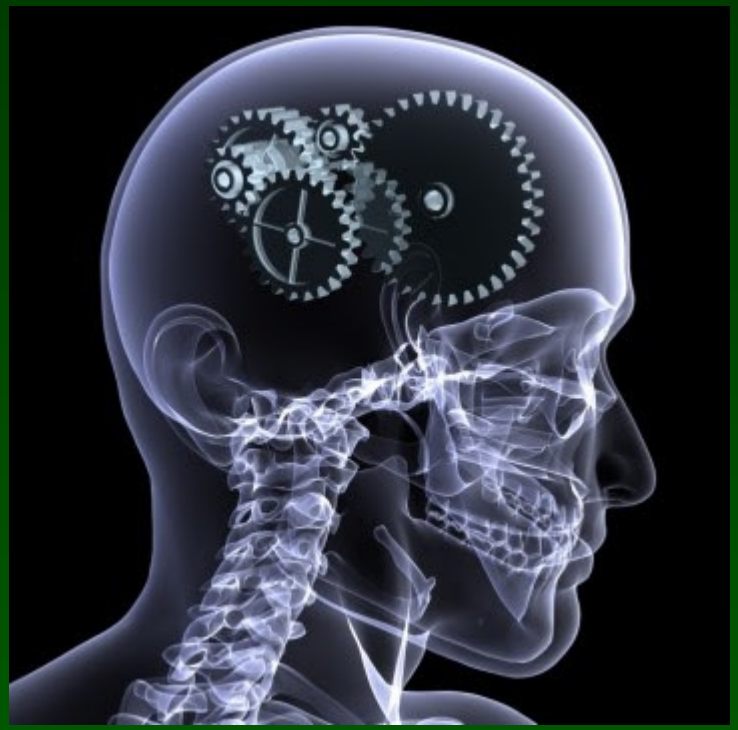
Selected topics in cognitive science and biomodeling



L7: Brainstem and emotions

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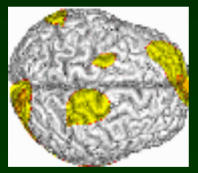
What it will be about



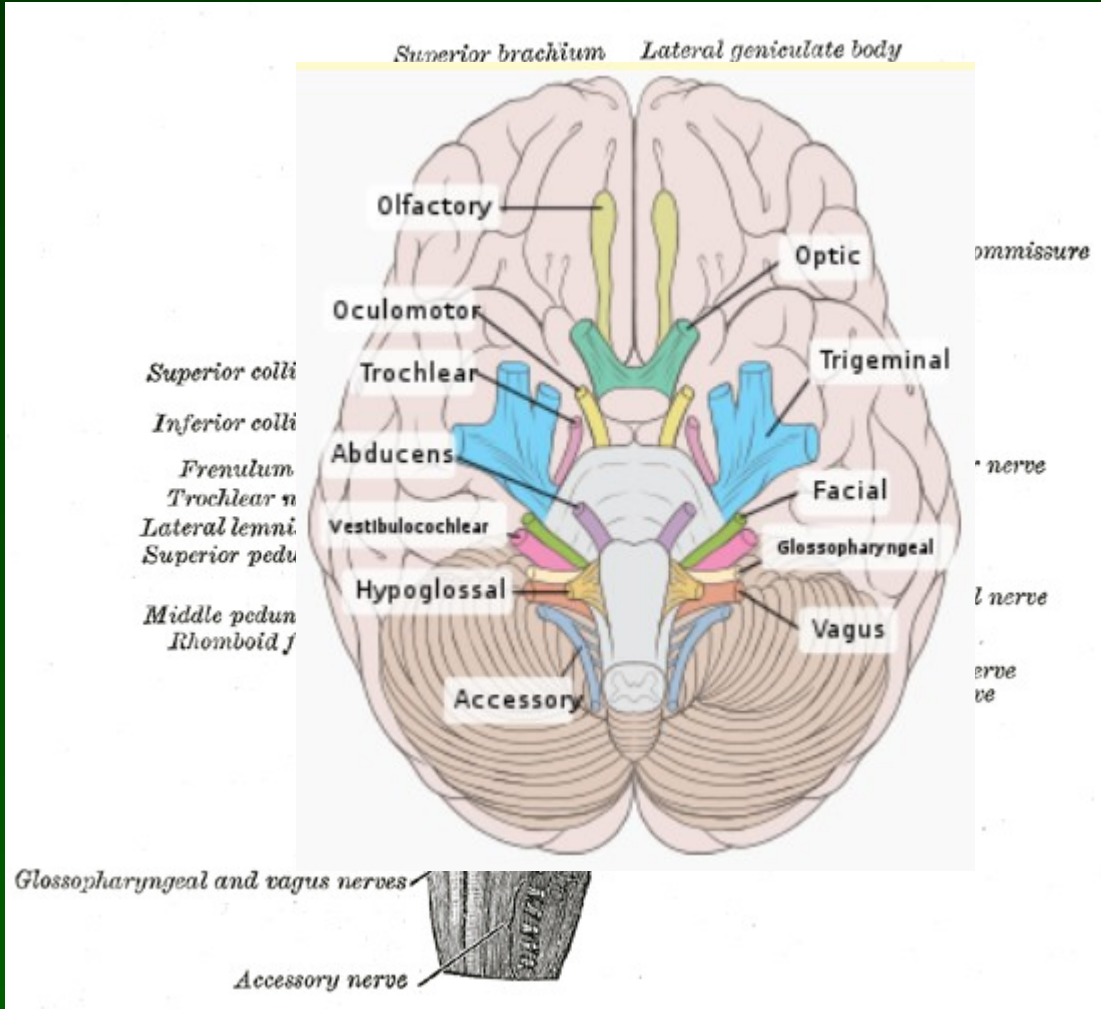
1. Core ideas and cybernetic explanations.
2. Basic brain architecture.
3. Information flow in the brain.
4. Examples of communication breakdown.
5. Functions of the brain stem and states of consciousness.
6. Limbic system and emotions.

Brainstem main functions

10 cranial nerves pass through the brainstem, transmitting sensory information and controlling eyes, face and speech related movements.

Central pattern generators or neural circuits producing rhythmic activity, in the brainstem and spinal cord enable respiration and locomotion.

Global control of access to sensory input, alertness, emotional states, pain, posture, locomotor reflexes.



Gray's anatomy (1918): spinal cord, medulla oblongata, pons, mesencephalon, midbrain.

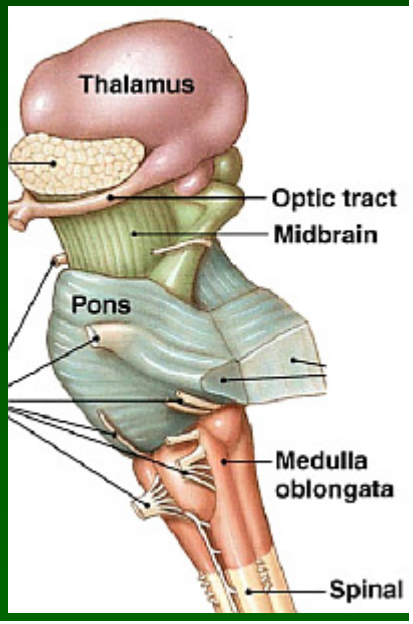
Brainstem functions

Brainstem is the sensory/motor gateway to the brain:

- breaking connections passing through the ventral part of the pons leads to the locked-in syndrome;
- patients are almost completely paralised, only eye blinks and breathing are controlled consciously;
- Jean-Dominique Bauby, Paris journalist, after stroke become locked-in, film *The Diving Bell and the Butterfly* (2007) is an adaptation of his story, he dictated it by blinking just one eye!

Medulla oblongata, lower half of brainstem has:

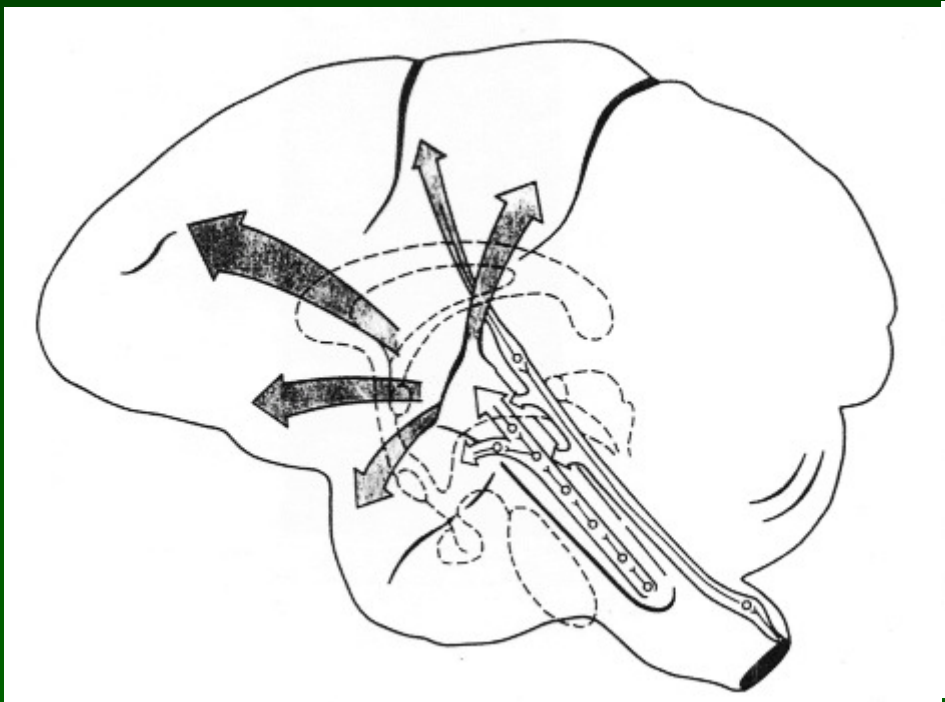
- respiration centers – chemoreceptors, O_2/CO_2 level
- cardiac center – sympathetic & parasympathetic system.
- vasomotor center – baroreceptors, blood pressure.
- reflex centers of vomiting, coughing, sneezing, swallowing.

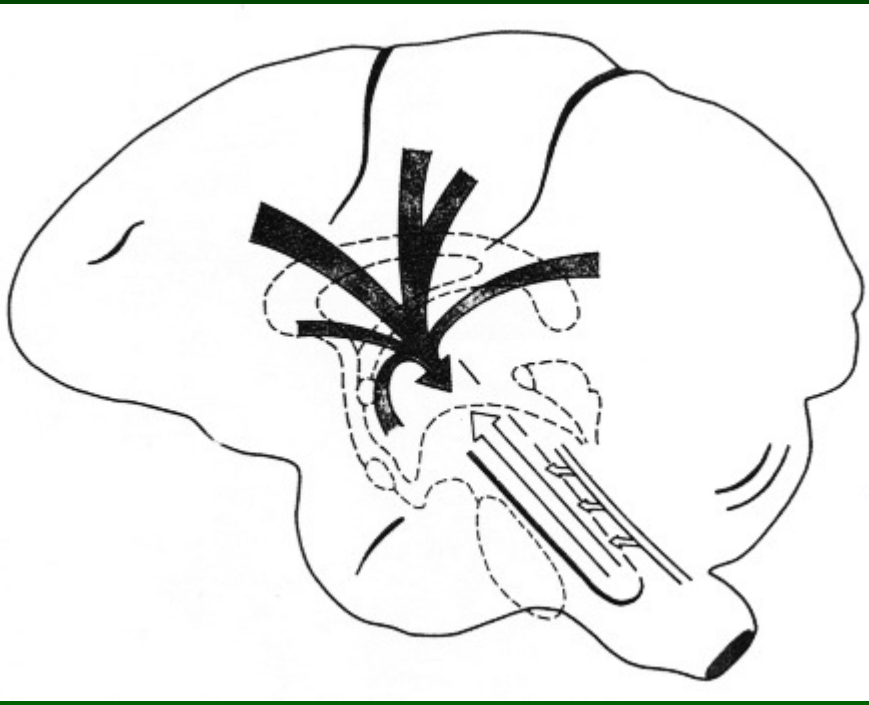


Brainstem reticular formation

Ascending reticular formation wakes the brain up, preparing for perception, mental and behavioral actions: rough control without precise analysis.

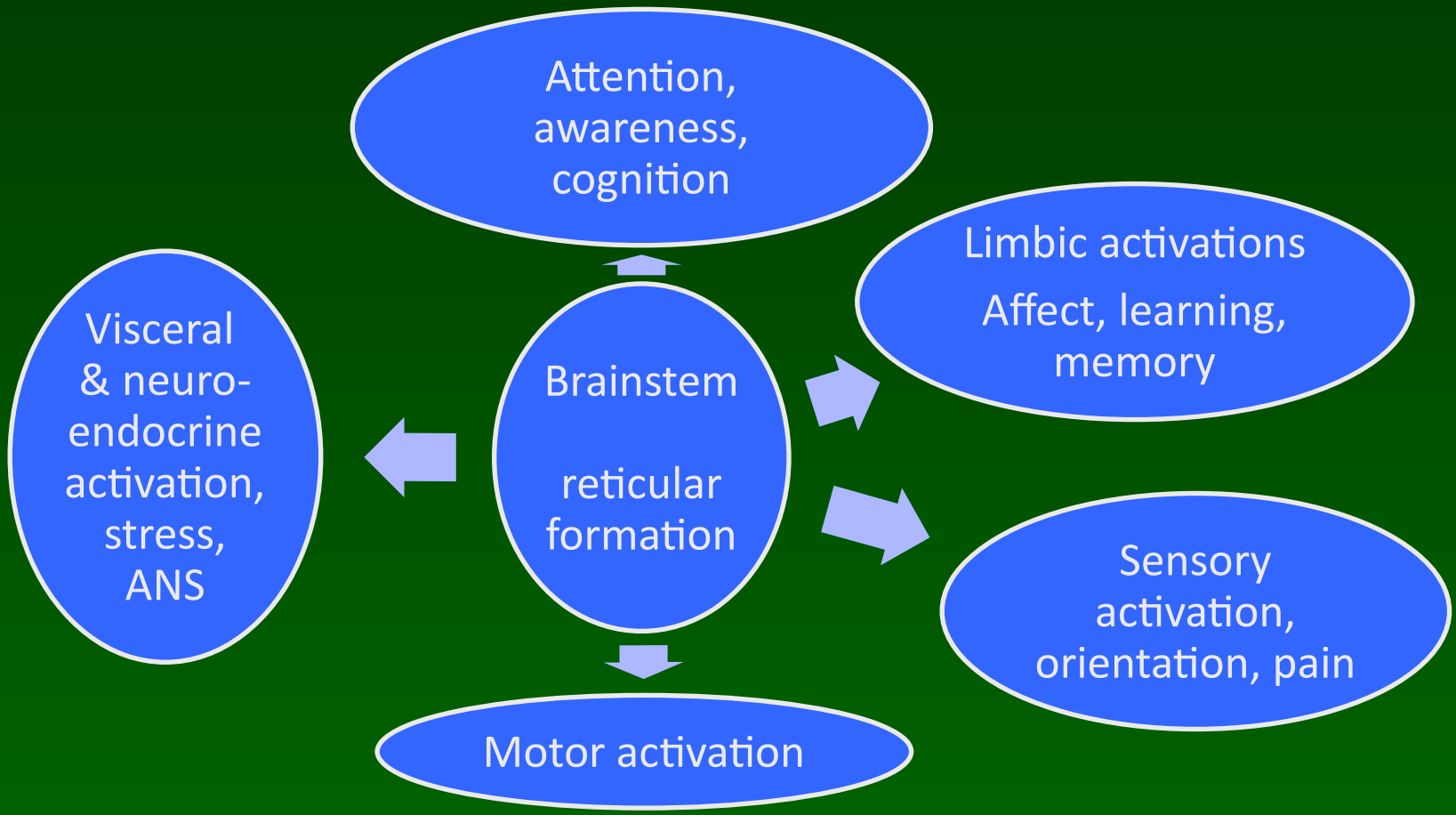
Descending reticulospinal tracts project to spinal cord motor neurons, modulating the tone, balance, posture, and coordination of body movements with the assistance of other sensory stimuli.





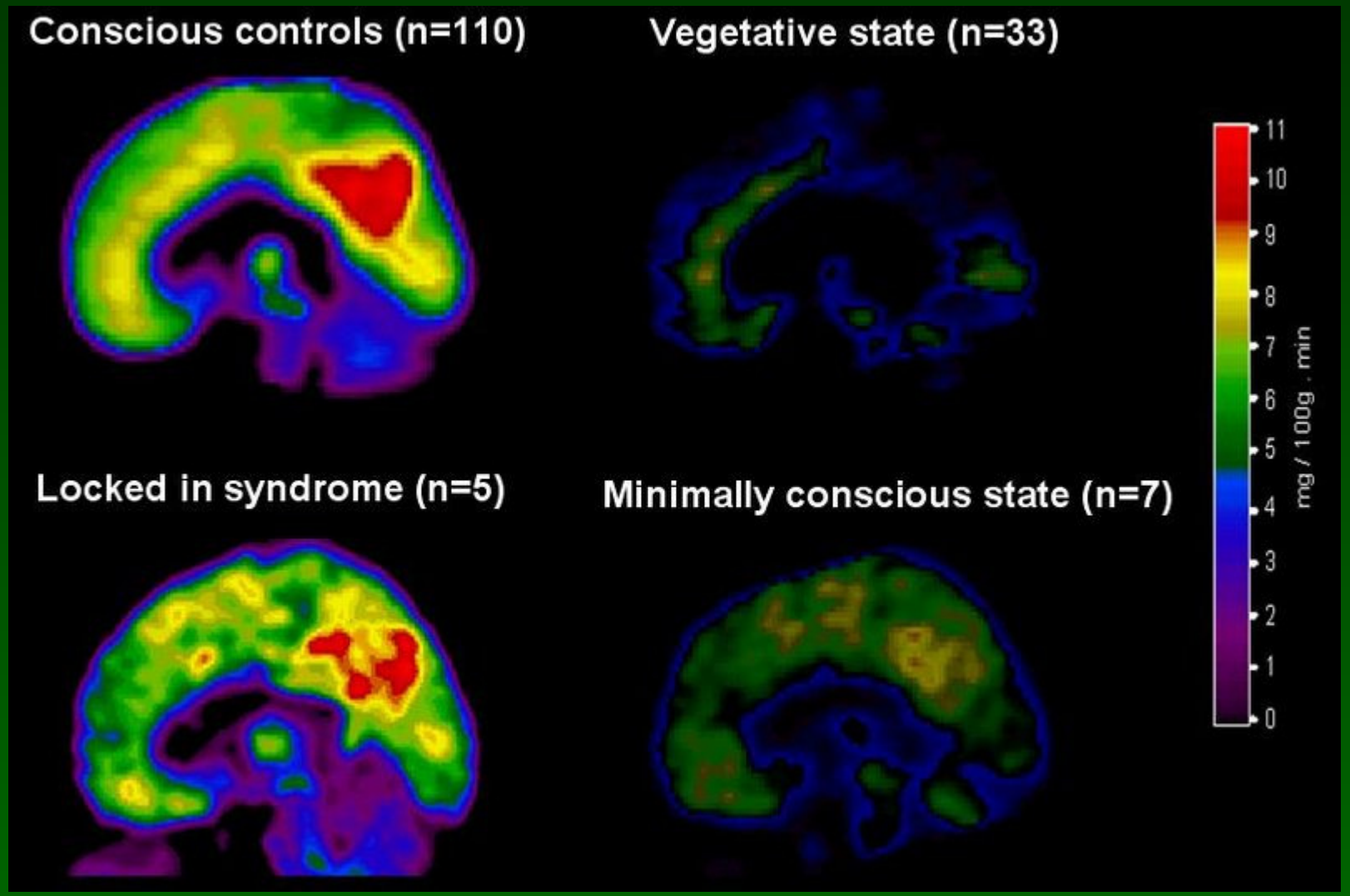
Brainstem activation

Ascending reticular formation wakes the brain up, preparing for perception, mental and behavioral actions: rough control without precise analysis.



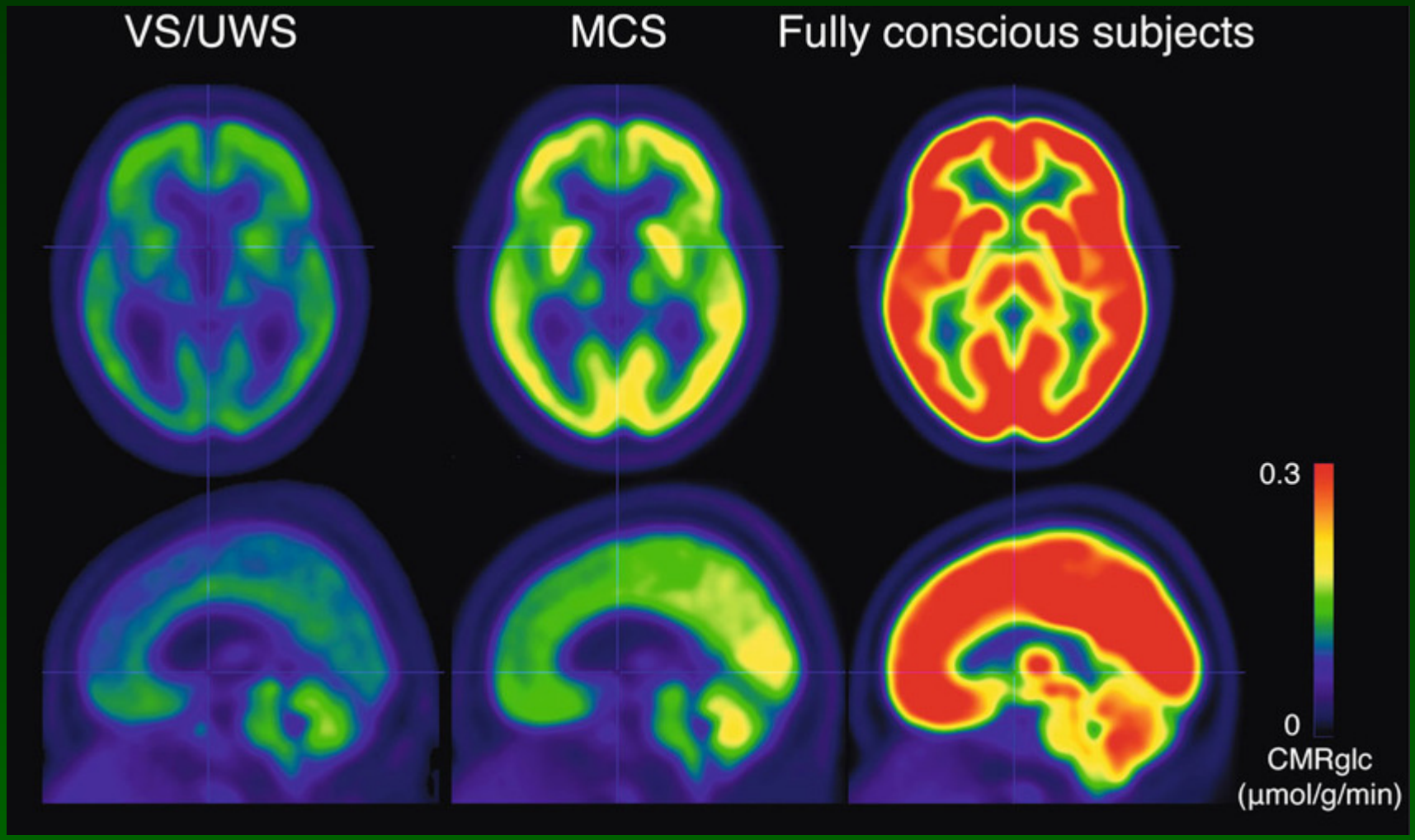
States of consciousness

PET studies; communication with people in MCS is difficult.



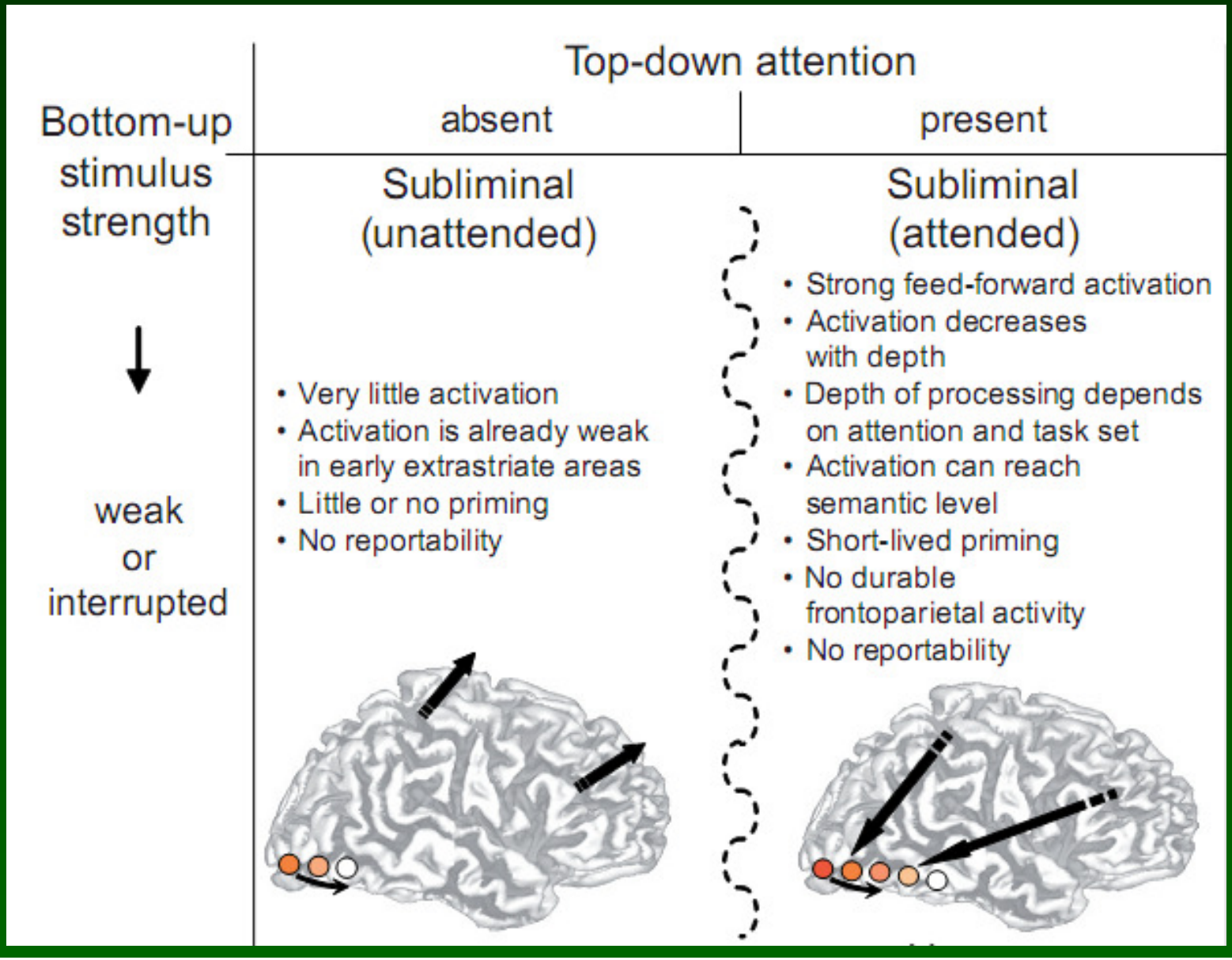
States of consciousness

Average cerebral metabolic rate of the use of glucose.



From: Stender J, Kupers R, Rodell A et al (2015) Quantitative rates of brain glucose metabolism distinguish minimally conscious from vegetative state patients. Journal of Cerebral Blood Flow and Metabolism 35(1):58-65

Subliminal stimuli

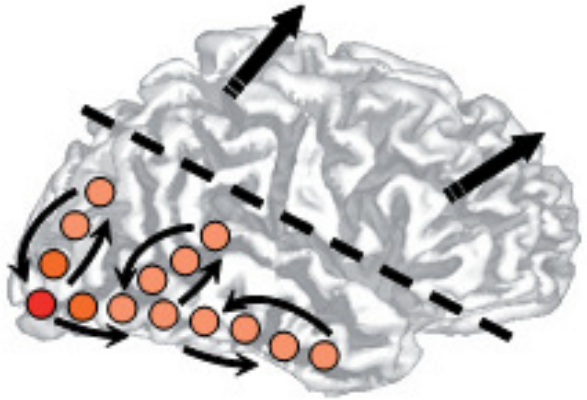


Strong stimuli

sufficiently strong

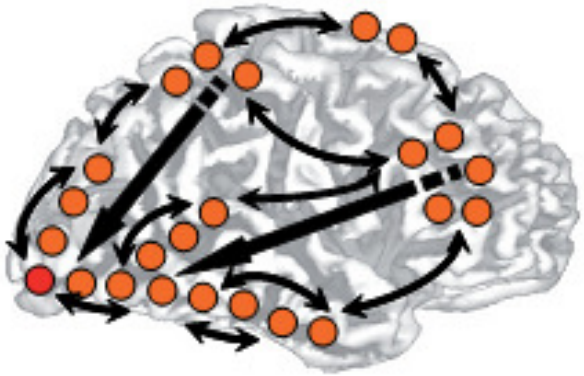
Preconscious

- Intense activation, yet confined to sensorimotor processors
- Occipito-temporal loops and local synchrony
- Priming at multiple levels
- No reportability while attention is occupied elsewhere



Conscious

- Orientation of top-down attention
- Amplification of sensori-motor activity
- Intense activation spreading to parietofrontal network
- Long distance loops and global synchrony
- Durable activation, maintained at will
- Conscious reportablity



How brains create experience?

Sensory cortex sends bottom-up signals.

Bottom-up and top-down activations create resonant states.

What if top-down connections are weak or missing?
C. Gilbert, M. Sigman, Brain States: Top-Down Influences in Sensory Processing. Neuron 54(5), 677-696, 2007

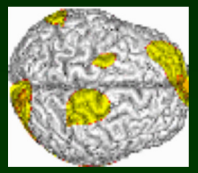
Cortical & thalamic sensory lower-level processes are shaped by complex top-down influences, attention, task-related expectations and sensory inputs.

Brain states are determined by the interactions between multiple cortical areas and the modulation of intrinsic circuits by feedback connections.
Disruption of this interaction may lead to behavioral disorders.

Dehaene et al, Conscious, preconscious, and subliminal processing. TCS 2006

Bottom-up strength & top-down attention combined lead to 4 brain states, with both stimulus and attention required for conscious reportability.

What it will be about



1. Limbic system and emotions.
2. Sensory input coding - receptors.
3. Topographical maps.
4. Population coding – active perception.
5. Senses and pathways.
6. Vision.

Expression of emotions

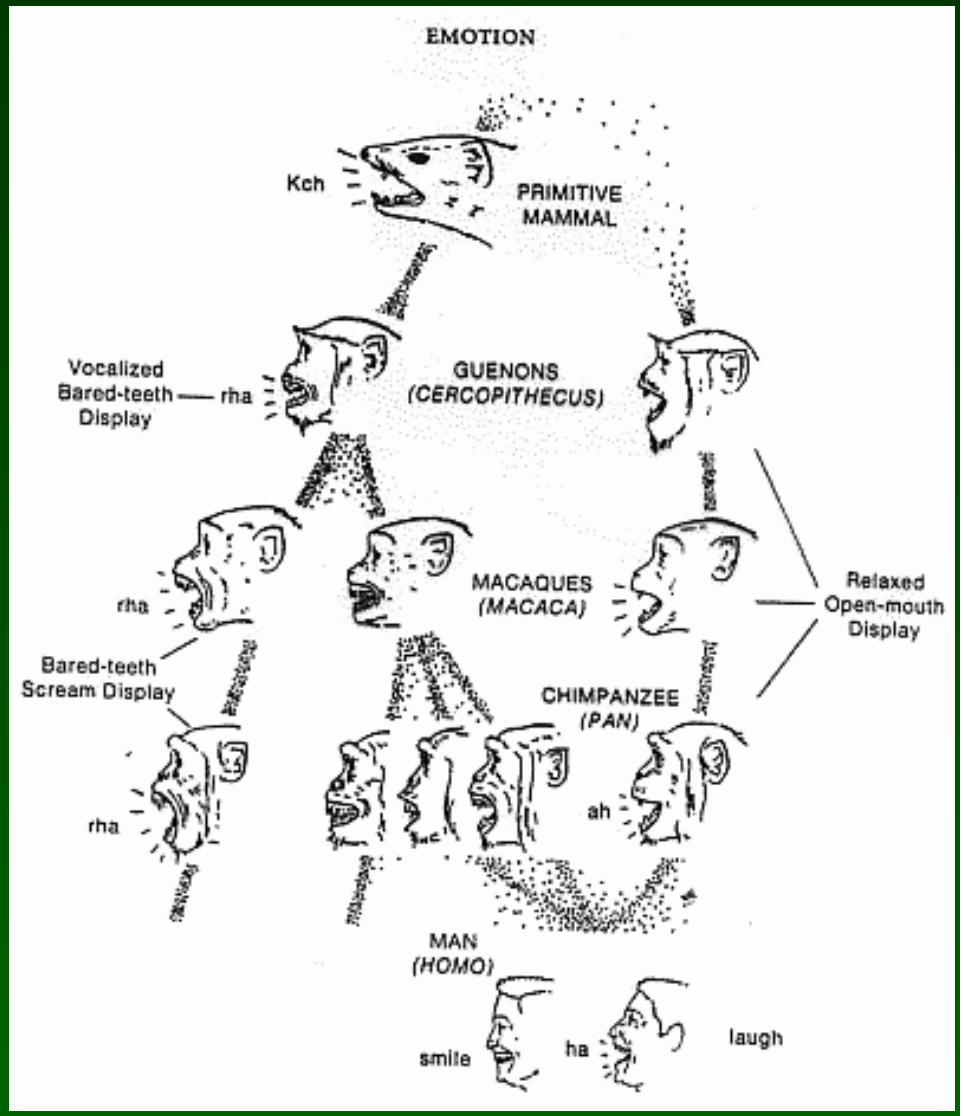
Charles Darwin (1872)
The Expression of the Emotions in Man and Animals

Even rats can laugh when tickled …

Basic emotions are similar in many animals, but higher emotions, feeling of shame or pride, require self-consciousness and thus may be accessible only to humans.

How do we know what is meant by emotions? Saudade? Amae?

Alexythymia: problems with understanding, processing, or describing emotions.



Emotions & drives

Emotions: categories of brain/body states.

Emotions may have many functions; they involve physiological arousal, expressive behaviors facilitating planning and actions by providing them with value.

Basic emotions are universal and can be recognized on photographs of people independently of their ethnic origin.

Facial Action Coding System is a parametric approach to code facial muscle expressions but the whole body is the canvas for expressing emotional states.

Emotions are associated with mood, temperament, personality and motivation. Drives motivate, direct and energize behavior, emotions provide affective evaluation of motivation, positive or negative.

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Anger - Happiness - Disgust
Surprise - Sadness - Fear

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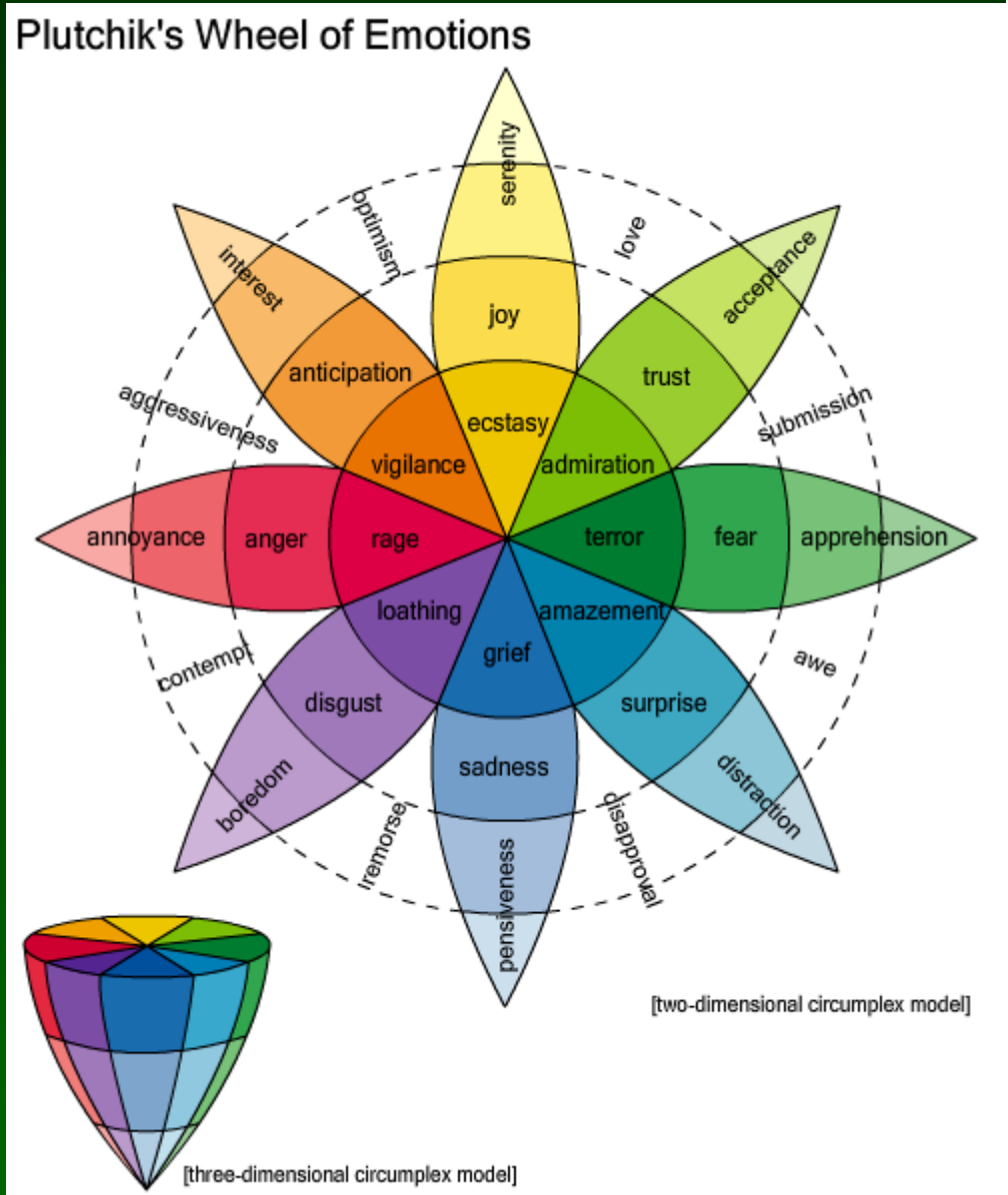
Affective computing

Robert Plutchik created 3D model of emotions based on combination of 2 or 3 basic emotions, although there are great differences in linguistic description of more subtle emotions around the world.

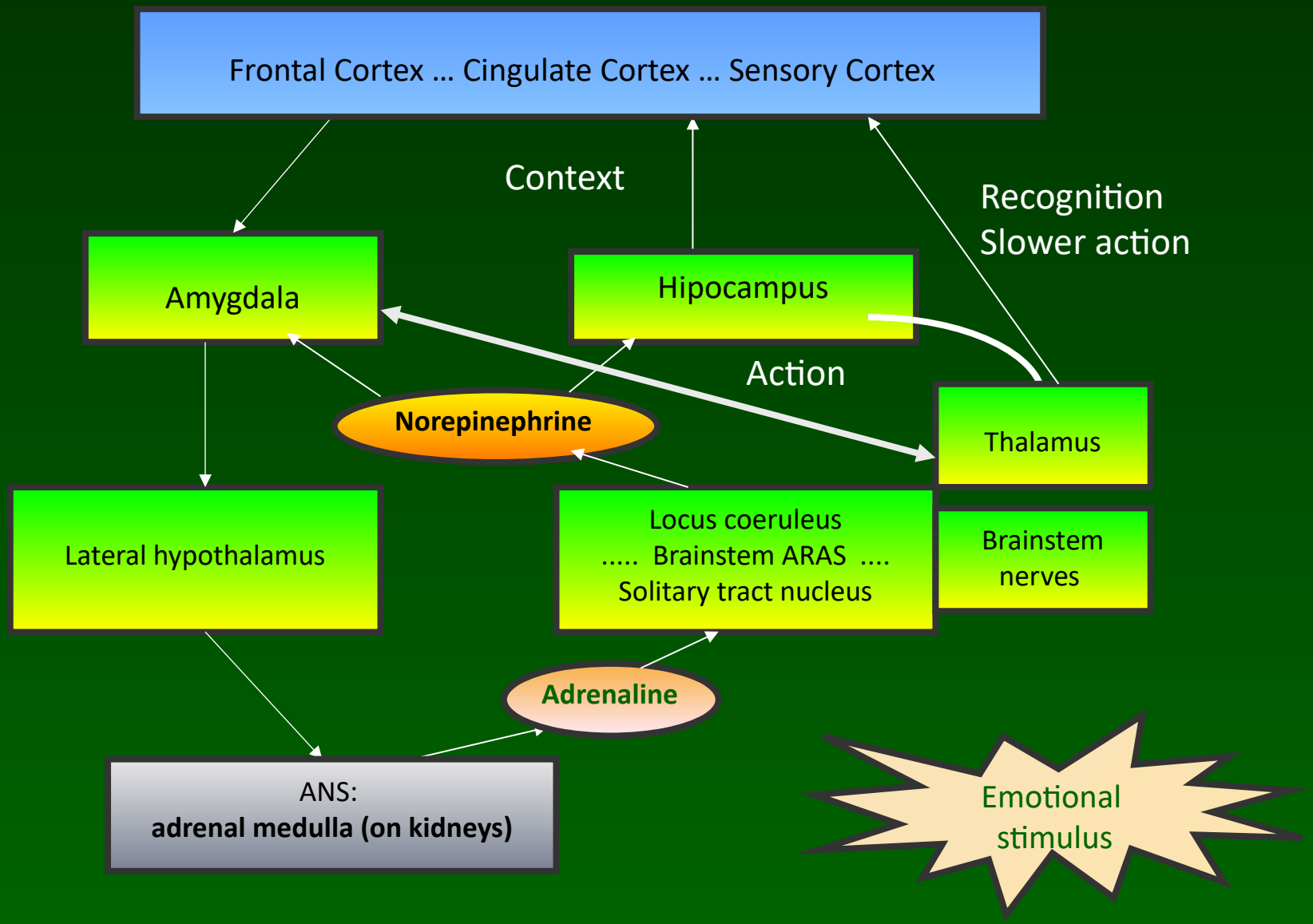
Affect in psychology = how emotions affect behavior.

Affective computing: recognize, interpret, process, and simulate human affects in artificial systems, including speech, facial and bodily expressions.

Emotion Markup Language (EmotionML).



Limbic system



Fear of snakes

Before I recognize that it is just a stick I stepped on I notice movements and jump. Emotions come later, preparing me for fight or flight.

Emotions: state of brain that changes how information is processed and initiates physiological processes preparing for action.

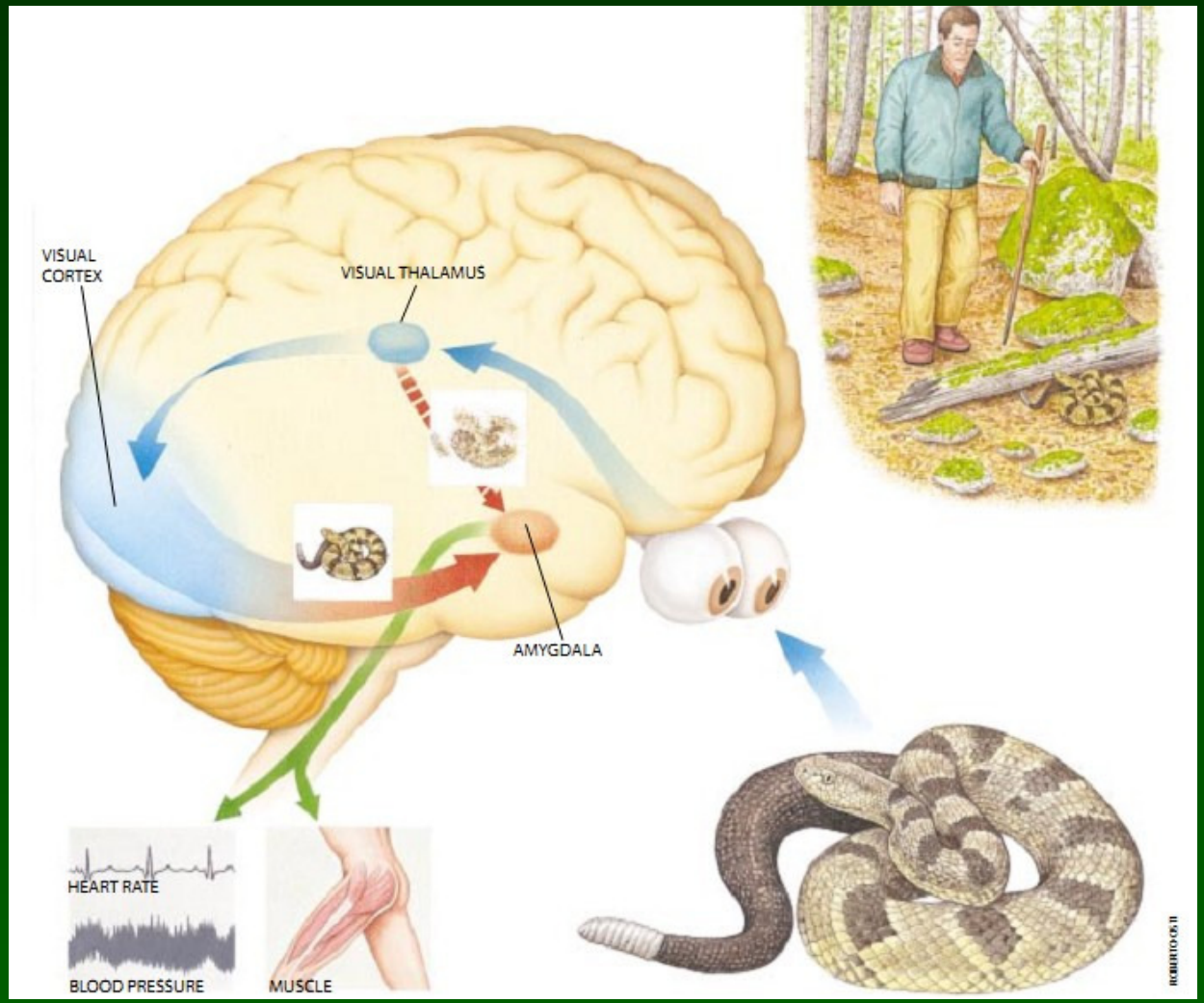
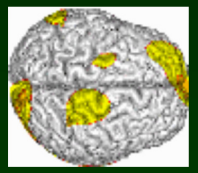


Fig. source: Scientific American Mind

What it will be about



Next:

- Perception
- Learning
- Memory
- Language
- Volition
- Consciousness