Language and Emotion

Pieter Breughel the Younger
The Tower of Babel, 1595

And the LORD said, Behold, the people is one, and they have all one language; and this they begin to do: and now nothing will be restrained from them, which they have imagined to do.

Go to, let us go down, and there confound their language, that they may not understand one another's speech.

Genesis 11:6-7

We begin this sessions with the story of the Tower of Babel.
A rather vindictive deity, worried about the achievements of humanity, decides to "confound their language."
The tower is unfinished; the people are scattered.

Brain and Mind: Course Outline

1. Introduction. Brain anatomy. Stroke**.** Neurons. Excitation. Action potentials. Synaptic transmission.. Body sensations. Braille.

2. Moving to the Music. Muscles. Stretch reflexes. Basal ganglia. Cerebellum. Parkinson's Disease. Balance. Hearing. Speech and music.

3. Sensation and Perception. Taste and smell. Hunger and satiety. Vision. Visual fields. Motion. Recognizing faces and objects. Illusions.

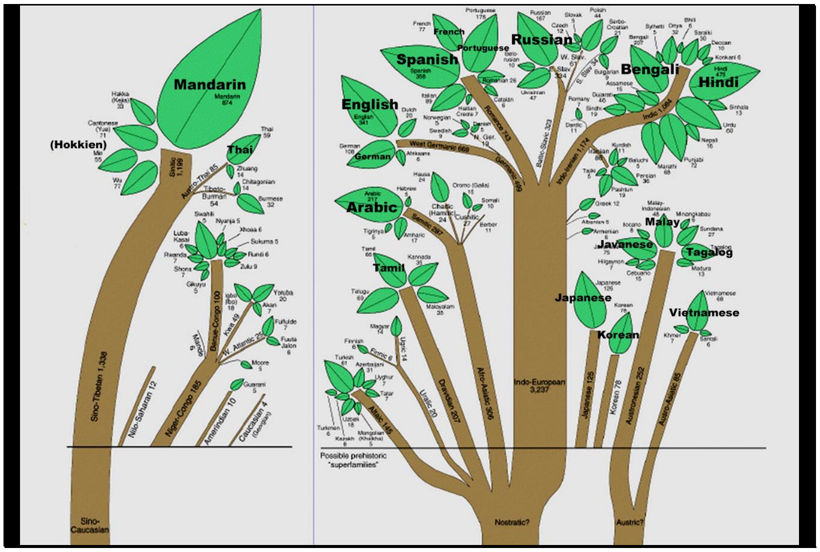
4. Consciousness. Sleep, meditation, coma, epilepsy. Locked-in syndrome. Attention. Consciousness. Theory of mind. Split-brain studies – interpreter.

5. Learning and Memory. Synaptic changes. Motor skills. Priming. Episodic vs semantic memory. Amnesia. Alzheimer's Disease.

6. Language and Emotion. Language. Humans vs chimps. Aphasia. Dyslexia. Basic emotions. Autonomic Nervous System. Love and Hate. Music.

7. Thought and Will. Executive functions. Psychopathy. Brain networks (attention and default). Determinism. Free will.

8. Madness and Wisdom. Psychiatric diagnosis. Anxiety. Schizophrenia. Depression. Addiction. Maturation of brain. Mental speed. Ageing. Wisdom.

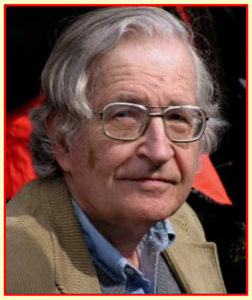


The story in Genesis is myth. Nevertheless, human beings have many different languages.
In this diagram the size of the leaves varies with the number of people who speak that language as a mother tongue.

There are some major branches – Sino-Tibetan and Indo European are the two largest.

Some spoken languages such as Japanese and Korean have little apparent relation to other languages. Hungarian and Finnish form a related group of uncertain origin. Hebrew and Arabic are both part of the Semitic group of languages.

Writing does not follow the same relations as spoken languages. The alphabet used in modern Europe derives from Phoenician, which is a Semitic rather than Indo-European language.
Chinese characters are used in written Japanese and Korean languages.



Noam Chomsky (1928-)

Syntax and Semantics

Although animals can use signs or symbols, they cannot manipulate these symbols as a language. This ability evolved with *Homo sapiens* about 200,000 years ago.

Nim Chimpsky (1973-2000)

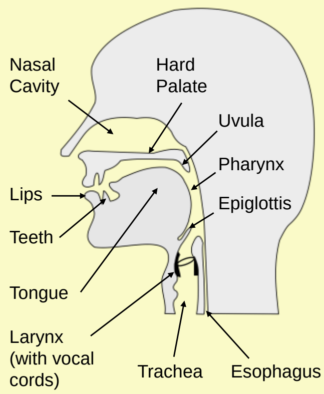
Language uses rules to put sounds, words, and sentences together to convey meaning. Different languages use different rules but all human languages can be translated into each other.

Noam Chomsky is the linguist who established our modern approach to language. His major idea was the "universal grammar" – every human being is endowed with a brain-module that allows us to speak in sentences. The sounds and the words may differ among languages, but the sentence structure remains essentially the same.

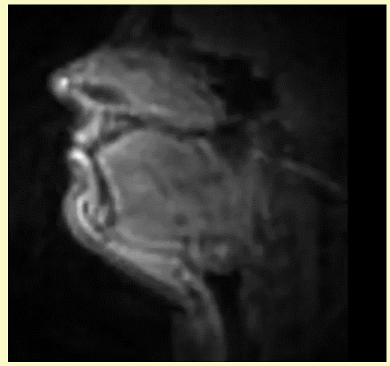
Nim Chimpsky was a chimpanzee who was raised like a human child by a surrogate family. He learned to use signs but never showed any definite evidence of using grammar. The movie *Project Nim* considered his life.

This is a clip from the movie. The supervisor of the research, Herbert Terrace, is looking over the video recordings of Nim interacting with two research assistants and a cat. The signs that Nim uses for "cat" – illustrating the whiskers (right hand with thumb and forefinger coming together as they move away from mouth – and "give me" – fingers together moving toward self – are loosely based on American Sign Language. Nim never really proceeded beyond "Give me cat."

Human Vocal Tract



During speech the vocal cords vibrate and the tongue moves rapidly to alter the resonance chambers of the mouth and throat:



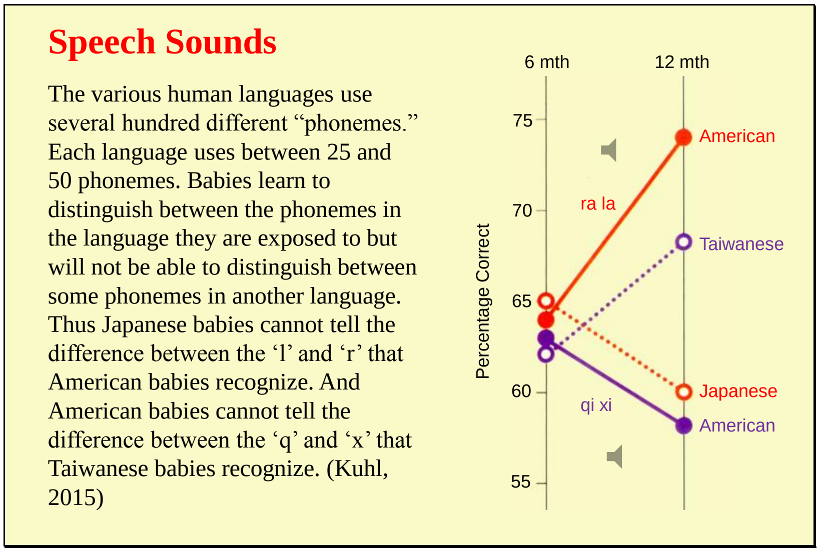
Speech is special. One of the reasons that the experimenters used sign language is that the vocal tract of the chimp cannot make the sounds of human language.
The human vocal tract is specially designed by evolution so that we can make all sorts of complex sounds.

The major differences between human beings and other primates animals is the descent of the larynx – this allows us to have a large resonance space in the throat (pharynx) as well as in the mouth.

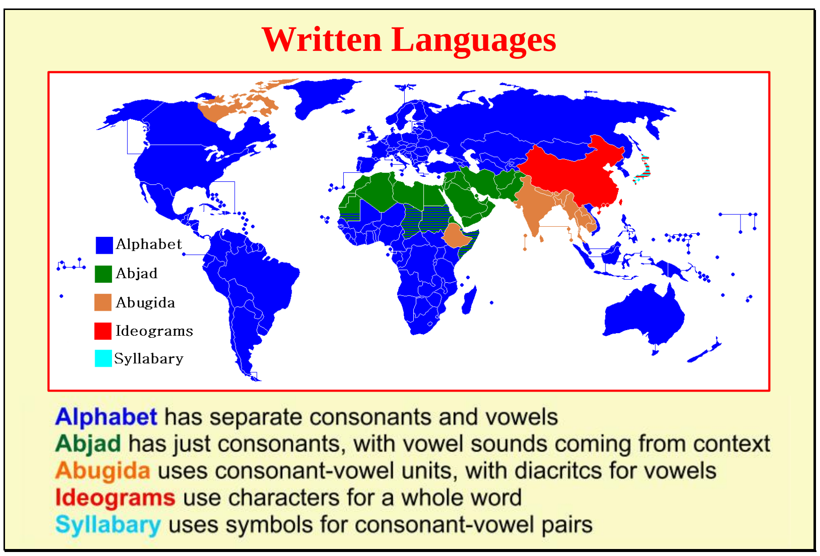
Another evolutionary development was the extremely high mobility of the tongue.
The resonances within the mouth and the pharynx gives us vowels. Altering the relative volumes between mouth and pharynx changes the vowels. Stopping the flow of air at the teeth, lips or palate causes specific consonants

The MRI video at the right (about grandfather) shows how the lips, tongue, soft palate, and throat move during speech.

Video (by Jangwon Kim) is available at
https://www.youtube.com/watch?v=-kHtGlhPs3Y



You can tell the difference between the 'l' and 'r' sounds in 'rate' and 'late.' (red – compares Japanese and American babies)
Most of you will not be able to discriminate the 'q' and 'x' of Mandarin Chinese (purple – compares Taiwanese and American babies)



Written languages are almost as various as spoken languages. However, there are only five basic systems for writing.
English and many other languages use an alphabet with both consonants and vowels. The most common is the Latin alphabet, which derived from Greek which derived from Phoenician. Some languages are strictly phonemic – the sound of a letter is always the same. Others, like English, are not.
Ancient Hebrew uses just consonants; modern Hebrew adds diacritics to show the vowels associated with the consonants.

Chinese uses ideograms. Words can be made up of a single ideogram or a combination of two or more ideograms. Each ideogram may be made up of simpler parts called radicals which can contribute to either the meaning or the sound of the ideogram
Japanese combines Chinese ideograms with two different sets of syllables: hirakana and katakana.

Localization of Function

In the 19th Century, the phrenologists led by Franz Josef Gall (1758-1828) proposed that human abilities were localized to different regions of the brain.

Jean Pierre Flourens (1794-1867) showed that the cerebral hemispheres were necessary for intelligent behavior but he was unable to distinguish any focal areas within the hemispheres.

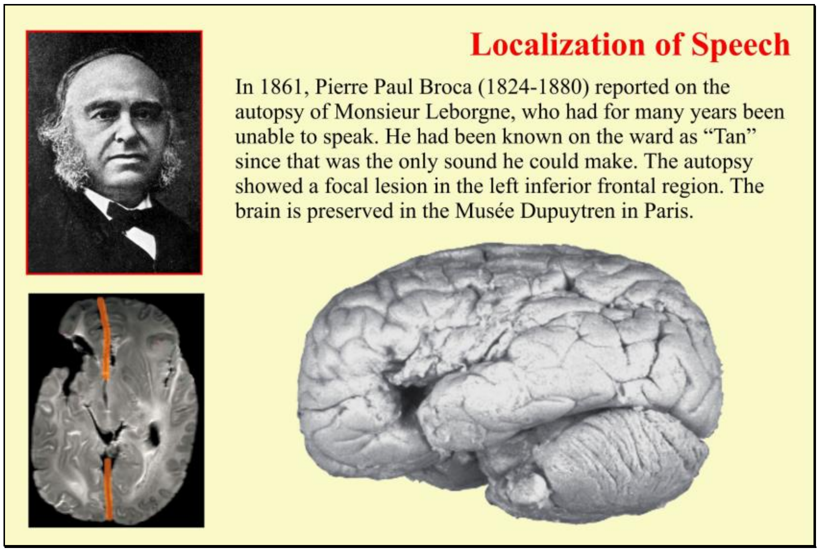
The controversy whether cognitive functions are localized or distributed in the brain continues to this day.

The discovery of how language is controlled in the brain is closely related to the idea that different functions are localized in different regions of the brain.

Phrenology was the study of the mind. It assumed that particular abilities would be localized in specific regions of the brain. If a particular ability were enhanced in a person, the regions of cerebral cortex related to that ability would be increased. Furthermore, the regions of the skull overlying the part of the cerebral cortex devoted to that ability would become recognizably prominent.

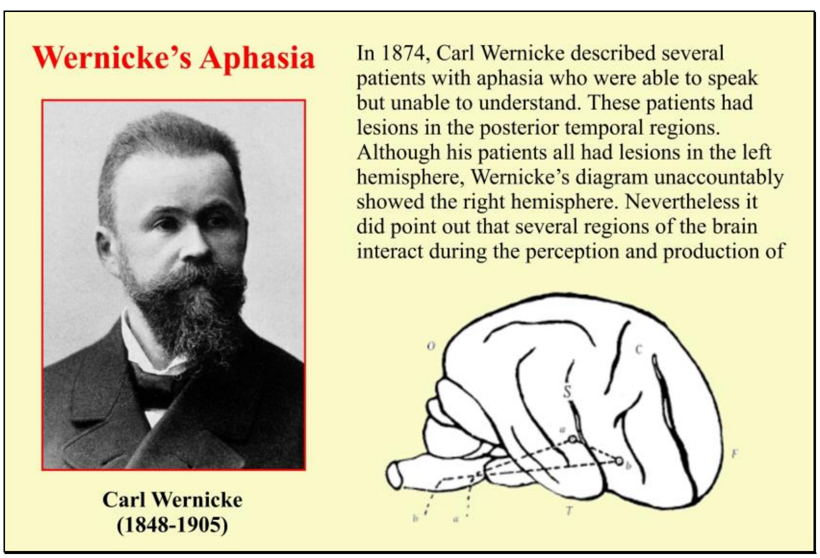
Though the ideas of phrenology were totally illogical, some principles continue – that abilities might show some localization and that increased use of those functions increased the size of that region of the cortex.

The controversy between whether cognition is localized or distributed continues to this day. Some regions of the brain are essential to some functions, and without them these functions are not possible. However, the functions normally involve many other areas of the brain as well.

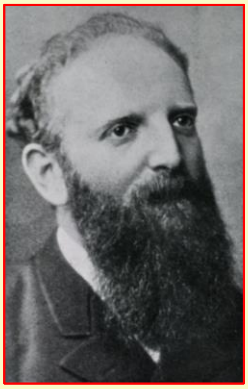


Those believing in the localization of function received some clear support when physicians began to look at the brains of patients with aphasia.

Interestingly the brains of other patients with similar findings that Broca had studied had lesions to other areas of the left hemisphere. The lesions were all left frontal but some were higher than M. Leborgne’s.
The MRI at the lower left was taken from Leborgne’s preserved brain.



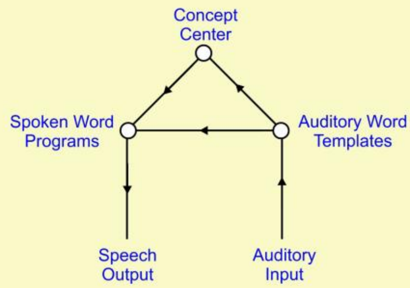
Wernicke suggested that the posterior temporal lobe was necessary for understanding speech and the inferior frontal lobe for producing speech. He did not pay attention to the fact that language defects involved the left hemisphere, and not the right.



Ludwig Lichtheim
(1845- 1928)

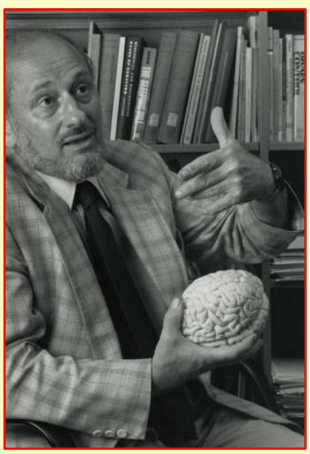
The House of Lichtheim

In 1885 Lichtheim published his ideas about the speech system with an influential diagram. Aphasia could be caused by lesions to any of the centers or by lesions disconnecting one center from another.



The third main father of aphasiology was Ludwig Lichtheim.
His speech diagram looks like a house.

Disrupting the connection between auditory center and the speech center would prevent the simple rapid repetition of auditory input, even though the patient could understand and speak normally.

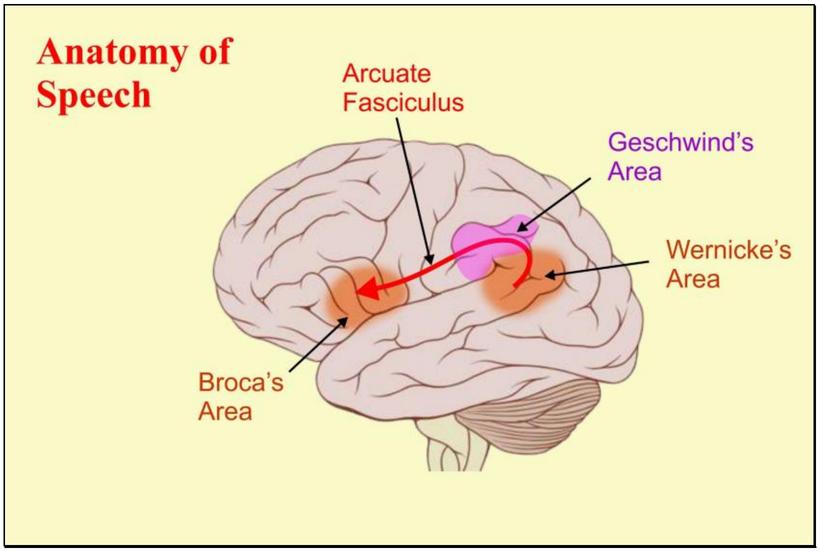


Norman Geschwind
(1926-1984)

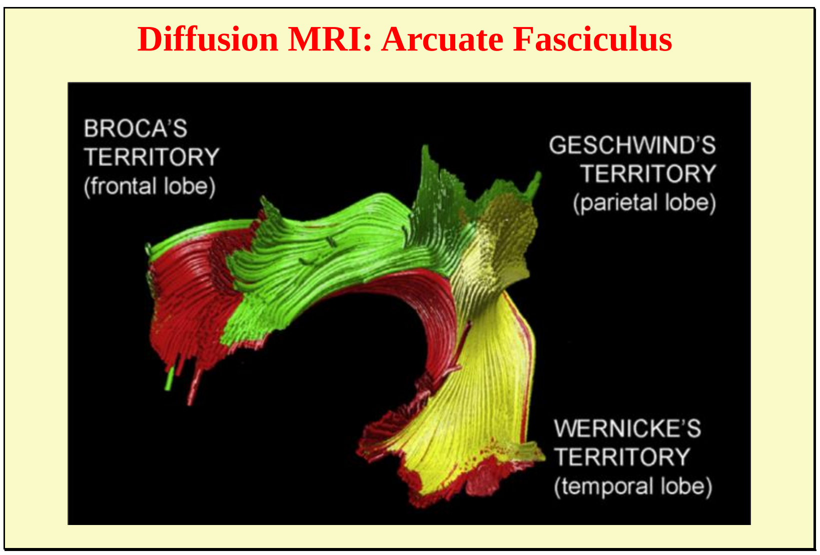
Disconnection Syndromes

Geschwind proposed that Lichtheim's concept center was located in the inferior parietal lobe, an area that was only fully developed in human beings. Lesions to the arcuate fasciculus could cause a "conduction aphasia" – patients had difficulty repeating phrases that were close to meaningless (such as "No ifs, ands, or buts"), although they could speak normally and could understand.

Norman Geschwind suggested an anatomical basis for the concept center, and proposed the idea of disconnection syndromes.
The prototype disconnection syndrome is conduction aphasia. A lesion to the arcuate fasciculus disconnect Wernicke's area from Broca's area.



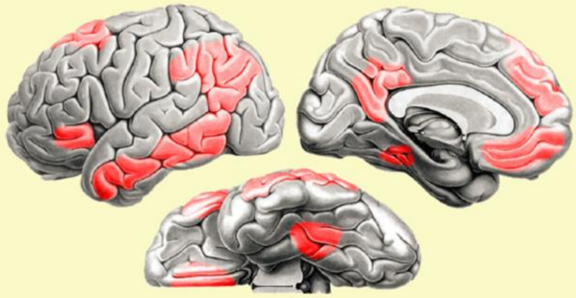
These are the main regions of the brain involved in speech and language in the classical (locationist) view.



A special type of Magnetic Resonance Imaging is used to demonstrate the fibers within the white matter of the cerebral hemispheres

This figure shows the arcuate fasciculus which connects Wernicke's area in the temporal lobe to Broca's area in the frontal lobe.

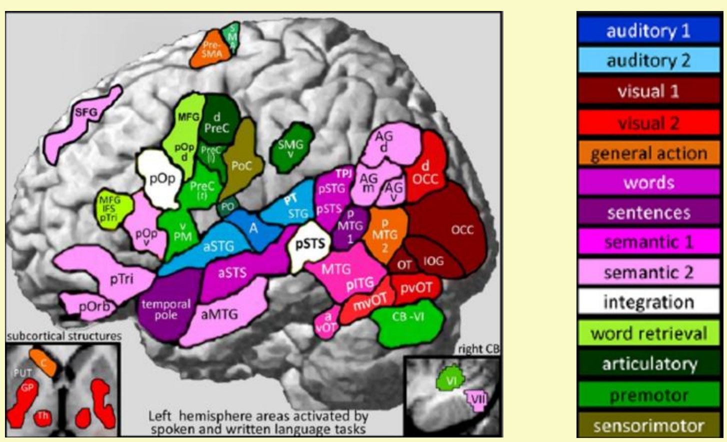
Semantic Memory



Recent studies using cerebral blood flow (e.g. Binder et al, 2009) have extended Geschwind's semantic area toward the middle temporal cortices. Damage to this area (by stroke or encephalitis) may significantly affect the memory for semantic concepts. The main clinical feature is "anomia" – the inability to find the word for an object or to say what it is used for. Sometimes the loss can be quite specific: the patient may be unable to recognize animals but can recognize tools, or vice versa.

Semantic memories – the facts that we have learned and consolidated – appear to be located in regions of the association cortex.
The main areas are the inferior parietal lobe (Geschwind's area) and the middle temporal gyrus.
The main symptom that follows lesions to these areas is anomia.
Other areas, particularly those in the frontal lobes, may be involved in searching or accessing semantic memories.

Blood Flow Studies of Human Language Processing



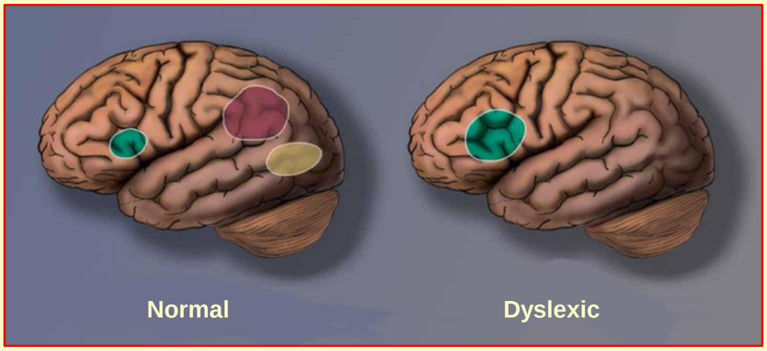
C. J. Price, *NeuroImage*, 2012

An abstract expressionist brain.
This figure is from a recent paper reviewing the cerebral blood flow studies over the last 20 years.
Many different regions of the left hemisphere are involved in language processing.

We have just considered semantic memories – these are shown in the darker shades of purple.

Light purple shows where syntax and semantics (grammar and meaning) come together.
Green is for articulation – the production of speech sounds.
Blue is auditory processing.
Red and brown are the areas for processing written language. These are disordered in dyslexia.

Dyslexia



Dyslexic children seem unable to process word forms (yellow) and meanings (pink). They activate the anterior word finding area (Broca's – green) more than normal children when trying to read words. (Shaywitz, 2005).

Dyslexia is an inability of processing written words and their meanings.
Two basic areas are affected – a word-form area in the temporo-occipital region (yellow), and a meaning area in the parieto-occipital region (pink).
Dyslexic children often show increased activity in the left inferior frontal region. This may perhaps be related to the increased effort devoted to searching, when the word- and meaning-stores are noisy or empty.

Aphasia

Etiology: Aphasia can be caused by any process that damages the speech areas of the left (or dominant) hemisphere – trauma, tumor, degenerative disorders (particularly fronto-temporal dementia). However, aphasia most commonly occurs following a stroke.

Types: Aphasic stroke patients show the following types of aphasia: global – speech neither understood nor produced (30%), Broca's (15%), Wernicke's (15%), anomic (25%), others (15%).

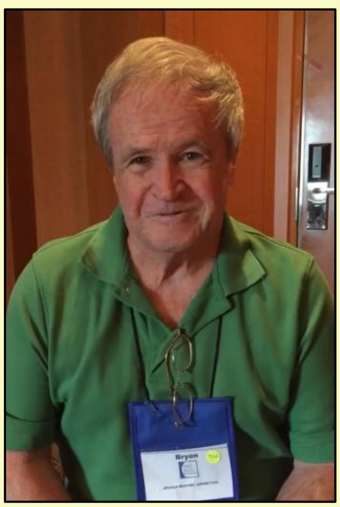
Prognosis: The more severe the initial symptoms, the worse the prognosis. However, all patients improve especially during the first year after the stroke. Global aphasia can progress to Wernicke's aphasia; Broca's aphasia tends to progresses to anomic aphasia. Fluent aphasias never become non-fluent.

Aphasia is a disorder of language.
It is almost always caused by damage to the left hemisphere (90+% of right-handed people and 70% of left-handed people).

Broca's Aphasia

Speech is very slow. Often the patient comes to a halt or can only make non-speech sounds like "um." There is great difficulty finding words. Writing is usually affected as well. Complete sentences are rare – the speech is like a telegram. The patient does not use grammatical features like the plural 's' or auxiliary verbs. Speech perception is good although the patient will not understand complicated grammatical structures (passives, etc.): "agrammatism." Patients are aware of their problems and sometimes very frustrated. There is almost always hemiparesis.

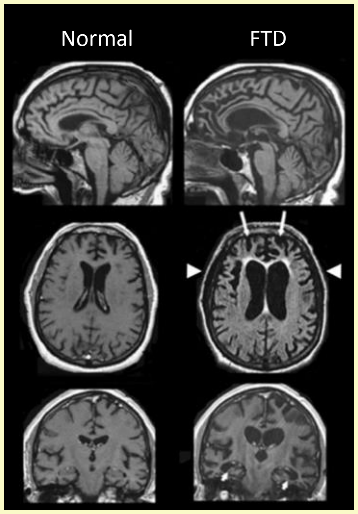
Full video is at
https://www.youtube.com/watch?v=khOP2a1zL9s



Wernicke's Aphasia

The speech is very fluent. However, the patient often makes mistakes, using the wrong word or changing the sounds in a word (paraphasias). Sometimes these paraphasias are so bad that the speech becomes gibberish or "jargon aphasia." The utterances are usually grammatically correct, but there is very little meaningful content to the speech. The patients have severe difficulty understanding questions. These patients tend to be unaware of their problems and have difficulty in understanding the need for therapy.

Note that he does not answer the questions posed to him. His speech is quite fluent – he is sometimes almost poetical in the way he repeats himself. He inadvertently repeats what the examiner says – there is no conduction aphasia.
Full video is at
https://www.youtube.com/watch?v=3oef68YabD0



Anomic Aphasia

Although the speech is fluent, the patient has difficulty finding words. Circumlocutions are common and both the patient and the listener become frustrated.

Testing involves (i) presenting the patient with an object (watch, pen, orange, etc.) and asking for its name, and (ii) asking the patient to give the meaning of a word, e.g., what is a knife?

As well as being caused by strokes, this type of aphasia is often seen in degenerative disorders such as frontotemporal dementia (FTD).

David Jane, *The Wall*, 2014. David has anomic aphasia and dyslexia after damage to the left temporal lobe from encephalitis in 1990.

David Jane was an artist who suffered severe damage to the left temporal lobe following Herpes encephalitis.
He was still able to paint after the encephalitis but has anomia and severe dyslexia.
This particular print gives some sense of what words look like in his consciousness.

Emotions

An emotion is a complex mixture of physical and mental states:

(i) physiological (changes in pupils, heart rate, sweating, breathing, etc.)

(ii) facial expressions

(iii) motivational tendencies (e.g., fight, flight, feed, and the other f)

(iv) subjective feelings (sad, happy, etc.), often associated with a cognitive interpretation of why.

Japanese Noh Mask

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.

Emotions

There are many different human emotions. Paul Ekman suggested that there are six basic emotions. Each is associated with a characteristic facial expression. Other feelings represent combinations of these basis emotions. For example anger and disgust could combine to give contempt.

Interestingly, if we simply adjust our facial muscles into one of the characteristic expressions we actually feel the emotion. The expression feeds back to the experience. Helen Mirren who had to give a hateful speech as Queen Margaret in Shakespeare's Henry VI Part III Act I Scene 4 found that afterwards she felt physically sick. She berates the captured Richard Plantagenet

> Where are your mess of sons to back you now?
> The wanton Edward, and the lusty George?
> And where's that valiant crook-back prodigy,
> Dicky your boy, that with his grumbling voice
> Was wont to cheer his dad in mutinies?
> Or, with the rest, where is your darling Rutland?
> Look, York: I stain'd this napkin with the blood
> That valiant Clifford, with his rapier's point,
> Made issue from the bosom of the boy;
> And if thine eyes can water for his death,
> I give thee this to dry thy cheeks withal.

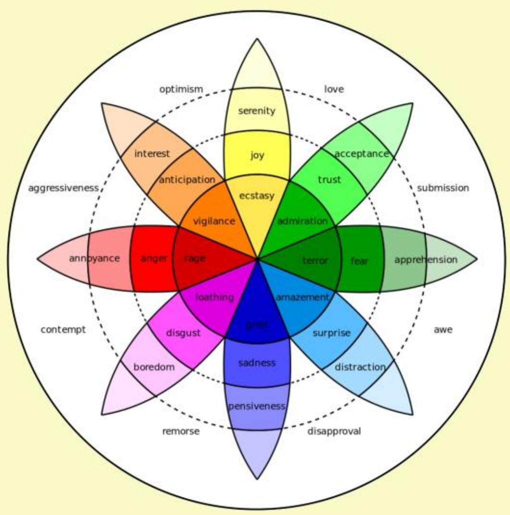
Robert Plutchik has placed the different emotions along four different axes:

joy vs sadness

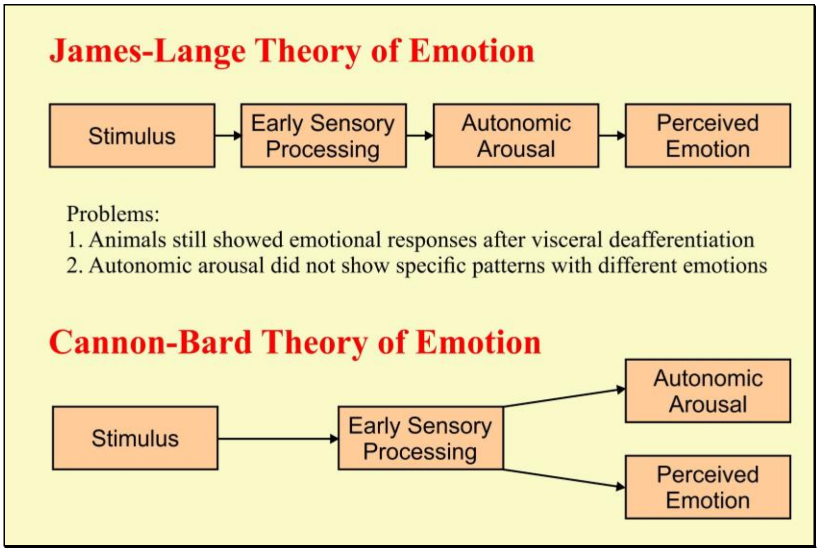
anger vs fear

trust vs disgust

surprise vs anticipation



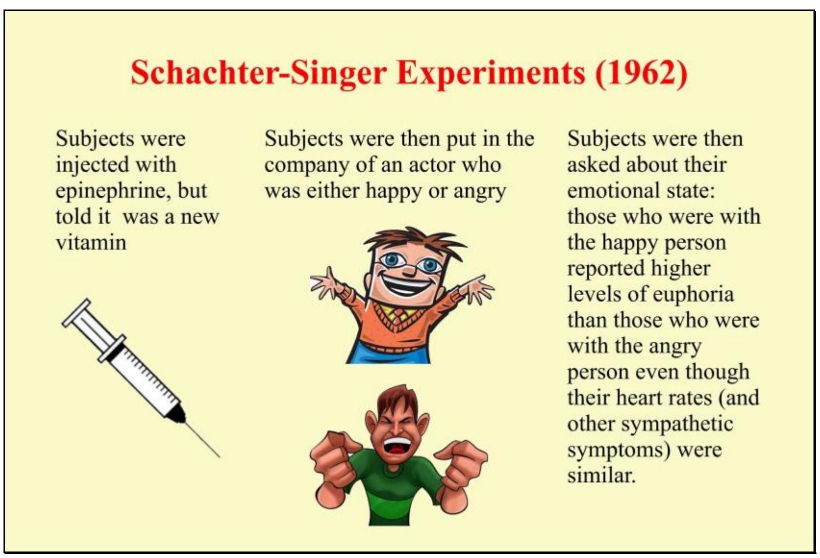
As well as the axes, the system uses an intensity scale – “ecstasy” is more yellow than “joy,” and “terror” more green than “fear.” This is similar to the saturation value of the color wheel. The Plutchik system has the advantage that the axes can define an emotional space. However, there is no convincing evidence that this defines the brain's actual emotional space.



We have long attempted to understand why we feel our emotions.

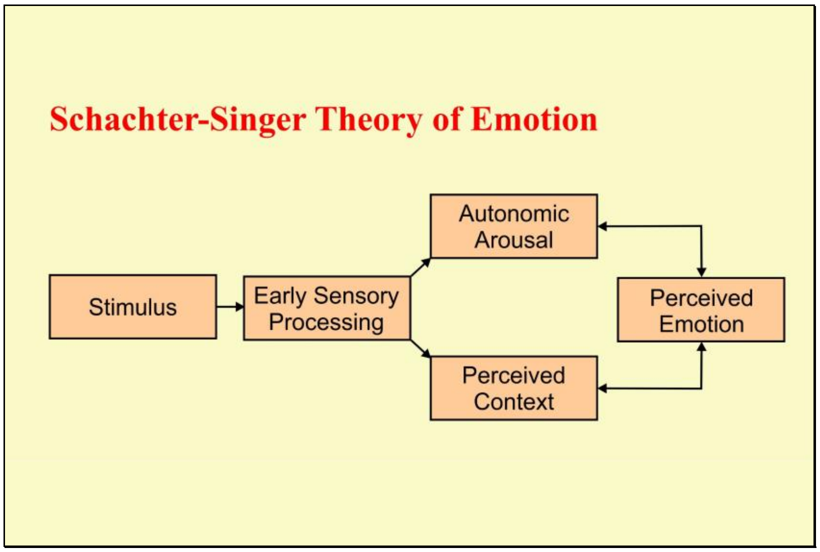
William James and Carl Lange thought that our emotions were caused by our perceiving bodily responses – heart rate, sweaty palms, etc. – that had been automatically triggered by the emotional stimulus. Psychology followed physiology.

Walter Cannon and Phillip Bard thought that all sensory processing must proceed through the thalamus and that the autonomic response and psychological perception could then occur in parallel.

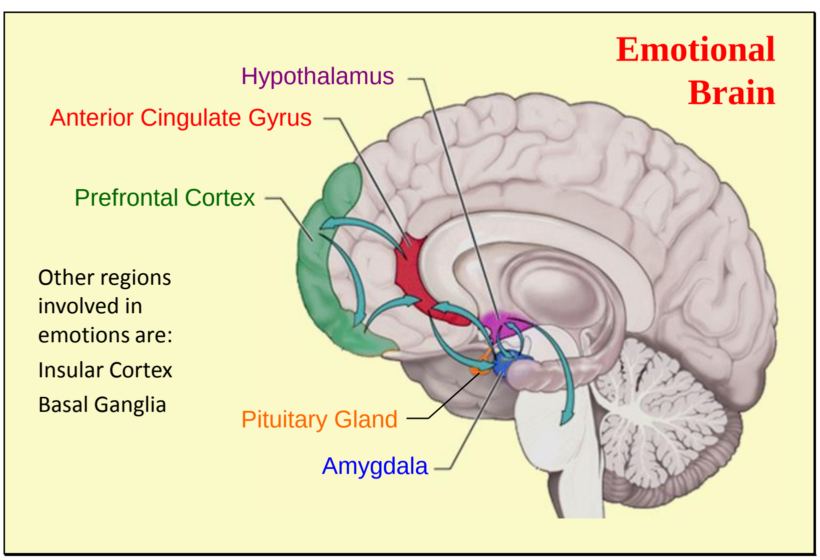


Stanley Schachter and Jerome Singer carried out a series of experiments in 1962 to look at the interaction between the autonomic and cognitive aspects of emotion. They injected epinephrine (named because it comes from the adrenal gland located above the kidney, also known as adrenaline from the Latin as opposed to the Greek).

The full experiment also included control groups. One group was given a placebo. They experienced the same emotions as the person with whom they were placed after the injection. Another group was informed that they would experience palpitations, etc. They showed similar responses but their emotions were much less intense – because they did not have to provide a cognitive explanation for their arousal.



This led to a "two-factor" theory of emotion. Emotional experience combine two types of information – we become aware that our body has changed and we interpret this in terms of the perceived context. Thus we can become emotional when we are autonomically aroused by an injection of epinephrine. We then have to find some context for this emotional arousal. In addition, the context itself can lead to emotions which then feedback to give some degree of autonomic arousal.

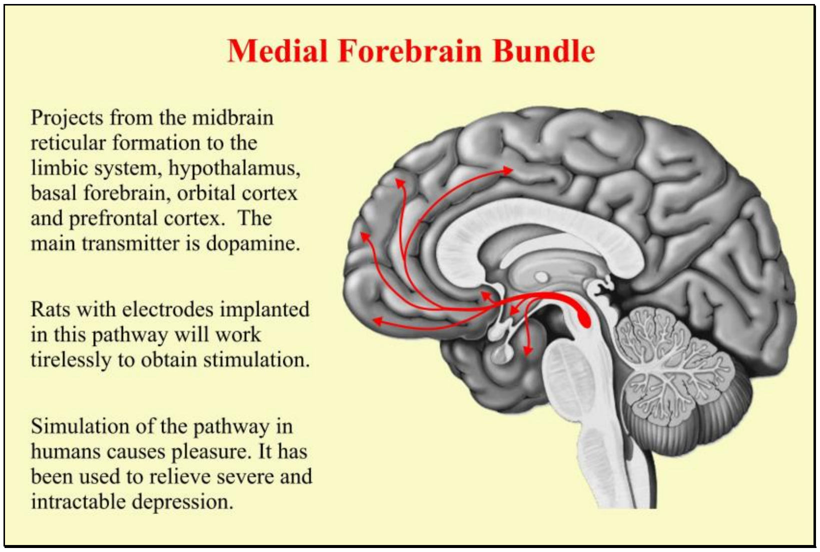


Many of the regions of the brain that are involved in emotion can be seen on the medial view.

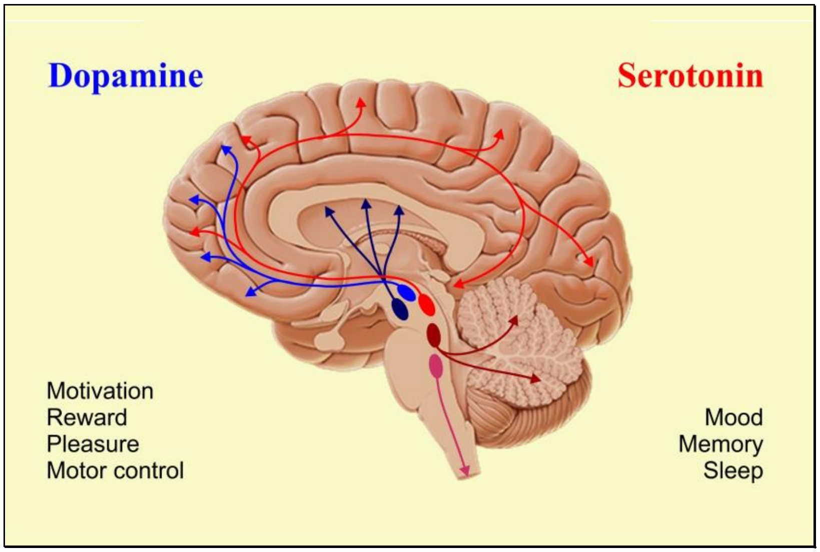
The main control of the physiological responses comes from the hypothalamus which sends out signals to the sympathetic nervous system, and the pituitary gland which releases hormones that mediate the stress response.

Rapid sensory processing can cause emotional responses through the amygdala and thence to the hypothalamus. We start to respond before we are aware of what we are responding to.

The prefrontal cortex is important for the cognitive evaluation of emotional responses and for initiating emotions as part of motivation – “getting all psyched up”

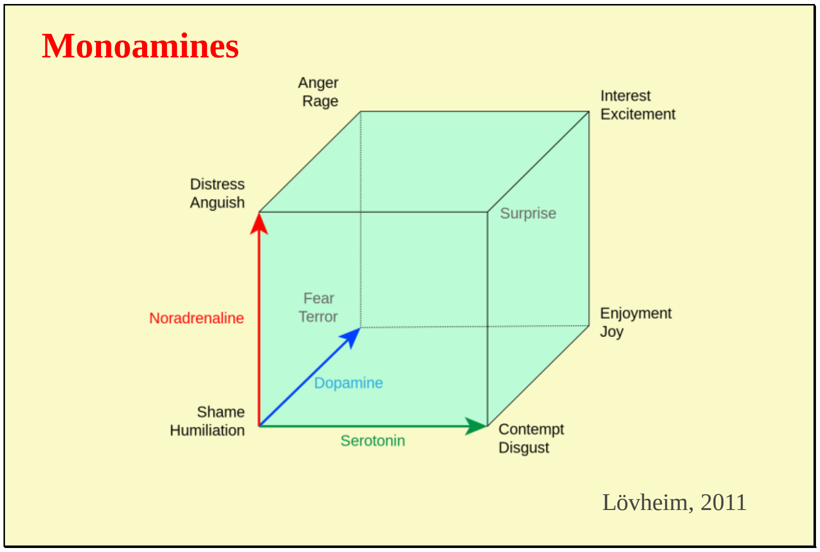


The medial forebrain bundle is a very important pathway for the emotions.

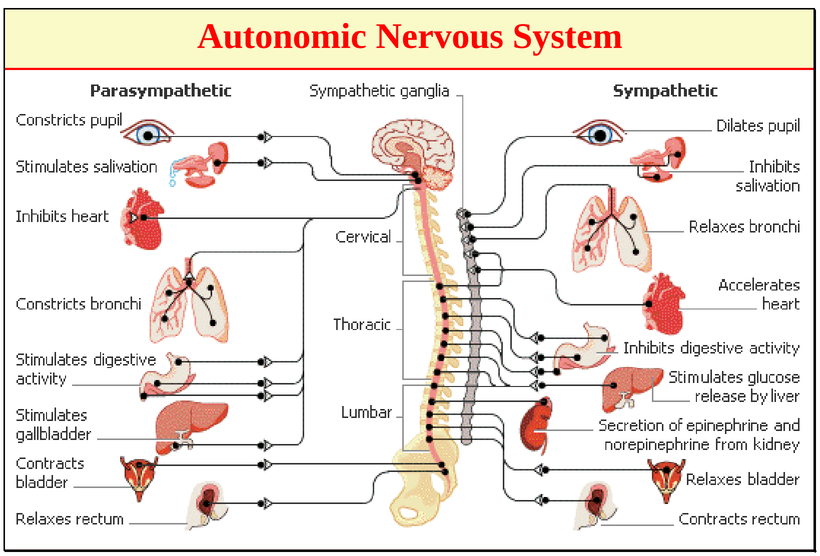


The monoamine systems in the brain are important for the emotions. They are widely distributed in the cortex. However, they have multiple functions. Dopamine is involved in motor control as well as pleasure. Serotonin controls sleep as well as mood.

There is also a third brain monoamine system – one involving noradrenaline.

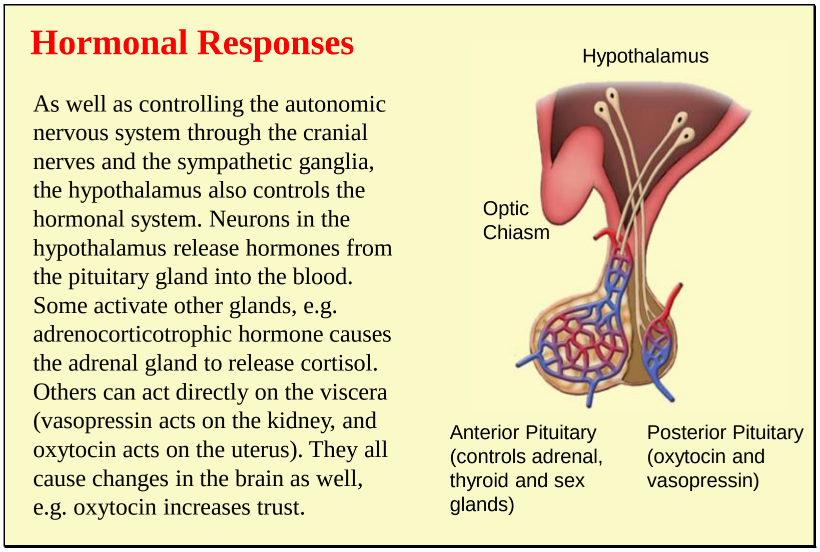


Many of the neuromodulatory transmitter systems – noradrenaline (norepinephrine), serotonin and dopamine – are involved in emotion and some scientists have tried to categorize the different emotions on the basis of their relative activities. For example joy may be a combination of high dopamine and high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

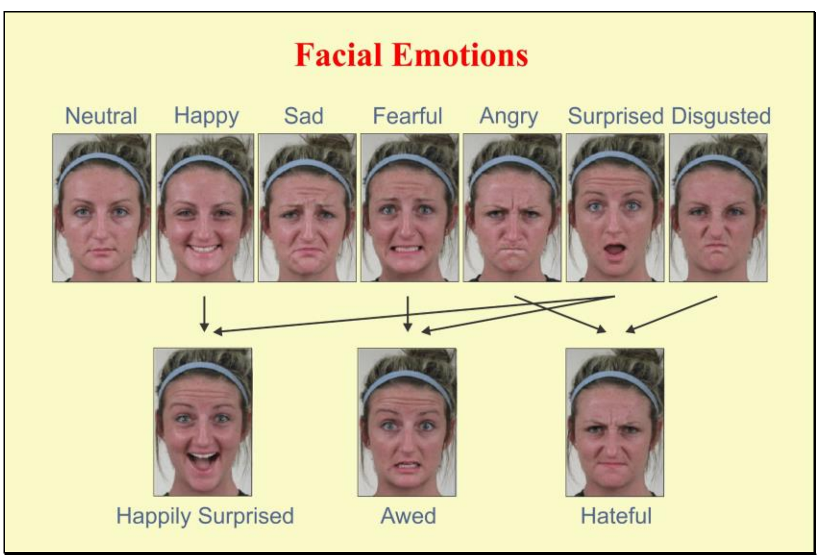


We have seen this slide before – when we discussed sleep and arousal.
The autonomic nervous system controls our internal organs. Little of their activity reaches consciousness. Our insides follow their own rules.

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.

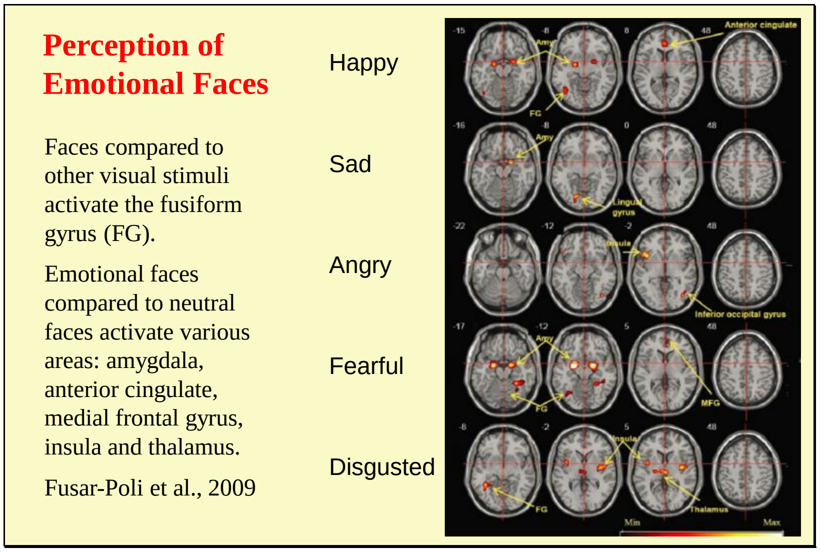


There have been some interesting experiments wherein groups of people play games for rewards. Giving subjects oxytocin (through a nasal inhaler) increases the amount of cooperation. Perhaps one should put oxytocin in the air-conditioning at the United Nations.

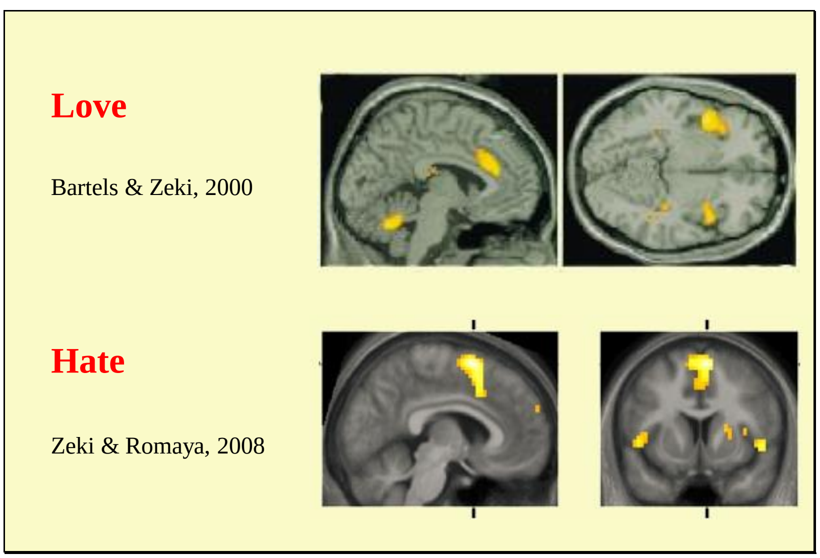


Most scientists propose that there are 6 basic emotions.
Each is associated with a particular facial expression.

The primary emotions can be combined to give such feelings as awe (fear+surprise) and hate (anger+disgust).

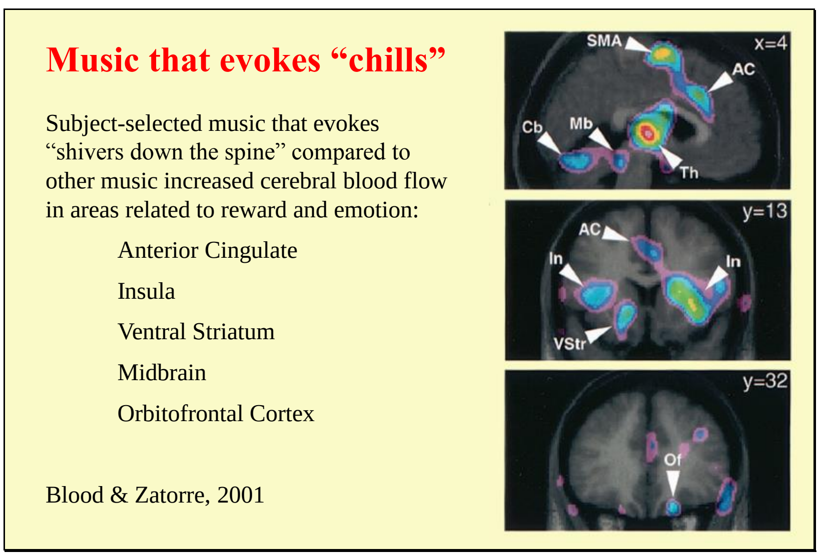


Emotions activate widespread regions of the brain. This slide shows the blood-flow changes when perceiving faces with five emotional expressions (surprise is not included). Most important are the amygdala and the medial frontal lobe. However, we have not been able to associate a specific pattern of brain activation with a specific emotion because they all tend to overlap, particularly in the amygdala.



This slide shows the activity in the brain as someone views photographs of people you love or hate (compared to photographs of people that you have no feelings for). The imaging was not quite the same – love is shown on sagittal and horizontal sections whereas hate is shown on sagittal and coronal sections. There are similarities in the patterns – both show activations in the medial frontal lobes and in the insular cortices. The different passions are similar. There are also differences but it is not clear what these represent.

Music is able to trigger emotions.
This is a clip from the movie Amadeus. Salieri recounts his first experience of Mozart's music.



Some music gives you the chills.
When it does several areas of the brain are prominently active.

The squeezebox, the oboe and the clarinet.