Memory and Emotion

Lulu Durand, 2012

… those short, plump little cakes called 'petites madeleines,' which look as though they had been moulded in the fluted scallop of a pilgrim's shell. … I raised to my lips a spoonful of the tea in which I had soaked a morsel of the cake. No sooner had the warm liquid, and the crumbs with it, touched my palate than a shudder ran through my whole body, and I stopped, intent upon the extraordinary changes that were taking place. An exquisite pleasure had invaded my senses but individual, detached, with no suggestion of its origin (Marcel Proust, *In Search of Lost Time*, 1913)

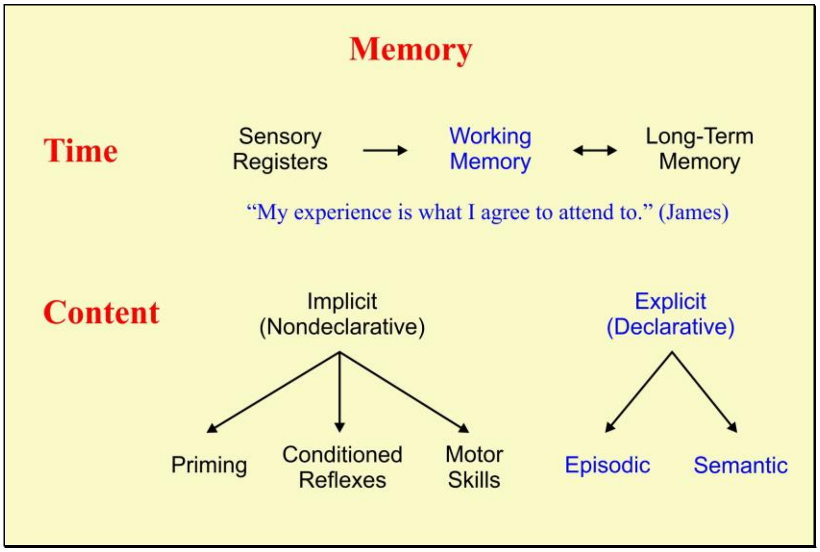
René Depasse

This is the famous quotation about memory by Marcel Proust.
It describes how the past can be re-experienced.
How little sensory triggers can bring forth memories.
How these memories are at first indistinct and mysterious and only later become clear.
How emotions form the glue that ties memories together.

Where to get madeleines in Toronto?
Try Madeleines bespoke pastry
http://www.madeleines.ca/

For green-tea madeleines – Uncle Tetsu's at Bay and Dundas.

Last week we discussed consciousness.
Consciousness is closely related to memory. Consciousness interprets what is happening.
Memory allows consciousness to interpret what we experience in terms of what occurred in the past.



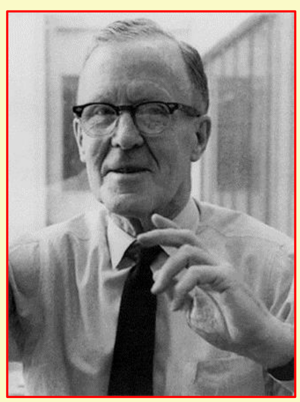
We can consider memory from two different viewpoints – time and content. In terms of time, information comes into our mind/brain through the sensory registers. Consciousness occurs in working memory. Long term memory receives new memories from working memory and allows working memory access to past experience in order to interpret what is happening in the present.

In terms of content, memories are either accessible to consciousness (explicit) or not (implicit). The only way we can demonstrate that a memory is explicit is to describe it – thus the term declarative.

We shall begin with implicit memories:

Neuronal Cell Assemblies

In his 1949 book *The Organization of Behavior,* Donald Hebb proposed that perception and memory are based on groups of neurons that activate each other through reverberatory circuits. When neurons are synchronously activated, some metabolic or structural change occurs in their synapses to facilitate and preserve the connections between them ("neurons that fire together wire together"). They could thus serve as memory engrams – activation of one neuron will automatically activate the other neurons in the cell assembly.

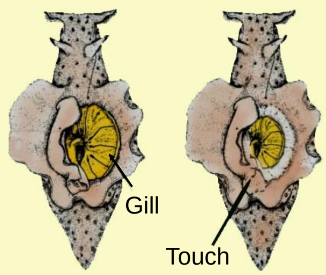


Donald Hebb (1904-1985)

Donald Hebb was Professor of Psychology at McGill University.

Aplysia (lateral view):

Gill Withdrawal Reflex:



Simple Learning System

When the nearby skin is touched, the gill withdraws. This reflex is controlled by neurons in the abdominal ganglion.

With repeated touching the reflex **habituates**. The reflex can be **sensitized** by shocking the tail. The withdrawal can also be **conditioned** to occur following a shock if the shock is repeatedly presented just before the touch.

Eric Kandel received the Nobel Prize in 2000 for studying the synaptic mechanisms of these changes.

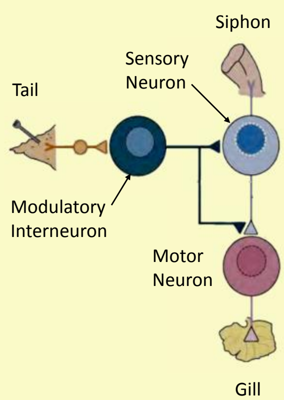
The Aplysia is a sea slug. This rather ugly animal has contributed a great deal to our understanding of learning. The main experimental preparation is the gill withdrawal reflex.

Habituation is a very simple form of learning. With repeated stimulation, the animal learns that a stimulus has no meaning.

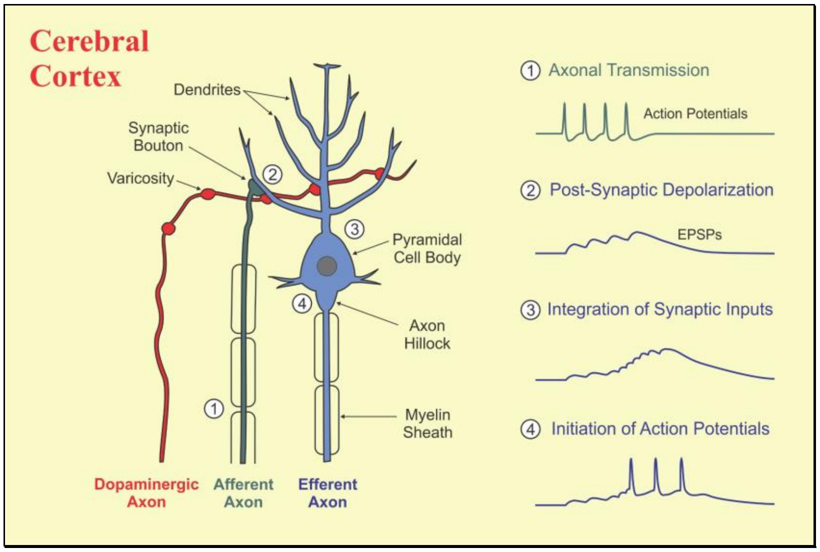
Synaptic Plasticity

Habituation, sensitization and conditioning of the gill withdrawal reflex are meditated through interneurons which alter the effectiveness of the synapse between the sensory and motor neurons. In the Aplysia, these interneurons use serotonin as a transmitter.

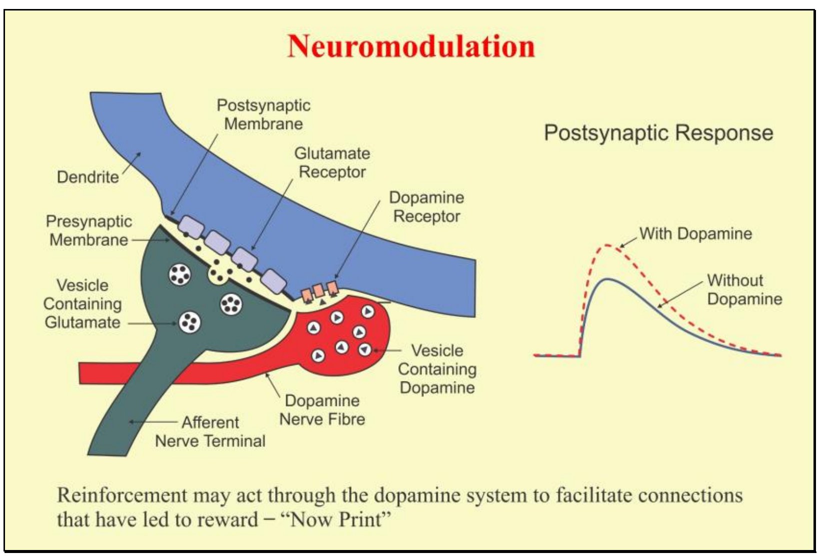
The modulatory interneuron acts both pre- and post-synaptically. In the short-term it causes greater (or lesser) release of neurotransmitter at the synapse. In the medium term it can increase (or decrease) the production of transmitter and receptors. In the long term it can cause more synapses to be made (or unused synapses to be pruned).



The same processes that occur in the Aplysia occur in the human brain. As well as serotonin, other modulatory transmitters involved in learning are dopamine and norepinephrine.



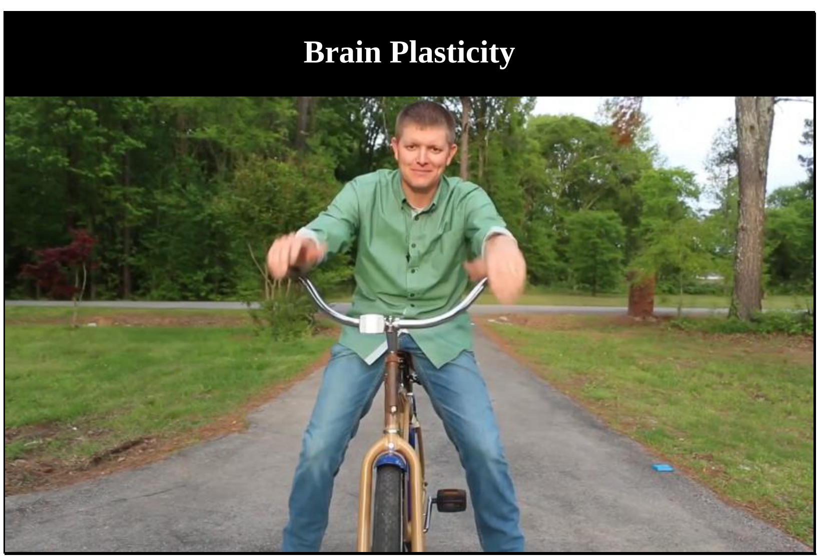
This slide illustrates some simple synaptic connections in the cerebral cortex. We have seen this slide before in the session on the synapse. Then we were concerned with how information comes into the cortex and actuates a response. This time we focus on the dopaminergic axon (red). Information comes to the cortex from the thalamus. This information is transferred to the pyramidal neuron, which then sends it on to other neurons.



This slide looks more closely at the synapse.
The afferent activity comes in and releases the excitatory transmitter glutamate.
How effective the glutamate is depends on the activity at the adjacent dopamine synapse. If dopamine is released at the same time, the postsynaptic response is greater (dashed red line)
In this way the dopamine system might reinforce synaptic activity, making the synapse more efficient.

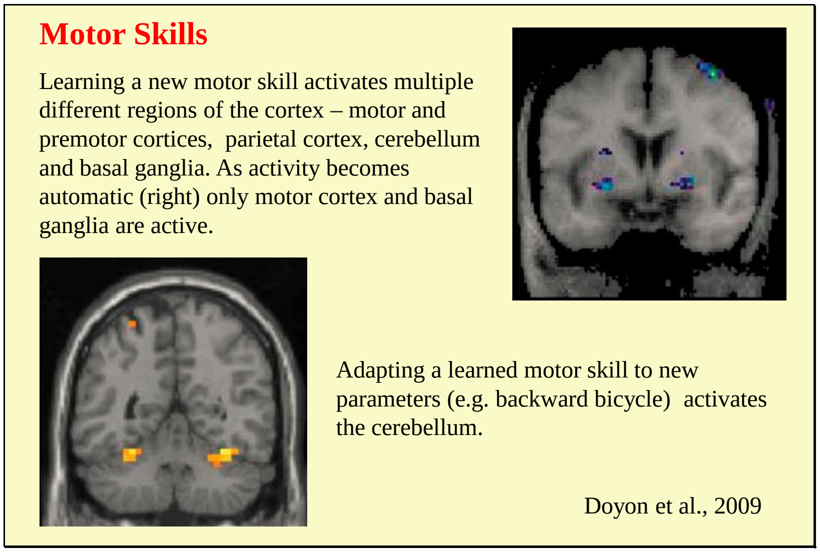
One old idea was that the dopamine system mediated a "Now Print!" process. The brain keeps trying to find the best way to respond. When it finally hits on the correct way to act, there is a feeling of great pleasure. This activates the dopamine system which reinforces the synapses that have been active during the successful behavior.

Now we can consider some of the simply learned activities such as riding a bike. These quickly become automatic. We cannot really describe what we are doing. When we learn these activities, we do so more by trial-and-error than by consciously thinking what we should do.
Automatic behaviors or habits are very efficient – they do not require much mental energy. But they are very difficult to change.
The backward bicycle video is available at
https://www.youtube.com/watch?v=MFzDaBzBlL0

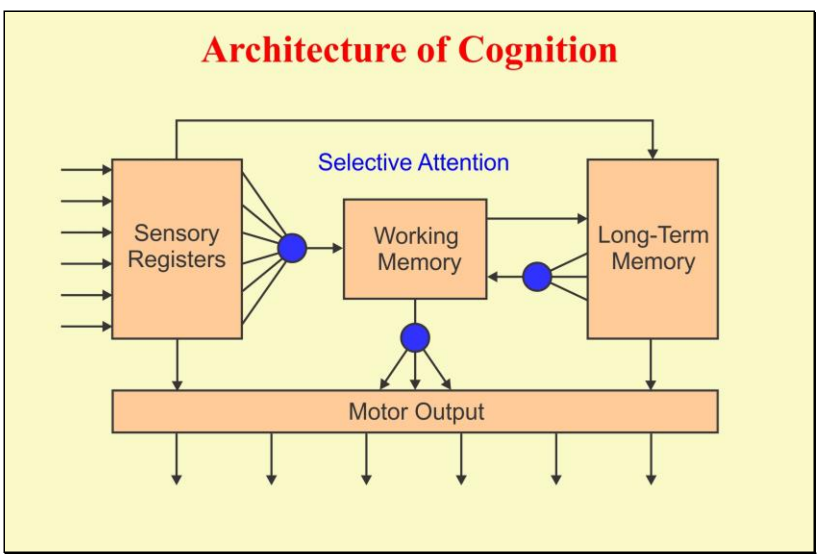


By dint of hard work, however, the brain can relearn how to do things. The neurons have to be re-wired – synapses have to change.

The ability to change our behavioral programs is called plasticity. As we grow older we become less and less plastic.
However, we need not be completely hidebound – we should try something new every day.



The brain scan at the upper right shows what happens as we learn a new motor skill.
Initially widespread regions of the brain are active. As the skill becomes learned it uses a few neurons in the motor cortex and the basal ganglia. The motor cortex initiates the behavior and the basal ganglia operate the programs.
The cerebellum is an important center for changing the programs (lower left).

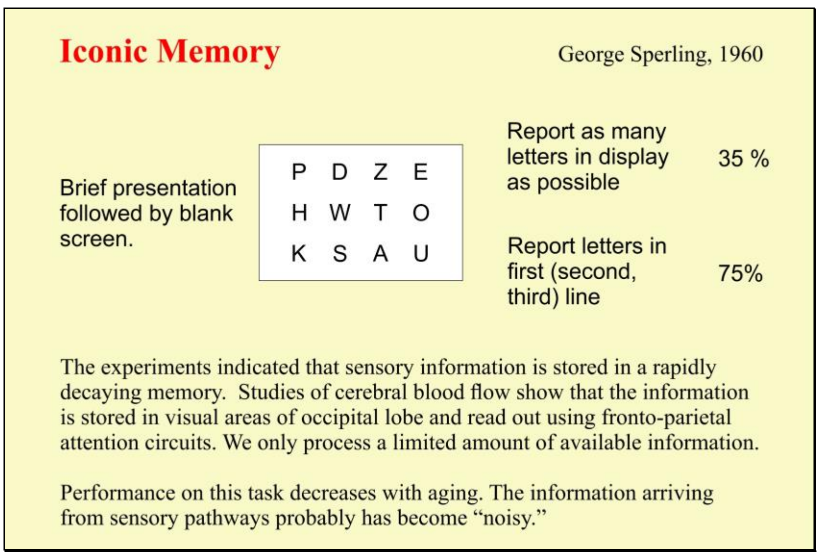


Having considered implicit memories – how we learn motor skills and automatic behavior – we can now look at how explicit memory works.

This diagram (previous page) shows the flow of information in the human brain/mind. Everything is much more inter-related than is suggested by the separate boxes, but it sometimes helps our understanding to look at things separately.

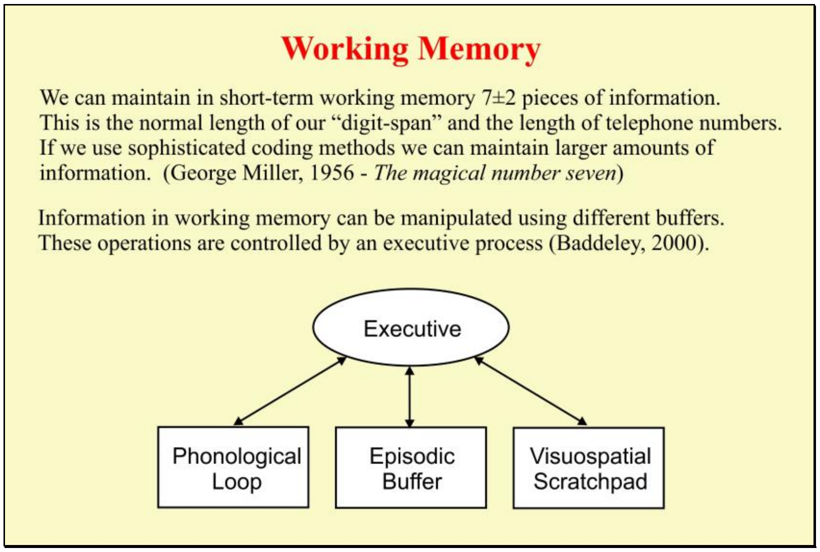
Information comes in via the senses and is stored in sensory registers.
Working memory is where consciousness operates.
Working memory can transfer information in and out of long term memory, and can initiate motor responses.

All of the transfers are under the control of selective attention.
Attention determines what we perceive and what we ignore, what we put into memory and what we remember, what actions we decide to respond with.



The large array of letters is briefly stored in a visual register called iconic memory.
If we try to read out all of the letters, most of them disappear before we get to them.
However, if after the presentation we are told to read out just one particular line, we are much more accurate – all the letters are there but only for a brief time.

In the auditory system, there is an analogous sensory register called echoic memory. This is the memory that allows you to read the paper while your spouse is talking. When he or she says, "You haven't been listening," simply say, "Oh yes, you were saying … " and fill in whatever words pop up from echoic memory.

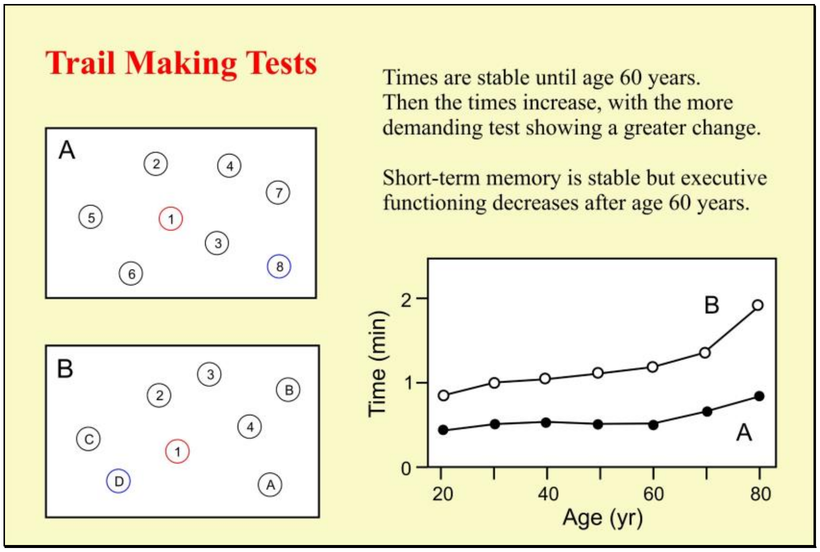


Information is read out of sensory registers into a working memory system.
This has limited capacity – about 7 separate pieces of information. The length of old-style telephone numbers.
This limited capacity makes us unable to attend to everything – we have to select only some inputs among all possible inputs.

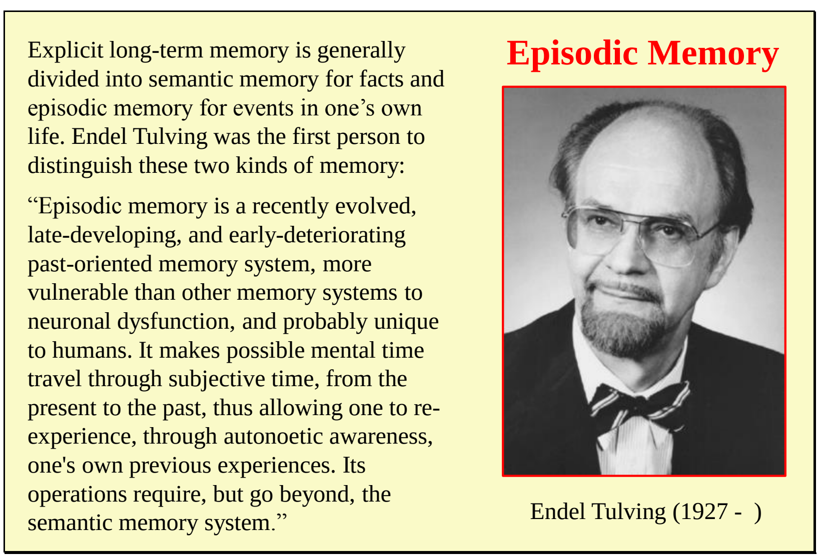
Working memory uses a variety of buffers to store information while it is operating. Alan Baddeley has proposed several buffers.
Another one might use somatosensory codes. This might be helpful in figuring out dance movements or athletic strategies.
Also, a musical buffer is likely separate from the phonological buffer.

The size of working memory can be assessed using the digit span. The normal young adult can recall 6 numbers forward and 5 numbers backward.
The digit span decreases with age. By 70 the average spans have decreased by 1. You can measure your own digit span at
http://www.cambridgebrainsciences.com/browse

(it is free but you will have to register)



The trail making test taps the processes of working memory rather than its size.
There are two kinds. In the first you draw a line to join up the numbers sequentially: 1 – 2 – 3 – 4, etc
In the second you alternate letters and numbers: 1 – A – 2 – B – 3 – C, etc.
To perform rapidly you have to see and keep in mind several numbers and letters. This is more complex in the B version.
As we get older we slow down. Some of this is just motor speed, but after 60 the slowing also involves the processing speed of working memory.



Now we move to long-term memory.
The most important conceptual advance in our understanding of long-term memory is the idea that there are two basic kinds: semantic memory for facts (What is the capital of France?) and episodic memory for one's personal experience (What did I have for breakfast this morning?).

When we recall facts they come back without any sense of personal involvement. We just "know" them.
When we recall episodes in our life they come back with a personal flavor – to some extent we re-experience them. We "remember" them.

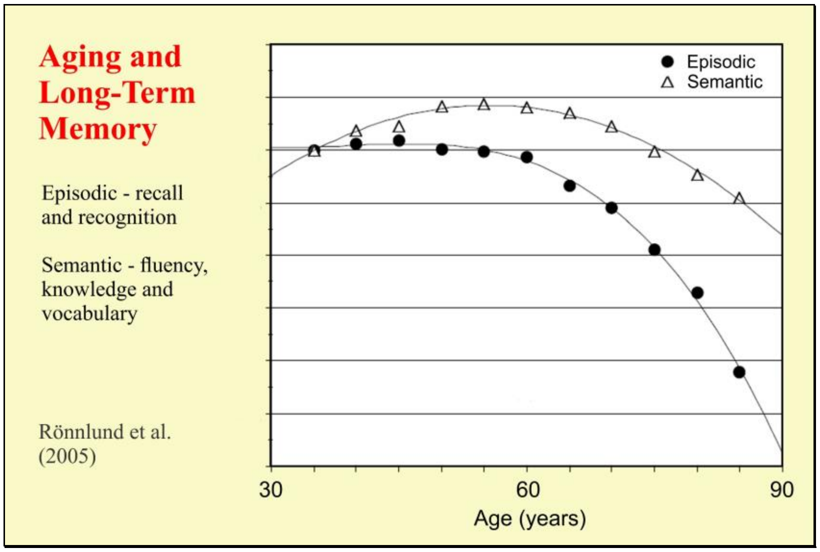
Autonoetic = self understanding

Endel Tulving has also proposed that episodic memory can also be directed to the future – we can imagine what we might be doing tomorrow. Mental time travel can go forward as well as backward.

Study these words. You will be tested later for your memory of them.

ASSASSIN
OCTOPUS
AVOCADO
MYSTERY
SHERIFF
ELEPHANT
CASHMERE
FLAMINGO
PENDULUM
OBELISK

A simple test of episodic memory is to remember a list of words.
After a period of time, you will be asked to recall as many words as possible.
You have thirty seconds to memorize the list. Your learning will be improved if you visualize what they represent, associate them with each other, tell yourself stories about them, etc. We remember what we process deeply. The concept of "depth of processing" comes from Gus Craik.



As you get older your performance on tests of episodic memory slowly decreases.
You recall fewer words from the list that you memorized. And you recall fewer episodes from your past – what was the name of that movie you saw a month ago?
Semantic knowledge increases with age. You know more words. You do better on crosswords at 70 than you did at 20.

The number of facts that we remember varies with the number we have learned and the number we have forgotten. After age 75 we start to forget more old stuff than we learn new stuff.

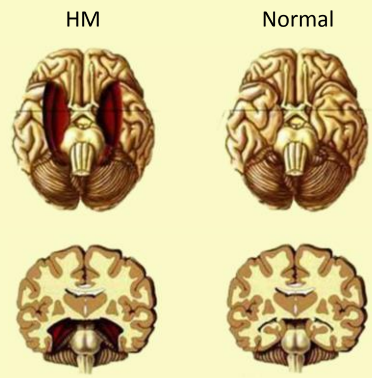
One of the problems with age is that we have difficulty maintaining our attention. We get distracted easily.
This may interfere with the laying down of new information. We remember things better if we focus our attention on them while we are trying to memorize them.

This video dramatizes the problem of "age-activated attention deficit disorder." The movie shows how distractibility prevents us from accomplishing things, as well as preventing us from laying down memories that can be easily recalled.
The full video is at
https://www.youtube.com/watch?v=6oHBG3ABUJU

HM

Henry Molaison
(1926-2008)

Patient HM suffered from severe epilepsy. In 1953, the medial halves of both his temporal lobes (including hippocampus and amygdala) were removed in an attempt to control his seizures.



Now we shall look as some of the disorders of memory – amnesia.
The most famous patient in neuropsychology is Henry Molaison – HM.
The neurosurgeon William Scoville removed both his medial temporal lobes in order to control his epileptic seizures.

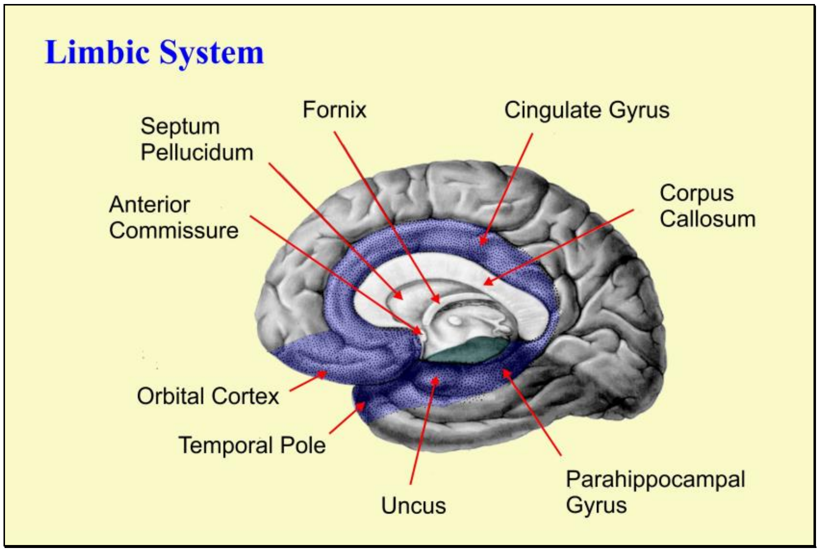
Pure Amnesia

Brenda Milner (1918 -)

After the operation, the Canadian neuropsychologist Brenda Milner found that HM was unable to form any new memories (anterograde amnesia) and had difficulty remembering past memories (retrograde amnesia) particularly for the three years preceding the operation.

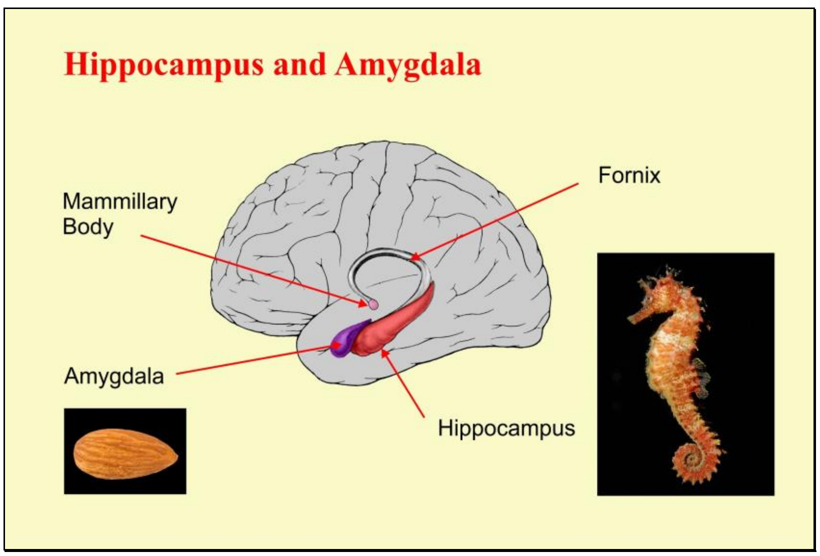
However, unlike other patients with amnesia, his other mental abilities were unaffected. His general IQ was 112. His language was normal. His forward digit span was 6.

After the surgery he was unable to make new memories – anterograde amnesia – and he only remembered some of his past – partial retrograde amnesia.
Brenda Milner – almost 98 years old – is still active at the Montreal Neurological Institute.



Two slides from the first presentation.

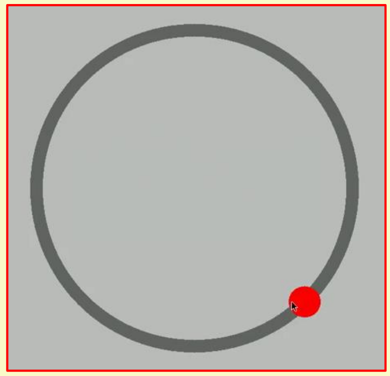
HM's surgery removed the hippocampus and parahippocampal gyrus in the limbic system. These areas are essential to the laying down of new memories and the recall of old memories.



The hippocampus projects to the mammillary body in the thalamus via the fornix. The mammillary body then projects to the thalamus and cortex.
The hippocampus is closely associated with the amygdala which is associated with emotion. This may account for the close relationship between memory and emotion. We remember most clearly those things in our lives that evoked great emotions – the birth of a child, the death of JFK, the events of 9/11.

Motor Skills

HM was able to learn a simple motor skill such as that needed in the Rotary Pursuit Test. During a week of exposure to the task his performance got progressively better over the first four days even though on each day he could not remember doing the test before. The improvement was maintained when he was tested again a week later.



Normal subjects performed better on the task than HM and continued to improve over more than four days.

Although HM could not remember what happened to him after the operation, he could learn a simple motor skill – such as keeping the cursor on a rotating disc.
This type of implicit learning is mediated by the basal ganglia and cerebellum and does not involve the hippocampus.

Complete these word fragments. Do the easier fragments first.

Priming occurs independently of whether the words were recognized as being on the study list and persists much longer than recognition memory.

Priming occurred normally in patient HM. It is mediated by the visual cortex in the occipital lobe.

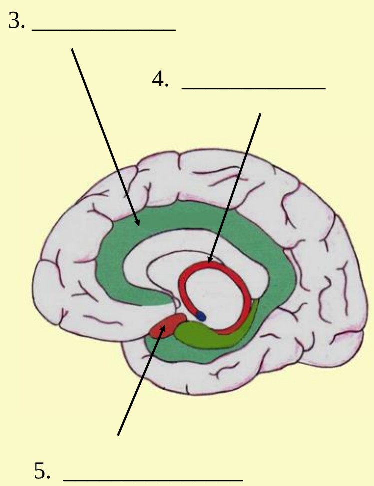
A__A__IN
O_T__US
_E_TUC_
_YS__RY
_UFF_A_
_L_P_A_T
_U_R_ET
MO_O___M
_G_O_T_C
OB__I_K

HM was also able to demonstrate "priming," another implicit memory process.
In this test you are asked to complete some word fragments.
Do as many as you can – do not get stuck on one, go on to the next. Write down which ones you can complete.
You will find that some of these are easier than the others – the red ones.
They are the ones that were in the list that you tried to memorize about fifteen minutes ago.

Quiz 7A

1. Amnesia is a
A) a large sea slug used for physiological studies of learning
B) an inability to recognize faces
C) an inability to understand speech
D) a loss of memory.

2. Normal working memory
A) can store about 7 pieces of information
B) is located in the occipital lobes
C) can store information for years
D) is not affected by aging

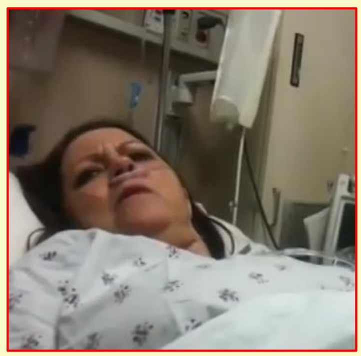


Transient Global Amnesia

The patient suffers from a complete inability to store new memories and has some difficulty recalling memories from the past few weeks. The patient is understandably confused but there are no other neurological symptoms.

The patient is typically between 55 and 75 years old. The attack lasts between 2 and 8 hours.

The patient often keeps asking the same question over and over again.



The etiology is unknown (perhaps some migraine or epileptic equivalent). Other disorders should be ruled out with a brain scan and EEG. Prognosis is good. The patient will not remember much about the attack.

Temporal lobe surgery is important for understanding how amnesia works, but it is an uncommon cause of amnesia.
We shall now turn to some more common amnestic syndromes.
The first is transient global amnesia. This presents with confusion and an inability to store new memories.
The characteristic repetition of the same question over and over again is like a broken recording. Other causes of confusion must be ruled out. Once the physician has made the diagnosis, there is no treatment.

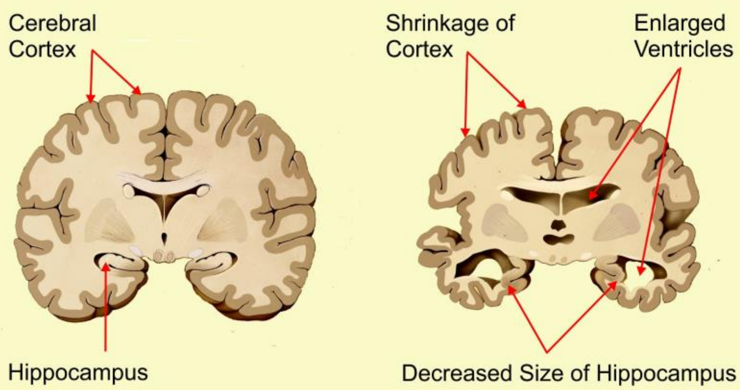
Characteristic hemorrhages in the mammillary bodies

Korsakoff's Psychosis

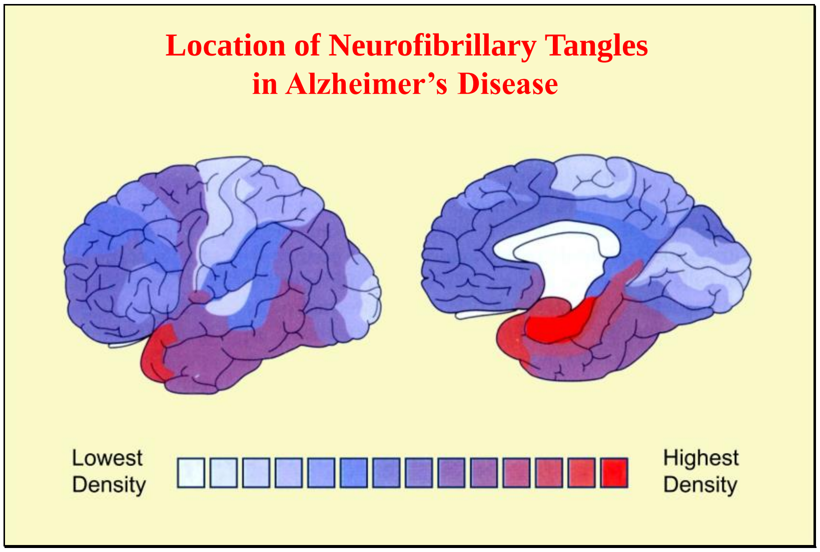
Alcoholism may cause acute thiamine (vitamin B1) deficiency. This can lead to hemorrhages in many different regions of the brain. The most commonly affected areas are the mammillary bodies. Damage to these causes acute amnesia. In the resultant Korsakoff's psychosis, amnesia is usually accompanied by **confabulation**. The patient fills in the memory gaps by inventing stories, some based on snippets of old memories and others wildly fanciful. Confabulation may be related to additional damage elsewhere in the brain, particularly in the frontal cortices.

The mammillary bodies are the main outflow connection of the hippocampi.

Normal Brain **Alzheimer's Disease**



By far the most common cause of amnesia is Alzheimer's Disease.
As we have seen this is associated with widespread degeneration of the brain.
The hippocampi are particularly affected.



Neurofibrillary tangles are most prominent in the medial and anterior temporal areas.
This fits with the patient's most prominent symptom being amnesia.
Note that the sensory and motor areas of the brain are much less affected.

Study these words. You will be tested later for your memory of them.

CANDY
SOUR
SUGAR
BITTER
GOOD
TASTE
TOOTH
CHOCOLATE
CAKE
EAT

Another memory test. You have a minute to study these words.

Slide 34

Which of these words were on the studied list?

TASTE
SWEET
POINT
CAKE
HOUSE

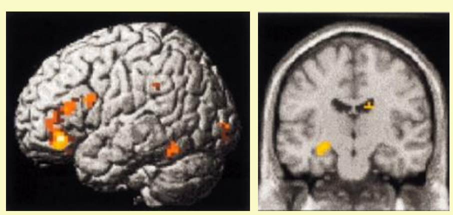
Sometimes, we remember things that did not occur or that did not occur when we think they did. Our memory system is creative in how it puts things together to make sense. Unfortunately this can lead to false beliefs, especially when real memories are out together with a therapist's suggestions.

This is an immediate recognition test. Which of these words was on the list.
Many of you will claim that the word SWEET was on the list that you studied.
It was not. Many words on the list were related to sweetness but the word SWEET was not on the list. This illustration (from Dan Schacter) shows that memories can sometimes be false.

False beliefs have occurred in court cases wherein people were accused of sexual abuse or Satanic cults.
We must be very careful not to suggest things when witnesses are asked about their memories, and we must always seek corroborative evidence.

Encoding

This involves interactions between frontal cortex (particularly left) and hippocampus. It is facilitated by "depth of processing"



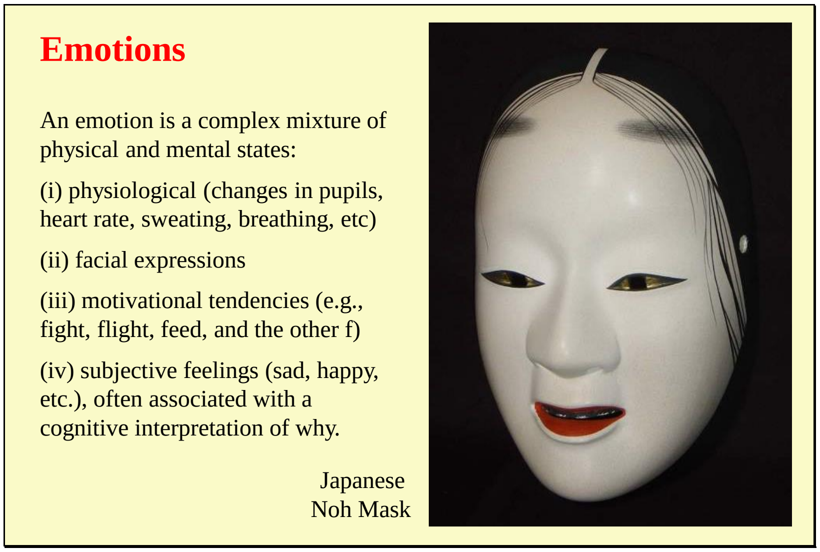
Otten et al., 2001

Retrieval

This can be triggered by a cue (recognition) or by deliberate memory search (recall). It involves interactions between the right frontal cortex and the medial temporal lobe.

Daselaar et al., 2001

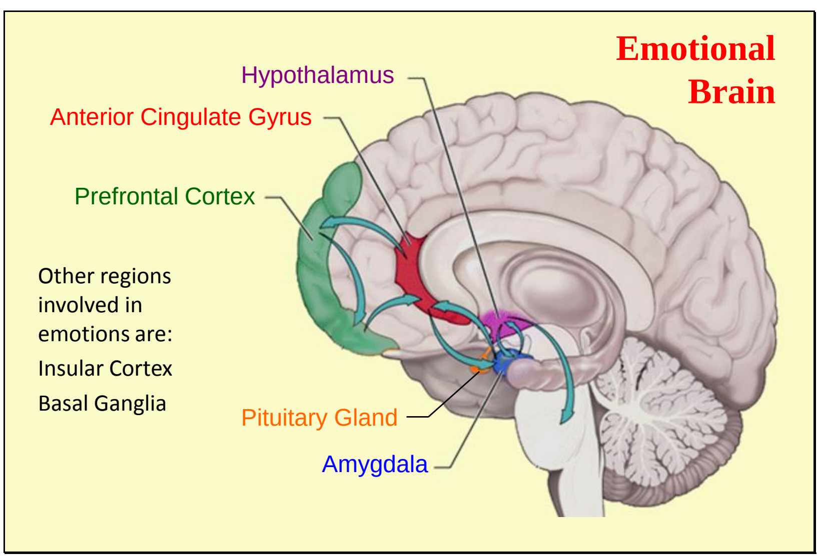
The hippocampal regions are involved in both encoding and retrieval.
Regions of the frontal cortex control the laying down and raising up of memories.



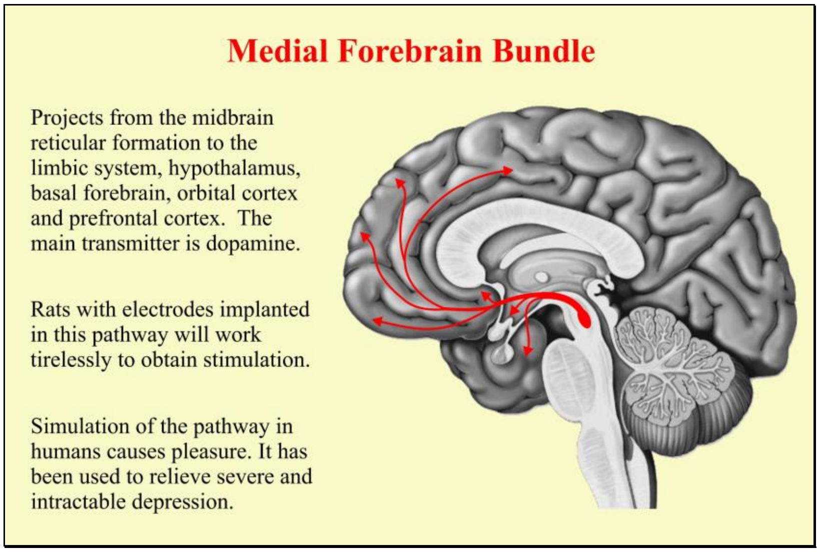
Now we turn to emotions.
These control much of what we do.

The movie *Inside Out* portrays the various emotions – joy, fear, disgust, sadness, anger – as they vie for control of a young girl's behavior.
An extended clip is available at
https://www.youtube.com/watch?v=pvMxhza4myY

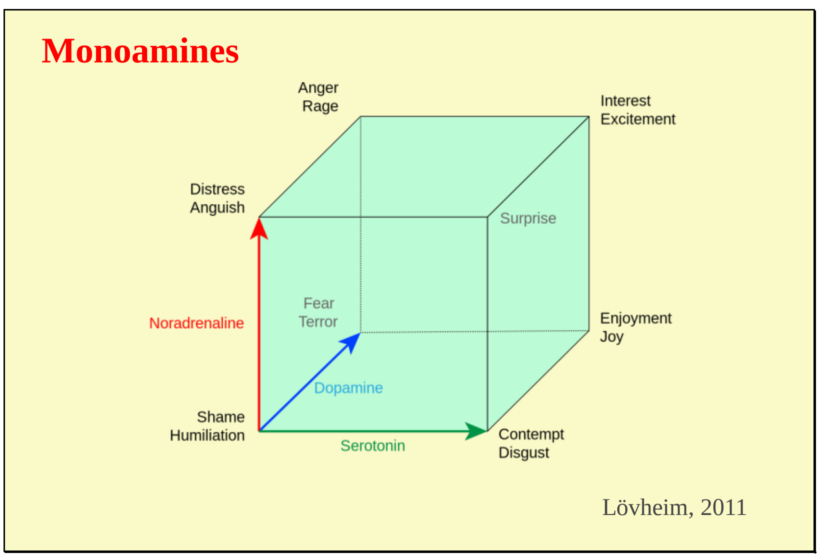
The movie uses several other metaphors – the train of thought, the islands of memory.



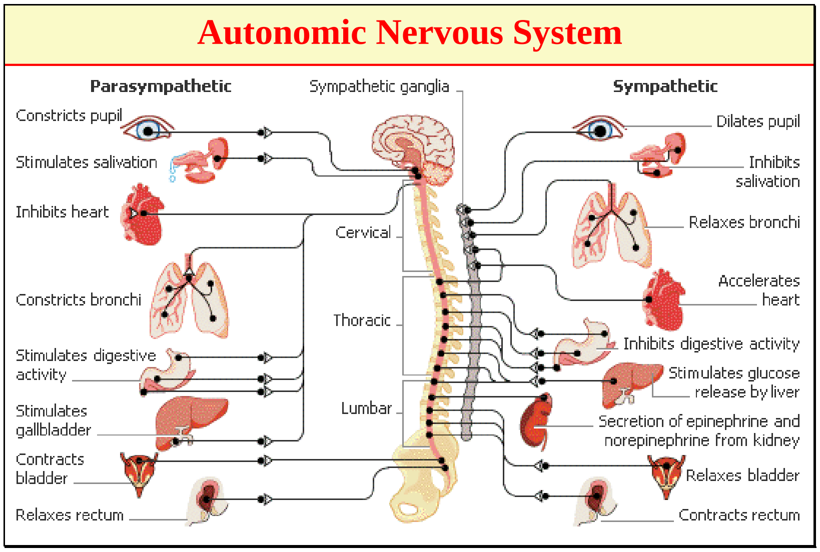
Many of the regions of the brain that are involved in emotion can be seen on the medial view.



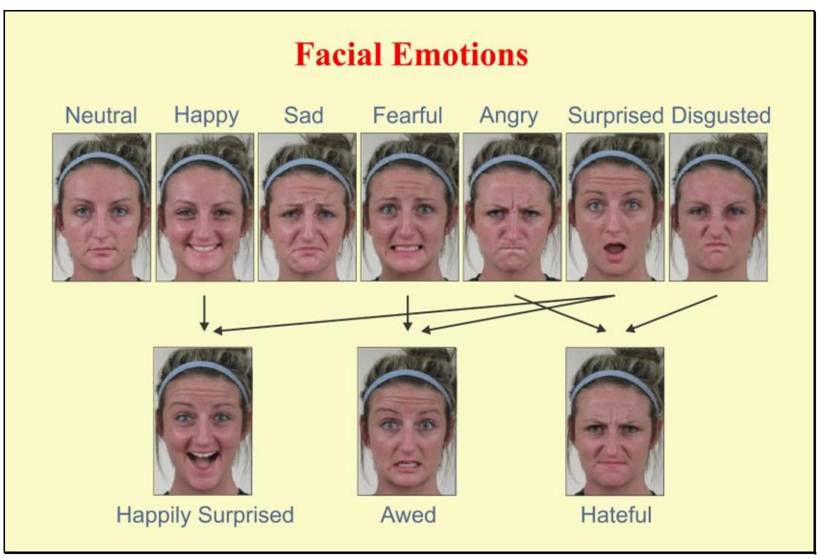
The medial forebrain bundle is a very important pathway for the emotions.



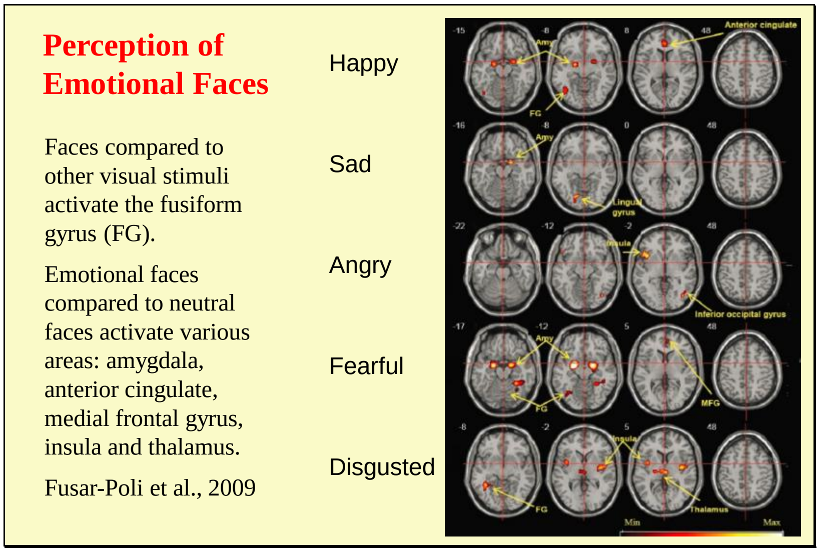
Many of the neuromodulatory transmitter systems – noradrenaline (norepinephrine), serotonin and dopamine - are involved in emotion and some scientists have tried to categorize the different emotions on the basis of their relative activities. For example joy may be a combination of high dopamine and high serotonin. However these ideas remain speculative.



The autonomic nervous system controls our internal organs. Little of their activity reaches consciousness. Our insides follow their own rules.
Emotions change these activities greatly. Our heart beats faster, our mouth goes dry and our pupils dilate when we are emotionally aroused.
The autonomic system is affected by the emotions via the medial frontal lobes and the hypothalamus.



Most scientists propose that there are 6 basic emotions.
Each is associated with a particular facial expression.
The primary emotions can be combined to give such feelings as awe and hate.



Emotions activate widespread regions of the brain. This slide shows the blood-flow changes when perceiving faces with five emotional expressions (surprise is not included).
Most important are the amygdala and the medial frontal lobe.

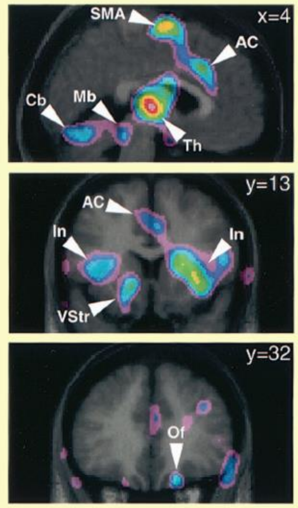
Music is able to trigger emotions.
This is a clip from the movie Amadeus. Salieri recounts his first experience of Mozart's music.
The music is the Adagio from the Gran Partita (Serenade No. 10).

Music that evokes "chills"

Subject-selected music that evokes "shivers down the spine" compared to other music increased cerebral blood flow in areas related to reward and emotion:

- Anterior Cingulate
- Insula
- Ventral Striatum
- Midbrain
- Orbitofrontal Cortex

Blood & Zatorre, 2001

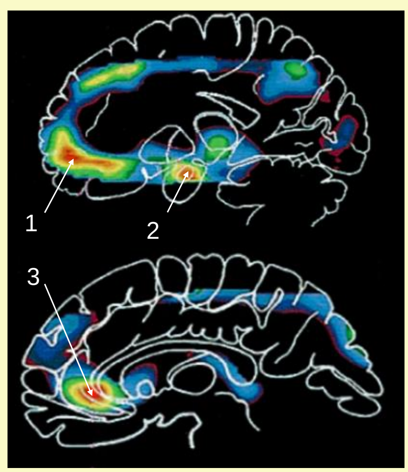


Some music gives you the chills. The onset of the oboe in the Mozart adagio works for me. When the chills occur several areas of the brain are prominently active.

Depression

The emotional brain consists of many interacting systems. Variations in the different monoamine transmitters, their receptors and their enzymes may lead to some systems becoming inappropriately overactive.

The brain of moderately depressed patients shows increased blood flow in the orbital frontal cortex (1), the amygdala (2) and the anterior cingulate gyrus (3).



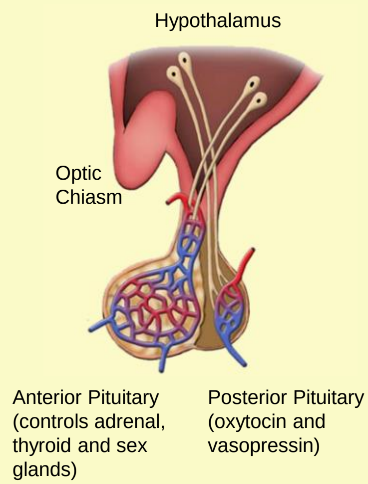
Drevets, 2000

Depression involves increased activity in the orbitofrontal cortex and the amygdala and the anterior cingulate gyrus. Electrical stimulation in the orbital regions of the frontal cortex may help severe intractable depression.

Anxiety

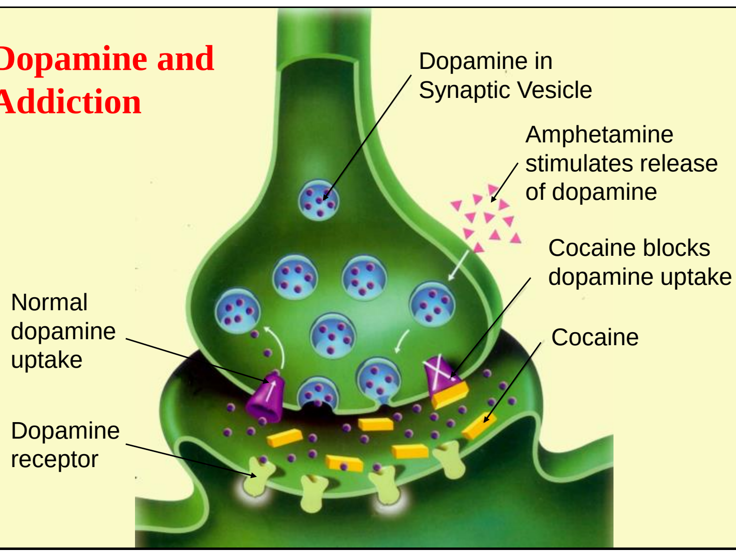
Anxiety is basically a fear response. However, the source of the fear is either not well defined (generalized anxiety) or is one for which the response is inappropriate (social anxiety, test anxiety, stage fright, etc.)

Anxiety causes a subjective feeling of turmoil and dread. Physiologically there is activation of the sympathetic nervous system (rapid heart rate, sweating, hyperventilation), and the pituitary gland which releases hormones into the blood.



Anxiety is a fear response without a clear source of the fear.

Dopamine and Addiction



This final slide shows how amphetamine and cocaine work.
Amphetamine triggers the release of dopamine.
Cocaine blocks the uptake of released dopamine from the synaptic cleft.
Both drugs increase and prolong the effects of dopamine at the synapse.
Dopamine is the main transmitter in the medial forebrain bundle – the pleasure pathway.

Quiz 7B

1. Transient global amnesia
A) is a forewarning of a stroke
B) is associated with aphasia
C) lasts for over 24 hours
D) requires no treatment

2. The dopamine concentration in the synaptic cleft
A) is increased in Parkinson’s disease
B) is decreased by cocaine
C) is increased by dopamine uptake transporters
D) is increased by amphetamines

3. ____________ 4. ____________

5. _______________

The squeezebox, the oboe and the clarinet.