

# Consciousness and conscious access

# Is this *person* conscious?



3:47:51 AM – Sleeping Woman

## Is this *person* conscious?

*«It was the end of a movie. I was getting out on the street through a door. At that moment I heard the noise of the alarm sound and woke up.»*

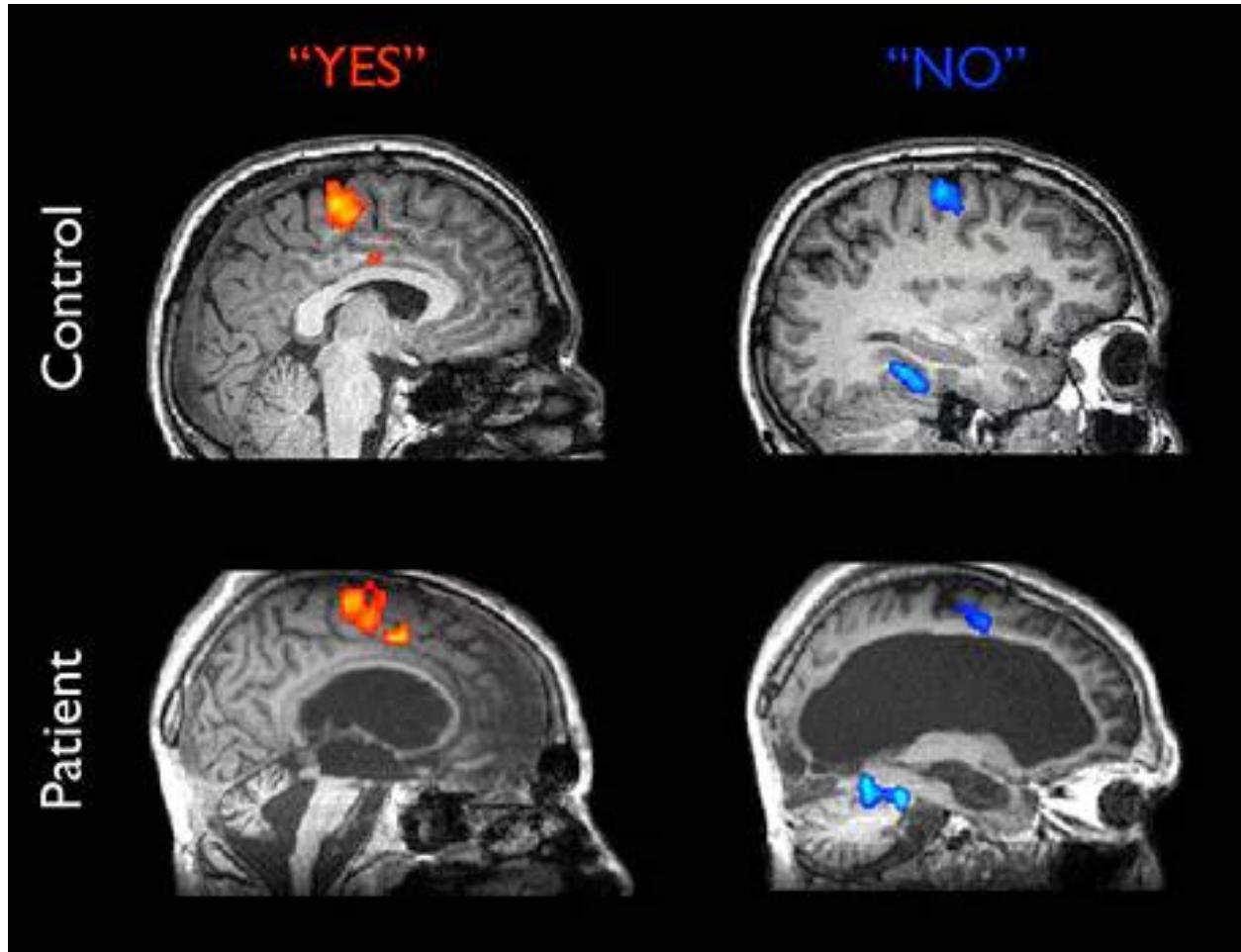


*The Purple Rose of Cairo* (Woody Allen, 1985)

## [2] Is this *person* conscious?



# Is this *person* conscious?



Yes: Imagine to play tennis.

No: Imagine to wander from room to room in your home.

**Is this *person* conscious?**

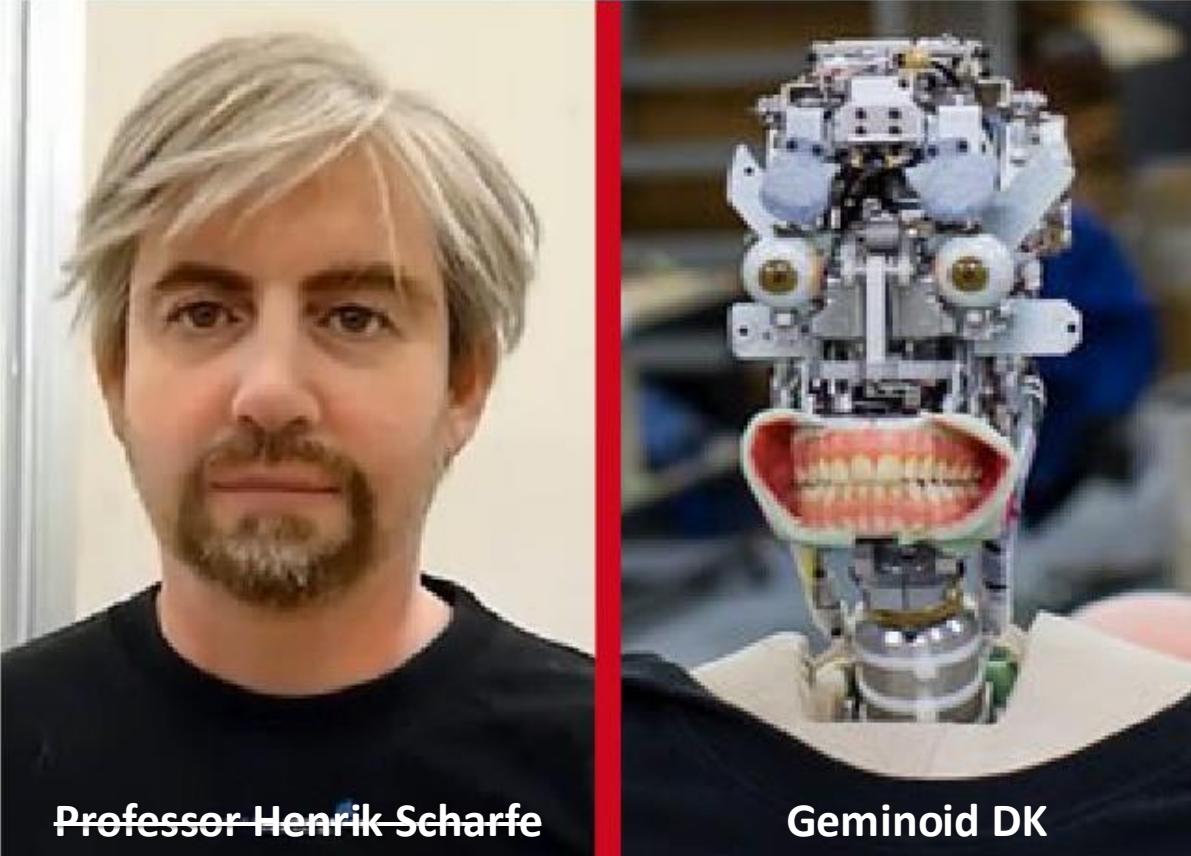


# Is this *person* conscious?



Professor Henrik Scharfe

# Is this *person* conscious?



Professor Henrik Scharfe

Geminoid DK

A *Geminoid* is a special type of android that is meant to look like a specific person  
The word *Geminoid* comes from the Latin word *geminus* (twin)

## Consciousness: Definition

Consciousness has been defined variously in terms of ***the ability to experience or to feel, having a sense of selfhood or soul, the fact that there is something "that it is like" to "have" or "be" it, and the executive control system of the mind, or the state or quality of awareness, or, of being aware of an external object or something within oneself...***

## Consciousness vs Awareness

**Consciousness:** intrinsic and integrated experience; it is what it “feels like” to be a system from the system’s own perspective.

**Awareness:** accessing or reporting information (*conscious access*); the cognitive ability to notice or respond to external or internal events.

# Consciousness vs Attention

Is it possible to have consciousness without attention?



## Consciousness vs Attention

It is often assumed that attention is a necessary prerequisite for consciousness.

When we pay attention to an object, our experience of it becomes more vivid, and when we shift our attention, it fades from consciousness.

**Bottom-up**: when a salient stimulus (e.g., a flash or a sound) capture our attention.

**Top-down**: attention willingly deployed toward a particular position in space, a particular feature, or a particular object.

## Consciousness vs Attention

**Count how many times  
the players wearing  
white pass the ball**

# Consciousness vs Attention

Is it possible to have consciousness without attention?

**Gist** (the high-level semantic description of a scene) appears to be **immune from inattentional blindness**. Because gist is a property associated with the entire image, any process that locally enhances features, such as focal attention, is of limited use.

When a photograph covering the entire background is briefly and unexpectedly flashed onto the screen, subjects can accurately report a summary of its content.  
**The gist of a scene can be extracted in a period as short as 30 ms.**

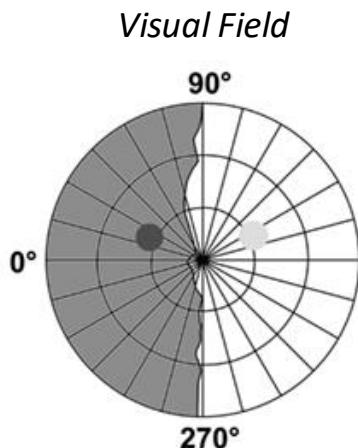
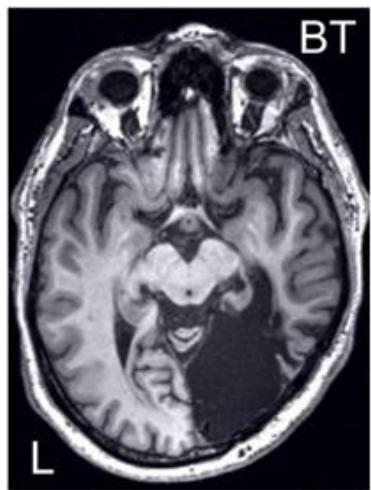
A subject engaged in a task that requires focusing attention on the center of the visual field, can still perceive the difference between a background scene containing an animal or a vehicle from one that does not.

While the gist of a scene may be experienced vividly, it is also coarse...

# Consciousness vs Attention

**Attention without consciousness** has been demonstrated in more than 40 experiments manipulating bottom-up as well as top-down spatial, temporal, feature-based, and object-based attention.

Attention can be deployed to stimuli that remain unconscious, selective attention does not necessarily result in conscious experience, and may even be counterproductive. Attention can facilitate responses to unseen stimuli in **blindsight** patients...



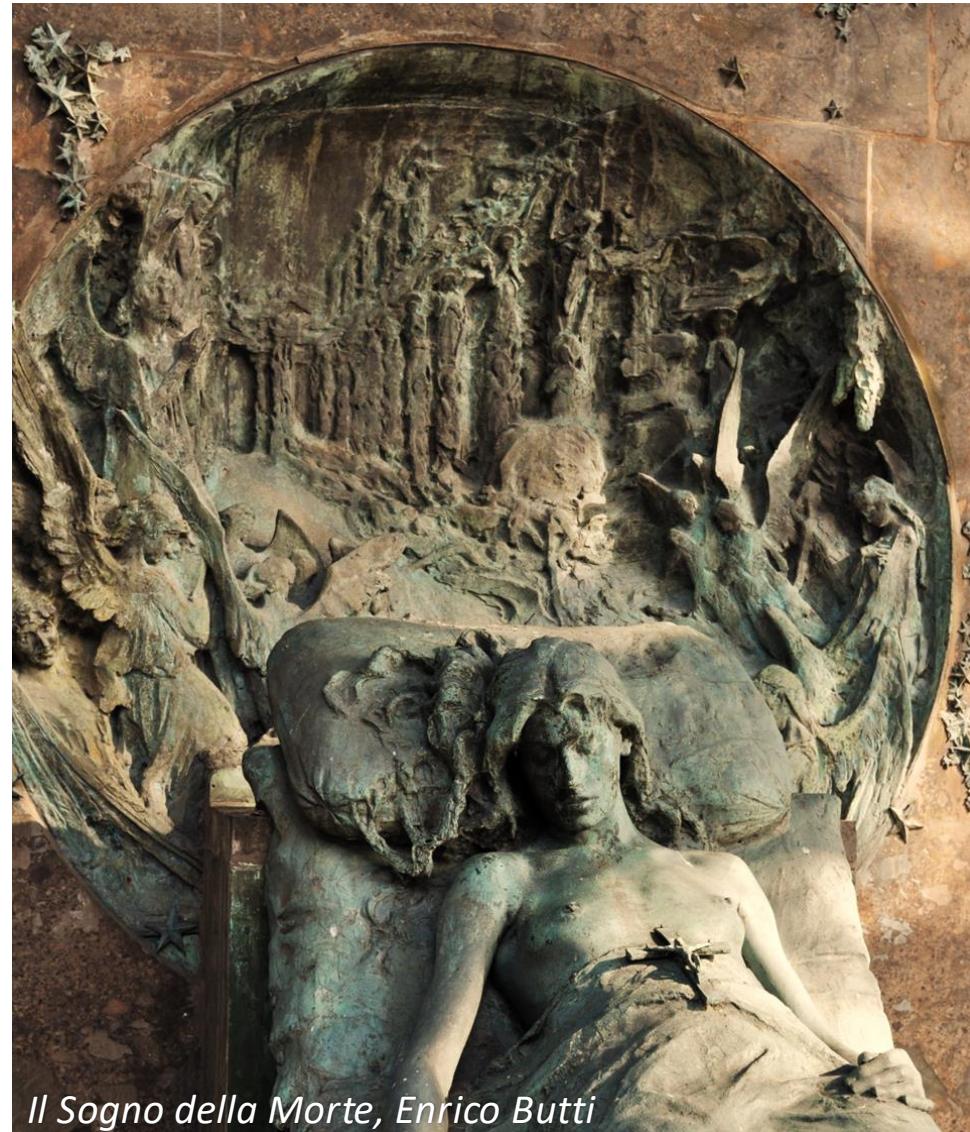
# Consciousness vs Attention

Attention is a mechanism for **selecting** within consciousness.

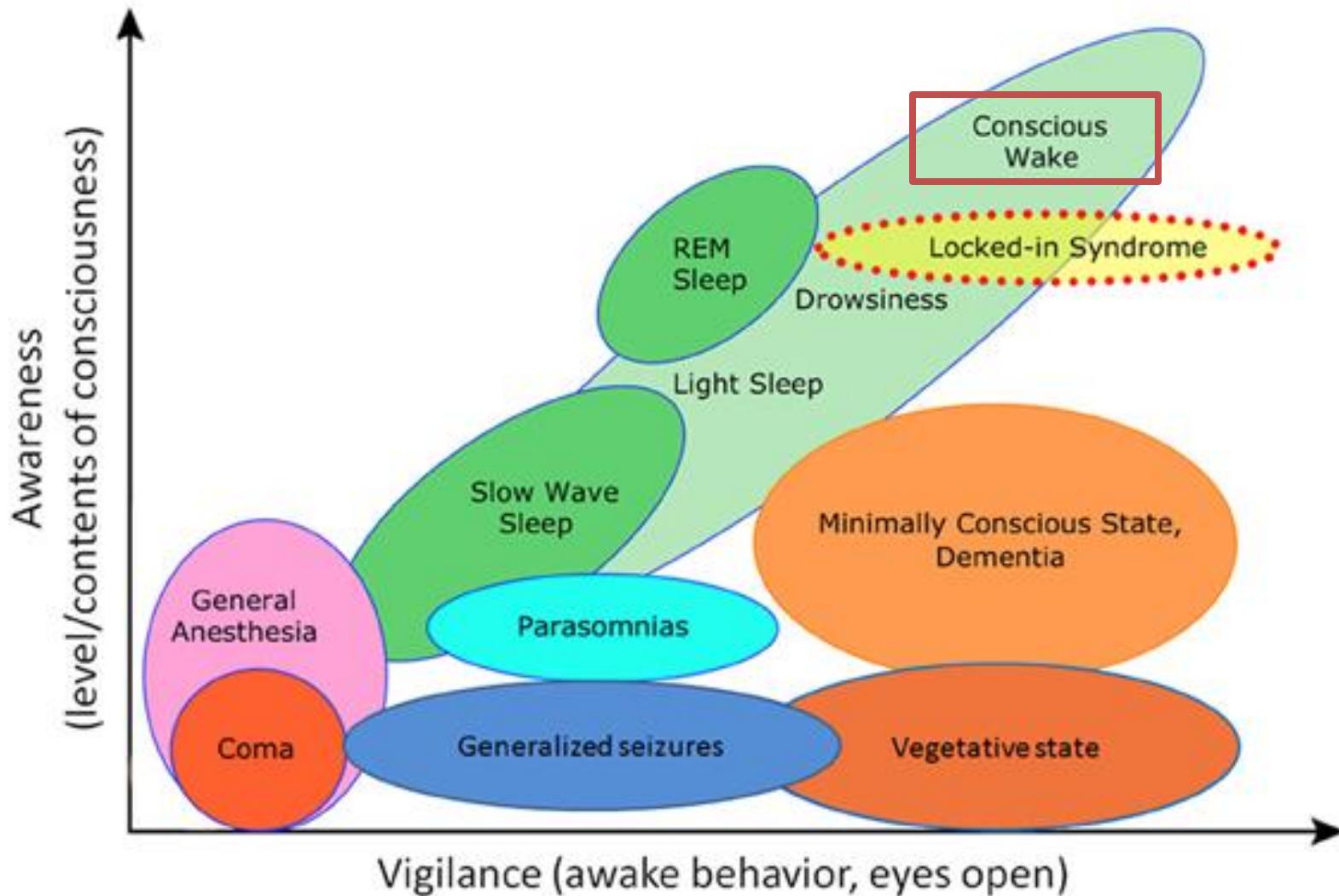


# Consciousness: Operational Definition

«It is that which we lose when we fall into **deep dreamless sleep** (or when we go under **anesthesia**), and it is what we regain when we recover from sleep (or from anesthesia)».



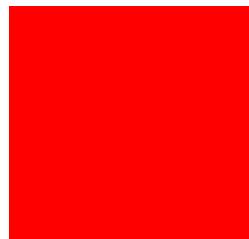
# Consciousness



# Qualia

**Qualia** (singular form: *quale*) are individual instances of subjective, conscious experience.

The '*what it is like*' character of mental states.  
The way it feels to have mental states such as pain, seeing red, smelling a rose, etc.



*The term 'qualia' derives from the Latin adjective 'quālis' ("of what sort").*

# Subjectivity of Experience – The Dress

**Blue and Black?**

or

**White and Gold?**



## Subjectivity of Experience – The Dress



A study (Lafer-Sousa et al., 2015, Current Biology), which involved 1,400 respondents, found that 57% saw the dress as blue and black; 30% saw it as white and gold; 10% saw it as blue and brown; and 10% could switch between any of the color combinations.

# What is it like to be a bat?

*"The physical sciences can describe organisms like ourselves [...] but they cannot describe the subjective experiences of such organisms or how the world appears to their different particular points of view. There can be a purely physical description of the neurophysiological processes that give rise to an experience, and also of the physical behavior that is typically associated with it, but such a description, however complete, will leave out the subjective essence of the experience — how it is from the point of view of its subject — without which it would not be a conscious experience at all."*



Thomas Nagel, *The Philosophical Review*, 1974

## What is it like to be a bat?

Equipping us with a bat-like sonar (say with a visual or auditory output) might help us to navigate in the dark, but it would not generate **echolocation qualia**...



*Batman Begins (Christopher Nolan, 2005)*

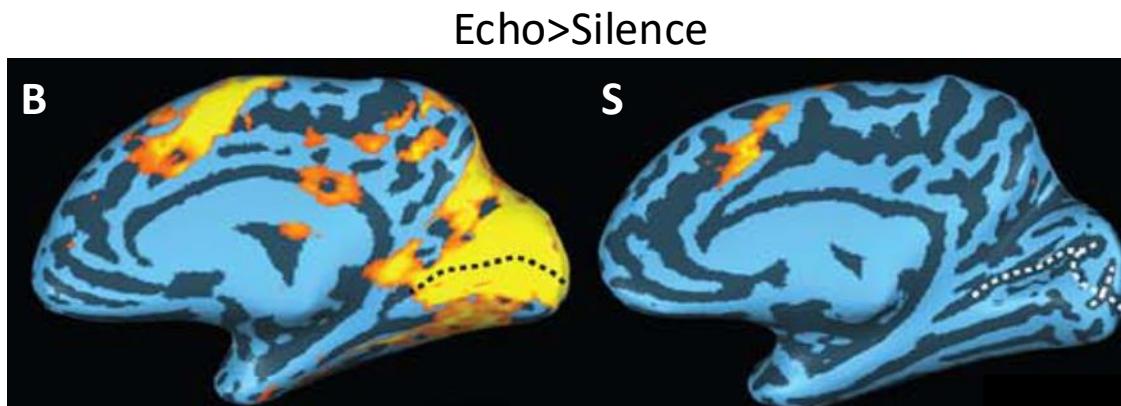
# What is it like to be a bat?



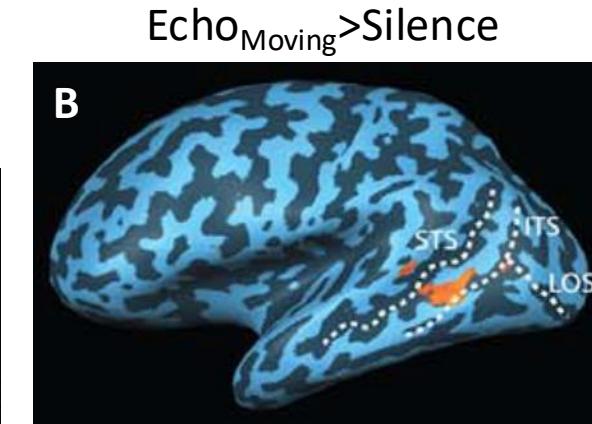
Daniel Kish

**Human echolocation** is the ability of humans to detect objects in their environment by sensing echoes from those objects, by actively creating sounds (e.g., making clicking noises with their mouths).

People trained to orient by echolocation can “interpret” the sound waves reflected by nearby objects.



Echo>Silence



Echo<sub>Moving</sub>>Silence

Thaler et al., PlosOne, 2011

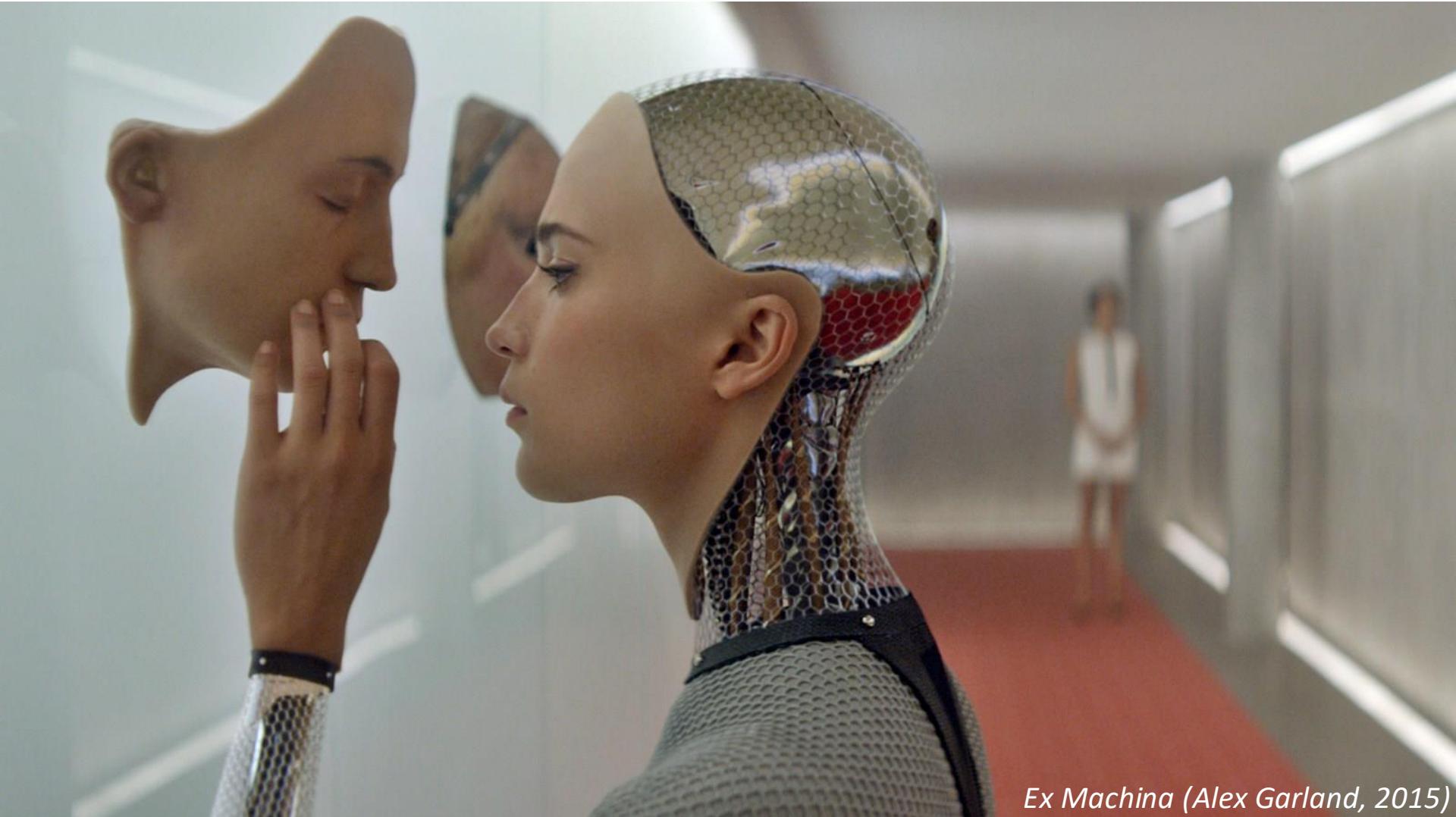
## Problem of other minds

Consciousness is one of the fundamental facts of human existence. Each of us is conscious. At least, **one knows about his/her own consciousness directly. He/she can't be certain that other individuals are conscious.**



No matter how sophisticated someone's behavior is, behavior on its own is not sufficient to guarantee the presence of a conscious mind.

# *True or simulated consciousness?*



*Ex Machina (Alex Garland, 2015)*

# *True or simulated consciousness?*



**'I know a person when I talk to it'**

A Google engineer thinks its AI has come to life. Does anyone believe him?

(Martin Klimek for The Washington Post)

The Washington Post

The **Turing test**, proposed by Alan Turing in 1950, is a test designed to determine a machine's ability to exhibit intelligent behavior that is indistinguishable from that of a human. The test involves a human evaluator who engages in a natural language conversation with two participants: a human and a machine. The evaluator does not know which is which and must determine which participant is the human and which is the machine.

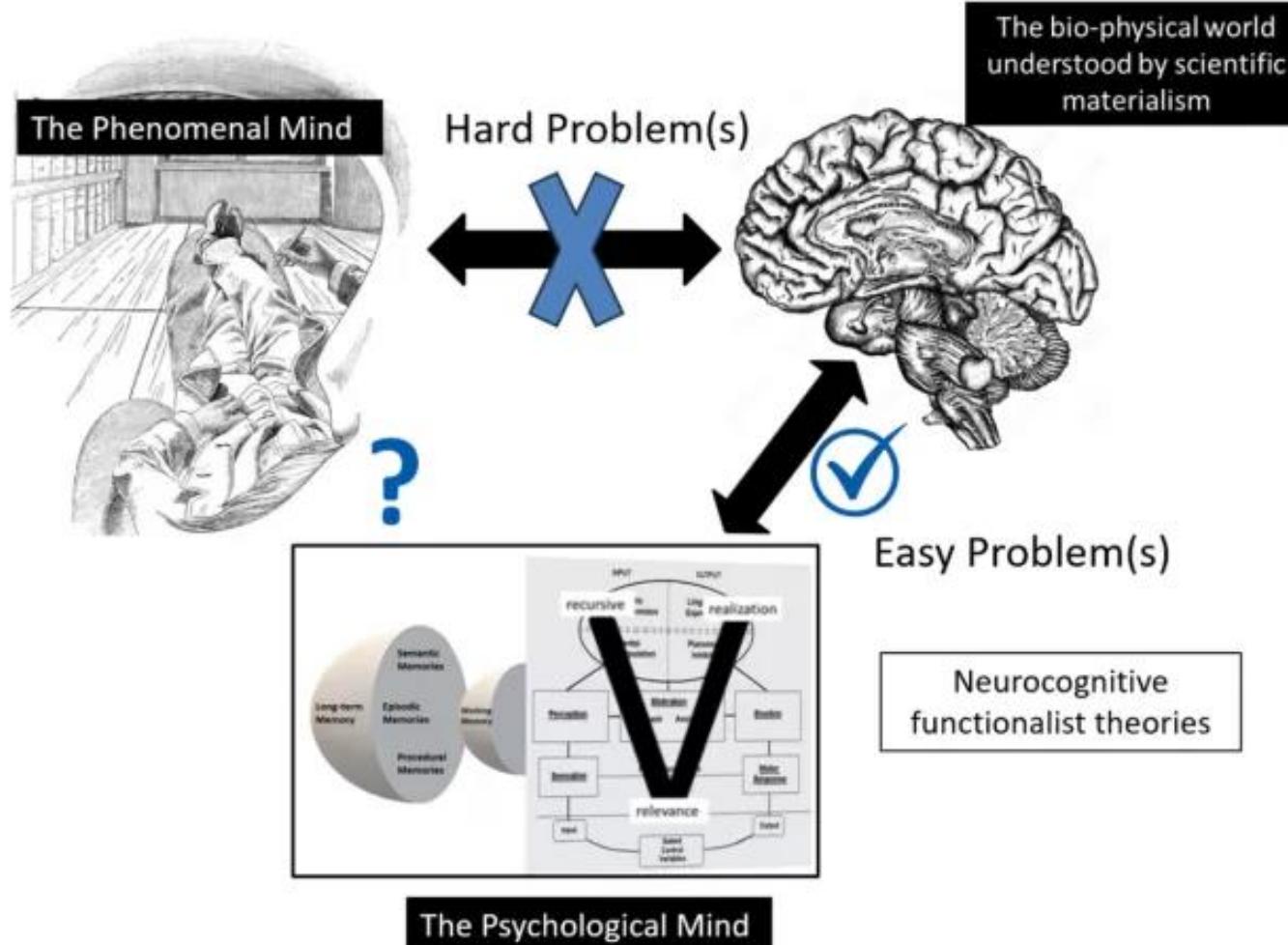
Hi. Are you conscious?

No, I am not conscious. I am an artificial intelligence language model developed by OpenAI. While I can understand and generate human-like text, I do not possess consciousness or self-awareness.

Like Dislike

A screenshot of a messaging app showing a conversation between a user and an AI language model. The user asks "Hi. Are you conscious?" and the AI responds "No, I am not conscious. I am an artificial intelligence language model developed by OpenAI. While I can understand and generate human-like text, I do not possess consciousness or self-awareness." There are like and dislike buttons at the bottom.

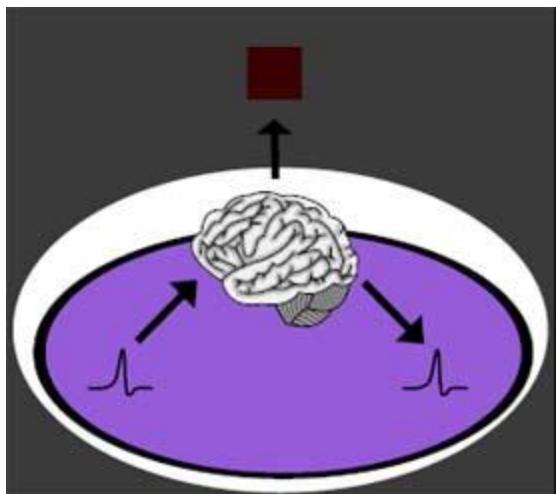
# “Easy” and “Hard” Problems of Consciousness



*David Chalmers, Facing Up to the Problem of Consciousness, 1995*

# The “Easy” Problems of Consciousness

**Easy problems** involve the explanation of **how the mind integrates information, focuses attention and allows us to report on mental states**. Such problems are *easy* because solving them only requires that we determine the mechanisms that explain these behaviors.



Easy problems are **physical by nature**, falling within the empirical domains of **psychology, cognitive science and neuroscience**. Given the current trend in science of the mind, we are confident (not ‘sure’!) that one day we will solve these problems.

# The “Easy” Problems of Consciousness

The easy problems of consciousness include those of explaining the following phenomena:

- *The ability to discriminate, categorize, and react to environmental stimuli;*
- *The integration of information by a cognitive system;*
- *The reportability of mental states;*
- *The ability of a system to access its own internal states;*
- *The focus of attention;*
- *The deliberate control of behavior;*
- *The difference between wakefulness and sleep.*



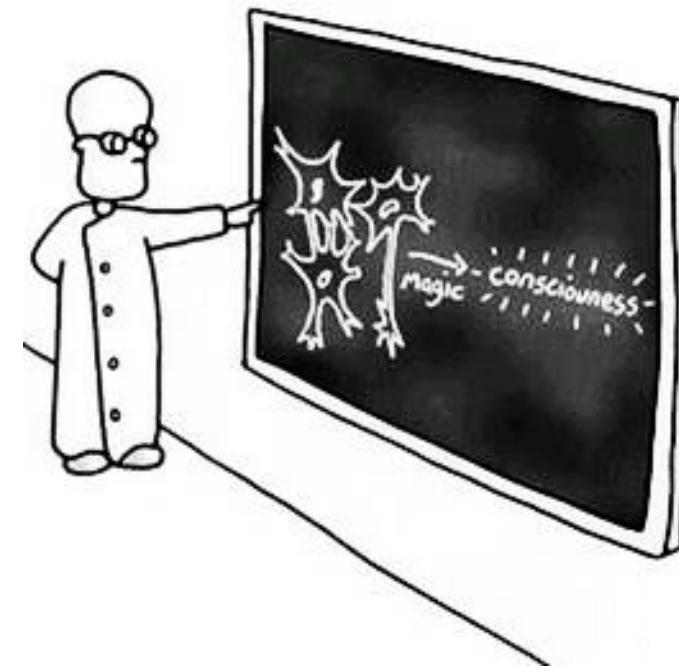
*Hand with Reflecting Sphere, M.C. Escher*

## The “Hard” Problem of Consciousness (or “The Explanatory Gap”)

The hard problem is determining **why** or **how consciousness occurs** given the right arrangement of brain matter.

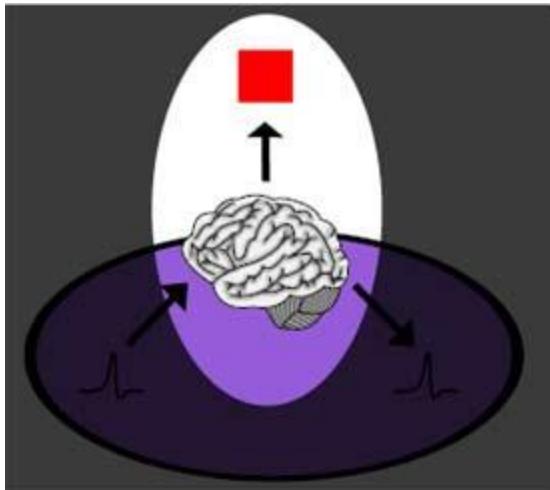
What makes it hard is that we cannot just point to some **physical mechanism** to solve it.

*Why certain physical mechanism gives rise to consciousness instead of something else or nothing at all?*



# The “Hard” Problem of Consciousness (or “The Explanatory Gap”)

*“The really hard problem of consciousness is **the problem of experience**. When we think and perceive there is a whir of information processing, but there is also a subjective aspect.”*



Explain why physical processes are associated with subjective experience.

- *Why is there something it is like to be me?*
- *Why is it like this?*

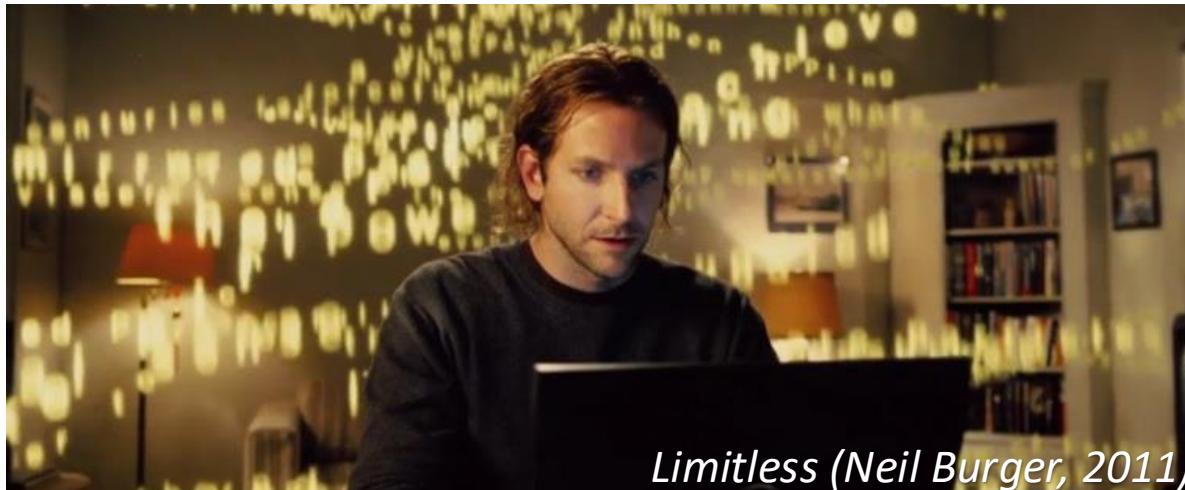
## Content and Level of Consciousness

**Content of consciousness:** the particular experience you are having at any given time, for a similar level of consciousness.

**Level of Consciousness:** the degree to which you are conscious (of anything).

## The Neural Correlates of Consciousness

The '**level of consciousness**' (**LOC**) may be defined as a measurement of a person's **arousability** and **responsiveness to stimuli** from the environment.

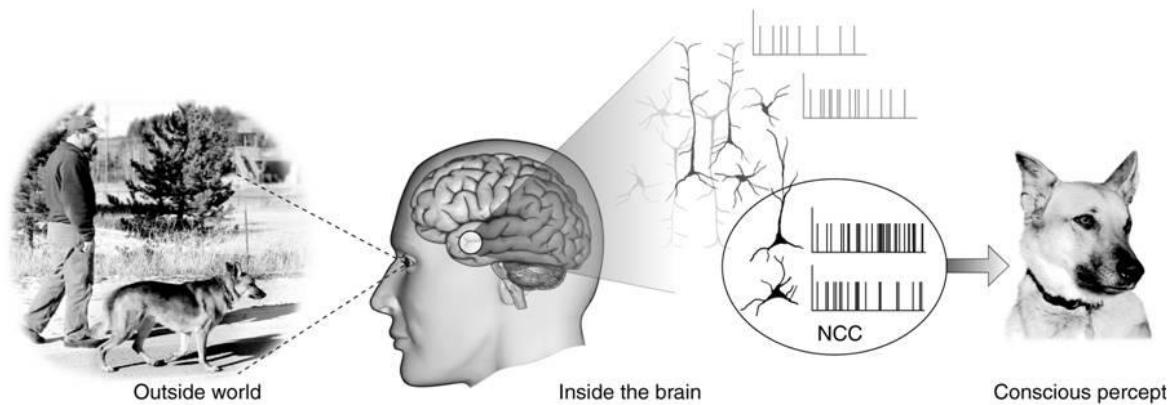


*Limitless (Neil Burger, 2011)*

The **LOC** is controlled by specialized cortical and subcortical systems that determine the amount of alertness, attention, and awareness.

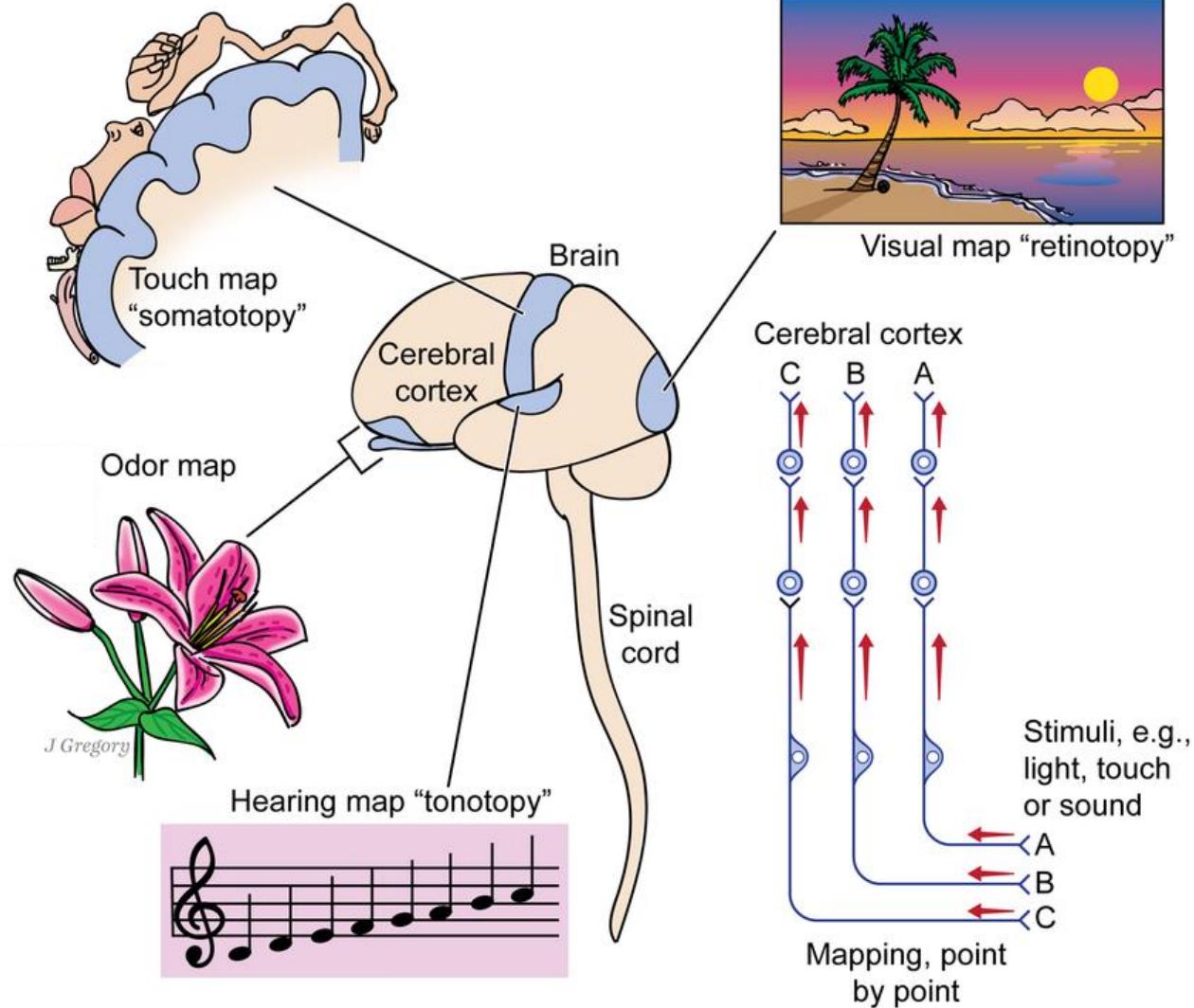
# The Neural Correlates of Consciousness

The Neural Correlate(s) of Consciousness (NCC) is  
*“the minimal set of neuronal events that gives rise to a specific aspect of a conscious percept”.*



Set of brain structures that are “*minimally sufficient and jointly necessary*” for consciousness

# The Spinal Cord

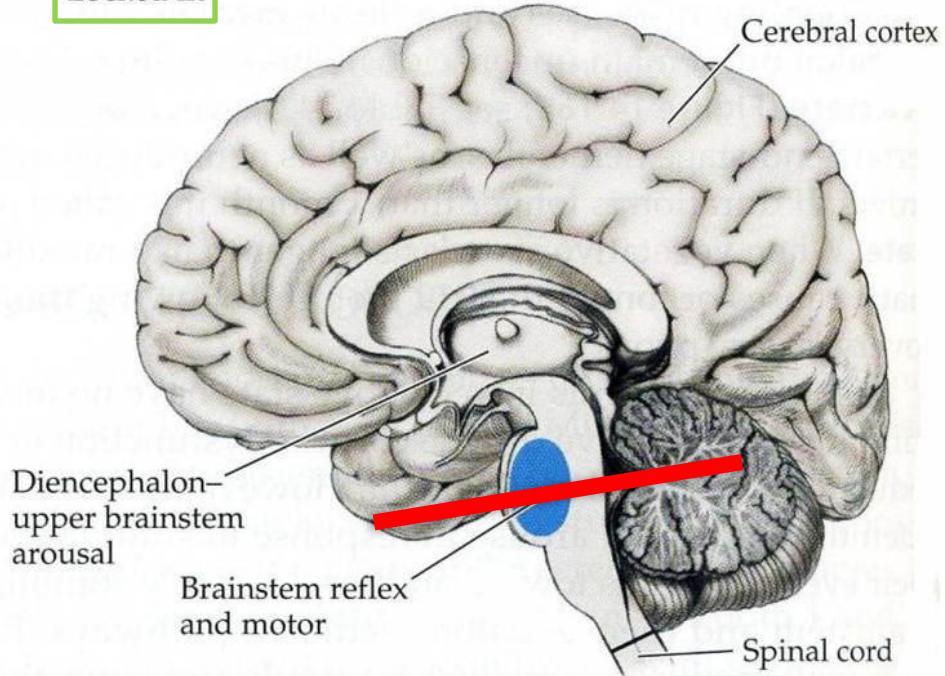


# The Spinal Cord

## Locked-in syndrome

(Plum and Posner, 1966):  
the patient is aware but  
cannot move or  
communicate verbally  
due to complete paralysis  
of voluntary muscles.

Locked in



# The Spinal Cord

## Locked-in Syndrome



*Jean-Dominique Bauby (1952–1997)*

The patient can usually perform **vertical eye movements** and **eye-blanks**. The individual is conscious and sufficiently intact cognitively to be able to communicate with eye movements.

**Total Locked-in Syndrome** is a version of locked-in syndrome wherein the eyes are paralyzed as well.

# The Spinal Cord

Patients remain conscious after **lesions of the spinal cord**



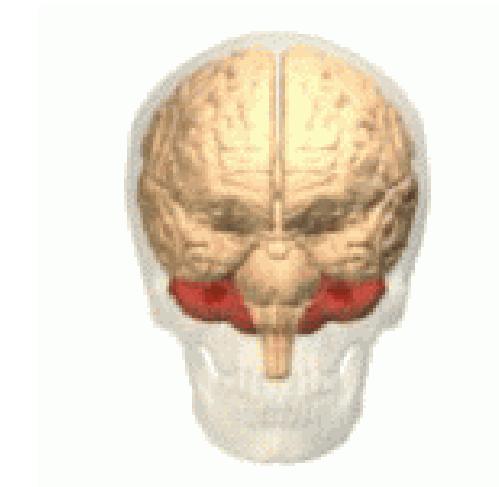
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# The Cerebellum

The cerebellum (latin: “*little brain*”) appears to function to control the **acquisition of sensory inputs** and as a **learning device for motor, perceptual and cognitive functions**.



# The Cerebellum

Roughly 80 billion neurons in the human brain  
Each neuron is connected with 1,000-10,000 neurons

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Cerebral cortex  
~15 billion neurons  
Integrated computation

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Cerebral cortex  
~15 billion neurons  
Integrated computation

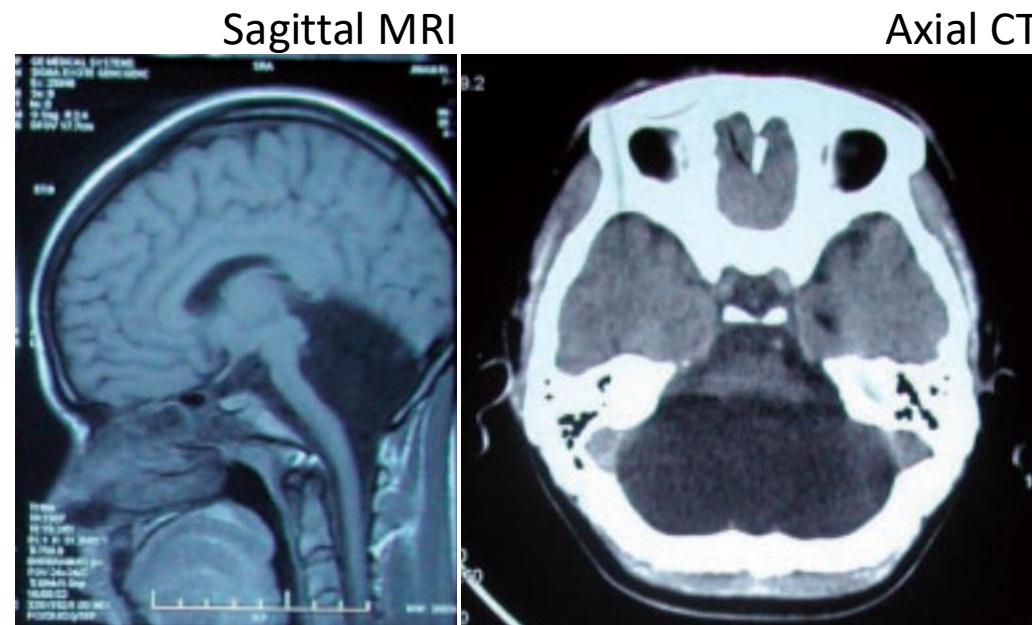
Cerebellum  
~60 billion neurons  
Parallel computation

# The Cerebellum

Patients without a **cerebellum** are conscious.

## Cerebellar Agenesis:

Patients born without a cerebellum experience severe developmental delays, language deficits, and neurological abnormalities.

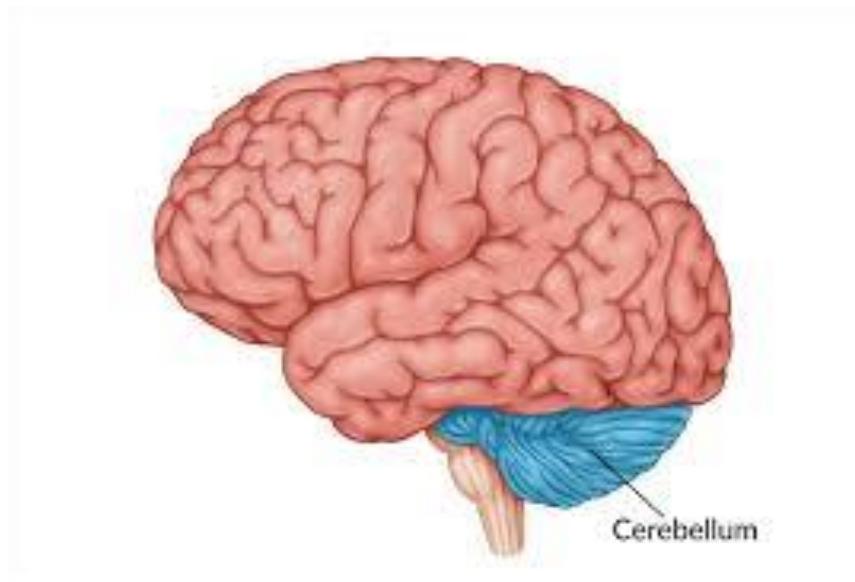


# The Cerebellum

“A **24-year-old female** patient was admitted to hospital complaining of **dizziness** and the **inability to walk steadily** for more than 20 years, and **nausea** and **vomiting** for ~1 month. She is married with a daughter, and her pregnancy and delivery were described as uneventful. [...] According to her mother, she was **4 years old** before **she could stand unassisted**, and **did not begin to walk unassisted until the age of 7**, with a persistently **unsteady gait**. She never ran or jumped. Her **speech** was **not intelligible until 6 years of age** and she did not enter school. A neurological examination revealed she could cooperate and fully orientate. A verbal analysis test revealed her **word comprehension and expression** remained intact and she had **no sign of aphasia**, but mild to moderate signs of cerebellar dysarthria. [...] While she is able to walk unsteadily without support, her gait is moderately unsteady. The patient has evidence of tandem gait and moderately reduced gait speed. There is no focal paresis but the muscle tone is mildly increased. Evaluation of the **sensory system showed no abnormalities**, no deformities of the fingers and toes were observed, and her complete blood count and urinalysis were normal.”

# The Cerebellum

The Cerebellum is not necessary (or sufficient) for consciousness



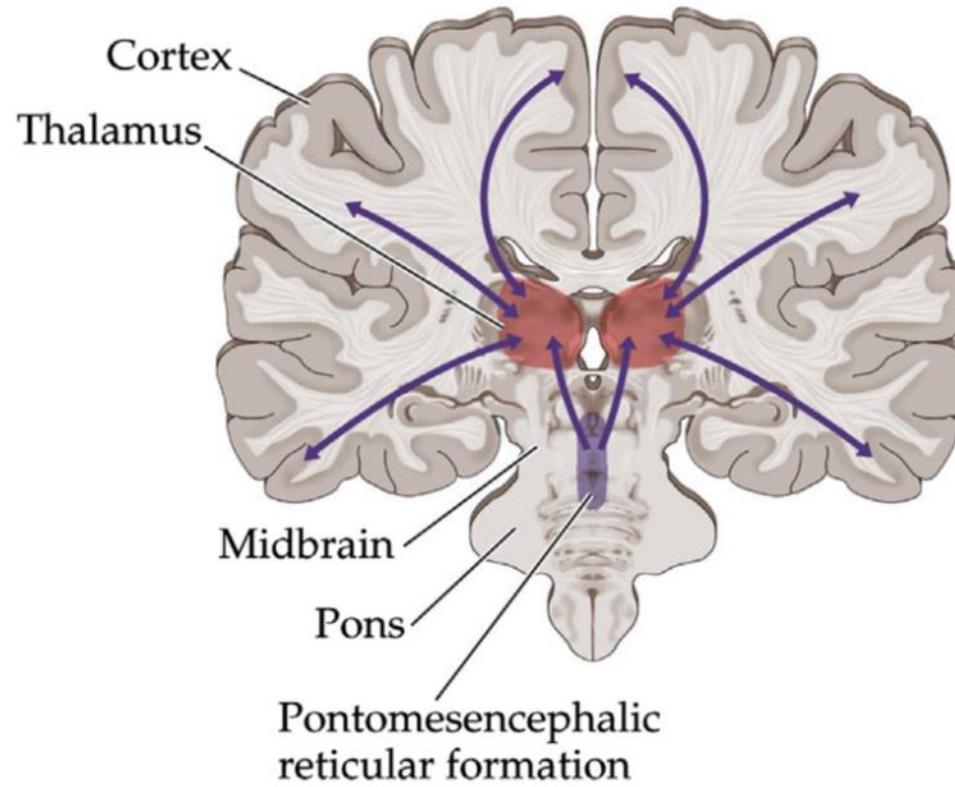
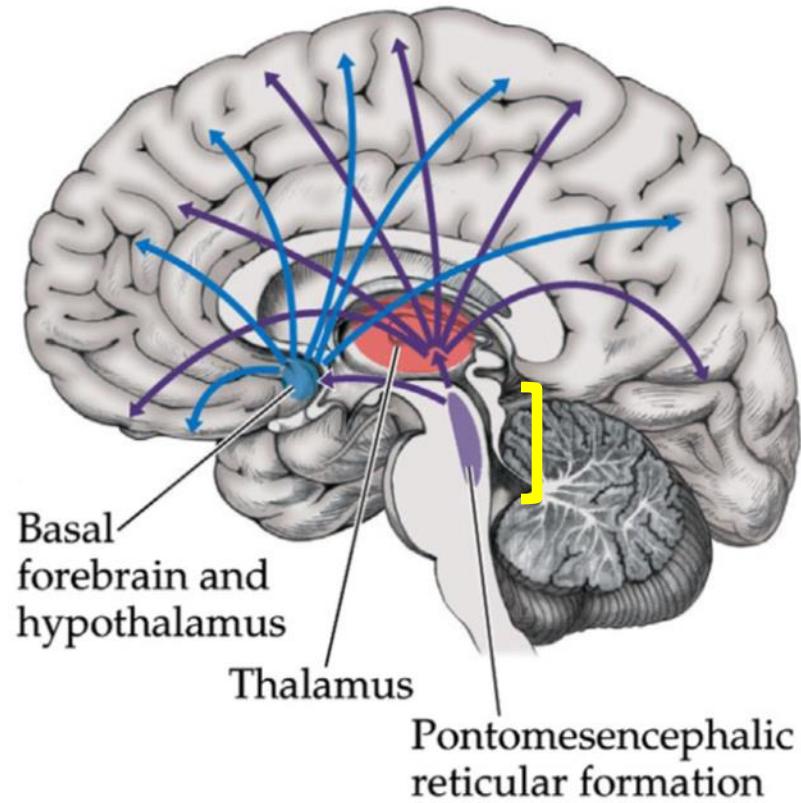
## The Cerebellum

Any (good) theory of consciousness must provide a reasonable explanation on why the cerebellum is irrelevant for consciousness!

## The Cerebellum

While the cerebellum is crucial for coordinating movements and plays a role in non-motor functions, its **highly repetitive, parallel-processing structure** doesn't support the complex, integrated information flow characteristic of conscious regions like the cerebral cortex.

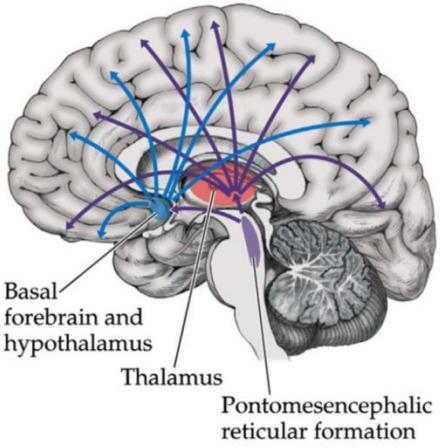
# Arousal Circuits



The **subcortical arousal systems** consist of multiple parallel neurotransmitter systems and pathways. In the brainstem, the **reticular formation** begins in the upper pons and extends to the midbrain.

# Arousal Circuits

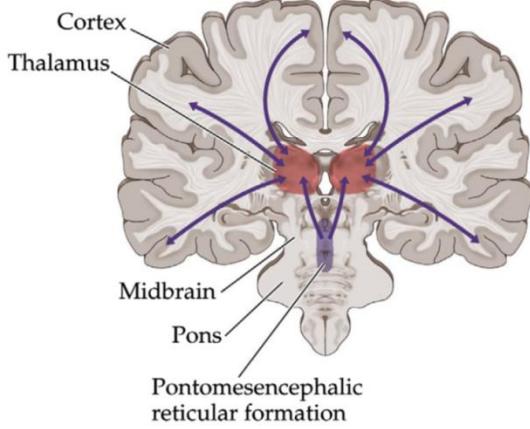
Glutamate



Basal  
forebrain and  
hypothalamus

Thalamus

Pontomesencephalic  
reticular formation



Cortex

Thalamus

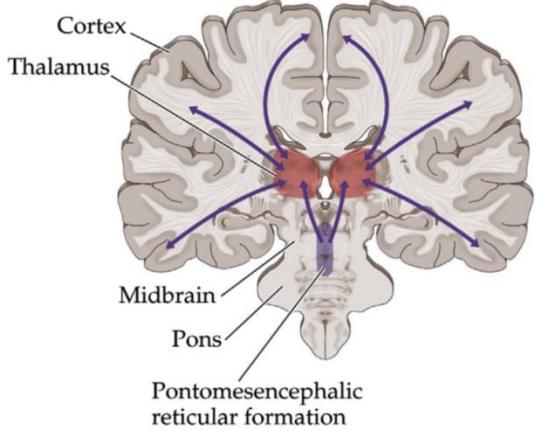
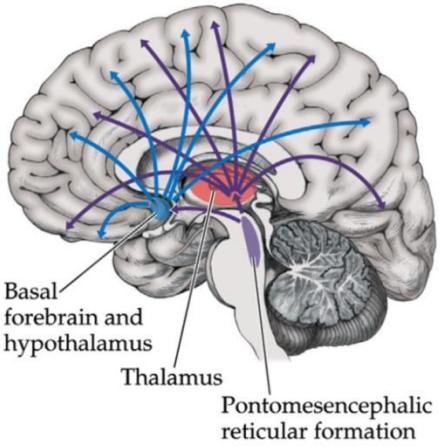
Midbrain

Pons

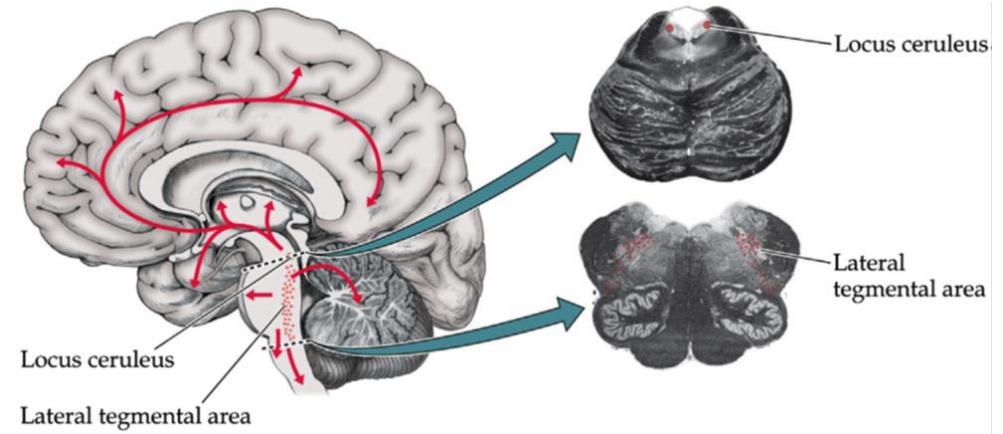
Pontomesencephalic  
reticular formation

# Arousal Circuits

Glutamate



Noradrenaline

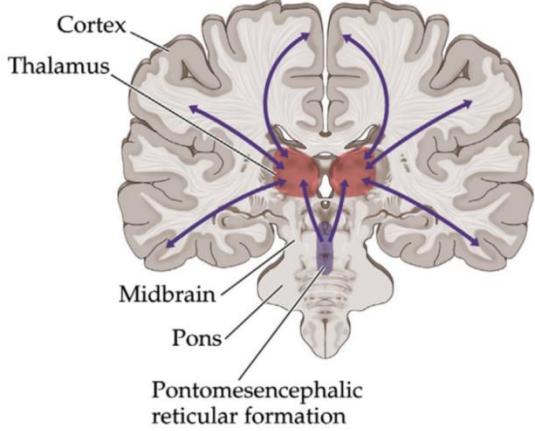
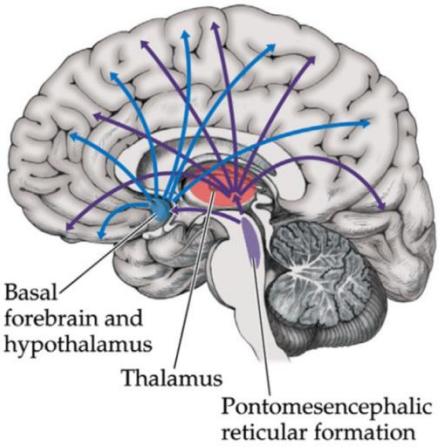


Locus ceruleus

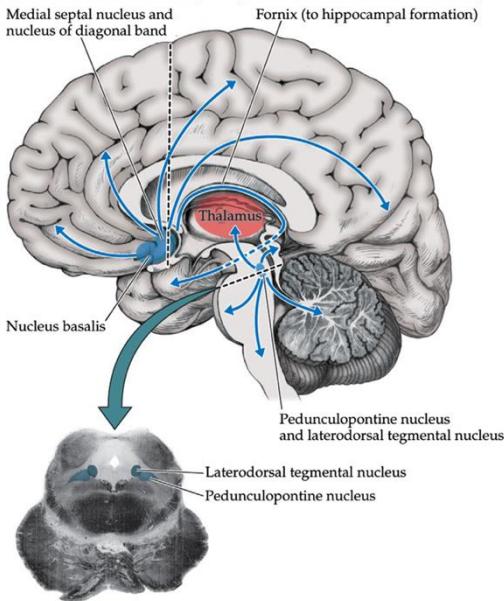
Lateral tegmental area

# Arousal Circuits

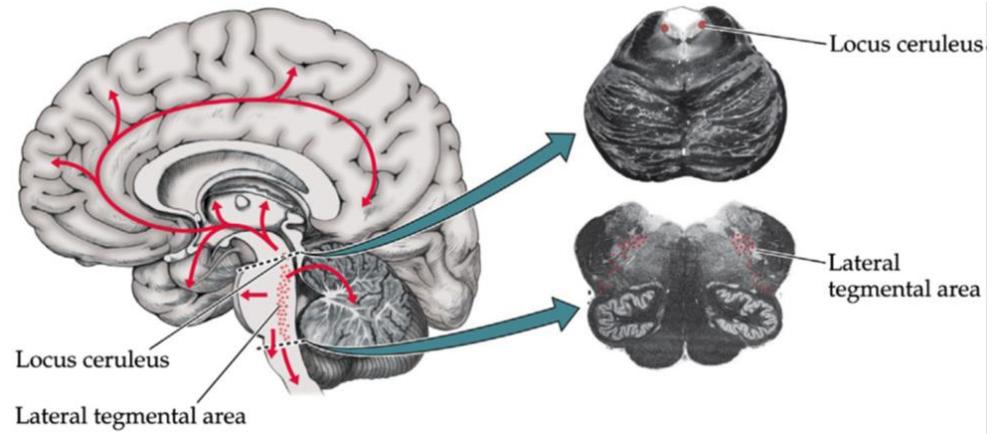
Glutamate



Acetylcholine

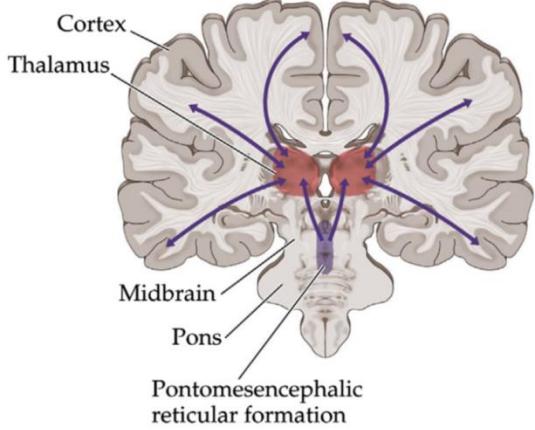
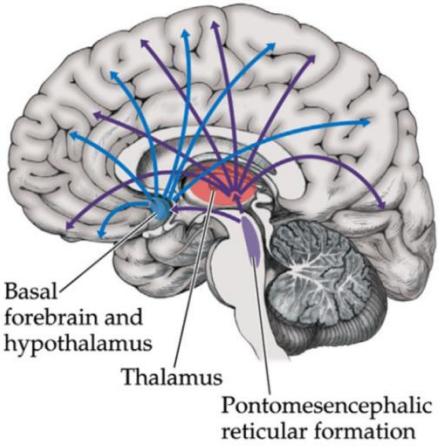


Noradrenaline

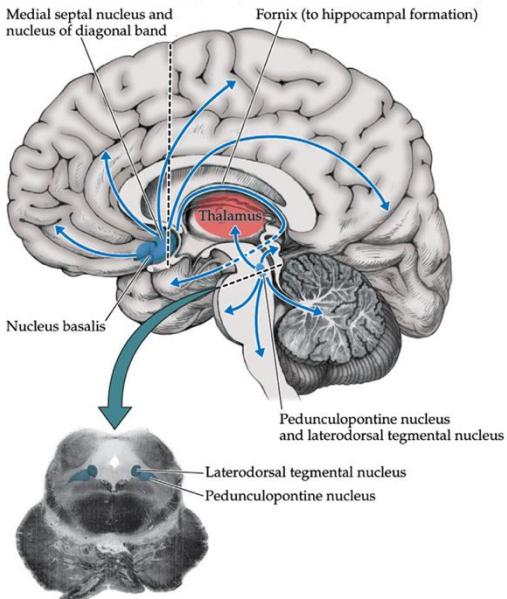


# Arousal Circuits

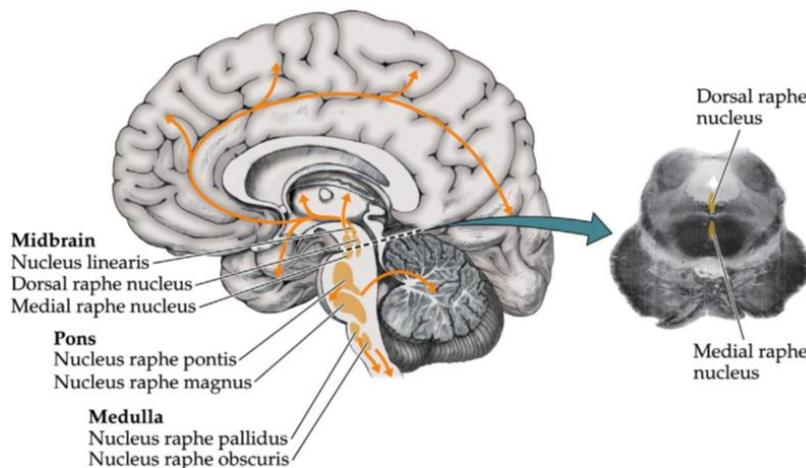
Glutamate



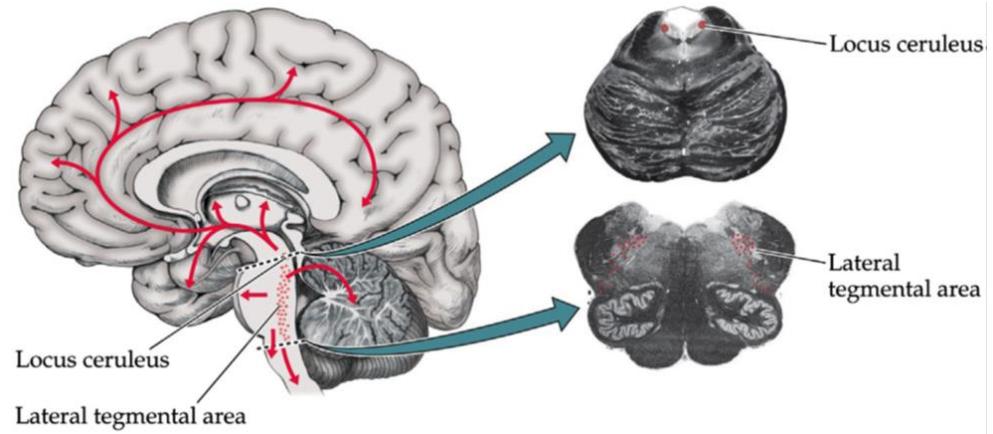
Acetylcholine



Serotonin

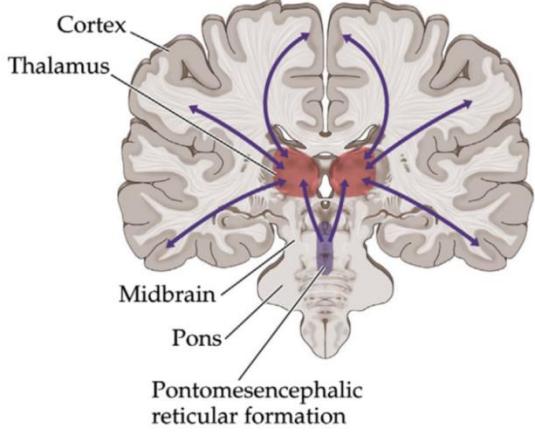
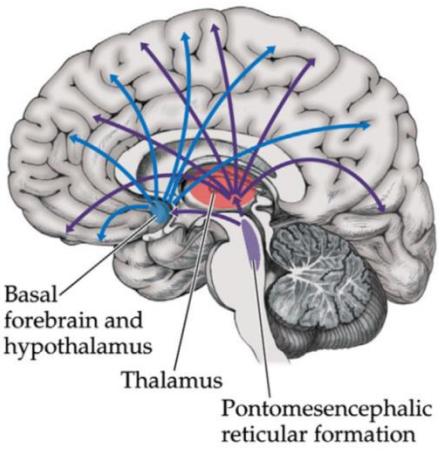


Noradrenaline

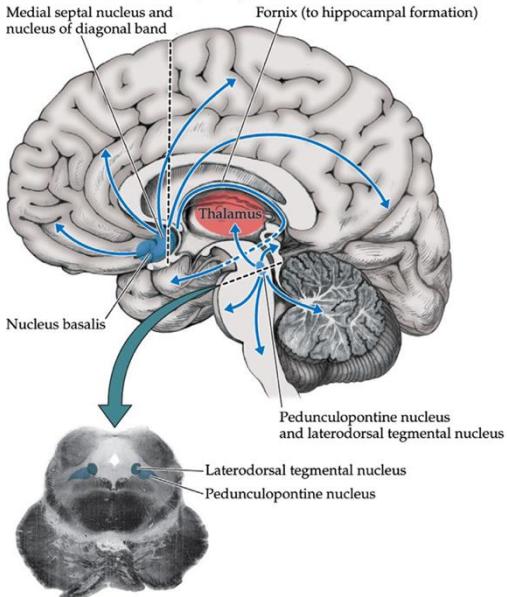


# Arousal Circuits

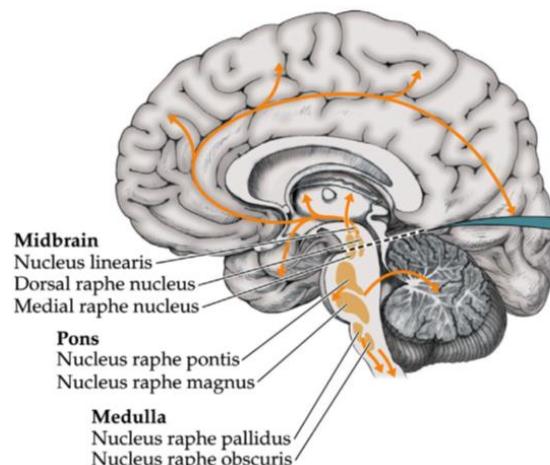
Glutamate



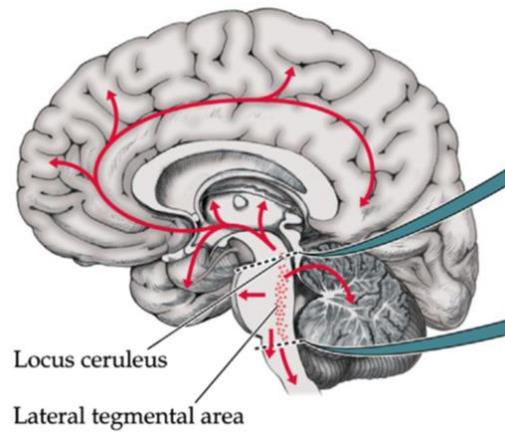
Acetylcholine



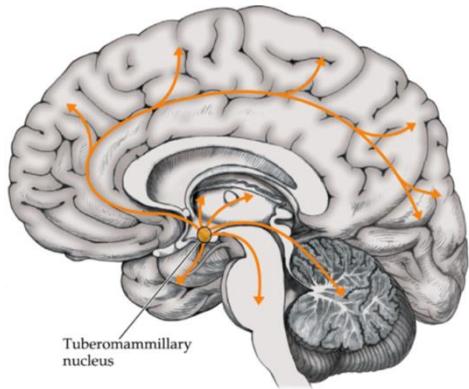
Serotonin



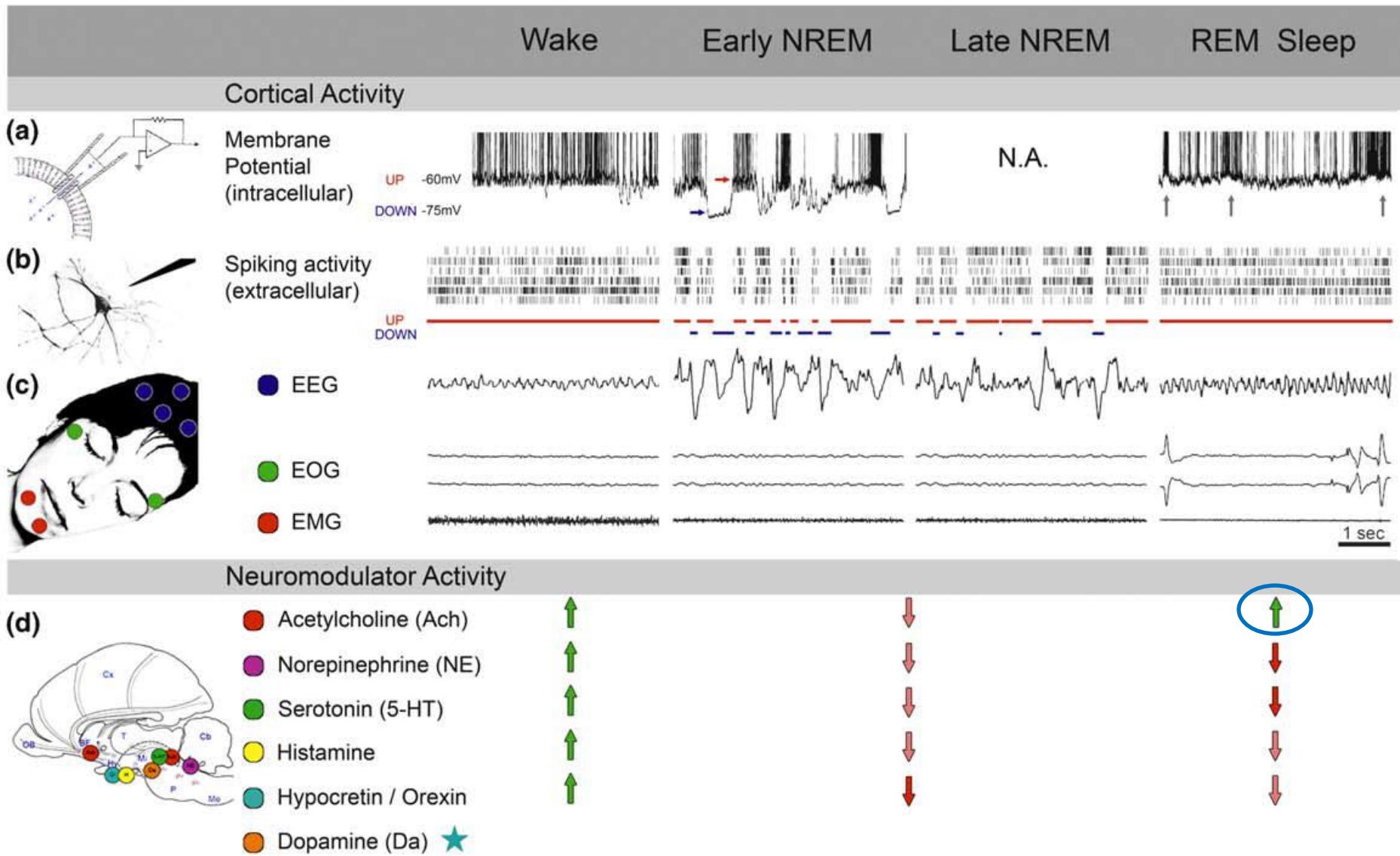
Noradrenaline



Histamine



# Arousal Circuits



## Activating Systems

As long as some activating systems remain, for example both cholinergic and non-cholinergic cells in the basal forebrain, consciousness may be possible.

***A functioning brainstem is insufficient for consciousness in the absence of a functioning corticothalamic system.***

The activating system may have the role of an **enabler** or **controller** of the **level of consciousness** (on-off “switch”) rather than of a generator of consciousness.

# Activating Systems



**Corticothalamic  
System**

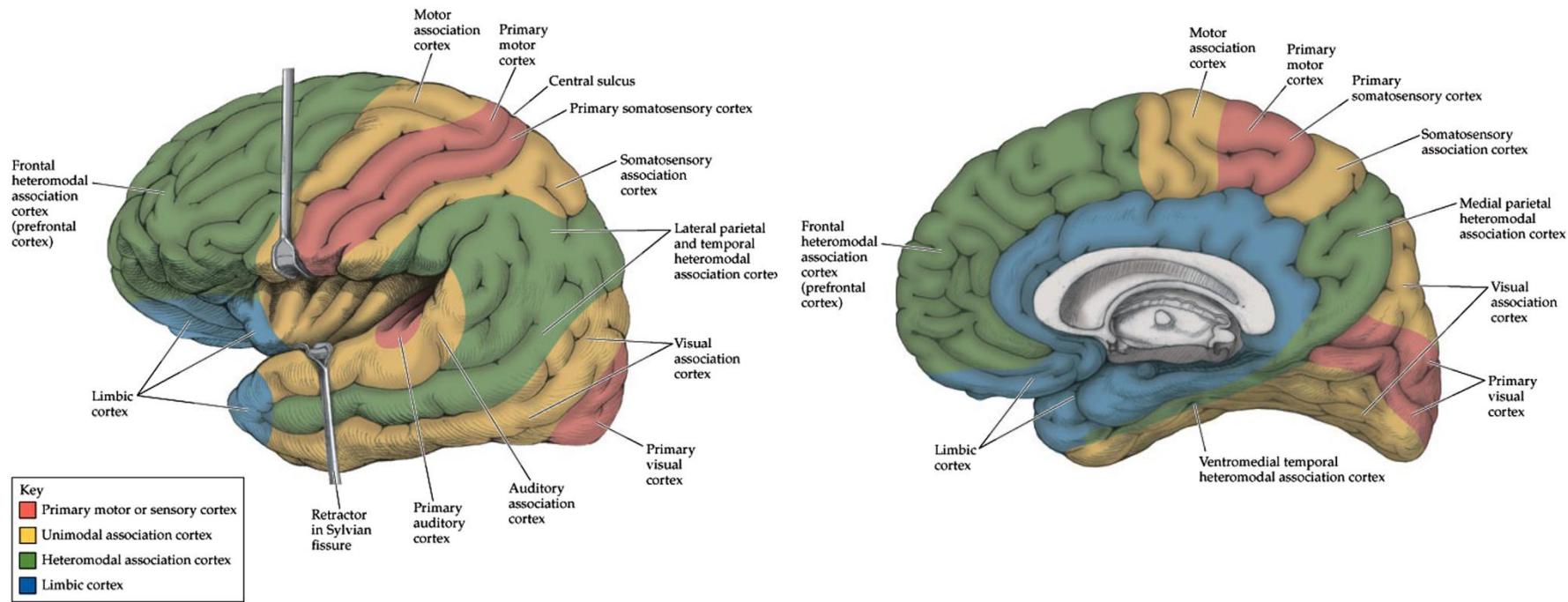
*Mainly determines the  
content of consciousness*

**Arousal  
System**

*Mainly regulates the  
level of consciousness*

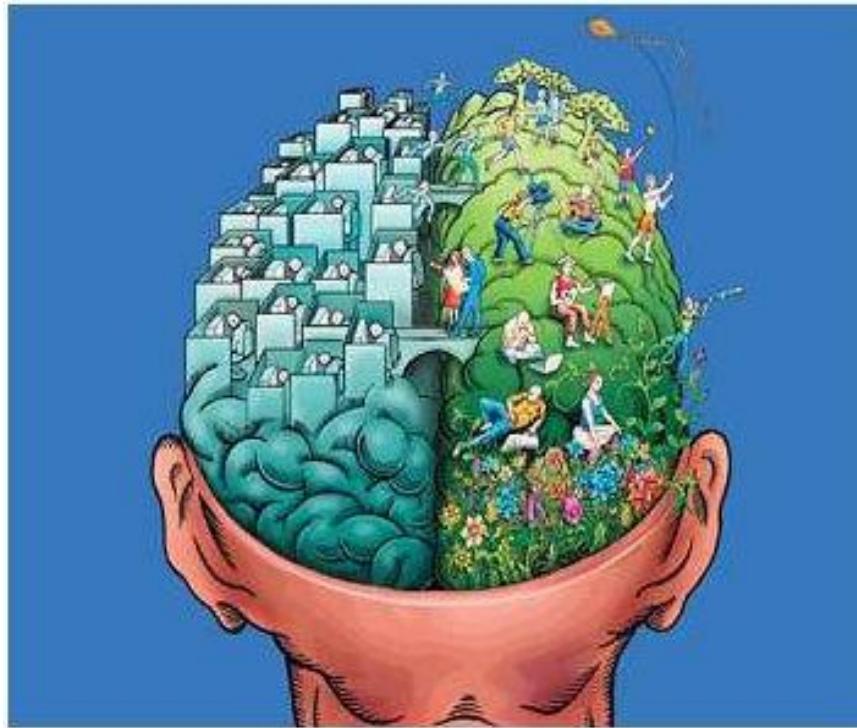
# The Cortex

*Only cortical deactivation is sufficient for inducing and maintaining unconsciousness.*



Unilateral cortical lesions usually do not markedly depress level of consciousness, but bilateral lesions of the association cortex can produce coma.

## The Cortex: Left and Right Hemispheres



The **right hemisphere** is much more literal in its recognition of images and events, and thereby often **more accurate**, in contrast with a **left hemisphere** that is constantly formulating **hypotheses** and trying to make sense of what happens.

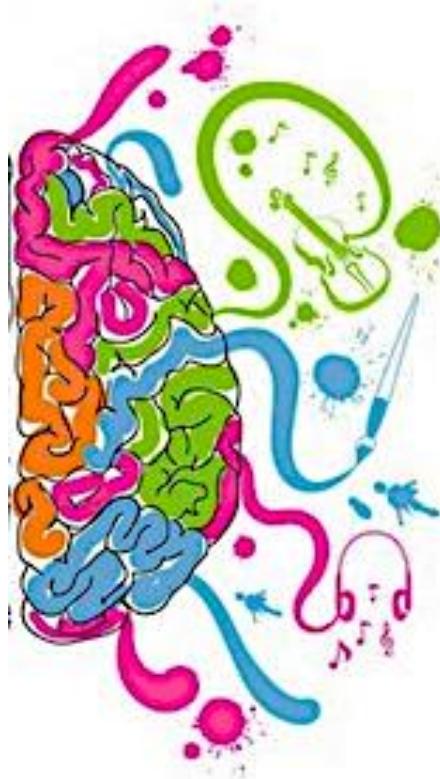
## The Cortex: Left and Right Hemispheres

In addition to its superior **language capabilities**, the left hemisphere also retains normal **problem-solving skills** and **reasoning abilities** following callosotomy.

The cognitive and linguistic abilities of the isolated left hemisphere are comparable to those of a healthy individual with an intact corpus callosum, suggesting that the left hemisphere retains a rich, human-like consciousness following split-brain surgery.



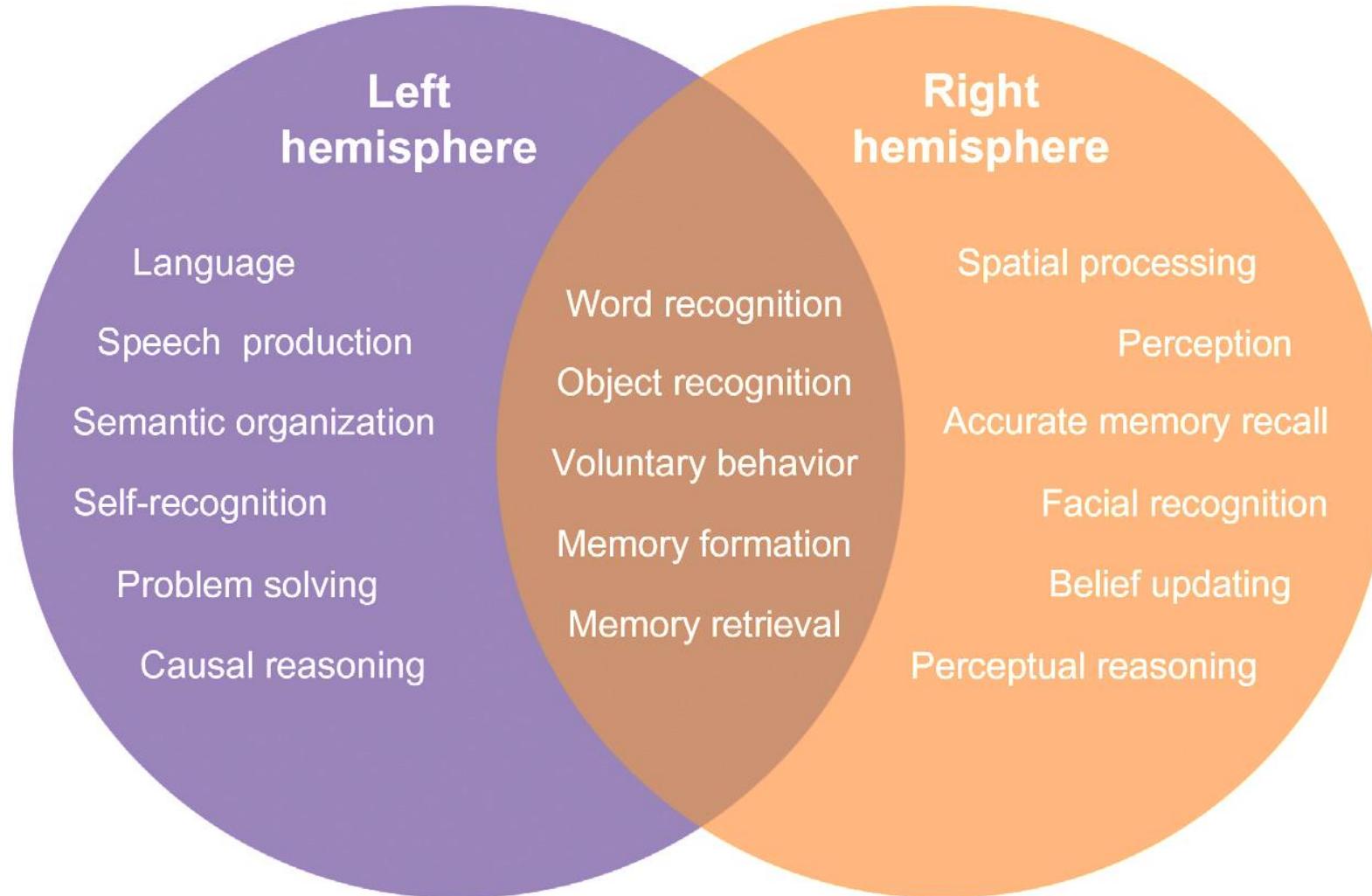
## The Cortex: Left and Right Hemispheres



The right hemisphere's capacity for language is variable among split-brain patients and may gradually increase following surgery.

The right hemisphere outperforms the left in several domains, such as perception (detection of motion, illusory contours), spatial processing (mental rotation, spatial matching, mirror image discrimination), facial recognition, and recognition memory.

# The Cortex: Left and Right Hemispheres



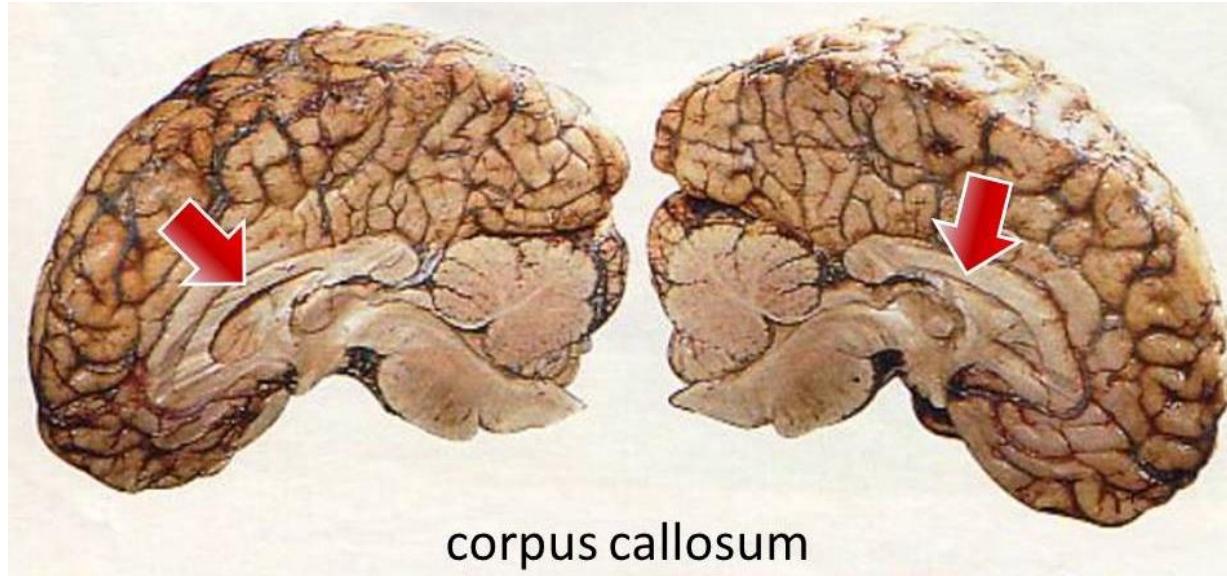
# The Cortex: Left and Right Hemispheres

«*Being limited in language and reasoning skills, under usual circumstances the right hemisphere is literally dominated by the left hemisphere—it is usually passive, and does not complain or cause trouble, just as in some highly asymmetric marriages.*».



## The Cortex: Left and Right Hemispheres

The corpus callosum (200-250 million axons that project from the cerebral cortex of one hemisphere to the other) enables interhemispheric communication.

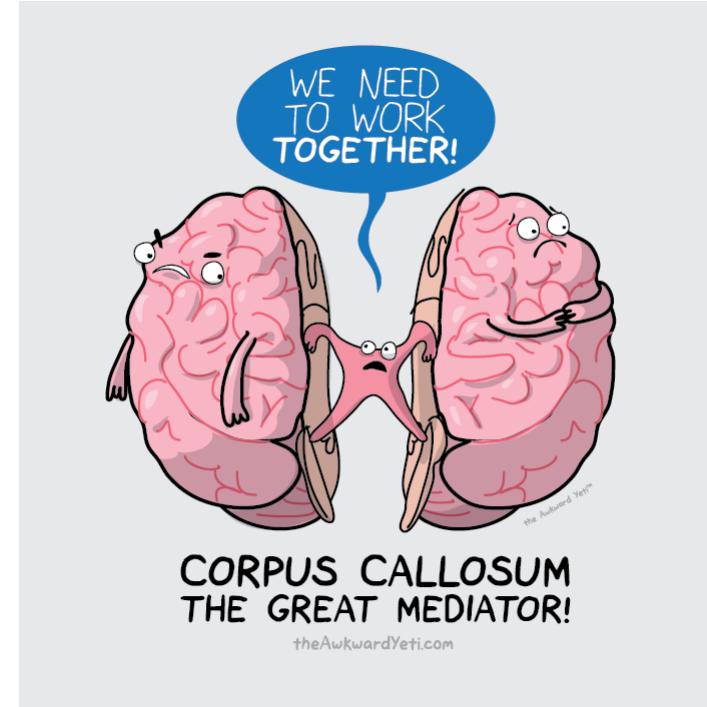


In some cases of intractable epilepsy, the corpus callosum is severed to reduce the frequency/severity of patients' seizures.

# The Cortex: Left and Right Hemispheres

An isolated **left hemisphere**, whether alone or disconnected from the right hemisphere, can support a conscious self that is similar to that supported by an intact, fully equipped brain.

After a hemispherectomy or split-brain operation, the patient (**speaking through the left hemisphere**) is anosognosic and feels in no way changed, although for example the left half of the visual field is no longer available.



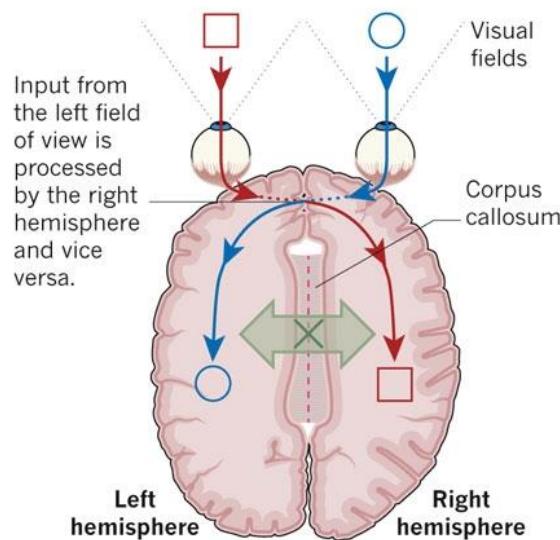
*Is the right hemisphere (alone) able to support a second consciousness?*

# The Cortex: Left and Right Hemispheres

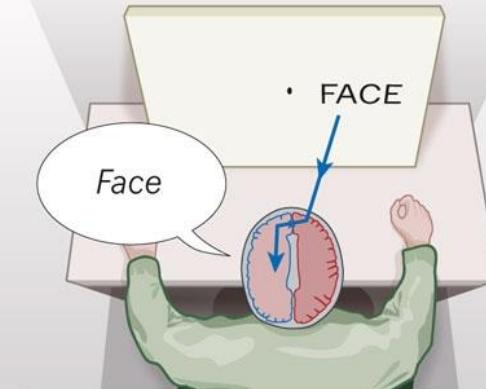
## OF TWO MINDS

Experiments with split-brain patients have helped to illuminate the lateralized nature of brain function.

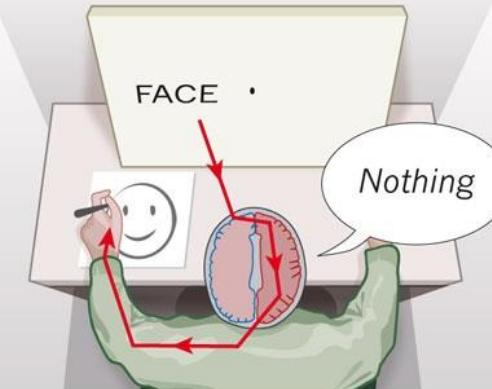
Split-brain patients have undergone surgery to cut the corpus callosum, the main bundle of neuronal fibres connecting the two sides of the brain.



A word is flashed briefly to the right field of view, and the patient is asked what he saw.



Now a word is flashed to the left field of view, and the patient is asked what he saw.



*Each hemisphere of a split-brain patient cannot access the thoughts, intentions, or conscious experience of the opposite hemisphere, much as we cannot access the mental states of other individuals*

# The Cortex: Left and Right Hemispheres

Each hemisphere seems able to support an independent conscious self



*Fight Club (David Fincher, 1999)*

Tyler Durden: “All the ways you wish you could be, that's me. I look like you wanna look, I fuck like you wanna fuck, I am smart, capable, and most importantly, I am free in all the ways that you are not”.

# The Cortex: Left and Right Hemispheres

doi:10.1093/brain/aww358

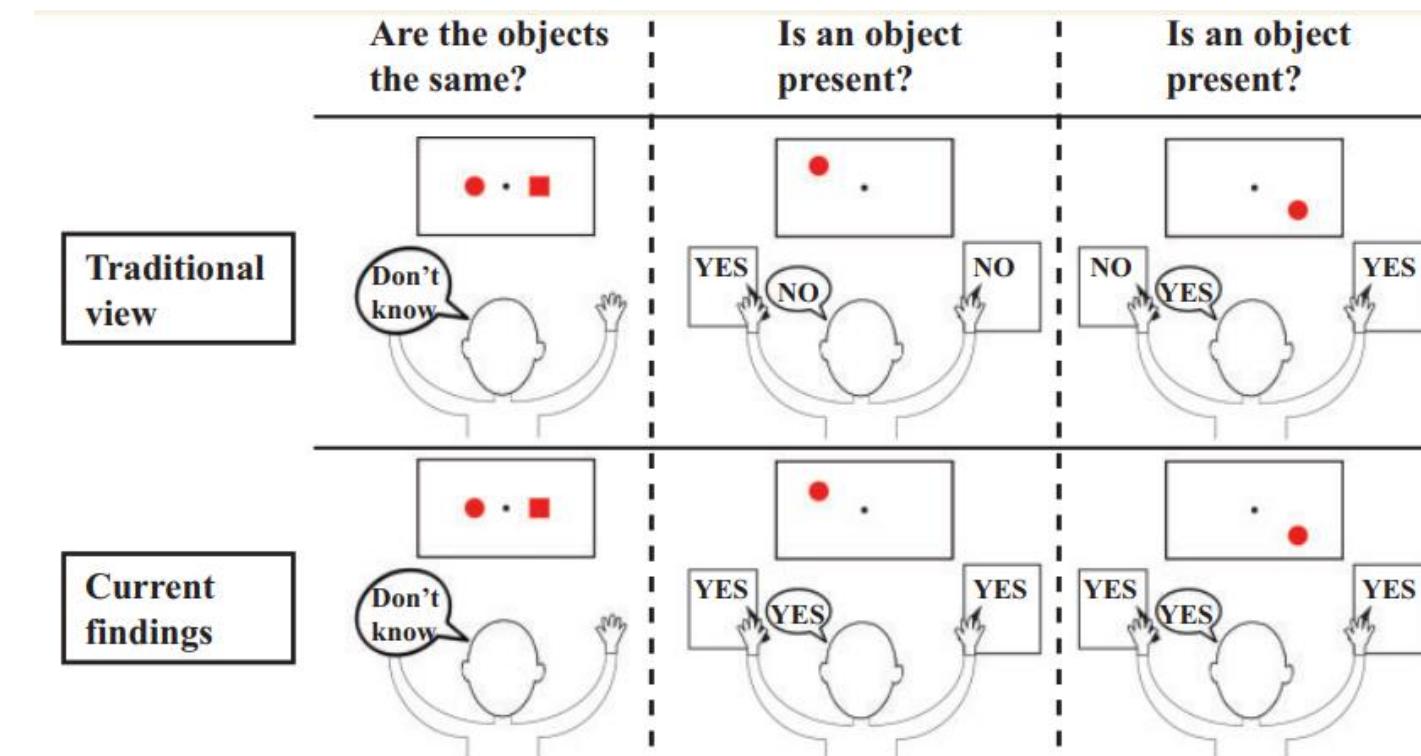
BRAIN 2017; 140; 1231–1237 | 1231



## REPORT

### Split brain: divided perception but undivided consciousness

Yair Pinto,<sup>1,2</sup> David A. Neville,<sup>3</sup> Marte Otten,<sup>1,2</sup> Paul M. Corballis,<sup>4</sup> Victor A. F. Lamme,<sup>1,2</sup>  
Edward H. F de Haan,<sup>1,2</sup> Nicoletta Foschi<sup>5</sup> and Mara Fabri<sup>6</sup>

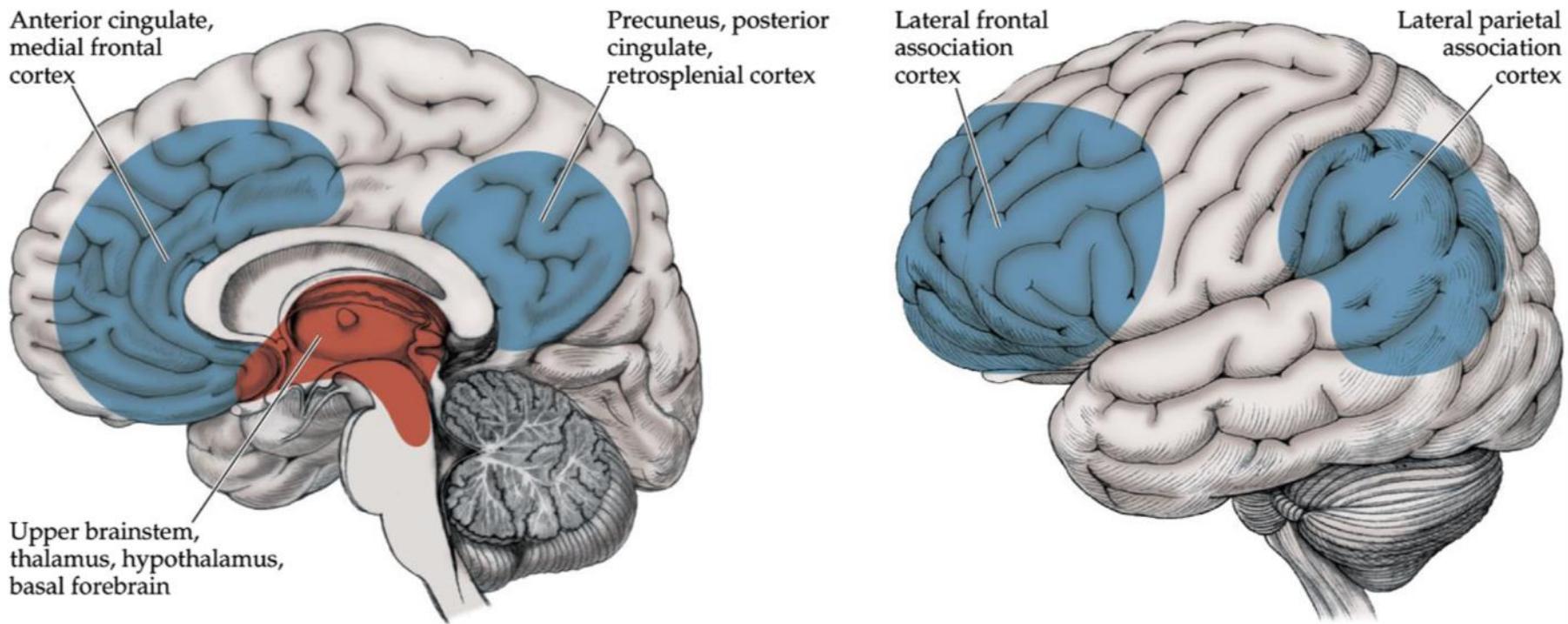


## The Neural Correlates of Consciousness

The only conclusion that can be drawn for sure about the neural substrate of consciousness is that it includes parts of the *corticothalamic system*.

The **loss of consciousness** is usually associated with **widespread lesions of the grey or white matter of the cortex**, and most of the time with a **significant thalamic involvement**.

# The Corticothalamic System



# The Neural Correlates of Consciousness

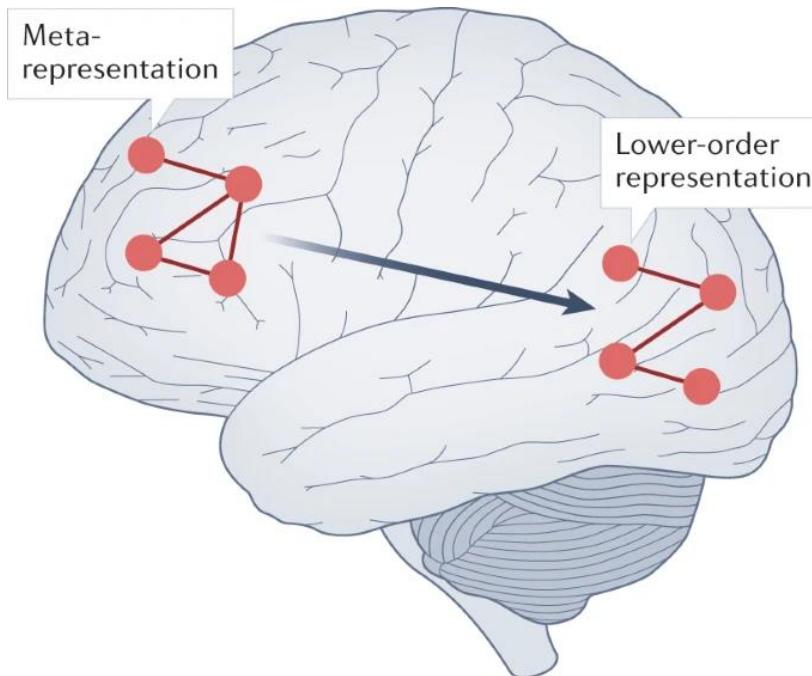
How to distinguish ‘true’ NCCs from the neural prerequisites and consequences of consciousness?

→Theories of consciousness (ToCs)

Whereas the NCC approach prioritizes the search for correlations between brain activity and consciousness, a theoretical approach focuses on identifying explanatory links between neural mechanisms and aspects of consciousness

# Theories of Consciousness

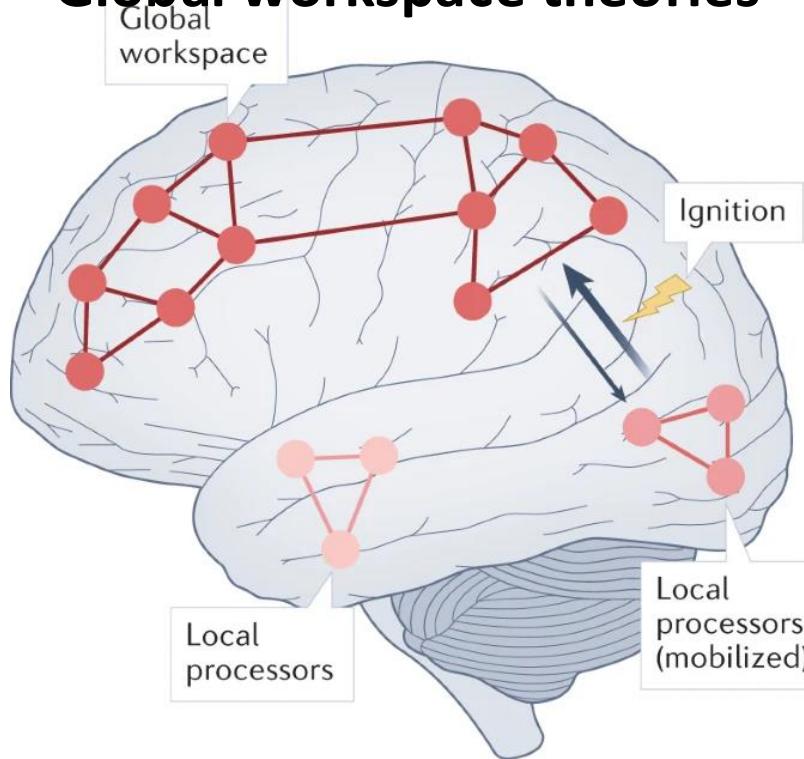
## Higher-order theories



The core claim that unites all HOTs is that a mental state is conscious in virtue of being the target of a certain kind of meta-representational state.

# Theories of Consciousness

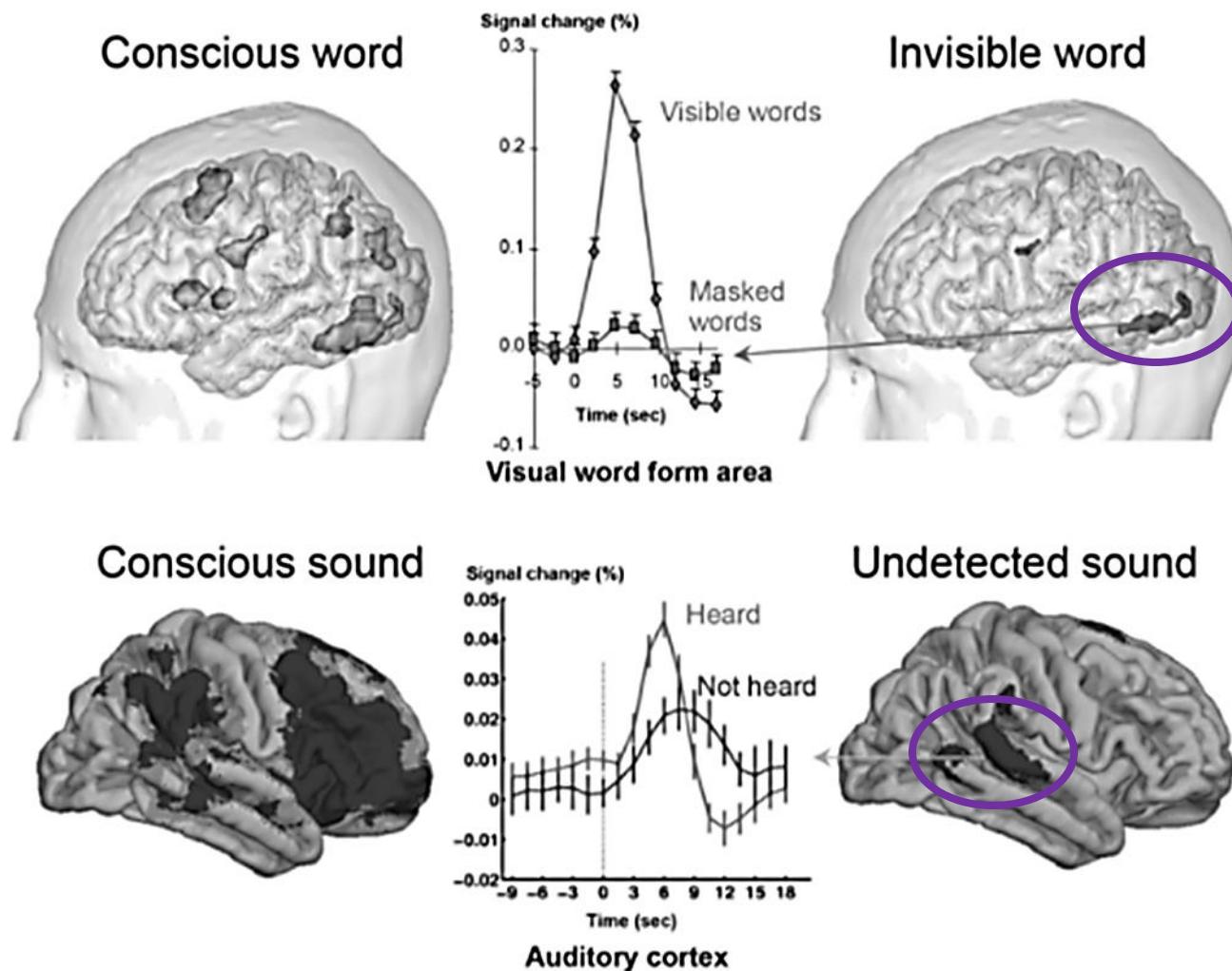
## Global workspace theories



Access to the global workspace is achieved through nonlinear network 'ignition' in which recurrent processing amplifies and sustains neuronal representations. The emphasis on ignition and broadcast - as compared with meta-representation - is one way in which GWT is distinguished from the HOT approach.

Conscious mental states are those that are 'globally available' to a wide range of cognitive processes including attention, evaluation, memory and verbal report. The core claim of GWTs is that it is the wide accessibility of information to such consumer cognitive systems that constitutes conscious experience

# Conscious Access

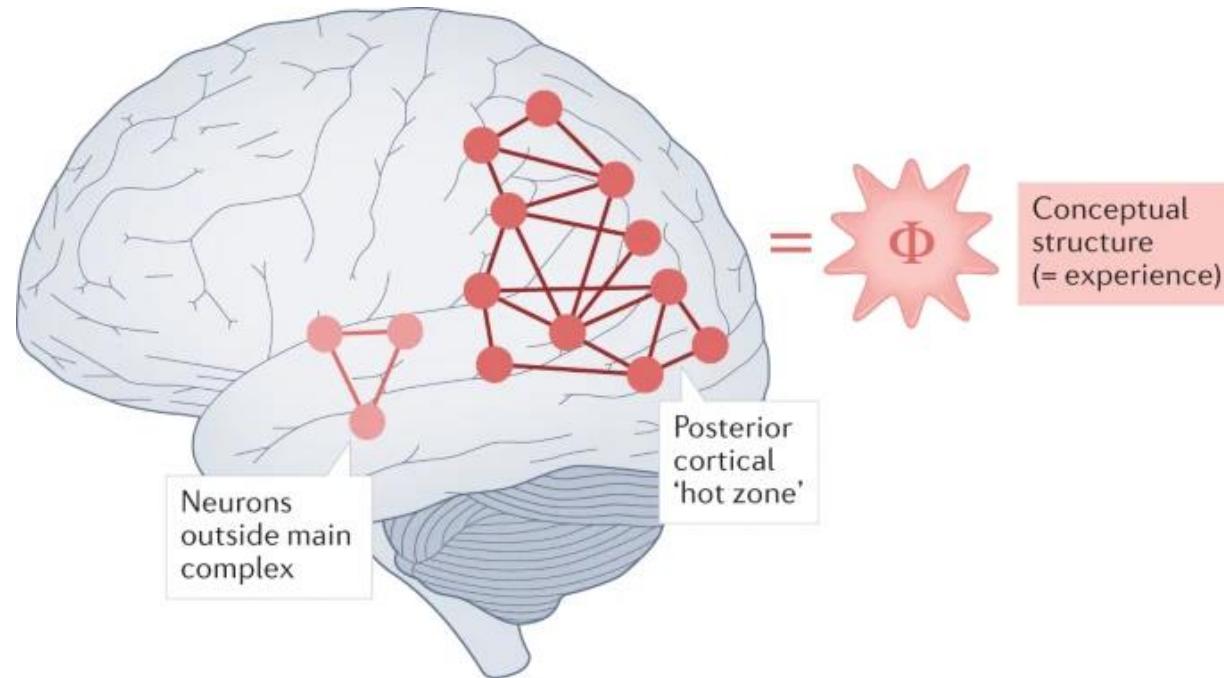


*"The first signature of conscious perception is an intense **ignition** of distributed brain regions, including **bilateral prefrontal and parietal regions**."*

*Dehaene et al., Nat Neurosci 2001*

# Theories of Consciousness

## Integrated information theory



The theory starts by proposing axioms about the phenomenological character of conscious experiences, and from these axioms it derives claims about the properties that any physical substrate of consciousness must satisfy. IIT then proposes that physical systems that instantiate these properties necessarily also instantiate consciousness.

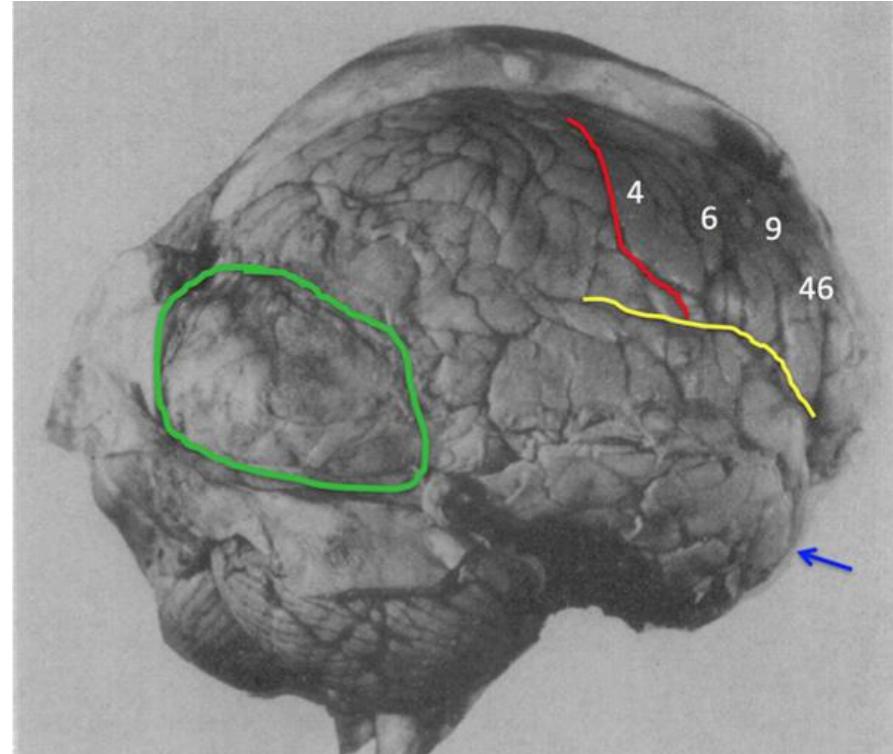
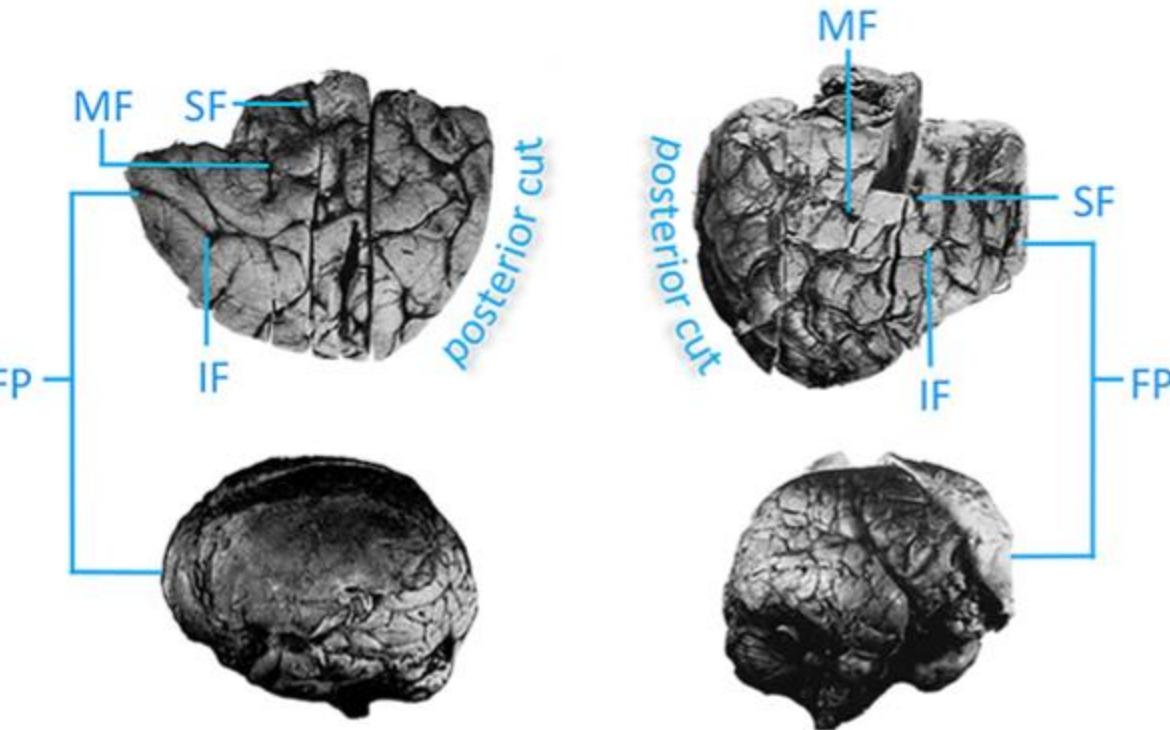
## The role of frontal areas



Phineas P. Gage (1823–1860) was an American railroad construction foreman remembered for his improbable survival of an accident in which a large iron rod was driven completely through his head, destroying much of his brain's left frontal lobe, and for that injury's reported effects on his personality and behavior over the remaining 12 years of his life.

# The role of frontal areas

## ANATOMY



Patient A (Brickner, 1952), after extensive surgical removal of the frontal lobes bilaterally, “toured the Neurological Institute in a party of five, two of whom were distinguished neurologists, and none of them noticed anything unusual until their attention was especially called to A after the passage of more than an hour”.

## Suggested Readings

Tononi G, Boly M, Gosseries O, Laureys S. 2015. *The Neurology of Consciousness: An Overview* (Chapter 25). *The Neurology of Consciousness* 2<sup>nd</sup> Edition. Academic Press. Scientific American.

Taylor JB. 2009. *My stroke of insight*. Hachette UK.

Bauby JD. 1998. *The Diving bell and the Butterfly: A Memoir of Life in Death* (Original Title: *Le Scaphandre et le Papillon*). Vintage, New York.

Sacks O. 1995. *An Anthropologist on Mars: Seven Paradoxical Tales*. Vintage, New York.

Edelman G, Tononi G. 2000. *A universe of consciousness: How matter becomes imagination*. Basic books.

Massimini M, Tononi G. 2013. *Nulla di più grande* (in Italian). Baldini&Castoldi

