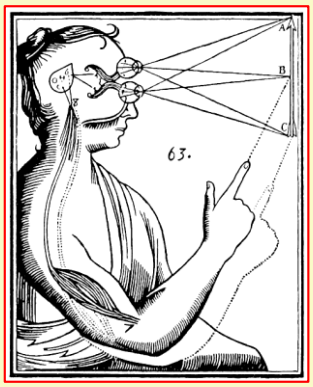
Consciousness

If we reject all of which we can entertain the smallest doubt, and even imagine that it is false, we can easily suppose that there is neither God, nor sky, nor bodies, and even that we ourselves have neither hands nor feet, nor body. Yet we cannot in the same way suppose, while we doubt of the truth of these things, that we ourselves are nothing, for there is a repugnance to conceiving that what thinks does not exist at the very time when it thinks. So "I think, therefore I am" [*cogito ergo sum*] is the first and most certain idea that occurs to anyone who philosophizes in an orderly way.

René Descartes, 1644



from *Treatise on Man*, written in 1632, withdrawn in 1633 because of Galileo's trial, finally published in 1662

We ended last week's session with some visual illusions.
Illusions have bothered philosophers for many years. If we cannot be sure of what we see, how can we be sure of anything?

Descartes began to write about how the human brain worked in his *Treatise on Man*. The illustration shows the eyes being activated by visual input. This sends fluid to the pineal gland which directs the fluid to the muscles causing the arm to point to the perceived object.

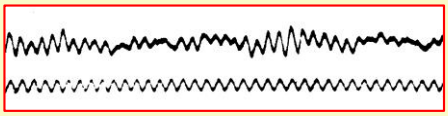
Fearing that the Church would not agree with his science, he decided first to provide a philosophical basis for his work – *The Discourse on the Method* (1637). Here he proposed a method of doubting everything until we are left with something that we cannot doubt – that we are conscious of our doubt. This led him to his famous *je pense donc je suis* or *cogito ergo sum*. The idea was first expressed in French and then in Latin in the *Principia Philosphiae* of 1644. Descartes used this irrefutable fact as a firm foundation on which to base an understanding of ourselves, the universe and God.
The conscious thinking self is thus the basis of all we know.

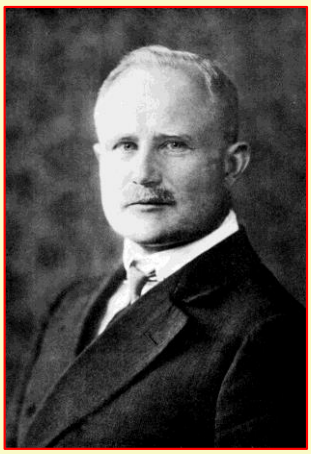
In *Les passions de l'âme* (1649), Descartes proposed that the pineal gland was *le principal siège de l' âme* (the seat of the soul).

Everyone experiences the transient unconsciousness that comes with sleep. We shall begin our study of consciousness with sleep and arousal, and then consider some disorders of consciousness. In the second half of today's presentation, we shall consider current ideas about the higher functions of the conscious brain – attention, self-consciousness, interpretation.

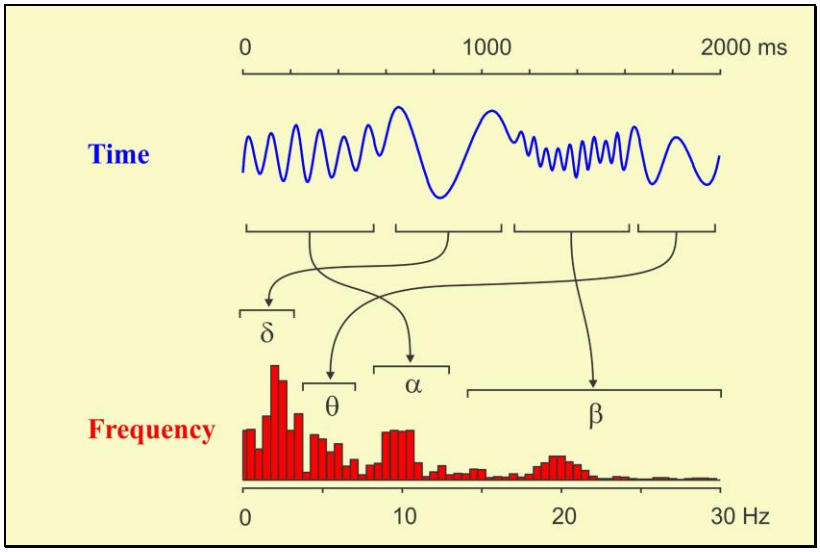
Electroencephalography

The first recordings of the electrical activity of the human brain were made by the psychiatrist Hans Berger (1873-1941) in Jena in the 1920s and 1930s. The top tracing in the recording below is from the scalp of his son Klaus. The bottom tracing is a 10/s timing signal. Berger named the rhythmic activity near 10/s "alpha", and the faster activity "beta." In 1938, Berger was summarily dismissed from his university position by the Nazis. Depressed by the war, he committed suicide in 1941.





One way to study human consciousness is to record the activity of the conscious brain. The first person to record from the human brain was Hans Berger, the father of electroencephalography (EEG).



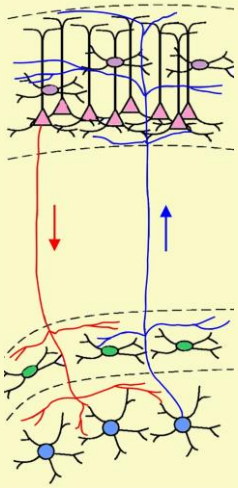
The electrical activity of the human brain is usually considered in terms of how rapidly the waves change in time.
Any time signal can be considered as a set (or spectrum) of frequencies.
Thus an EEG signal can be thought of as a mixture of waves of different frequencies.
Berger named the first type of rhythm that he discovered alpha – α. This is between 8 and 13 cps. (also known as Hertz or Hz – as stated on the x-axis of the frequency spectrum). Faster rhythms were called beta – β. Even faster waves were named gamma γ (though these were studied much later).

Slow rhythms were also named later: δ for "damage" and θ for "thalamus" although δ did not always mean damage and θ waves usually did not come from the thalamus. Delta waves are very prominent in normal deep sleep.

EEG Frequencies/Rhythms

delta (δ)	<4 Hz
theta (θ)	4-8
alpha (α	8-13
beta (β)	13-35
gamma (γ)	35-80

EEG rhythms are caused by the synchronous firing of groups of cortical neurons, caused by feedback connections with the thalamus. Rhythms generally occur when there is little input to the cortex. When information arrives, each neuron becomes specifically involved in processing and the rhythm goes away ("becomes desynchronized"). Thus the α rhythm goes away when the eyes open.

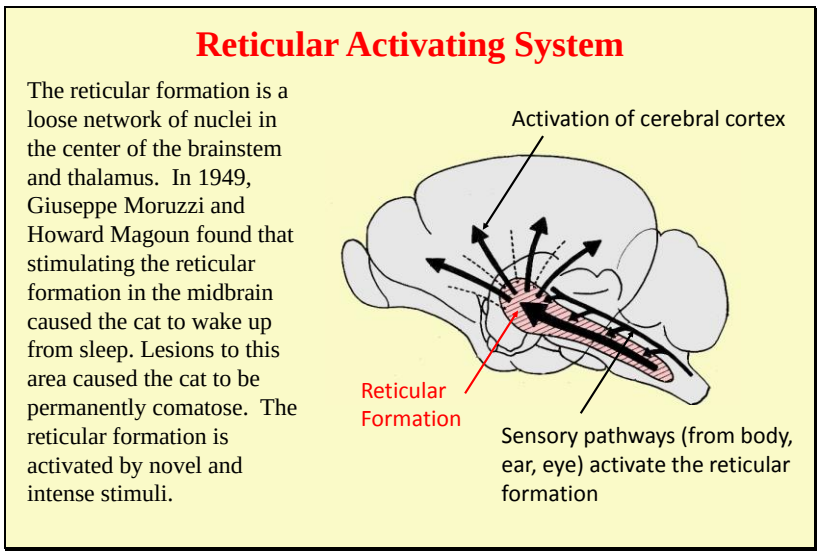


The rhythms of the EEG are generated in the cortex through the synchronous activation of multiple neurons.

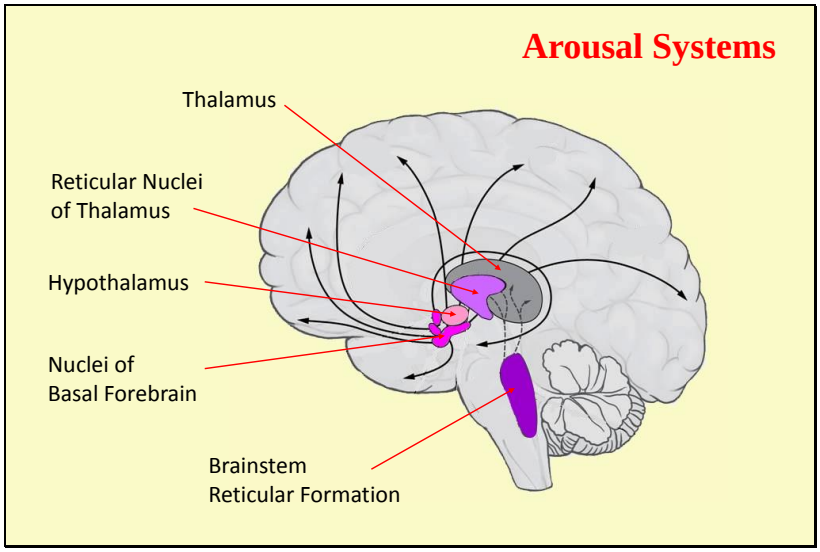
In the diagram the thalamus is at the bottom and the cortex at the top. Thalamocortical circuits have excitatory and inhibitory feedback connections. One set of neurons activates another set which inhibits the first set and so on. In this way there is an ongoing oscillation between activation and inhibition.

When the neurons are processing information they are no longer synchronized and the rhythm goes away.

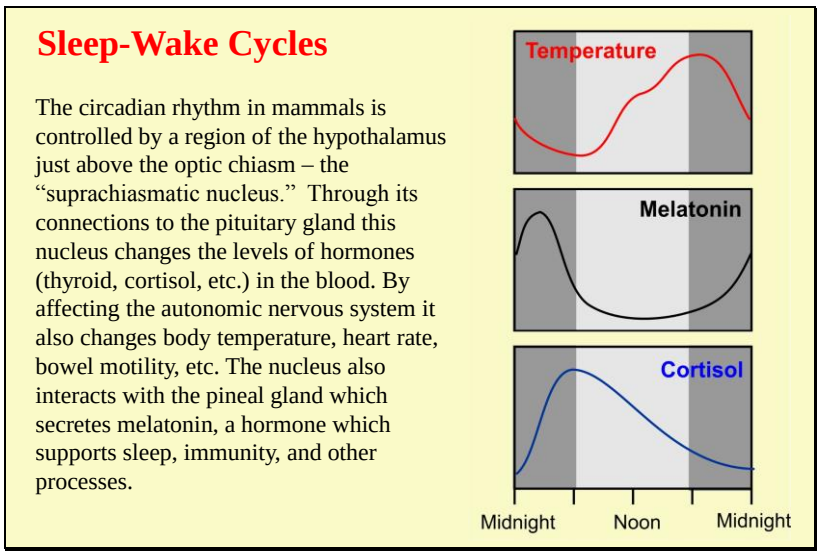
The alpha rhythm recorded from the back of the head indicates the resting activity of visual cortex. It is biggest when our eyes are closed and we are relaxed, i.e. not imagining anything specific. When we open our eyes, or when we imagine a complex visual scene with the eyes closed, the alpha rhythm goes away.



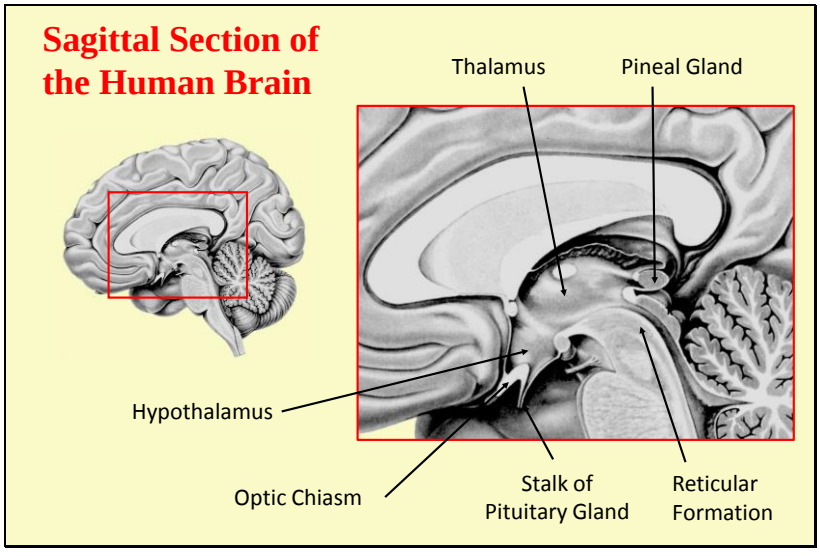
Arousal is controlled by an area in the center of the brainstem called the reticular formation. The midbrain reticular formation causes wakefulness, whereas areas of the pontine reticular formation control sleep.



Moruzzi and Magoun studied the cat. This slide shows the arousal systems in the human brain. The brainstem reticular formation projects to the thalamus (gray, and mauve) and thence to the cortex.
Other connections are to the hypothalamus (pink), which controls the autonomic nervous system (heart rate, breathing, etc.), and the nuclei of the basal forebrain, which are involved in emotions. As well as waking up the brain, arousal activates the body and triggers the emotions – we get "excited."



Many things in the human body go through daily cycles. Much of this cycling is controlled by the hypothalamus and two special glands – the pineal and the pituitary.
In the graphs the light and dark periods of the day are shaded.
Body temperature is lowest in the morning and highest in the evening. It starts to go down just before we go to bed.
Melatonin, a hormone secreted by the pineal gland is inhibited by daylight. Its concentration is highest at night - it does not initiate sleep-onset but it helps to maintain the state of sleep. The pineal thus serves to preserve our unconsciousness.
The stress-hormone cortisol (secreted by the adrenal gland under the control of the pituitary) is largest in the morning as we get ready to handle the problems of a new day.



This anatomical illustration shows the parts of the brain that are important to maintaining our circadian rhythms.

The hypothalamus controls the pituitary gland which supervises the other glands in the body. In this picture we just see the stalk of the pituitary. This is behind the optic chiasm.
The special area of the hypothalamus that controls sleep is right above the chiasm – the suprachiasmatic nucleus.
The pineal gland secretes melatonin which supports sleep and also interacts with the immune system.

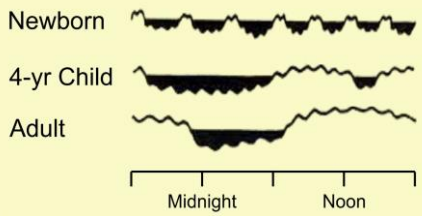
Sleep Rhythms

Sleep is not a unitary state. Two types of sleep (REM and non-REM) alternate during the night with a cycle duration of 90-100 minutes. The switching between them is controlled by neurons in the pontine reticular formation, particularly the midline raphe nuclei and the adjacent locus ceruleus. The brain thus follows both "circadian and ultradian" rhythms.

REM sleep is characterized by an EEG that looks similar to wakefulness, rapid eye movements (REMs), lack of muscle tone, muscle twitches, and vivid visual dreams.

Non-REM sleep shows various EEG patterns, resistance to arousal, and "thought-like" dreams.

Sleep Rhythms at Different Ages



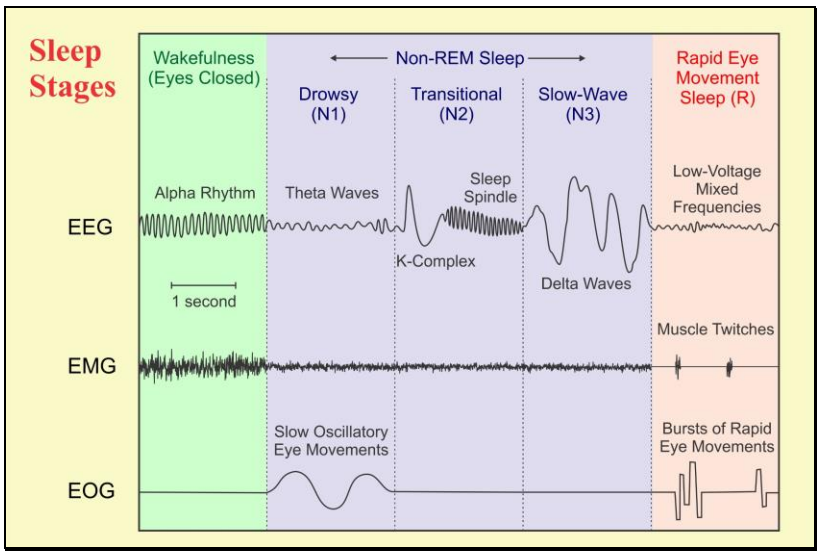
There are two kinds of sleep characterized by the presence or absence of rapid eye movements. Non-REM sleep may be important for restoration or recuperation of the body. Growth hormone secretion is higher during this stage.

The function of REM sleep is unknown. One speculation is that it may serve to erase unimportant memories from the day before and help consolidate important ones.

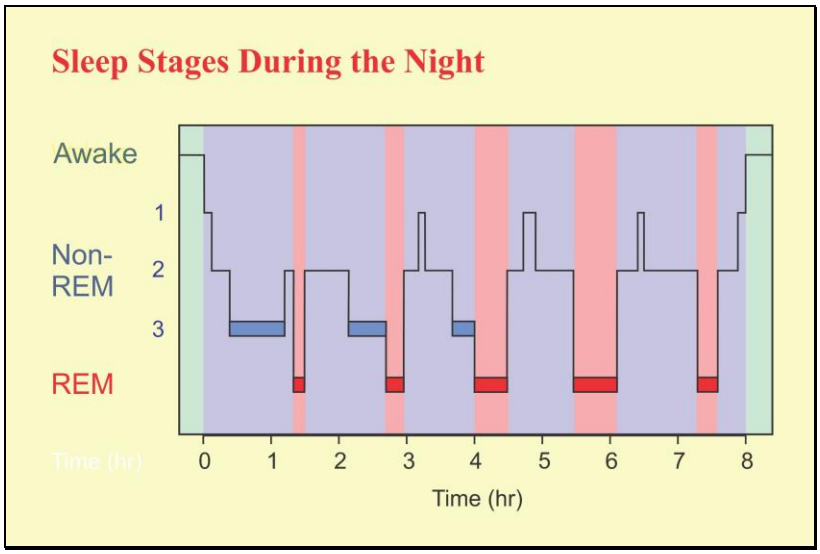
Consciousness is different in the two states – REM sleep is associated with vivid visual dreams, Non-REM sleep with thought-like mentation.

The diagram shows two rhythms. The slow rhythm is sleep/wake. The baby alternates between sleep and wakefulness every three hours or so throughout the day. The four-year-old has a nap in the afternoon. The normal adult only sleeps at night. Some say we should have an afternoon nap just like the child.

The faster rhythm occurring once every 90-100 minutes is REM/Non-REM. Some people have suggested that this rhythm persists in wakefulness as well as sleep.

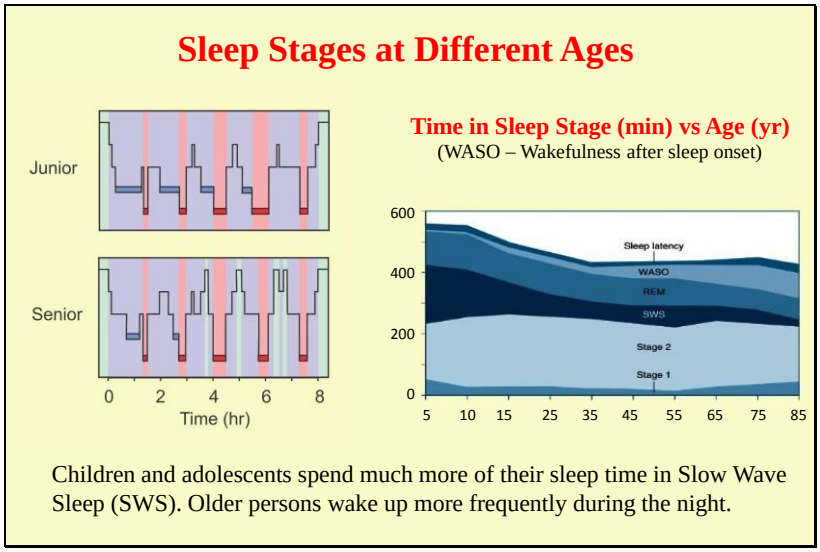


This slide shows the EEG, muscle and eye changes during the different sleep stages.
Non-REM sleep is divided into three stages. It shows special EEG patterns like the sleep spindles and the K-complex.
An important stage of Non-REM sleep is "slow-wave sleep," characterized by large delta waves.
Every 90 minutes or so during sleep we go into REM-sleep. During this stage, the EEG looks like it does in drowsiness, the muscles twitch, the eyes move quickly back and forth, and we have vivid dreams.

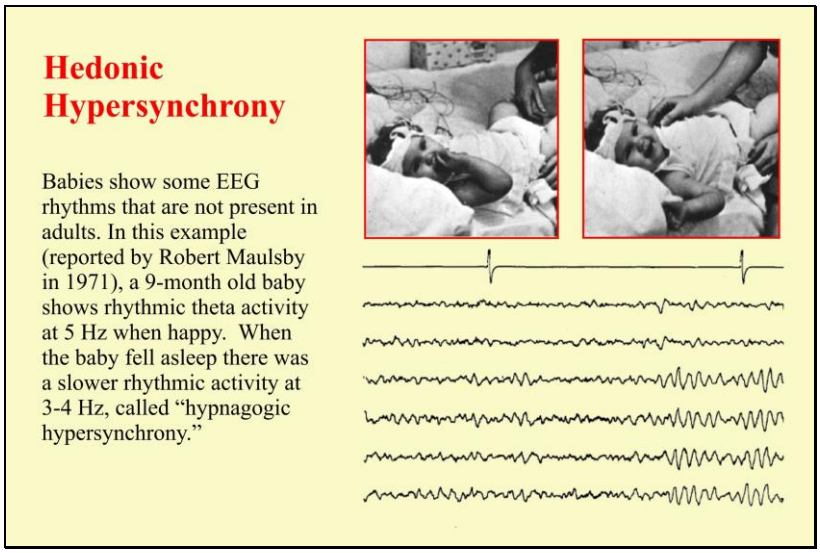


This is a graph of the sleep stages during the night – a hypnogram.
Slow wave sleep (blue) is more prominent in the first half of the night.
REM sleep (red) occurs every 90 minutes. The stages are longer in the second half of sleep.

Note that in some hypnograms the REM stages are plotted at the top rather than the bottom of the graph – as stage 1REM. However this can be confusing, since the N1 and REM states are very different even though the EEG patterns are similar.



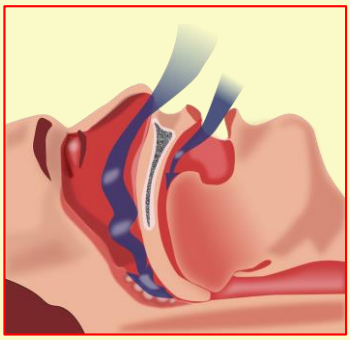
The hypnograms on the left come from a young adult and from a normal elderly subject. WASO – wakefulness after sleep onset.
Elderly people wake up a lot during the night and have much less SWS (dark blue on the right graph).



Sometimes we might wish for the happy rhythms of childhood.
The upper tracing shows the timing of the camera.

Sleep Apnea

The tongue and soft palate can obstruct the respiratory tract during inspiration, leading to snoring and periods of apnea. The apneic episodes may keep waking the patient up. This prevents the patient from having a normal night's sleep. The patient becomes very sleepy during the daytime and unable to work properly.



The condition is diagnosed using polysomnography – the EEG, eye movements, muscle activity and breathing are monitored to determine the frequency and duration of the apneic episodes.

The treatment is with Continuous Positive Airway Pressure (CPAP) – this keeps the respiratory tract open.

A sleep disorder that becomes more common as we get older is sleep apnea – stoppages of breathing.

The Somnambulist, J. E. Millais, 1871

Sleep Walking

Sometimes the various components of sleep and wakefulness get mixed up. Sleep walking often occurs on arousal from slow wave sleep. Sleepwalkers can perform various automatic acts and navigate around obstacles. Although their eyes are open, they are only vaguely conscious of their actions, and remember very little about the episode afterwards. They generally do not respond to questions, but they can be coaxed back to bed.

Sleep walking – somnambulism – is a disorder of consciousness that is more common in childhood and adolescence – perhaps affecting about 5% of children. The body is awake but the mind is not.

Meditation

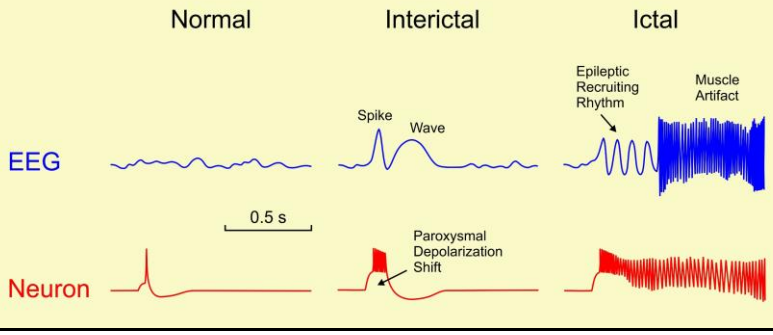
During meditation, the amount of EEG alpha activity decreases and the amount of theta activity increases. The EEG thus becomes similar to that recorded in N1 sleep. Perhaps the subject enters the state of withdrawal characteristic of sleep without losing either consciousness or muscle tone. States of mind have many dimensions; with practice these can be dissociated. Instead of the diffuse floating sensations that occur with falling asleep, the meditating mind becomes sharply aware of the world but undisturbed by it.

Luohan, Glazed Earthenware
China, 11th-12th Century CE

Meditation is a technique that alters the state of consciousness.

Epilepsy

Neurons in an area that is epileptic undergo spontaneous "paroxysmal depolarization shifts," with a brief burst of discharges. This may be recorded in the scalp-EEG as a spike. If normal inhibitory connections are not working, this may go on to a sustained discharge and cause a seizure.

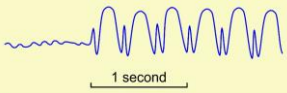


Epilepsy is a paroxysmal disorder of consciousness. The disorder may or may not be associated with motor convulsions.
In animals with epilepsy, the characteristic finding is a sudden sustained depolarization of the neuronal membrane – the "paroxysmal depolarization shift (PDS)."
What causes these shifts is not known. Perhaps some genetic abnormality of the neuronal membrane, the effects of scar tissue, the formation of unusual synapses?
The epileptic fit occurs when the PDS in one area recruits other areas of the brain and the generalized activity becomes self-sustaining for a period of time until the discharging neurons become metabolically exhausted.

Classification of Seizures

Generalized

Convulsive:	grand mal/tonic-clonic attack (others are myoclonic, tonic, atonic)
Non-convulsive:	petit mal/absence attack



Focal/Partial

Simple:	manifestations depend on location of seizure (initial discharge may be an "aura" preceding a generalized seizure)
Complex:	if discharge involves frontal or temporal lobes, behavior may be automatic and repetitive, and patient is confused rather than completely unconscious

The absence attack shows a characteristic EEG discharge – 3/s spike and wave discharges. This pattern may indicate that the seizure is sufficient to disrupt consciousness (spikes) but is stopped from proceeding to a motor seizure (convulsion) by inhibitory mechanisms (waves).

The presentation of simple focal seizures varies with where in the cortex the seizure begins. For example, foci in the postcentral gyrus may cause numbness and tingling of the opposite hand, foci in the precentral gyrus may cause twitching in that hand.
When the focus is in the temporal or prefrontal regions, the presentation is "complex"

This video shows a partial complex seizure with a source in the temporal lobe. The patient is confused but not completely unconscious and shows lip-smacking movements (perhaps from activation of the adjacent regions of the insula and motor cortex.
https://www.youtube.com/watch?v=arkq8DtyI8M

Unconsciousness

Coma: The patient is unconscious and unresponsive to sensory stimulation. This is caused either by generalized malfunction of the cerebral cortex or by interference with the brainstem arousal systems. Severe **metabolic abnormalities** cause coma by their generalized effect on neurons. Coma can be pharmacologically induced in **anesthesia**. **Head injury** can cause coma by shearing damage to the axons – "diffuse axonal injury."

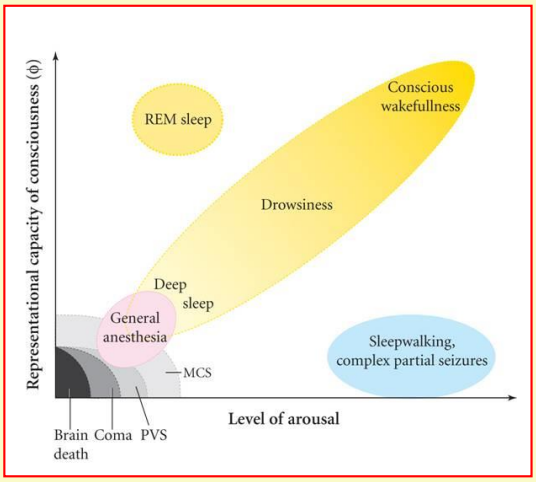
Persistent Vegetative State: If a patient remains in coma for a period of weeks, the sleep-wake rhythms may slowly return. The patient may sometimes appear awake, although they still do not show any clear response to stimulation. As time progresses, the patient may even become slightly responsive – a "minimally conscious state."

Brain Death: The patient shows no evidence of any brain function. There are no brainstem reflexes (pupils, eye-movements, gag, etc.). Most importantly, the patient is unable to breathe without assistance.

We are normally unconscious during much of sleep. Unconsciousness can be pharmacologically induced by anesthesia. This slide categorizes the abnormal states of unconsciousness that occur following brain damage or dysfunction.

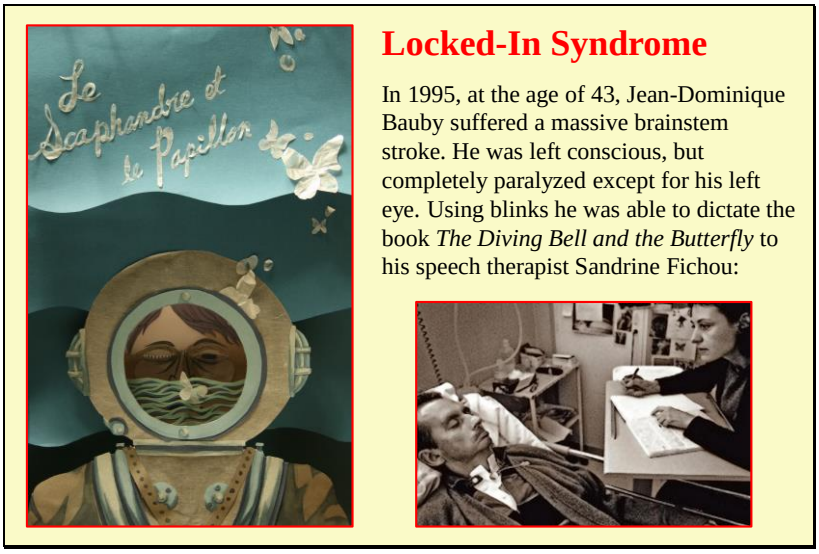
Brain death is diagnosed in Canada by withdrawing the patient from the respirator, and seeing whether the patient can start to breathe spontaneously – the apnea test.
In the persistent vegetative state, the patient is able to maintain breathing without a respirator. This state is very difficult to handle – the patient is not dead but there is usually little hope for any return to normal cognitive function. The issue for the family and the physicians is what should one do?

Dimensions of Consciousness



Florian Mormann & Christof Koch
Scholarpedia
2007

This graph attempts to map the different states of consciousness.
The y-axis denotes the level of cognitive processing.
The x-axis shows the level of bodily arousal.



The graph in the previous slide did not plot the "locked-in syndrome." This is what happened to Jean-Dominique Bauby. The French *scaphandre* is a "diving suit" rather than a "diving bell," but the latter sounds better in English.

Although the patient is separated from his body – unable to feel and unable to move – he cycles through sleep and wakefulness and is fully conscious when he is awake.
If there is some residual motor control – of the eyes – the patient can communicate.
One particular problem raised by this disorder concerns how many patients with Persistent Vegetative State are actually "fully" locked-in? And how can one tell? Recently neurologists have been using brain scans to see if these patients can respond.

This clip from the movie by Julian Schnabel portrays the solitude of the locked-in patient. The waves go on and on but the patient in the wheel chair is by himself and cannot communicate. Jean-Dominique liked jazz – the background music.

Quiz 6A

1. Slow wave sleep is

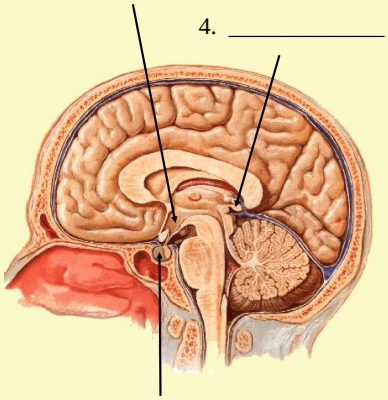
A) full of rapid eye movements
B) more abundant in the elderly than in children
C) more abundant in the first half of sleep than in the second half
D) characterized by vivid dreams

2. In brain death

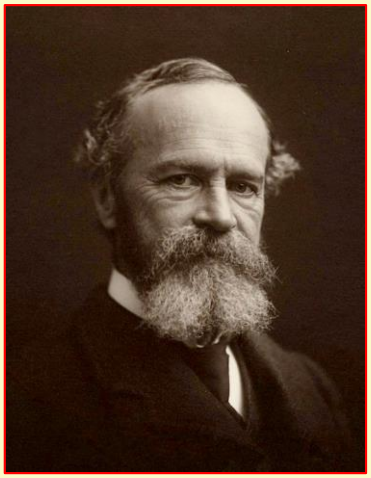
A) the pupils do not react to light
B) the eyes spontaneously wander
C) the patient can breathe without assistance
D) the patient responds to loud sounds

3. _____

4. _____



5. _____



Photograph 1903

William James (1842-1910)

1) Every thought tends to be part of a personal consciousness.

2) Within each personal consciousness thought is always changing.

3) Within each personal consciousness thought is sensibly continuous.

4) It always appears to deal with objects independent of itself.

5) It is interested in some parts of these objects to the exclusion of others, and welcomes or rejects – chooses from among them, in a word – all the while.

The Principles of Psychology, 1890
Chapter IX: The Stream of Thought

Now we move from the idea of arousal – how it works and how it can be disrupted - to what is going on in the consciousness of an awake human being – the stream of thought.
William James characterized our waking consciousness as personal, changing, continuous, independent and selective. William James was the older brother of the novelist Henry James.

Mind and Brain

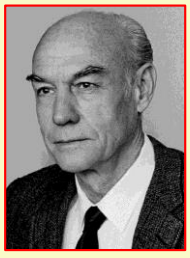
MIND, n. A mysterious form of matter secreted by the brain. Its chief activity consists in the endeavour to ascertain its own nature, the futility of the attempt being due to the fact that it has nothing but itself to know itself with (Ambrose Bierce, *The Devil's Dictionary*, 1911).

Dualism: Mind and brain are two separate kinds. God knows how they communicate. (e.g. René Descartes, 1596-1650)

Idealism: All that exists are ideas. The "real" world is just an illusion (e.g. Bishop George Berkeley, 1685-1753).

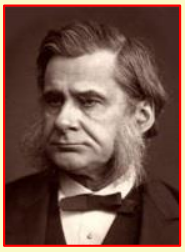
How consciousness occurs – how mind is manifest in brain – is a matter of great philosophical debate.

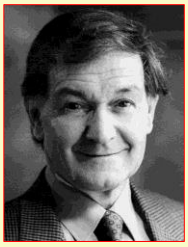
Mind and Brain



Emergentism: Consciousness is an emergent property of particular patterns of neuronal activity. (e.g. Roger Sperry, 1913-1994)

Materialism: Consciousness is an epiphenomenon with no causal connection with matter. (e.g. Thomas Huxley, 1825-1895)



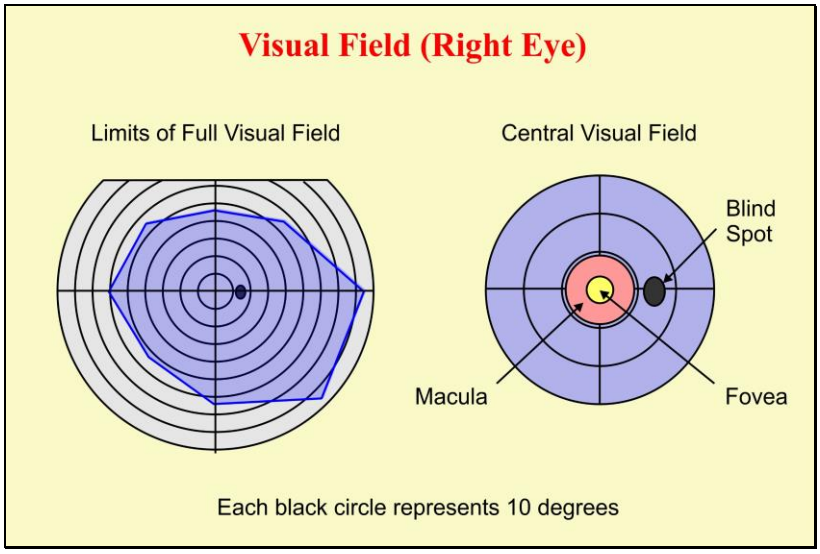


Quantum uncertainty: Consciousness is a result of quantum processes in neuronal microtubules in the human brain. (e.g. Roger Penrose, 1931-)

So which approach is true?
How should we understand our consciousness?

This is a clip from the movie *The Matrix*.
Keanu Reeves plays the character Neo who has come to believe that there may be more to the world that what he is being told.
Lawrence Fishburne plays Morpheus. He tells Neo that he can take the blue pill and accept what he is told or take the red pill and try to figure out what is really happening.
The full scene is on YouTube:
https://www.youtube.com/watch?v=3VFDIKgm_QI

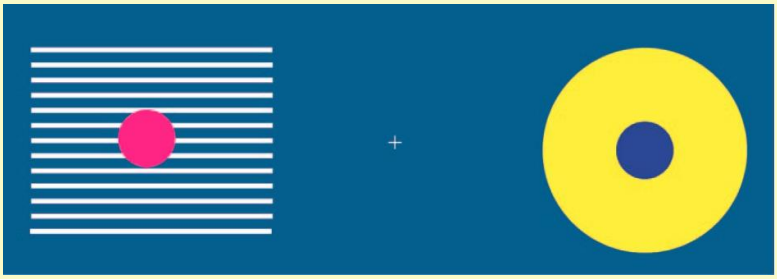
My suggestion is that you should not accept a completely materialist or a completely idealist interpretation of reality. Bishop Berkeley and Thomas Huxley took the blue pill. I suggest that you take the red pill and , to quote Morpheus, "see how deep the rabbit-hole goes."



Now that we are in wonderland, perhaps we should begin with something very, very simple.

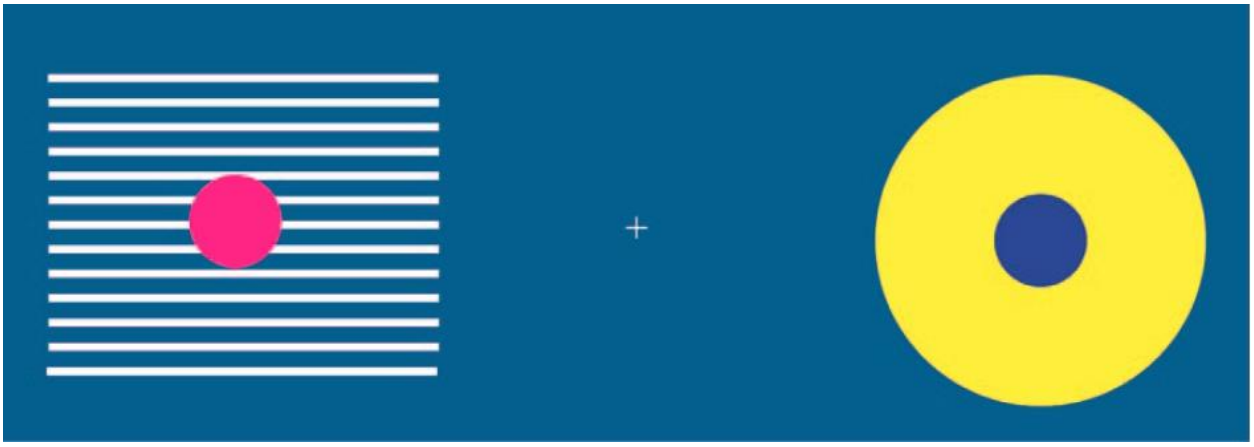
This is the visual field of the right eye.
When you look at the world through the right eye, you do not see the blind spot.
This is about 12-15 degrees from the midline. We cannot see anything in this area of the retina.
But there is no emptiness there. Our vision is full – there is no hole.

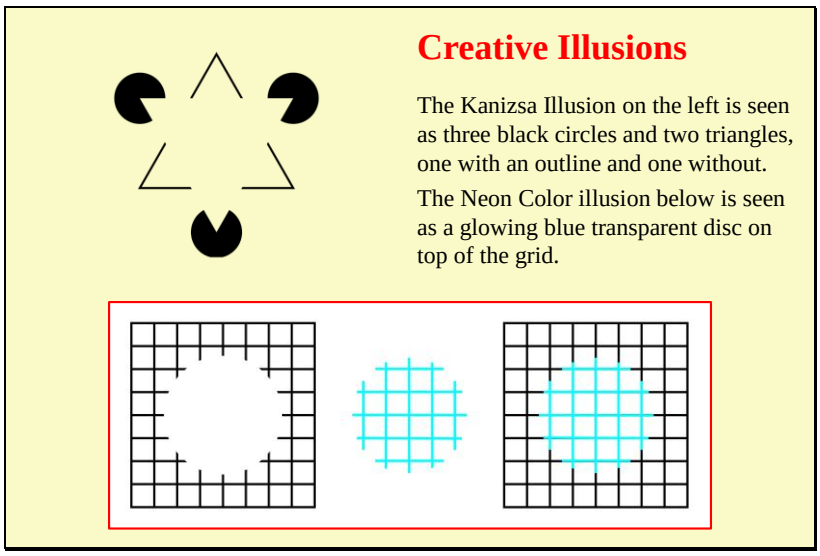
Filling in the Physiological Blind Spot



Close the left eye and fixate on the white cross. Adjust the distance from the eye so that the small blue disc on the right is in the blind spot. Not only does the disc disappear, where it was is "filled in." You see a large all-yellow disc. When you close the right eye and open the left eye, you see a set of continuous white stripes and no pink disc..

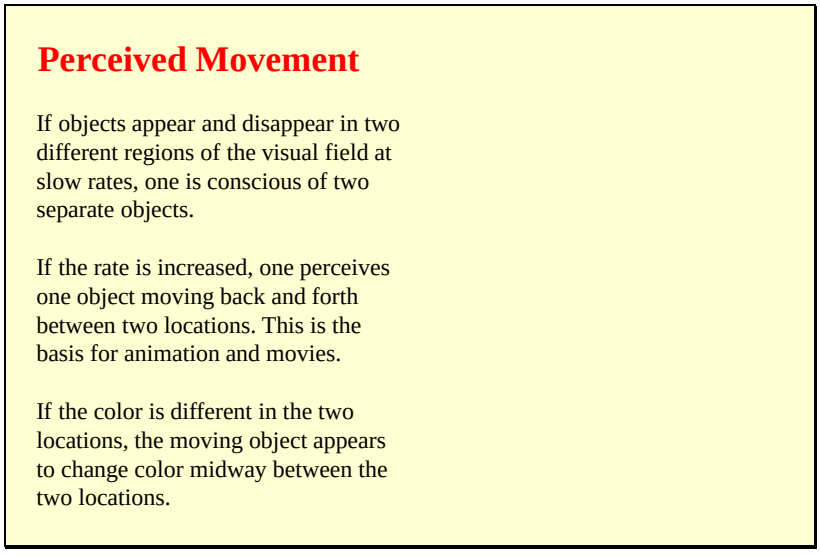
This demonstration will only work in the lecture room for some of you. Stare at the white cross with the right eye and see if you can make the blue disc on the right disappear.
In the notes for this session, this will happen if you hold the large illustration (below) about 4 or 5 inches away from your eyes.
This filling-in of the blind spot indicates that the brain perceives the world to be as it should be on the basis of what we see, and not necessarily as it is.
However, filling-in is more often correct than not. The real world usually does not have something strange at the location of our visual blind spot.





Illusions often play on how the mind interprets the world as it should be rather than as it is. Art and magic work similarly because the mind can be convinced that something is there that is not there.

Watch as I throw my invisible ball into a paper bag.
Perceiving an invisible ball explains the sound that you hear and the movement of the bag. Without the hypothesis of an invisible ball we have no other (visible) explanation for what occurred. Our consciousness tries to make sense of the world. Most of the time it is correct.



Perceived movement is the basis of the movies.
We perceive movement when an object disappears from one location and reappears soon after at another location.

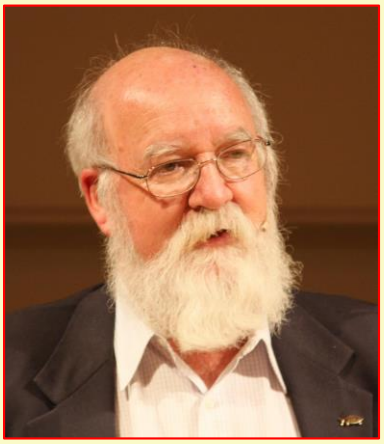
If the time between disappearance and reappearance is long we perceive two objects appearing and disappearing.
If the time shortens we perceive one object moving back and forth.
If there are different colors, it makes sense to perceive the object as changing its color as it moves. You can even imagine when they change color.

The animations are available on the webpage
http://creatureandcreator.ca/?page_id=1068

Multiple Drafts

Daniel Dennett has proposed that consciousness involves the brain making multiple interpretations of the information that is a available to it. As more information arrives, the brain may discard inappropriate interpretations. The contents of consciousness are under "continual editorial revision."

At higher levels, the brain constructs a personal narrative to link together the events of our lives. This is also continually revised. We are all "virtuoso novelists."



Daniel Dennett, 2008

These findings – filling-in, visual illusions, perceived motion – indicate that conscious perception actively interprets what is happening in the world to cause our sensations. We try to make the best sense out of what we see.

Dan Dennett has proposed that consciousness involves an ongoing interpretation of what is happening. We make multiple drafts to explain our experience.

What we are conscious of at any one time is our best attempt to explain the information that we are receiving through the senses – the current draft.

Cocktail Party

We can listen to one conversation at a cocktail party and ignore others. This is easier if the attended conversation is coming from a particular location, and if the voice is distinctive or well known.

However, the "unattended" conversations are not completely blocked. For example, our name will draw our attention even if we are not attending to the person who says it. Or if someone asks "Are you listening to me?" our attention is drawn back to the person to whom we are supposed to be listening.

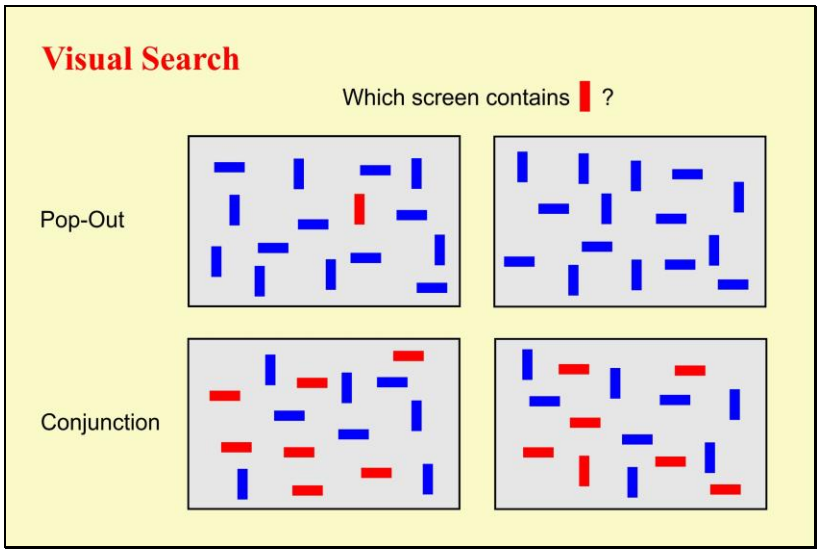
As we get older, the ability to attend to one conversation among others is reduced. This is related both to a deterioration in our hearing and to our reduced cognitive capacity.

Now we turn to the process in our consciousness that selects what we perceive – attention. The cocktail party provides an example of attention at work – we can follow one conversation and ignore others.

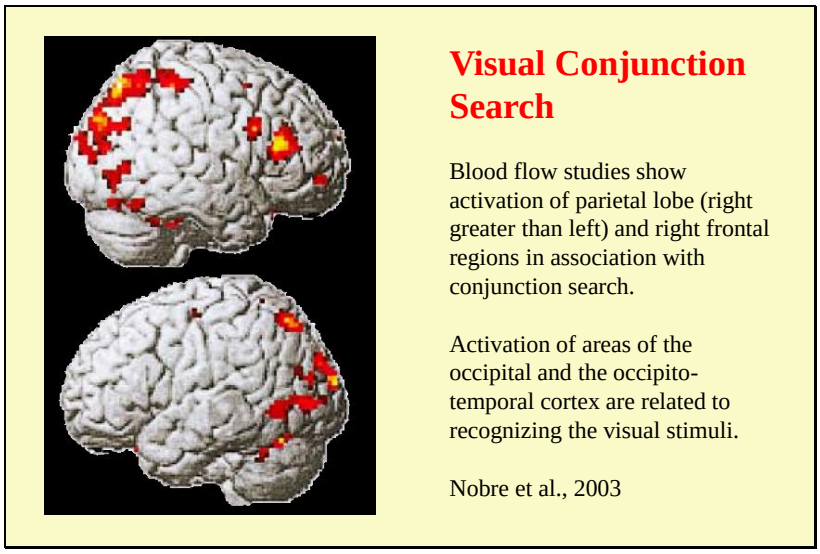
This illustration of the cocktail party was made by the magician Mark Mittman.
You can listen to only one conversation at a time. Listening is helped by paying close visual attention to the face. This allows some amount of lip-reading and using other physical cues to follow the conversation. The conversation on the right is easier to follow – perhaps because it is a little louder.

If you find it difficult to follow, you are not alone. Selective attention of this kind gets much worse as you get older. Part of this is due to a deterioration in hearing. Part is due to a decreased ability to maintain focus.
The video is available at
https://www.youtube.com/watch?v=mN--nV61gDo

As a magician, Mark Mittman knows that you can only attend to one thing at a time. This is used in magic. The magician distracts you away from what is happening – misdirection.
A video is available on the web showing a 1-hr presentation by Mark Mittman about consciousness, attention, causal inference, deception and magic:
http://bestplay.pk/watch/h2ZJ47l0jlY

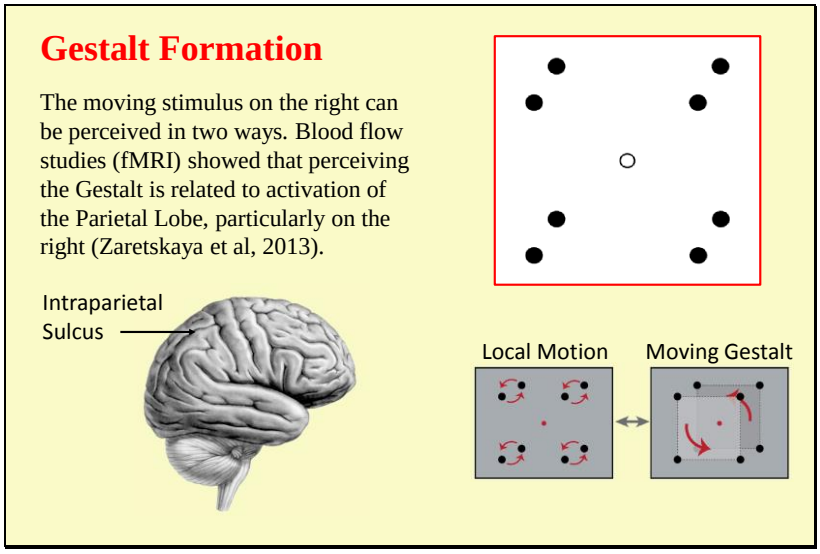


During visual attention some stimuli are easy to detect – they 'pop out.'
Stimuli that combine different features such as color and shape take much longer to detect. They require visual search. Where is the upright red rectangle in the lower stimulus sets is very difficult - a little like *Where's Waldo?*

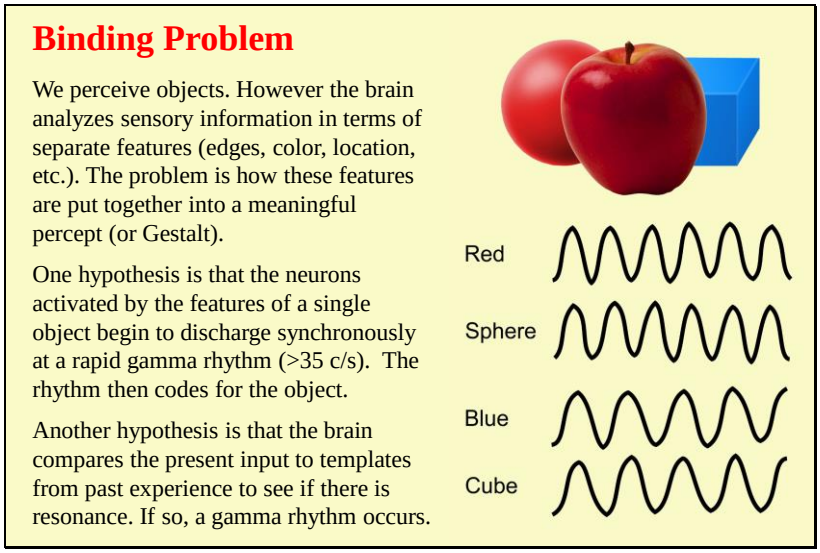


Visual search (finding the target in the conjunction-search experiment illustrated at the bottom of the preceding slide) activates regions of the parietal cortex – especially on the right. This part of the brain is important for spatial attention. It is in the same region that we considered last week

when we discussed the "where" system. But it is quite asymmetrical – the right hemisphere controls general spatial attention.
The inferior occipital and temporal regions are involved in detecting exactly "what" the stimuli are – these regions are activated bilaterally

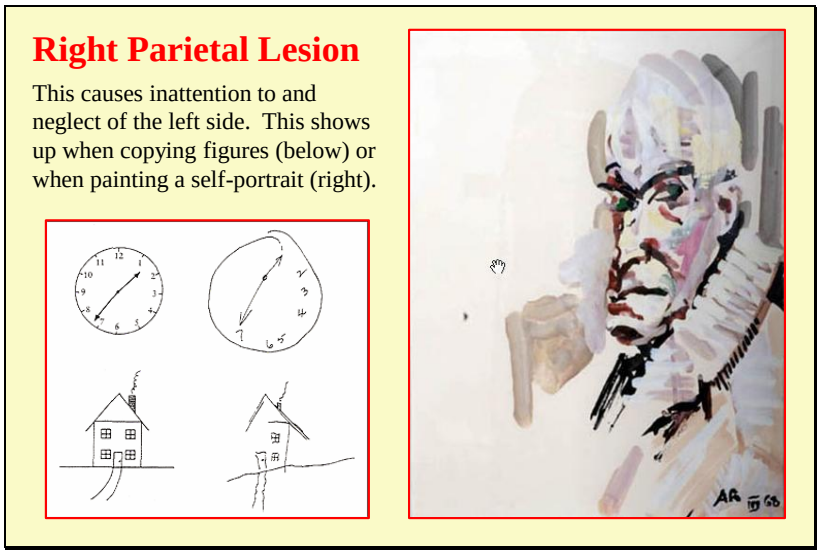


The intraparietal sulcus in the right parietal lobe is involved in putting stimuli together to form objects or Gestalts.
The animation is available on the webpage
http://creatureandcreator.ca/?page_id=1068



How the brain puts together different kinds of sensory information to make up the objects that we perceive is the Binding Problem.
EEG gamma rhythms are somehow involved in binding together sensory data to make perceptual objects, but exactly how is not known.
How does one distinguish the red sphere that is an apple from the red sphere that is a ball?

Next time you are at a loss for conversation at a cocktail party, you can ask about the binding problem ☺ .



An intriguing syndrome that occurs with right parietal lesions is “Inattention” or “Neglect” The patient ignores the left side.

This video demonstrates how attention can be focused.
You must pay very close attention to the white team and count how many times they pass the ball. They will move around and so it is not easy to keep count. Pay close attention!

The monkey business illusion is the work of Daniel Simon, who also has a book *The Invisible Gorilla.* The video is available at
https://www.youtube.com/watch?v=IGQmdoK_ZfY

The main lesson is that we often do not perceive what we are not attending to.
The problem with talking on the telephone when we are driving is that we are completely unaware of much that is going on and we do not even know that we are unaware.

Theory of Mind

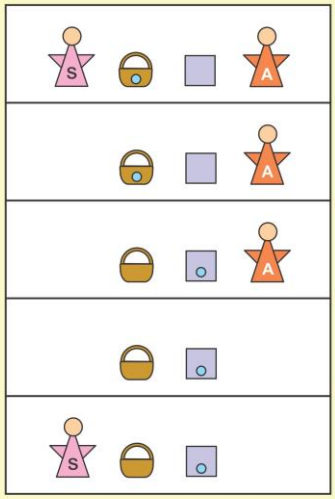
Individuals have a "theory of mind" if they impute mental states, such as awareness or intentions, to others. The idea was initially considered when David Premack and Guy Woodridge were studying the cognitive abilities of chimpanzees (1978).

Children arrive at a theory of mind at the same time as they are developing a sense of self.

One way to assess this is to see whether someone understands what someone else knows and correctly identifies the "false beliefs" of others: the Sally-Anne test

David Premack (1925-2015)

The next section of this presentation will deal with self-consciousness.
Our sense of self – the understanding that we have a mind – develops at about the same time as we recognize that other people have minds as well.



Sally puts her marble in the basket.

Sally leaves

Anne transfers the marble from the basket to the box

Anne leaves

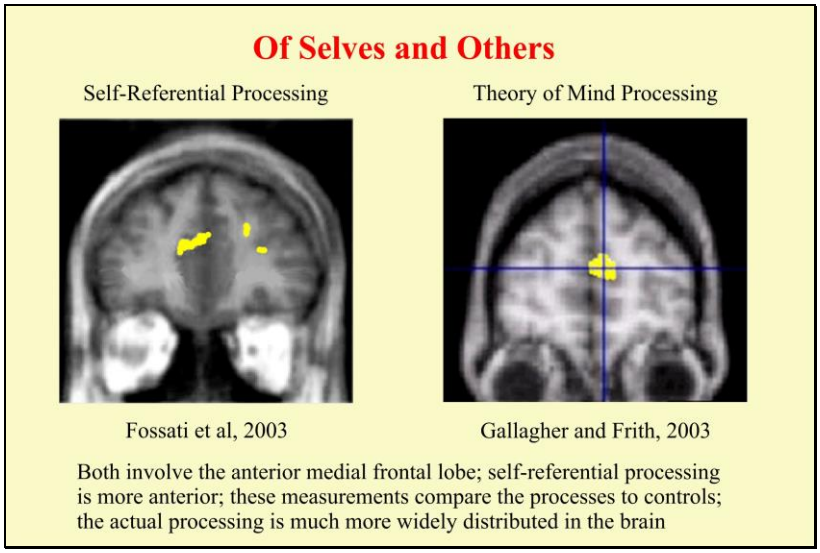
Sally returns. "Where will she look for her marble?"

This is the Sally Anne test for whether someone has a theory of mind – whether they can understand what is in the mind of another person.

Initially the test was performed with puppets. The actions are performed and then the person watching is asked where Sally would look for her marble.

Someone with a theory of mind will understand that Sally will look for her marble in the basket because she does not know that Anne has moved it to the box. Someone without a theory of mind will say that Sally will look in the box because that is where the marble is. Such a person will have no idea what is in Sally's mind.

Chimpanzees have only a rudimentary theory of mind and do not recognize Sally's false belief.
Normal human children develop a theory of mind after age 3-4 years.
Autistic children have difficulty on theory-of-mind testing – they may suffer "mind-blindness"

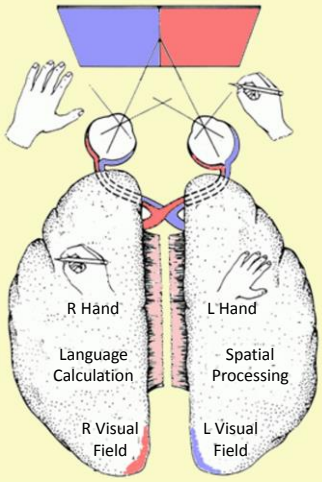


The right side of this illustration shows the regions of the brain that are active when someone is figuring out a theory of mind problem – trying to determine what someone else is doing. The medial surface of the anterior frontal lobe (just above the eyes) is specifically active.
As shown on the left, a similar region is active when one is considering something in reference to oneself.
The anterior region of the frontal lobe is important to perceiving both one's self and the selves of others.

Split-Brain Patients

In the 1960s, Roger Sperry and Michael Gazzaniga studied the mental abilities of patients in whom the corpus callosum had been sectioned to prevent the spread of epileptic discharges. In many respects the patients acted as though there were "two separate spheres of consciousness."

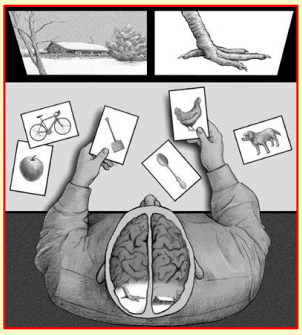
Information could be specifically provided to one hemisphere through the contralateral visual field. Language was only present in the left hemisphere.



William James proposed that our stream of thought is "unitary."
Studies of "split-brain" patients have contributed a great deal to our understanding of consciousness. They raise the possibility that each cerebral hemisphere may be separately conscious.
Because the left visual field goes only to the right hemisphere and vice versa, information can be specifically provided to only one hemisphere.
Since each hemisphere controls the contralateral hand but not the ipsilateral hand, what each hemisphere perceives can be tracked using the hands.
Language is only present in the left hemisphere – this leads to some intriguing results.

The Interpreter

When presented with a chicken claw on the right and a snow scene on the left, the split-brain patient picked drawings of a chicken and a shovel, verbally explaining, "The chicken claw goes with the chicken, and you need a shovel to clean out the chicken shed." The subject's right hemisphere had actually picked the shovel because it went with the snow-scene that had been shown on the left side.

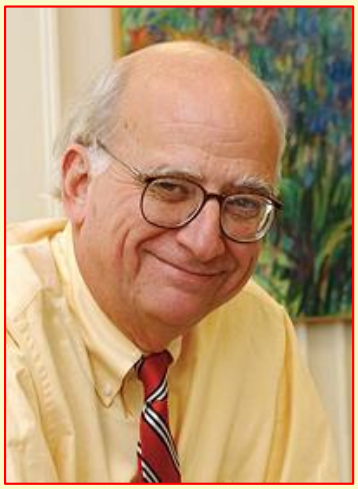


However, only the left hemisphere, which had not seen the snow-scene, could give a verbal response. It had observed the response of the left hand (controlled by the right hemisphere but visible to the left), and had interpreted this response in a context consistent with its (hemi)sphere of knowledge, in terms of the right-sided chicken rather than the left-sided snow scene.

The stimuli are presented briefly when the subject is looking at the center of the screen. (If the subject could move his eyes, he could put both stimuli into both hemispheres.)

When the patient looks at the responses of his hands – his eyes are free to move. Thus his left hemisphere can see the response of the left hand (even though this hemisphere had not seen the stimulus that initiated it).

The left hemisphere is mistaken – it has interpreted what happened incorrectly. Nevertheless it has come up with a plausible interpretation of what happened.



Hemispheric Asymmetries

The right hemisphere maintains an accurate record of events, leaving the left hemisphere free to evaluate and make inferences about the material presented. In an intact brain, the two systems complement each other, allowing elaborative processing without sacrificing veracity.

Michael Gazzaniga, 2008

Michael Gazzaniga has proposed that the left hemisphere acts as an imaginative interpreter of what is going on.
In the normal subject, both hemispheres work together. The left proposes an explanation and the right makes sure that it fits with the sensory information.

Quiz 6B

1. The physiological blind spot is caused by

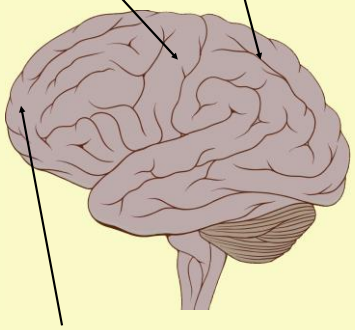
A) pupils that do not react to light
B) no receptors over the optic disc
C) retinal blood vessels
D) prolonged pressure on the eye

2. When a picture is presented to the left visual field of a split-brain subject

A) he can name the picture
B) he can identify a corresponding object with the left hand
C) he can identify a corresponding object with the right hand
D) he can see nothing

3. Motor Cortex for _____

4. _____ Sulcus



5. _____

Hic Anima Est

Consciousness is a particular pattern of neuronal activity. This pattern occurs when the cerebral cortex has been activated by brainstem and thalamic reticular systems to process information in a manner that relates present experience to past memory and makes predictions for the future. The pattern is necessarily distributed across multiple areas of cortex and characterized by intense communication between these areas.

Robert Fludd
1619

So we come to the end of our discussion of consciousness.

It is a special kind of cerebral activity that compares what is happening to what we predict should be happening on the basis of what we have learned so far. It is based upon a complex, widespread, intense interaction between many cerebral neurons.

The diagram is from Robert Fludd (not the quotation – that is pure Picton). He shows various processes in the brain – sensation, imagination, reason, memory. The soul is located in all of these processes – *hic anima est*.