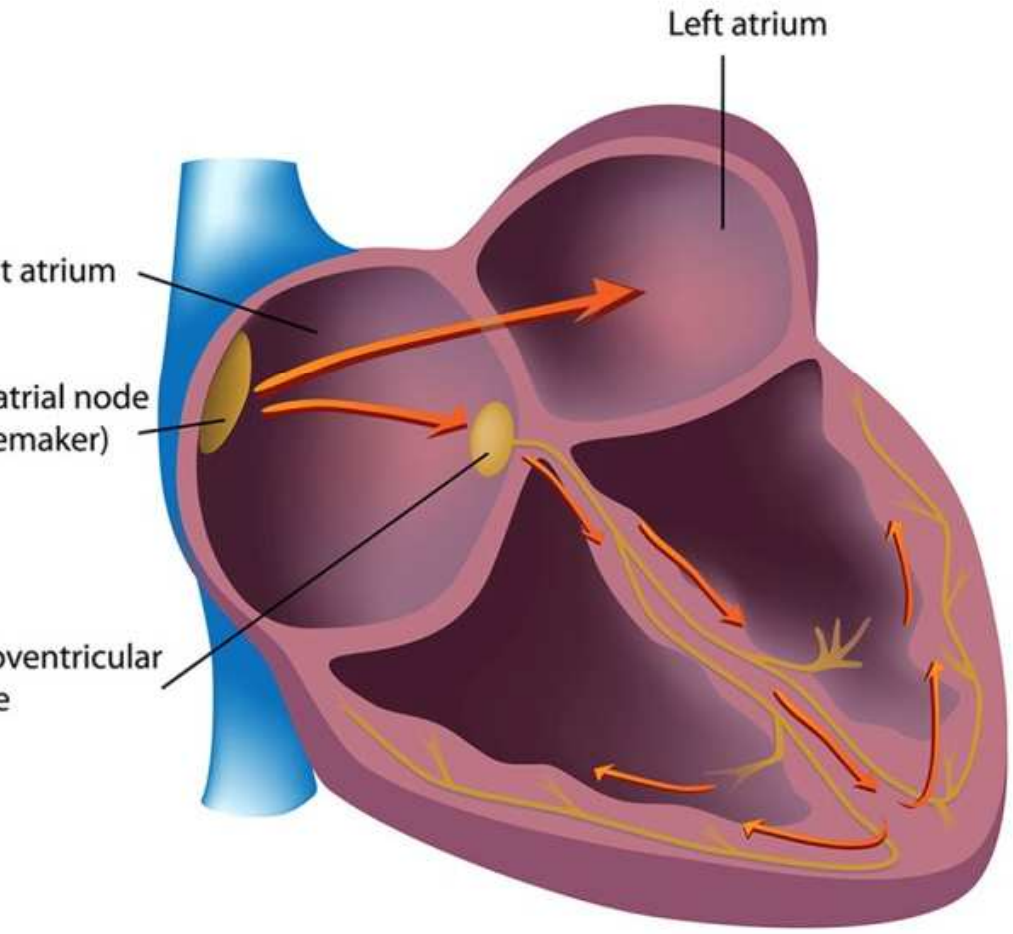
L'azione parasimpatica vagale ha un tempo di latenza < 1 s, quella simpatica è >5 s; *(Nunan et al., 2010)*

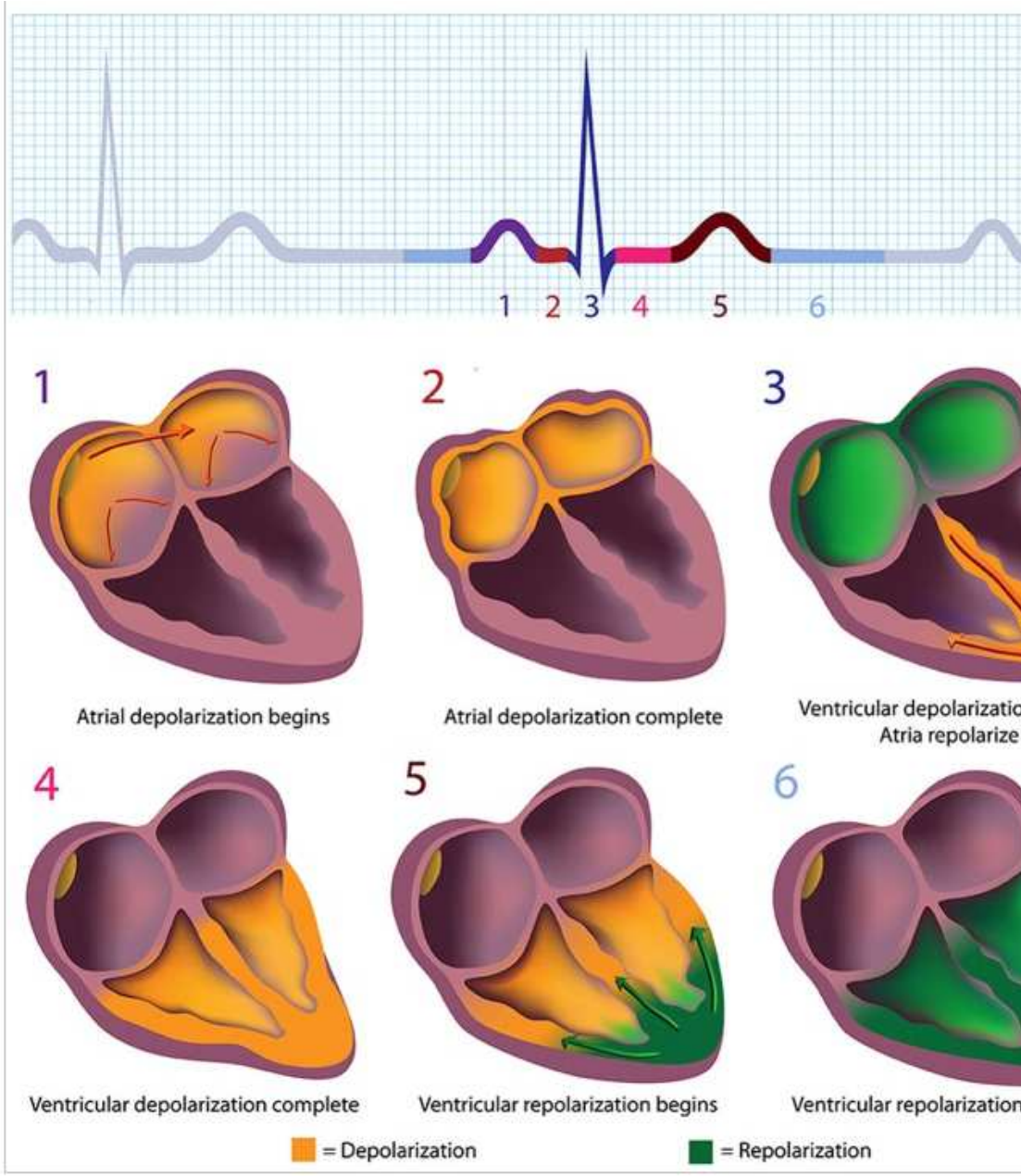
REGISTRAZIONE DELL'ATTIVITÁ DEL CUORE





REGISTRAZIONE DELL'ATTIVITÁ DEL CUORE





CONTROLLO DEL CUORE E TONO VAGALE

Il tono (cardiaco) vagale rappresenta il contributo del sistema nervoso parasimpatico vagale al controllo del cuore, ma è anche strettamente collegato ai meccanismi di autoregolazione vegetativi, emotivi e in generale dello stato di salute.

Il tono vagale è strettamente legato alla **HRV**

Per lo studioso e il terapeuta il fatto che il tono vagale sia una variabile misurabile, rappresenta un importante strumento nell'ambito della ricerca e della cura.

CAN - NEUROVISCERAL INTEGRATION MODEL AND HRV

Thayer J. F., Hansen A. L., Saus-Rose E., Johnsen B. H. *Heart rate variability, prefrontal neural function and cognitive performance: the neurovisceral integration perspective on self-regulation, adaptation, and health*. Ann. Behav. Med. 2009

La HRV è una proprietà emergente di sistemi regolatori interdipendenti che operano su diverse scale temporali per adeguarsi alle sfide ambientali e psicologiche.
Thayer J.F.

La frequenza cardiaca

a frequenza cardiaca può essere definita come il numero medio di battiti
ardiaci al minuto: in realtà il tempo che intercorre fra un battito e l'altro, no
costante ma varia in continuazione.

Variabilità cardiaca (Heart Rate Variability)

La variabilità cardiaca (HRV) descrive la variazione del tempo che intercorre tra un battito e l'altro misurato come intervallo R-R.

L'intervallo R-R viene espresso in millisecondi.

Malik & Camm, 1995

Misurare la HRV

La HRV può essere analizzata attraverso:

Dominio del tempo (Time domain measures)

Dominio delle frequenze (Frequency domain measures)

Tempi di Misurazione

Long-term measurement >5 min - 24 h
Short-term measurements 5 min
Ultra short-term measurements 1 min

surazioni di breve durata (Short-term measuremen

1 minuto è la durata minima per ottenere una misurazione significativa

Un tempo di **5 minuti** è considerato il "gold standard" delle misurazioni **in tempi brevi** (short-term readings).

I dati ottenuti con una registrazione di breve durata (*short readings*) sono **più sensibili** alla presenze di anomalie .

surazioni di breve durata (Short-term measuremen

O'Neal WT, Chen LY, et al .
Reference ranges for short-term Heart Rate Variability measures in individuals free of cardiovascular disease: the Multi-Ethnic Study of Atherosclerosis (MESA).
J Electrocardiol. 2016

Baek HJ, Cho CH et al.
Reliability of ultra-short-term analysis as a surrogate of standard 5-min analysis of heart rate variability.
Telemed J EHealth. 2015

Munoz ML, van Roon A, et al.
Validity of (Ultra-) Short recordings for Heart Rate Variability measurements.
PLoS One. 2015

Nussinovitch U, Elishkevitz KP et al.
Reliability of Ultra-Short ECG Indices for heart rate variability.
Ann Non invasive Electrocardiol. 2011

Analisi Time Domain

'analisi nel **Dominio del tempo** (Time domain) consiste in semplici
tatistiche derivate dagli intervalli battito-battito (*interbeat interval*
BI) e sono espresse in unità di tempo (msec)

'esclusione di intervalli RR non normali (artefatti) è un prerequisito
er il calcolo dell'HRV.

Analisi Time Domain

DNN (msec) → Deviazione standard (standard deviation) SD degli ntervalli R-R normali (normal to normal) NN. Riflette attività parasimpatica e simpatica, le variazioni a breve e lungo termine

MSSD (msec) → Radice quadrata della media (root main square) RMS elle differenze al quadrato tra intervalli R-R adiacenti (differences of uccessive R-R intervals) SD.

n(rMSSD) Il logaritmo naturale di rMSSD ne favorisce il calcolo e utilizzo clinico

ANALISI FREQUENCY DOMAIN

nalisi ***Frequency domain*** → si basa sull'identificazione e quantificazion

termini di frequenza e potenza) dei principali ritmi oscillatori di origine

iologica di cui si compone una sequenza di intervalli R-R.

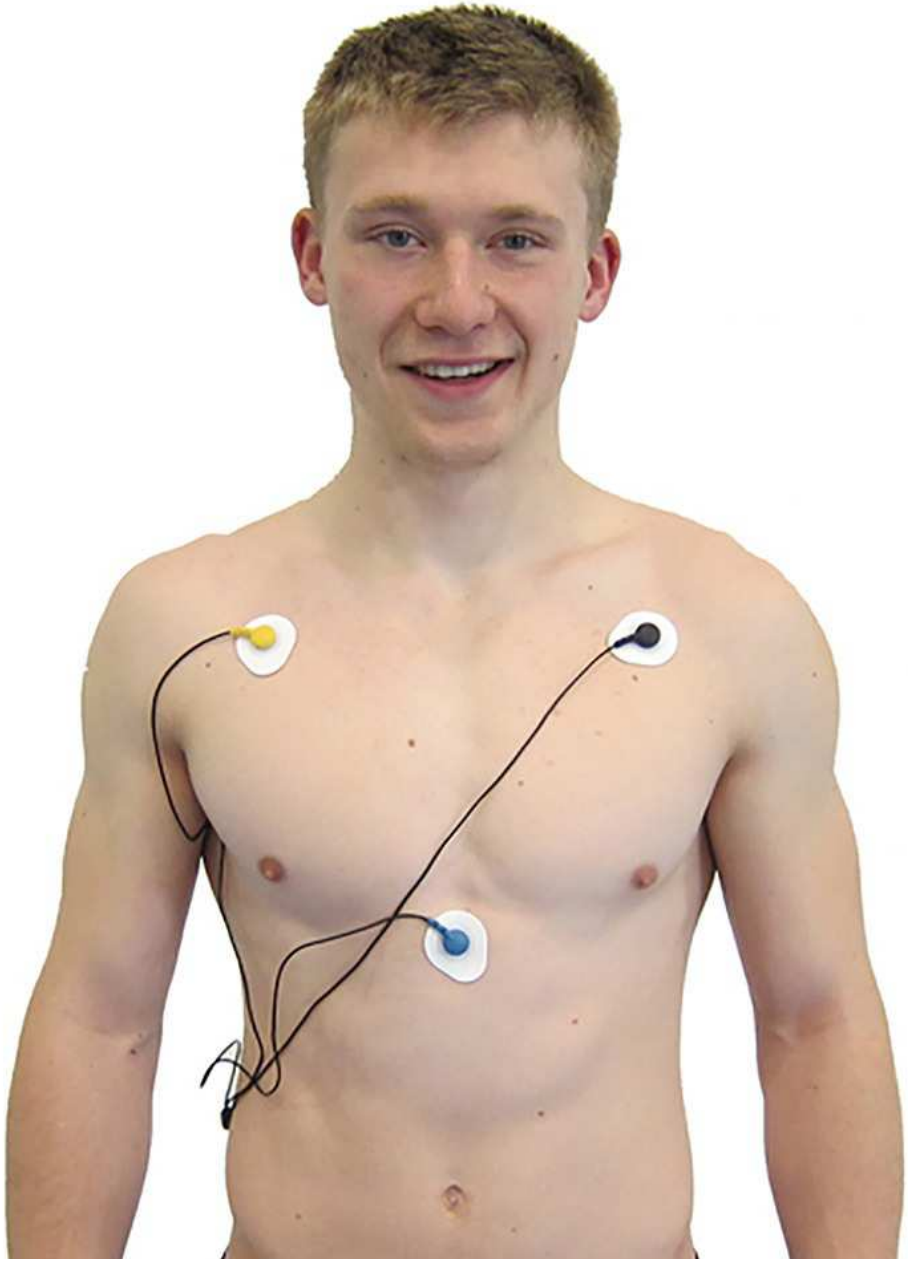
mponente ad alta frequenza (HF) → **modulazione vagale**

nge 0,15-0,45 Hz)

mponente a bassa frequenza (LF) **modulazione simpatica**

nge 0,04-0,15 Hz)

Misura e analisi della HRV



Misura e analisi della HRV

Photoplethysmographic Sensors (PPG)

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Misura e analisi della HRV

(Ultra-) Short recordings for Heart Rate Variability

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Misura e analisi della HRV

Photoplethysmographic Sensors (PPG) → the Phone's Camera

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Smartphone-enabled pulse rate variability: an alternativevbmethodology for the collection of heart rate variability in psychophysiological research.
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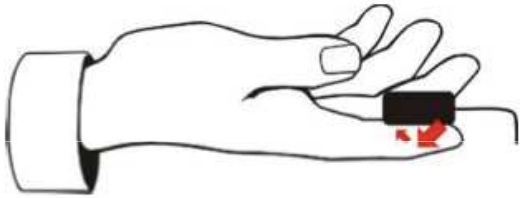

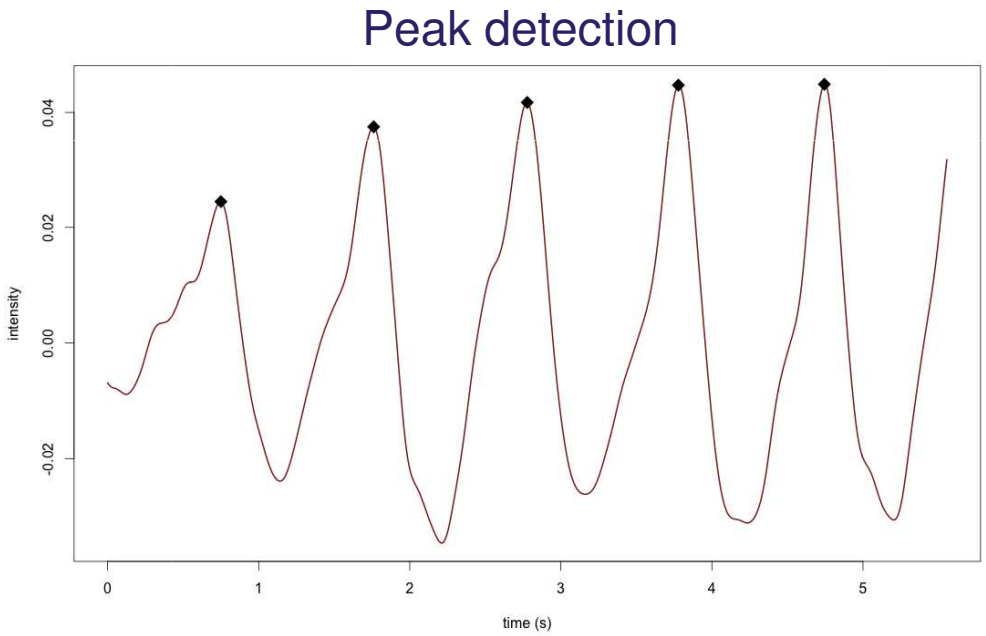

Misura e analisi della HRV

Photoplethysmographic Sensors (PPG) → the Phone's Camera

Smartphone-enabled pulse rate variability: An alternative methodology for the collection of heart rate variability in psychophysiological research☆

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ABSTRACT

Heart rate variability (HRV) is widely used to assess autonomic nervous system (ANS) function. It is traditionally collected from a dedicated laboratory electrocardiograph (ECG). This presents a barrier to collecting the large samples necessary to maintain the statistical power of between-subject psychophysiological comparisons. An alternative to ECG involves an optical pulse sensor or photoplethysmograph run from a smartphone or similar portable device: *smartphone pulse rate variability* (SPRV). Experiment 1 determined the simultaneous accuracy between ECG and SPRV systems in n = 10 participants at rest. Raw SPRV values showed a consistent positive bias, which was successfully attenuated with correction. Experiment 2 tested an additional n = 10 participants at rest, during attentional load, and during mild stress (exercise). Accuracy was maintained, but slightly attenuated during exercise. The best correction method maintained an accuracy of +/− 2% for low-frequency spectral power, and +/− 5% for high-frequency spectral power over all points. Thus, the SPRV system records a pulse-to-pulse approximation of an ECG-derived heart rate series that is sufficiently accurate to perform time- and frequency-domain analysis of its variability, as well as accurately reflecting change in autonomic output provided by typical psychophysiological stimuli. This represents a novel method by which an accurate approximation of HRV may be collected for large-sample or naturalistic cardiac psychophysiological research.

Misura e analisi della HRV

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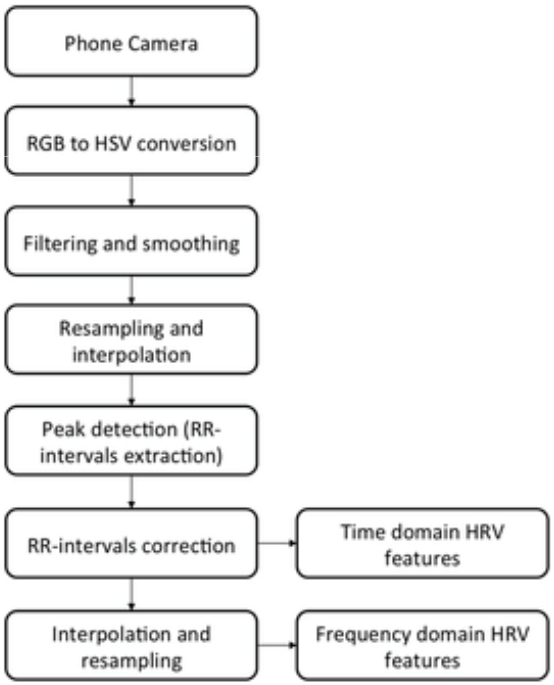

Misura e analisi della HRV

HRV ED EMOZIONI

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