Emozioni e risposte corporee: il ruolo del Sistema Nervoso Autonomo

Corso di Modelli di Computazione Affettiva e Comportamentale

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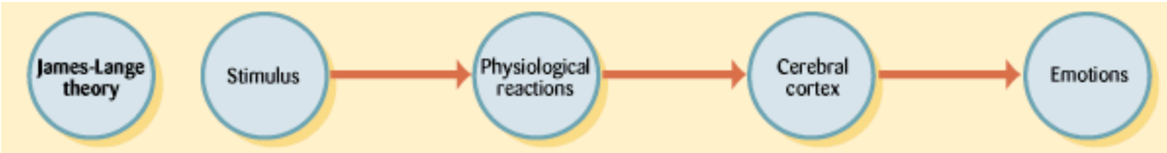
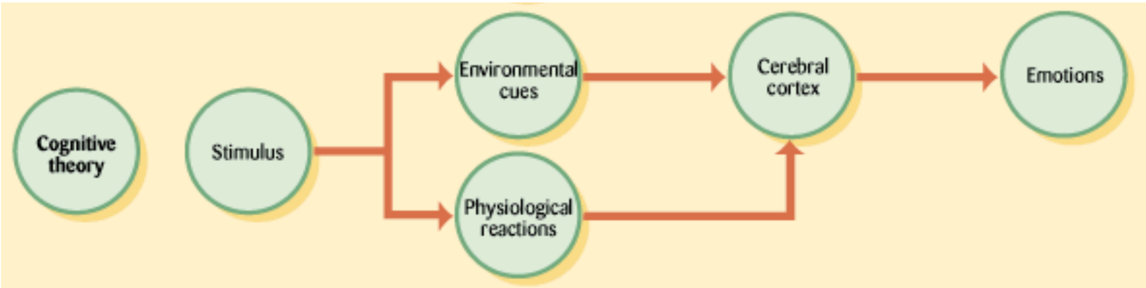
Dalla psicologia alla neurobiologia delle emozioni

- A livello psicologico si confrontano due ipotesi:
  - percezione inconscia di un certo stimolo (appraisal) che causa un cambiamento specifico nel SNA per generare l'emozione (associabile a James)
    - *''. . .the bodily changes follow directly the PERCEPTION of the exciting fact, and that our feeling of the same changes as they occur IS the emotion''*
  - l'emozione \`e un'attivazione (arousal) indistinta del SNA unita ad un appraisal cognitivo (Schachter e Singer), un raffinamento di questa teoria (Lazarus) distingue l'appraisal in due momenti, quello primario (inconscio), e quello secondario (cognitivo)

Dalla psicologia alla neurobiologia delle emozioni





Emozione e SNA
//Emozione come embodiments: James-Lange

- Stimoli emotigeni
  - suscitano specifiche variazioni viscerali e comportamentali,
    - da cui consegue l'esperienza emotiva, che dipende completamente dal feedback autonomo e somatico

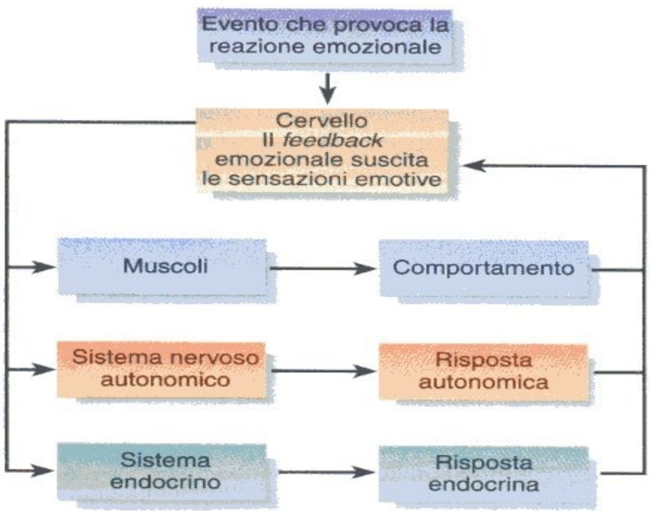
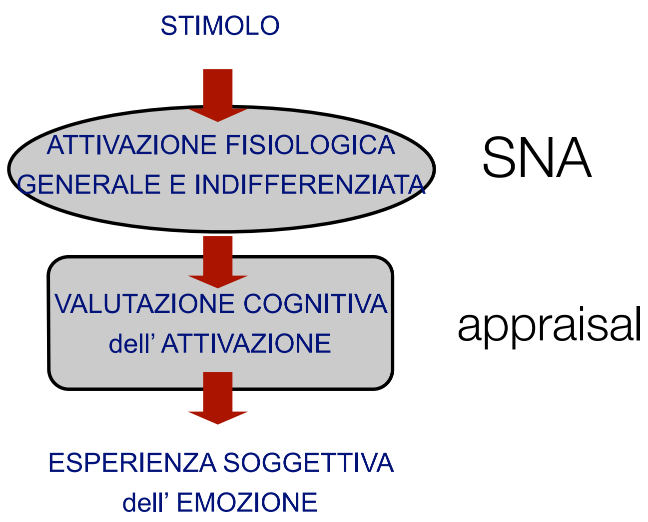


FIGURA 10.12

Una rappresentazione schematica della teoria dell'emozione di James-Lange. Un evento ambientale scatena risposte comportamentali, vegetative ed endocrine. Il *feedback* sensoriale a partenza da queste risposte produce le sensazioni emotive.

Emozione: il ruolo dell'appraisal // Schachter e Singer

- Schachter e Singer (1962): si prova un'emozione quando si sceglie un'etichetta cognitiva per designare uno stato diffuso di attivazione fisiologica cui diamo il nome di una particolare sensazione
- Emozione = arousal + appraisal
- Dati di supporto:
  - transfert
  - attribuzione errata



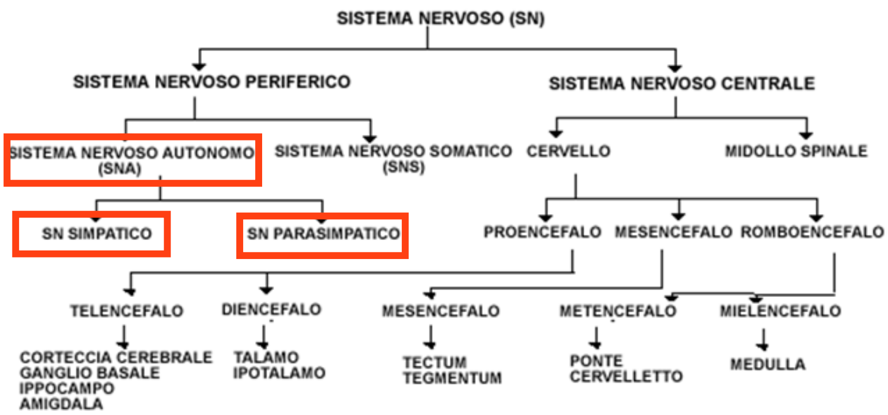
Emozione: il ruolo dell'appraisal // Schachter e Singer

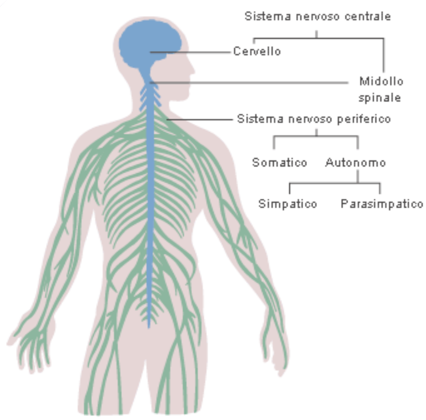
- Schachter and Singer (1962) gave some people a mild stimulant and others a placebo (on a pretence of testing vitamins). They then gave them a questionnaire containing rather personal questions. A stooge in the room got angry at the questionnaire and the people who had been given the stimulant (and who hence felt aroused) got even angrier (the people with the placebo were not that angry).
- Dutton and Aron (1974) had an attractive woman ask for interviews of young men both on a swaying rope bridge, 200 ft above a river, and also on terra firma. A part way through the interview, she gives them her phone number. Over 60% from the rope bridge called her back, versus 30% from terra firma. They had interpreted their arousal from fear on the bridge as attraction to the woman.

Dalla psicologia alla neurobiologia delle emozioni

- Problemi aperti:
    - Attivazione: è specifica per singole emozioni?
    - Azioni: i cambiamenti del SNA supportano le azioni?
    - Esperienza: il SNA è la base per esperire un emozione (feeling)?

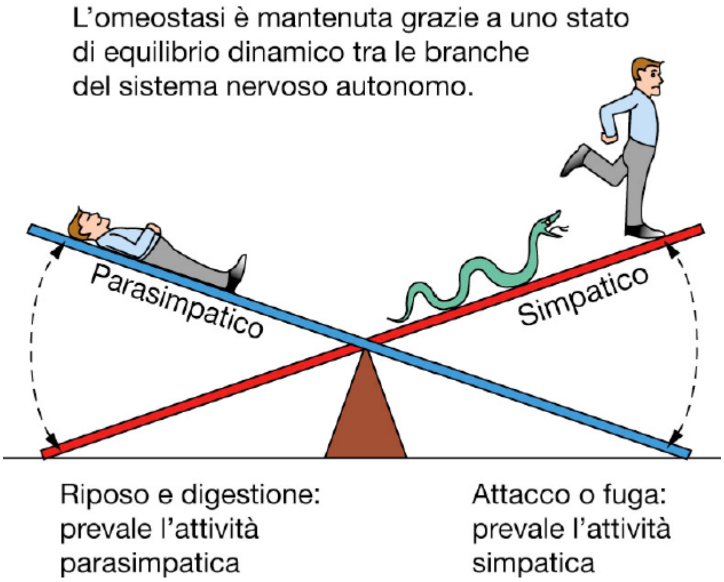
Sistema nervoso autonomo



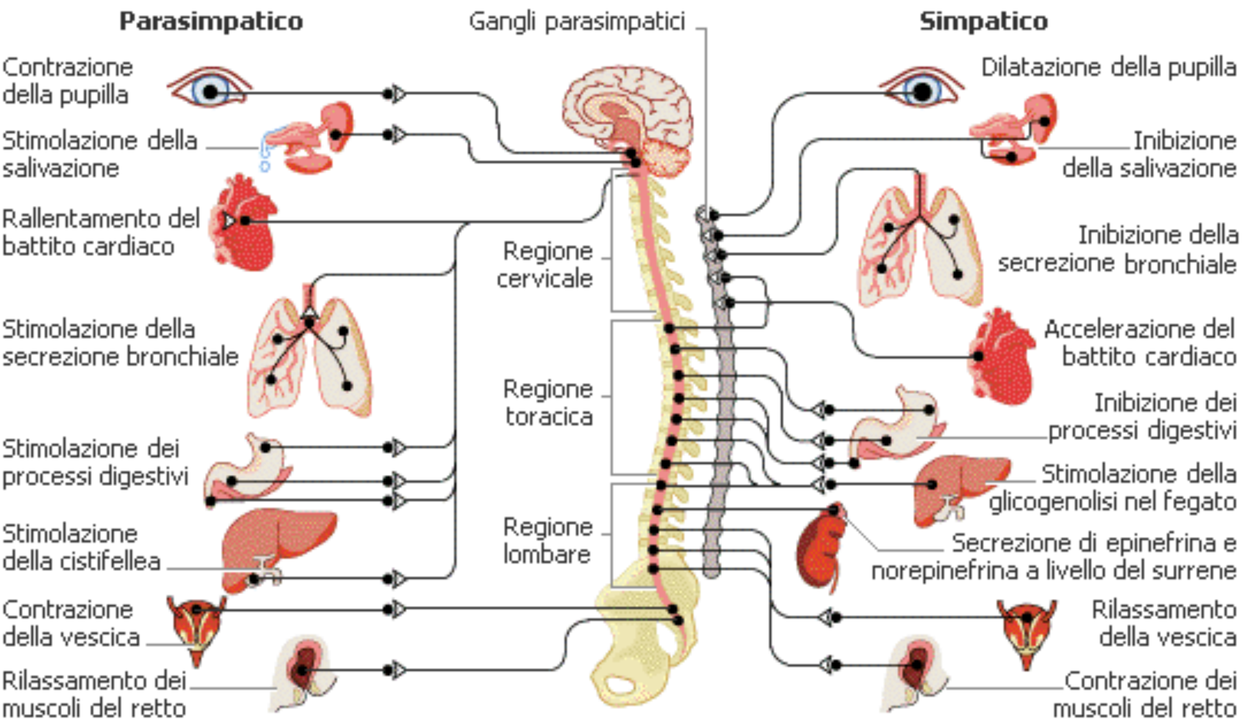


Sistema nervoso autonomo

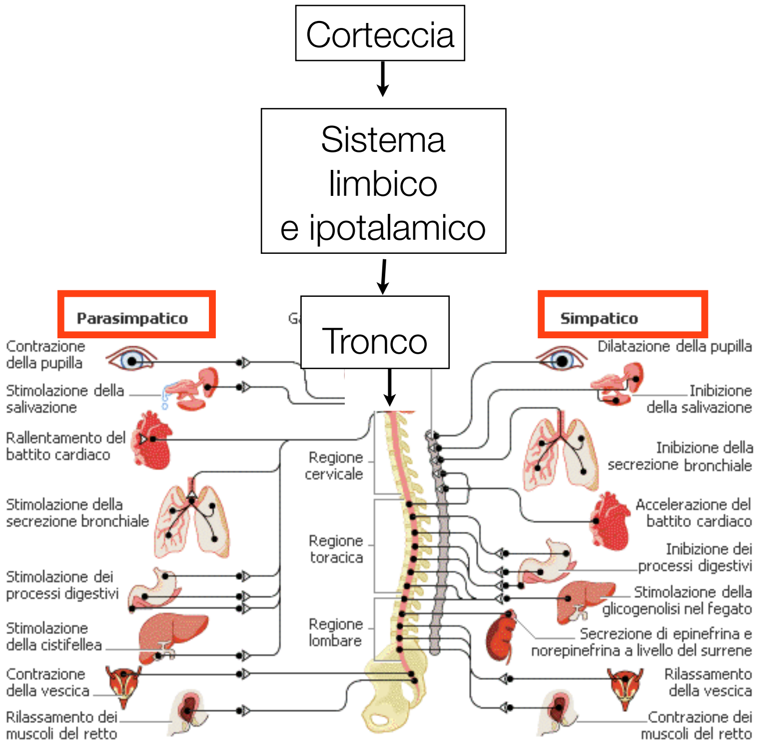
- Provvede alla regolazione delle funzioni viscerali dell'organismo, finalizzate al mantenimento dell'omeostasi del mezzo interno



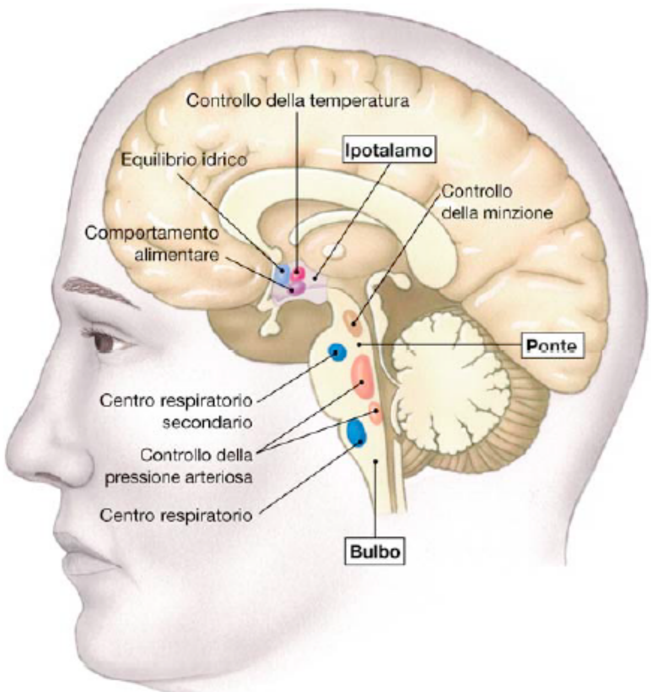
Sistema nervoso autonomo //struttura e regolazione

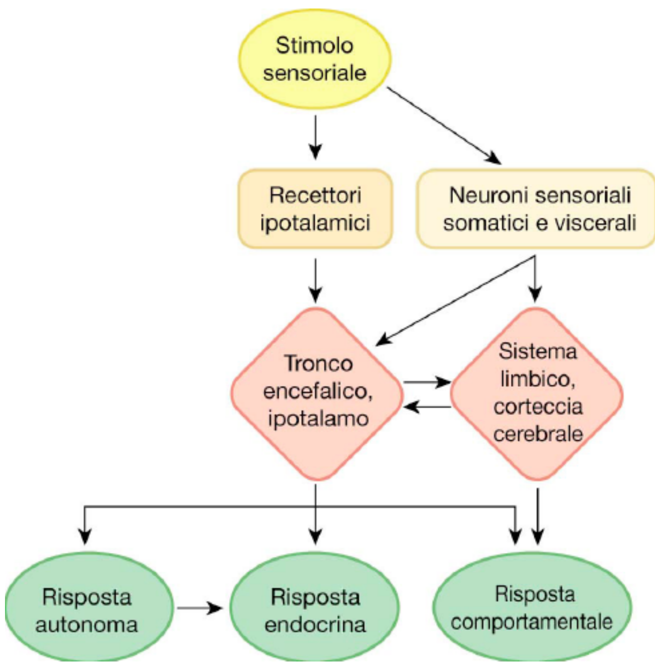


Sistema nervoso autonomo
//struttura e regolazione: da SNC a SNA



Sistema nervoso autonomo
//struttura e regolazione





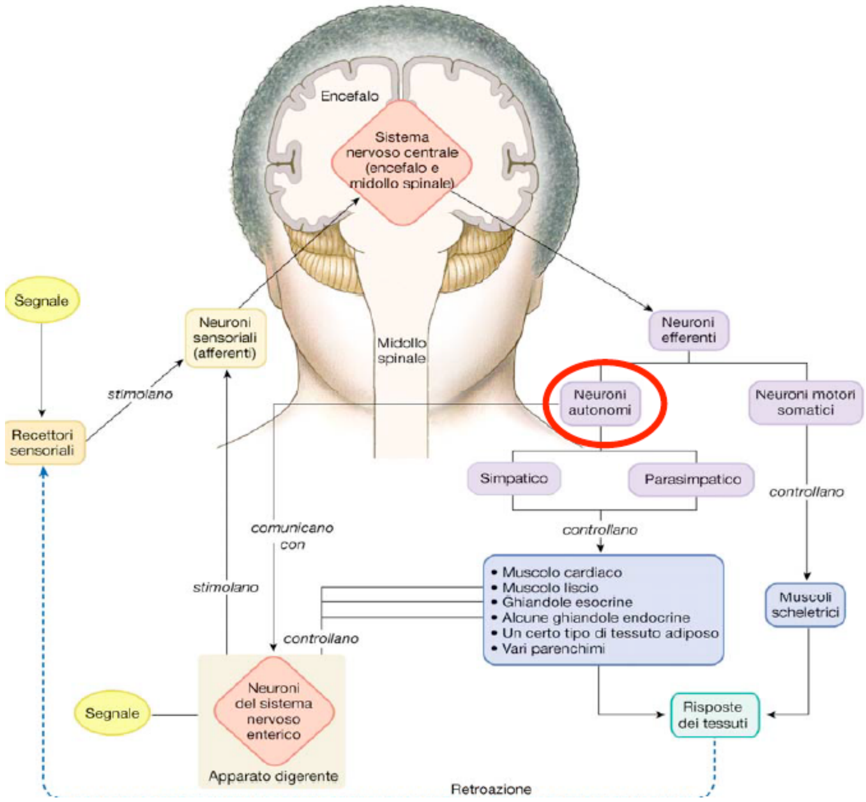
Sistema nervoso autonomo
//struttura e regolazione: relazione con ipotalamo

- Riceve segnali da tutto il corpo (informazioni viscerali, visive, termiche e dolorifiche).
- Al suo interno nascono segnali relativi a: temperatura del sangue(termocettori centrali), osmolarità plasmatica (osmocettori), glicemia (glicocettori), concentrazione di diversi ormoni.
- Informazioni interne + periferiche
    - confrontate con valori di riferimento
        - risposte finalizzate a mantenere l'omeostasi (temperatura corporea, pressione del sangue, equilibrio idrico-salino, metabolismo energetico).
- Oltre a coinvolgere il SNA le azioni ipotalamiche possono essere di tipo endocrino (dirette o mediate dall'adenoipofisi) e comportamentali (assunzione acqua e cibo, attività riproduttiva).

Sistema nervoso autonomo
//struttura e regolazione: relazione con ipotalamo

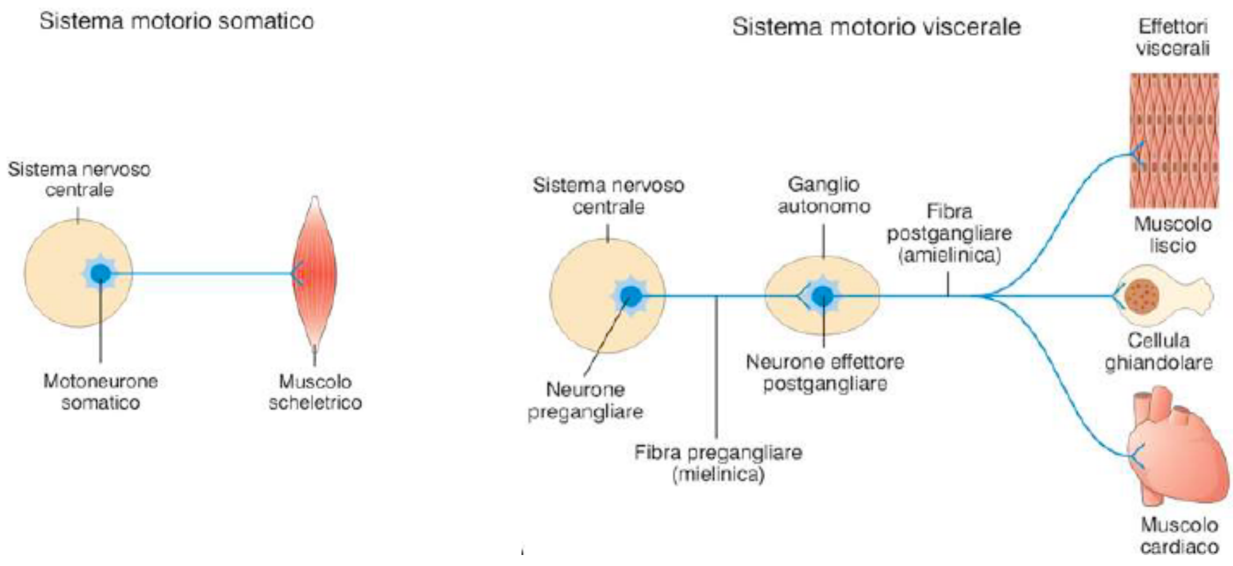
- Ipotalamo anteriore
    - risposte riconducibili ad azioni parasimpatiche (aumento motilità e secrezione gastrica, contrazione vescica)
- Ipotalamo postero-laterale
    - risposte simpatiche di lotta-fuga (aumento frequenza cardiaca, pressione arteriosa, frequenza respiratoria, diminuzione motilità gastro-intestinale, aumento flusso ematico muscolare)

Sistema nervoso autonomo
//struttura e regolazione

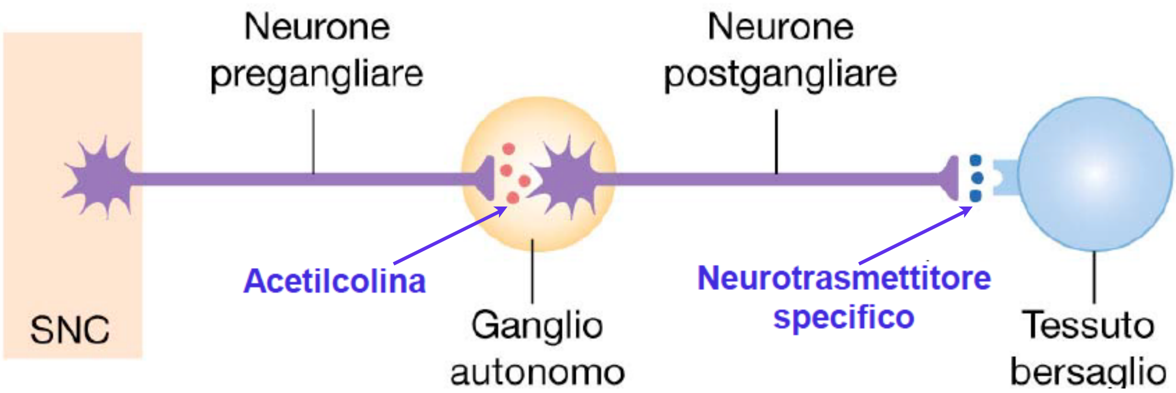


Sistema nervoso autonomo
//struttura e regolazione

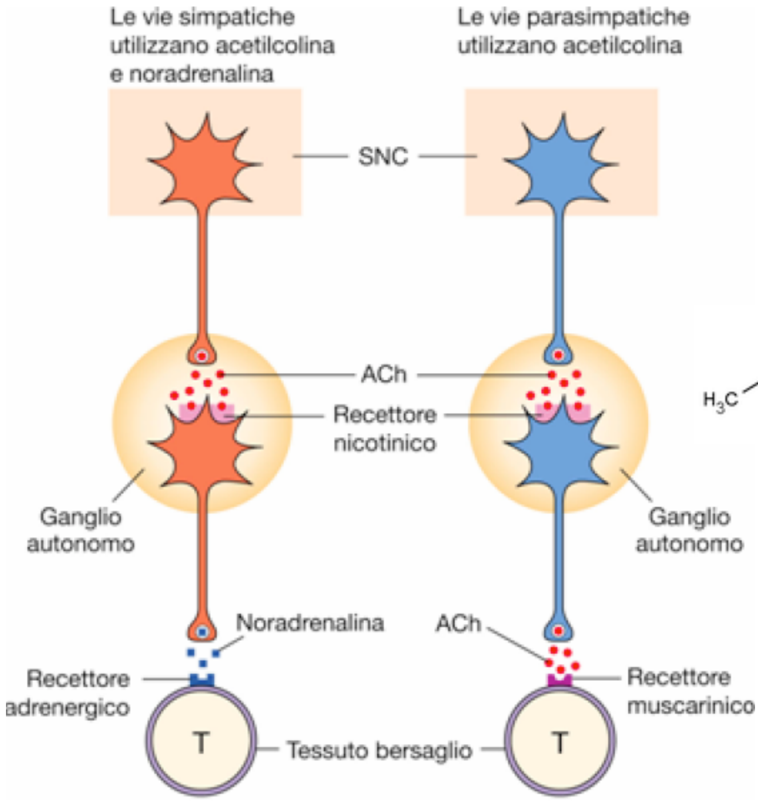
- Il SNA opera soprattutto attraverso archi riflessi viscerali

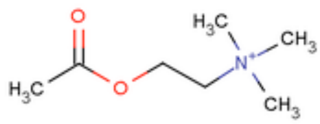


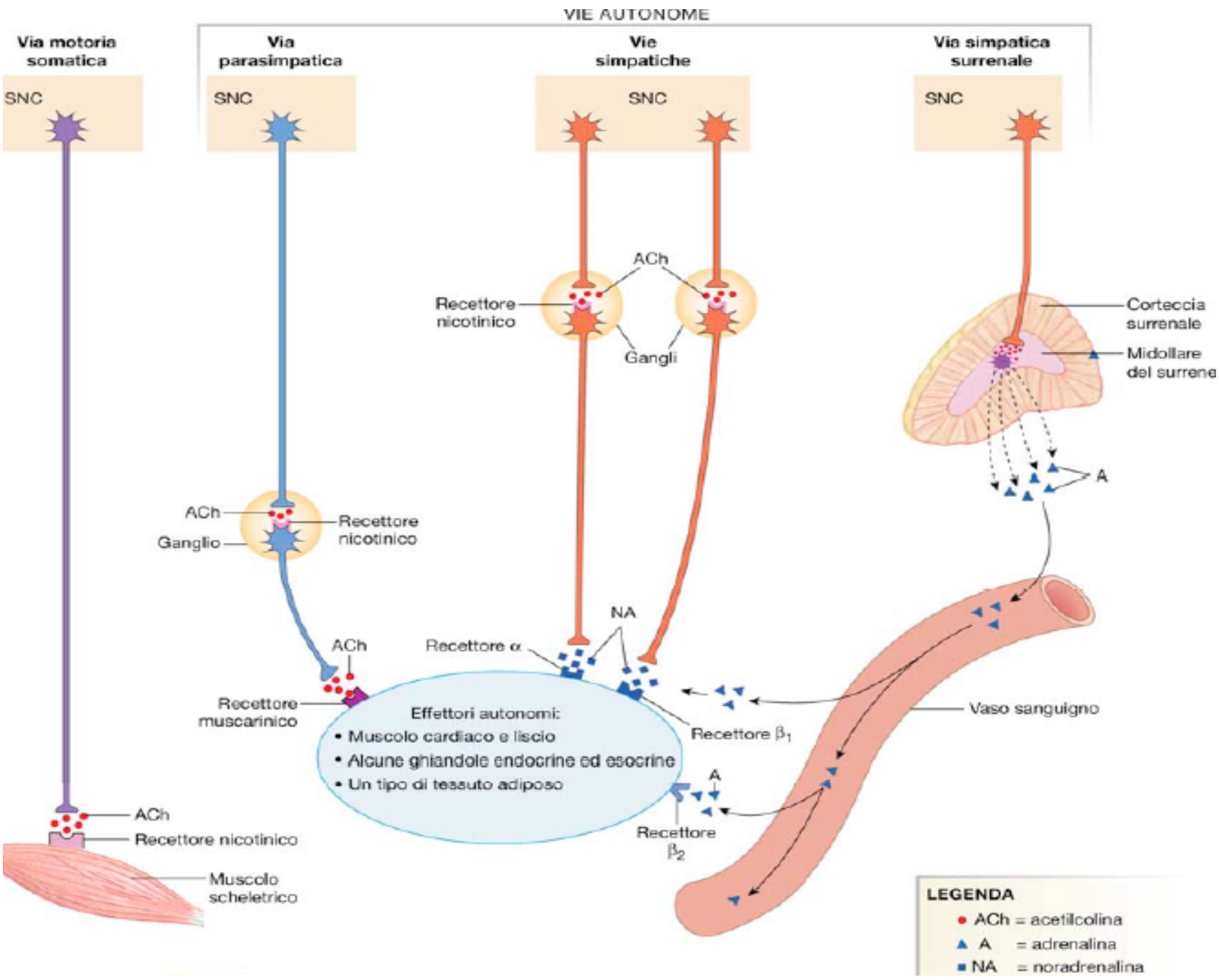
Sistema nervoso autonomo
//struttura e regolazione



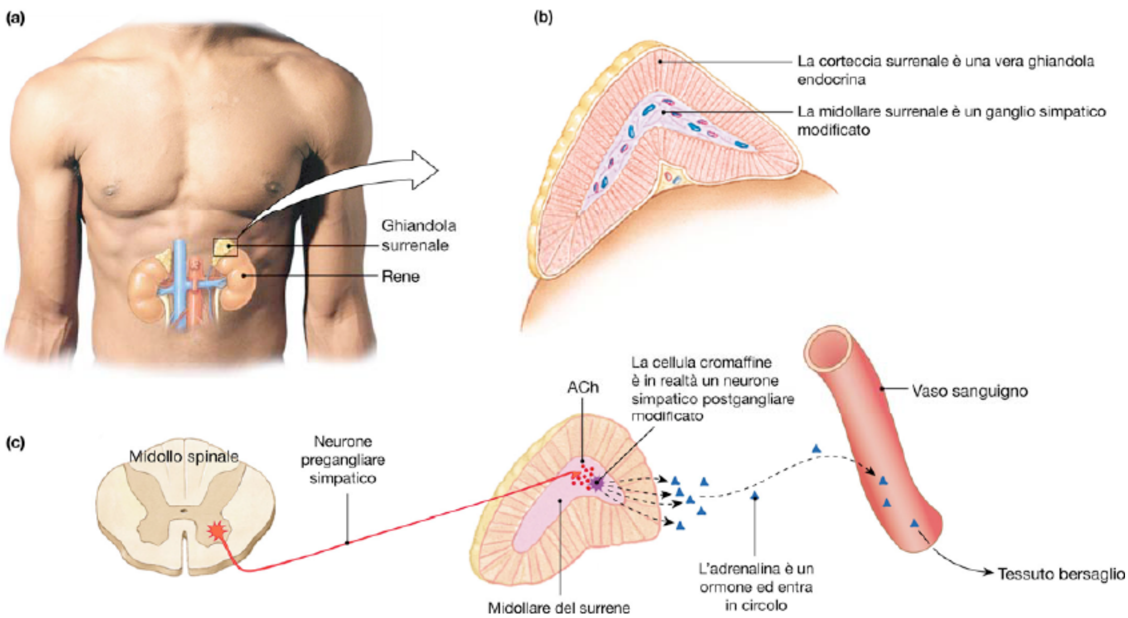
Sistema nervoso autonomo
//struttura e regolazione: neurotrasmettitori

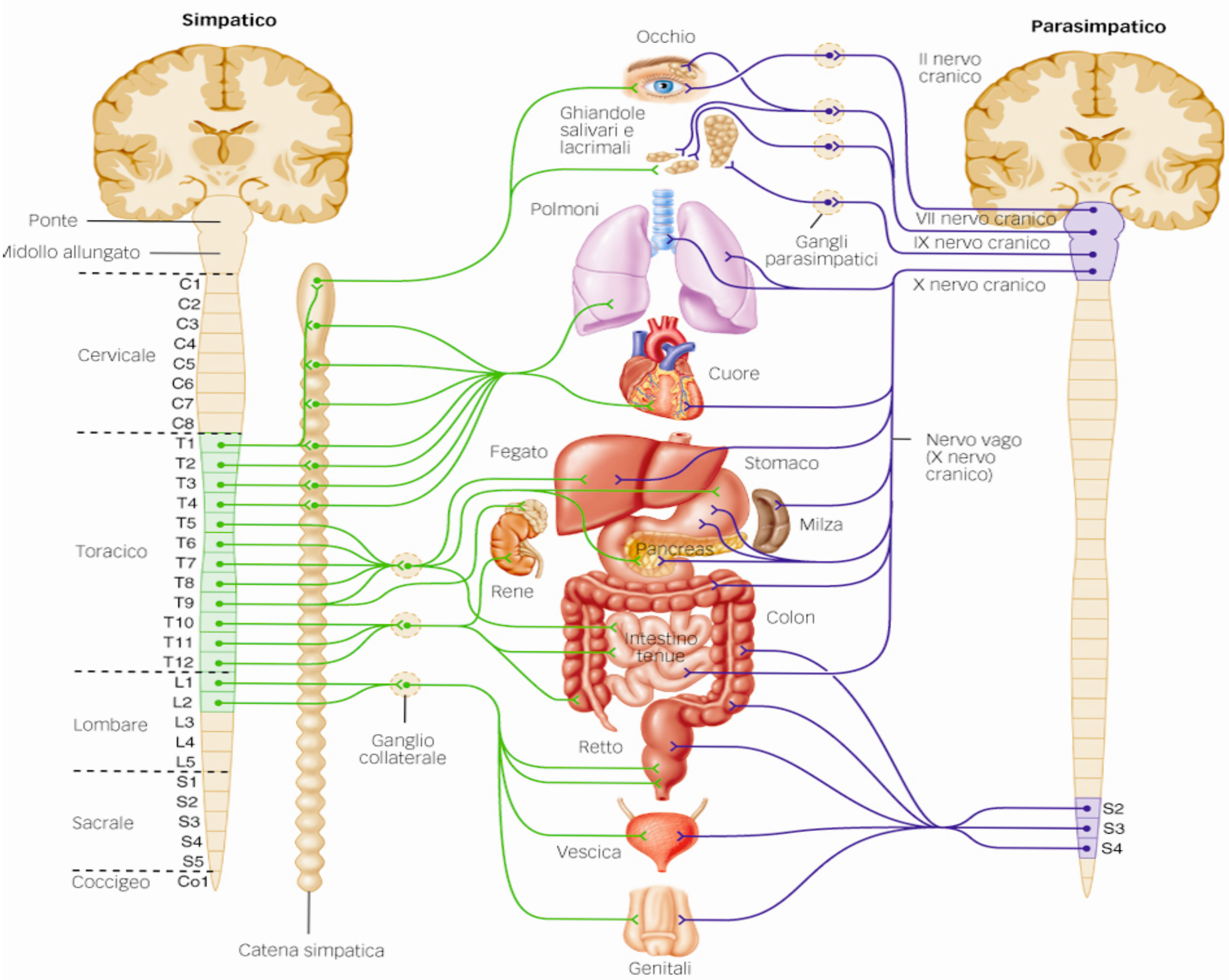




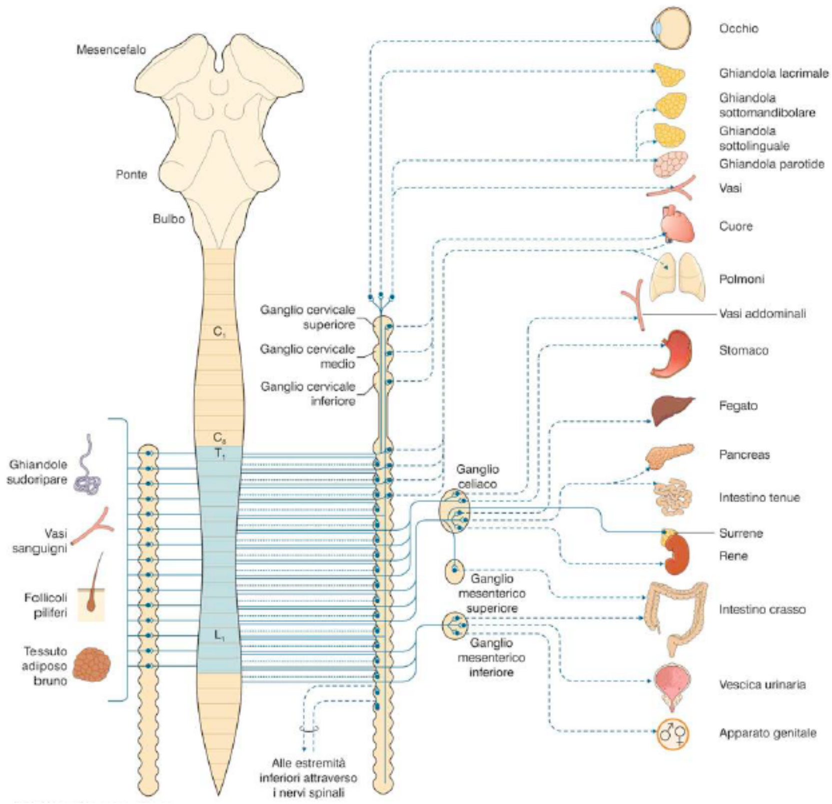


Sistema nervoso autonomo //struttura e regolazione: via surrenale

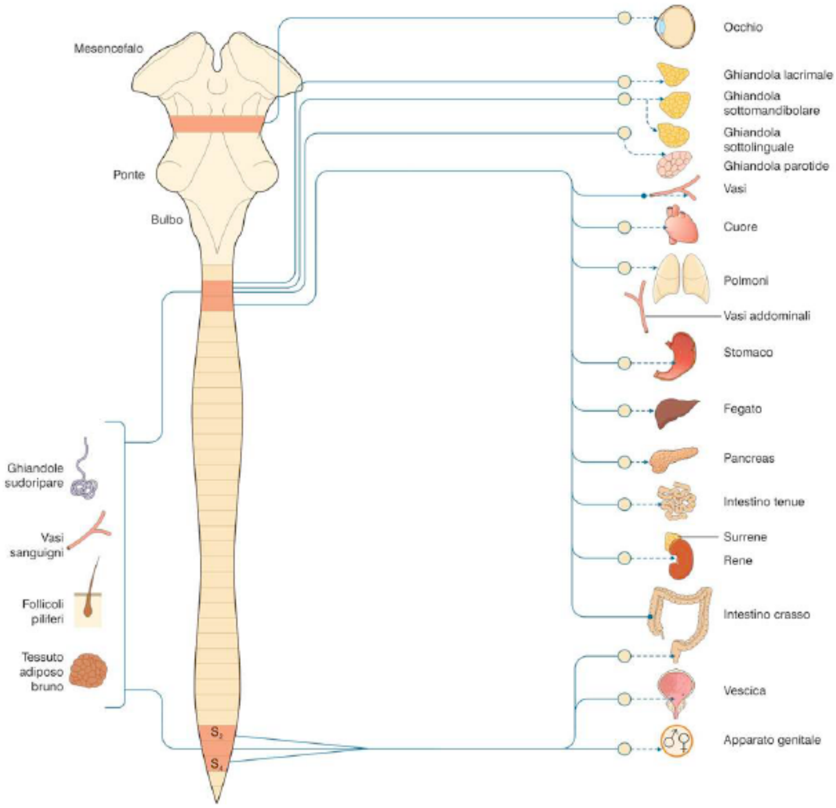




Sistema nervoso autonomo //simpatico

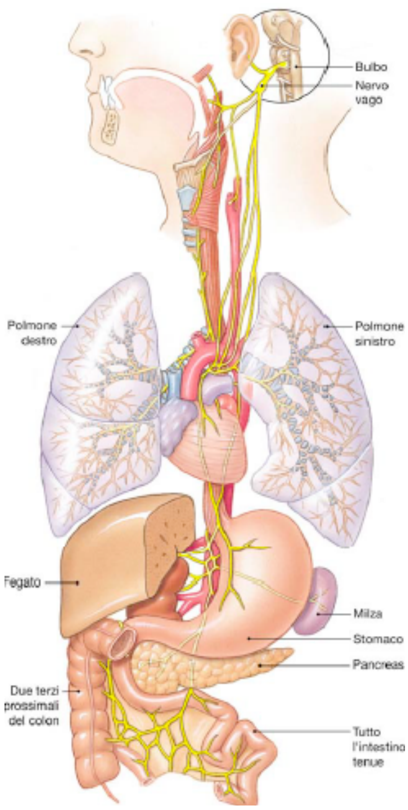


Sistema nervoso autonomo //parasimpatico

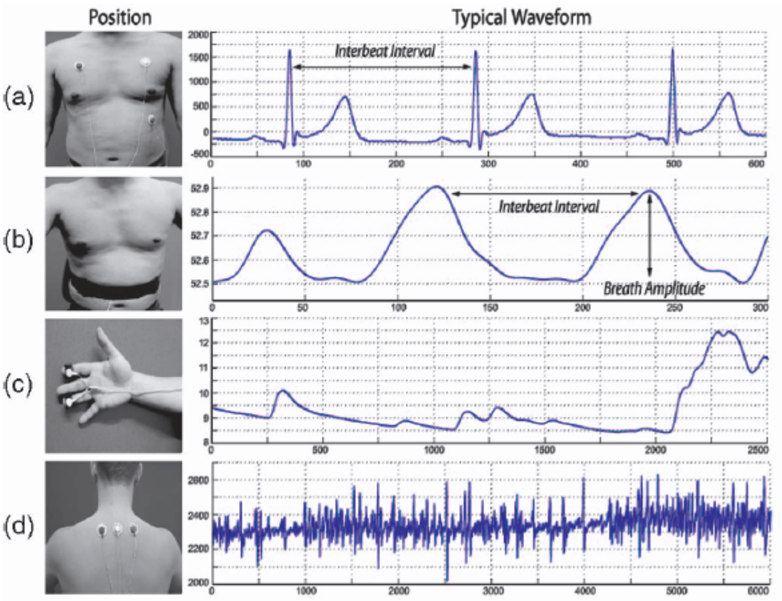


Sistema nervoso autonomo //parasimpatico: sottosistema vagale

- Il nervo vago



Sistema nervoso autonomo //misurazione dell'attività



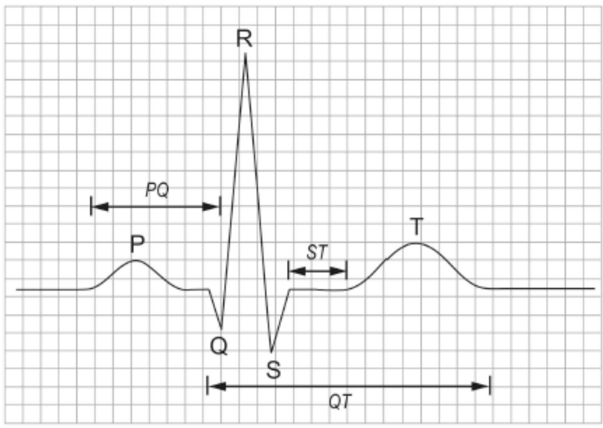
Electrocardiogram: measure the average action potential on the skin
Heart rate variability (HRV) refers to the oscillation of the interval between consecutive heartbeats

Respiration: RSP belt used to capture the breathing activity of the subjects. It can be worn either thoracically or abdominally over clothing. The amount of stretch in the elastic is measured as a voltage change and recorded. The rate of RSP and depth of breath are the most common measures of RSP

Skin Conductivity sensor measures the skin's ability to conduct electricity

Electromyogram measures muscle activity by detecting surface voltages that occur when a muscle is contracted.

Sistema nervoso autonomo //misurazione dell'attività: Hearth Rate Variability



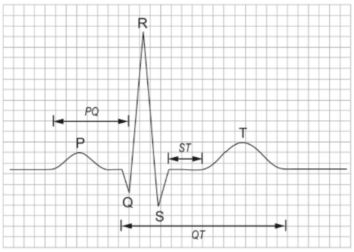
QRS waveform in an ECG signal. Usual lengths: P-wave (0.08-0.10 s),

QRS (0.06-0.10 s),

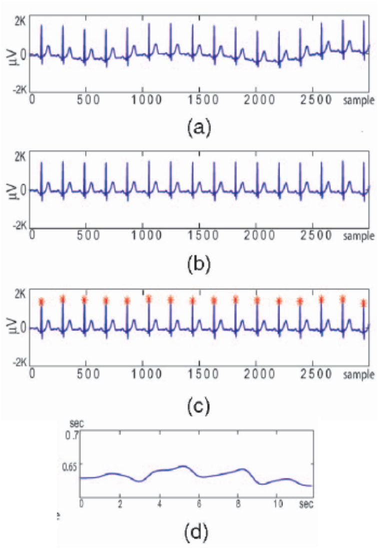
PR-interval (0.12-0.20 s), and

QTc-interval

Sistema nervoso autonomo
//misurazione dell’attività: Hearth Rate Variability



QRS waveform in an ECG signal. Usual lengths: P-wave (0.08-0.10 s), QRS (0.06-0.10 s), PR-interval (0.12-0.20 s), and QTc-interval



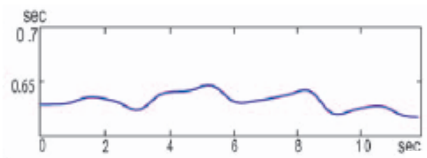
Raw ECG signal with RSP (respiration) artifacts

Detrended signal

Detected RR interbeats

Interpolated HRV time series using RR intervals

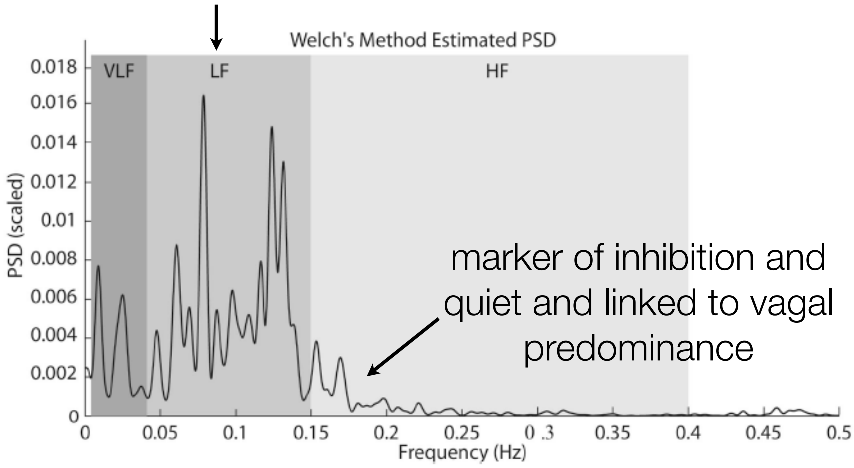
Sistema nervoso autonomo
//misurazione dell’attività: Hearth Rate Variability



$$R_{ff}(\tau) = \mathrm{E}\left[f(t)\overline{f}(t-\tau)\right]$$

$$S(f) = \int_{-\infty}^{\infty} R(\tau)\, e^{-2\pi i f \tau}\, d\tau = \mathcal{F}(R(\tau)).$$

a marker of excitation and intrinsic in sympathetic activation



marker of inhibition and quiet and linked to vagal predominance

Fig. 8. Example of the heart rate spectrum in three subbands using the 1,024-point Fast Fourier transform.

Sistema nervoso autonomo
//misurazione dell'attività: nuove prospettive

A Portable Emotion Auxiliary Device

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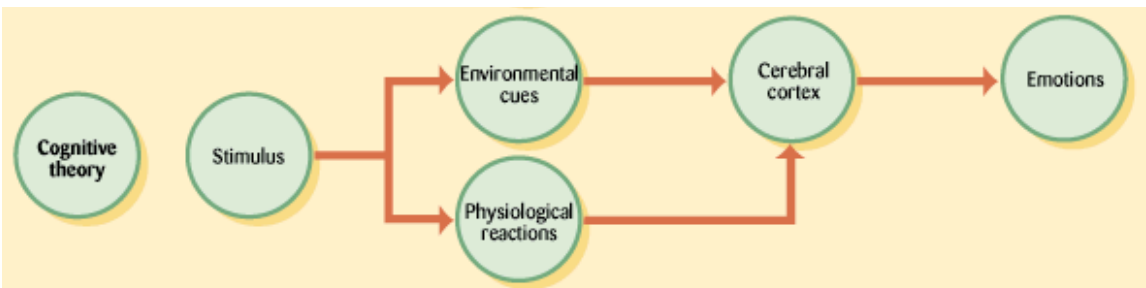
Abstract—**Adequate reminding would facilitate the management of emotion. That would prevent out control of destructive rage, and facilitate the emotion expression and balance. This study developed a portable system for emotion assessment basing on HRV method, which would feedback to user with proper advices for help the management of emotion. The system is constructed with an embedded system and a PDA phone, which firstly measures the ECG signal, and then analyzes HRV, finally presents the emotion status.**

Keywords—**Emotion, HRV, MSP430, Portable, PDA**

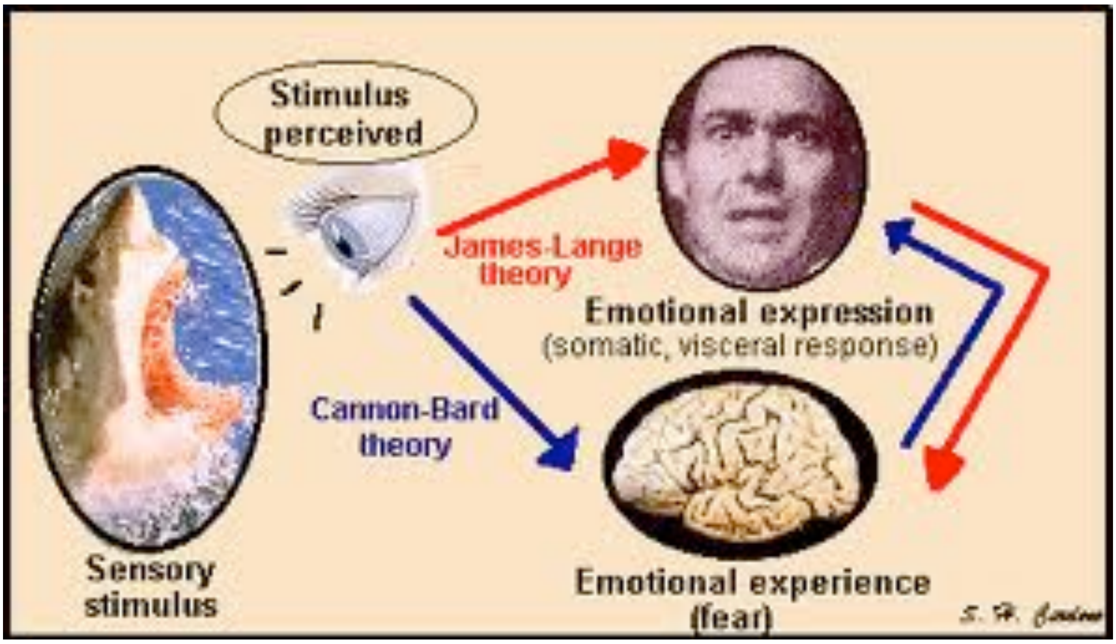
sympathetic activation. HRV analysis can be divided into time-domain, frequency-domain, and nonlinear methods. Frequency-domain HRV analysis is performed using the nonparametric method of the fast Fourier transform (FFT). The direct current component is deleted and a Hamming window is used to attenuate the leakage effect [3]. The HRV power spectral density (PSD) is on the basis of FFT.

PSD is obtained from the analysis of successive discrete RR interval series taken from the ECG. The power spectrum is divided into 3 major frequency ranges: low frequency (LF), medium frequency (MF), and high frequency (HF).

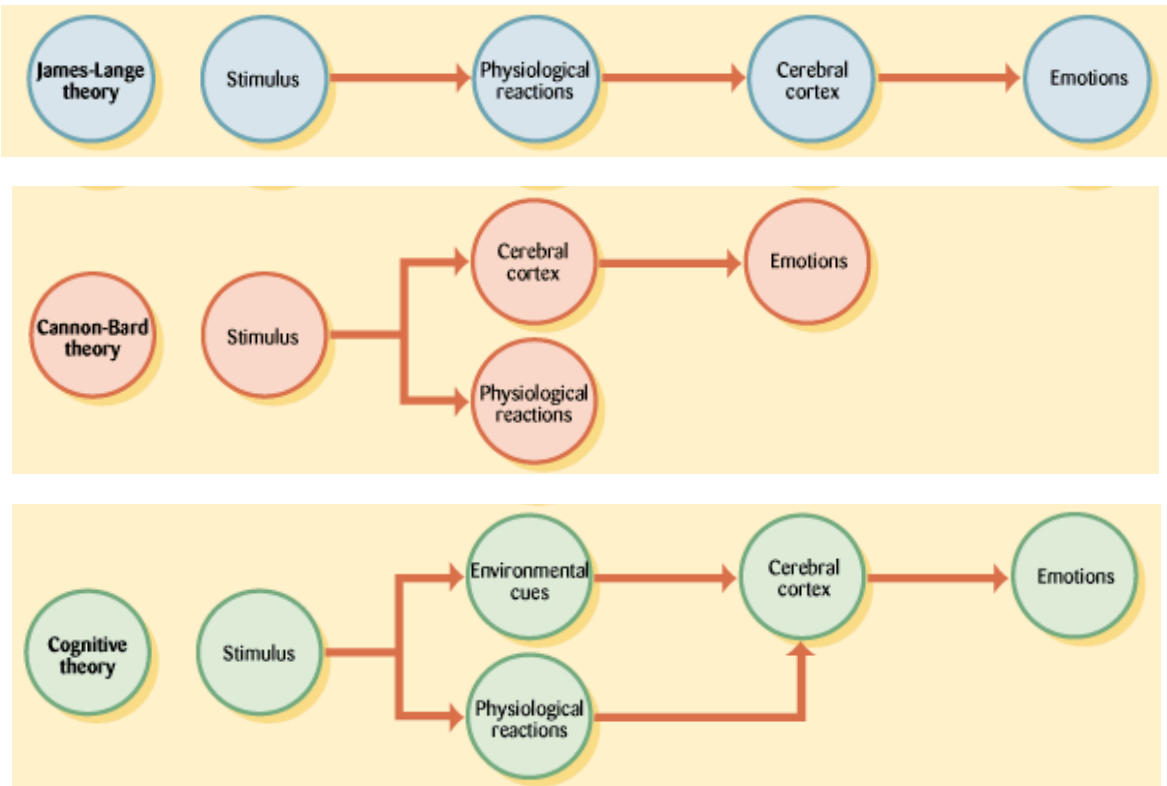
Sistema nervoso autonomo
//quale ruolo?



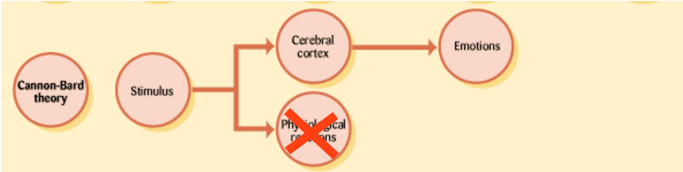
La critica neurobiologica a James: //Cannon & Bard



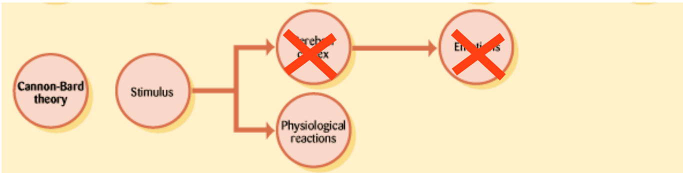
La critica neurobiologica a James: //Cannon & Bard



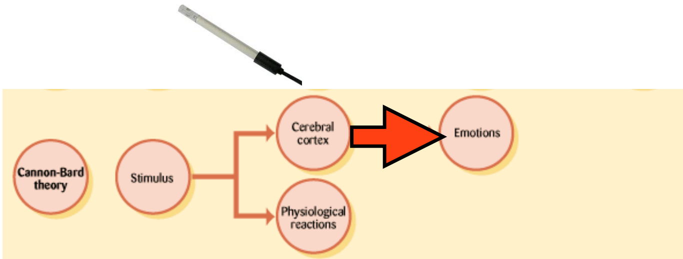
La critica neurobiologica a James: //Cannon & Bard: esperimenti



resezione di afferenti al SNA



rimozione ipotalamo

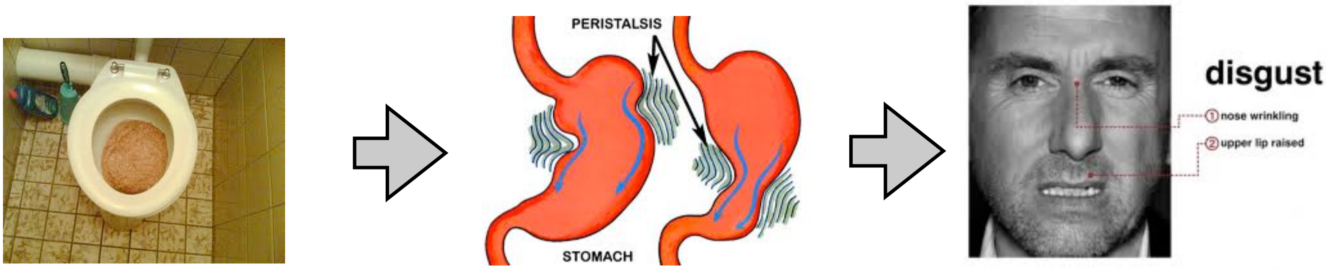


stimolazione ipotalamo (sham rage)

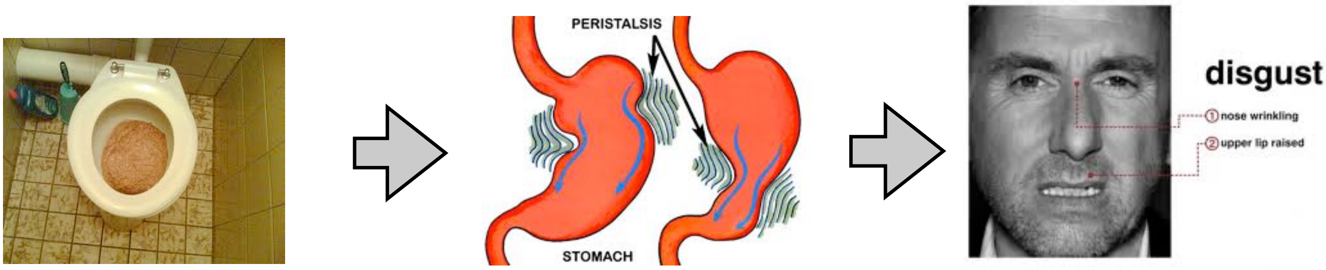
La critica neurobiologica a James: //Cannon & Bard: sintesi

- Problemi aperti:
  - Attivazione: è specifica per singole emozioni?
    - Indifferenziata, diffusa e non specifica, attivazione anche in stati non emotivi (febbre)
  - Azioni: i cambiamenti del SNA supportano le azioni?
    - No, attivazione troppo lenta
  - Esperienza: il SNA è la base per esperire un emozione (feeling)?
    - Non accessibile alla coscienza

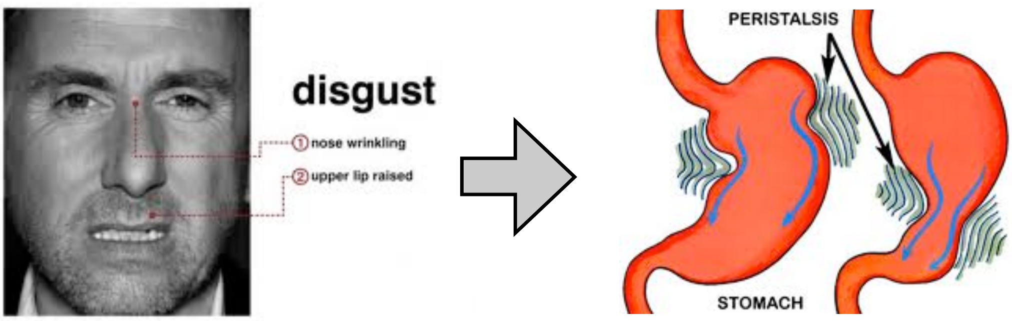
Il supporto neurobiologico a James: //Bob Levenson (+ Ekman & Friesen): DFA



Il supporto neurobiologico a James: //Bob Levenson (+ Ekman & Friesen): DFA



- DFA: directed facial action task



Sistema nervoso autonomo //specificità: DFA (Levenson, Ekman, Friesen, 1990)

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Voluntary Facial Action Generates Emotion-Specific Autonomic Nervous System Activity

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University of California, San Francisco

ABSTRACT

Four experiments were conducted to determine whether voluntarily produced emotional facial configurations are associated with differentiated patterns of autonomic activity, and if so, how this might be mediated. Subjects received muscle-by-muscle instructions and coaching to produce facial configurations for anger, disgust, fear, happiness, sadness, and surprise while heart rate, skin conductance, finger temperature, and somatic activity were monitored. Results indicated that voluntary facial activity produced significant levels of subjective experience of the associated emotion, and that autonomic distinctions among emotions: (a) were found both between negative and positive emotions and among negative emotions, (b) were consistent between group and individual subjects' data, (c) were found in both male and female subjects, (d) were found in both specialized (actors, scientists) and nonspecialized populations, (e) were stronger when the voluntary facial configurations most closely resembled actual emotional expressions, and (f) were stronger when experience of the associated emotion was reported. The capacity of voluntary facial activity to generate emotion-specific autonomic activity: (a) did not require subjects to see facial expressions (either in a mirror or on an experimenter's face), and (b) could not be explained by differences in the difficulty of making the expressions or by differences in concomitant somatic activity.

Sistema nervoso autonomo //specificità: DFA (Levenson, Ekman, Friesen, 1990)

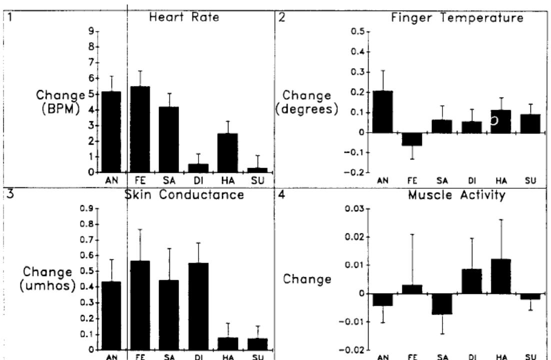


Figure 2. Heart rate (panel 1), finger temperature (panel 2), skin conductance (panel 3), and muscle activity (panel 4) changes and standard errors during six emotional configurations. AN = Anger, FE = Fear, SA = Sadness, DI = Disgust, HA = Happiness, SU = Surprise.

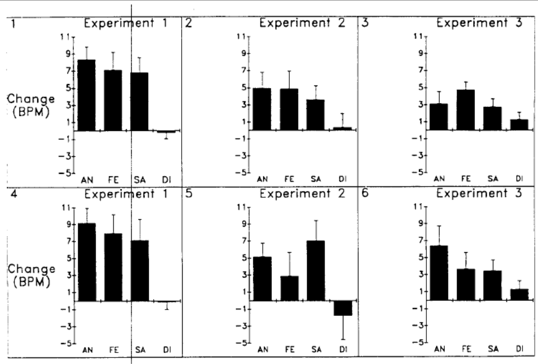


Figure 4. Heart rate changes and standard errors during four negative emotional configurations in Experiments 1, 2, and 3. Panels 1, 2, and 3 portray data from all trials; Panels 4, 5, and 6 portray data from trials in which configurations most closely resembled universal emotional expressions. AN = Anger, FE = Fear, SA = Sadness, DI = Disgust.

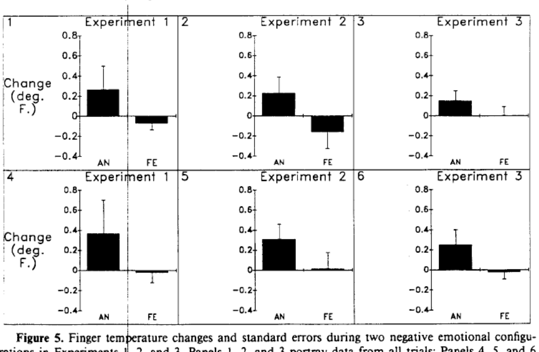


Figure 5. Finger temperature changes and standard errors during two negative emotional configurations in Experiments 1, 2, and 3. Panels 1, 2, and 3 portray data from all trials; Panels 4, 5, and 6 portray data from trials in which configurations most closely resembled universal emotional expressions. AN = Anger, FE = Fear.

Table 1

Hit rates for individual subjects showing distinctions between emotions found in group data

Distinctions	Number of Matches	Number of Cases	Hit Rate
Between negative and positive emotions:			
Heart rate acceleration larger for anger than happiness	38	60	63.3%
Heart rate acceleration larger for fear than happiness	42	61	68.9%
Skin conductance level increase greater for fear than happiness	39	61	63.9%
Skin conductance level increase greater for disgust than happiness	37	61	60.7%
All	156	243	64.2%
Among negative emotions:			
Heart rate acceleration larger for anger than disgust	43	59	72.9%
Heart rate acceleration larger for fear than disgust	44	60	73.3%
Heart rate accleration larger for sadness than disgust	38	58	65.5%
Finger temperature increase larger for anger than fear	36	59	61.0%
All	161	236	68.2%

Sistema nervoso autonomo
//specificità: DFA (Levenson, 2003)

Blood, Sweat, and Fears

The Autonomic Architecture of Emotion

ROBERT W. LEVENSON

TABLE 1. Changes in appearance and ANS activity associated with specific emotions

Type	Change	ANS-Mediated Basis	Emotion
Coloration	reddening	vasodilation, increased contractility	anger
	blushing	vasodilation	embarrassment
	blanching	vasoconstriction	fear
Moisture and secretions	sweating, clamminess	sweat glands	fear
	salivating, drooling	salivary glands	disgust
	foaming	salivary glands	anger
	tearing, crying	lacrimal glands	sadness
	lubricating	mucus membranes	sexual arousal
Protrusions	piloerection	muscle fibers at base of hair follicles	fear, anger
	genital erection	vasodilation	sexual arousal
	blood vessels bulging	vasodilation	anger
Appearance of eyes	constriction	pupils	anger
	dilation	pupils	fear
	bulging	eyelid muscles	anger, fear
	drooping lids	eyelid muscles	sexual arousal
	twinkling	lacrimal glands plus contraction of orbicularis oculi	happiness

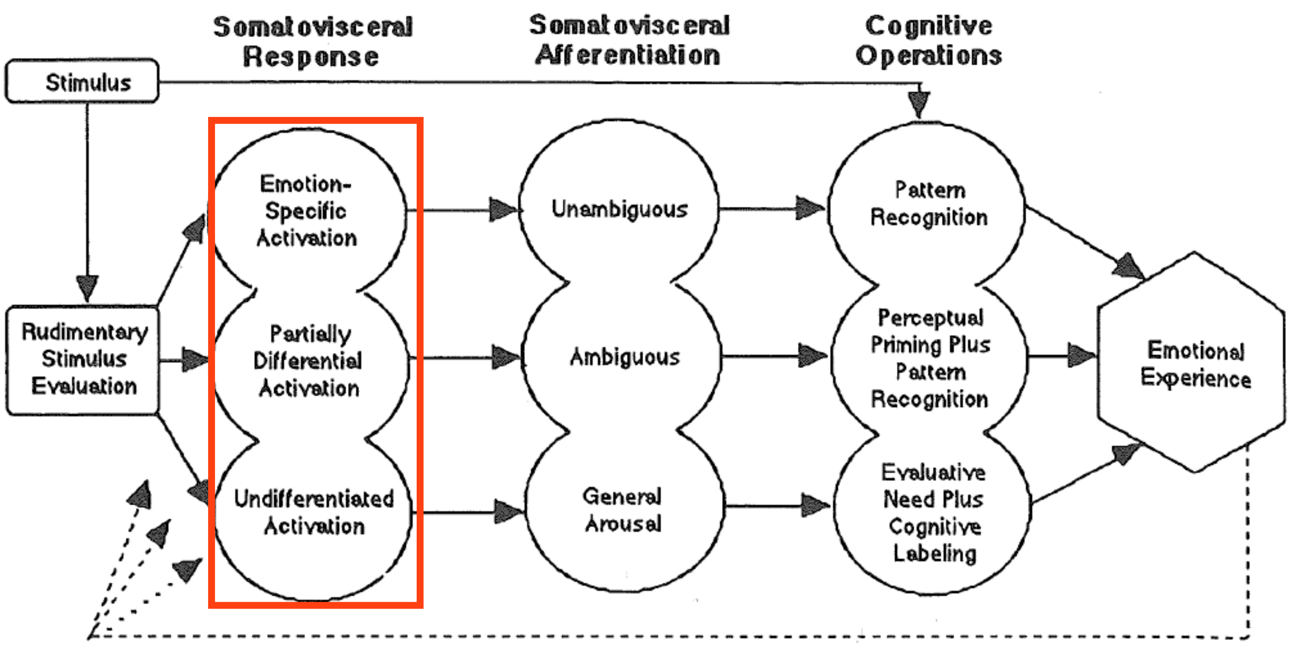
Ann. N.Y. Acad. Sci. 1000: 348–366 (2003). © 2003 New York Academy of Sciences.

Il supporto neurobiologico a James:
//Mark Leary: arrossire (blushing)

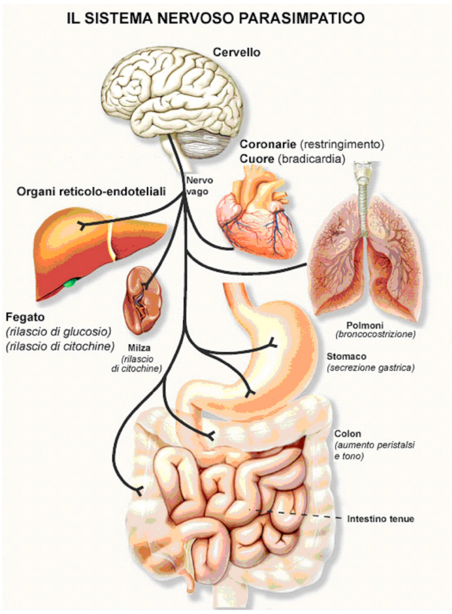
- Critica dell'ipotesi di Darwin
- Causa: attenzione sociale indesiderata (ansietà sociale)
- Reazione legata all'imbarazzo
- Inibizione del simpatico, aumento del parasimpatico

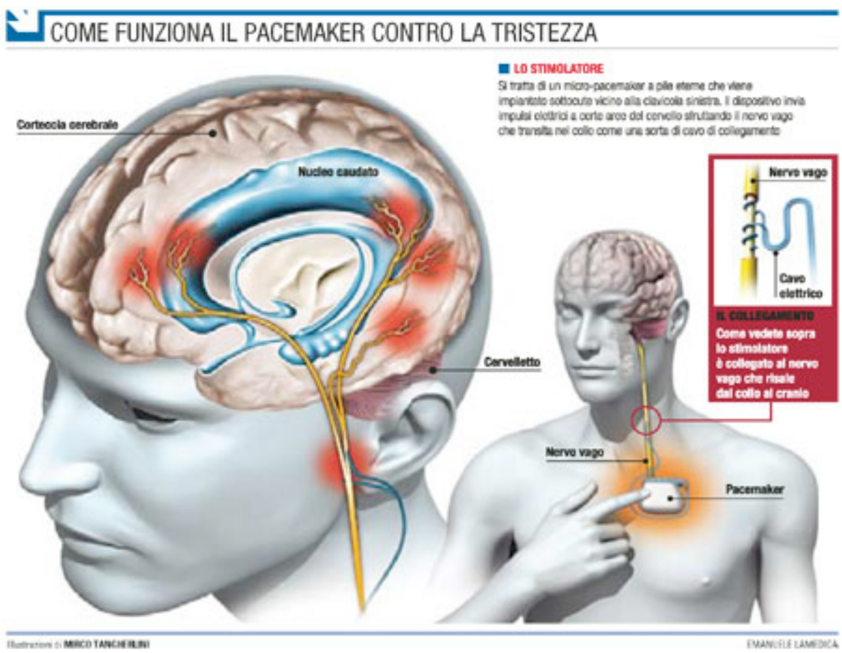
	flusso sanguigno guance	temperatura guance	HRV	conduttanza dita	correlazione colorito/temp.
imbarazzo	↑	↑	↓	↑	↓
paura			↑		↑

Sistema nervoso autonomo
//quale ruolo?



Sistema nervoso autonomo
//il ruolo del nervo vago





Il supporto neurobiologico a James:
//nervo vago e affetti pro-sociali (Porges)

- The polyvagal theory of emotion proposes that the evolution of the autonomic nervous system provides the organizing principle to interpret the adaptive significance of affective processes. The theory proposes that the evolution of the mammalian autonomic nervous system, and specifically the brainstem regulatory centers of the vagus and other related cranial nerves, provides substrates for emotional experiences and affective processes that are necessary for social behavior in mammals. In this context, the evolution of the nervous system limits or expands the ability to express emotions, which in turn may determine proximity, social contact, and the quality of communication

- Unlike the architectural dictum that form (i.e., structure) follows function, the function of the nervous system is derivative of structure. The flexibility or variability of autonomic nervous system function is totally dependent on the structure

Il supporto neurobiologico a James:
//nervo vago e affetti pro-sociali (Porges)

- 1. Emotion depends on the communication between the autonomic nervous system and the brain; visceral afferents convey information on physiological state to the brain and are critical to the sensory or psychological experience of emotion, and cranial nerves and the sympathetic nervous system are outputs from the brain that provide somatomotor and visceromotor control of the expression of emotion.

- 2. Evolution has modified the structures of the autonomic nervous system.

- 3. Emotional experience and expression are functional derivatives of structural changes in the autonomic nervous system due to evolutionary processes.

- 4.The mammalian autonomic nervous system retains vestiges of phylogenetically older autonomic nervous systems.

- 5.The phylogenetic“level” of the autonomic nervous system determines affective states and the range of social behavior.

- 6. In mammals, the autonomic nervous system response strategy to challenge follows a phylogenetic hierarchy, starting with the newest structures and, when all else fails, reverting to the most primitive structural system.

Il supporto neurobiologico a James: //nervo vago e affetti pro-sociali (Porges)

THE POLYVAGAL THEORY

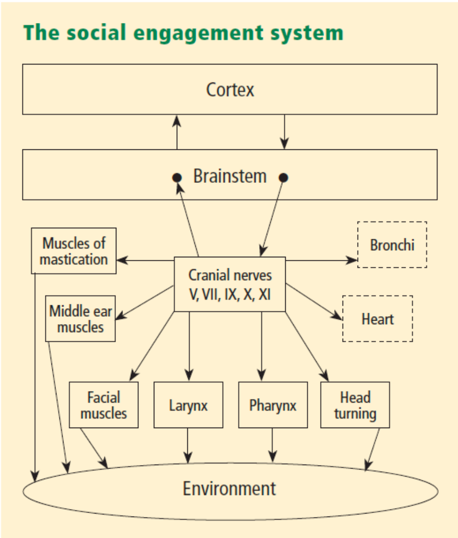


FIGURE 1. The social engagement system consists of a somatomotor component (solid blocks) and a visceromotor component (dashed blocks). The somatomotor component involves special visceral efferent pathways that regulate the striated muscles of the face and head, while the visceromotor component involves the myelinated vagus that regulates the heart and bronchi.[7]

Reprinted from *Biological Psychology* (Porges SW. The polyvagal perspective. Biol Psychol 2007; 74:116–143), copyright 2007, with permission from Elsevier. www.sciencedirect.com/science/journal/03010511

	ANS Component	Behavioral Function	Lower motor neurons
III	Myelinated vagus *(ventral vagal complex)*	Social communication, self-soothing and calming, inhibit "arousal"	Nucleus ambiguus
II	Sympathetic-adrenal system	Mobilization (active avoidance)	Spinal cord
I	Unmeyelinated vagus *(dorsal vagal complex)*	Immobilization (death feigning, passive avoidance)	Dorsal motor nucleus of the vagus

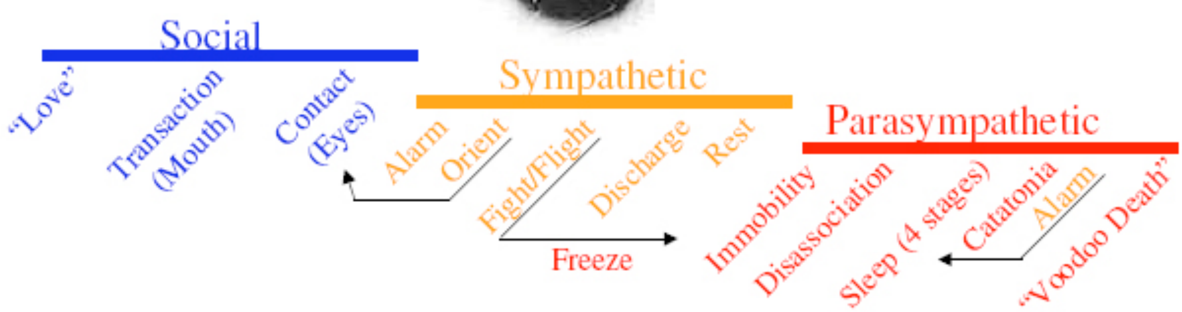
Fig. 1. Phylogenetic stages of the polyvagal theory.

Il supporto neurobiologico a James: //nervo vago e affetti pro-sociali (Porges)

Theory of Dissolution

"The higher nervous system arrangements inhibit (or control) the lower, and thus, when the higher are suddenly rendered functionless, the lower rise in activity."

–John Hughlings Jackson (1835-1911)
Father of English Neurology
Quoted by Stephen Porges 11/01



Il supporto neurobiologico a James:
//nervo vago e affetti pro-sociali (Porges)

Tre Livelli Viscerali

I. Mammiferi	Contatto Sé/Altro Sentirsi abbastanza equilibrati
II. Rettili	Attaccare – Rabbia Fuggire - Paura
III. Pesci-Anfibi	"Tutto è perduto" / Calo interno Il Sé/Altro scompare Trauma

Livelli II + III: Strategie di Difesa Primordiali

	ANS Component	Behavioral Function	Lower motor neurons
III	Myelinated vagus *(ventral vagal complex)*	Social communication, self-soothing and calming, inhibit "arousal"	Nucleus ambiguus
II	Sympathetic-adrenal system	Mobilization (active avoidance)	Spinal cord
I	Unmeyelinated vagus *(dorsal vagal complex)*	Immobilization (death feigning, passive avoidance)	Dorsal motor nucleus of the vagus

Fig. 1. Phylogenetic stages of the polyvagal theory.

Il supporto neurobiologico a James:
//nervo vago e affetti pro-sociali (Porges)

- (1) when tone of the VVC is high, the ability to communicate via facial expressions, vocalizations, and gestures exists;
- (2) when tone of the VVC is low, the sympathetic nervous system is unopposed and easily expressed to support mobilization such as fight or flight behaviors; and
- (3) when tone from DVC is high, immobilization and potentially life-threatening bradycardia, apnea, and cardiac arrhythmias occur.

Il supporto neurobiologico a James:
//nervo vago e affetti pro-sociali (Porges)

- La teoria polivagale apporta importanti dati anatomo-funzionali a sostegno del superamento della dicotomia esperienza/espressione emozionale
- Il terzo stadio (mammiferi): è caratterizzato dallo sviluppo della porzione mielinica del nervo vago (sistema parasimpatico)
  - implicato in risposte viscerali e vegetative rapide in risposta a stimoli ambientali,
  - contemporaneamente legato anche all'attività dei nervi cranici della muscolatura facciale implicati nella comunicazione sociale tramite la produzione di espressioni facciali e la vocalizzazione.
- La muscolatura facciale e la vocalizzazione, implicate nella trasmissione sociale dell'emozione, dipendono dallo stesso sistema di controllo dei parametri vegetativi implicati nella modulazione delle risposte emozionali, e che secondo William James sono la causa dell'esperienza emozionale