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16

Neocortex II

Neocortex
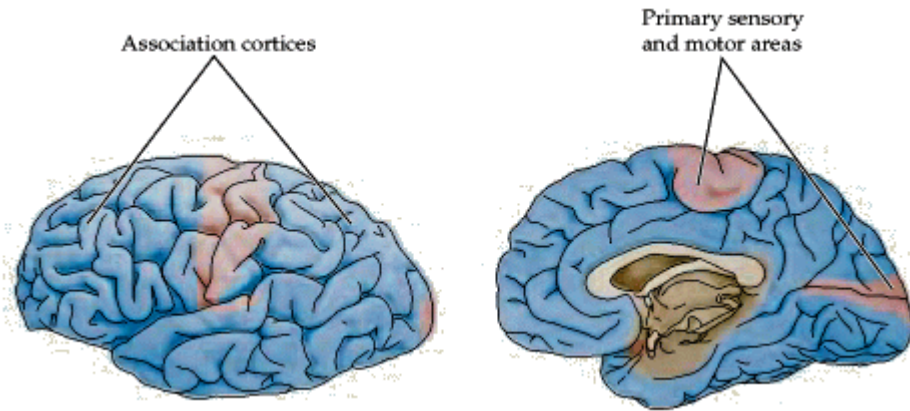
Association cortices

Primary sensory and motor areas
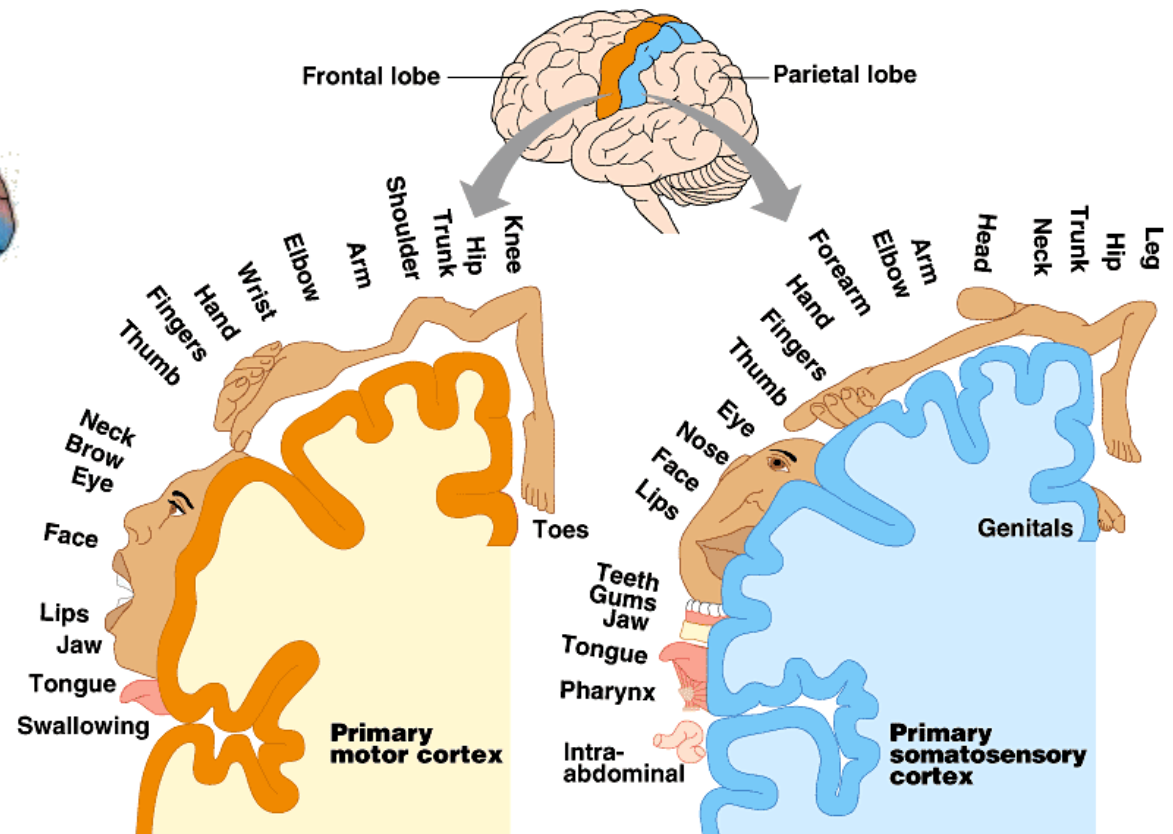
Primary areas
✓Somathotopic organization

Association areas
✓No somathotopic organization

Frontal lobe — Parietal lobe

Shoulder, Trunk, Hip, Knee, Arm, Elbow, Wrist, Hand, Fingers, Thumb, Neck, Brow, Eye, Face, Lips, Jaw, Tongue, Swallowing

Primary motor cortex

Toes

Leg, Hip, Trunk, Neck, Head, Arm, Elbow, Forearm, Hand, Fingers, Thumb, Eye, Nose, Face, Lips

Teeth, Gums, Jaw, Tongue, Pharynx, Intra-abdominal

Genitals

Primary somatosensory cortex
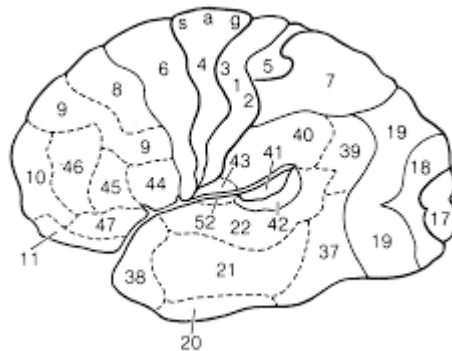
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http://www.emunix.emich.edu

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Cortical functions

Frontal lobe
Executive functions, thinking, planning, organising and problem solving, emotions and behavioural control, personality

Motor cortex
Movement

Sensory cortex
Sensations

Parietal lobe
Perception, making sense of the world, arithmetic, spelling

Occipital lobe
Vision

Temporal lobe
Memory, understanding, language

http://www.modernfamilyideas.com

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Language represents one of the highest brain functions

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Executive functions, thinking, planning, organising and problem solving, emotions and behaviour...

Motor cortex
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Sensory cortex
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Parietal lobe
Perception, making sense of the world, spelling

Temporal lobe
Memory, understanding, language

Language is the most sophisticated tool of communication

Language represents one of the highest brain functions

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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

Source → Msg → Encoding → Msg → Channel → Msg → Decoding → Msg → Receiver

Feedback

Context

https://www.mindtools.com/media/Diagrams/CommunicationsProcess.jpg
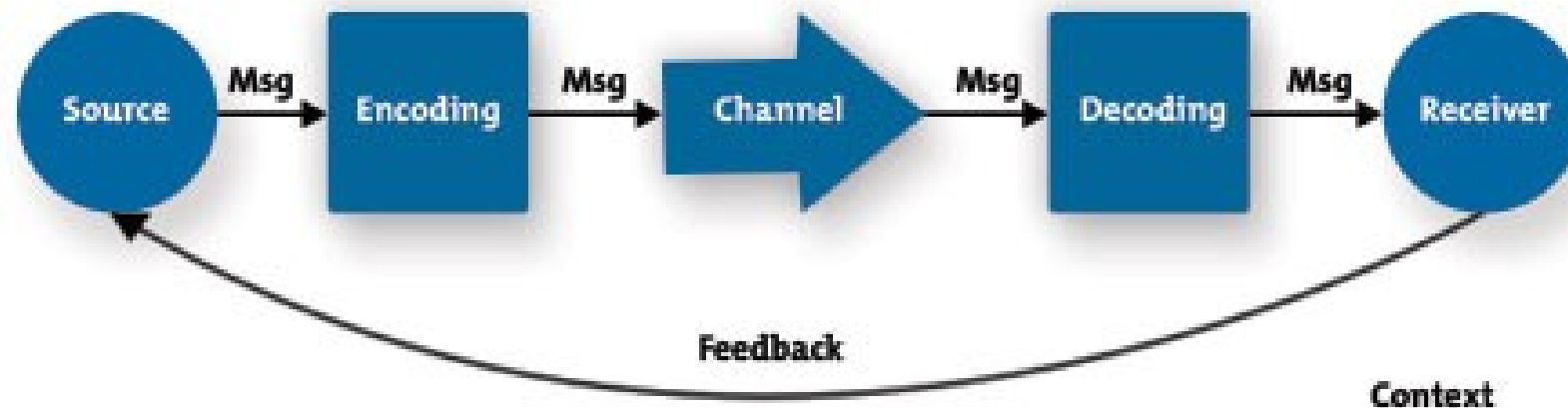
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Communication in human society

- 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
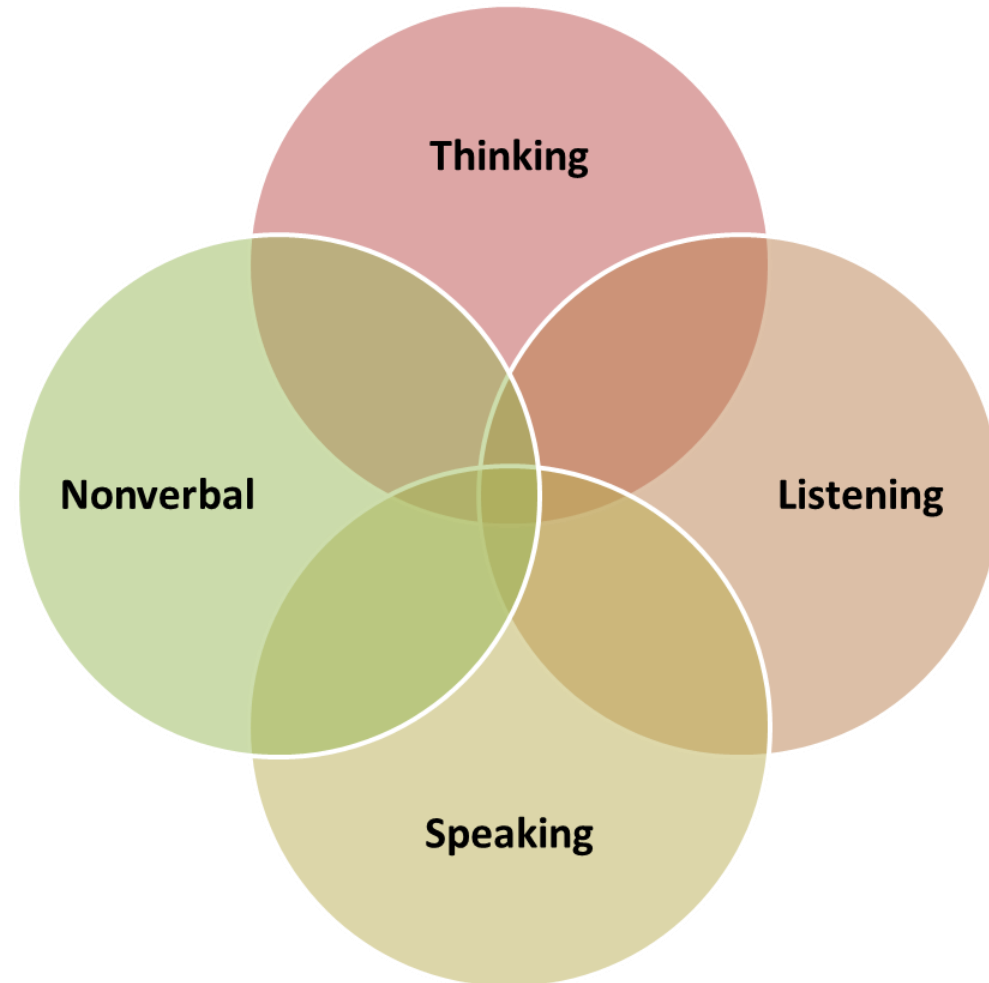
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Language

- 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

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

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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
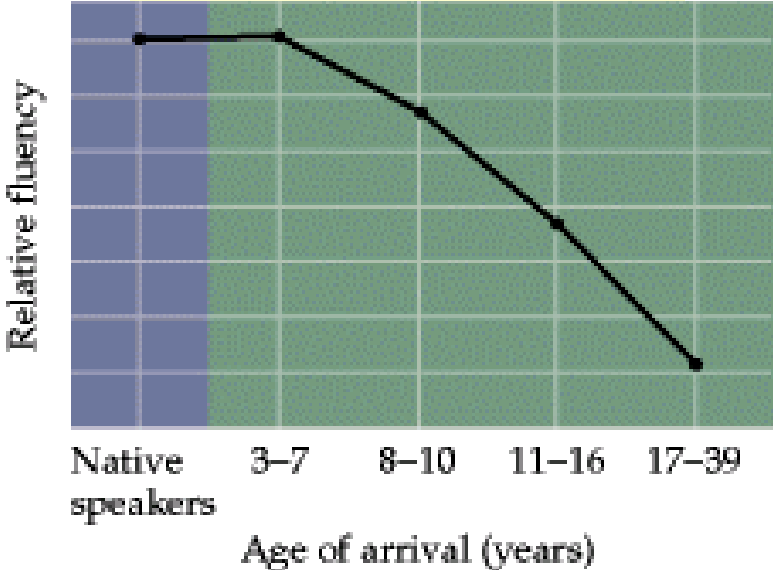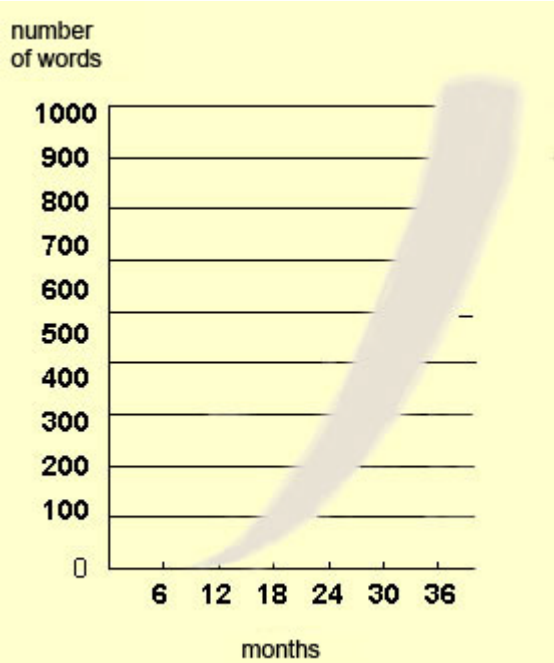
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Language

- 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

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➢ Syllable

   - Unit of organization for

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➢ Word

   - Symbol with a meaning

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

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➢ Syllable

   - Unit of organization for

    a sequence of speech sounds

➢ Word

   - Symbol with a meaning

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

➢ 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"

number of words

1000
900
800
700
600
500
400
300
200
100
0

6 12 18 24 30 36

months

Relative fluency

Native speakers   3–7   8–10   11–16   17–39

Age of arrival (years)

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

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Learning to speak

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

- 7.-12. month – baby begins to understand simple orders

- 1. year – baby uses a couple of words

- 2.-5. years – baby maters syntax rules
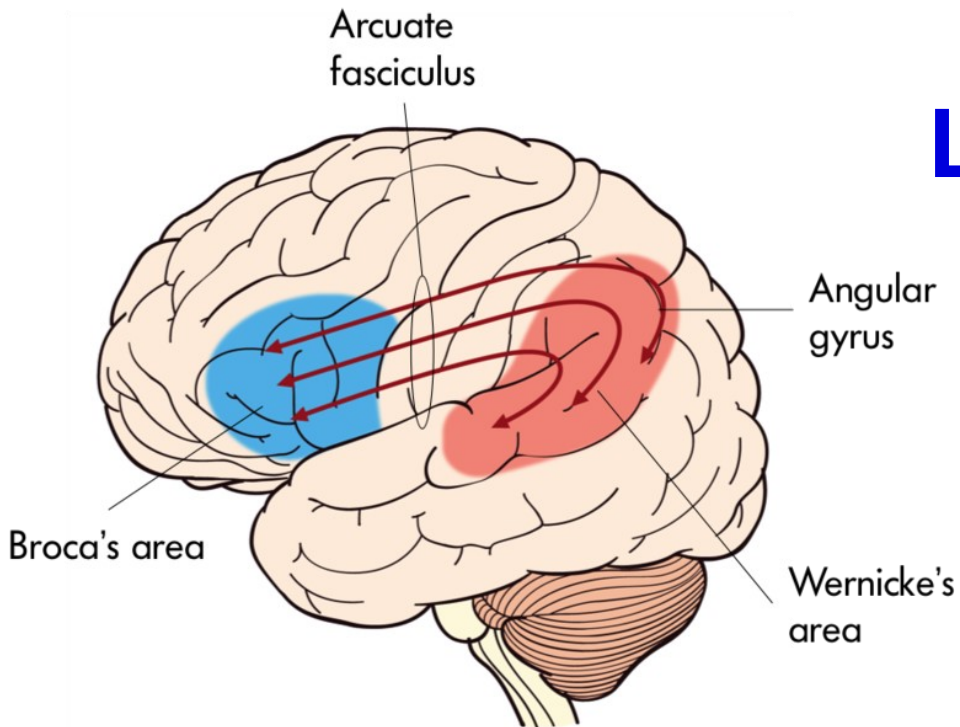
- 6. years – child uses around 2500 words

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Learning to speak

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- 6. years – child uses around 2500 words

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

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

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Arcuate fasciculus

Angular gyrus

Broca's area

Wernicke's area

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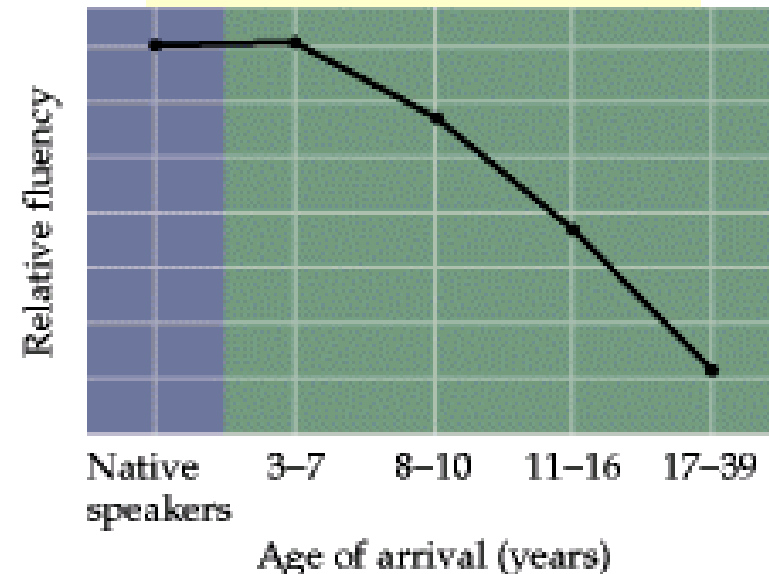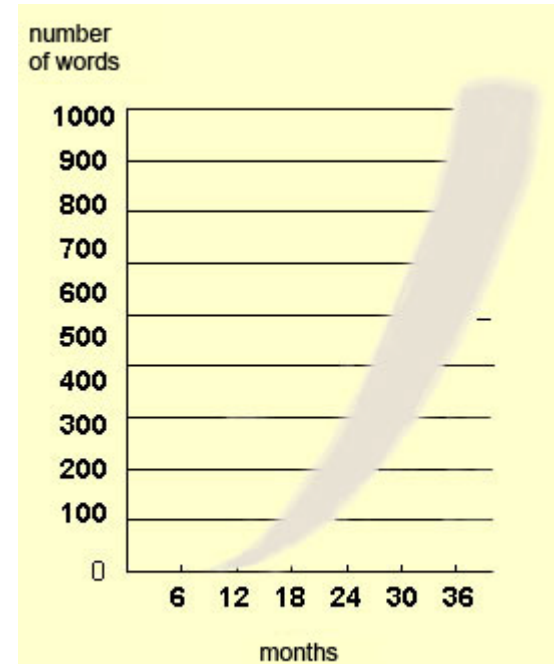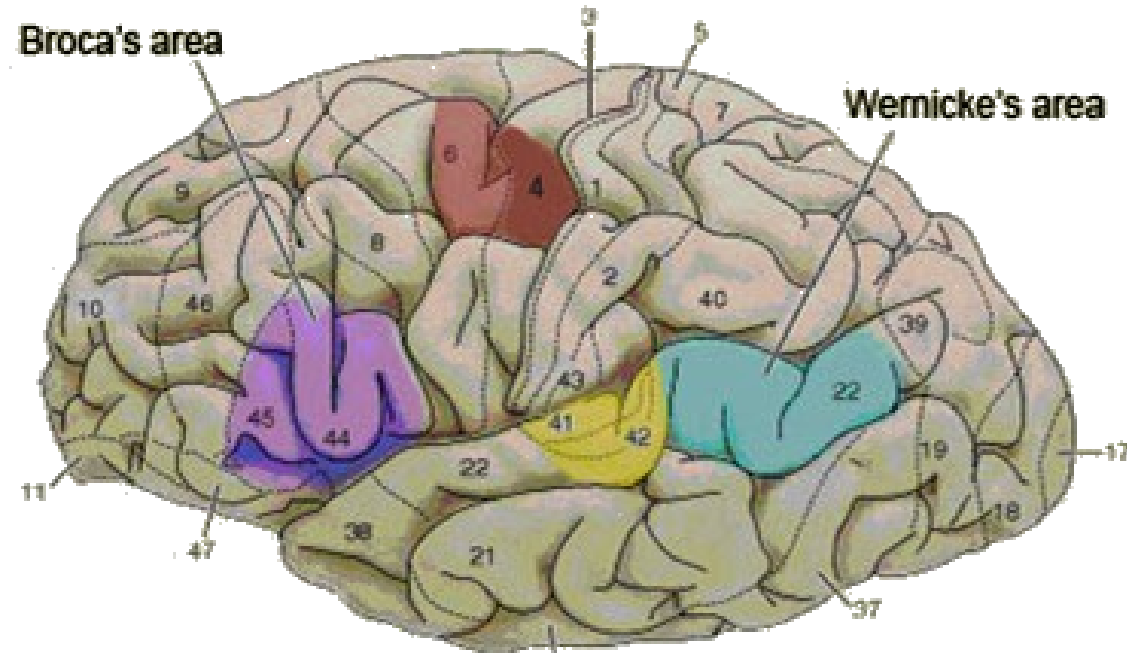
Language areas

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

Arcuate fasciculus

Angular gyrus

Broca's area
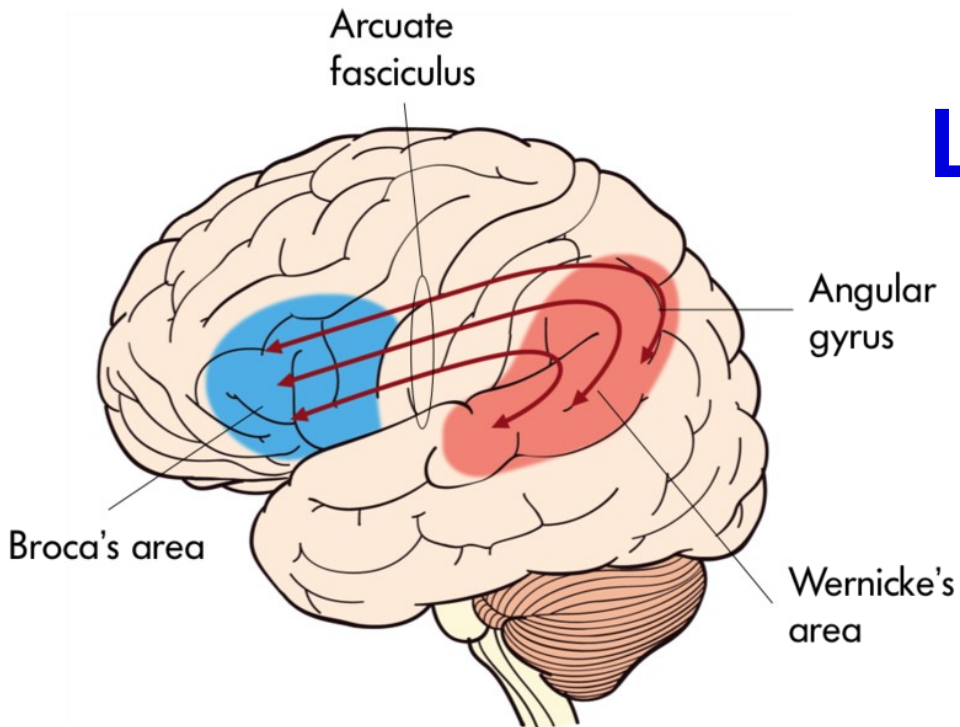
Wernicke's area

There are two main language areas

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

- 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

Broca's area
Wernicke's area
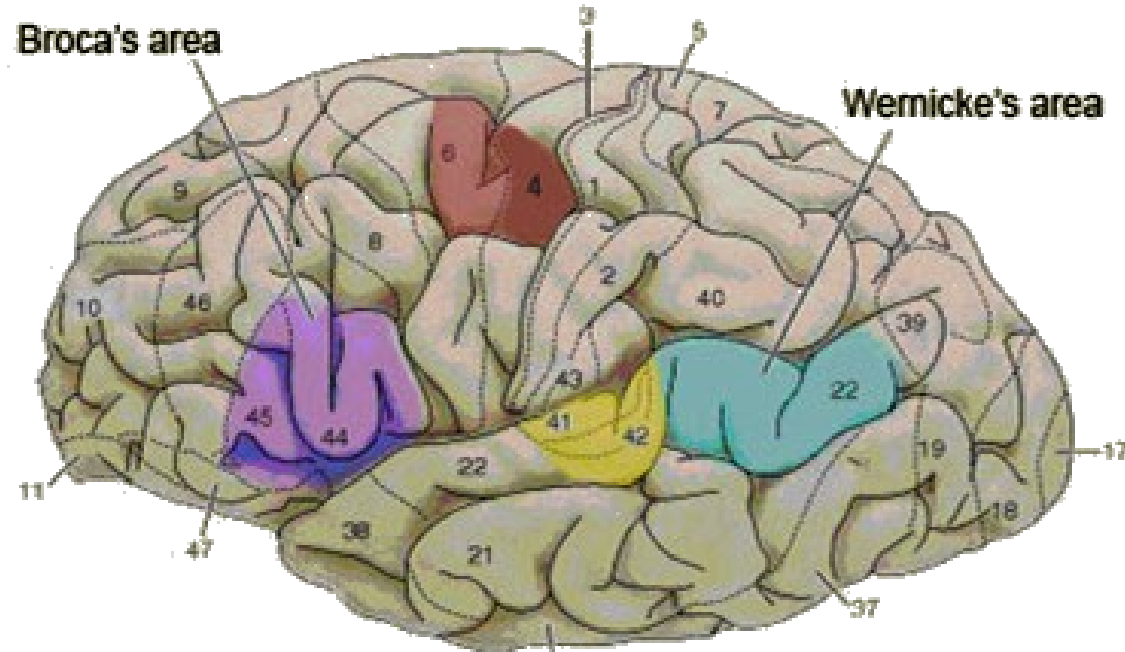http://www.slideshare.net/drpsdeb/presentations

Area 45
- ✓ Semantic processing

„selection and manipulation with appropriate words"

Area 44
- ✓ Phonological processing and language production

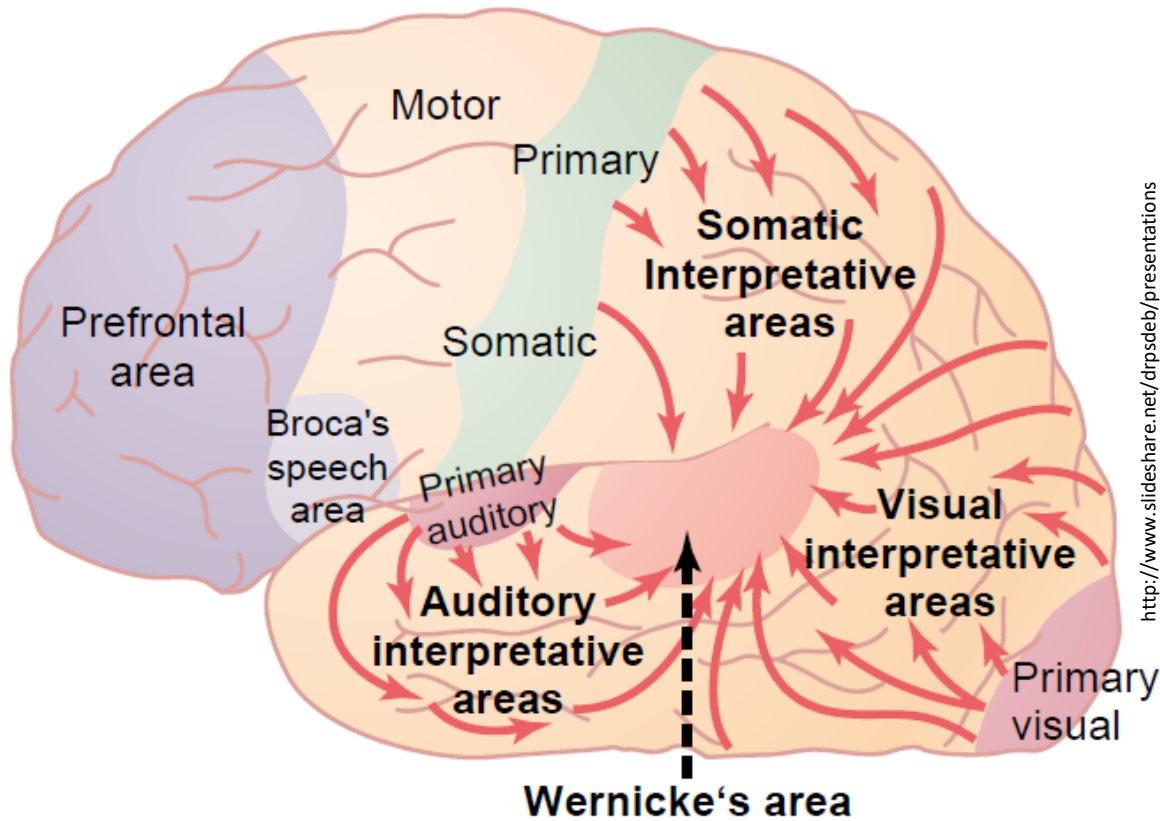„selection and activation of particular motor centers"

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Wernicke´s area

http://www.slideshare.net/drpsdeb/presentations
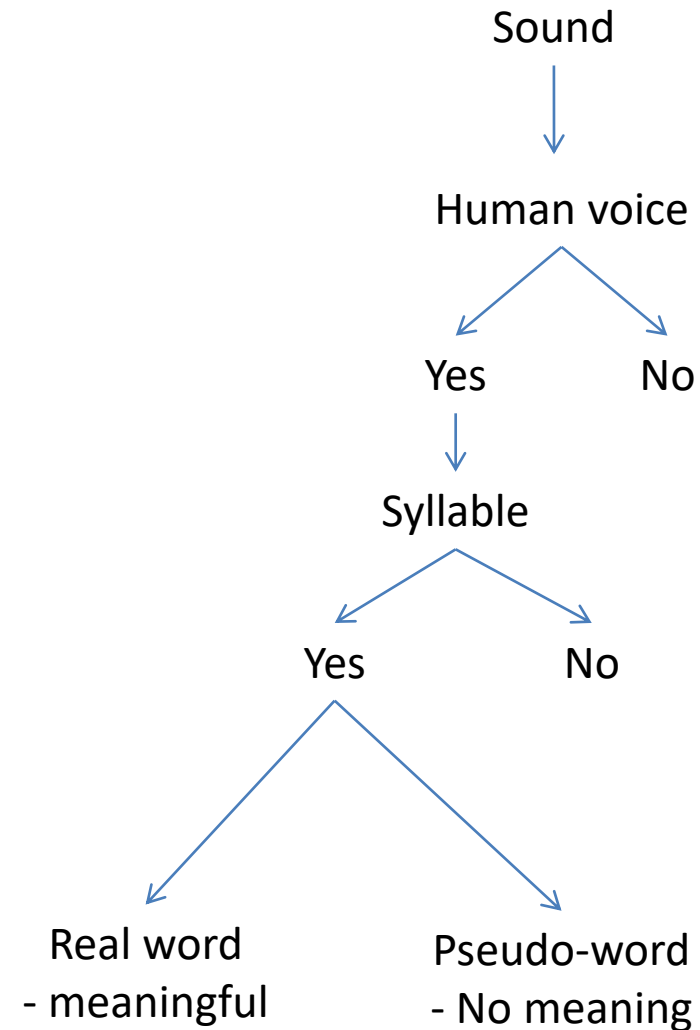
Area 22

✓ 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
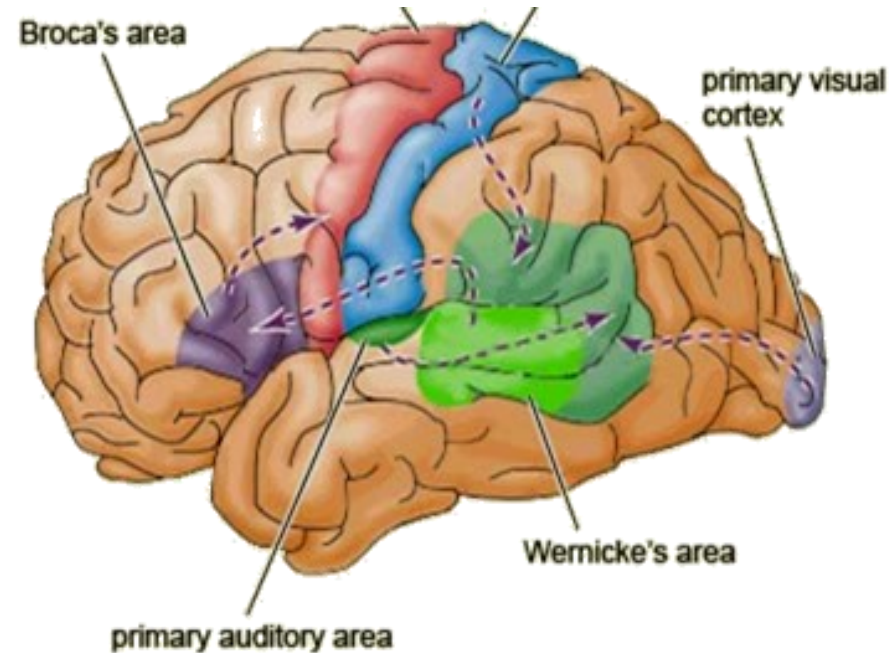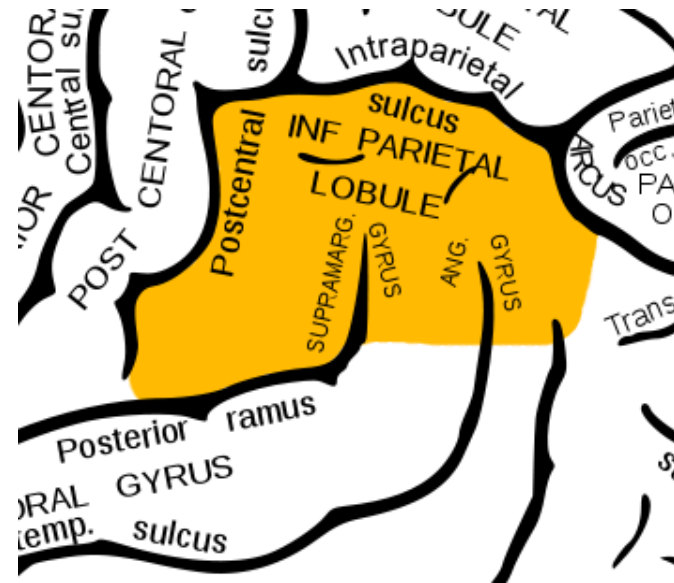
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Algorithm of sound processing

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

Sound

↓

Human voice

Yes — No

Yes ↓

Syllable

Yes — No

Real word
- meaningful

Pseudo-word
- No meaning

✓ **Wernicke´s area**

✓ **Broca´s area**

✓ **P-O-T association cortex**

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Lobulus parietalis inferior

Broca's area

primary visual cortex

Wernicke's area

primary auditory area

Gyrus supramarginalis (Area 40)

✓ Phonological and articulatory processing of words
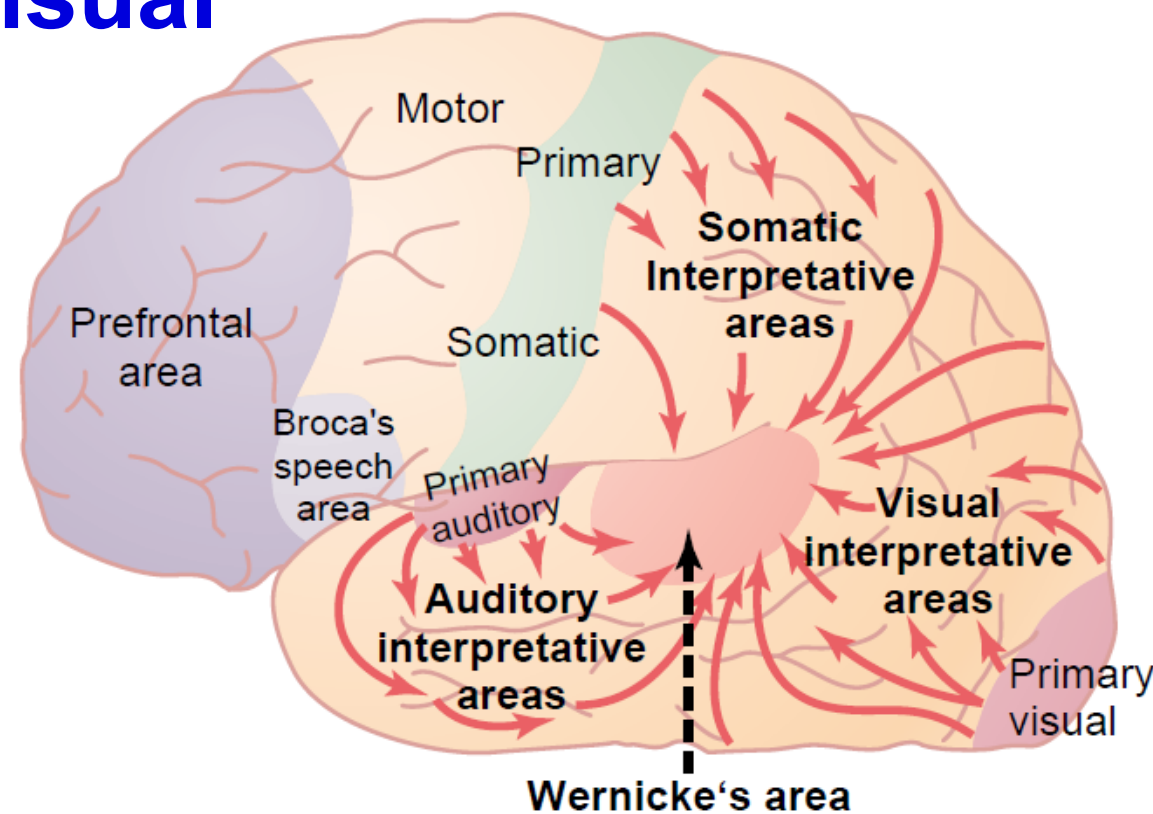
Gyrus angularis (Area 39)

✓ 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

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

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 „activelly" read before this age (understand the meaning of the text which he/she reads)

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- The language functions algorythms are also involved in complex „inner" categorization

- The language („both spoken and inner") enabled development of complex (abstract) thinking and development of culture

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- The human society development is linked to information technology development
  - ✓ Spoken language
  - ✓ A system of writing
  - ✓ Printing
  - ✓ Internet

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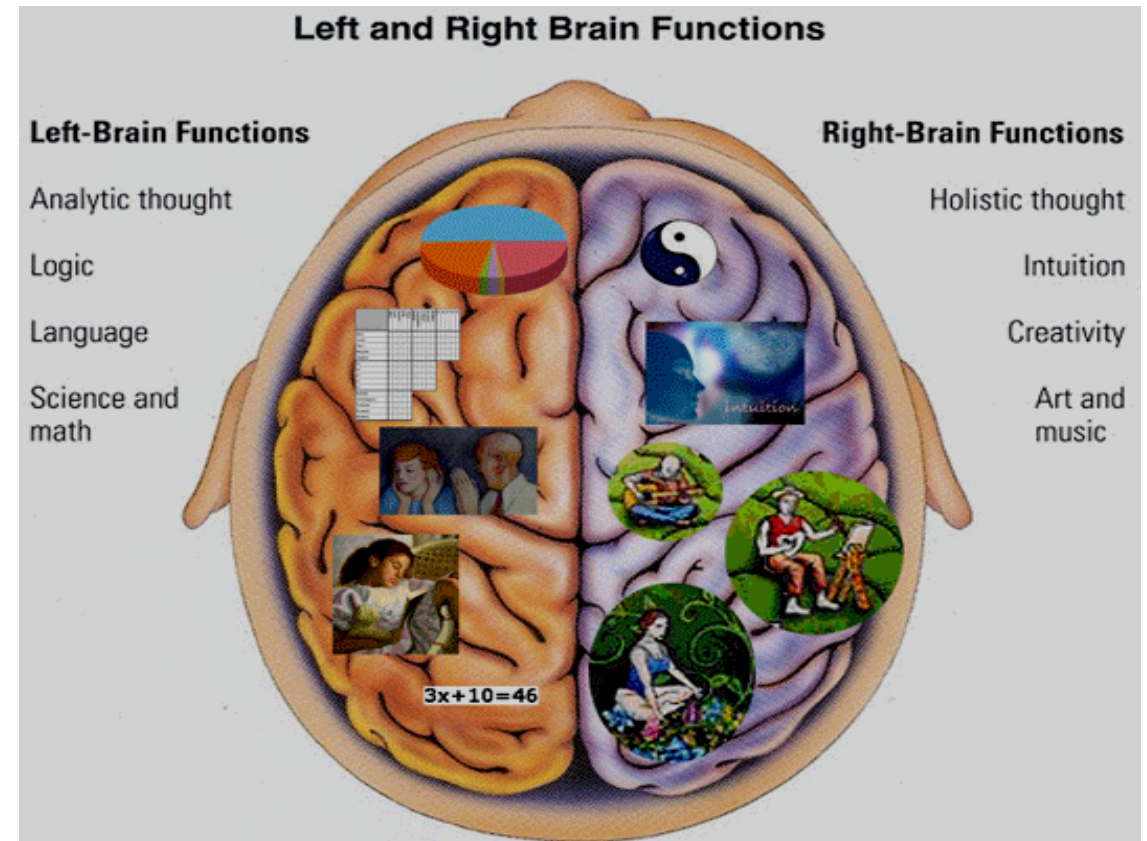MED

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
  - ✓ The majority of left handed people has B-W areas also in 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

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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

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

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Women and language

- Females' speech is more fluent
  - they can pronounce more words or sentences in a given amount of time
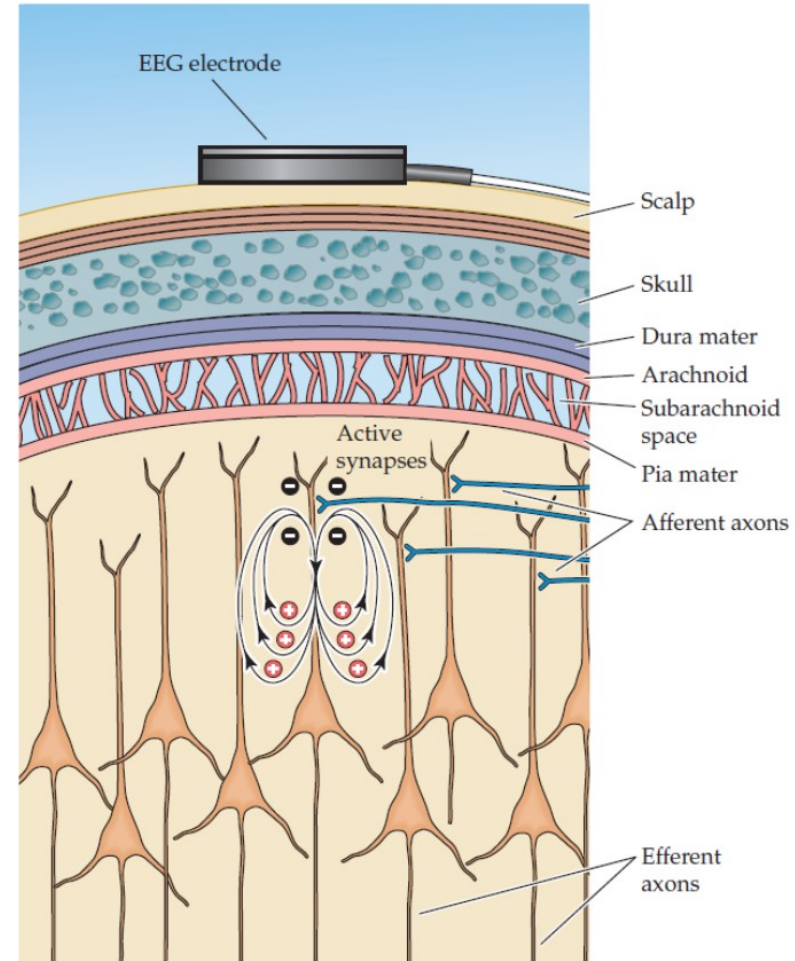
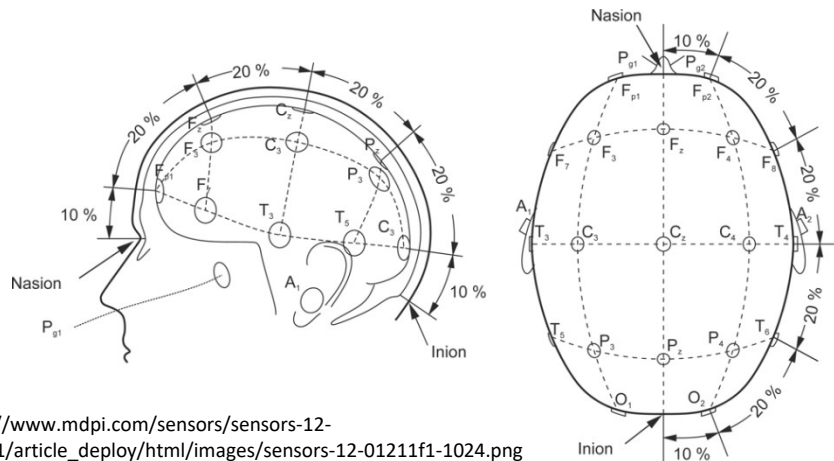MUNI
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Women and language

- Females' speech is more fluent
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- Women have the reputation of being able to talk and listen while doing all sorts of things at the same time
- Women language is more widespread in both hemispheres while in men more left lateralized
  - more nerve fibers connecting the two hemispheres of their brains, which also suggests that more information is exchanged between them.

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  - more nerve fibers connecting the two hemispheres of their brains, which also suggests that more information is exchanged between them.
- The males' higher levels of testosterone, which delays the development of the left hemisphere
  - 4 times more boys than girls suffer from stuttering, dyslexia

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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)
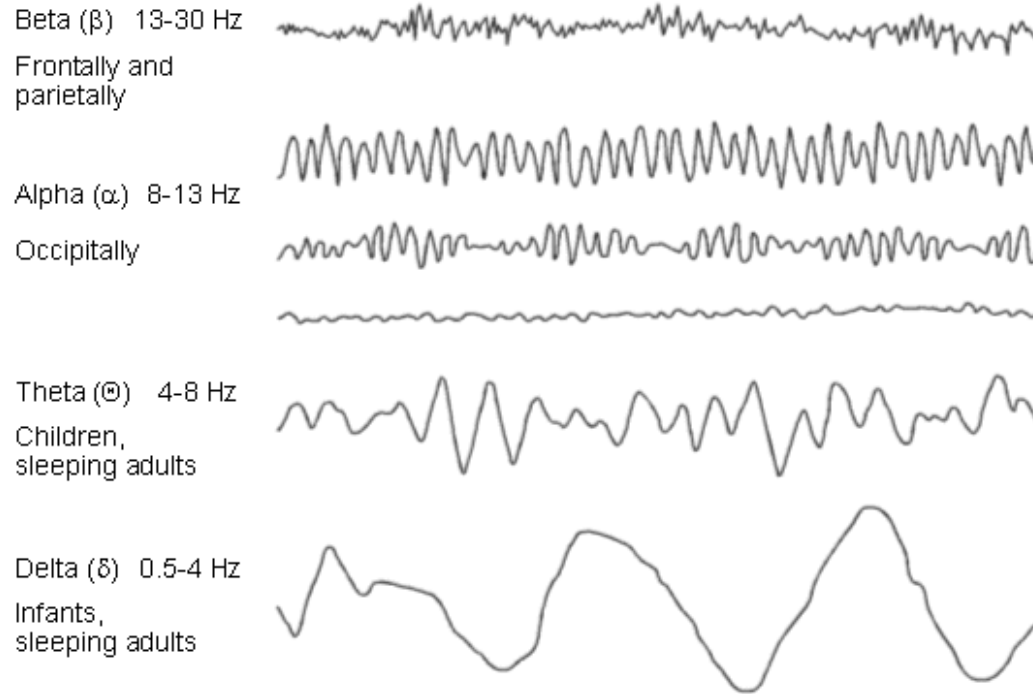 - Functional magnetic resonance imaging (fMRI)

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EEG

- Detection of neuronal electrical activity

- monopolar arrangement:
  - active electrode
  - indifferent electrode

  <u>= referential recording</u>

- <u>bipolar recording</u>
  - lead (channel)
  - ground electrode

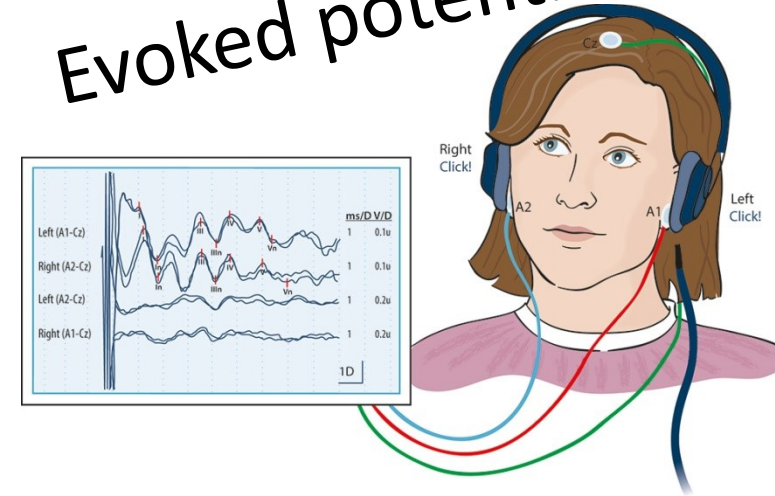- EEG voltage in microvolts (*vs.* in mV in neurons)

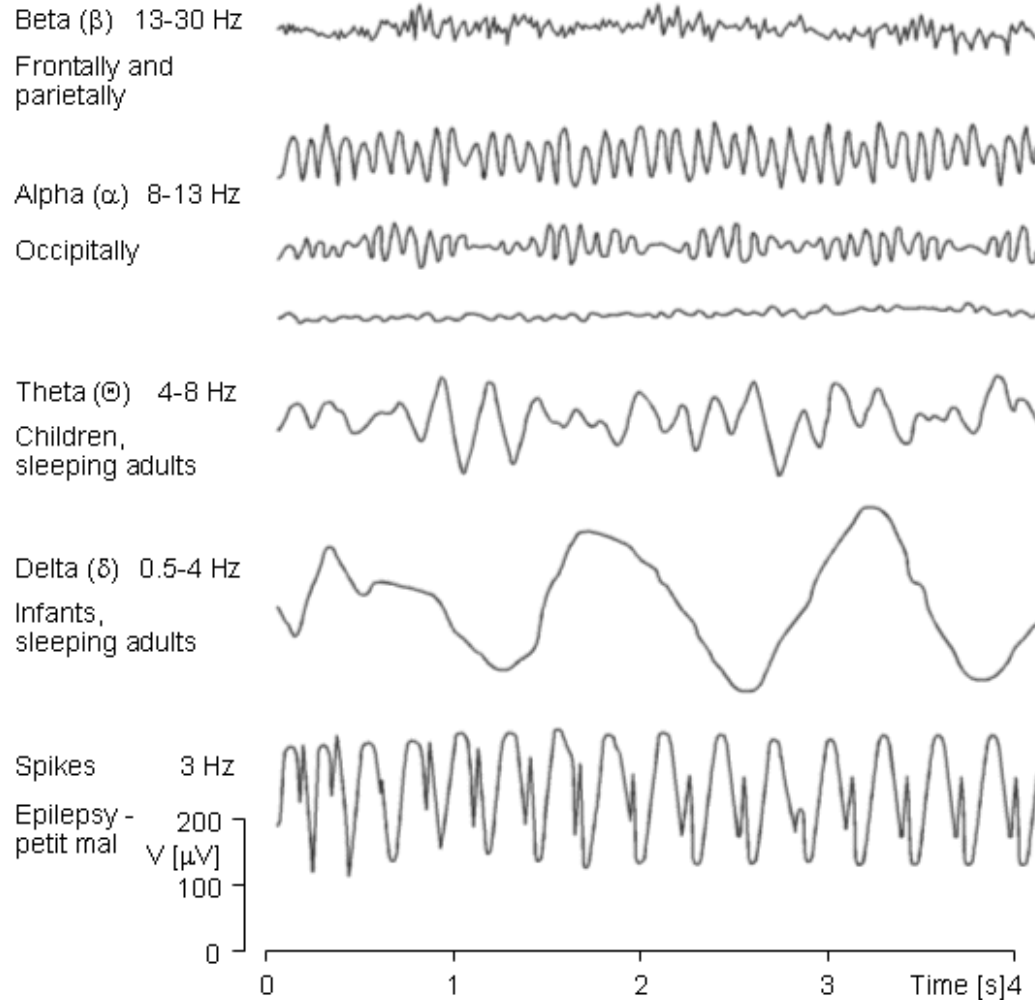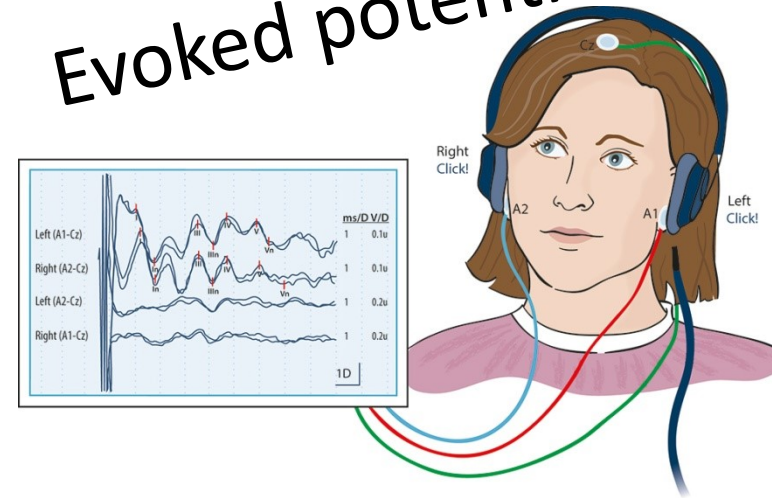http://www.slideshare.net/kj_jantzen/biophysical-basis-of-eeg

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

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EEG

Evoked potentials

Beta (β) 13-30 Hz
Frontally and parietally

Alpha (α) 8-13 Hz
Occipitally

Theta (Θ) 4-8 Hz
Children, sleeping adults

Delta (δ) 0.5-4 Hz
Infants, sleeping adults

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

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EEG

Evoked potentials

Beta (β) 13-30 Hz
Frontally and parietally

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Theta (Θ) 4-8 Hz
Children, sleeping adults

Delta (δ) 0.5-4 Hz
Infants, sleeping adults

Spikes 3 Hz
Epilepsy - petit mal

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

Grand mal epilepsy

]100 µv

http://www.slideshare.net/akashbhoi12/eeg-53489764

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

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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)

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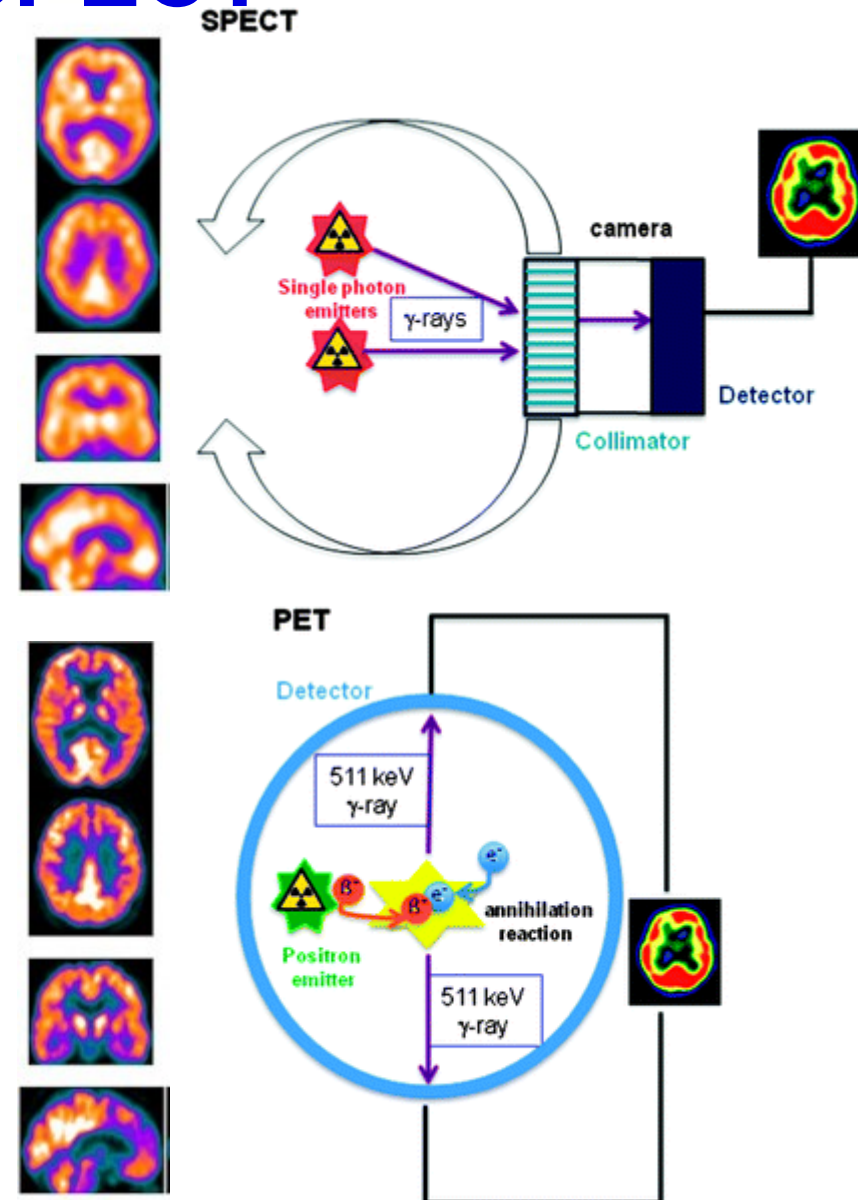
fMRI

- 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
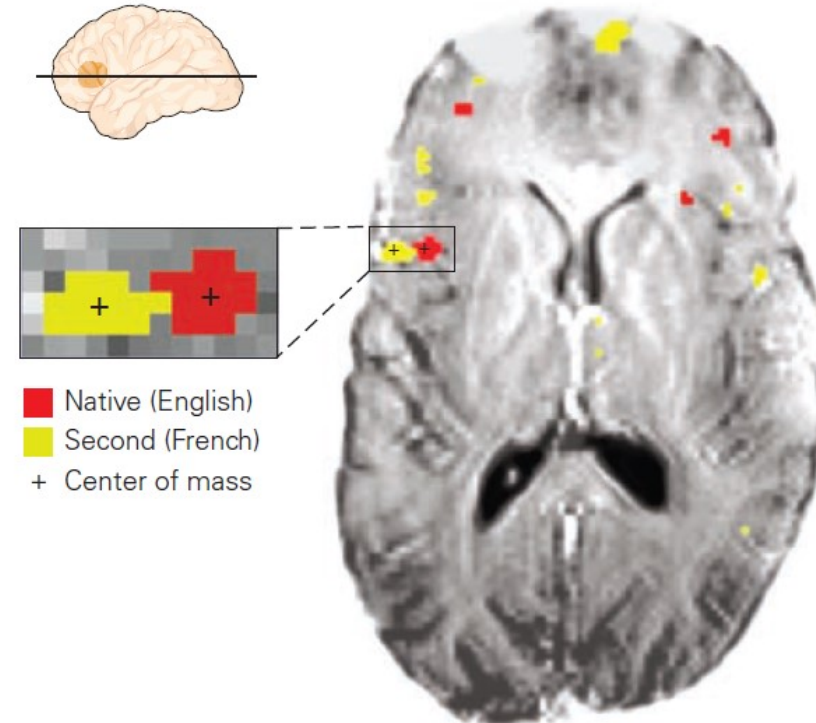
- High resolution (up to1mm)

- No radiation

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

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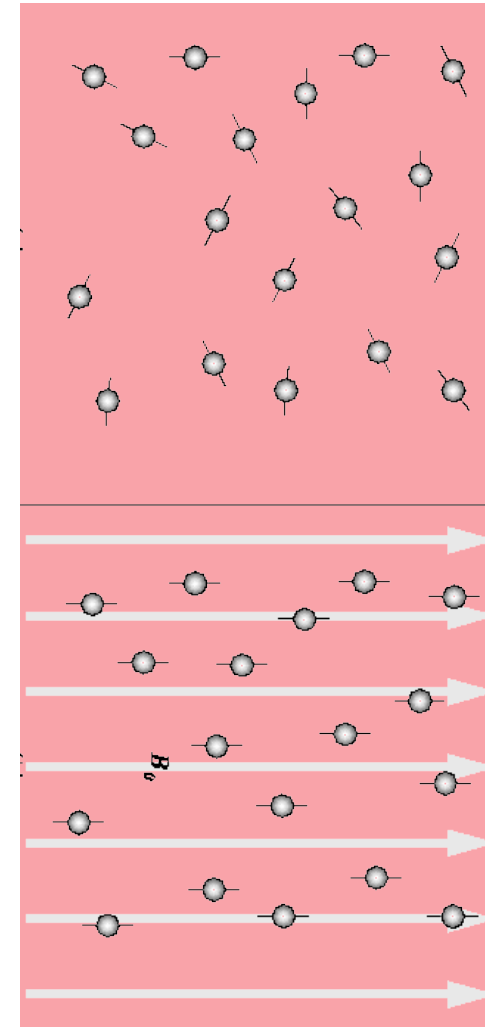
fMRI
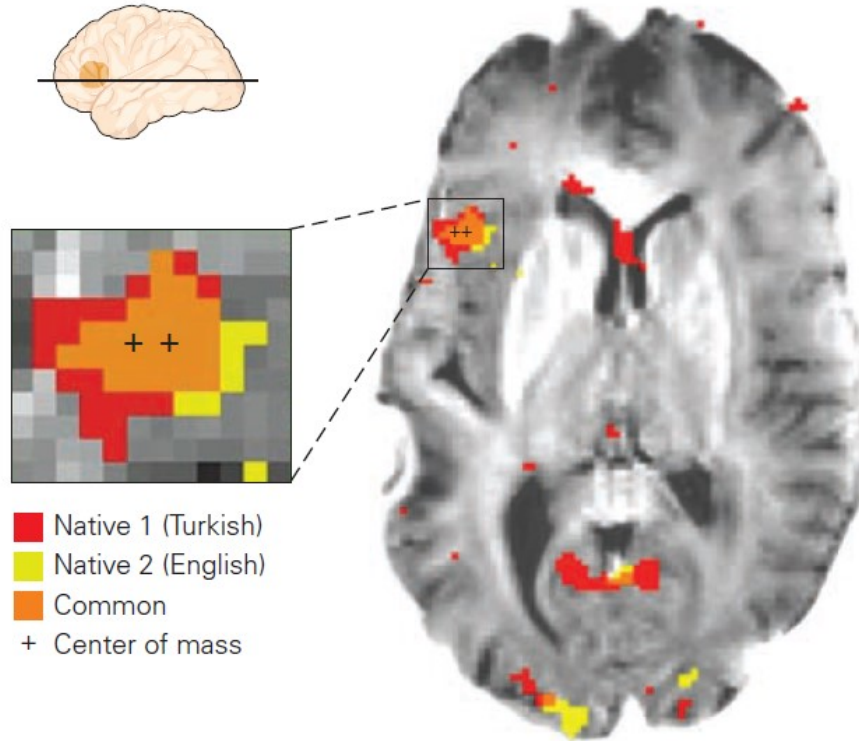
Kim, K. H. S., Relkin, N. R., Lee, K.-M. & Hirsch, J. Distinct cortical areas associated with native and second languages. *Nature* **388,** 171–174 (1997).

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

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.

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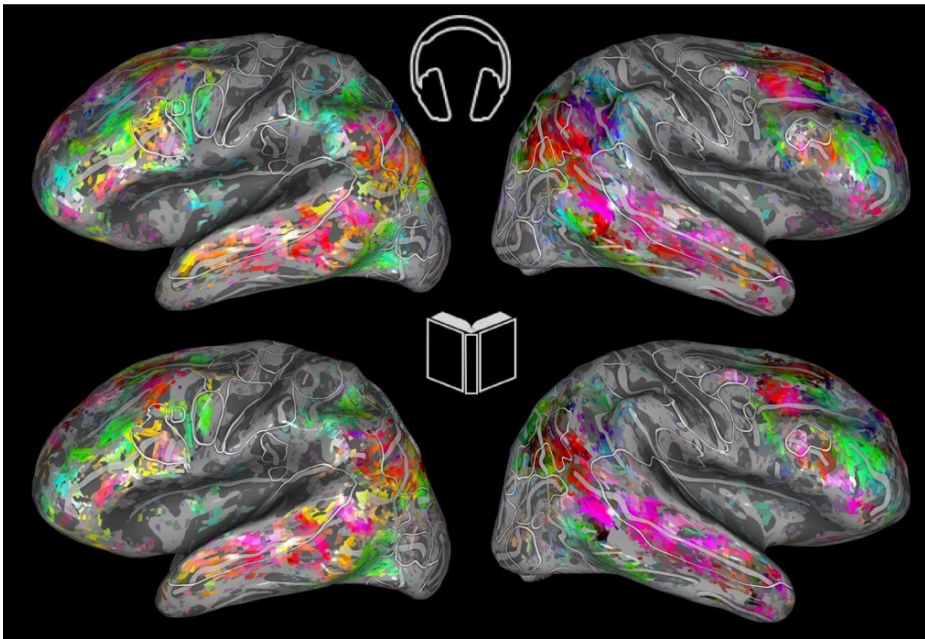
86. The basic characterization of neocortical functions – language and social brain, basic overview of functional diagnostic methods used in neurology

- Communication and language
  - Language areas – localization and fuctuion including lobulus parietalis inferior, aphasia…
  - Lateralization of language functions, gender differences

- Social brain
  - Human is a social beeing, so the brain has to be designed accordingly
  - Frontal lobe and limbic system in behavioral control
  - Triune brain theory, whole brain model, mentalization, dehumanization

- Functional diagnostic methods (EEG, SPECT, PET , fMRI)

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