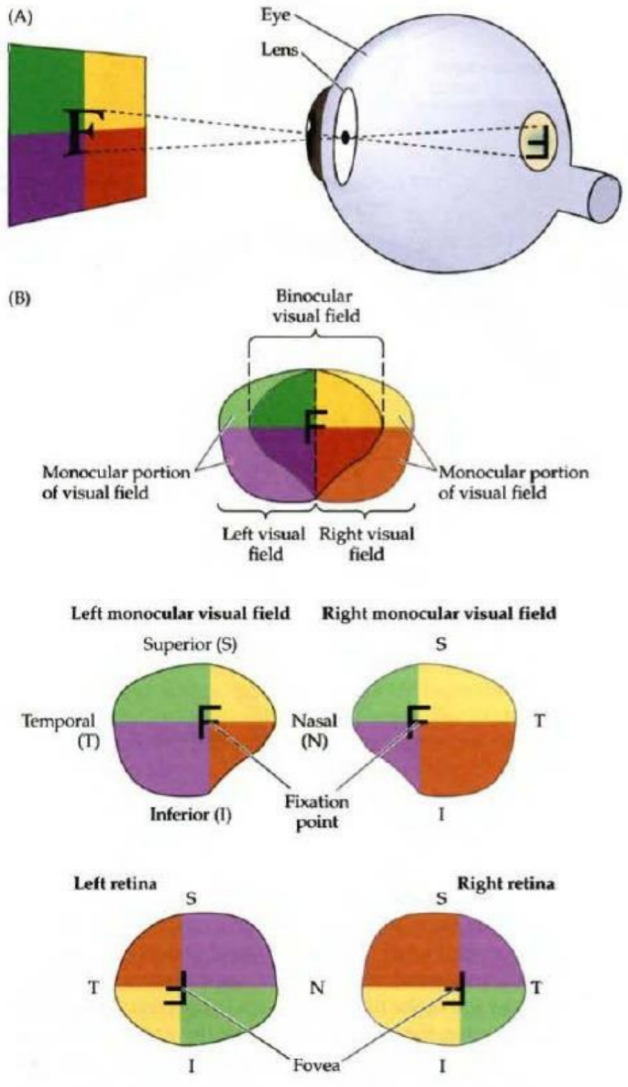
Cognitive abilities. Intelligence and personality

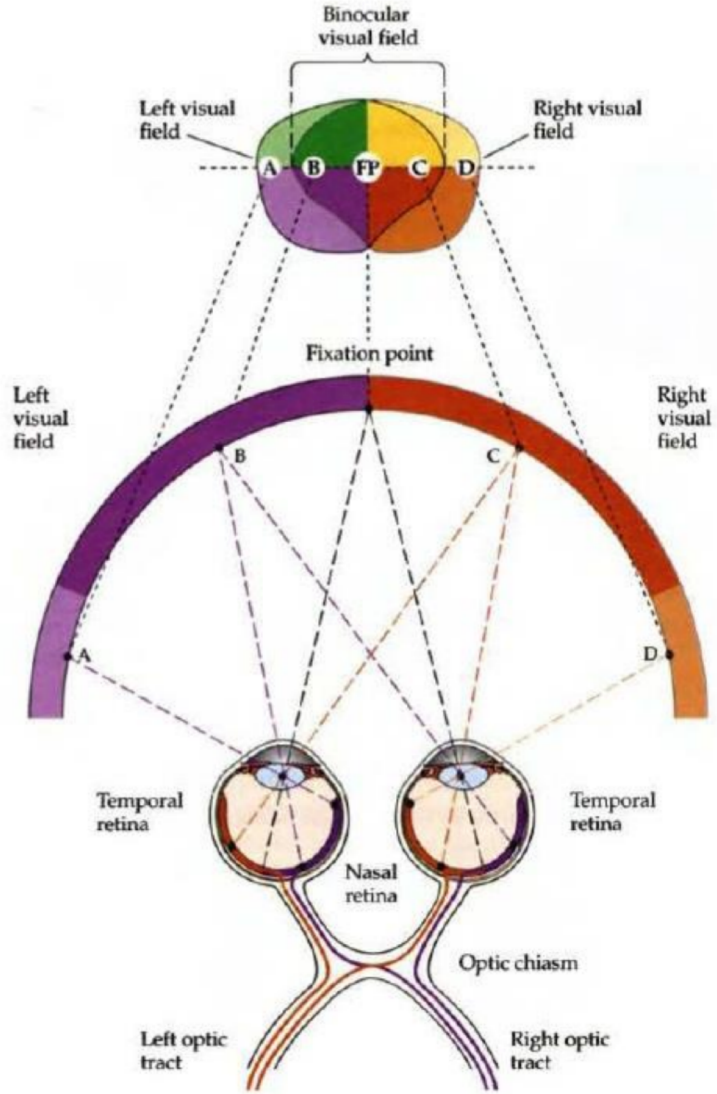
Lecture 10

Outline

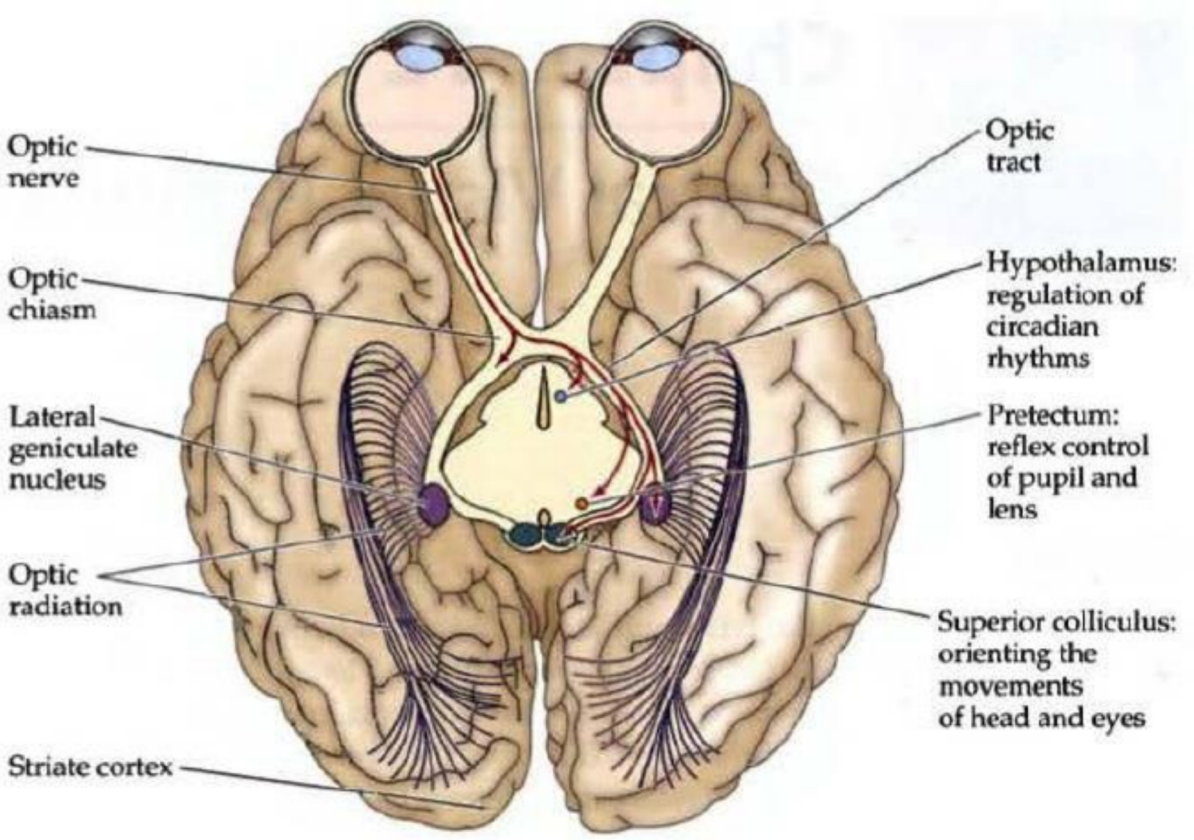
- Basic cognitive processes
  - Sensations and perceptions
  - Attention
  - Memory
- Consciousness

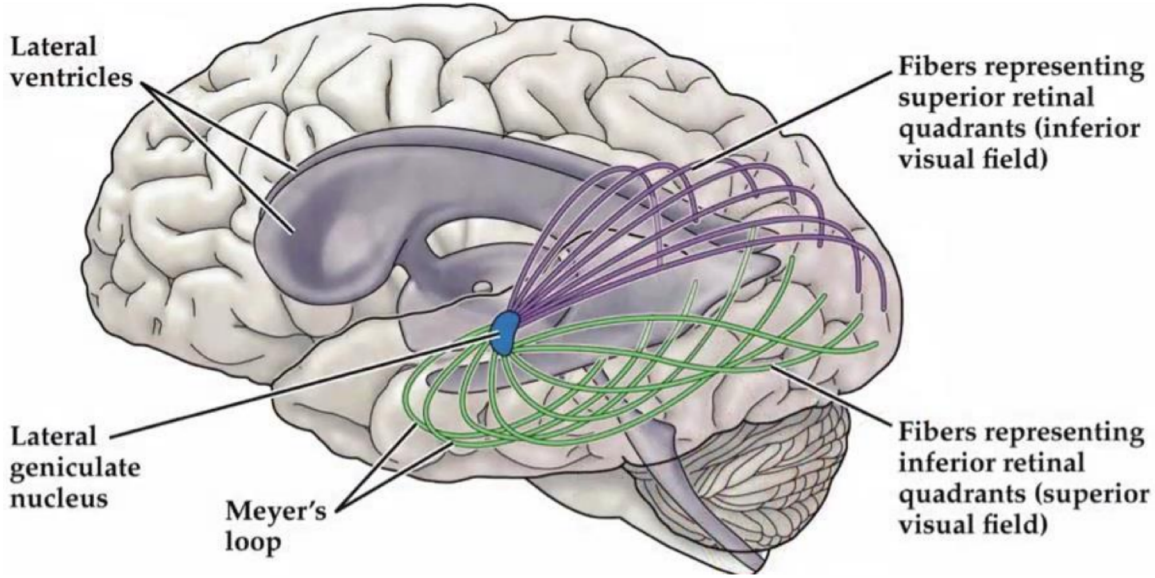
Visual system (analysis of visual information)



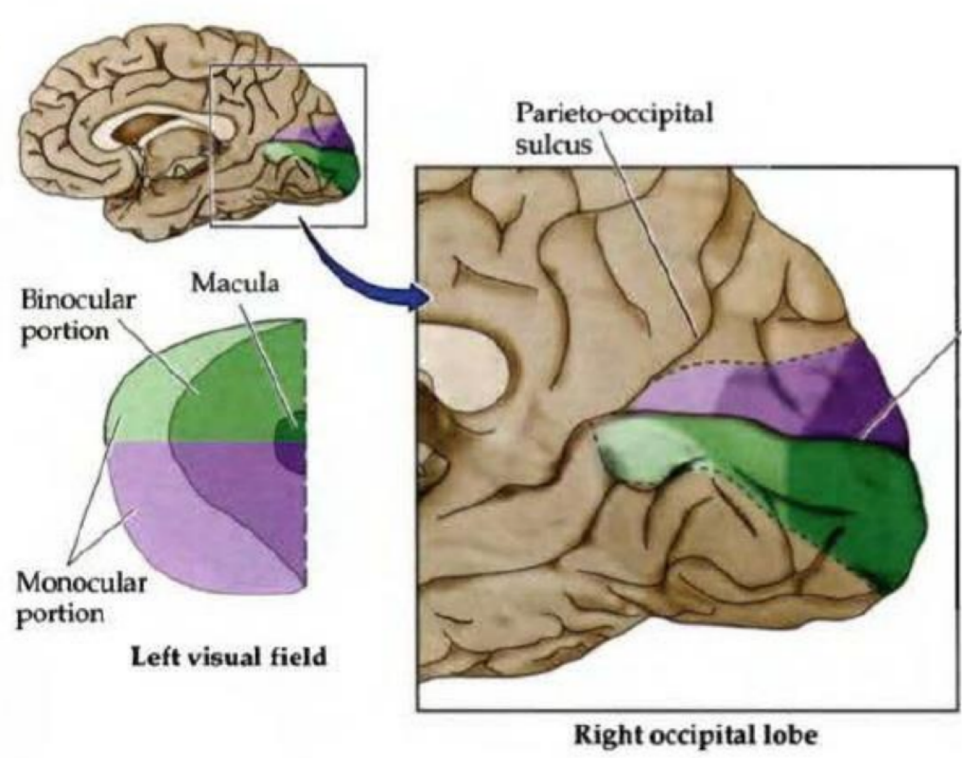


Central projections of the retina

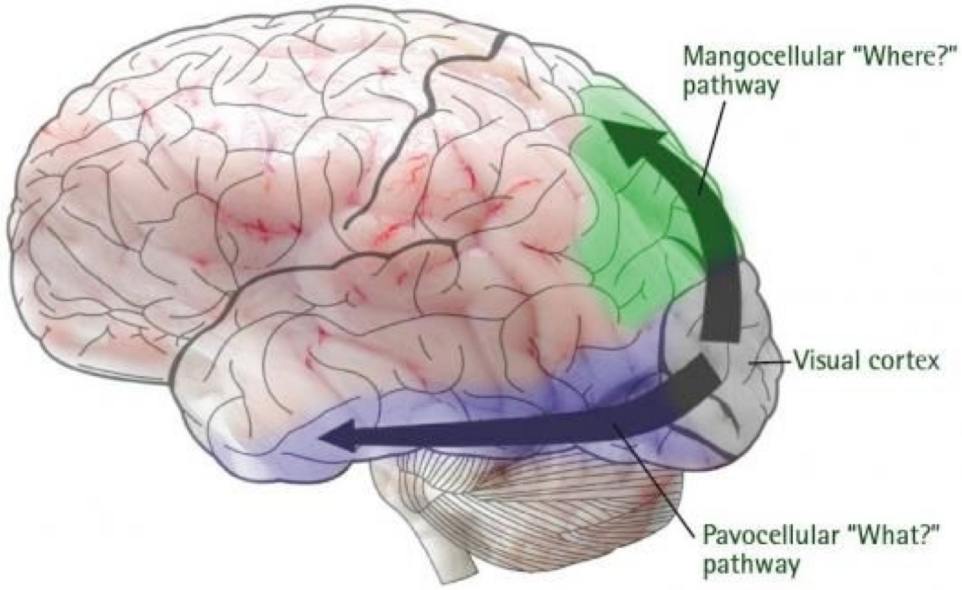


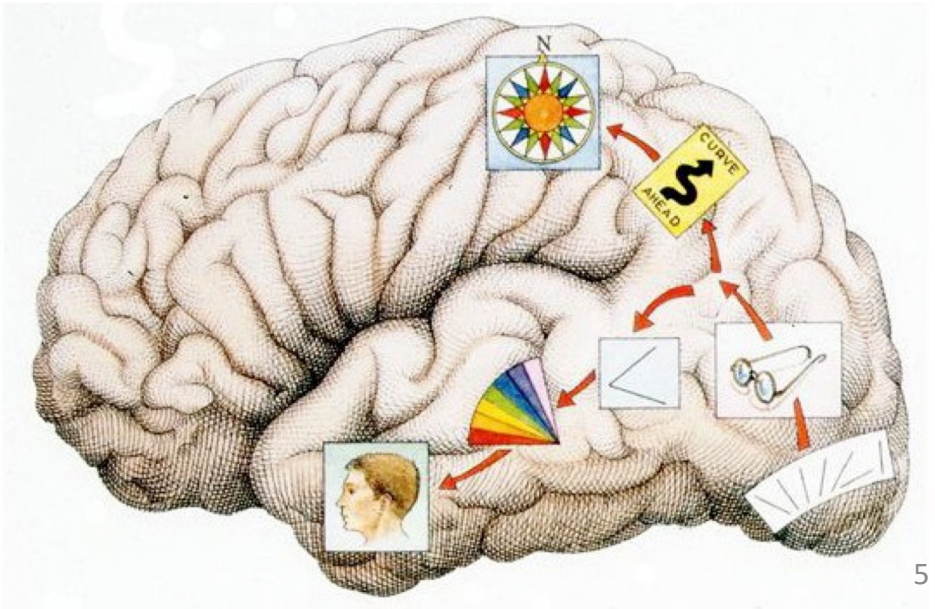


Primary visual cortex
Dorsal and ventral pathways

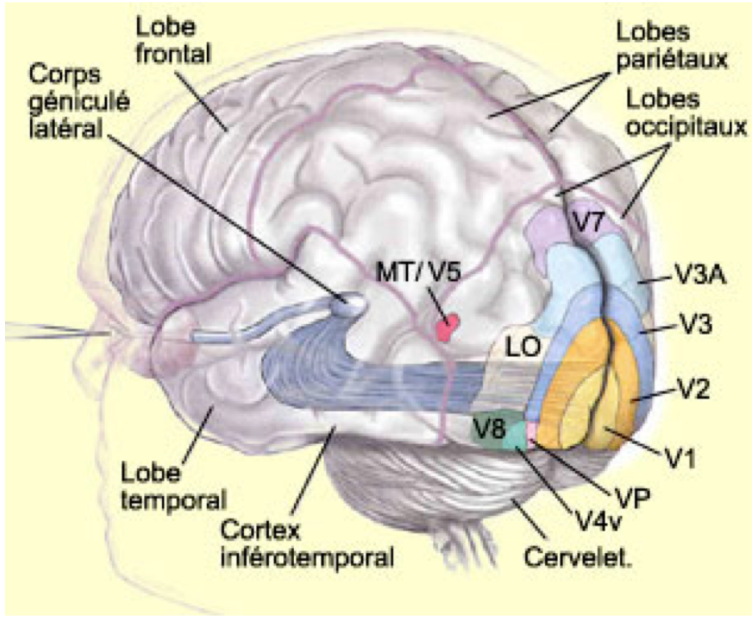


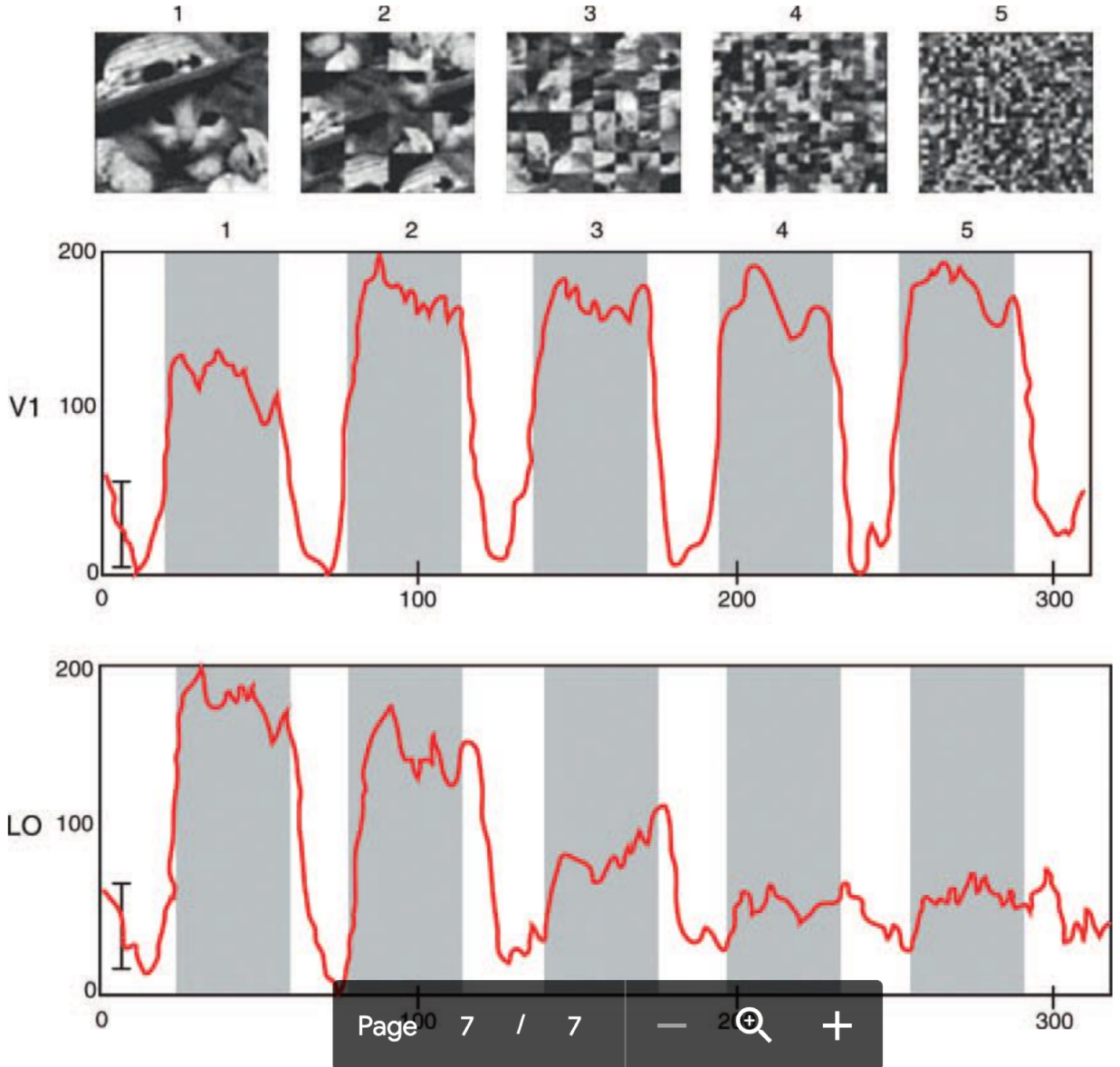
Calcarine sulcus





Neural responses from low and high level areas





Attention

- the brain has inherent limitations on the amount of information that it can process in a given time. Therefore, the brain works effectively only if it can select specific information for subsequent processing.
- **This selective process is called attention.**

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- **Alertness and arousal**
- **Vigilance or sustained attention**
- **Selective attention**
- **Distributed attention**

Alertness

- basic level of attention;
- without it, it is not possible to extract information from environment or choose a response;
- alertness and arousal is low when we are tired or sleeping, so at these moments we miss important information and we have problems with the responses;
- in some extreme cases, such as a coma, this type of attention is so disturbed that a person does not react to the outside world and cannot control his reactions.

Vigilance or sustained attention

- this is the ability to maintain attention for a long time;
- important when we solve the problem in non-stop mode;

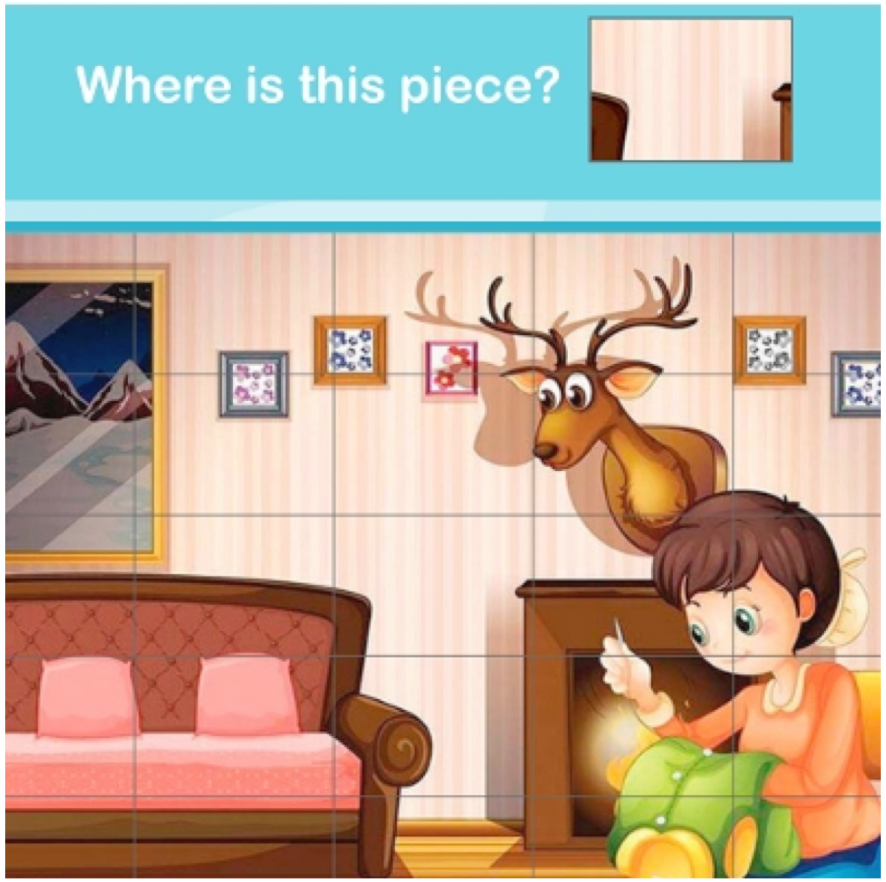
Vigilance or sustained attention

- this is the ability to maintain attention for a long time;
- important when we solve the problem in non-stop mode;
- sustained attention is especially necessary when you try to listen to every word in my lecture throughout its length.

Selective attention

- The process of filtering important information from a large amount of available information;

- This selection can be made in relation to incoming sensory information, information that we keep “in mind” or when choosing a response from a set of possible ones.



Distributed attention

- used when performing several tasks, i.e., process stimuli in parallel or processing is distributed across the spatial array;
- it is assumed that there is a limited set of resources;
- brain processing ability is higher when tasks use various resources.

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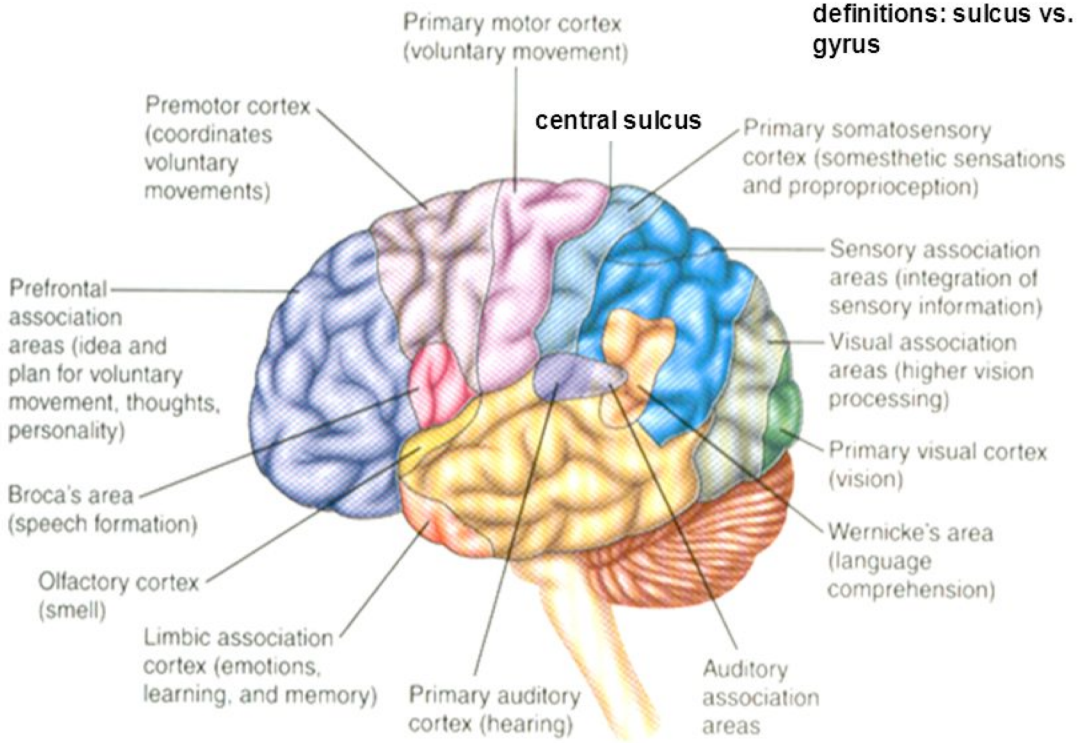
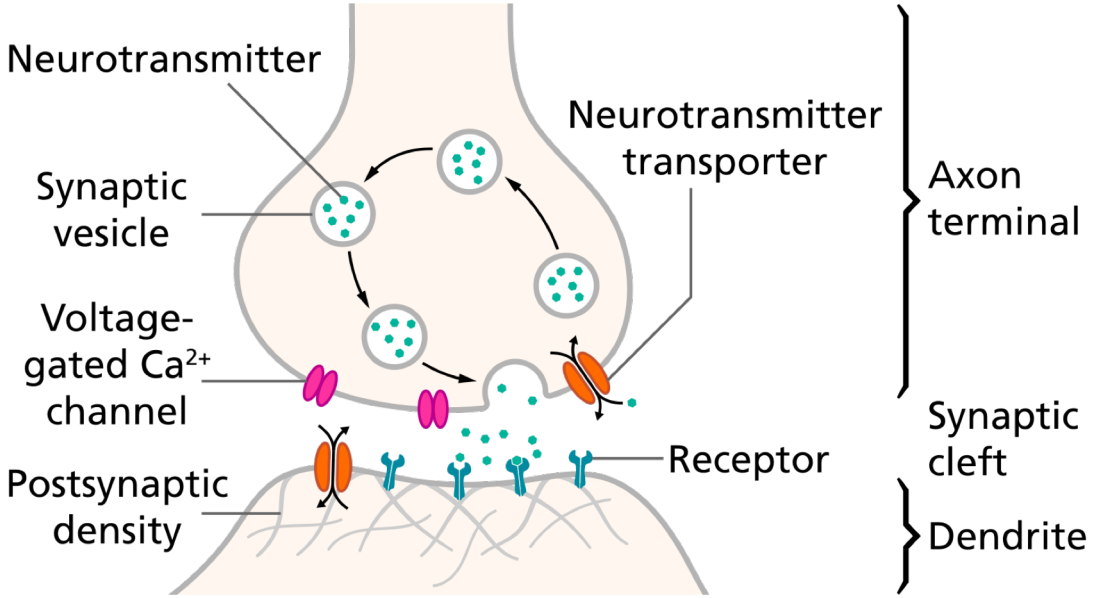
Neurophysiology of attention

- Actively developing area
- Attention modulates and modifies all other mental processes;
- The implementation of attention involves many brain structures located in different areas



Neurotransmitters (lecture #2 reminder)

- Neurotransmitters are endogenous chemicals that enable neurotransmission. It is a type of chemical messenger which transmits signals across a chemical synapse, such as a neuromuscular junction, from one neuron to another "target" neuron, muscle cell, or gland cell.



- Neurotransmitters play a major role in shaping everyday life and functions. Their exact numbers are unknown, but more than 200 unique chemical messengers have been identified

Reticular activating system (alertness, arousal)

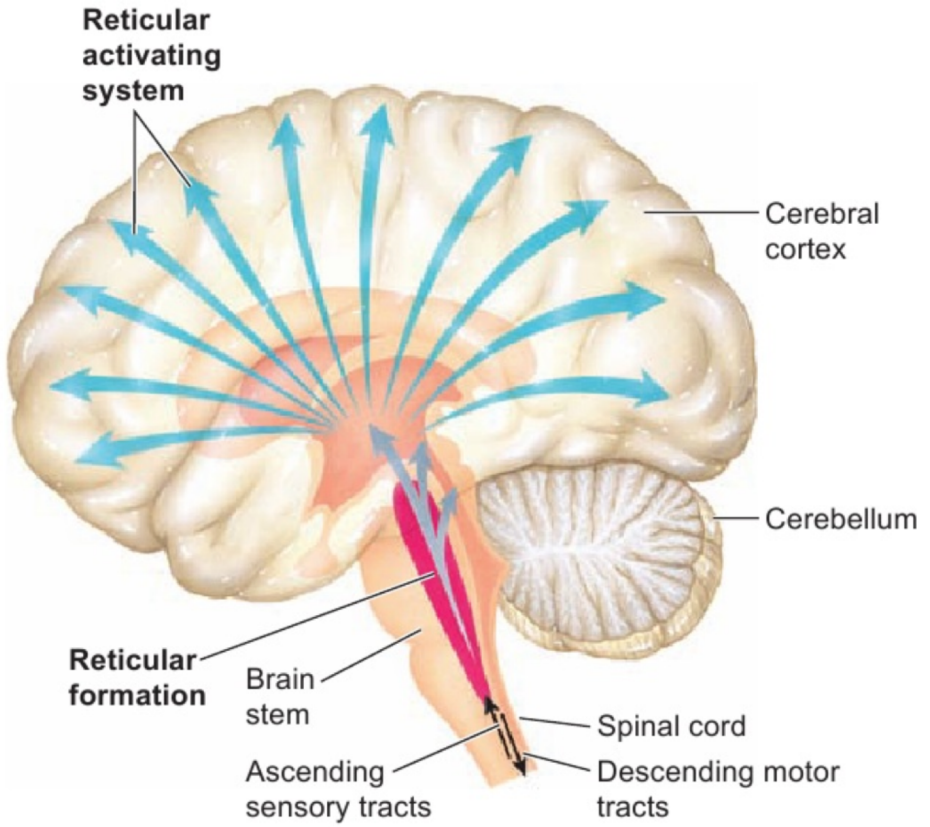


FIGURE 11.1 The reticular activating system is involved in overall arousal. The reticular formation is a widespread network of neurons within the brainstem (in red). The ascending portion of the RAS (in blue) projects to many different regions of the cerebral cortex. This input serves to arouse and activate the cerebral cortex. © 2010 Cengage Learning

- Neurotransmitter glutamate;
- Controls the sleep-wake cycle;
- Cell bodies are located in the reticular formation of the brainsteam;
- Ascending projections in the cortex;
- Two pathways
  - Dorsal one goes to the cortex through the thalamus;
  - Ventral goes through the hypothalamus, basal ganglia and only then in the cortex;
- Coma occurs when the RAS is damaged

Other neurotransmitter systems for attention control

- **Acetylcholine** is the cell bodies are localized in the brain steam and form a path parallel to the reticular activating system. These neurons are projected into the thalamus and basal nuclei, stimulation of the acetylcholin of neurons of the trunk leads to activation of the cortex.

- **Norepinephrine** is the cell bodies are localized in a blue spot (brain steam). Projected into various regions of the brain. Blue spot cells discharge at a regular slow rhythm, but the discharge frequency increases in response to an exciting stimulus and decreases during falling asleep

Thalamus and sustained attention

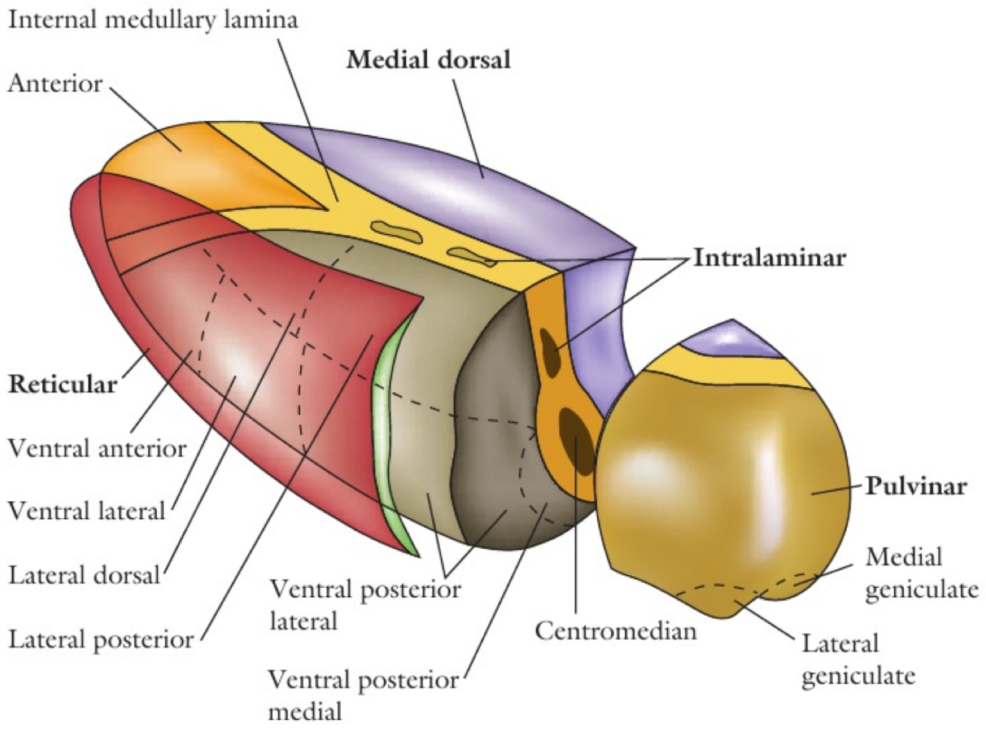
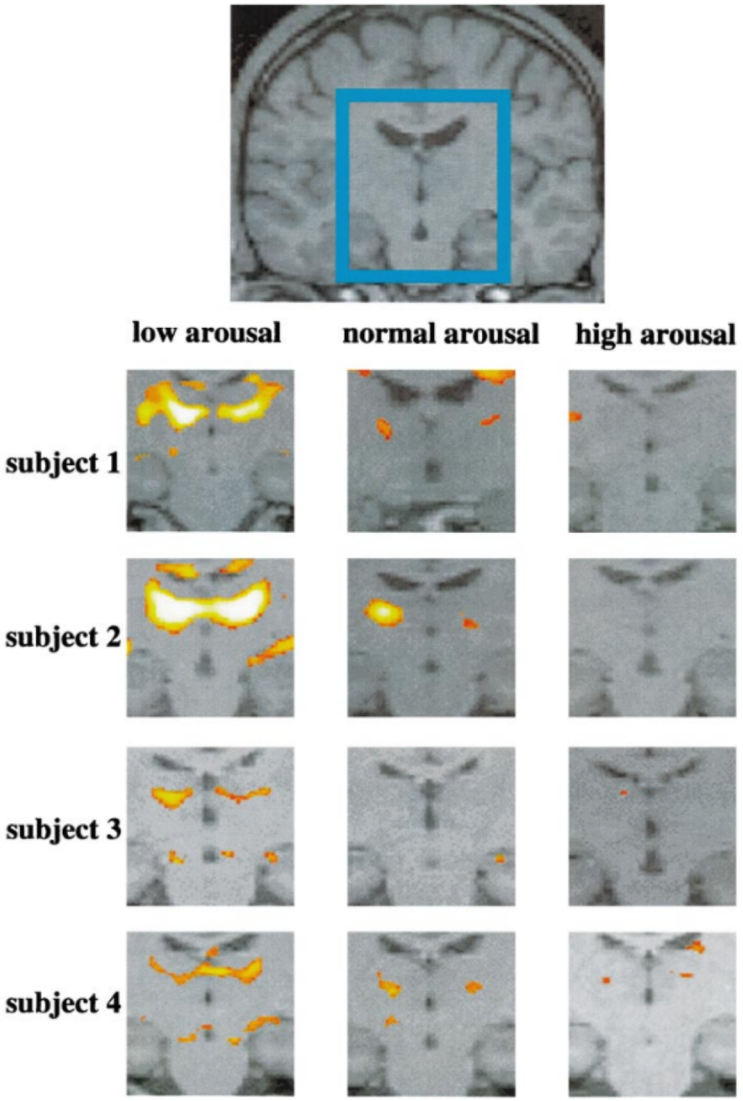


FIGURE 11.2 The nuclei of the thalamus thought to be involved in attention. The reticular, intralaminar, and medial dorsal nuclei have been implicated in arousal and vigilance; the pulvinar has been implicated in selective attention. © 2011 Cengage Learning

- Damage to these nuclei is enough to cause coma
- The thalamus is seen as an interface between alertness and other types of attention, such as sustained attention.

Thalamus and levels of arousal



- Normal levels of arousal, low levels of arousal (after sleep deprivation), and high levels of arousal (after being given caffeine)
- Cortical regions showed activation during the task, but cortical activation did not change as a function of arousal level
- Activation of thalamus was greatest under conditions of low arousal, when the cortex required stimulation to counter the effects of sleep deprivation, and lowest under conditions of high arousal, when no such additional boost to the cortex was required

Portas, C. M., et al. "A specific role for the thalamus in mediating the interaction of attention and arousal in humans." *Journal of Neuroscience* 18.21 (1998): 8979-8989.

Selective attention

- ***controlled* or *top-down***

- higher brain areas (prefrontal and other areas of the cerebral cortex) trigger a process that extends to the brain structures of a lower level.

- ***automatic* or *bottom-up***

- under the influence of sensory stimulation, the process is expanded from structurally low-level sensory formations and the stem reticular formation) upwards (to the cerebral cortex).

Stroop Effect

Word set #1

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

Word set #2

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

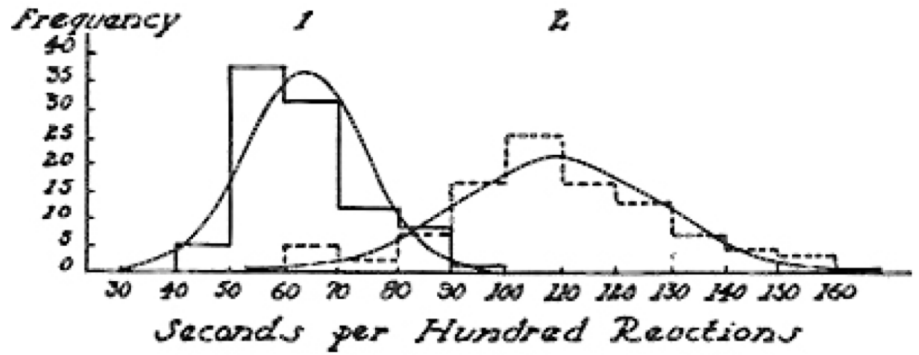
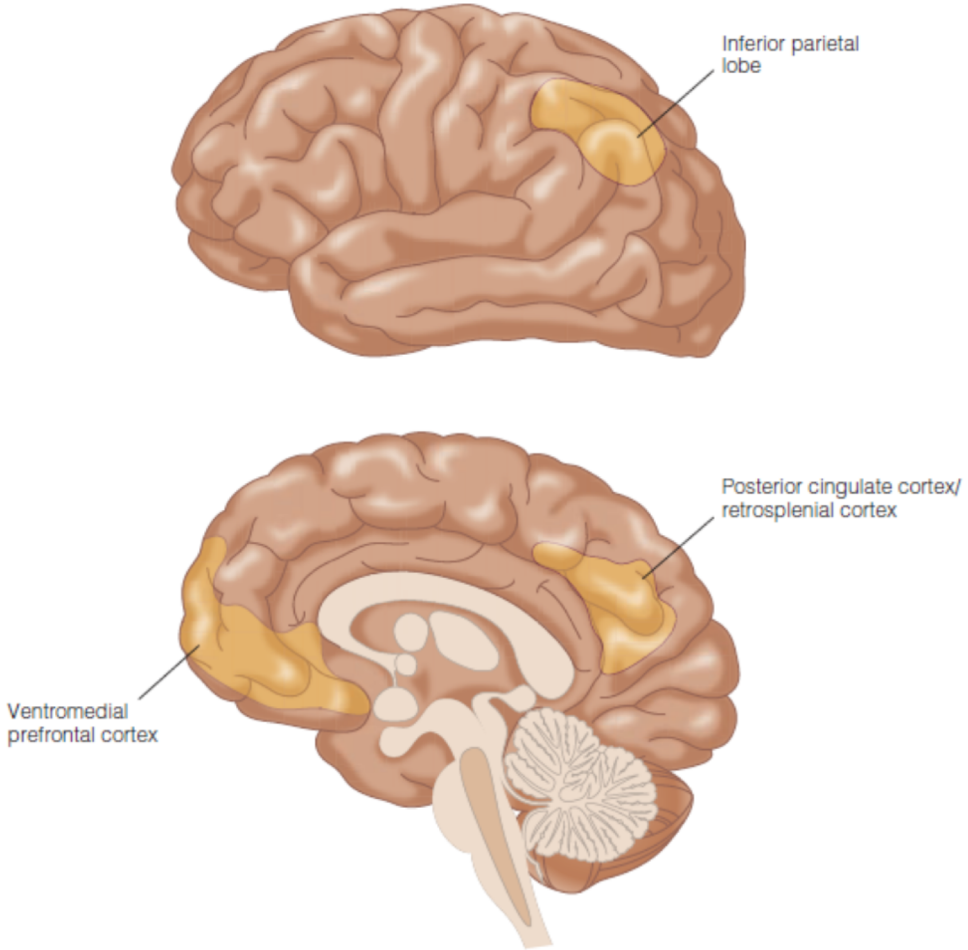


FIG. 1. Showing the effect of interference on naming colors. No interference (1); interference (2).

Figure from experiment of the original description of the Stroop Effect (1935). "1" is the time that it takes to name the color of the dots while "2" is the time that it takes to say the color when there is a conflict with the written word.

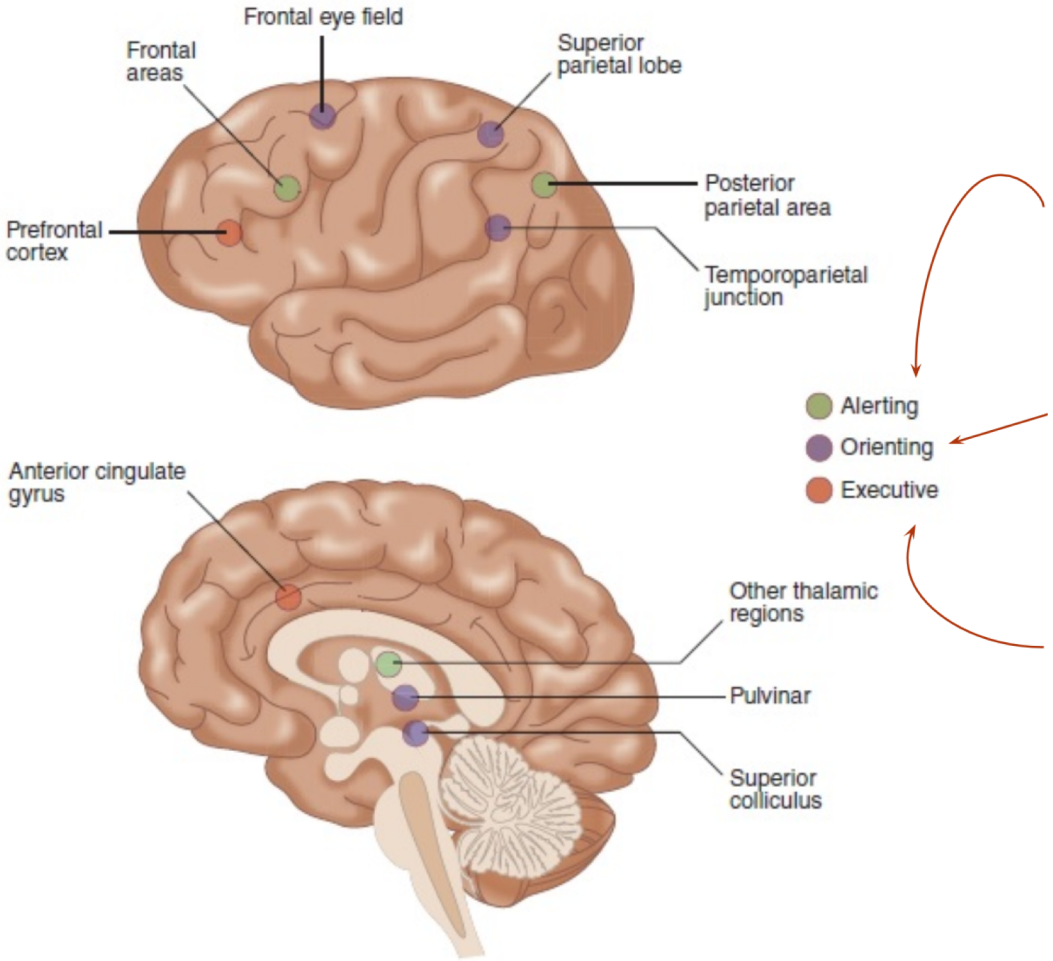
Default mode network (DMN) or default state network (DSN)



● FIGURE 11.10 The main regions involved in the so-called "default network." This network is active when people are doing relatively little cognitive processing of external stimuli. The greater the activity within regions involved in attentional control, the more activity within this default network is reduced.

- The DMN was most commonly active when a person is not focused on the outside world and the brain is at wakeful rest, such as during day-dreaming and mind-wandering.
- The DMN has been shown to be negatively correlated with other networks in the brain such as attention networks.

Attention functional networks



The state of wakefulness and readiness for action

Indicative response to sensory stimuli

Choosing a goal and managing behavior aimed at this goal; error detection; conflict resolution; suppression of reflex reactions

What is memory?

- **Memory** is the property of the brain by which data or information is encoded, stored, and retrieved when needed. It is the retention of information over time for the purpose of influencing future action.

- **Memory** is a group of mechanisms or processes through which experience changes the brain and behavior

- **Human memory**
  - **Sensory memory** — < 1 sec
  - **Short-term memory** — < 1 min
  - **Long-term memory** — life-time
    - **Explicit memory** — conscious
      - **Declarative memory** — MEDIAL TEMPORAL LOBE, DIENCEPHALON
        - **Episodic memory** — events, experiences
        - **Semantic memory** — facts, concepts
    - **Implicit memory** — unconscious
      - **Procedural memory** — Skills and habits — Striatum
      - **Skeletal musculature** — Cerebellum
      - **Emotional responses** — Amygdala

Sensory memory

- SM holds sensory information less than one second after an item is perceived.

- **Iconic memory** is a fast decaying store of visual information.
- **Echoic memory** is a fast decaying store of auditory information, another type of sensory memory that briefly stores sounds that have been perceived for short durations.
- **Haptic memory** is a type of sensory memory that represents a database for touch stimuli.

Partial report paradigm

F	G	Z	S
S	A	H	Q
K	E	M	E

G. Sperling, A model for visual memory tasks, Sperling, G. (1963). A Model for Visual Memory Tasks. Human Factors: The Journal of the Human Factors and Ergonomics Society, 5(1), 19–31. doi:10.1177/001872086300500103

This was first proved by using a partial report procedure in the following experiment (Sperling, 1960b). Subjects were presented stimuli consisting of 12 letters and numbers in three rows of 4 symbols each. The exposure duration was 50 msec. The stimulus exposure was immediately followed by a tonal signal. The subjects had been told to report only one row of letters and the signal indicated to the subject the particular row to be reported. Subjects were able to report correctly 76 per cent of the called-for letters even though they did not know in advance which particular row would be called for. This result indicates that after termination of the exposure, subjects still had available (somewhere inside them) 76 per cent of the 12 symbols, that is, 9.1 symbols. However, when the tonal signal was delayed for only one second, the accuracy of report dropped precipitously from 76 to 36 per cent. Note that 36 per cent of 12 symbols is 4.3 symbols; the previously measured memory span for this material was also 4.3 symbols.

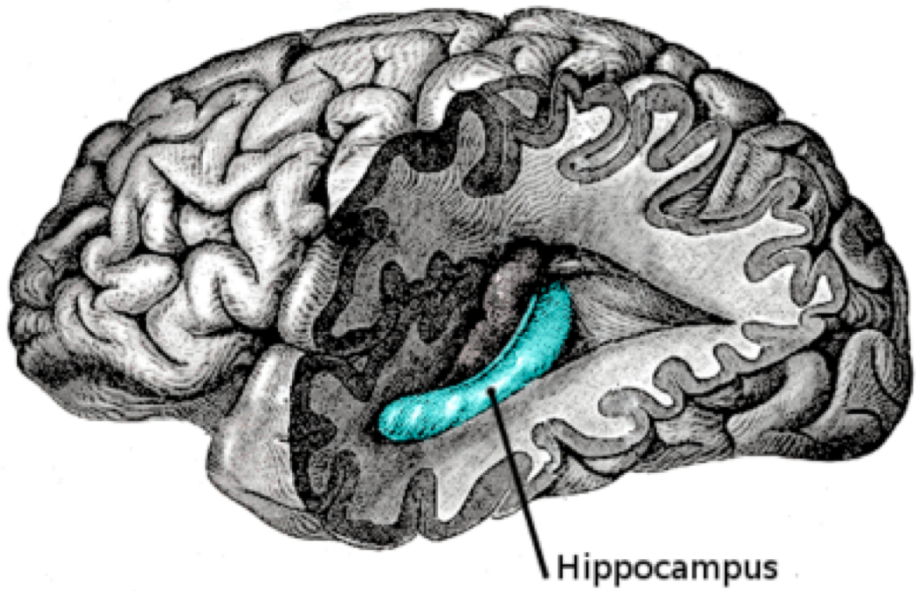
Short-term memory

- **Working memory**
- Short-term memory allows recall for a period of several seconds to a minute without rehearsal
- Its capacity is very limited

- In 1956, George A. Miller conducted experiments showing that the store of short-term memory was 7±2 items (the title of his famous paper, "The magical number 7±2").
- Modern estimates of the capacity of short-term memory are lower, typically of the order of 4–5 items

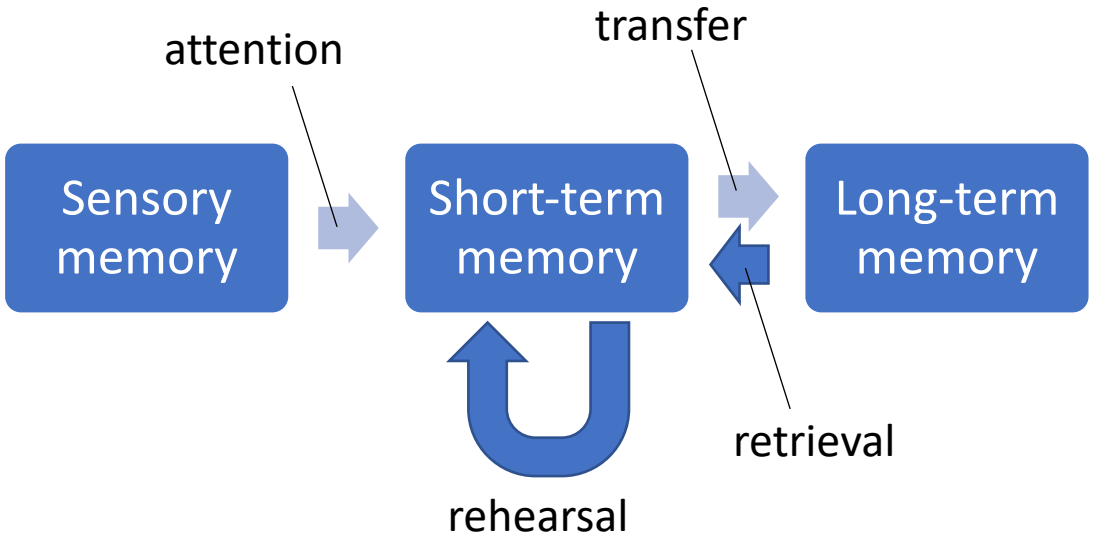
Long-term memory

- LTM can store much larger quantities of information for potentially unlimited duration (sometimes a whole life span).



- Short-term memory is supported by transient patterns of neuronal communication, dependent on regions of the frontal lobe (especially dorsolateral prefrontal cortex) and the parietal lobe.
- Long-term memory, on the other hand, is maintained by more stable and permanent changes in neural connections widely spread throughout the brain.
- The hippocampus is essential (for learning new information) to the consolidation of information from short-term to long-term memory, although it does not seem to store information itself.

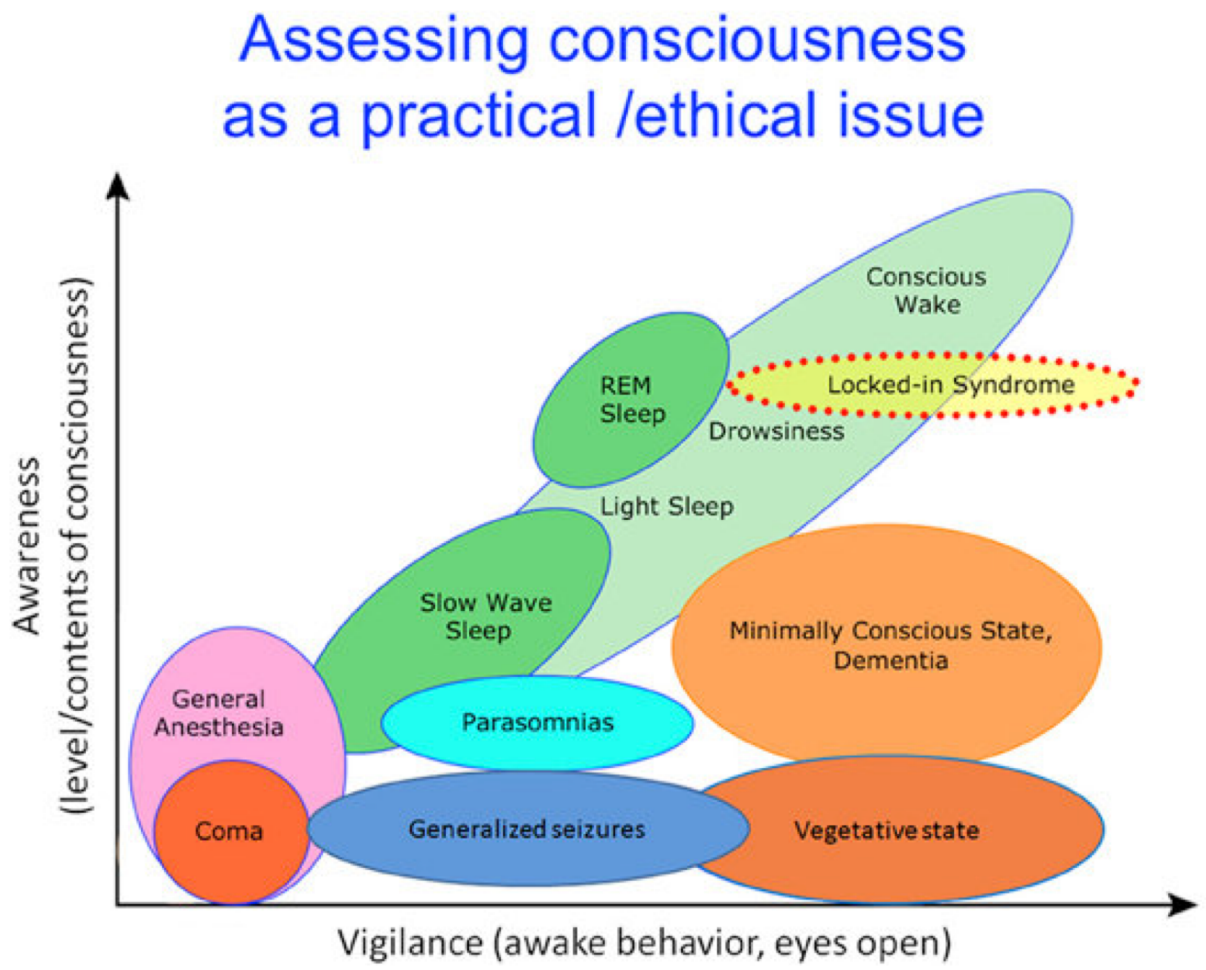
Multi-store model (Atkinson–Shiffrin memory model)



Neuroscience basis of consciousness

- **Sentience** refers to the ability to have positive and negative experiences caused by external affectations to our body or to sensations within our body.
- **Wakefulness** – not asleep or otherwise incapacitated
- **Phenomenal consciousness (P-consciousness)** – is simply raw experience: it is moving, colored forms, sounds, sensations, emotions and feelings with our bodies and responses at the center
- **Access consciousness (A-consciousness)** – is the phenomenon whereby information in our minds is accessible for verbal report, reasoning, and the control of behavior. So, when we perceive, information about what we perceive is access conscious; when we introspect, information about our thoughts is access conscious; when we remember, information about the past is access conscious, and so on.

Level of consciousness



- The level of wakefulness is provided by the reticular activating system (RAS) – see slide #22
- The level of consciousness (the sum of cognitive and emotional-psychological functions) is ensured by the integrative activity of the cortex (**MOST LIKELY - but nobody really knows**)

Boly M,Seth AK,Wilke M,Ingmundson P, Baars B, Laureys S, Edelman DB and Tsuchiya N (2013) Consciousness in humans and non-human animals: recent advances andfuture directions. Front. Psychol.4:625.doi: 10.3389/fpsyg.2013.00625

What is consciousness?

- The highest manifestation of the psyche associated with abstraction, separation of oneself from the environment and social contacts with other people. In this sense, such a definition applies only to a person
- Instant creation of neural patterns that describe the relationship between an organism on the one hand and an object or event on the other

Not an event or phenomenon! This is the process!

Easy and hard problems of consciousness

Chalmers provides the following list of easy problems:

- 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.

- David John Chalmers is an Australian philosopher and cognitive scientist specialising in the areas of philosophy of mind and philosophy of language.

Hard problems of consciousness

- In "Facing Up to the Problem of Consciousness" (1995), Chalmers wrote:
- *It is undeniable that some organisms are subjects of experience. But the question of how it is that these systems are subjects of experience is perplexing. Why is it that when our cognitive systems engage in visual and auditory information-processing, we have visual or auditory experience: the quality of deep blue, the sensation of middle C? How can we explain why there is something it is like to entertain a mental image, or to experience an emotion? It is widely agreed that experience arises from a physical basis, but we have no good explanation of why and how it so arises. Why should physical processing give rise to a rich inner life at all? It seems objectively unreasonable that it should, and yet it does.*

Hard problems of consciousness

- Why are processes in the brain accompanied by consciousness?
- Why the processes of information processing in the brain do not occur "in the dark", but there is some of our I (our personality)
- Why does such a material system as the brain even generate consciousness?
- Why is consciousness experienced as something?

Why do we have consciousness?

- Suppose animals (even the simplest ones) act like zombies.
- Their reaction is controlled by various systems; they are more likely to be reflex than conscious. For example, frog

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- Reflex systems work well when their number is small.
- An increase in the number of such systems leads to reflexivity inefficiencies due to conflicts between them.

Why do we have consciousness?

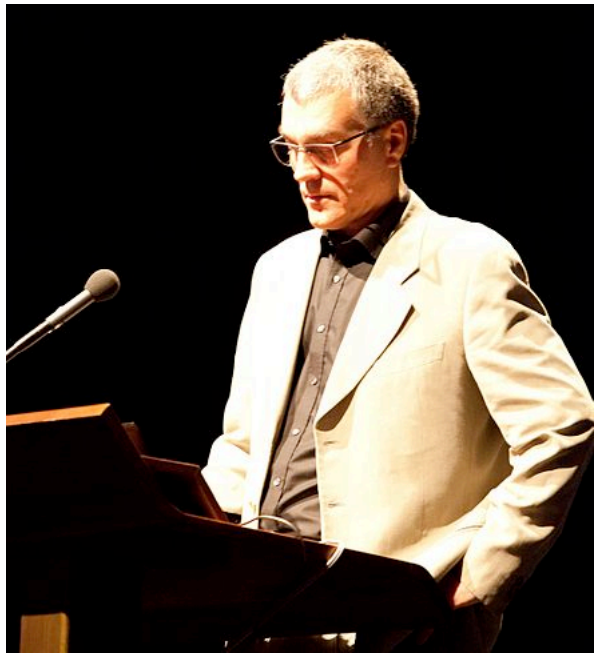
- Human (and higher mammals) receive a huge amount of information from the environment, complex representations are formed and they become accessible to that part of the brain that is able to make an adequate choice from the many possible answers.

- Perhaps consciousness is such a complex system of choice.

- But a hard problem remains open (see slides 36/37)

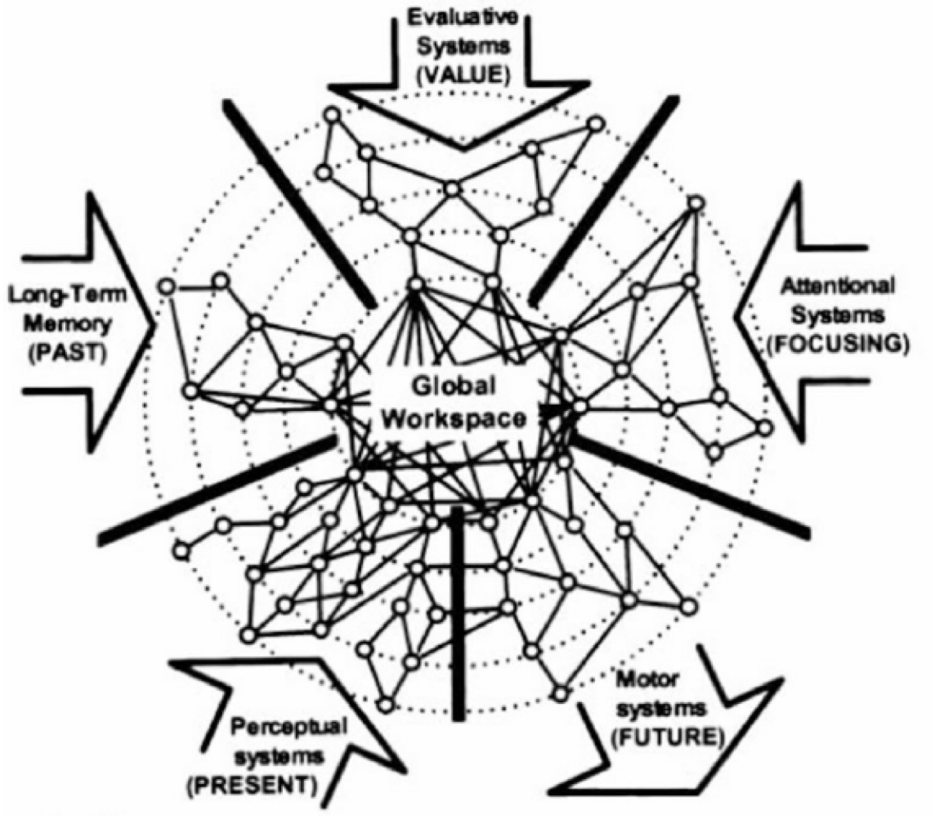
Why do we have consciousness?

- Sensory signals enter the brain. After analyzing them, the brain forms a model of the environment in real time (flight simulator or game simulator). Then this simulator begins to simulate the virtual model of the pilot (player). At the same time, the pilot's model does not even realize that he/she is a model and takes everything at face value. This is "I" - some virtual phenomenon



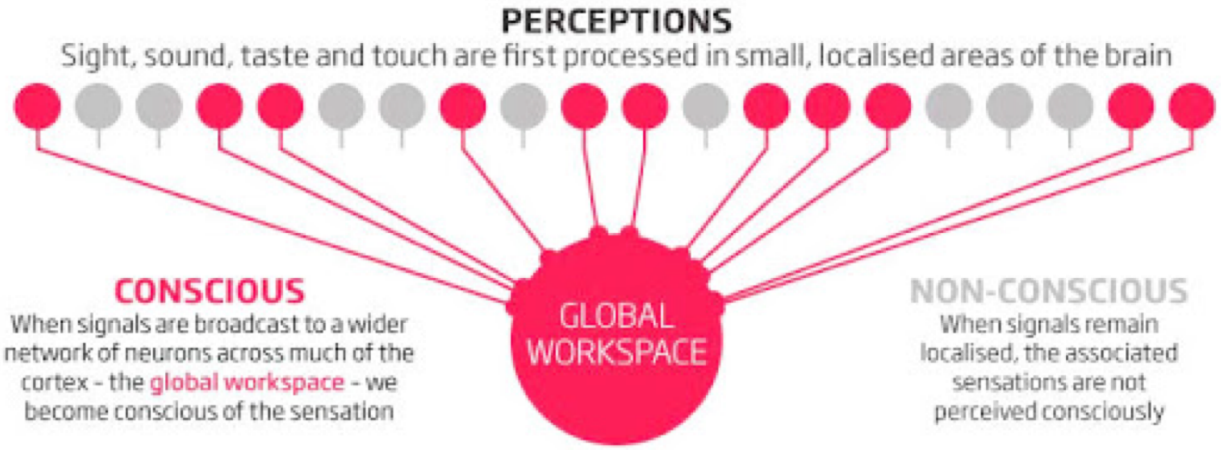
Thomas Metzinger is a German philosopher and professor of theoretical philosophy at the Johannes Gutenberg University of Mainz.

Global workspace model (GWM)



- The brain consists of many different parallel processors, each of which solves one problem.
- Separately, each processor operates unconsciously, but their interaction at the GWM-level is consciously

Global workspace model (GWM)



- Consciousness is a wide network of links between specialized unconscious processing modules competing for access to a global workspace
- The message that wins this competition and spreads throughout the global workspace forms the current content of consciousness.
- The neuronal extract of the global workspace is not clear. There is an assumption that in it, the sensory cortex is involved, where stimuli are presented as patterns of cortical activity, and the activity of the reticular formation and thalamus