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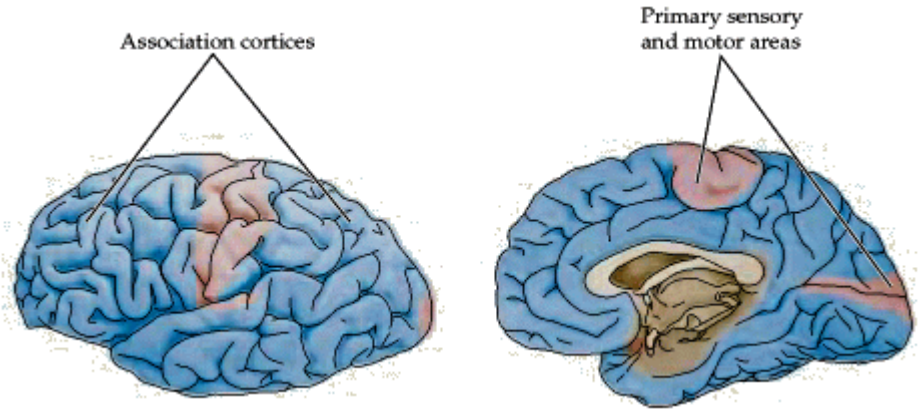
# 16

# Neocortex II
# The Highest Level of Cerebral Activity

# Neocortex

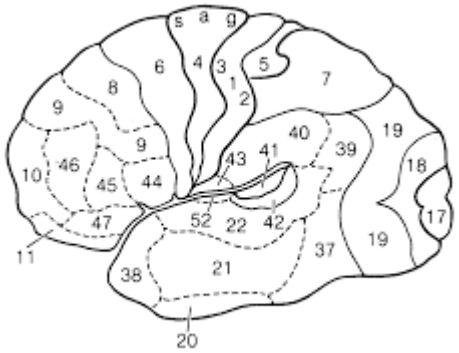


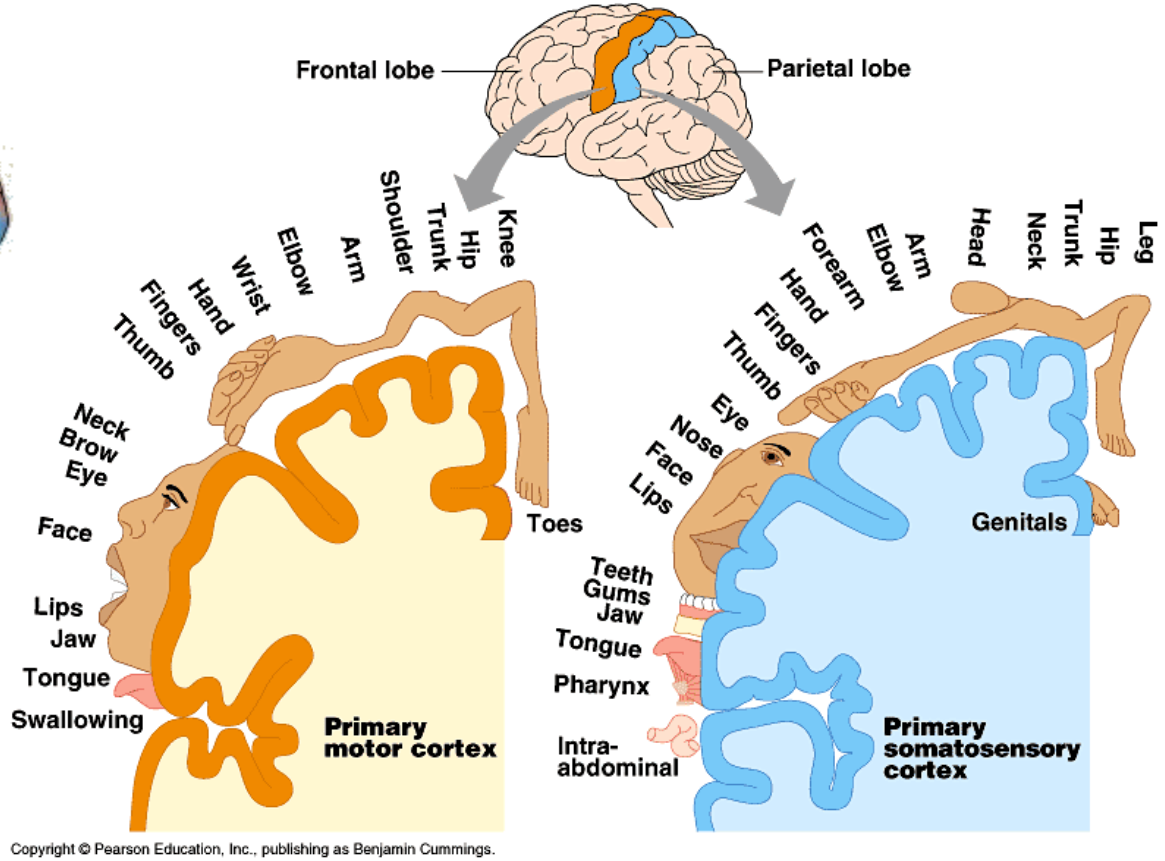

**Primary areas**

✓Somathotopic organization

**Association areas**

✓No somathotopic organization






http://www.emunix.emich.edu



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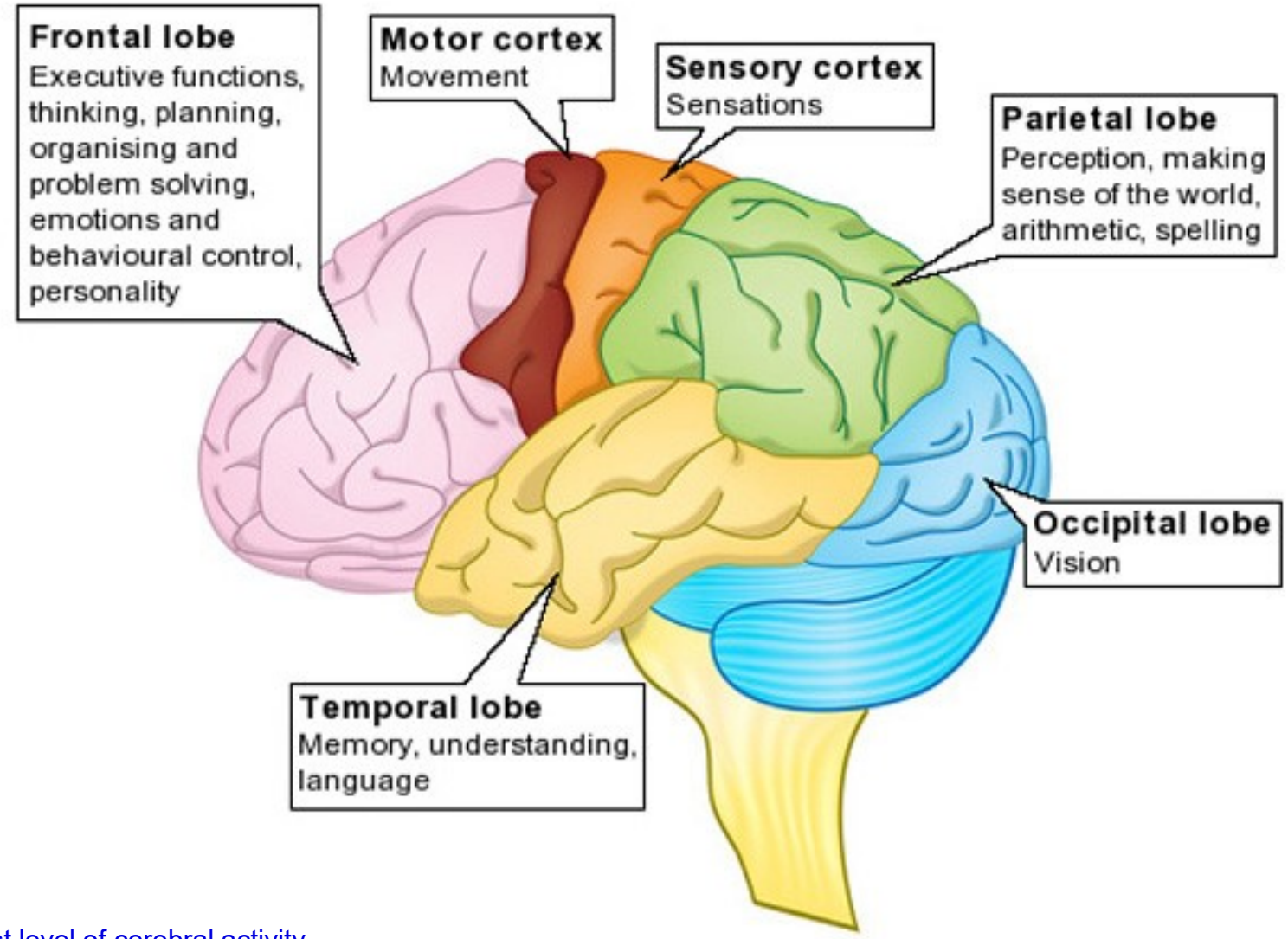
# Cortical functions

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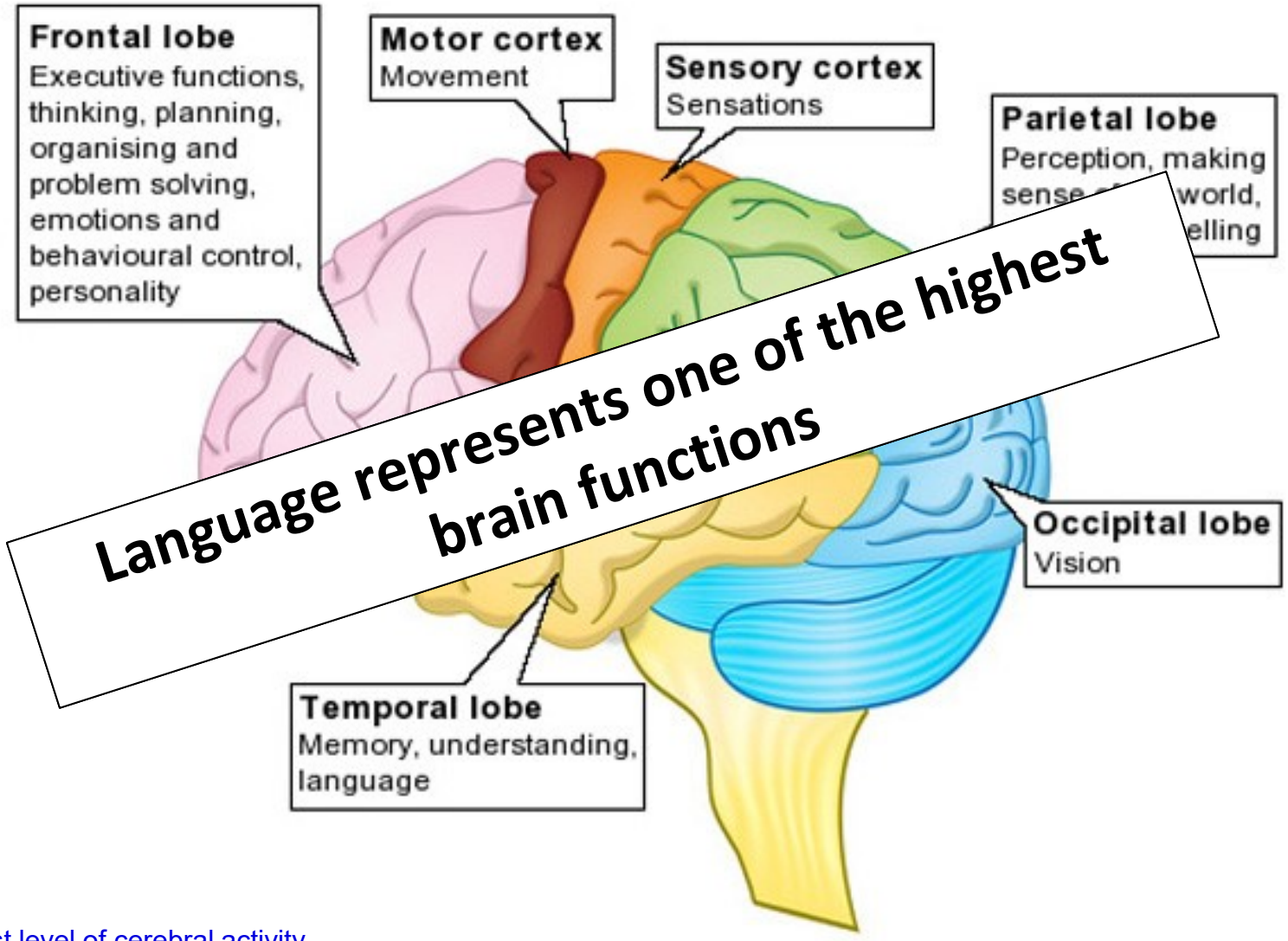


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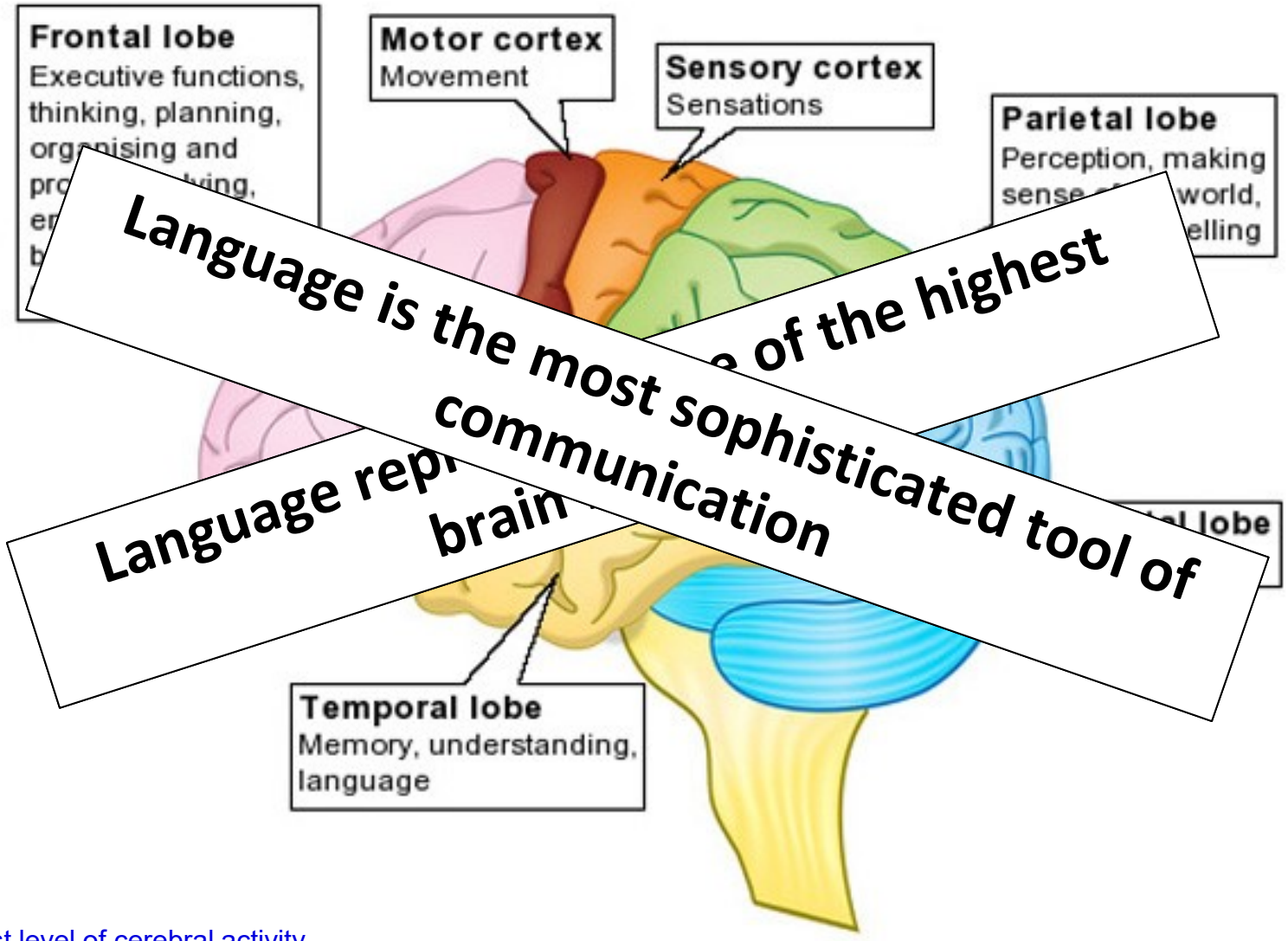




http://www.modernfamilyideas.com

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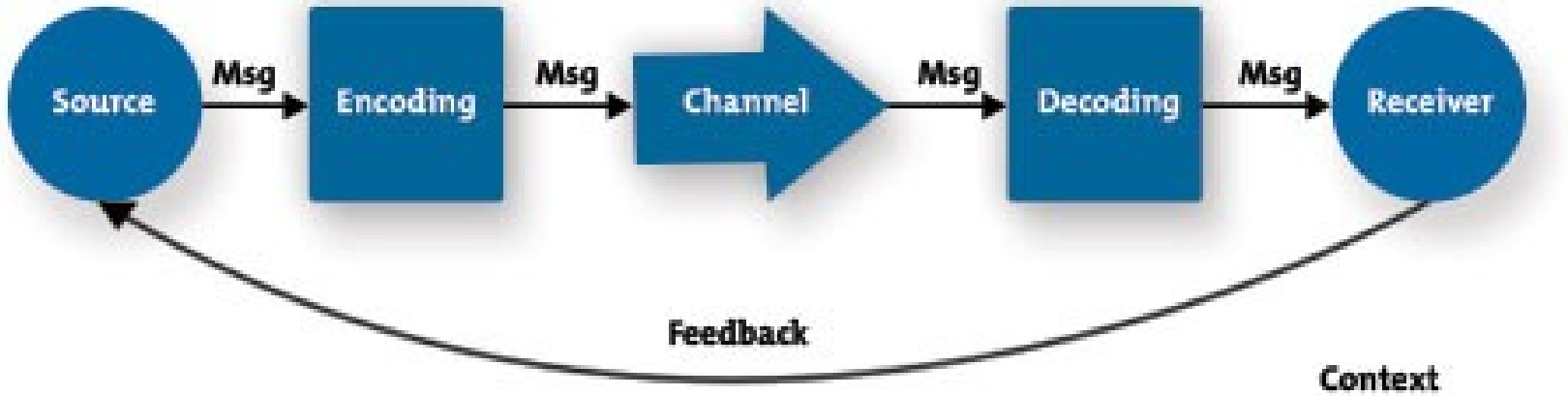
# Communication

- Signal exchange
  - ✓ Smell
  - ✓ Visual
  - ✓ Acoustic
- Between individuals of
  - ✓ Same species
  - ✓ Different species

- Encoding
  - ✓ Simple – body size
  - ✓ Complex – dance of the honey bee




https://www.mindtools.com/media/Diagrams/CommunicationsProcess.jpg



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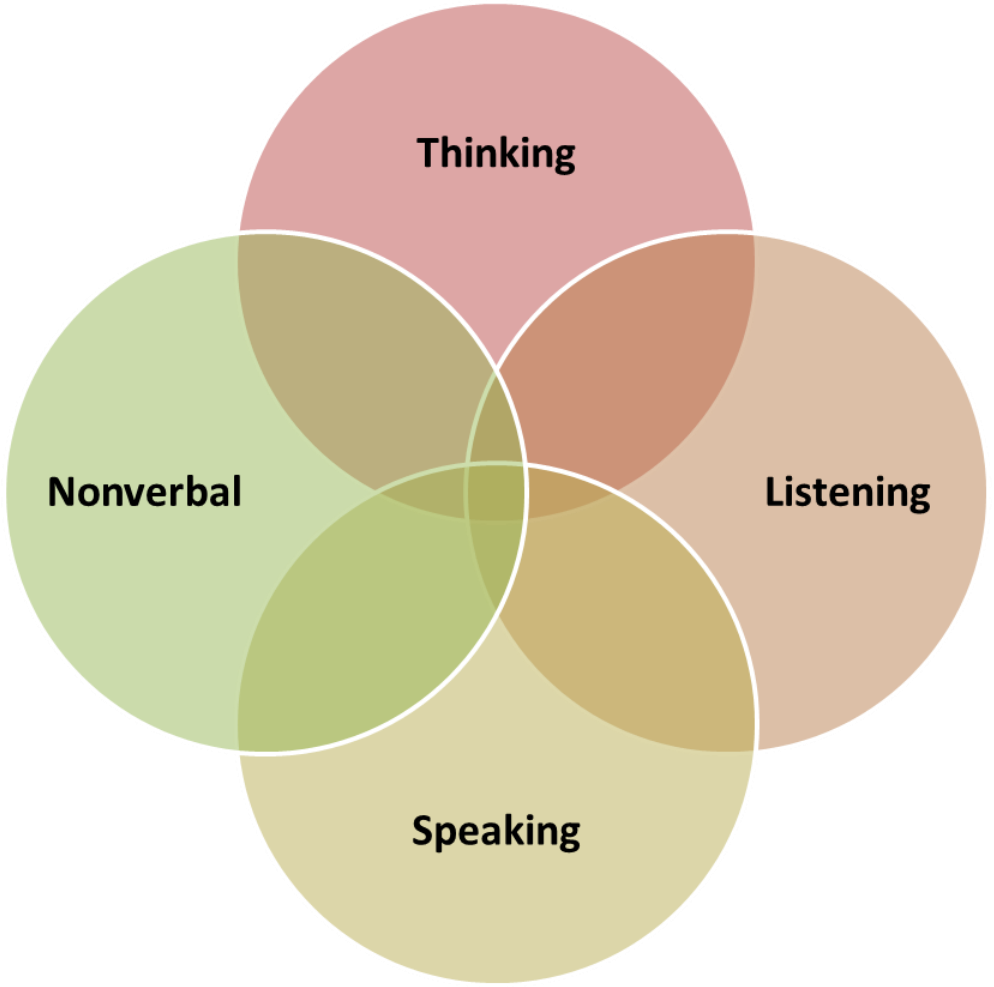
# Communication in human society

- Non-verbal
  - Hard to control
  - Influence of limbic system
- Verbal
  - Fully controllable
  - Neocortex




https://s-media-cache-ak0.pinimg.com/originals/93/dc/42/93dc4240059a0635eed4d672c98c343c.png



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# Language

- The most sophisticated tool of communication

- Language is characteristic that defines the human species
  - No human society without language
  - No other species that have a language

- Language was a precondition for development of complex society and development of culture




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http://www.zywave.com/wp-content/uploads/2015/08/culture1.jpg

# Language

- The ability to acquire and use complex systems of communication, particularly the human ability to do so

http://parsleysinmissions.org/images/postimages/language.jpg



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# Language

- The ability to acquire and use complex systems of communication, particularly the human ability to do so

- Complex hierarchic code

➢ Syllable

- Unit of organization for

a sequence of speech sounds

http://parsleysinmissions.org/images/postimages/language.jpg

➢ Word

- Symbol with a meaning

➢ Sentence

- A group of words organized according to the rules of syntax



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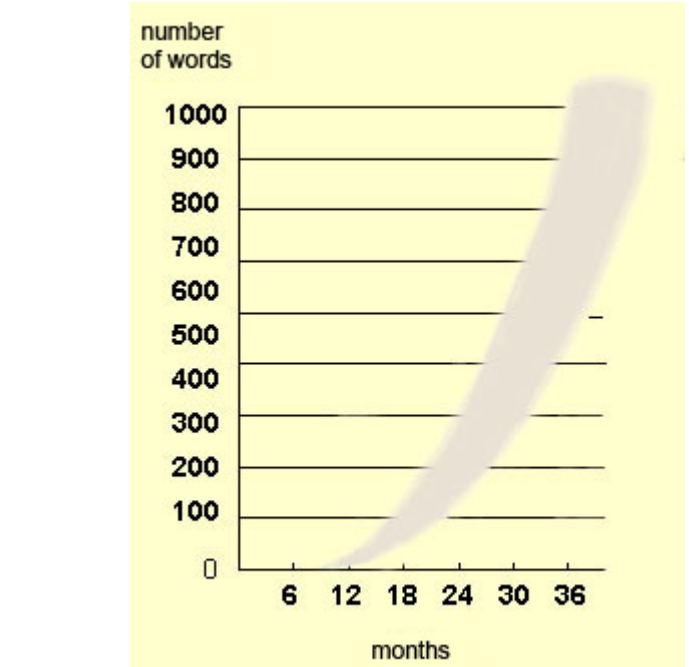
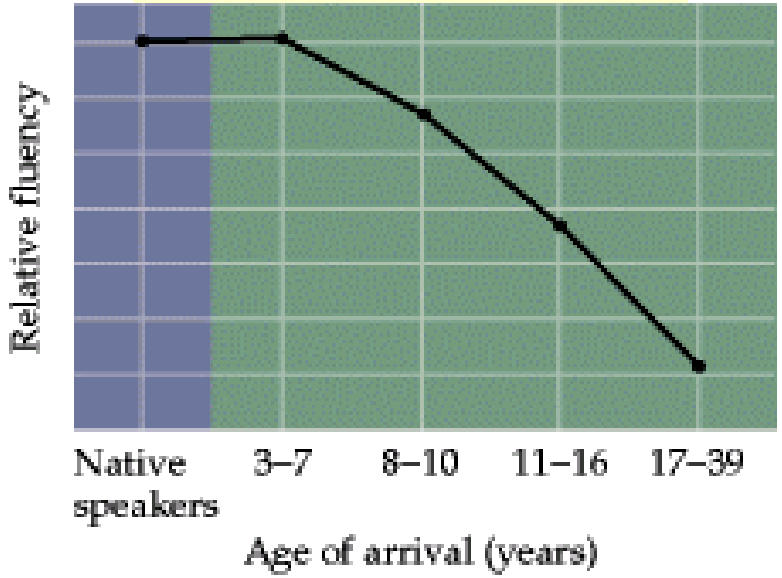
# Learning to speak

- Learning to speak takes a long time period
  - Understanding – „sensoric“
  - Speaking – „motor action“




http://www.slideshare.net/drpsdeb/presentations



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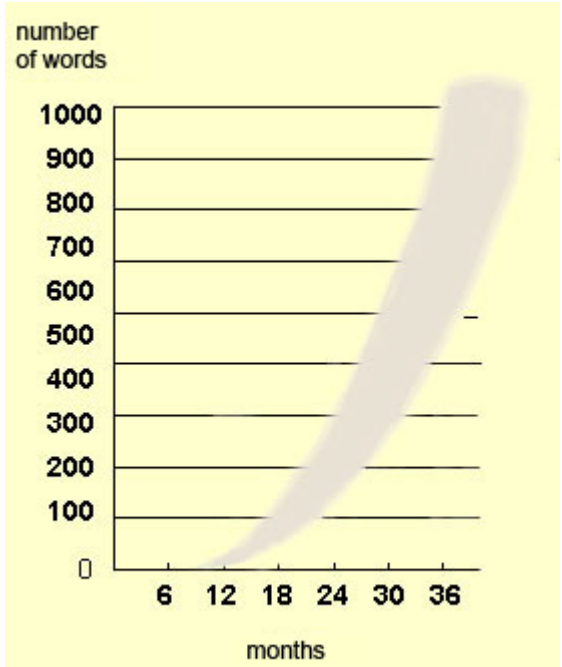
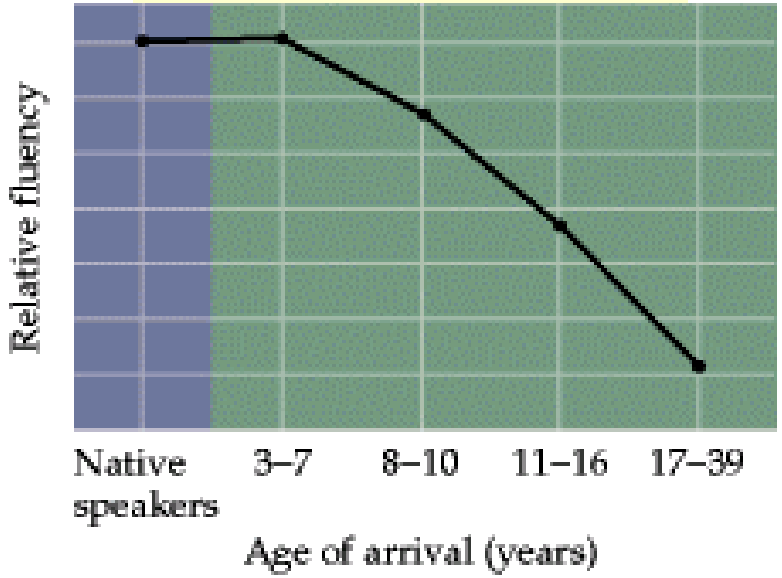
- 6. years – child uses around 2500 words

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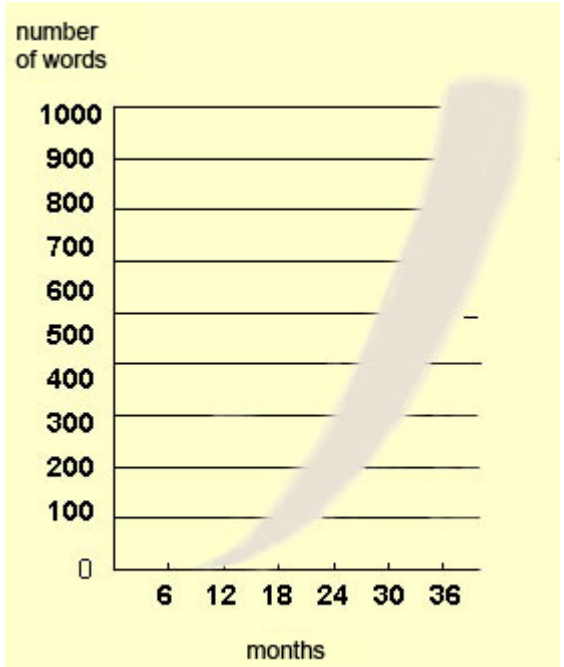
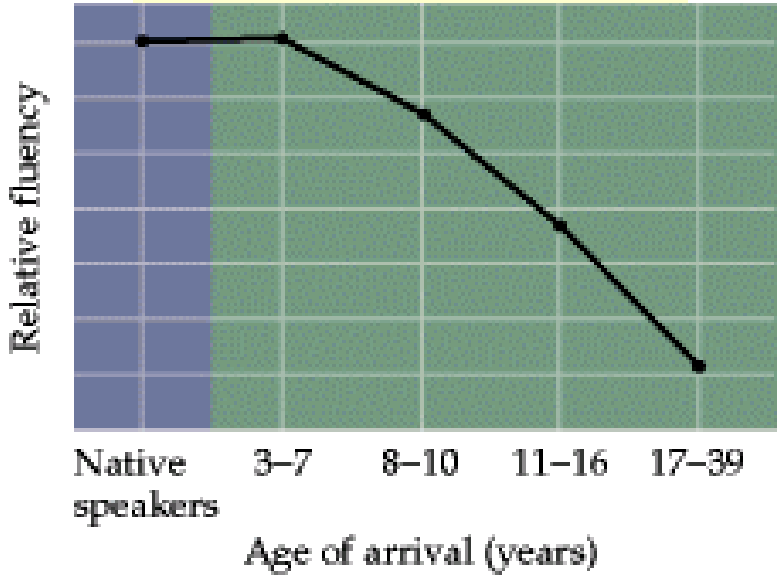
- Adult vocabulary
  - Active: 3000 -10 000 words
  - Passive: 3-6x higher than active v.

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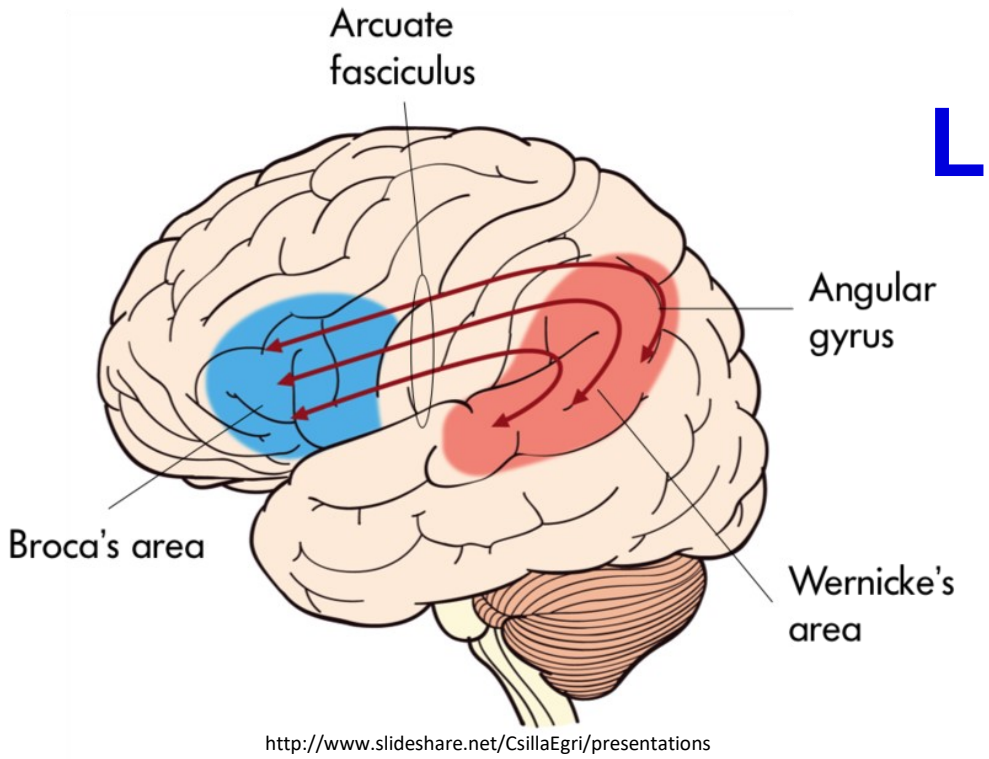
# Language areas




http://www.slideshare.net/CsillaEgri/presentations

**There are two main language areas**

- Broca´s area (motor)
  - ✓ Close to motor cortex
- Wernicke´s area (sensor)
  - ✓ Close to auditory cortex
- Fasciculus arcuatus



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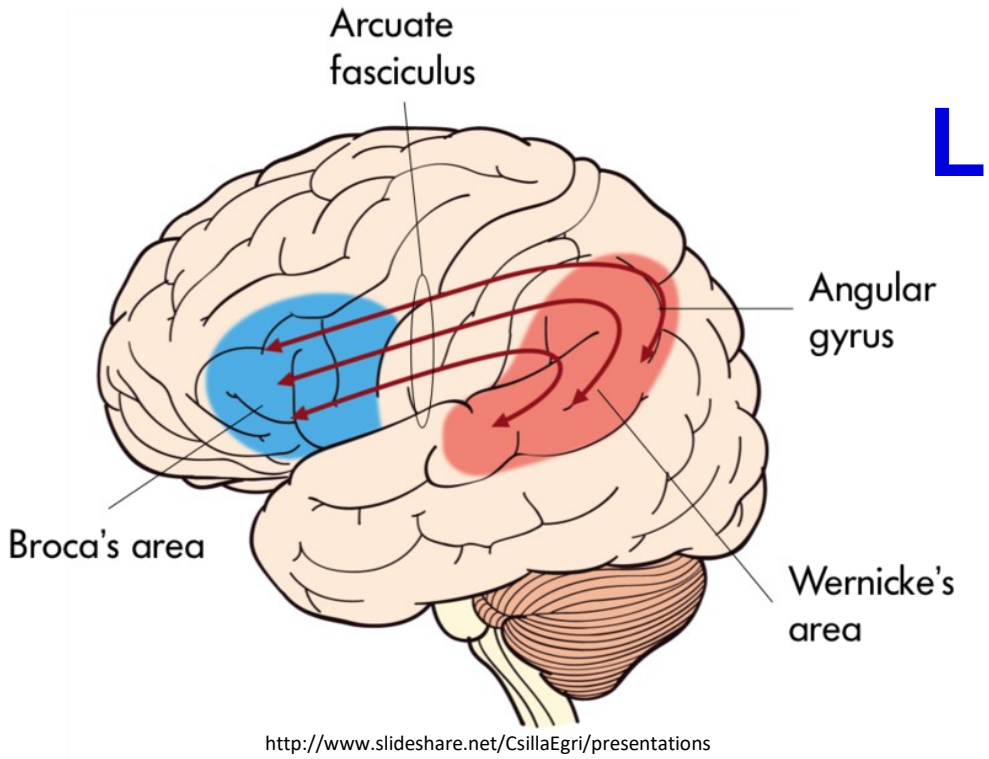
# Language areas



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- Broca´s aphasia
  - ✓ Motor, expressive
  - ✓ Comprehension preserved, speach unarticulated
- Wernicke´s aphasia
  - ✓ perceptive, sensor
  - ✓ Comprehension damaged, speech fluent, but not meaningful

- Conduction aphasia
  - ✓ Damage of fasc. arcuatus
  - ✓ Speech fluent, comprehension preserved
  - ✓ Problem with repeating words and sentences
- Dysarthria
  - ✓ Problem with articulation
  - ✓ For example, damage of vocal cord …



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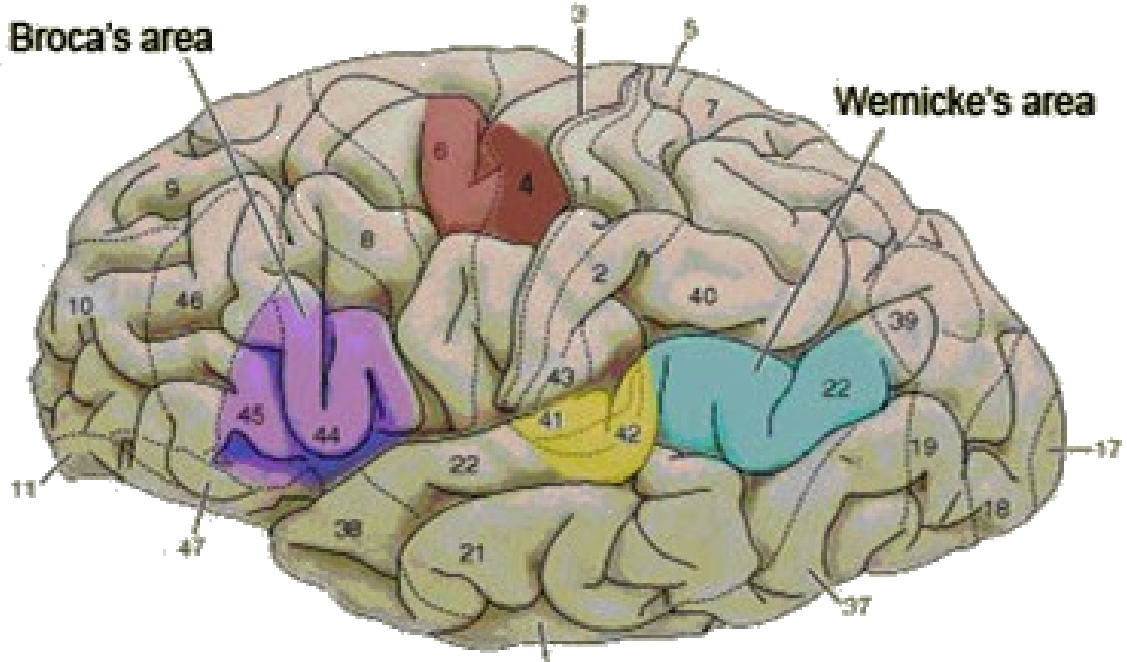
# Broca´s area




## Area 45

- ✓ Semantic processing

„selection and manipulation with appropriate words“

## Area 44

- ✓ Phonological processing and language production

„selection and activation of particular motor centers“



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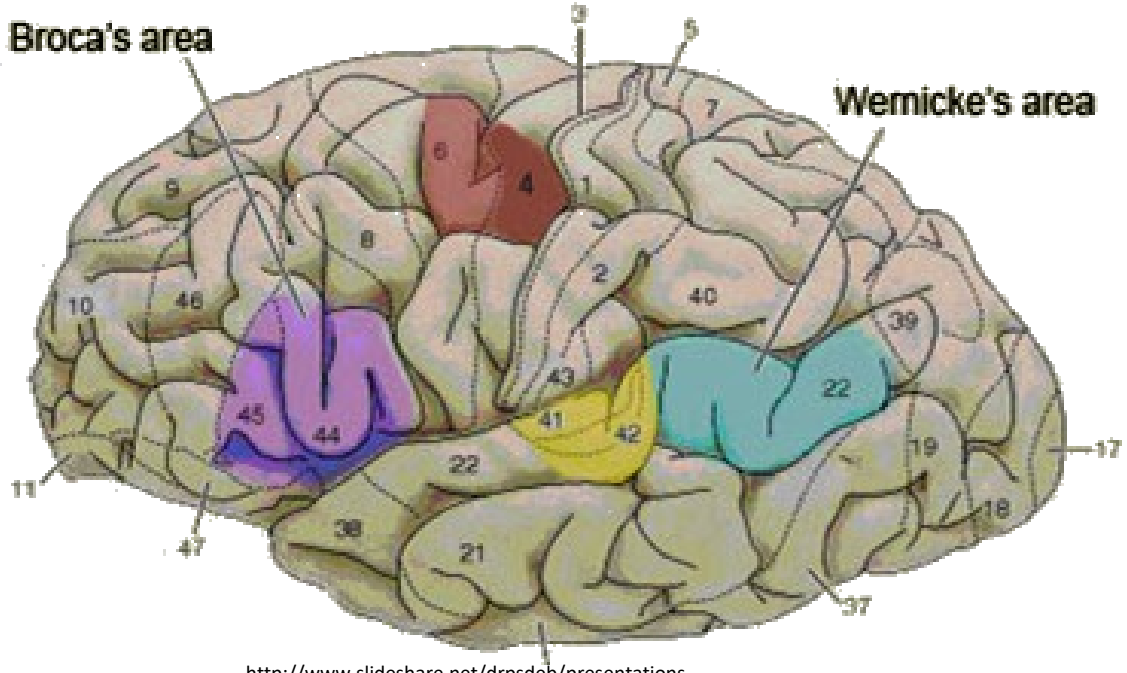
# Wernicke´s area




http://www.slideshare.net/drpsdeb/presentations

## Area 22

✓ Three subdivisions

1. The first responds to spoken words (including the individual's own) and other sounds
2. The second responds only to words spoken by someone else but is also activated when the individual recalls a list of words.
3. The third sub-area seems more closely associated with producing speech than with perceiving it



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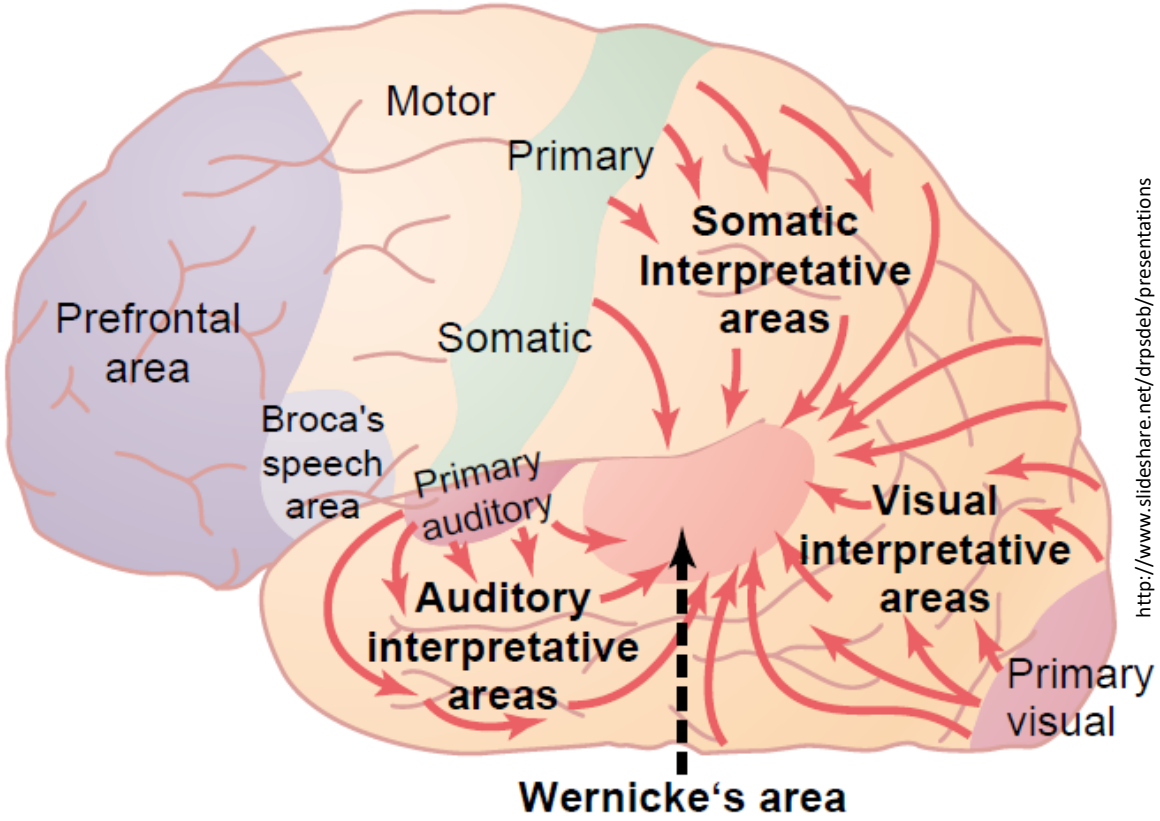
# Algorithm of sound processing

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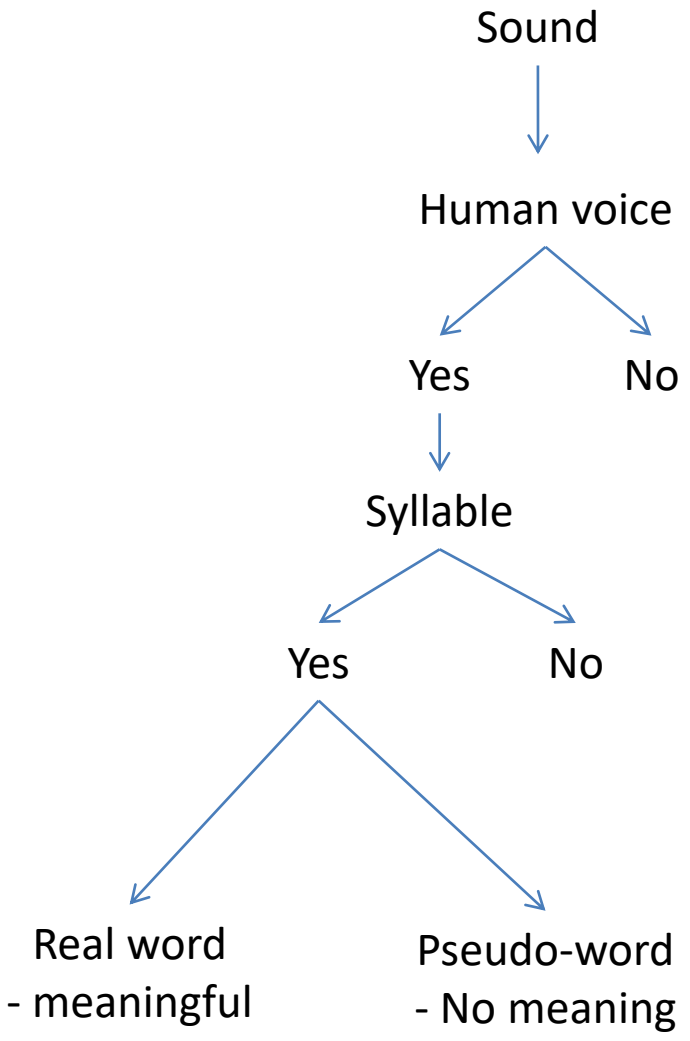


- ✓ **Wernicke´s area**
- ✓ **Broca´s area**
- ✓ **P-O-T association cortex**



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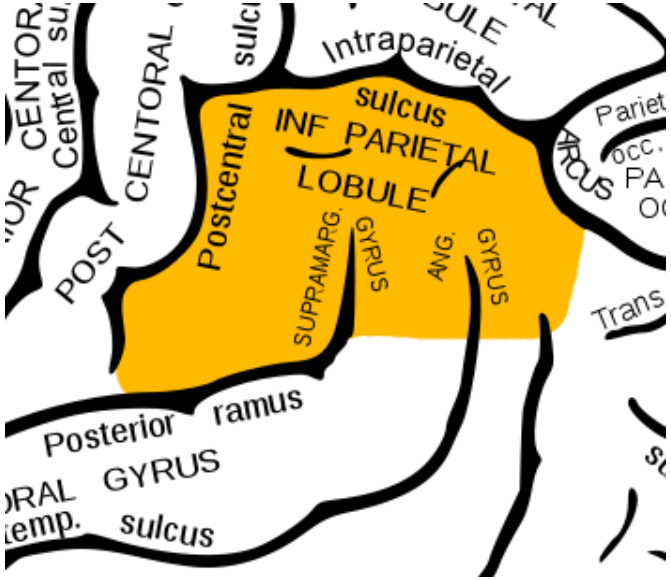
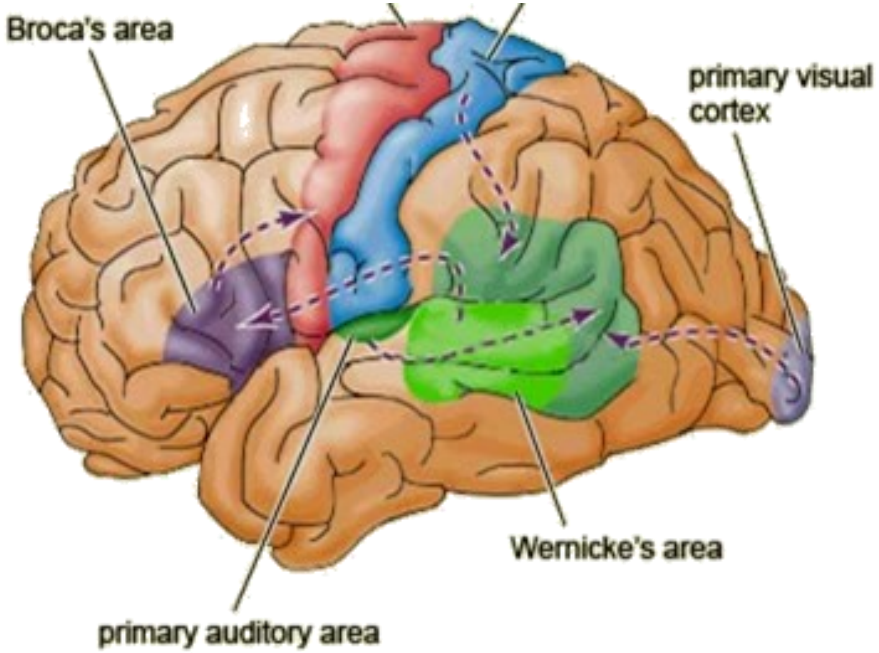
# Lobulus parietalis inferior

https://en.wikipedia.org/wiki/Inferior_parietal_lobule#/media/File:Gray726_inferior_parietal_lobule.png

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**Gyrus supramarginalis (Area 40)**

- ✓ Phonological and articulatory processing of words

**Gyrus angularis (Area 39)**

- ✓ Semantic processing

Rich communication with Broca´s and Wernicke´s areas (triangular communication)

**Integration of auditory, visual and somatosensory information**



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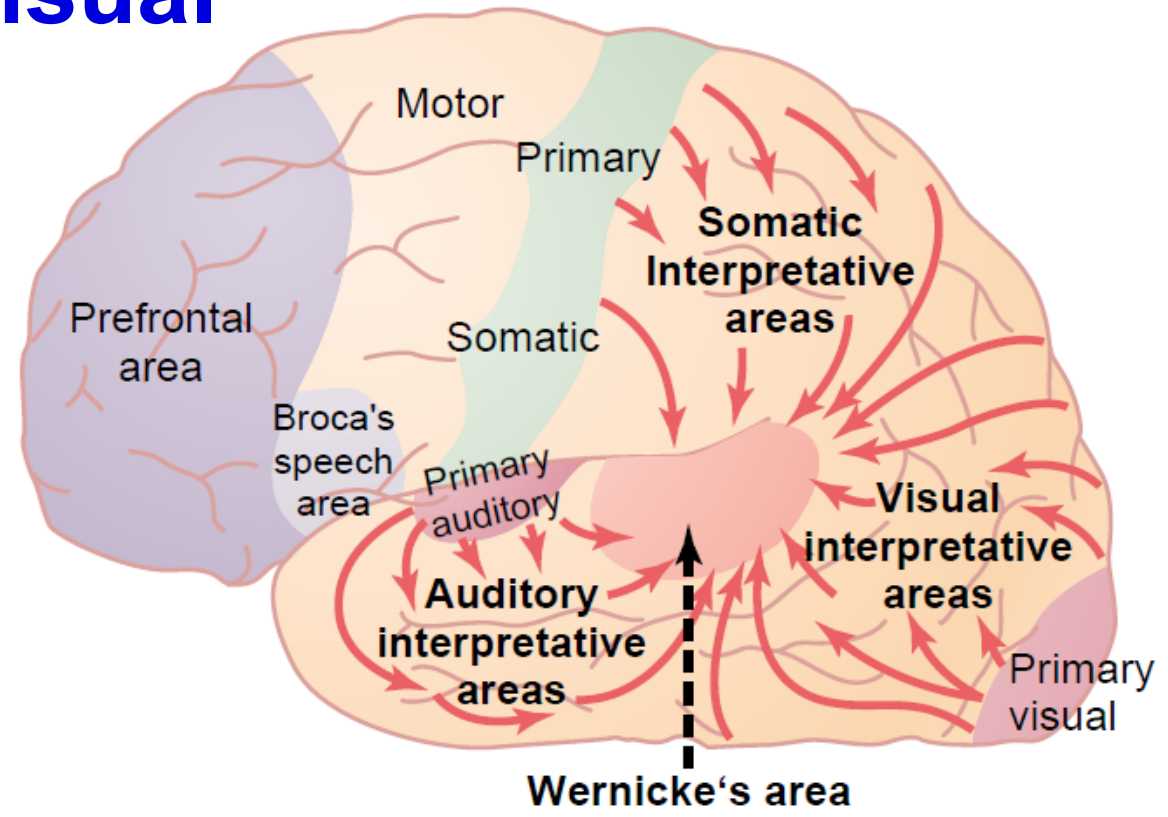
# Integration of auditory, visual and somatosensory information

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**P - O - T association cortex**

**Lobulus parietalis inferior**

- Interpretation of sound
- Interpretation of visual signal
- Interpretation of somatosensation
- Interpretation of spoken/read word

**Categorization**



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# Lobulus parietalis inferior

- Late evolutionary as well as ontogenic development
- Fully developed at the age of 5 – 6 years
  - Children usually cannot „actively“ read before this age (understand the meaning of the text which he/she reads)

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- The language („both spoken and inner“) enabled development of complex (abstract) thinking and development of culture
- The human society development is linked to information technology development
  - ✓ Spoken language
  - ✓ A system of writing
  - ✓ Printing
  - ✓ Internet

# Language functions lateralization

- Broca´s and Wernicke´s area is localized in the left hemisphere in 97% of people

- Localization of B-W areas is not fully linked to left/right hand lateralization
  - ✓ 90% of people are right handed
  - ✓ 95% of right handed people have B-W area in the left hemisphere
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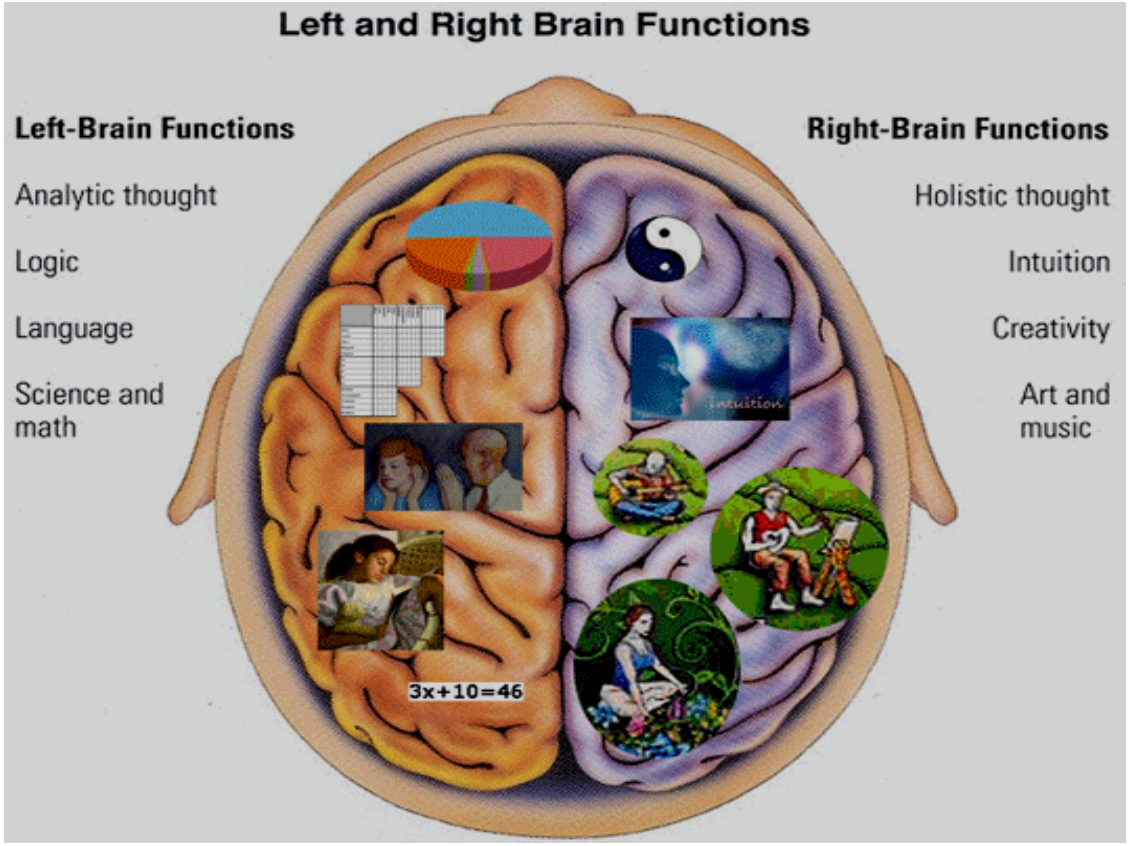
- Some scientists suggest that the left hemisphere dominance for language evolved from this hemisphere's better motor control
- The language specialization develops in the left hemisphere, which matures slightly earlier

# Right hemisphere language functions

- Non-verbal aspect of language
  - ✓ Prosody – intonation, stress…
- Non-literal language aspects
  - ✓ Irony
  - ✓ Metaphors
- Understanding to discourse / complex speech
  - ✓ Lecture, discussion

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# Women and language

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- The males' higher levels of testosterone, which delays the development of the left hemisphere
  - 4 times more boys than girls suffer from stuttering, dyslexia

# Functional diagnostic methods

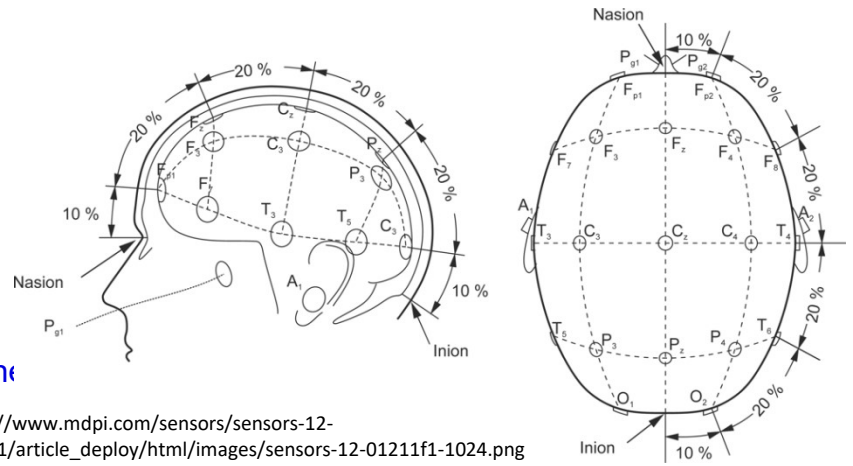
- Detection of electrical activity
  - Higher neuronal activity  - higher electrical activity
  - Electroencephalography (EEG)

- Detection of regional blood flow
  - Higher neuronal activity – increased blod flow
  - Single photon emission tomography (SPECT)
  - Positron emission tomography (PET)
  - Functional magnetic resonance  imaging (fMRI)

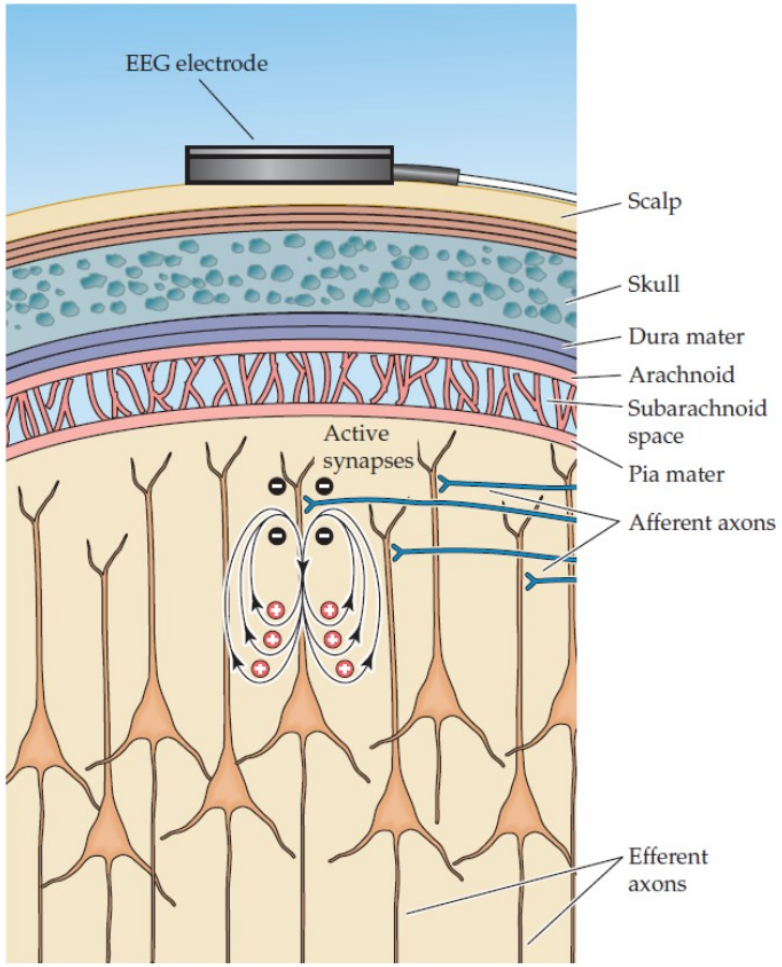
# EEG

- Detection of neuronal electrical activity
- monopolar arrangement:
  - active electrode
  - indifferent electrode

  = referential recording
- bipolar recording
  - lead (channel)
  - ground electrode
- EEG voltage in microvolts (*vs.* in mV in neurons)




http://www.mdpi.com/sensors/sensors-12-01211/article_deploy/html/images/sensors-12-01211f1-1024.png




http://www.slideshare.net/kj_jantzen/biophysical-basis-of-eeg



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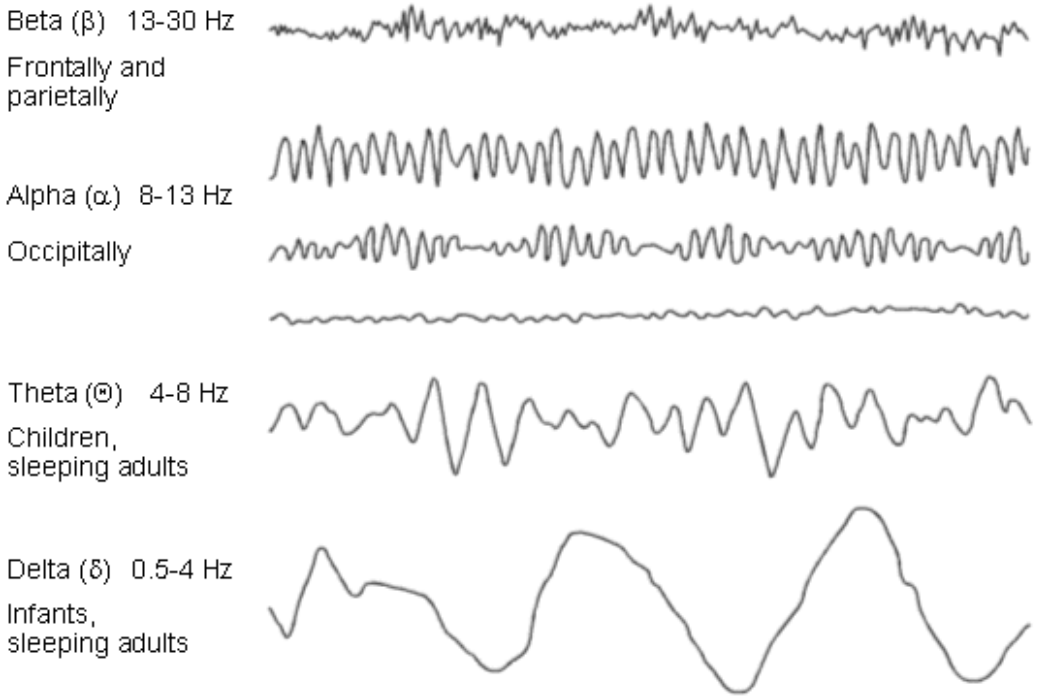
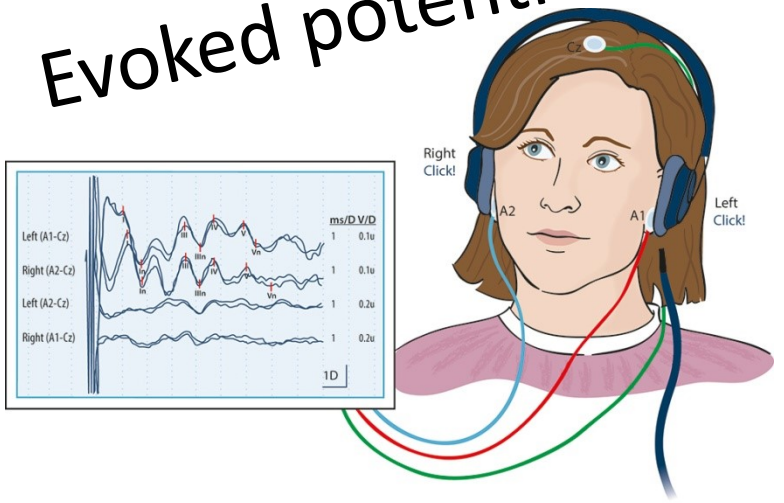
# EEG




## Evoked potentials




http://tidsskriftet.no/2013/05/evoked-potential-tests-clinical-diagnosis



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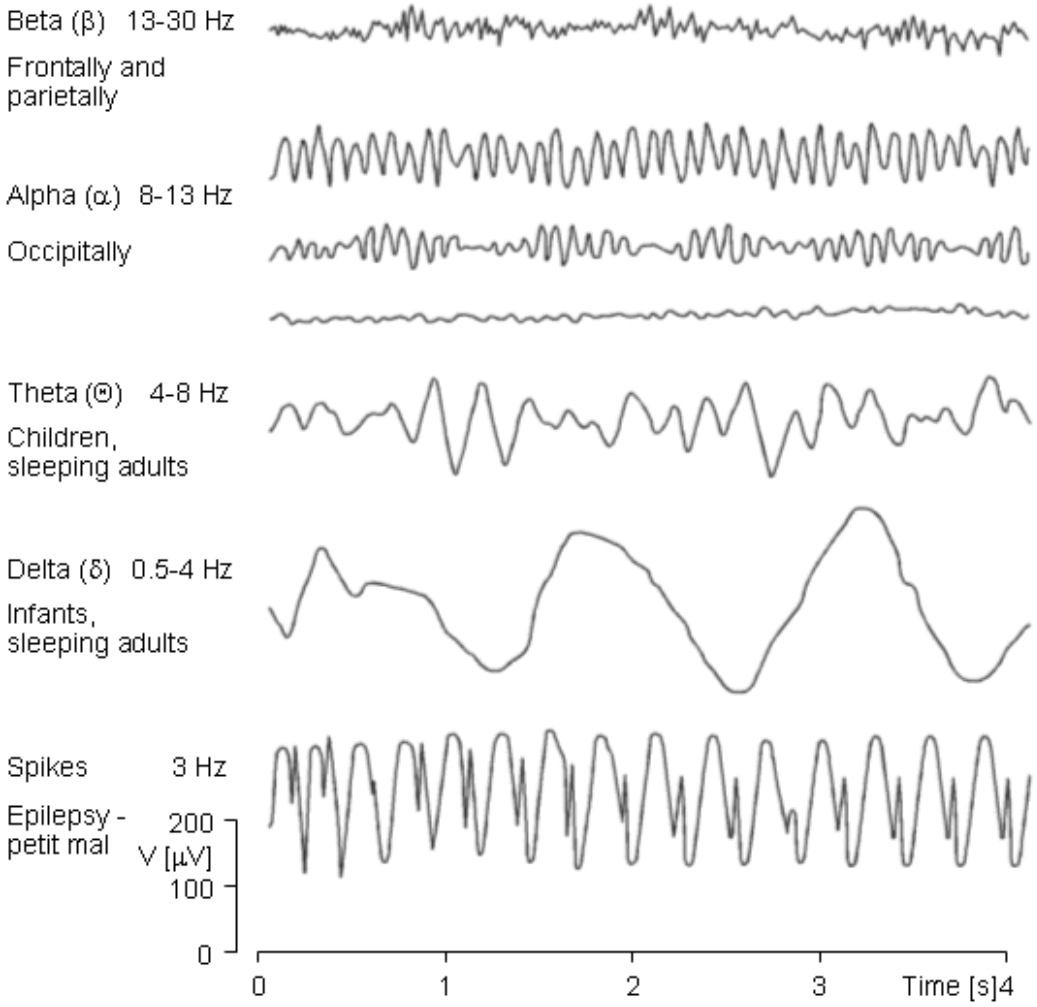
# EEG

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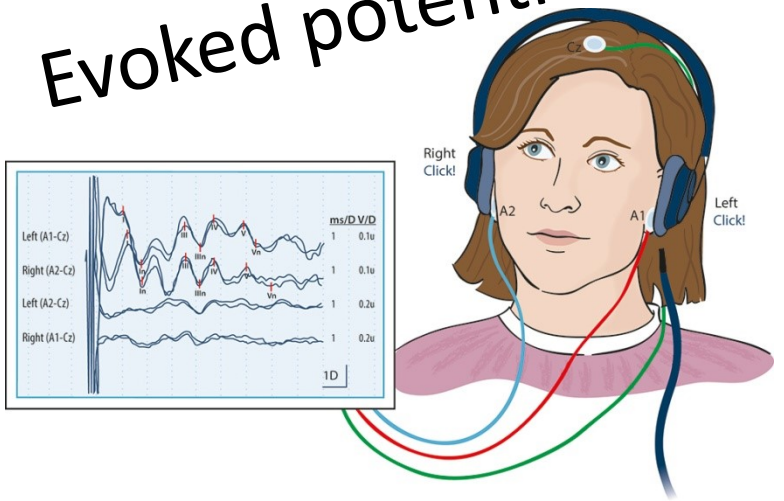


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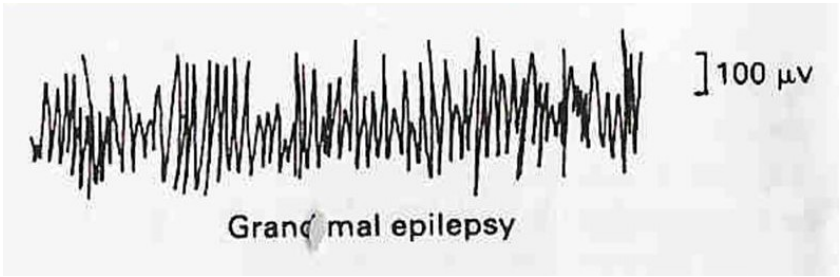


https://www.google.com/search?q=GRAND+MAL+EEG&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjyr82Im6veAhUliaYKHfquClkQ_AUIDigB&biw=1222&bih=574#imgrc=nCNGCX88H3K7ZM:

http://www.slideshare.net/vaishbhoi12/eeg-53489764



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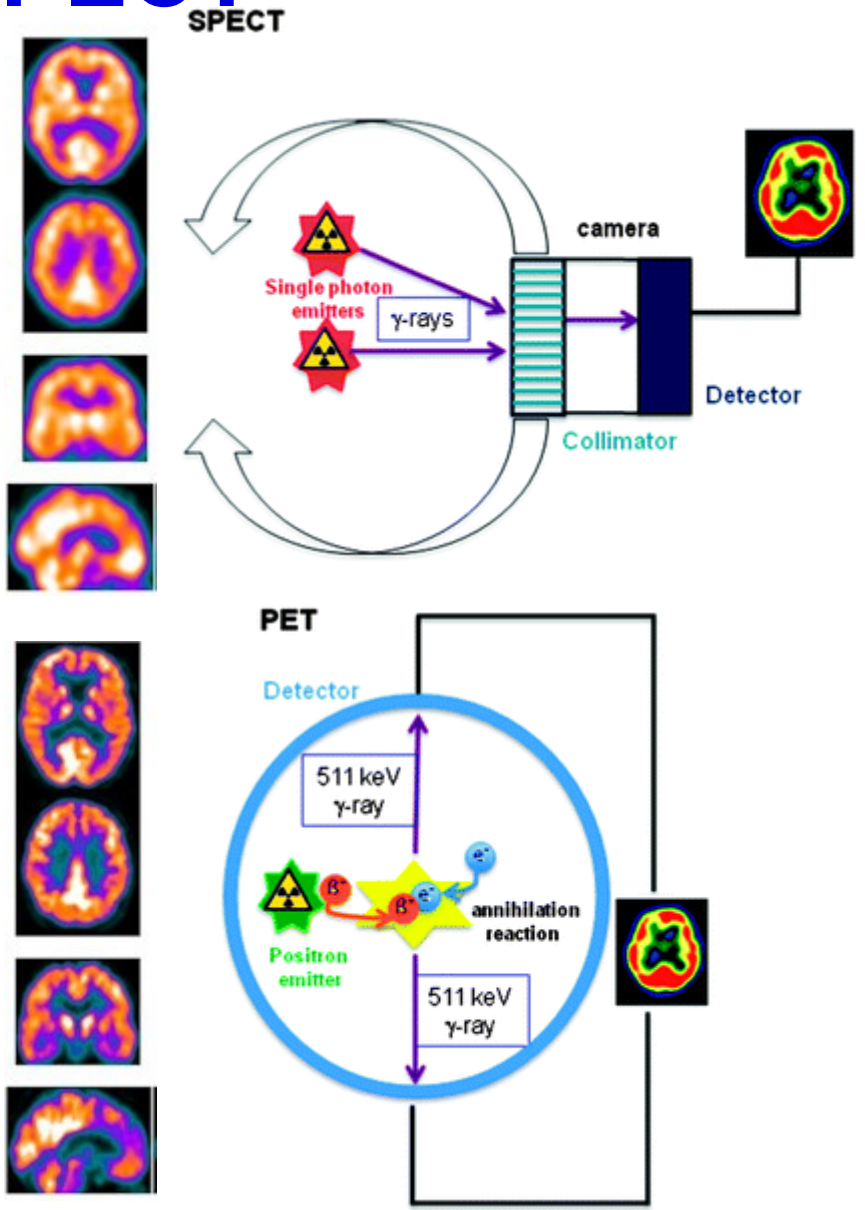
# PET a SPECT

- Injection of radionuclide labeled substances
- Short half live of radionuclide
  - Necessary to prepare shortly before application
  - Nuclear medicine department
- SPECT
  - Single photon emission computer tomograhy
  - radionuclide is the source of gamma rays
  - Low resolution (around 1 cm)
- PET
  - Positron emission tomography
  - radionuclide  is the source of positrons
  - Positron annihilation produces two gamma photons – higher resolution (around 2mm)




http://pubs.rsc.org/services/images/RSCpubs.ePlatform.Service.FreeContent.ImageService.svc/ImageService/Articleimage/2013/CS/c3cs60086f/c3cs60086f-f4.gif



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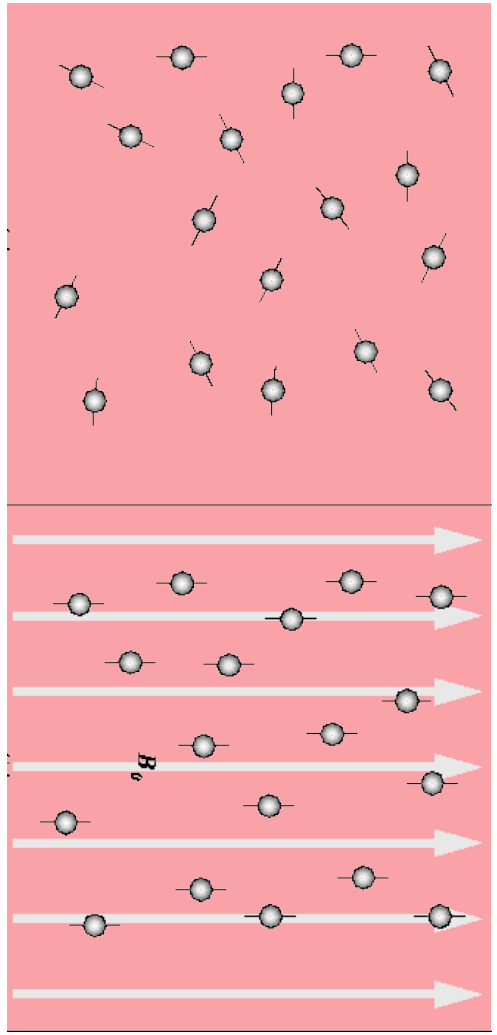
# fMRI

- Different atoms (nuclei) have various magnetic properties when exposed to strong magnetic field
- Hydrogen
- fMRI uses different magnetic properties of oxy- and deoxyhemoglobin
- reduced hemoglobin becomes paramagnetic, change the signal emitted by blood, we can measure the amount of oxy- and deoxyhemoglobin as an indicator of the blood flow
- High resolution (up to1mm)
- No radiation



https://www.cs.sfu.ca/~stella/papers/blairthesis/main/node11.html



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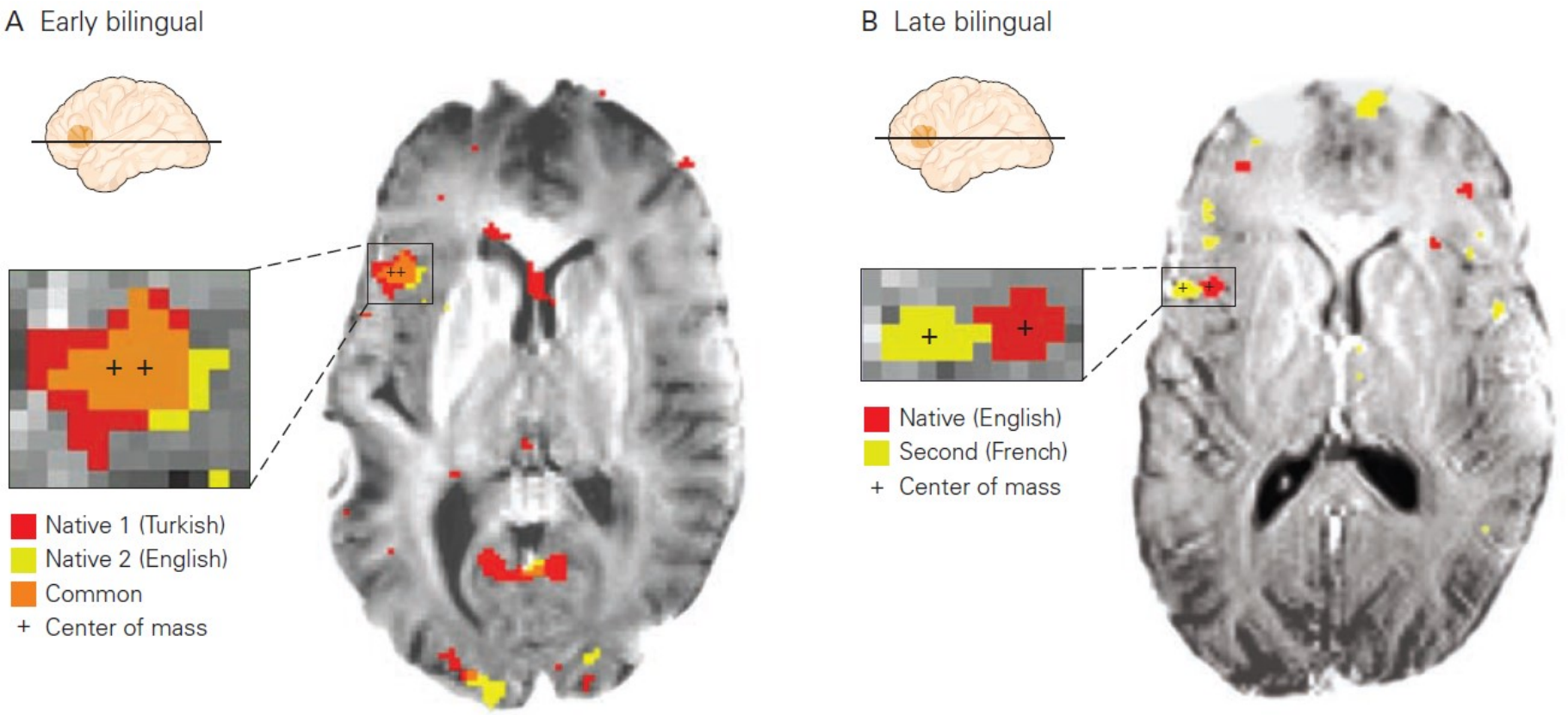
# fMRI




Kim, K. H. S., Relkin, N. R., Lee, K.-M. & Hirsch, J. Distinct cortical areas associated with native and second languages. *Nature* **388,** 171–174 (1997).



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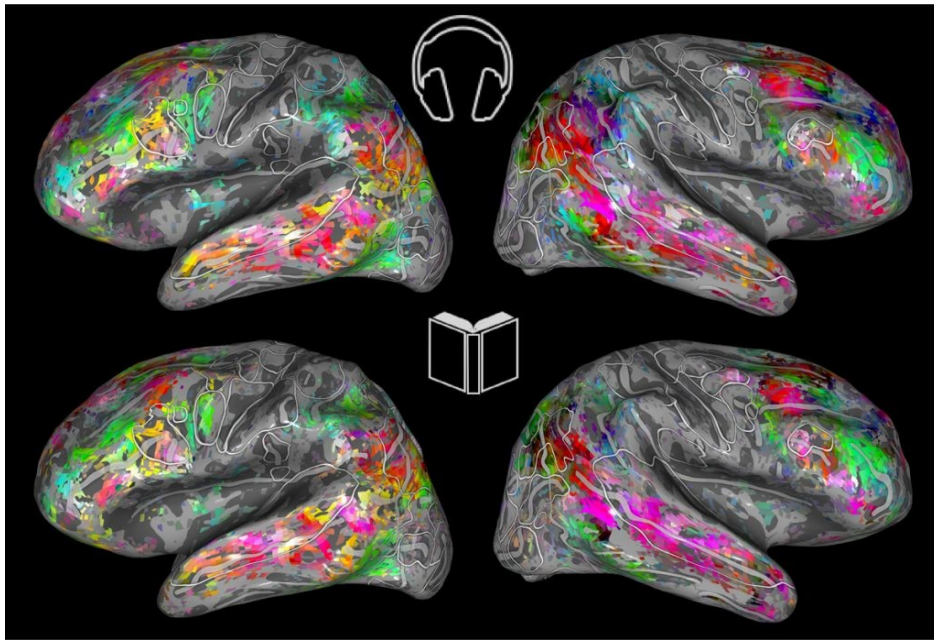

http://blogs.discovermagazine.com/d-brief/2019/08/22/reading-listening-activate-same-brain-regions/#.XbhBsppKi00

J Neurosci. 2019 Sep 25;39(39):7722-7736. doi: 10.1523/JNEUROSCI.0675-19.2019. Epub 2019 Aug 19.

## The Representation of Semantic Information Across Human Cerebral Cortex During Listening Versus Reading Is Invariant to Stimulus Modality.

Deniz F[1,2,3,4], Nunez-Elizalde AO[1], Huth AG[1], Gallant JL[5,3].

Author information

**Abstract**

An integral part of human language is the capacity to extract meaning from spoken and written words, but the precise relationship between brain representations of information perceived by listening versus reading is unclear. Prior neuroimaging studies have shown that semantic information in spoken language is represented in multiple regions in the human cerebral cortex, while amodal semantic information appears to be represented in a few broad brain regions. However, previous studies were too insensitive to determine whether semantic representations were shared at a fine level of detail rather than merely at a coarse scale. We used fMRI to record brain activity in two separate experiments while participants listened to or read several hours of the same narrative stories, and then created voxelwise encoding models to characterize semantic selectivity in each voxel and in each individual participant. We find that semantic tuning during listening and reading are highly correlated in most semantically selective regions of cortex, and models estimated using one modality accurately predict voxel responses in the other modality. These results suggest that the representation of language semantics is independent of the sensory modality through which the semantic information is received. **SIGNIFICANCE STATEMENT** Humans can comprehend the meaning of words from both spoken and written language. It is therefore important to understand the relationship between the brain representations of spoken or written text. Here, we show that although the representation of semantic information in the human brain is quite complex, the semantic representations evoked by listening versus reading are almost identical. These results suggest that the representation of language semantics is independent of the sensory modality through which the semantic information is received.



**KEYWORDS:** BOLD; cross-modal representations; fMRI; listening; reading; semantics

PMID: 31427396 PMCID: PMC6764208 [Available on 2020-03-25] DOI: 10.1523/JNEUROSCI.0675-19.2019



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# The Highest Level of Cerebral Activity

# Three States of Cognition

Philosophy : Mind behind Mind


Neuroscience: Brain

Psychology : Mind

**PS Deb**



http://www.slideshare.net/drpsdeb/presentations

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# Why?


A human is an individual
A human is a social being
Decision making



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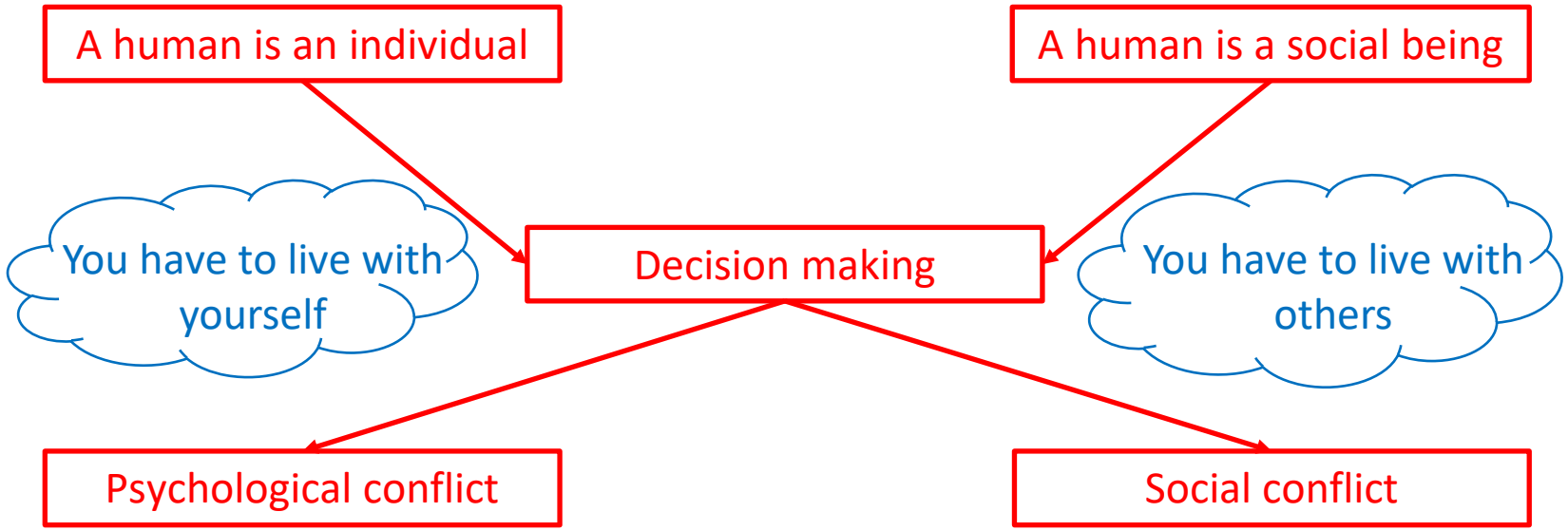
# Why?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Decision making
You have to live with others
Psychological conflict
Social conflict



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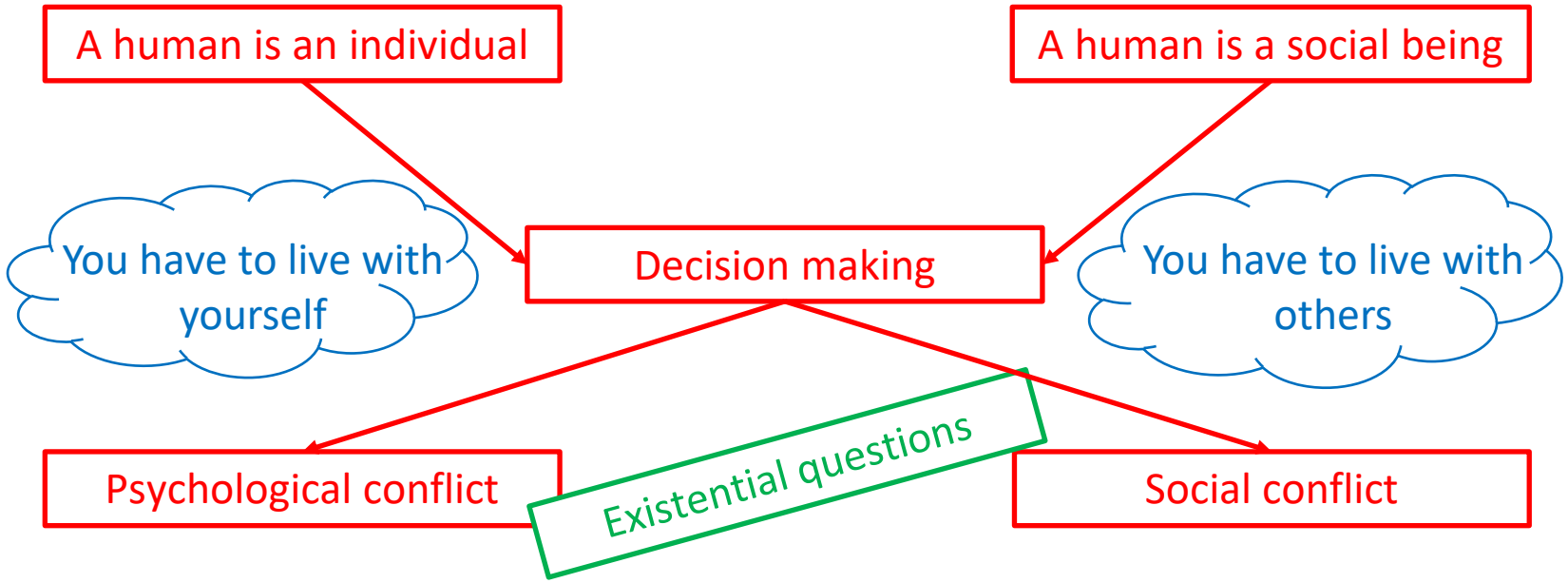
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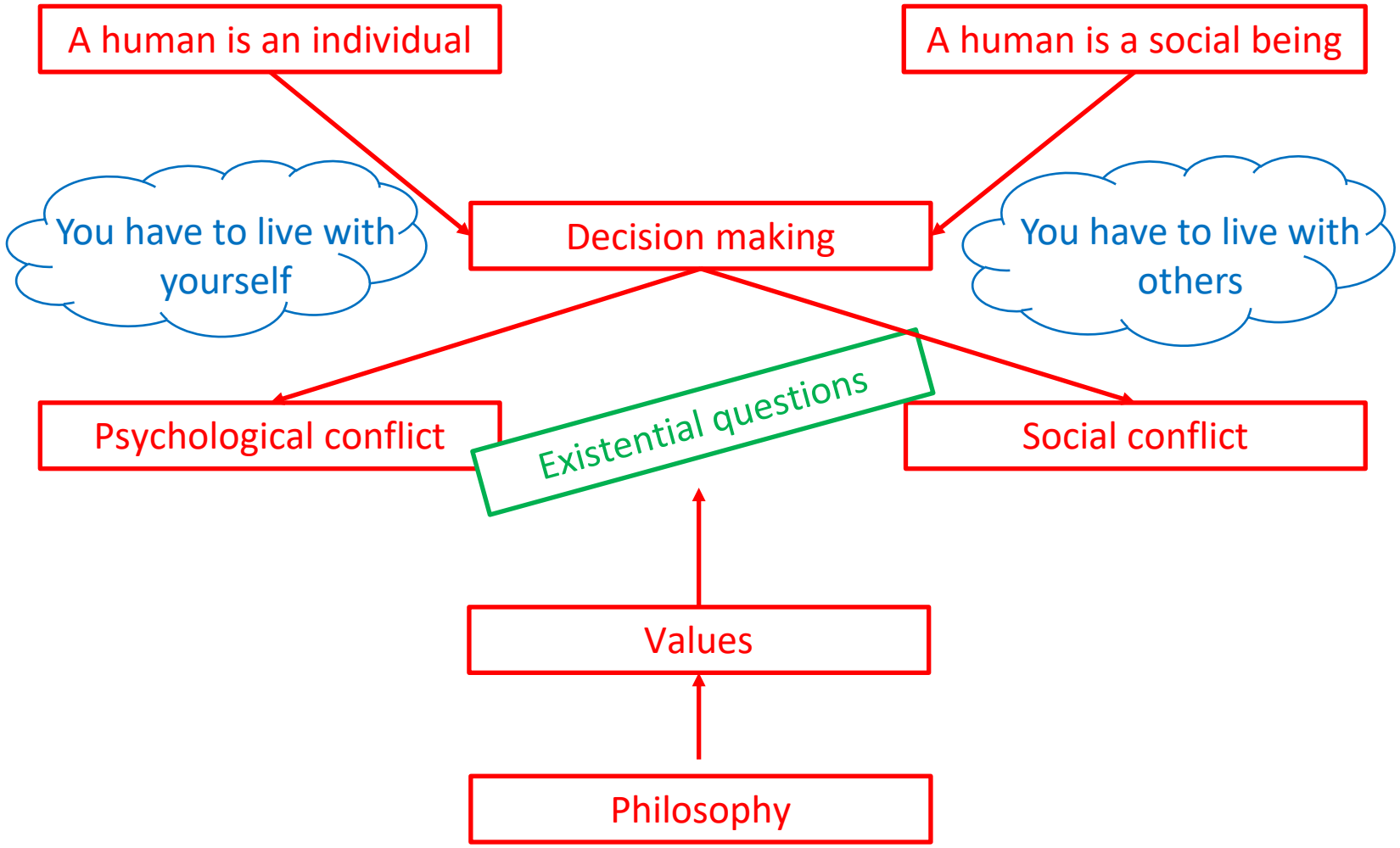
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Values
Philosophy



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# Philosophy

**Philosophy of life** is a personal philosophy, whose focus is **resolving the existential questions** about the human condition.

Wikipedia



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FORMAL PHILOSOPHY

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COLLECTIVE CONSCIOUSNESS

**Collective consciousness** or collective conscio us is the **set of shared** beliefs, ideas and moral attitudes which operate as a **unifying force within society.**

Wikipedia



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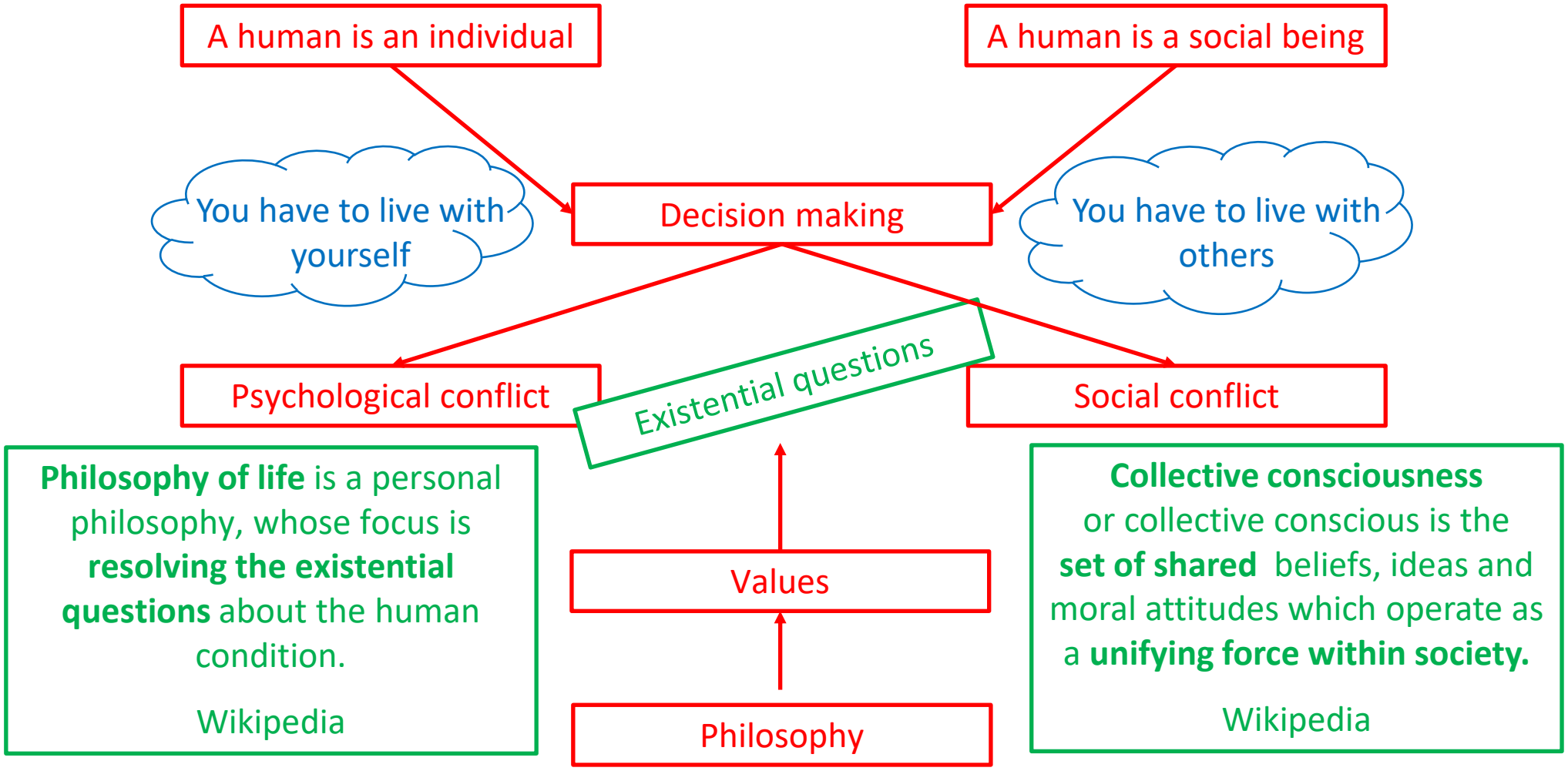
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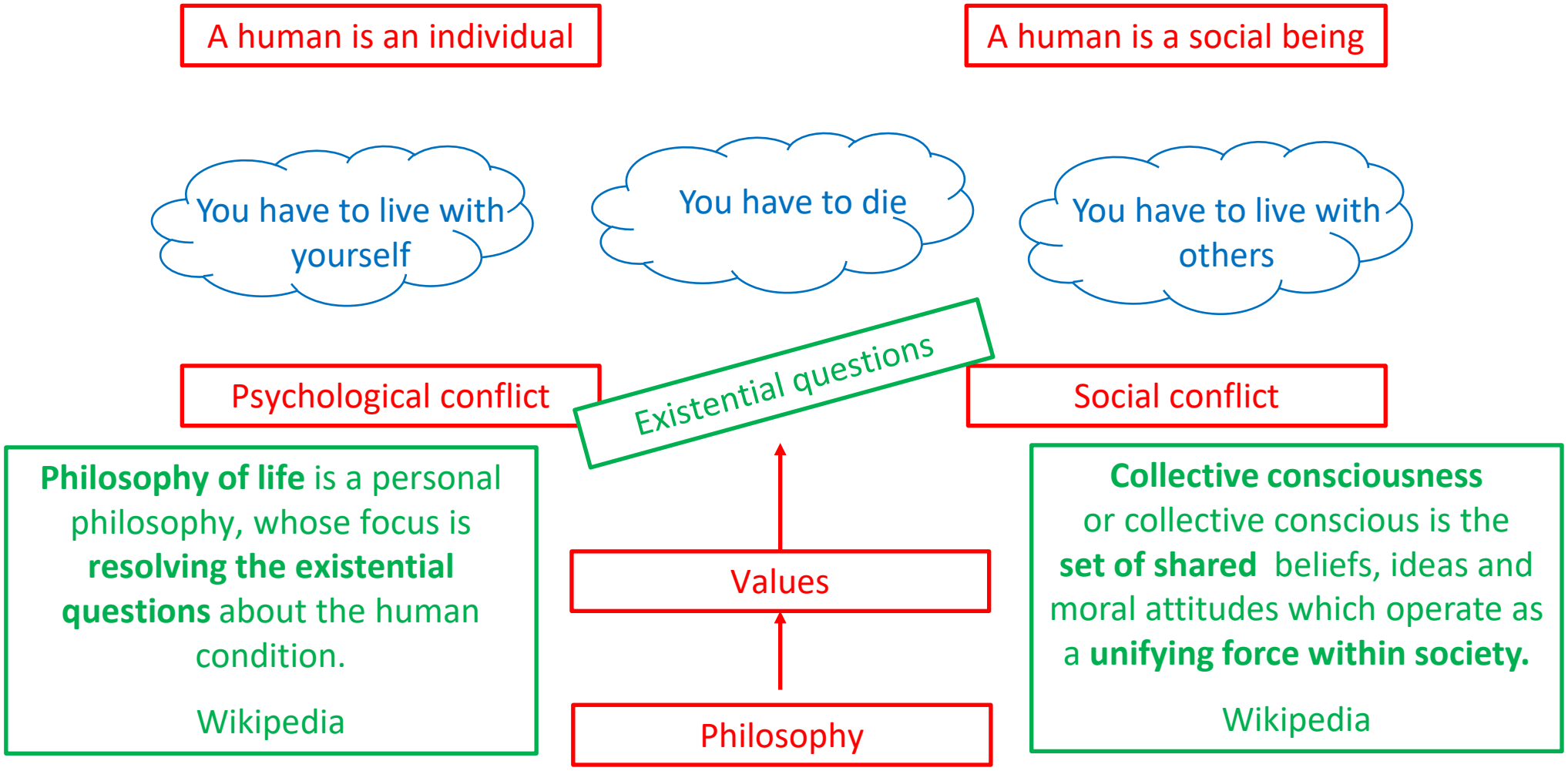
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# Jan Sokol

http://www.jansokol.cz/2014/03/civilizace-kultura-a-nabozenstvi/

## Three levels of life in society

Civiliztion level

- Everyday activities, user
- „Manual“ is sufficient, imitation

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- Creativity
- Knowldege and technique are needed

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**Civiliztion level**

- Everyday activities, user
- „Manual“ is sufficient, imitation

**Cultural level**

- Creativity
- Knowldege and technique are needed

**Religious level**

- Inspiration of creativity
- Awareness of meaning is needed



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# Culture

## – the sum of knowledge

- ✓ Material
- ✓ Spiritual

https://cdn.nexternal.com/tjb/images/FC-11.jpg

https://s-media-cache-ak0.pinimg.com/564x/9a/86/da/9a86da32052973bb085dc1511d4b7102.jpg

http://previews.123rf.com/images/dja65/dja651107/dja65110700341/10025966-Stone-age-axe-Stock-Photo-tools-ancient-stone.jpg

http://www.thebushcraftstore.co.uk/ekmps/shops/bduimportsltd/images/condor-greenland-pattern-axe-[2]-12105-p.jpg

https://en.wikipedia.org/wiki/File:Mary16thC.jpg

https://www.wikiart.org/en/leonardo-da-vinci/the-madonna-of-the-carnation

https://pixels.com/featured/1-madonna-and-child-peter-paul-rubens.html

https://www.wikiart.org/en/m-h-maxy/madonna



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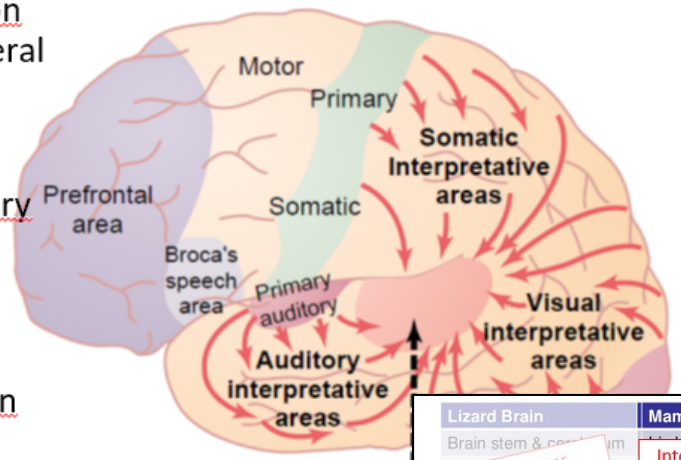
# Complementary ways of thinking

Analytical functions

## Parieto-occipito-temporal association area

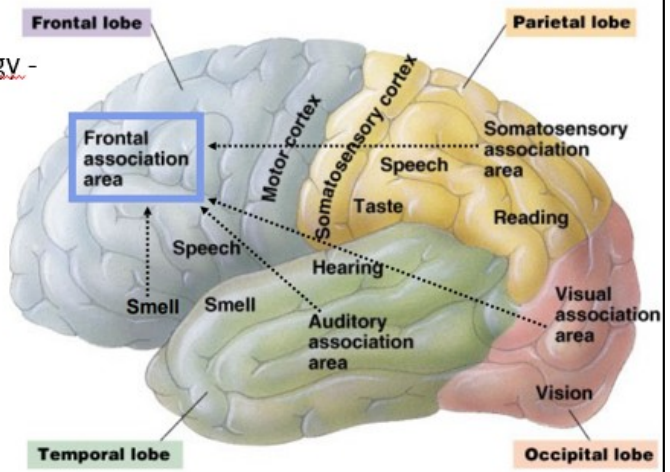
- Linking and interpretation of information from several sensory modalities
- Visual – acoustic – sensory analysis
- Object recognition and categorization
- Language comprehension
- Attention



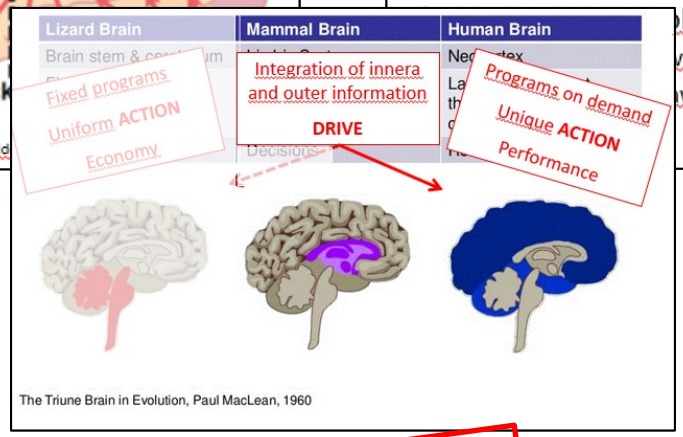

Executive functions

## Frontal association area

- Motor/non-motor planning/organization - strategy - anticipation
- Thinking – mental models processing
- Attention – „information filtering“




https://www.slideshare.net/thelawofscience/cns-13256395




The Triune Brain in Evolution, Paul MacLean, 1960

Analysis
Categorization

Anticipation
Expectation

Drive



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# Comp inking

## Parieto-occipito-tempora association area

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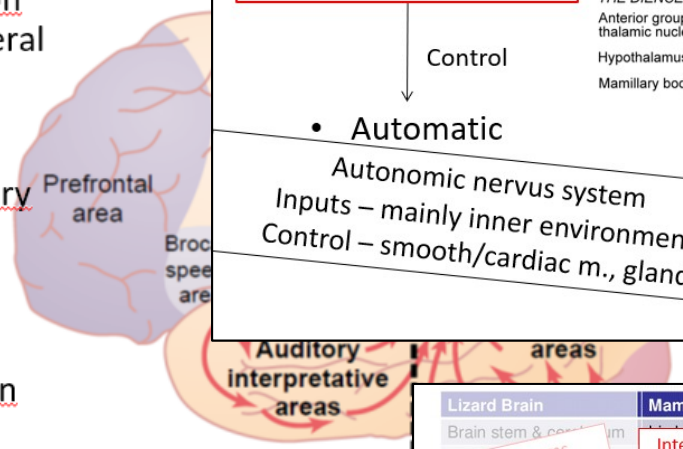



## Concept of the limbic system

Somatic nervous system
Inputs – mainly from outer environment
Control – skeletal muscle

- Voluntary

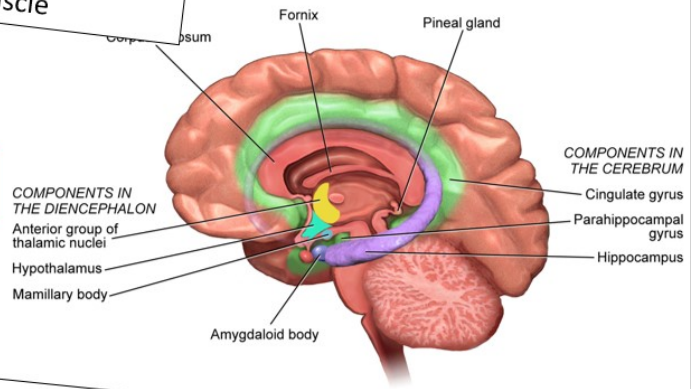
Modulation

**Limbic system**

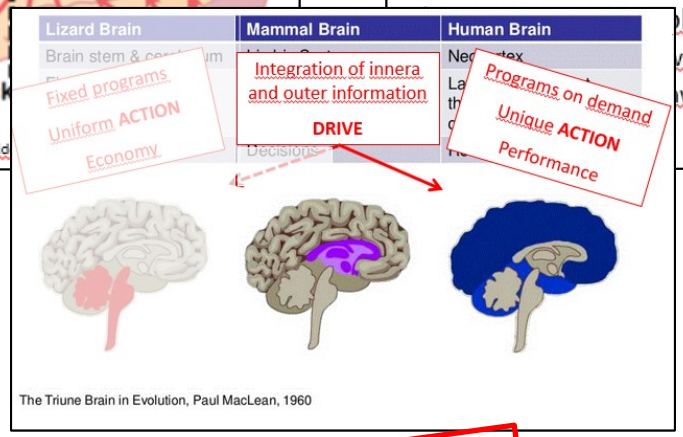
Control

- Automatic

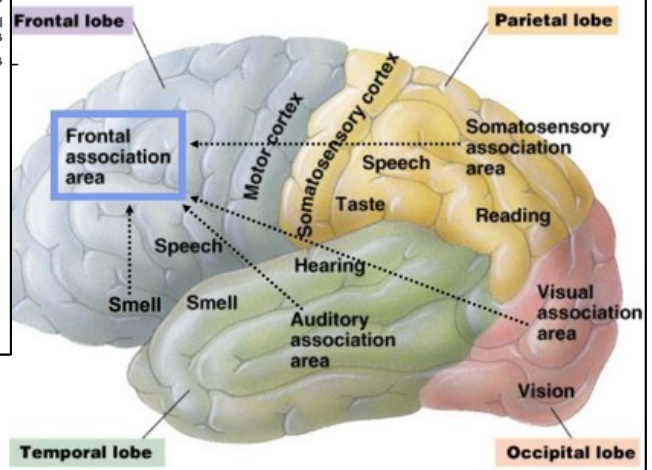
Autonomic nervus system
Inputs – mainly inner environment
Control – smooth/cardiac m., glands




https://upload.wikimedia.org/wikipedia/commons/d/d1/Blausen_0614_LimbicSystem.png




Executive functions

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**Analysis Categorization**

**Drive**

**Anticipation Expectation**



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# Limbic system and neocortex

**Instinctive behavior**

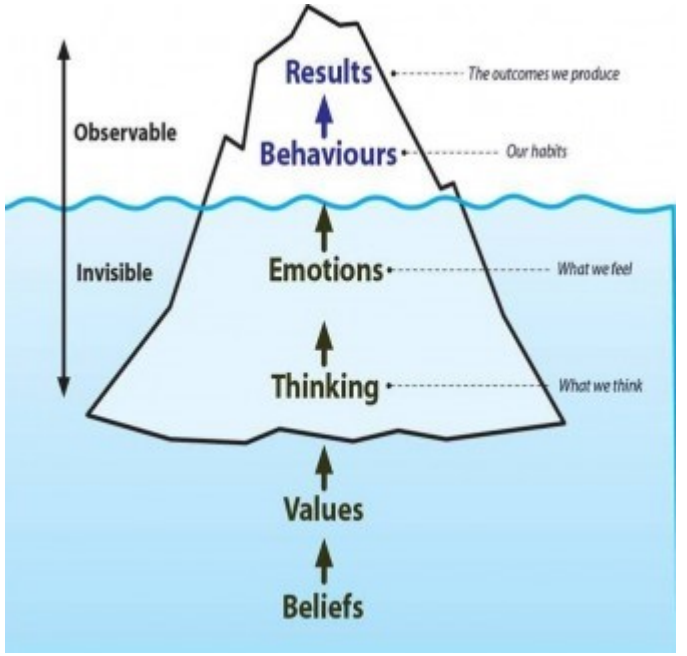
- ➢ Limbic system
- ✓I see a nice thing, so why not to steel it?

**Socially enforced behavior**

- ➢ Legal behavior
- ➢ Neocortex – limbic system
- ✓Theft is a crime, and punishment may come

**Moral behavior**

- ➢ Legitime behavior
- ➢ Limbic system
- ✓Stealing is a bad thing

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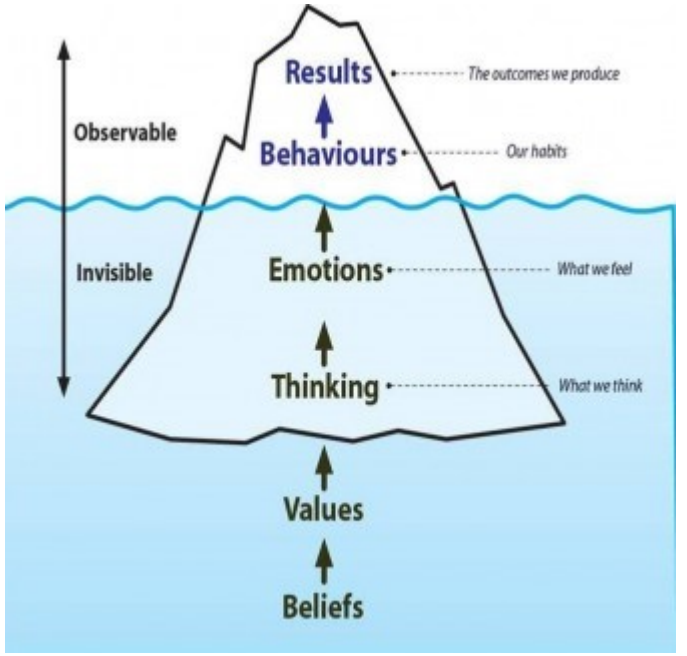
- ➢ [illegible]mbic system
- ✓[illegible]s a crime, and punishment may come

Fear of punishment

**Moral behavior**

- ➢ L[illegible]avior
- [illegible]stem
- ✓Stealing is a bad thing

Moral stance

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# Limbic system and neocortex

**Information**

NEOCORTEX

vs

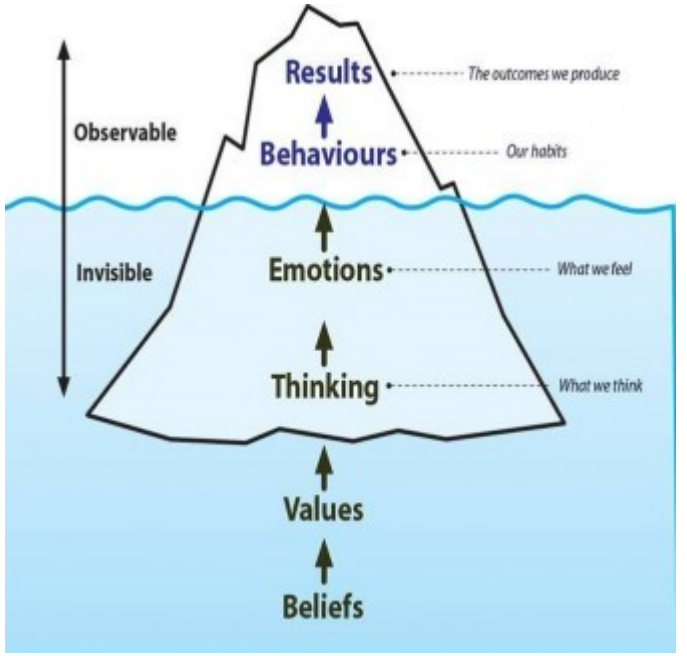
**Complex information**

NEOCORTEX/limbic system

vs

**Values/Philosophy/Faith**

Neocortex/LIMBIC SYSTEM

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# Cognitive maps

Type of **mental representation** which serves an individual to acquire, code, store, recall, and decode information about the **relative locations and attributes** of phenomena in their everyday or metaphorical spatial environment.

Wikipedia



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- Origins of endbrain: Structures underlying olfaction
- Two major links between olfactory system and the motor systems of the midbrain

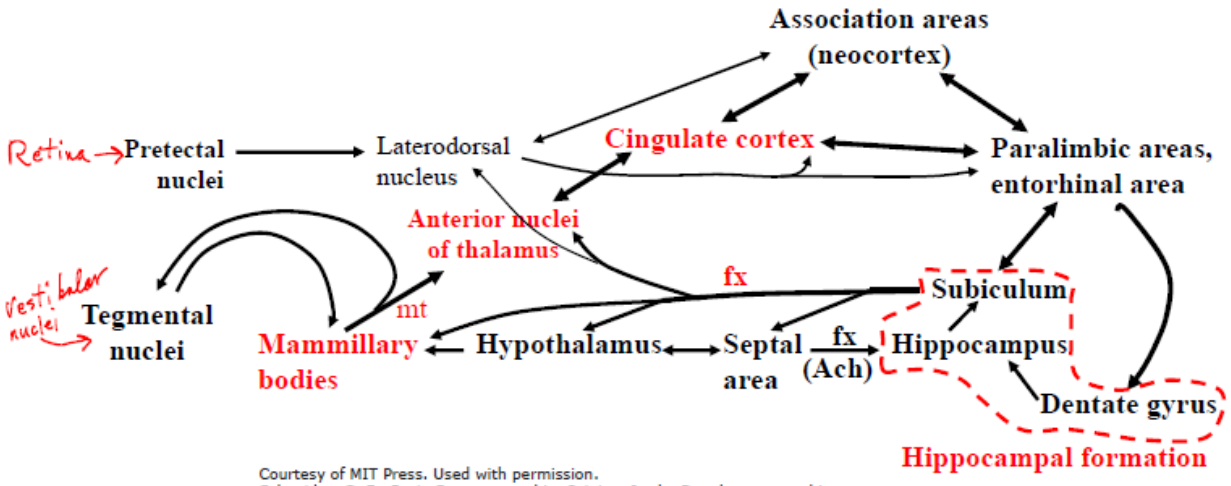
1) Through the ventral endbrain, which became corpus striatum and basal forebrain (including much of the septal area)
   - Outputs to hypothalamus, (epithalamus, subthalamus), midbrain
   - These outputs affected locomotion and orienting movements
   - The links were plastic, so habits were formed according to rewarding effects mediated, e.g., by taste effects.

**2) Through the medial part of the dorsal endbrain, which became medial pallium—the hippocampal formation**
   - **Outputs to ventral striatum, hypothalamus, epithalamus**
   - **The links were plastic, but the "habits" formed were different: The association of place with good or bad consequences of approach.**

✓ Object oriented
✓ Implicite

✓ **Location oriented**
✓ **Explcite**

**mt** = mammillothalamic tract
**fx** = fornix bundle






http://www.slideshare.net/drsunilsuthar/neurobiology-of-emotion

Prof. Gerald Schneider



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# Learning and memory

- Connections of striatum and hippocampus are plastic
- Plasticity is a base of learning
- Learning is a forming of long- term memory

- Declarative memory (explicit)
- Based on hippocampus
- Explicit information is stored and later recollected
- „Construction of the maps (relationships)“ – spatial or abstract

Location oriented:
Where am I and what has happened here?

- Procedural memory (implicit)
- Based on striatum
- Habitual learning – motor skills, but also social habits
- „Construction of the algorithms“

Object oriented:
Can I eat it and how to eat it?

**Cognitive map term definition**

Edward C. Tolman

1948

https://en.wikipedia.org/wiki/Edward_C._Tolman

**Anatomical correalte?**

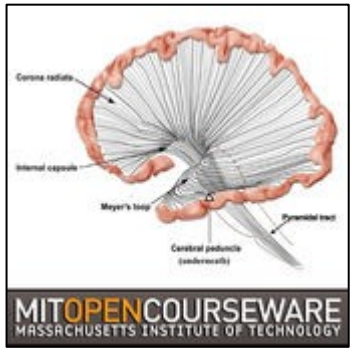
Gerald Schneider

O´Keefe and Nadel
´70s
And others

2009


https://itunes.apple.com/us/podcast/brain-structure-and-its-origins-2009/id385157530?mt=2

2014

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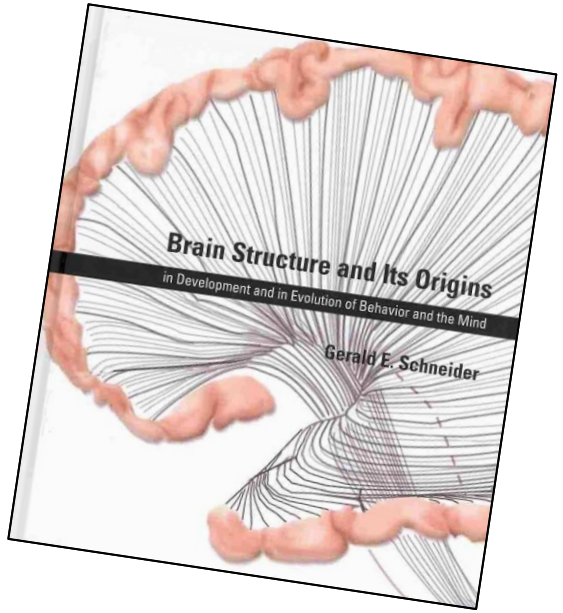


2014



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- ✓ Complex
- ✓ Unique
- ✓ Egocentric, but multiple points of view

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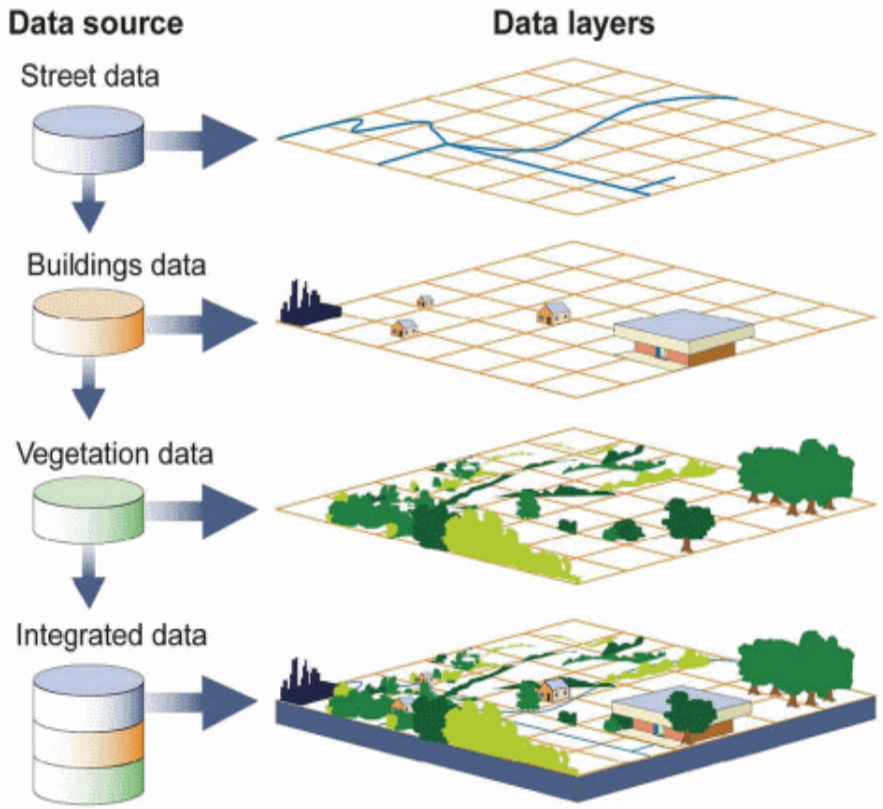


https://geoserver.geo-solutions.it/edu/en/pretty_maps/wms.html



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