

Academic lectures for general medicine
Summer course 3rd year
Updated 2004- 2014

**GENERAL
PATHOPHYSIOLOGY**

Pathophysiology of consciousness

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Everything what we know about ourselves, about our existence, our body and its parts, everything what we know about surrounding physical reality is created in the brain and projected for us as an experienced reality. As brain's awareness grows it allow us to „humanize“ everything. i.e. to consider that we are inevitable an to admit that other creatures are just actors in reality. Persistence of consciousness outside of the brain is unprobable. One's consciusnes however may persist in form of recorded thoughts, ideas, or imprinted in memories of others.

R.Benacka (2013)



Consciousness – general considerations

- **Consciousness** = various manifestation of neuronal assemblies of different size and complexity; no center in the brain; structural components of arousal, alertness, attentiveness, memory, emotion
- **Consciousness** = activation state achieved in the brain, maintained by the brain for the brain; outside of the brain consciousness has no real meaning
- **Consciousness** = continuum of behavioral states; changing throughout the night and day; also including somatic idiognosia
- **Consciousness** = morphed throughout the ontogeny; different in the kid, adulthood, man, woman; it is rather subjective than objective; similar to memory and emotions
- **Consciousness** = practical medicine through interviewing persons evaluates rather „awareness“ (Can you hear me ?, Where are you, Who are you ?)

Consciousness Tetrad (Singh & Singh, 2011)

- **Default consciousness**: basic manifestation of the life; differentiating living from dead; biological principle from non-living physical principle
- **Aware consciousness**: continuum of behavioural states (lucidity, somnolency, sleep) po patologické (somnolencia, stupor, koma)
- **Operational Consciousness**: ability to perform motor, sensoric, cognitive, creative, emotional, esthetical manifestations
- **Exalted Consciousness**: connection with the source; God meditation, creativity

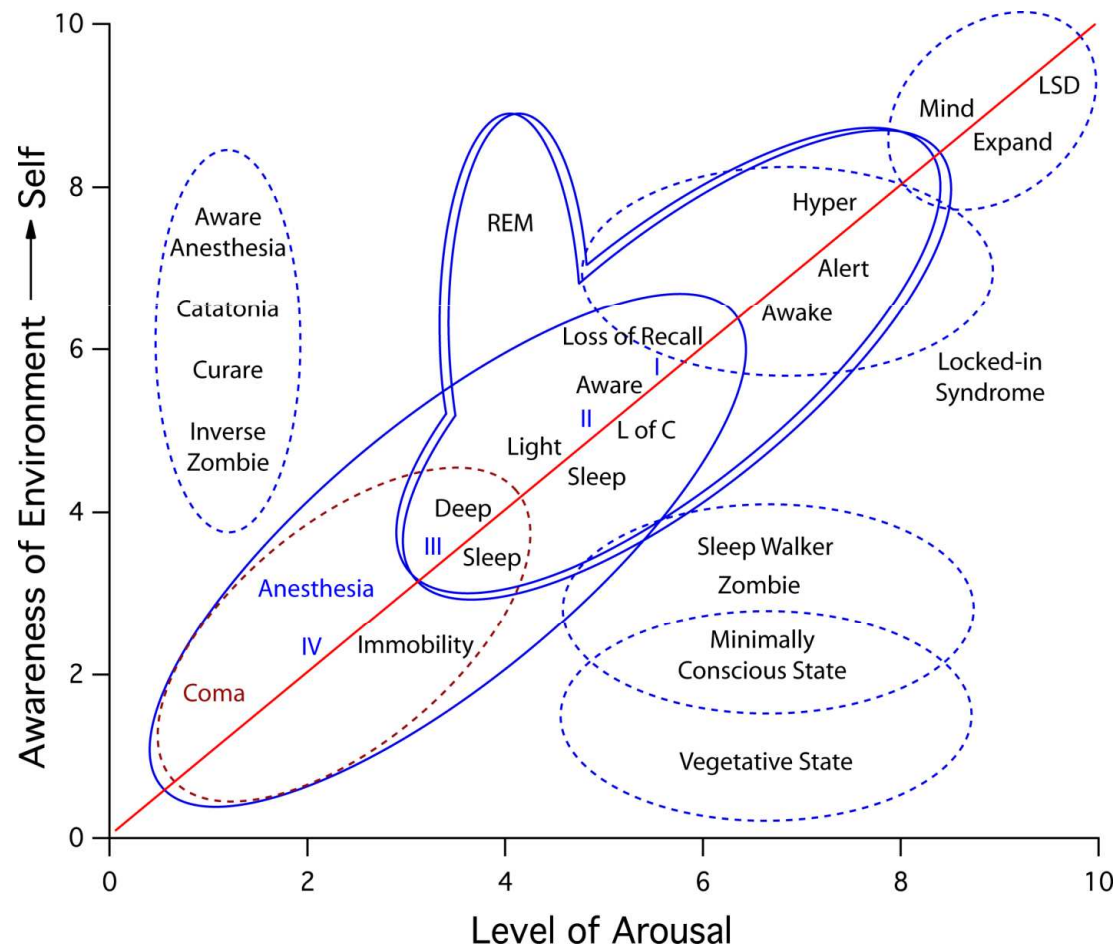


1 Neuronal representation of consciousness

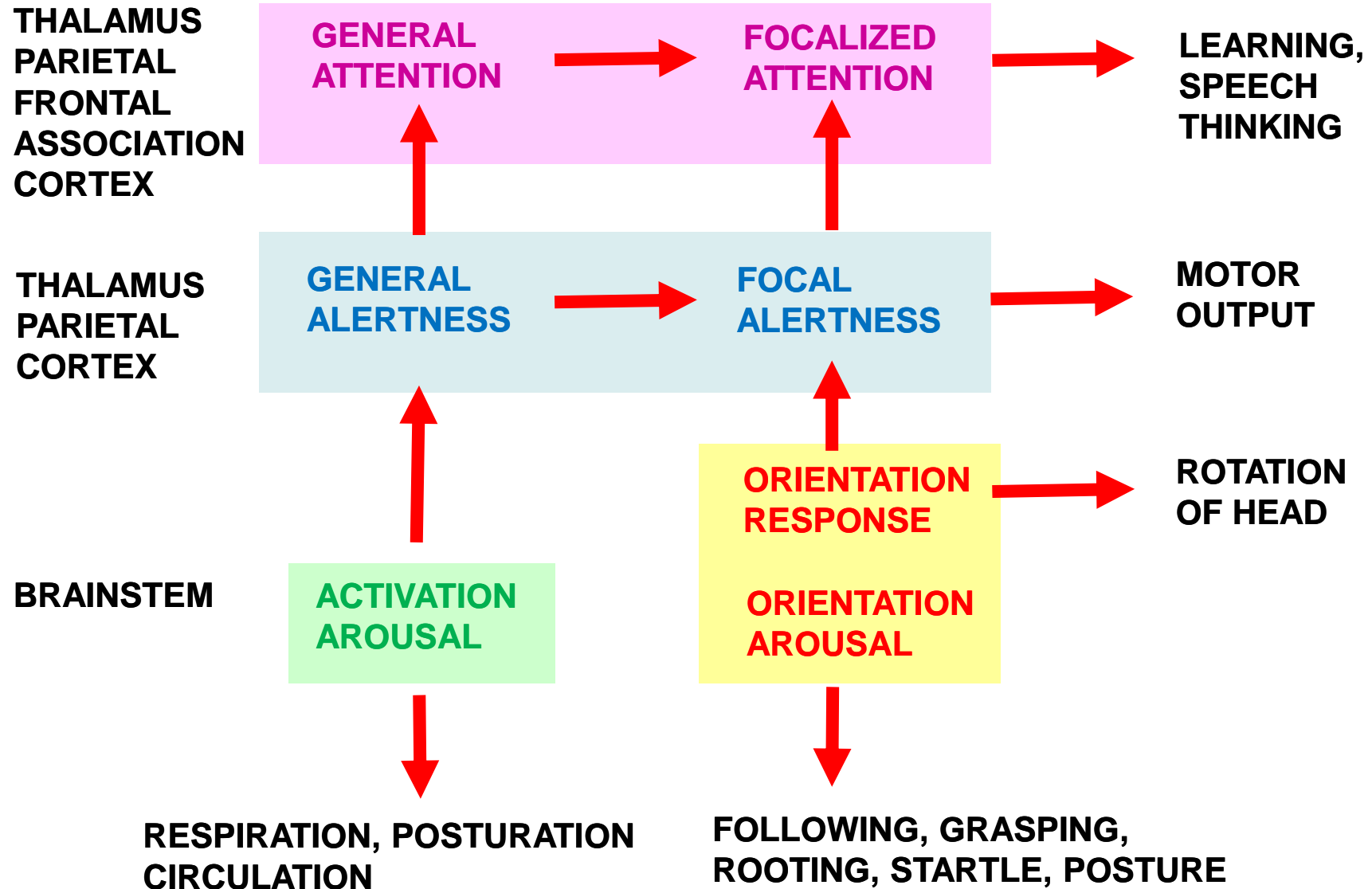
Various levels of consciousness – older view

■ Consciousness components

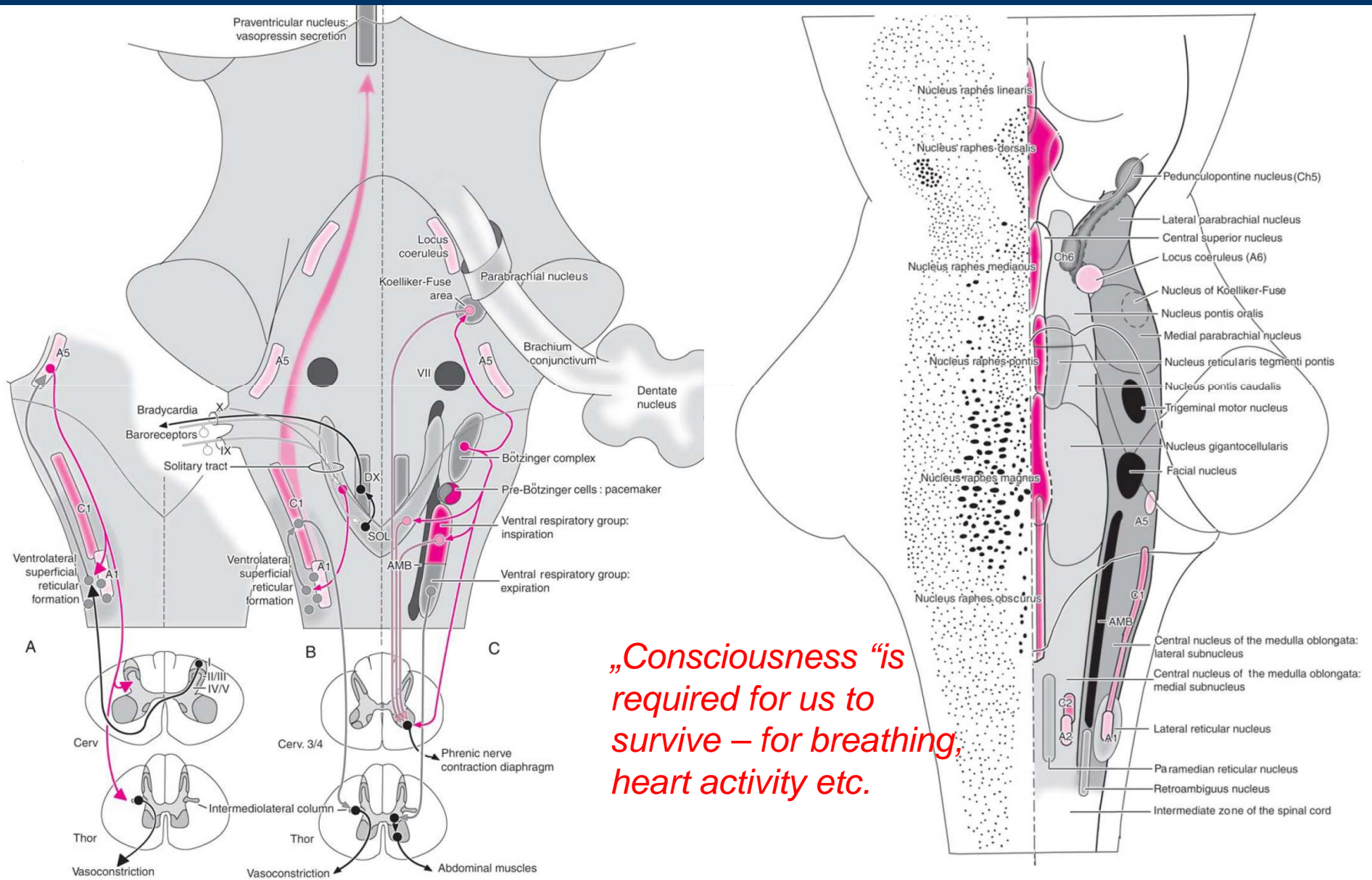
- **arousal** = activity level, charge, energy level
- **content** = awareness of self and awareness of environment



Continuum of behavioural states

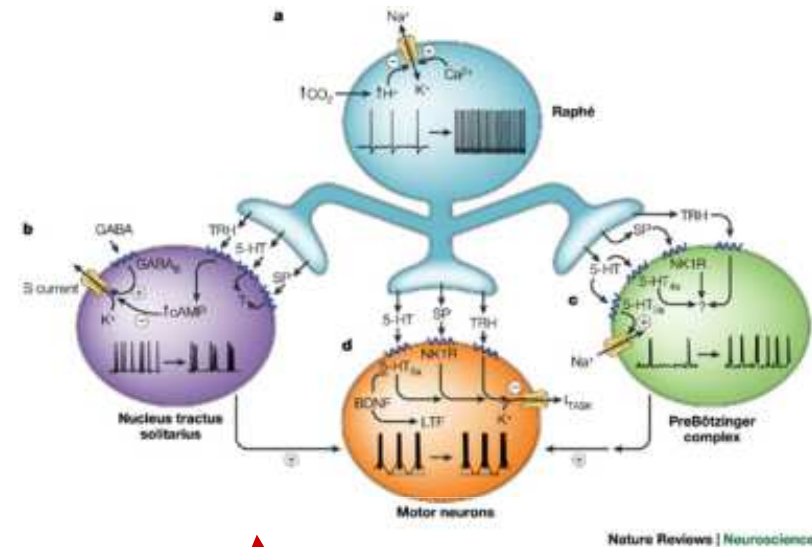
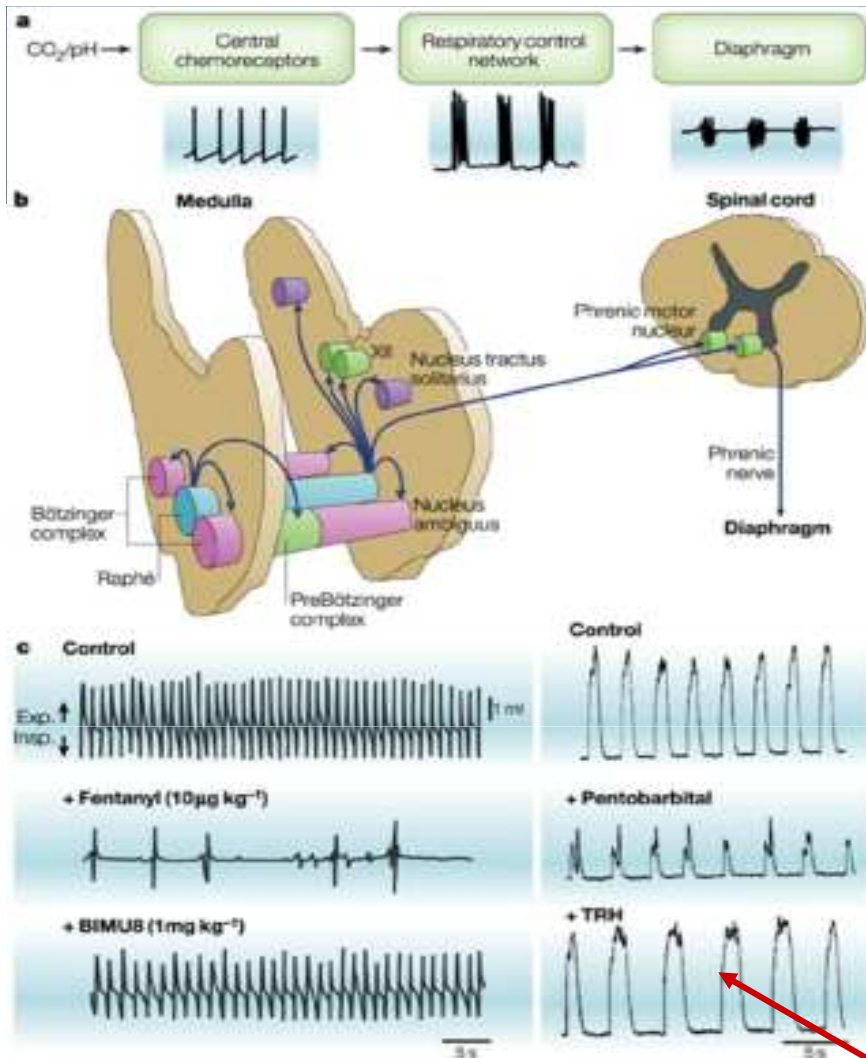


Brainstem – arousal systeme



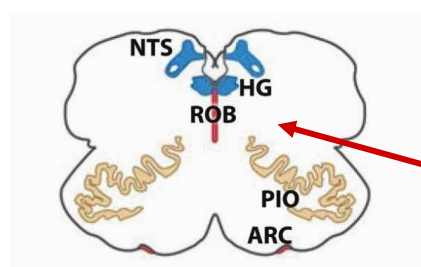
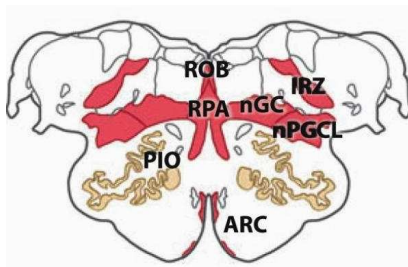
„Consciousness “is required for us to survive – for breathing, heart activity etc.

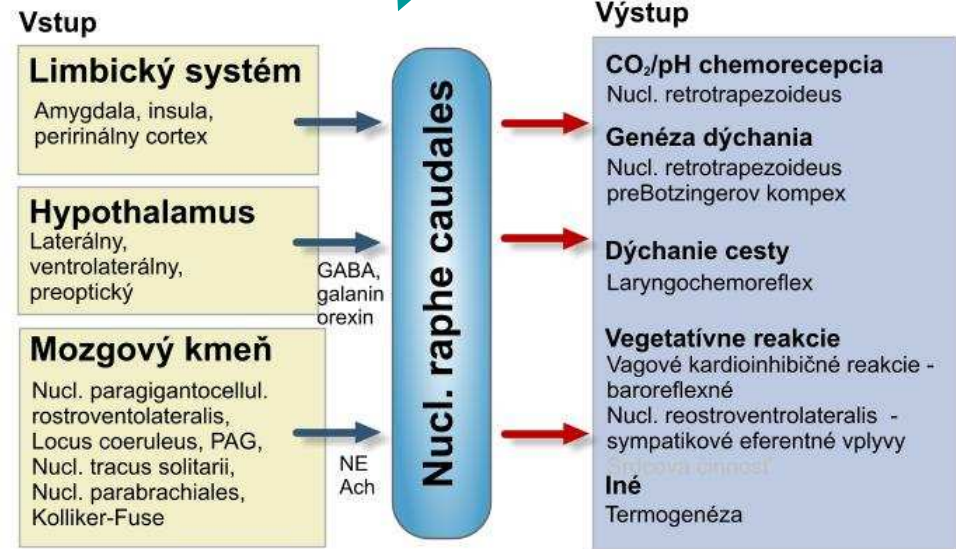
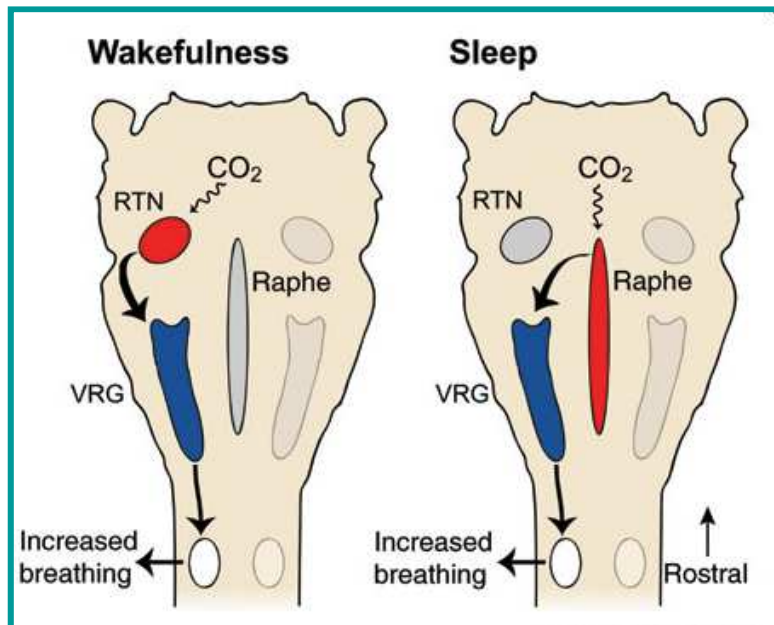
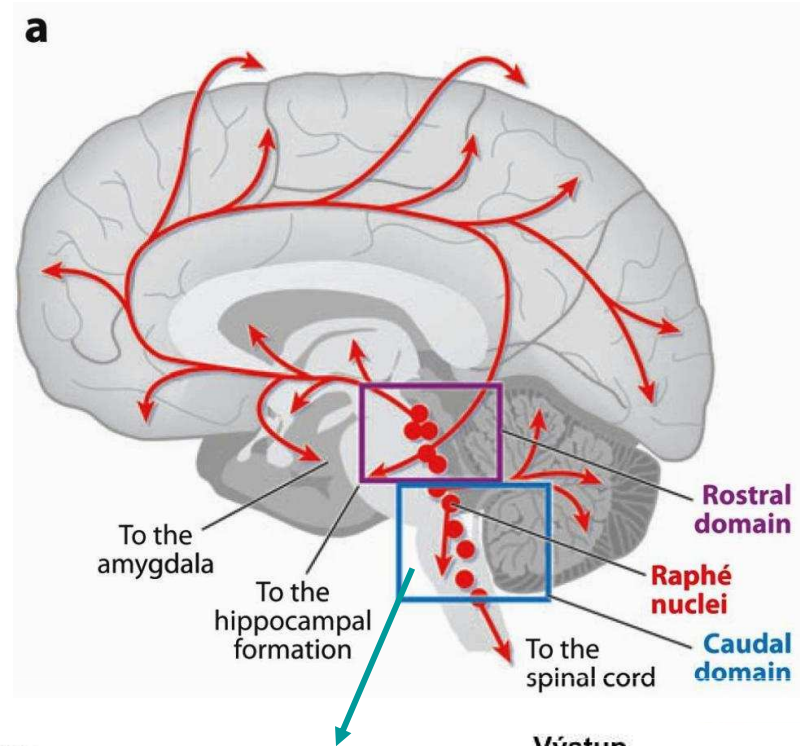
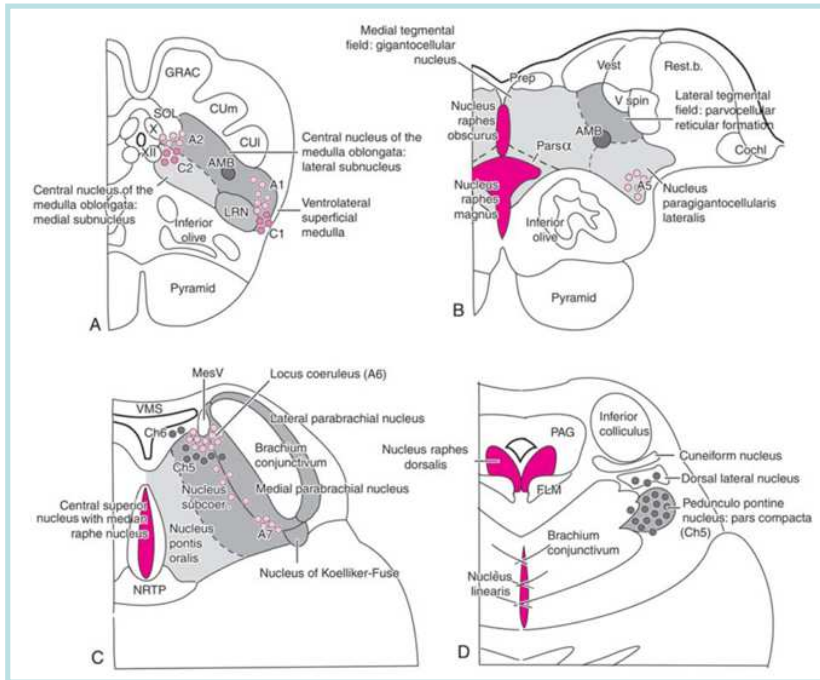
Chemoreception and wakefulness



CO_2 stimulates serotonergic neurons. Respiratory motoneurons are stimulated via 5-HT, TRH a SP. Neurons in pre-BötC are stimulated through 5-HT_{4a}, 5-HT_{2a} as well as neurokin1 (NK1)

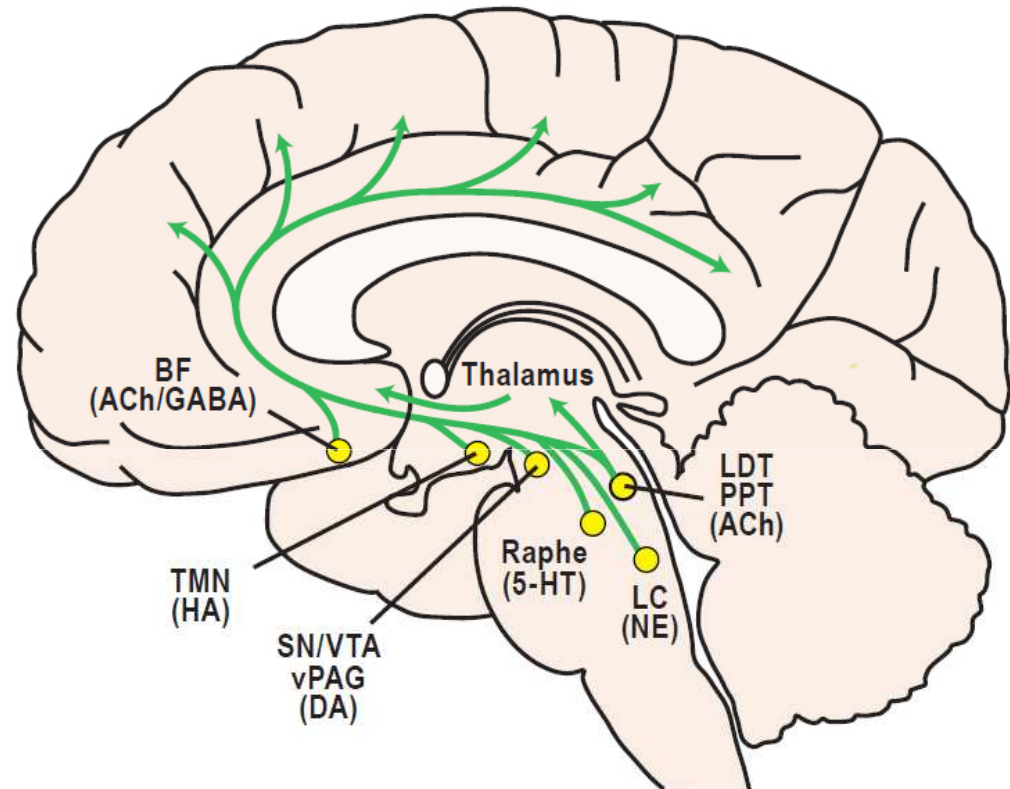
- Reversal of respiratory rhythm induced by anaesthetics (Fentanyl)
- projekcie do všetkých hlavných respiračných jadier (NTS, NA, preBöt, Böt complex, XII i frenikové motoneuróny).





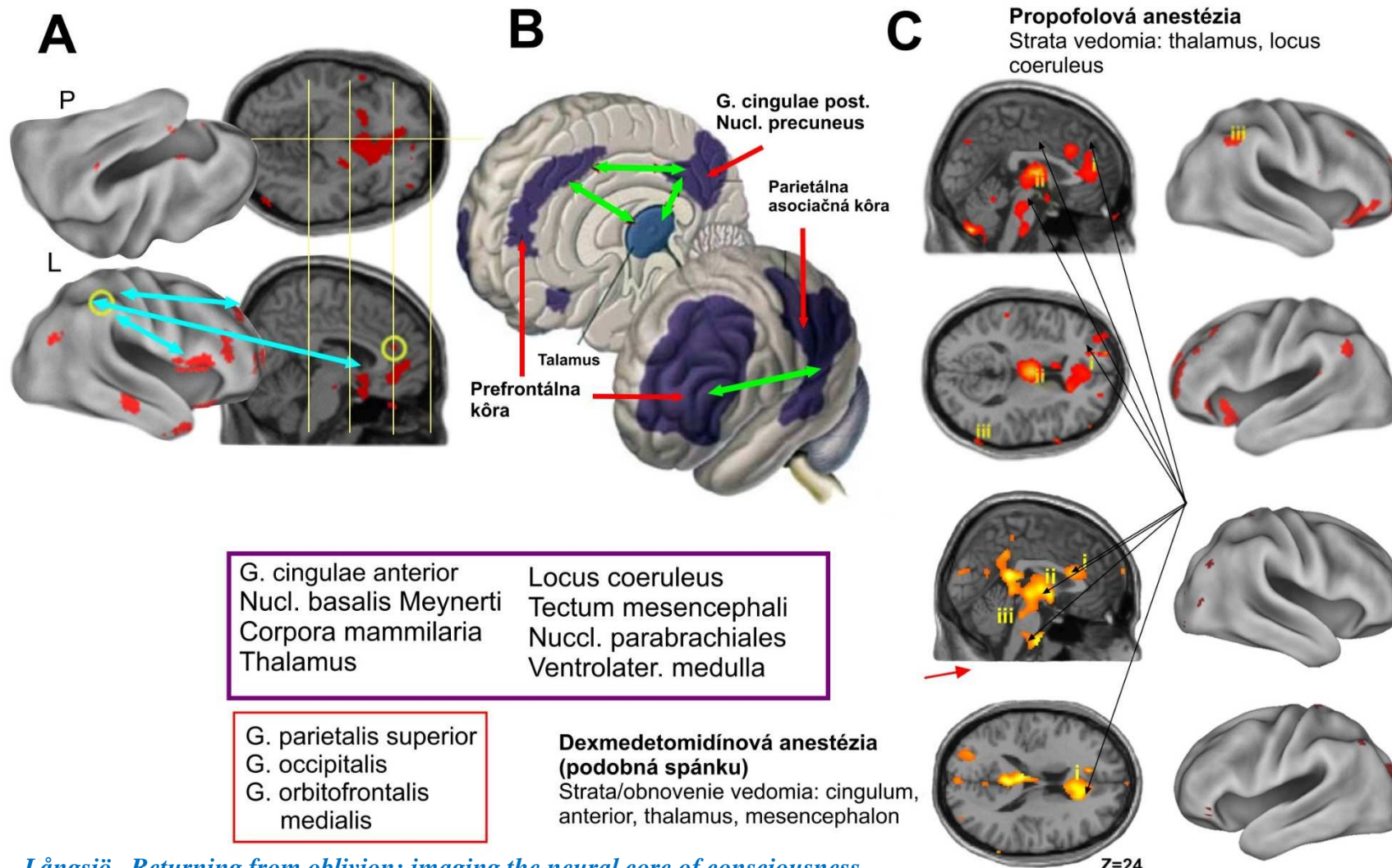
Arousing Diffuse Modulatory Systems (ADMS)

- **Norepinephrine (NE):** locus coeruleus (LC),
- **Serotonin (5-HT):** raphe nuclei,
- **Dopamine (DA):** substantia nigra (SN), ventral tegmental area (VTA), ventral periaqueductal grey (vPAG).
- **Acetylcholine (ACh) :** laterodorsal, peduncular - pontine tegmental nucleus (LDT/PPT), basal forebrain (BF)
- **Histamine (Hi):;** tuberomamilar nuclei (TMN)



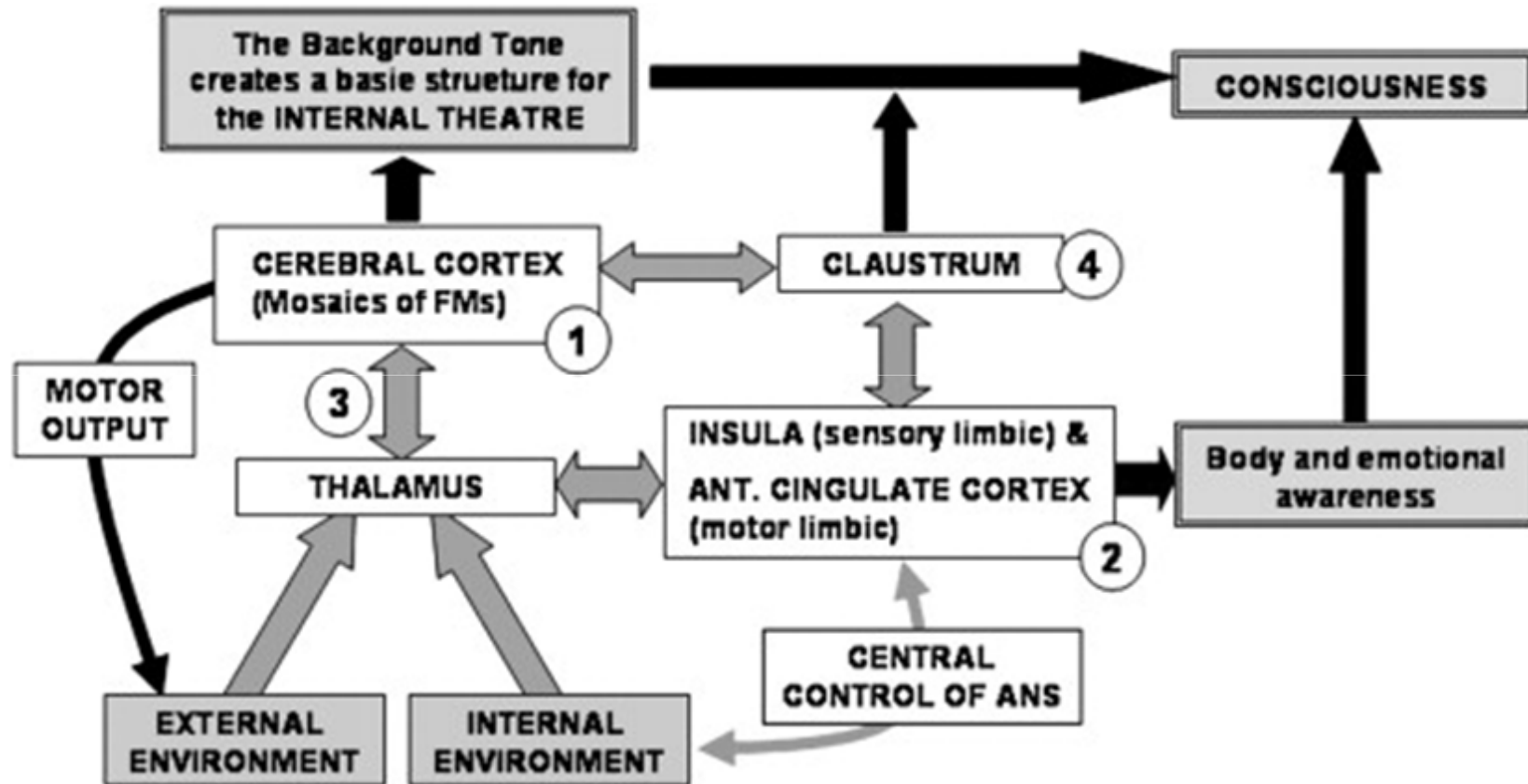
España, R. A., & Scamell, T. E. (2011). Sleep Neurobiology from a Clinical Perspective. Sleep, 34(7), 845-858.

Minimal neuronal substrate – experimental anesthesia



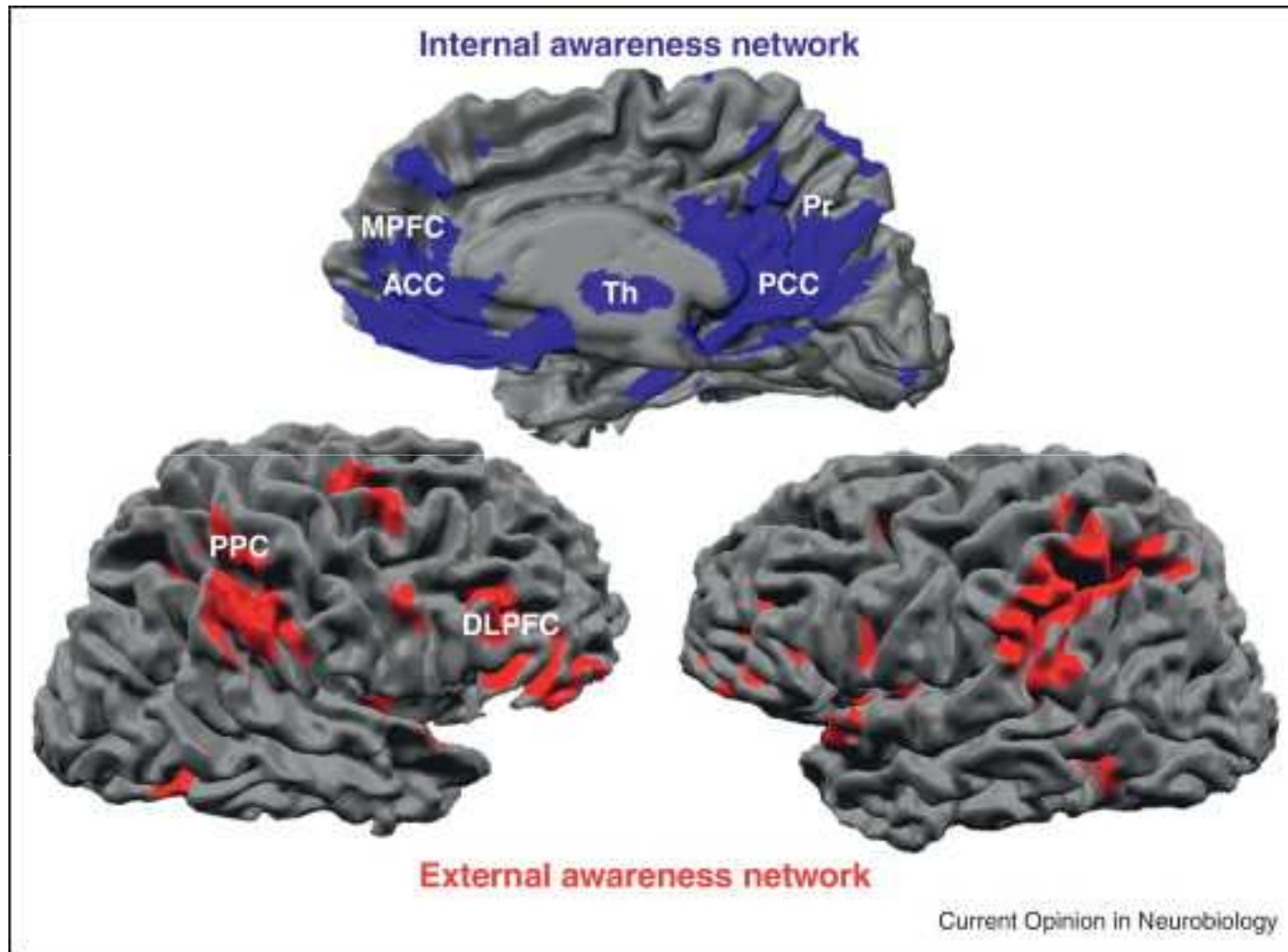
*Långsjö, Returning from oblivion: imaging the neural core of consciousness.
J Neurosci. 2012 Apr 4;32(14):4935-43*

Principal parts of consciousness generator



Schiff, N. D., Giacino, J. T., Fins, J. J.: Deep brain stimulation, neuroethics, and the minimally conscious state: moving beyond proof of principle. *Arch. Neurol.* 66, 697–702 (2009)

Principle of internal and external awareness network



Demertzi, A. , Soddu, A., Laureys, S.: *Consciousness supporting networks. Current Opinion in Neurobiology*, 23 (2), 2013, p. 239–244

Continuum of behavioural states

Awareness of the self in the world around

Myslenie
(Thinking, reasoning)

Explicit memory
(Explicitná pamäť)

Atentiveness (pozornosť)
- selective (selektívna)
- general (všeobecná)

Implicit memory
Implicitná pamäť

Advanced consciousness (Pokročilé vedomie)

Awareness of the momentary world around (register)

Alertness (čulosť)
- selective (selektívna)
- general (všeobecná)

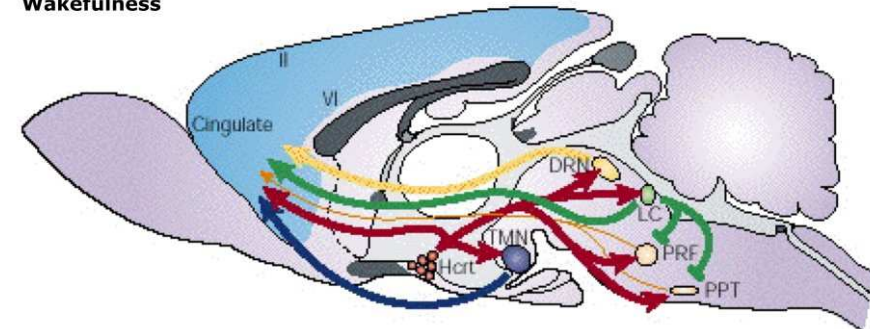
Implicit memory
Implicitná pamäť

Orienting reflexes
(Orientačné reflexy)

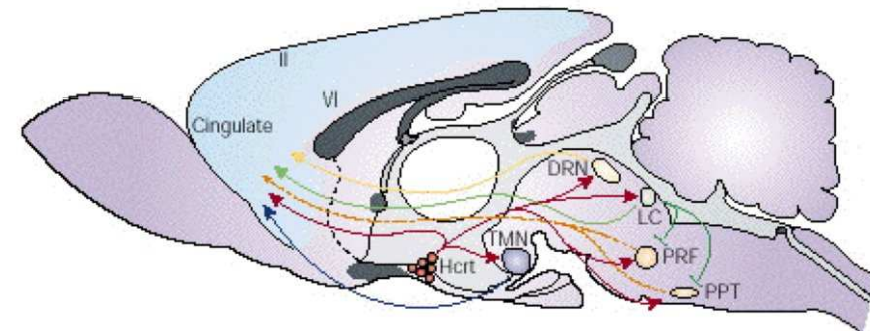
Orienting responses
(Orientačné odpovede)

Basal consciousness (Základné vedomie)

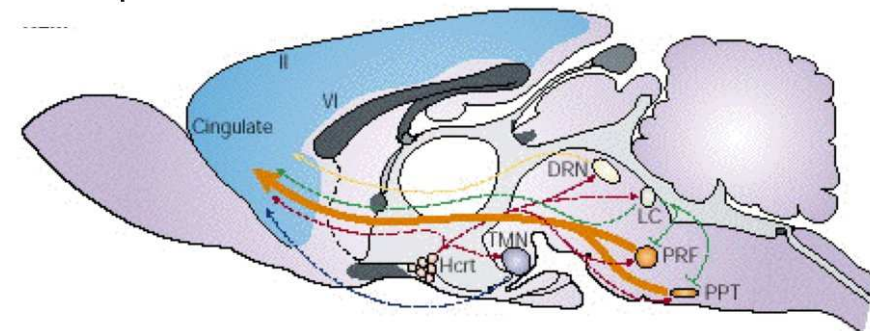
Wakefulness



Non-REM sleep



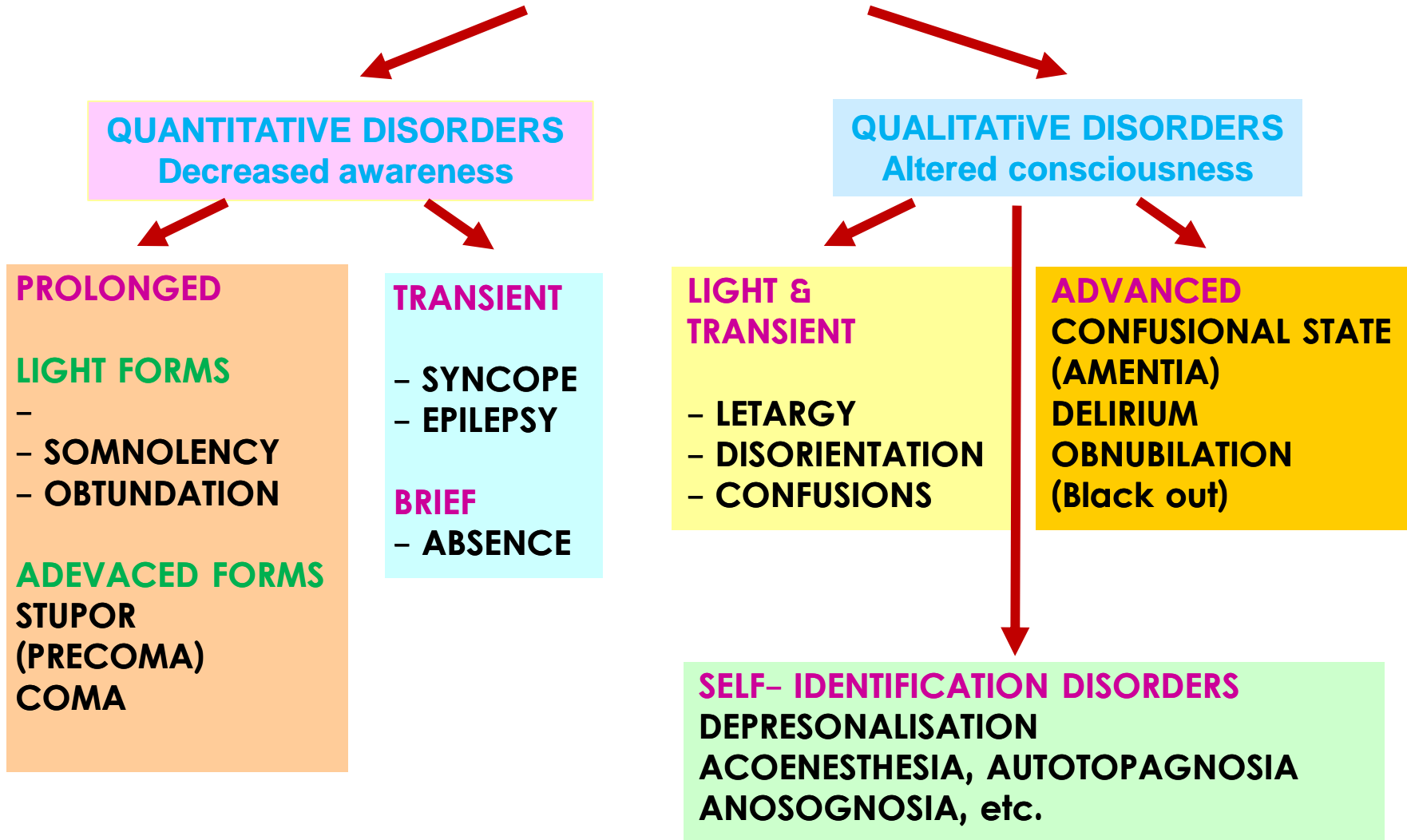
REM sleep





2 Disorders of consciousness

Disorders of consciousness



Quantitative disorders of consciousness

■ Transient (sec- min)

● **Syncope (faintness)** short disorder of consciousness

■ **systemic hypotension, resp. collaps**

(postural/ ortostatic synkopa), kardiálne (ischémia srdca, vazovagálna synkopa, ASM)

■ **disordered redistribution of blood** –

changes in intrathoracic pressure (cough syncope, laugh syncope, food jedlo (postprabdial defecation), psychogenic factors, (neurogenic syncope)

■ **changes in vessel lumen** (vertebro-basilar artery insufficiency, carotic stenotisation)

■ **disorders in electric stability** (brain commotio, brain contusion, electrical current shock, epilepsy, electroconvulsions)

■ Prolonged (hod- dni- týždne)

■ **Somnolency, lethargy** – pathological sleepiness, waking up upon light stimuli (opening eyes, orientation), response are correct, targeted, make sense, but are slowed

■ **Obtundation** – communication is difficult, person spontaneously fall asleep, can be waken up by stronger mechanical stimuli (rarely verbal), responses are not so precised, limited, not comprehensive, disorientation

■ **Stupor (precome)** – deep unconsciousness; person reacts to painful stimuli pain stimuli; reactions are delayed little localized, sporadic movements, verbalisation

■ **Coma** - total unreactivity to outer stimuli, no spontaneous motor response, eyes are closed, breathing is shallow, vegetative responses present

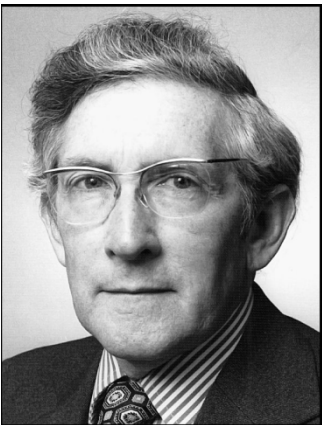
Causes of disordered consciousness

| Causes | Lesions | |
|---------------------------------|--|--|
| Supratentorial Lesions | Epidural or Subdural Hematoma Large Isquemic Infarction | Intraparenchymal hemorrhage Trauma Abscess Tumor |
| Infratentorial Lesions | Basilar artery thrombosis Pontine or Cerebellar Hematoma | Ischemic Cerebellar Infarction Tumor Abscess |
| Diffuse Encephalopathies | Hypoglycemia Drug Intoxication Hepatic Encephalopathy Hyperosmolar States Hyponatremia Global Cerebral Ischemia | Hyperthermia Meningitis and Encephalitis Subarachnoid Hemorrhage Myxedema Renal Failure Hypercarbia Thiamine Deficiency Hydrocephalus |
| Psychogenic | Catatonic States Hysteria-malingering | Acute psychotic delirium |

Gosseries O, Bruno MA, Chatelle C, Vanhauzenhuysse A, Schnakers C, Soddu A, Laureys S: Disorders of consciousness: what's in a name? NeuroRehabilitation 2011, 1:3-14.

Glasgow Coma scale

<http://www.glasgowcomascale.org/who-we-are/>

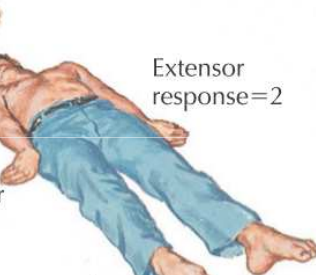


Eye opening (E)



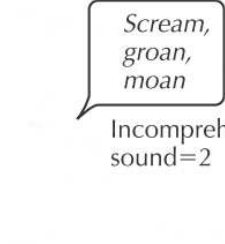
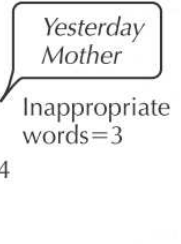
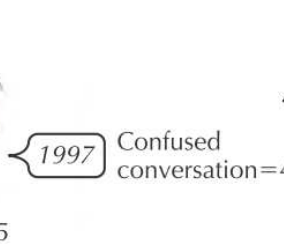
| E | |
|-----------------------|---|
| Spontaneous | 4 |
| To speech | 3 |
| To pain | 2 |
| Nil | 1 |

Motor response (M)



| M | |
|-----------------------------|---|
| Obeys | 6 |
| Localized | 5 |
| Withdraws | 4 |
| Abnormal flexion | 3 |
| Extensor response | 2 |
| Nil | 1 |

Verbal response (V)



| | |
|-----------------------------------|---|
| Oriented | 5 |
| Confused conversation | 4 |
| Inappropriate words | 3 |
| Incomprehensible sounds | 2 |
| Nil | 1 |

Coma score (E+M+V)=3 to 15

Sir Graham Teasdale & Bryan Jennett (1926-2008) – Glasgow neurosurgeons, introduced Glasgow Coma Scale (GCS); 1974 *Lancet*, entitled "Assessment of coma and impaired consciousness: a practical scale"

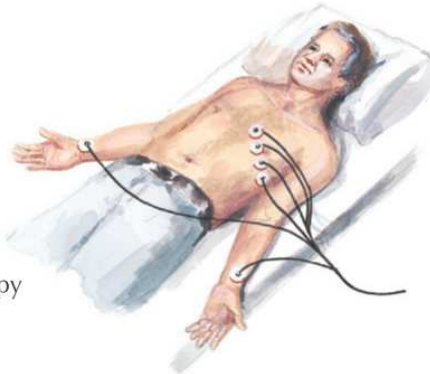
Maximum = 15 Healthy >12
Minimum = 3 Critical <8

Syncope – four stage management

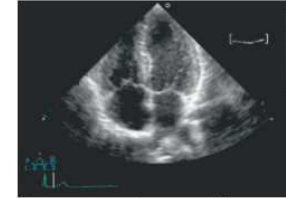
Step 1: Electrocardiogram



All patients with syncope should undergo electrocardiography. If ECG is abnormal, confirmatory testing and appropriate therapy should be instituted.

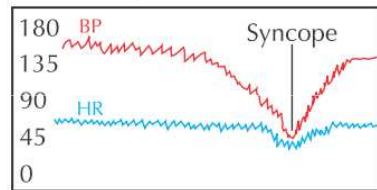


Step 2: Echocardiography



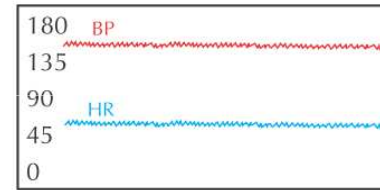
In most patients without a diagnosis, a structural evaluation with echocardiogram is required.

Step 3: Head-up tilt-table test



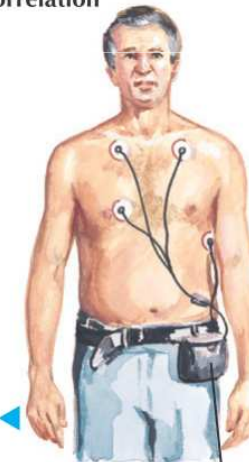
Positive neurocardiogenic tilt-table test shows drop in BP and heart rate.

Should be considered if steps 1 and 2 are negative



Normal tilt-table test shows maintenance of normal BP and heart rate.

Step 4: Monitoring for symptom-rhythm correlation



Holter monitor



Ambulatory monitoring recommended for patients with negative evaluation; duration of monitoring dependent on frequency of episodes; for daily symptoms, 48-hour monitor adequate

JOHN A. CRAIG MD
with
D. Mascaro

Pupils

| Pattern | Description | Lesion |
|--------------------------------|-----------------------------------|---|
| Dilated (bilateral) | Ø 7 mm , (-) reaction to light | <ul style="list-style-type: none"> • Transtentorial herniation of both medial temporal lobes • Intoxication: anticholinergics, sympathicomimetic drugs |
| Narrowed (bilateral) | Ø 1-1,5 mm | <ul style="list-style-type: none"> • Intoxication by opiates, organophosphates, cholinomimetics, miotic eye drops • Pontine haemorrhage, Neurosyphilis |
| Asymmetric (anisocoria) | Ø 1 mm difference | <ul style="list-style-type: none"> • Normal ~ 20% of population; (+) photoreaction • (-) photoreaction - dilation: ipsilateral pressure in mesencephalon + nucl..III (tumors, bleeding) |
| Fixed pupils | Ø 5 mm , (-) photoreaction | <ul style="list-style-type: none"> • Mesencephalic lesions |

Qualitative disorders of consciousness

- **Lighter forms** (often combined with quantitative disfunctions; patients are mostly aware of disorder)
 - **Apathy, letargy** – similar to tiredness (e.g. depression, toxic, infection, ictus, metabolic)
 - **Disorientation** – slowness, blunted attentiveness and preparedness, (e.g.. altitude sickness, hypoxia, cold , starvation, hypoglycemia)
 - **Confusion** – a person is not orientated to time, place and/or person; responses or behaviours to situations may be inappropriate. agitation, restlessness with sleepiness (somnia) or even stupor (difficult to arouse or state)
- **Progressive forms (altered state of consciousness, cognition)**
 - **Acute confusion state** – disordered perception, disorientation, disorders of memory (intoxication – posttraumatic, post-narcotic, inflammation)
 - **Delirium** – disorder of thinking, perception, hallucinations, disorders of memory, agitation, sleepiness, amnesia, organic damage (infection, toxic, abstinence)
 - **Obnubilation (blackout)** – disorder of perception of reality; amnesia
 - **Depersonalisation**

Acute confusional state

(Alternatives: confusional state, organic brain syndrome, confusional insanity, transient psychotic reaction, organic psychosyndrome; Meynert-Korsakoff syndrome)

Characteristics: amentia (behaviorálna demencia) patrí aj ku kognitívnym poruchám)

- forma delíria s prevahou deficitu percepcie, pozornosti a orientácie, dezorientovaný v čase a priestore, často je nadmieru aktívny – úniky; aktívna obrana
- schopnosť rozpamätania (anterogádna, retrogádna amnézia), zastreté vedomie (neschopnosť presunu a fokalizácie pozornosti)
- Môže sa prejavíť úzkosť, strach, hnev, eufória, tras, potenie, búšenie srdca.

Causes:

- Intoxication (37% cannabis, marihuana), pooperative (probably post-narcotic or combination of effects) (in elderly suprisingly high incidency after hip fracture surgery), tramadol, infections,
- Diabetes – hypoglycaemia, cardiac decompensation, infarction,
- Confusional arousals (sleep terror),
- Alzeheimer disease, kidney failure (uremia)
- Dehydratation, disorders of electrolytes



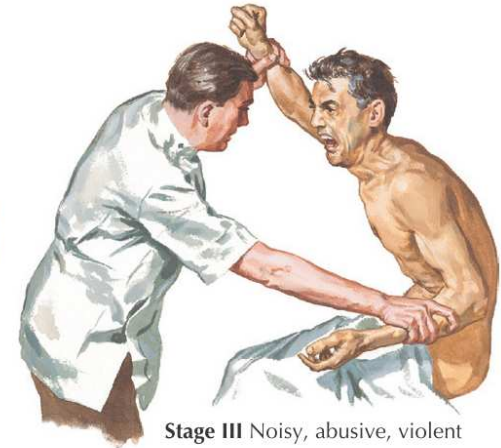
Delirium



Stage I Personality changes, vacant stare

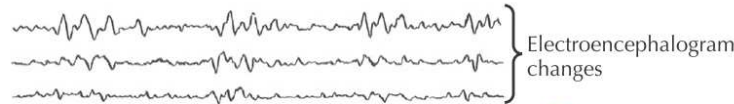


Stage II Lethargy, flapping tremor, muscle twitching



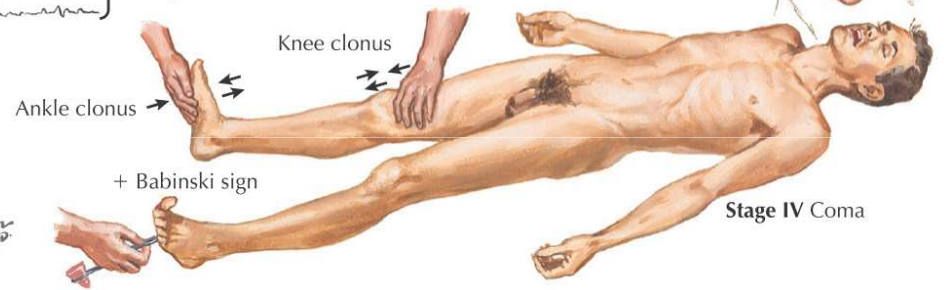
Stage III Noisy, abusive, violent

Withdrawal symptoms in chronic alcohol abuse



Electroencephalogram changes

Fetor hepaticus



Stage IV Coma

Decrease in BAC results in

Hypertensive response

Tremor

Generalized seizures



Sweating

Flush



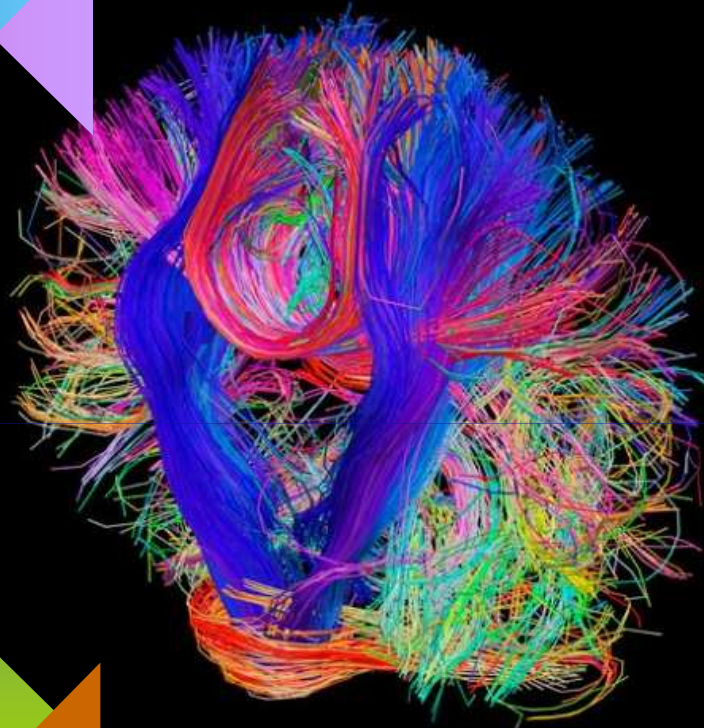
Hallucinations



Anxiety, cognitive effects, inner voice, confusion

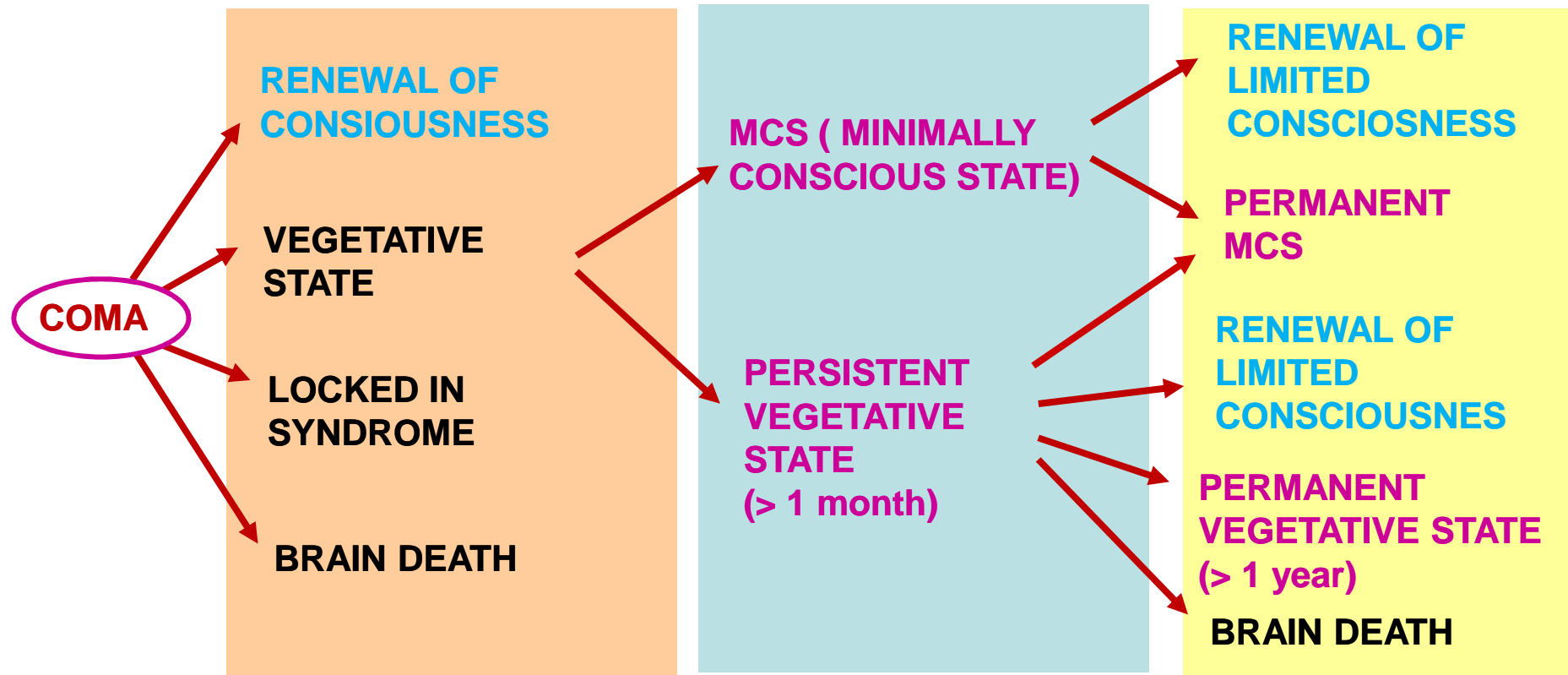


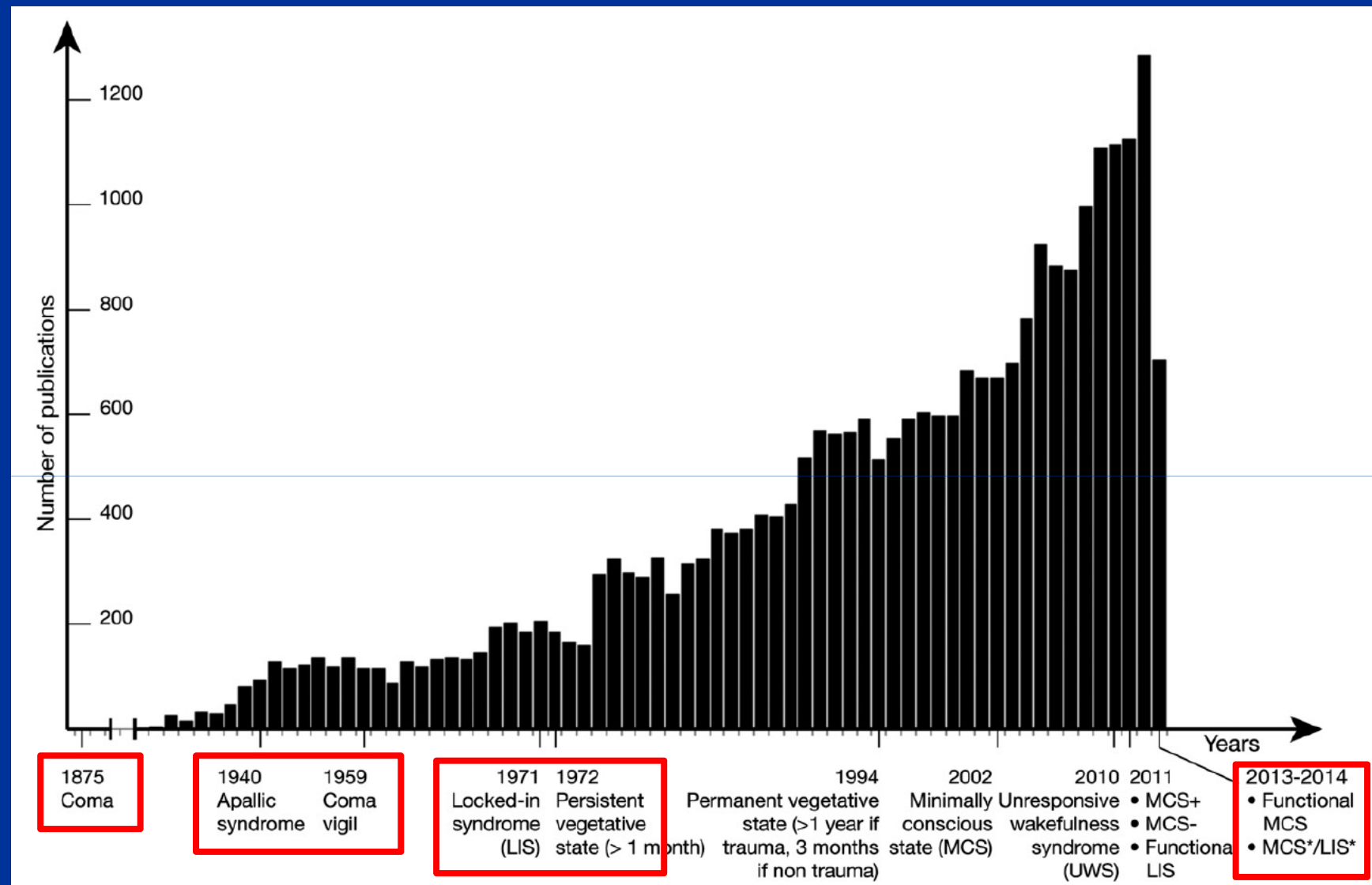
Stages in development of delirium due to the substance withdrawal



4 Postcomatous disorders of consciousness

Postcomatous disorders & coma like states





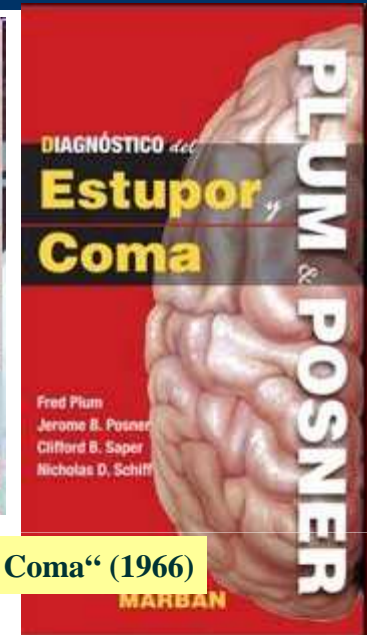
Number of published papers per year on patients with disorders of consciousness and evolution of the terminology. Medline search (7/2013) keywords used were 'coma', 'vegetative state', 'unresponsive wakefulness syndrome', 'minimally conscious state' and 'locked-in syndrome'

Honors

- **Fred Plum (1924 – 2010)** – american neurologist; he introduced the term "locked-in syndrome: together with Dr. Byron Jennett, they introduced the term "persistent vegetative state"

Jennett B, Plum F (1972) Persistent vegetative state after brain damage: a syndrome in search of a name. Lancet:734–737

- **Schiff, N.D. (1997)** tzv. deep brain stimulation
- **Laureys, S (2005).**: usage of fNMR, PET in research



„Diagnosis of Stupor and Coma“ (1966)

Laureys S, Schiff ND: Coma and consciousness: paradigms (re)framed by neuroimaging. Neuroimage, 2012, 2:478-491.

Laureys S: Science and society: death, unconsciousness and the brain. Nat Rev Neurosci 2005, 11:899-909.

Jennett B, Plum F: Persistent vegetative state after brain damage. A syndrome in search of a name. Lancet 1972, 7753:734-737

Postcomatous disorders & coma like states

Vegetative state (Apallic syndrome 1940, Coma vigil 1952)

Unresponsive wakefulness syndrome (UWS) (2010)

Etio: traumatic/ atraumatic, drug dependencies/ independency

- severe global metabolic, toxic, ischaemic, traumatic cortical injury (cardiac arrest, brain surgery, etc.)
- bilateral damage of frontal lobe, lesion of upper brainstem,

Sy:

- return to wakefulness (eye opening), but without awareness of self and environment; with no communication, no visual contact with persons, nor surroundings, no verbal response
- without paralysis, spontaneous movements exist, normal reflexes (breathing)
- bulbar reflexes present, eye-ball movement, swallowing, yawning
- occasionally decerebration or decortication rigidity, Babinski's sign
- pupillary response to light often not present on both sides
- vegetative response normal or hyperactive (CVS – tachycardias, hypertensive episodes, thermoregulation, neuroendocrine, bowel movement)
- without sensory disturbances, reactions to pain are present but delayed

- **Persistent vegetative state** – lasting > 1 month
- **Permanent vegetative state** – lasting > 1 year after traumatic brain damage or > 3 months after atraumatic brain damage

Post- comatose recovery outcomes

Persistent vegetative state



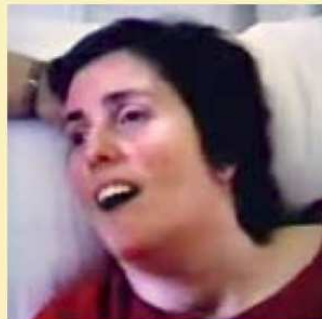
<http://www.usatoday.com>



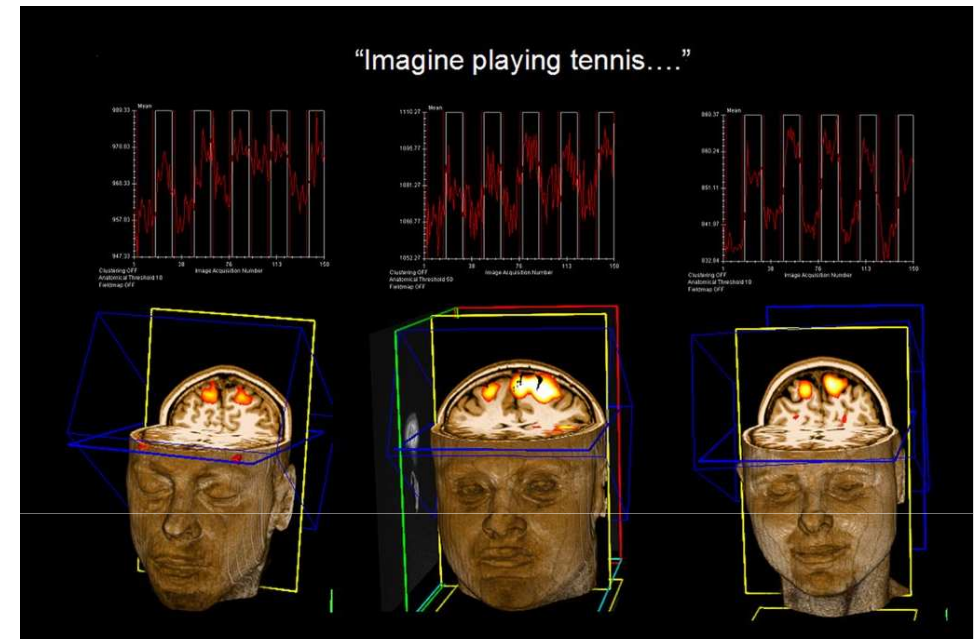
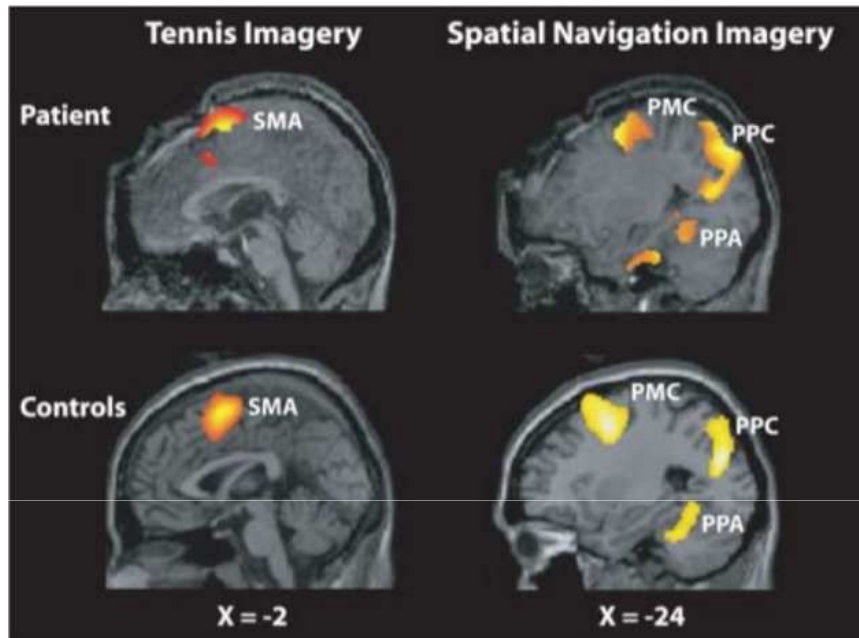
www.9to5TurnerShow.com



Akinetic mutism



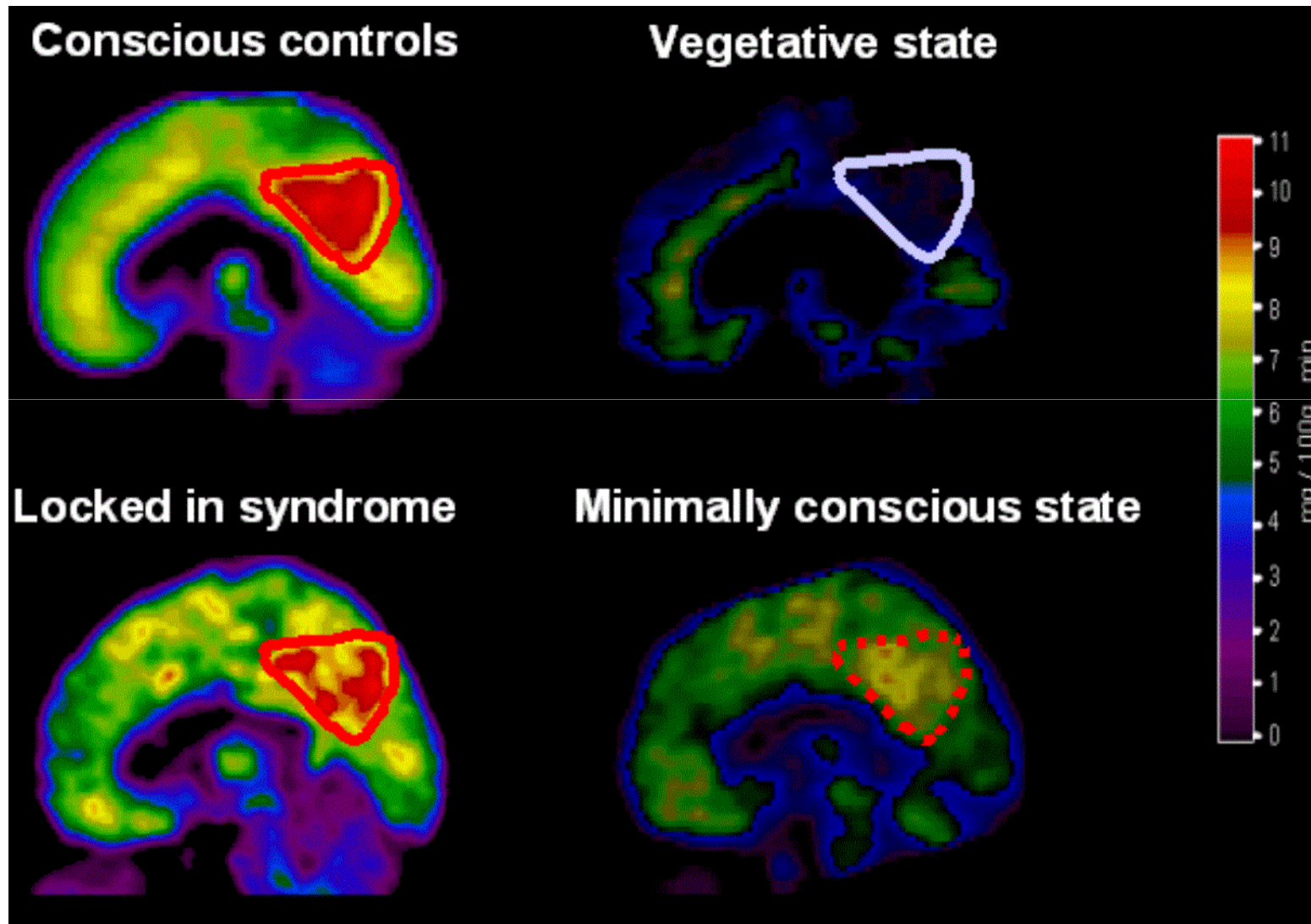
Vegetative state



Patients can imagine various activities; there is lack of outer manifestations of awareness

- *Gosseries O, Bruno MA, Chatelle C, Vanhaudenhuyse A, Schnakers C, Soddu A, Laureys S: Disorders of consciousness: what's in a name? NeuroRehabilitation 2011, 1:3-14.*
- *Schiff, N.D.: Recovery of consciousness after brain injury: a mesocircuit hypothesis. Trends Neurosci. 33, 1-9, 2010*
- *Demertzi, A., Soddu, A., Laureys, S.: Consciousness supporting networks. Current Opinion in Neurobiology, 23(2)? 239-244, 2013*
- *Laureys S, Schiff ND: Coma and consciousness: paradigms (re)framed by neuroimaging. Neuroimage 2012, 2:478-491.*

Using NMR and PET scans in diagnostics

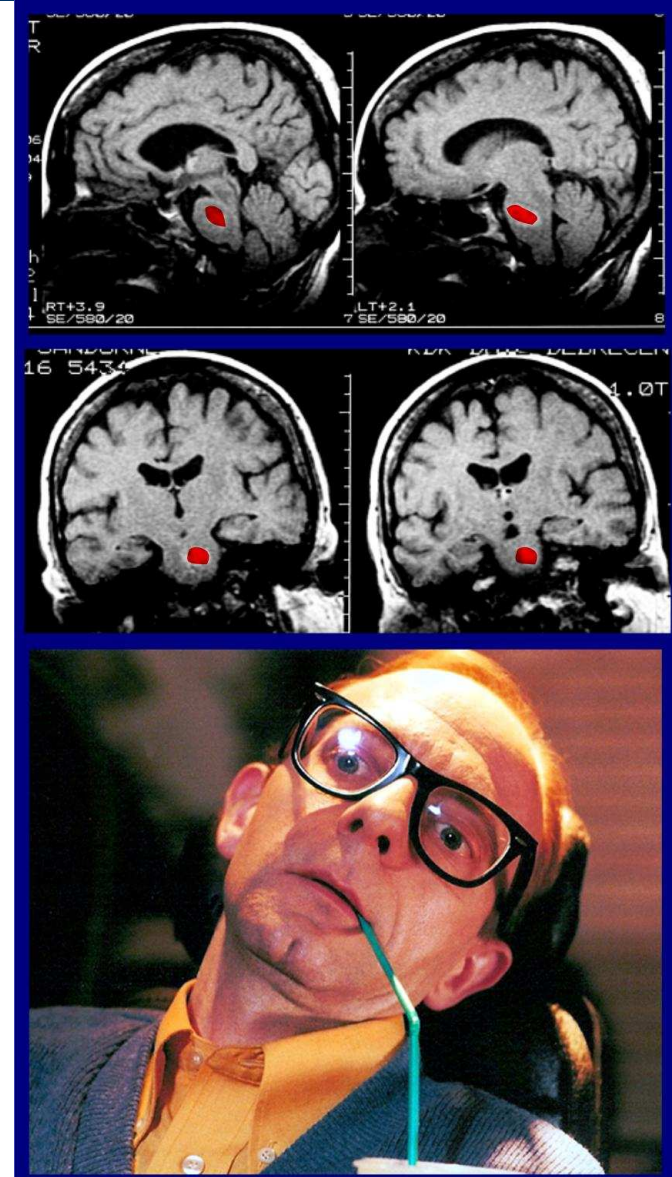


Postcomatous disorders & coma like states

Locked in syndrome (LIS)

- **Alt.:** pseudocoma, deafferentation sy.)
- **Etio:** rare clinical entity results typically from a ventral pontine infarction (rarely pontine tumours, haemorrhage, central pontine myelinolysis, head injury or brain stem encephalitis.) that damages cortico-spinal tracts below the level of the III.n. nuclei., leading to complete paralysis of voluntary muscles except for eye movements
- **Sy:**
 - total paralysis (tetraplegia loss of voluntary movement);
 - Bulbar paralysis (dysarthria, amimia, dysphagia) – artefital feeding
 - patients can open their eyes and elevate and depress eyes to command. ; horizontal eye movements are usually lost
 - Patients are on artefital ventilation
 - No sensory defect; reactivity to pain present □
 - Recovery is exceptional

Damasio A, Meyer K: Consciousness: an overview of the phenomenon and of its possible neural basis. In The Neurology of Consciousness: Cognitive Neuroscience and Neuropathology. Laureys S, Tononi G. (Ed) Oxford:UK: Academic Press; 2009: 3-14



Other disorders of consciousness

Akinetic mutism

- **Etio:** first described in patients that suffered from diencephalic damage; lesions that interfere with reticular cortical/integration (but spare the corticospinal pathways); hydrocephalus, tumors close to 3rd ventricle; gross bilateral lesion of gyrus cinguli, frontal lobe, periaqueductal mesencephalon
- **Sy:** immobility, eye closure, little or no vocalisation; little movement to painful stimuli
- the relative paucity of signs indicating damage to descending motor pathways, despite the immobile state (as in LIS); spasticity and rigidity are not usually evident (as in vegetative state)
- Sleep/wake cycles can be seen, as indicated by eye opening.
- !! debate about whether or not the syndrome should be clearly differentiated from the vegetative state; indistinguishable from early stages of the vegetative state

Abulia = lighter form of akinetic mutism: hypokinesia (bradykinesia instead of akinesia (delayed verbal and other motor reactions))

Psychogenic coma (Hysterical pseudocomma)

- eyelids are kept firmly shut and are resistant to opening
- oculocephalic responses are unpredictable (nystagmus is evident on caloric testing)
- motor tone is normal or inconsistent and limb reflexes retained.
- EEG shows awake rhythms

Catatonia

1874-Karl Ludwig Kahlbaum (Die Katatonie oder das Spannungsirresein)

Etio: associated with psychiatric illness (affective) schizophrenia; metabolic/ drug induced disorders; no organic lesions

Sy:

- no spontaneous movement, patients seem unresponsive to their surroundings, but appear conscious. Neurological examination is normal. passive limb positioning in postures “waxy flexibility”.
- eyes open and unblinking, pupils dilated but reactive, oculocephalic responses absent or impaired, and caloric responses intact. EEG: low voltage, fast record rather than the “slowing” of true coma.
- difficult to distinguish from organic disease, particularly in lethargic unresponsiveness



Comparison of coma-like disorders of consciousness

| | Minimally conscious state | Vegetative state | Coma | „Locked in“ syndrome |
|--------------------------|--|--|--|---|
| Vigility - communication | Reduced, partial | Absent | Lost | Full |
| Sleep - Wake cycle | Present | Present | Absent | Present |
| Motor functions | Localized response to pain; touches and hold things; | Minimal spontaneous movements; withdrawal response to pain | Reflex and postural responses | Quadruplegia |
| Auditory functions | Localises source of sound; turn the head | Startle (orientation) after recovery some remember | None; after recovery some remember what they heard | Present |
| Visual functions | Visual fixation (prezerá; akoby do prázdna) | Startle (orientation), no focusing | No | Present |
| Communication | No words, sounds | | No | Present; limited to vertical eye movement |
| Cognition understanding | Present but limited | Limited, little or missing | No | Present; cannot react |
| Emotions | Smiling, crying, clenching, mimics | Reflex smiling, crying | No | Present ; cannot react |

Bruno MA, Vanhau denhuys e A, Thibaut A, Moonen G, Laureys S: From unresponsive wakefulness to minimally conscious PLUS and functional locked-in syndromes: recent advances in our understanding of disorders of consciousness. *J Neurol* 7:1373-1384. 2011,

Assesment

Standardized validated scales

- bedside assessment neurologist, internist
- Glasgow coma scale (GCS)
- Coma Recovery Scale-Revised (CRS-R)
- Full Outline of Unresponsiveness scale (FOUR)

Specific assessment tools:

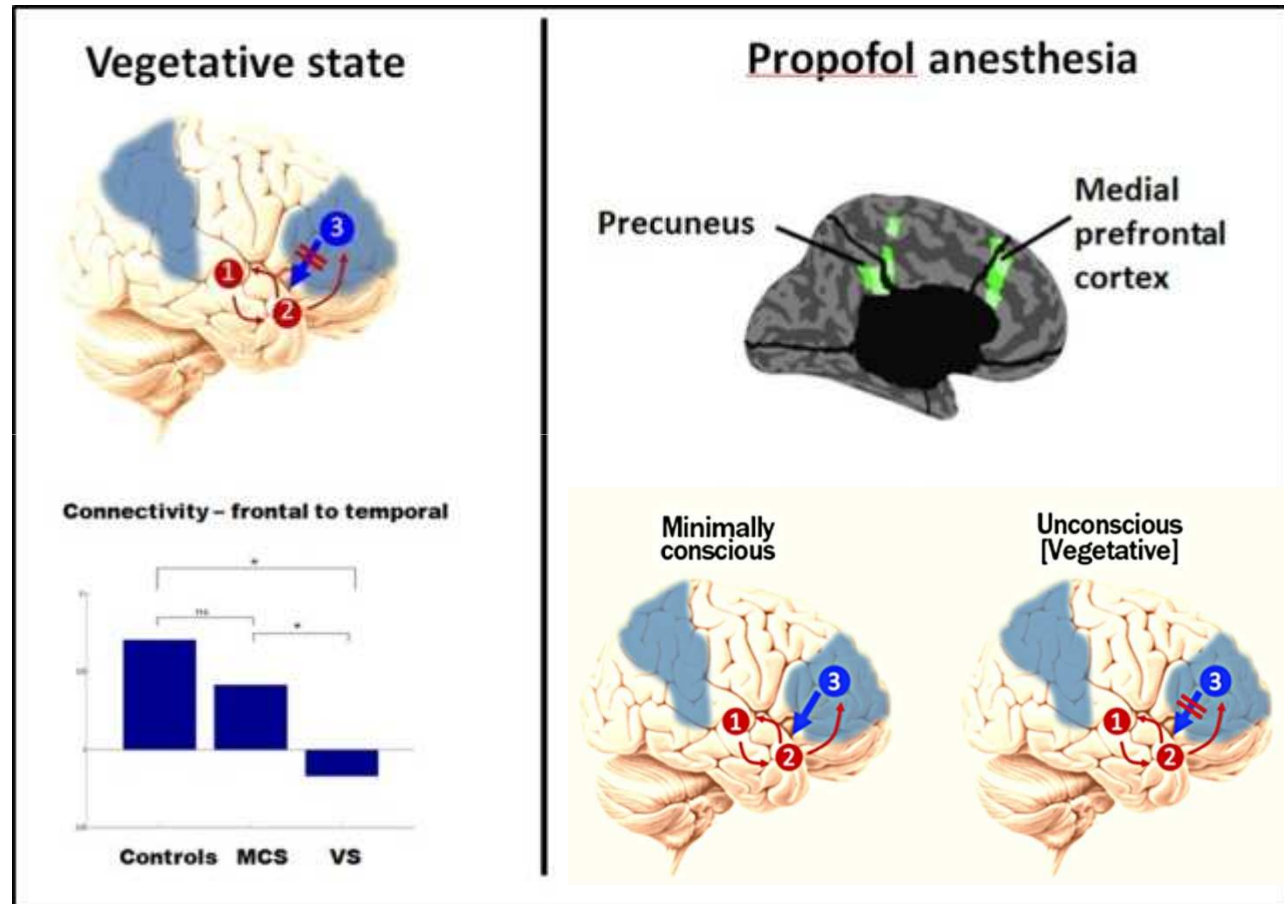
- mirror (to evaluate visual pursuit), patient's own name (to assess auditory localization),
- self-referential stimulus (their own face)
- written commands (absence of response to oral commands)

What are not the signs of consciousness

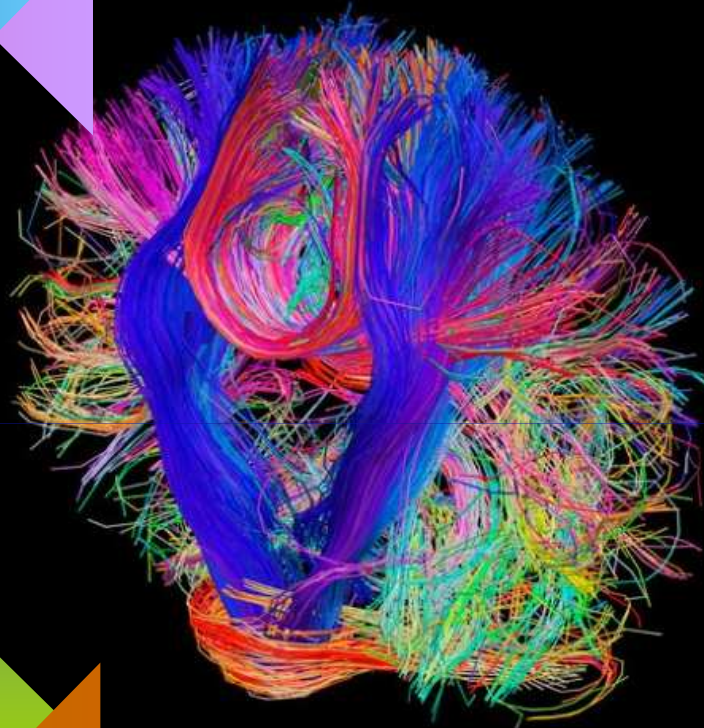
- blinking in response to a threat (blink reflex may be elicited due to corneal stimulation by air flow)
- visual fixation (at least in patients with anoxia)
- resistance to eye opening is related to consciousness

Frontal- parietal disconnection

- PET studies hypometabolism in frontal-parietal regions
- Strata spojení medzi frontálnou a parietálnou kôrou pri VS a propofolovou anestéziou



Boly, M., Garrido, M.I., Gosseries, O., et al.: Preserved feedforward but impaired top-down processes in the vegetative state. *Science* 2011, 6031: 858-862



5 Body - related agnosias

Disorders of self-recognition and its parts

| | |
|-----------------------|--|
| Autotopagnózia | neschopnosť rozoznať dráždené miesto na povrchu tela |
| Dermaalexia | neschopnosť rekonštrukcie priestorovej mapy povrchu tela. Prejavuje sa tým že postihnutý nie je schopný rozoznať rôzne tvary, písmená ktoré sa mu kreslia na kožu |
| Alloestézia | je porucha stálosti lokalizácie podnetu. Pri opakovanom dráždení toho istého miesta cíti chorý dráždenie stále v iných oblastiach |
| Dyzestézia | je porucha, pri ktorej sa podnet jednej modality interpretuje ako vnem inej modality, napr. dotyk ako pálenie, chlad ako teplo a pod |
| Stereoagnózia | strata schopnosti rozoznať predmety hmatom pri zatvorených očiach. Táto porucha sa prejavuje dvomi, relatívne samostatnými formami |
| Amorfognózia | neschopnosť rozoznať tvary predmetov (napr. kocku, guľu, knihu). Porušená je centrálna integrácia podnetov z povrchových i hĺbkových mechanoreceptorov i proprioreceptorov |

Qualitative disorders

| | |
|-----------------------|--|
| Ahylognózia | neschopnosť rozoznávať látkovú podstatu ohmatávaných predmetov (napr. sáčok s vodou, pieskom a pod.). Porušená je centrálna reprezentácia podnetov z termoreceptorov chladu, tepla a povrchových mechanoreceptorov |
| Akinestézia | neschopnosť rozoznávať pohyb tela a jeho jednotlivých segmentov, napr. chôdzu, pohyby ruky nohy a pod. |
| Statanestézia | neschopnosť rozoznávať statické postavenie tela alebo jeho jednotlivých častí, napr. stoj |
| Hypopalestézia | neschopnosť vnímať hĺbkovú tzv. vibračnú citlivosť. Vzniká poruchou rýchlo sa adaptujúcich vibračných mechanoreceptorov v tlanive okolo svalov a kíbov |
| Hypobarestézia | neschopnosť vnímať tupý, do hĺbky pôsobiaci tlak. Vzniká poruchou pomaly sa adaptujúcich nízkoprahových hĺbkových mechanoreceptorov |
| Acoenesthesia | neschopnosť vnímať vlastné telo a jeho jednotlivé časti. Vzniká integratívnom poruchou baroreceptcie, termoreceptcie, povrchovej a hlavne hĺbkovej mechanoreceptcie, propioceptcie |
| Amorphognosia | |

Self-location, self-consciousness



Gyrus angularis – speech processing (aphasia), acalculia, space cognition, attentiveness, memory (Brodmann 39)

A PRESENCE BEHIND

Stimulation of the **left angular gyrus** gave the patient a sensation of a shadowy person lurking behind.

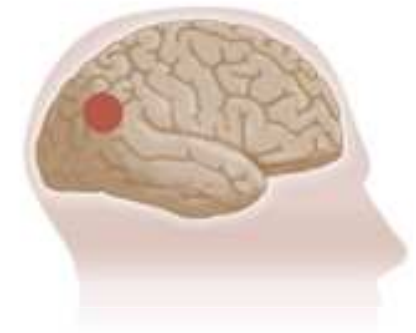


The shadowy figure is actually a perceived double of the self.



OUT-OF-BODY

Stimulation of the **right angular gyrus** resulted in an out-of-body experience, as if the patient were floating from the ceiling, looking down at herself.



Perceived location

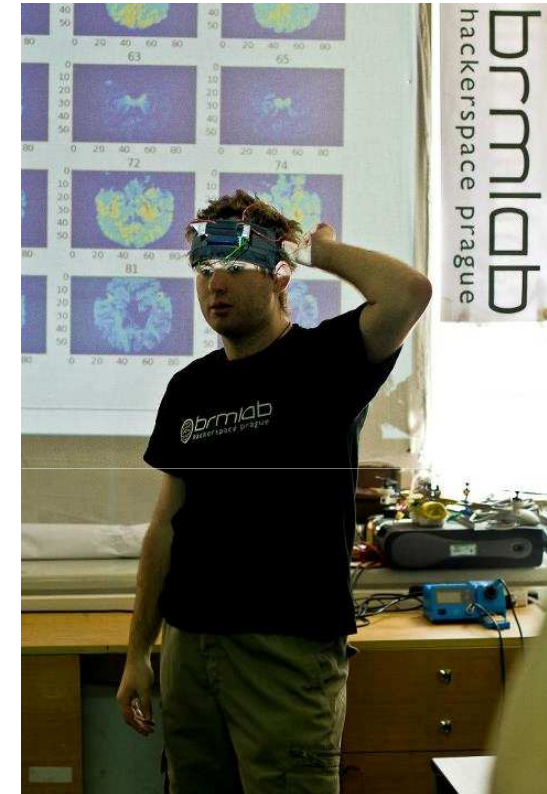


Actual location

Blanke O (2012) Multisensory brain mechanisms of bodily self-consciousness. Nature Reviews Neuroscience: 13: 556-571.

Ionta S, Heydrich L, Lenggenhager B, Mouthon M, Gassert R, Blanke O (2011): Temporo-parietal cortex encodes self-location and first-person perspective. Neuron 70:363-374.

Temporal cortex – mystical experiences



- Persinger, M: Stimulation of temporal lobe by weak magnetic stimuli may evoke special feeling and mystical experiences of encountering with God (well – being, absolute safety, endless love, http://en.wikipedia.org/wiki/God_helmet)