Methods of Cognitive Neuroscience

Focus on Language

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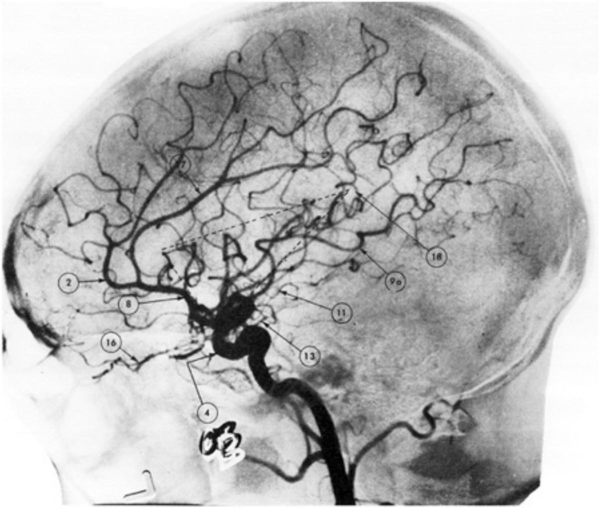
The brain's blood supply



Angiography (血管造影术) (DeArmond, Fusco, & Dewey, 1989)

Vascular Disorders

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- Ischemia (脑出血)

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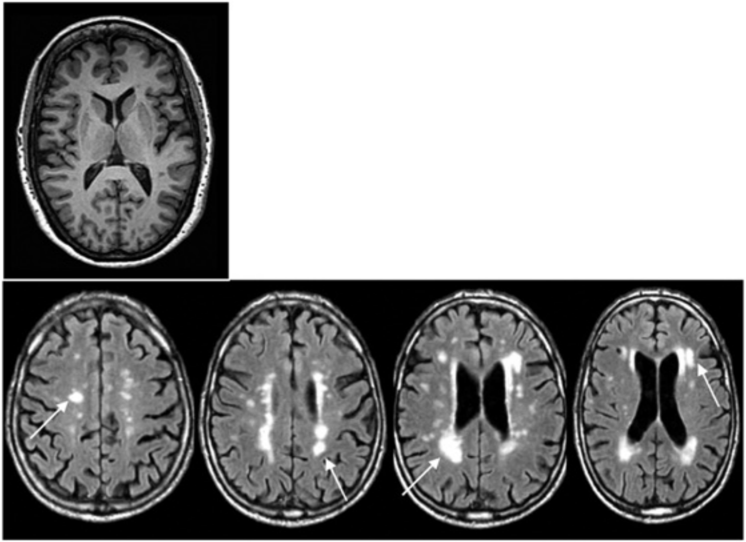
- Glial cells and other supporting white matter tissues.
- Benign (良性的) vs Malignant or cancerous (恶性的)
- Brain tumor: location, prognosis

Degenerative and Infectious Disorders

Disorder	Type	Most common Pathology
Alzheimer's disease	Degenerative	Tangles (结节) and plaques (斑块) in limbic and temporoparietal cortex
Parkinson's disease	Degenerative	Loss of dopaminergic neurons (多巴胺神经元)
Huntington's disease	Degenerative	Atrophy (萎缩) of interneurons in caudate and putamen nuclei of basal ganglia
Pick's disease (皮克氏病)	Degenerative	Fronto-temporal atrophy (萎缩)
Progressive supranuclear palsy (PSP) (进行性核上性麻痹)	Degenerative	Atrophy of brainstem, including colliculus (丘)
Multiple sclerosis (多发性硬化)	Possibly infectious	Demyelination (髓鞘脱失), especially of fibers near ventricles
AIDS dementia (痴呆)	Viral infection	Diffuse white matter lesions
Herpes simplex (单纯性疱疹)	Viral infection	Destruction of neurons in temporal and limbic regions
Korsakoff's syndrome (健忘综合征)	Nutritional deficiency	Destruction of neurons in diencephalon and temporal lobes

A MRI image of Alzheimer's disease



(de Leeuw, Barkhof, & Scheltens, 2005)

Traumatic Brain Injury

- Traumatic Brain Injury (外伤性脑损伤) can result from either a closed or an open head injury

Epilepsy

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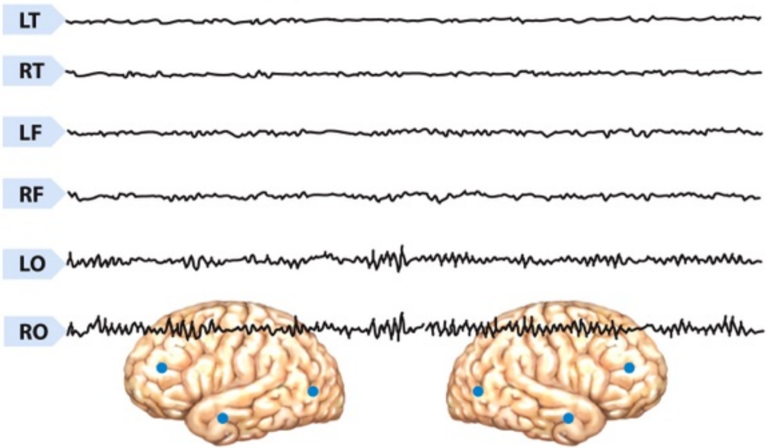
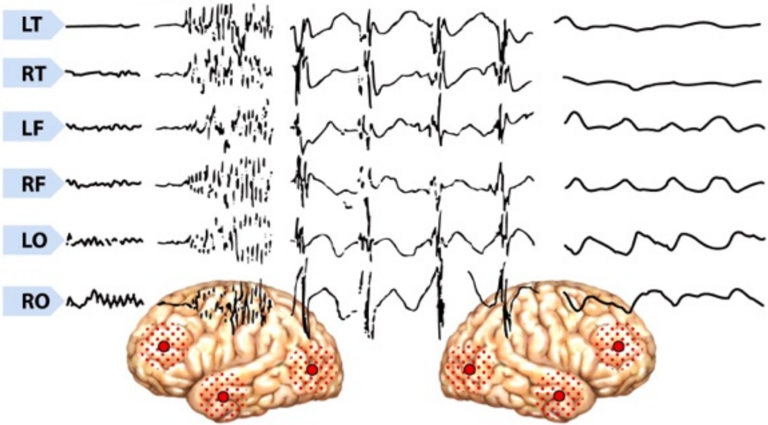
- Although 0.5% of the general population has epilepsy, it is estimated that 5% of people will have a seizure at some point during life, usually triggered by an acute event such as trauma, exposure to toxic chemicals, or high fever.

Epilepsy and electroencephalography



(Chappell et al., 2006)

Epilepsy and electroencephalography



(Chappell et al., 2006)

Functional Neurosurgery

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- Epilepsy and Callosotomy (胼胝体离断术):
  Split-brain procedure;
- Parkinson's disease and Deep-brain stimulation (DBS) (深部脑刺激):
  Electrodes are implanted in the basal ganglia.

Studying the Damaged Brain

Neurological dysfunction and Language deficits

Language deficits

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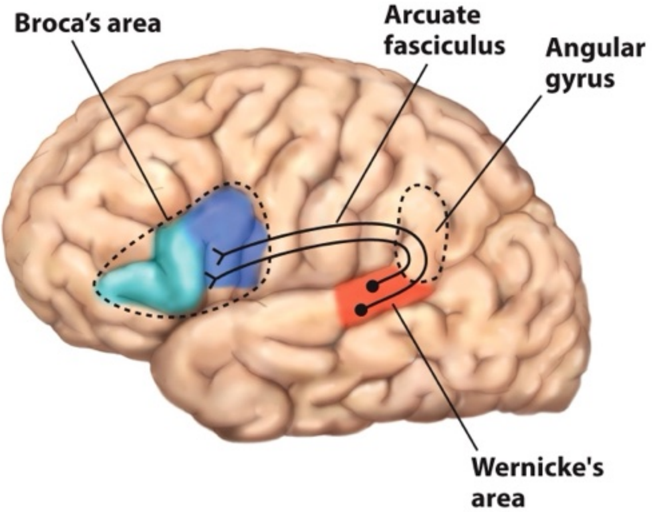
- Speech apraxia (语言失用): Deficits in the motor planning of articulations.
- Dysarthria (构音障碍): Caused by the loss of control overt articulatory muscles.

Lateral view of the brain of Leborgne

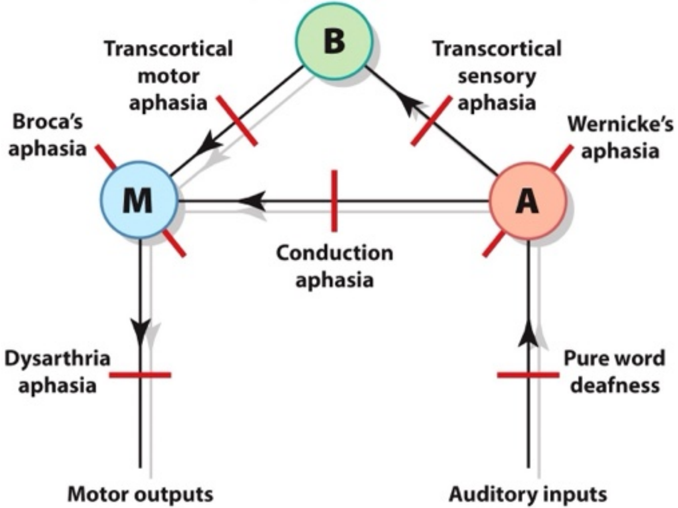
(Dronkers, Plaisant, Iba-Zizen, & Cabanis, 2007)

Broca’s area and Wernicke’s area



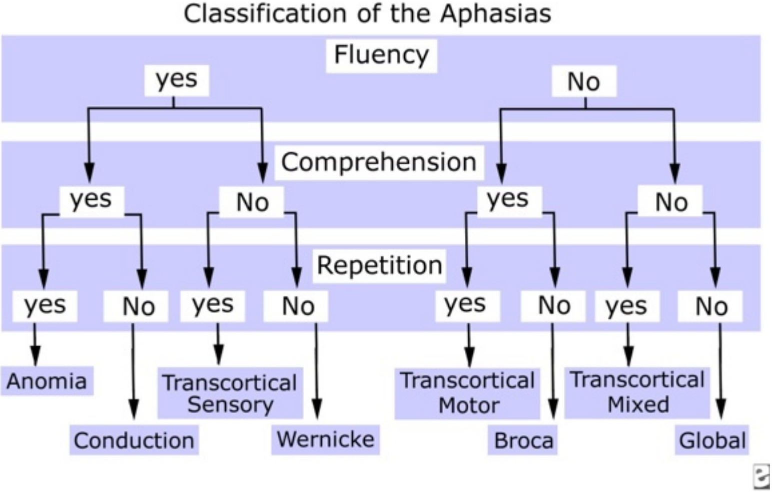
(Gazzaniga, Ivry, & Mangun, 2014, p.473)

Lichtheim's model of language processing



(Gazzaniga et al., 2014, p.474)

Summary of Cortical Aphasias

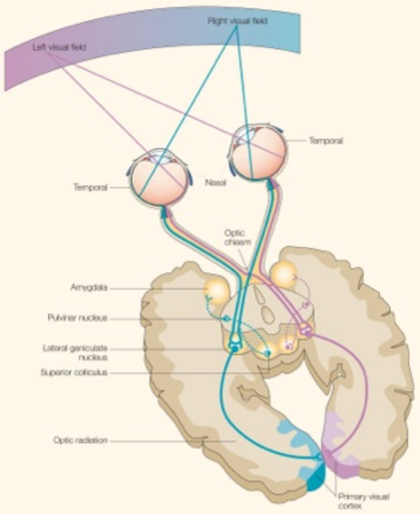


https://emedicine.medscape.com/article/317758-overview

Studying the Damaged Brain

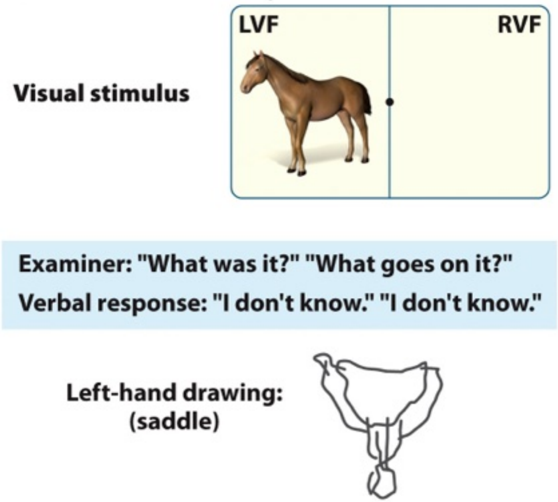
Functional neurosurgery and language disorders

Information projecting into two hemispheres



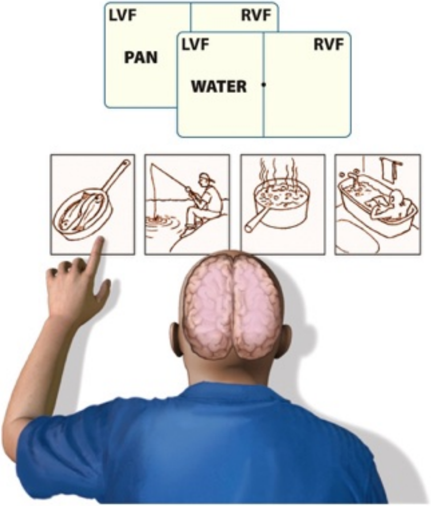
(Hannula, Simons, & Cohen, 2005)

Object naming



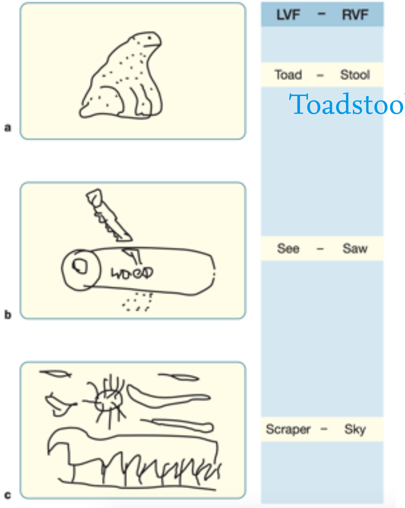
(Gazzaniga et al., 2014, p.138)

Make inference



(Gazzaniga et al., 2014, p.138)

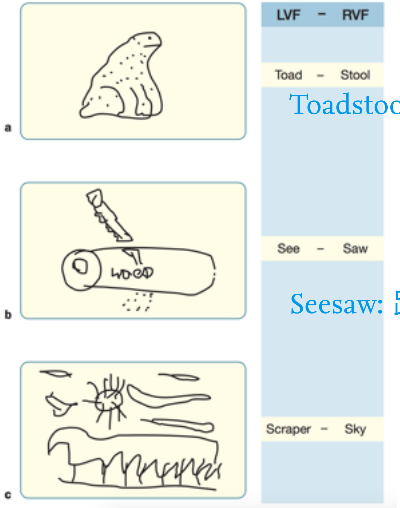
Information integration



Toadstool: 伞菌

(Gazzaniga et al., 2014, p.142)

Information integration

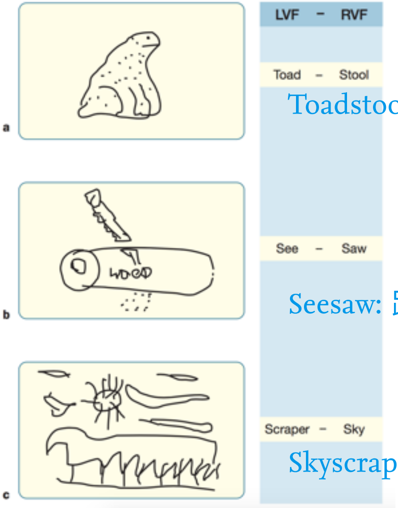


Toadstool: 伞菌

Seesaw: 跷跷板

(Gazzaniga et al., 2014, p.142)

Information integration



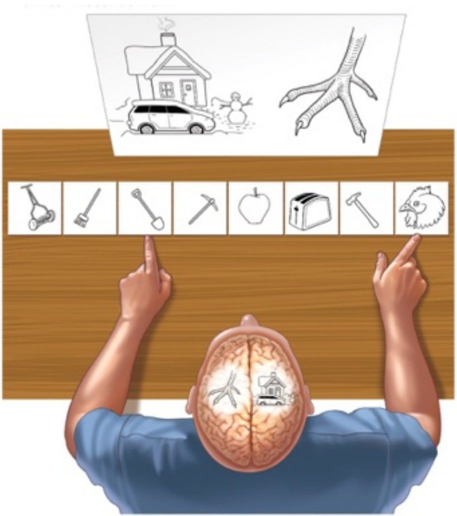
Toadstool: 伞菌

Seesaw: 跷跷板

Skyscraper: 摩天大楼

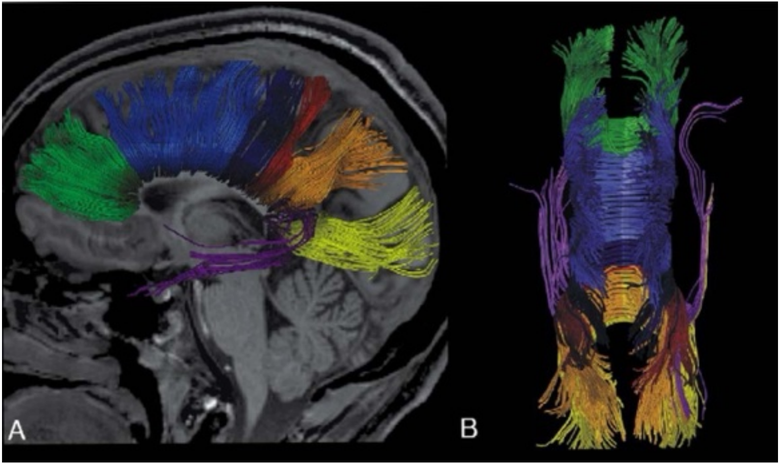
(Gazzaniga et al., 2014, p.142)

The interpreter



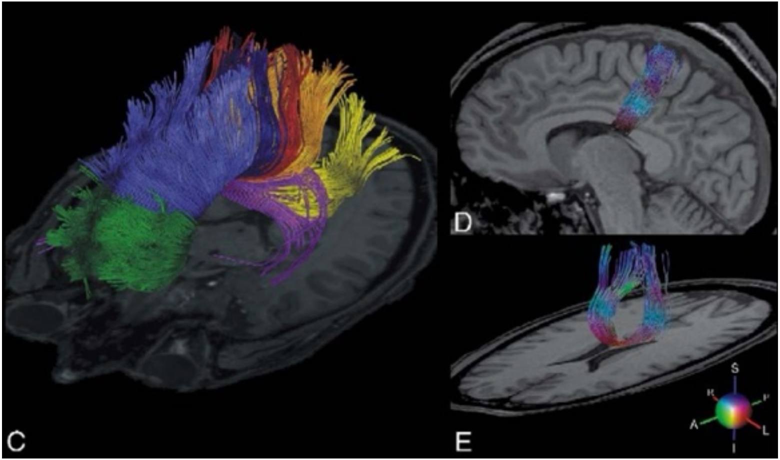
(Gazzaniga et al., 2014, p.147)

Callosal projection



(Hofer & Frahm, 2006)

Callosal projection



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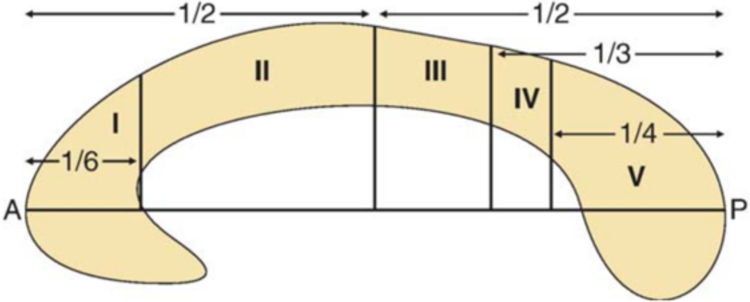

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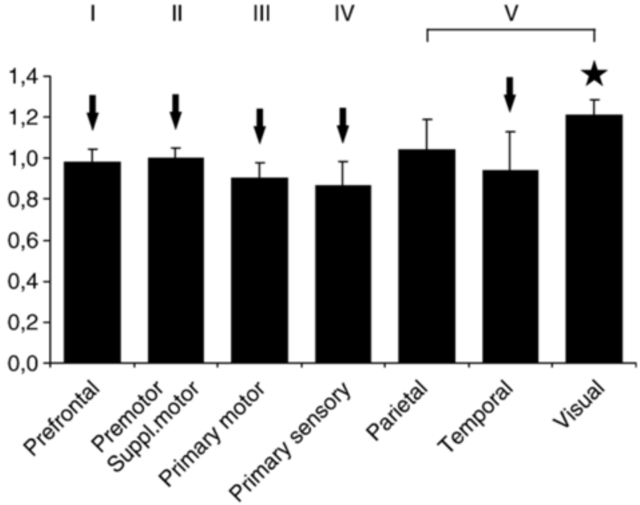
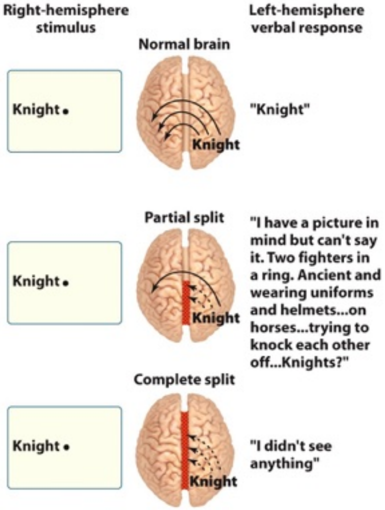


(Hofer & Frahm, 2006)

Callosal Function Specificity



(Gazzaniga et al., 2014, p.136)

Perturbing Neural Function

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- Pharmacology (药理学)

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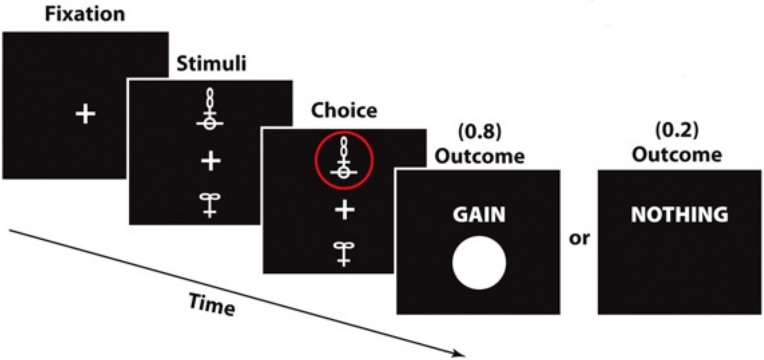
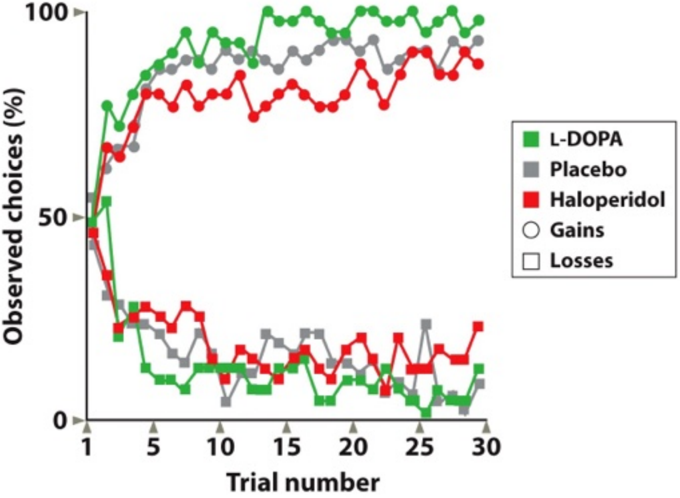
- Genetic manipulation (基因控制)
  - Knockout gene (基因敲除)
  - Optogenetics (光遗传学)

Pharmacology



(Pessiglione, Seymour, Flandin, Dolan, & Frith, 2006)

Pharmacology



(Pessiglione et al., 2006)

Transcranial Magnetic Stimulation

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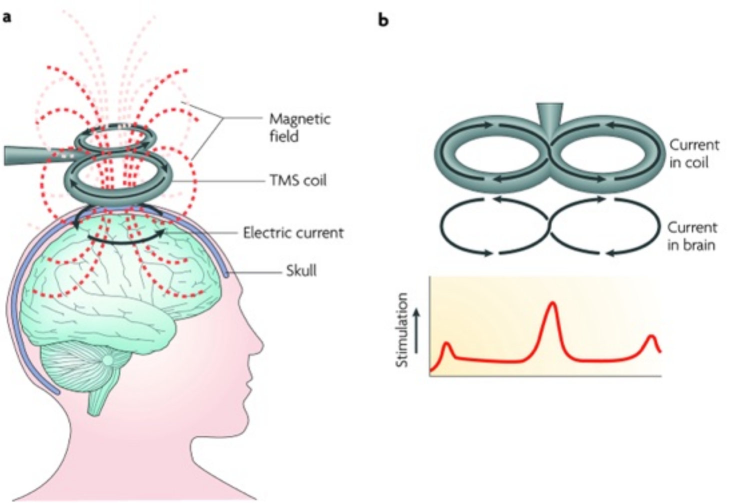
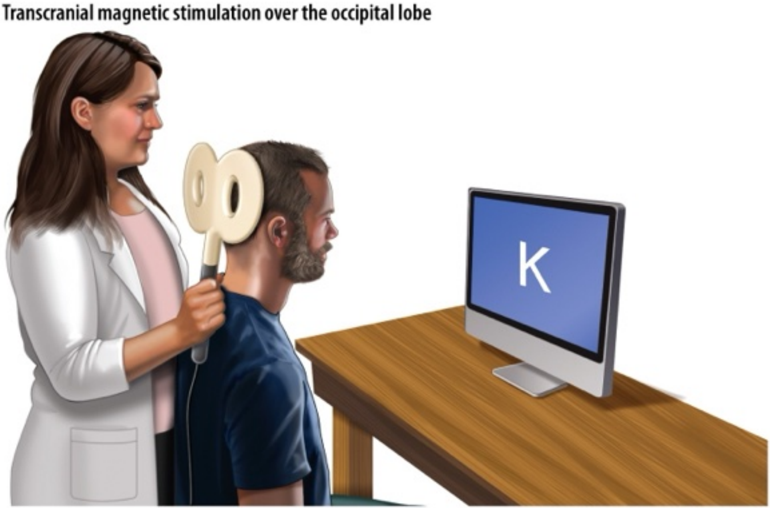


(Ridding & Rothwell, 2007)

Occipital lobe and letter identification



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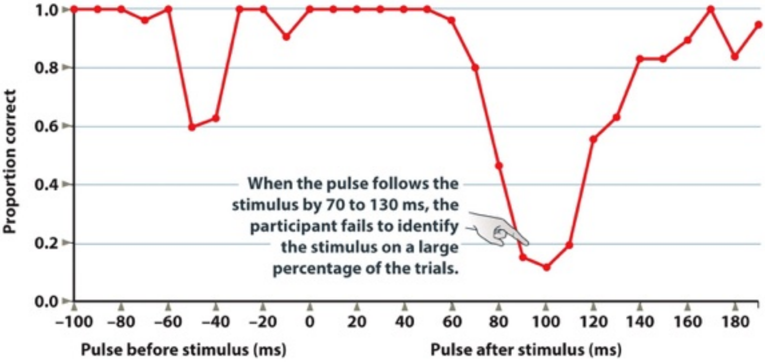
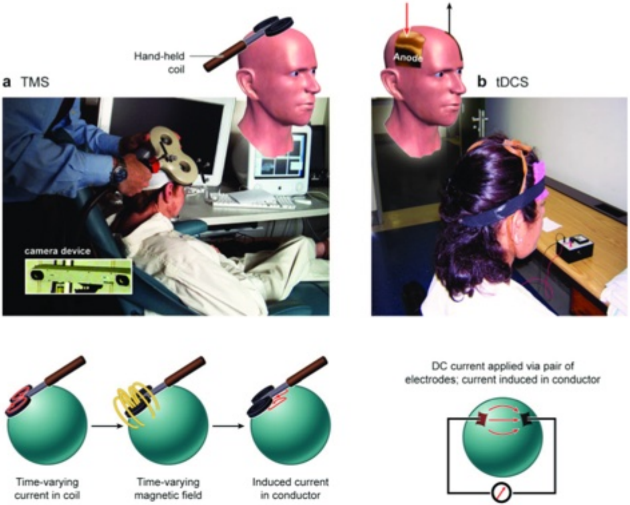
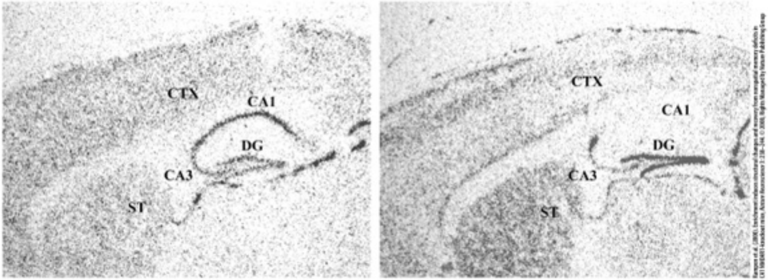


Transcranial Direct Current Stimulation



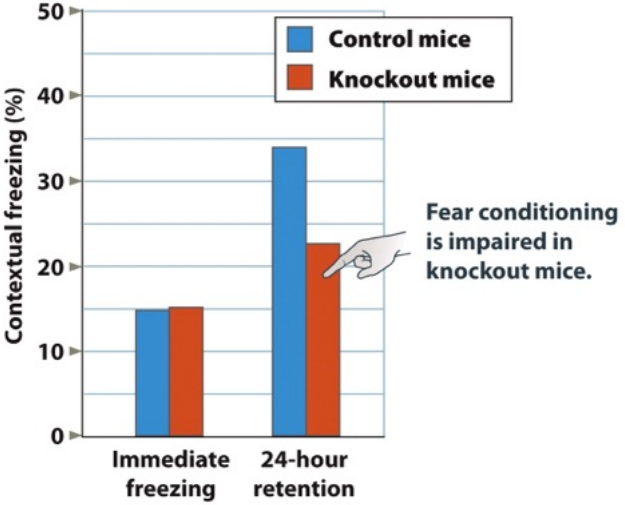
(T. Wagner, Valero-Cabre, & Pascual-Leone, 2007)

Gene knockout



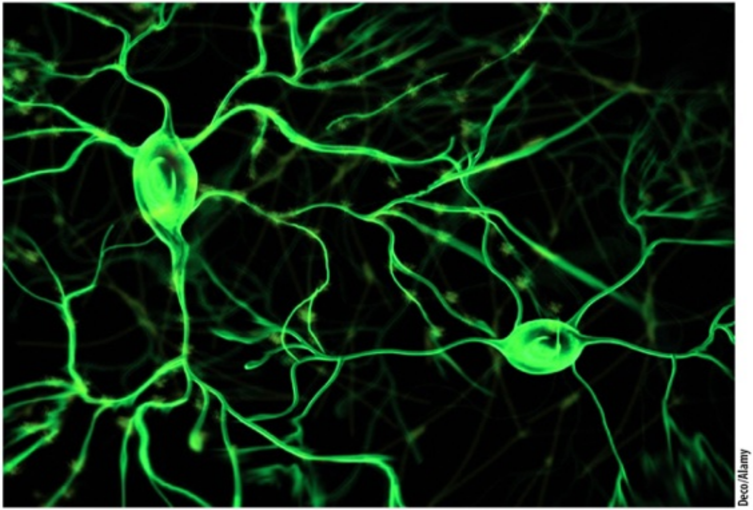
(Rampon et al., 2000)

Gene knockout



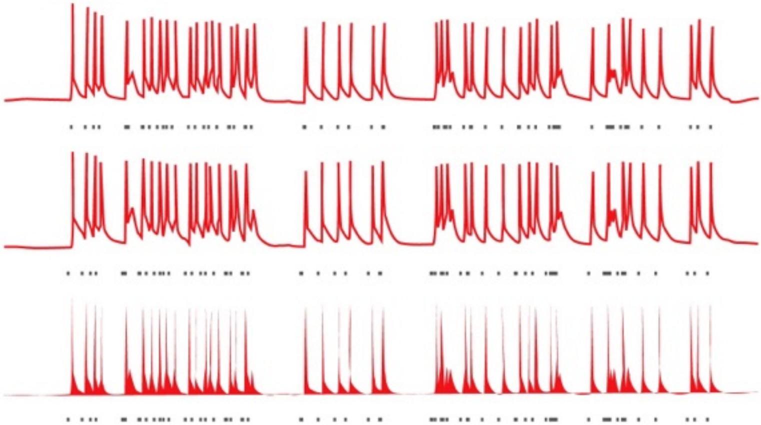
(Rampon et al., 2000)

Optogenetics



(Tye et al., 2011)

Optogenetics



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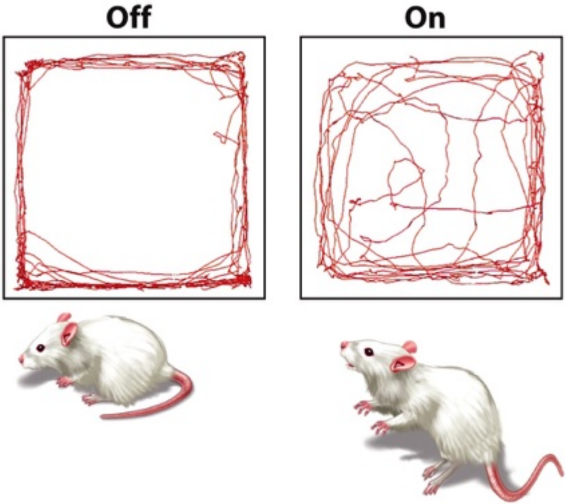


(Tye et al., 2011)

Studying Neural function

Studying Neural function

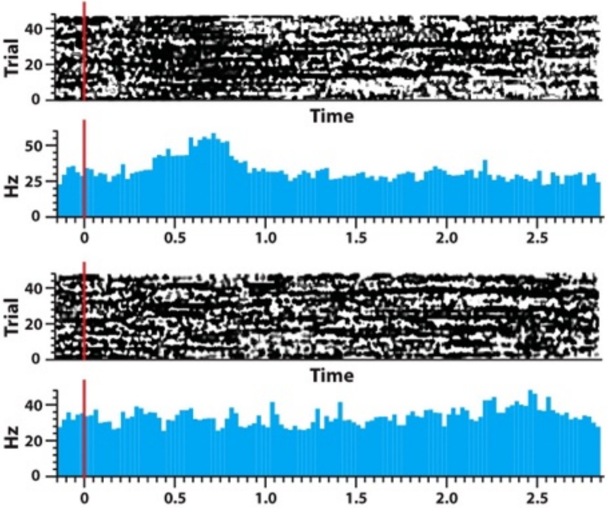
- Single-Cell Recording
- Magnetoencephalography (MEG, 脑磁图仪)
- Scalp Electroencephalography (EEG, 脑电仪)
- Intracranial electroencephalography (iEEG) or Electrocortogram (ECoG, 皮层下脑电)

Studying Neural function

Single-Cell Recording

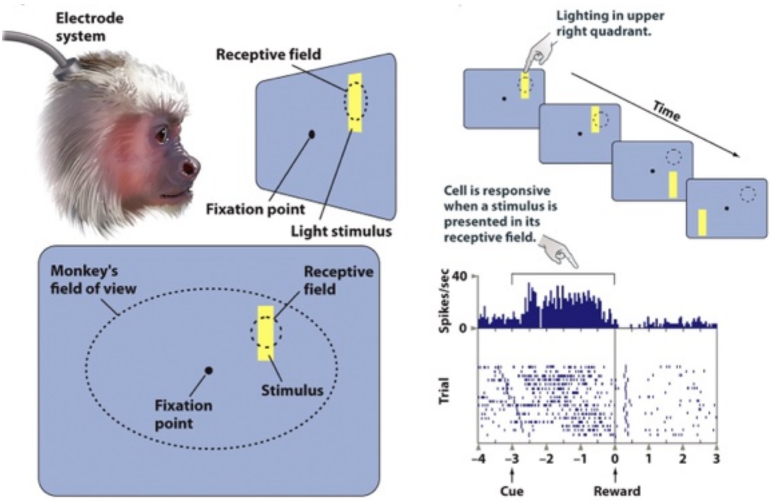
Neural signals

Raster plots (光栅图)



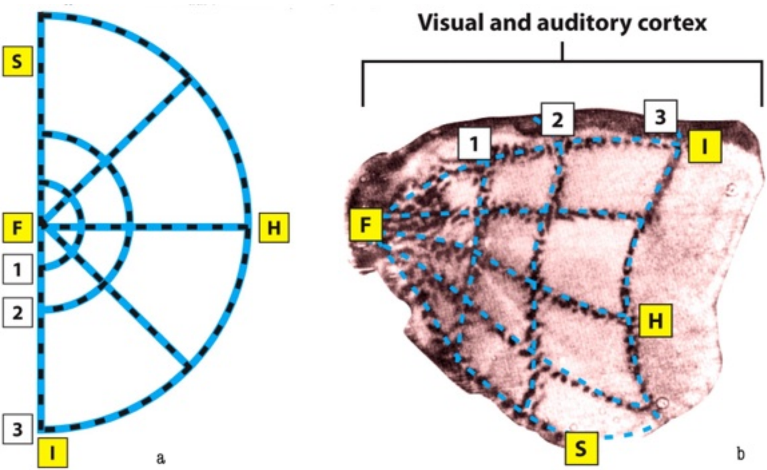
(Gonzalez Andino & Grave de Peralta Menendez, 2012)

Single-Cell Recordings in Animals



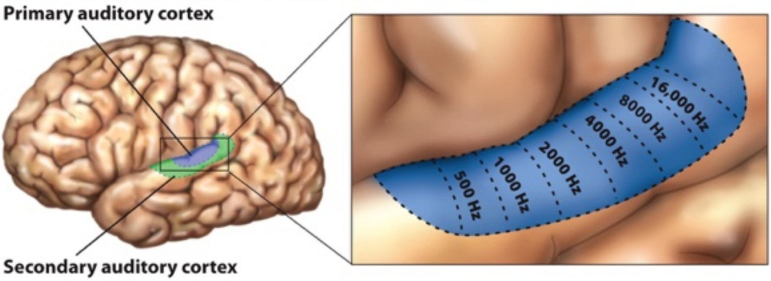
(Mori & Zhang, 2006)

Retinotopic map



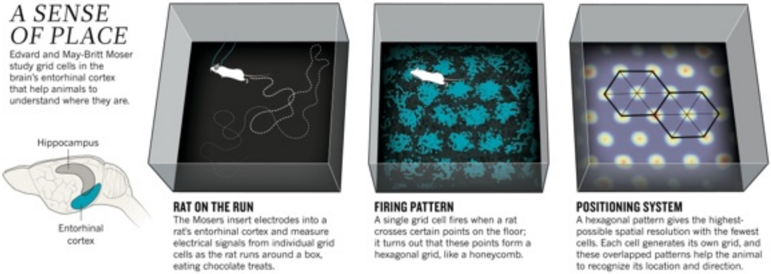
(Gazzaniga et al., 2014, p.98)

Tonotopic or Cochleotopic maps



(Gazzaniga et al., 2014, p.98)

Place cells



(Abbott, 2014)

The Nobel Prize in Physiology or Medicine 2014 was divided, one half awarded to John O'Keefe, the other half jointly to May-Britt Moser and Edvard I. Moser "for their discoveries of cells that constitute a positioning system in the brain".

Single-Cell Recordings in human

(Quiroga, Reddy, Kreiman, Koch, & Fried, 2005)

Studying Neural function

MEEG

EEG and MEG

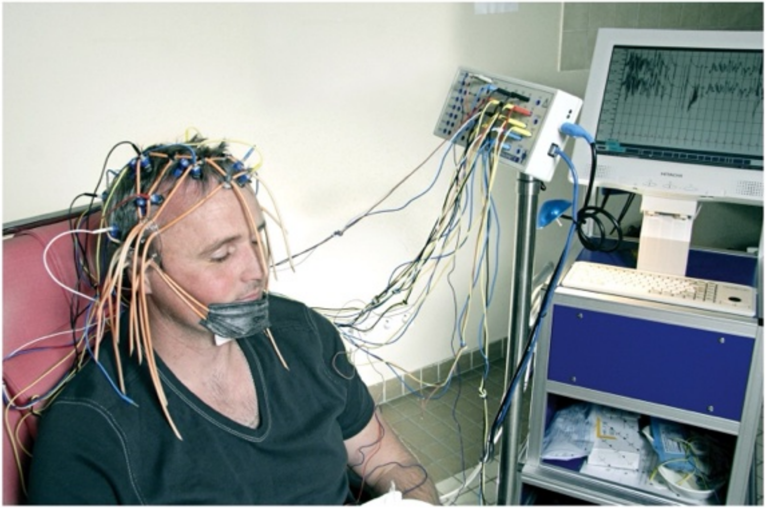
EEG and MEG

- 脑电仪是记录大脑中生物电信号的脑成像技术。
  Electro Encelphalo Graphy (EEG)
  电　　　脑　　　图

EEG and MEG

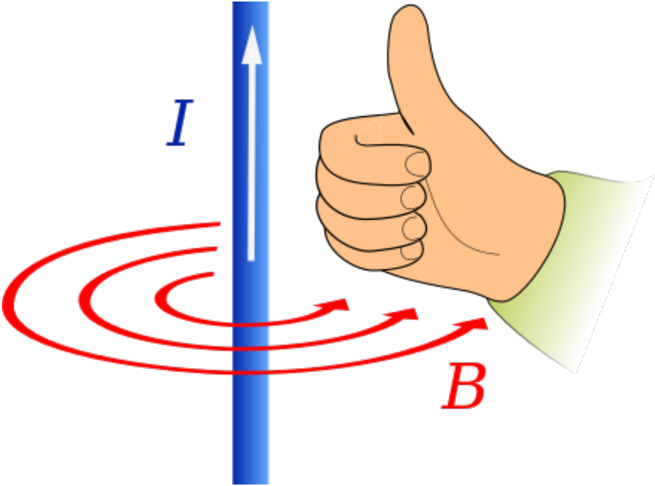
- 脑电仪是记录大脑中生物电信号的脑成像技术。
  Electro Encelphalo Graphy (EEG)
  电 脑 图
- 脑磁图仪是记录大脑中生物磁信号的脑成像技术。
  Magneto Encelphalo Graphy (MEG)
  磁 脑 图

Electroencephalography

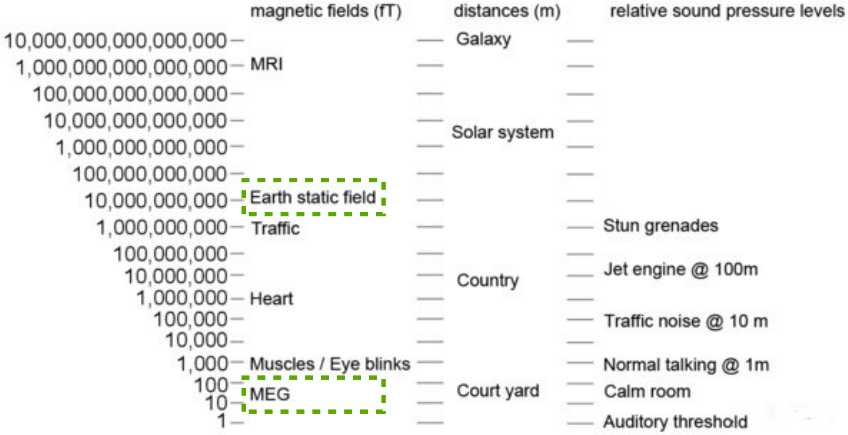


(Gazzaniga et al., 2014, p.99)

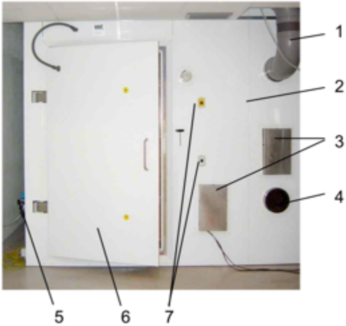
Bioelectric and biomagnetic signals



Biomagnetic signals are tiny



Magnetically shielded room



SQUIDs

Superconducting Quantum Interference Device (SQUIDs)

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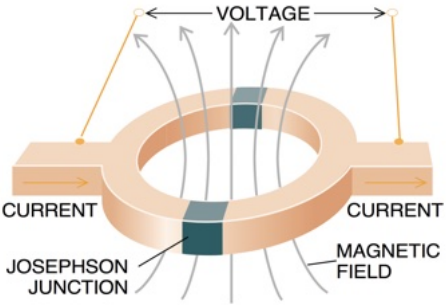
超导 量子 干涉 仪

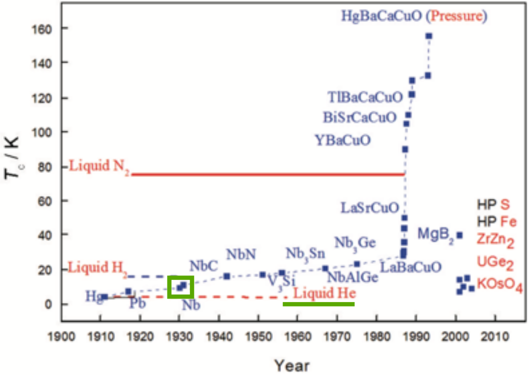
SQUIDs

Superconducting Quantum Interference Device (SQUIDs)

超导 量子 干涉 仪



Superconductors



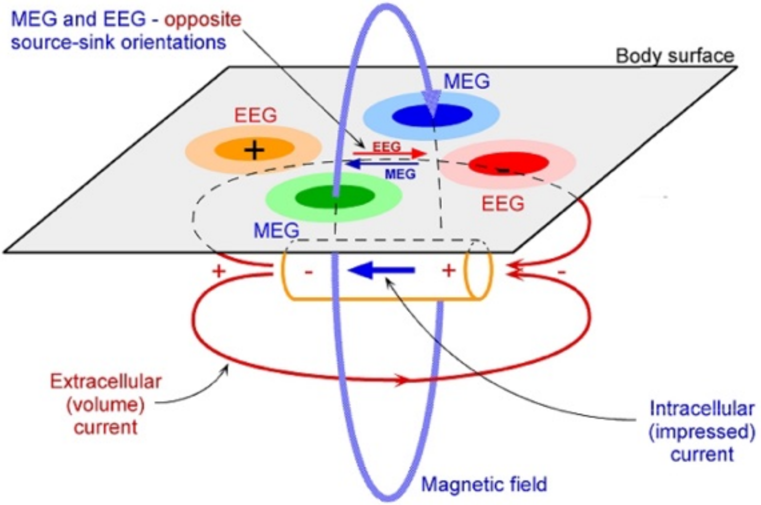
- 铌临界温度 (Nobium, Nb): -263 摄氏度
- 液氦沸点 (Liquid Heliem, LHe): -269 摄氏度

Dewar and Boat in a bottle

全脑磁束计

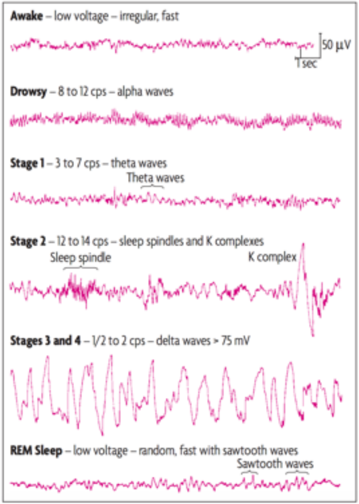
杜瓦罐形状

Comparing EEG and MEG



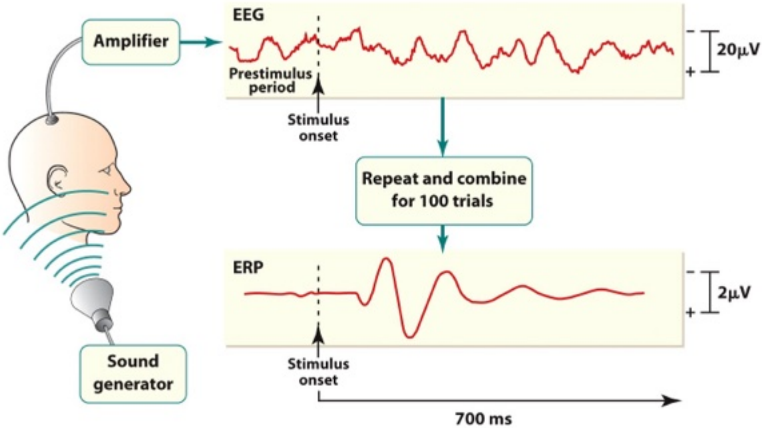
(Vrba & Robinson, 2001)

EEG profiles at different states of consciousness



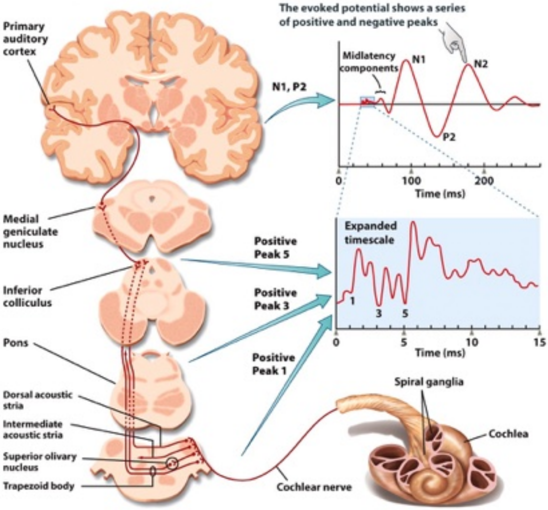
(Gerrig, 2013)

Event-related potentials



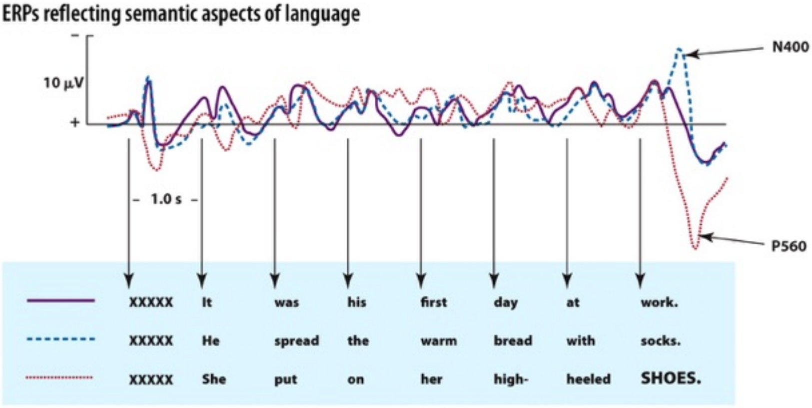
(Gazzaniga et al., 2014, p.100)

Auditory evoked potentials (AERs)



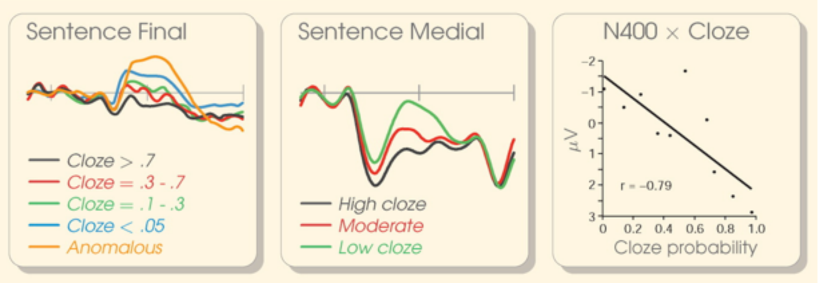
(Quiroga et al., 2005)

Semantic Processing and the N400 Wave



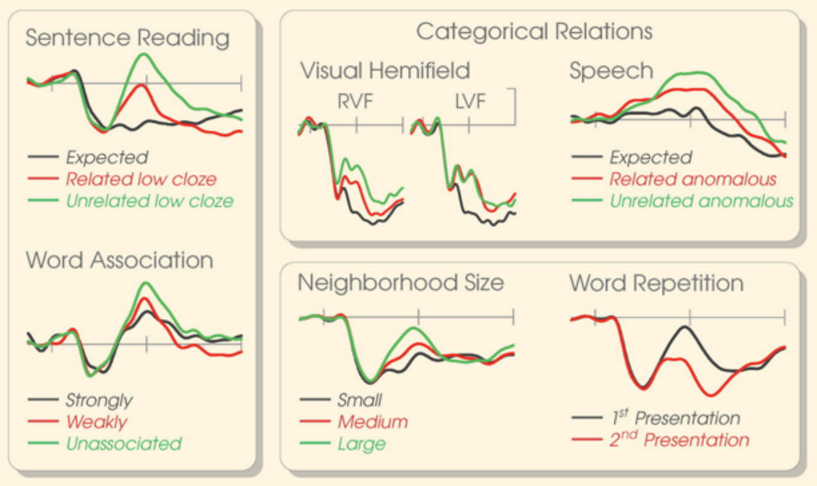
(Kutas & Hillyard, 1980)

Semantic Processing and the N400 Wave



(Kutas & Federmeier, 2011)

Semantic Processing and the N400 Wave

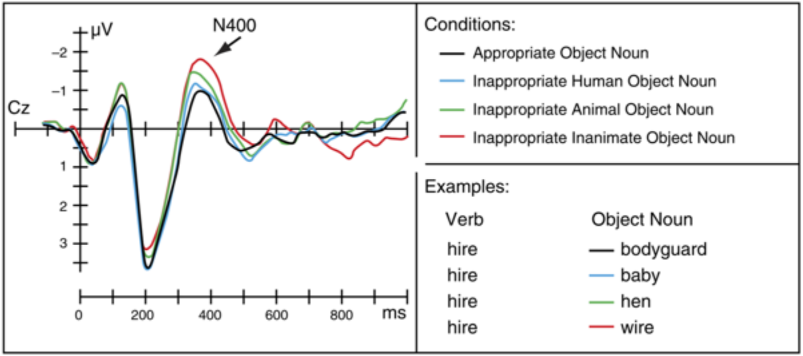


(Kutas & Federmeier, 2011)

Semantic Processing and the N400 Wave

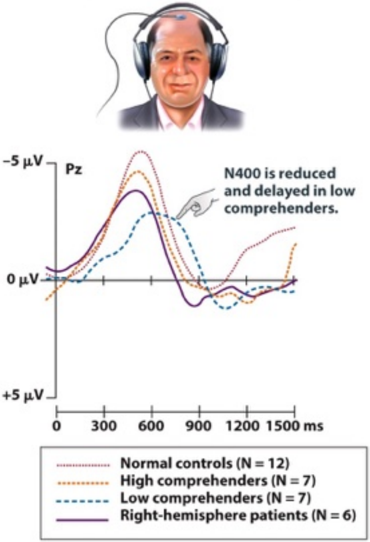
(Kutas & Federmeier, 2011)

Semantic Processing and the N400 Wave



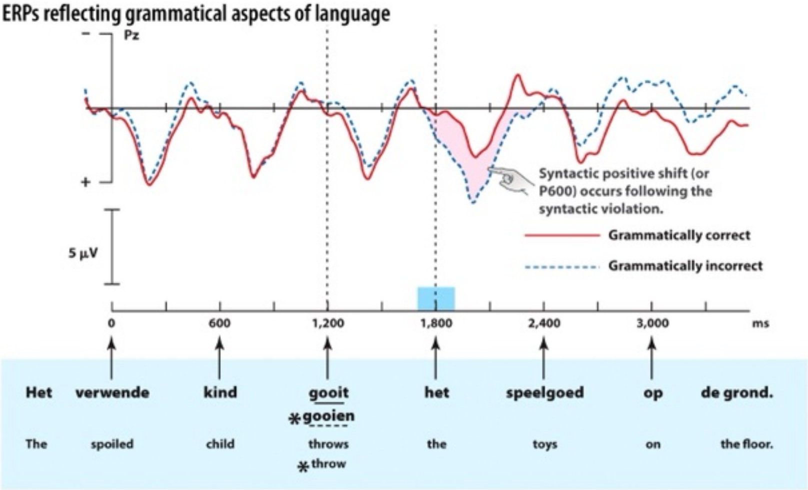
(Friederici, 2011)

Semantic Processing and the N400 Wave



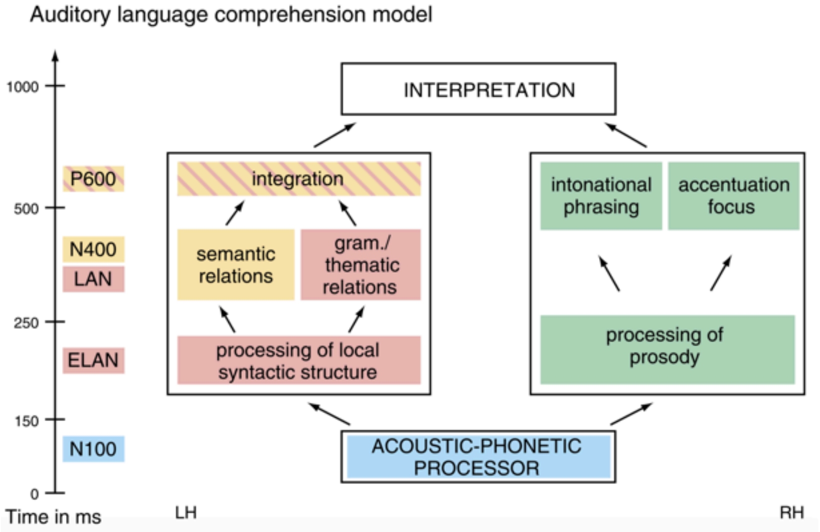
(Swaab, Brown, & Hagoort, 1997)

Syntactic Processing and the P600 Wave



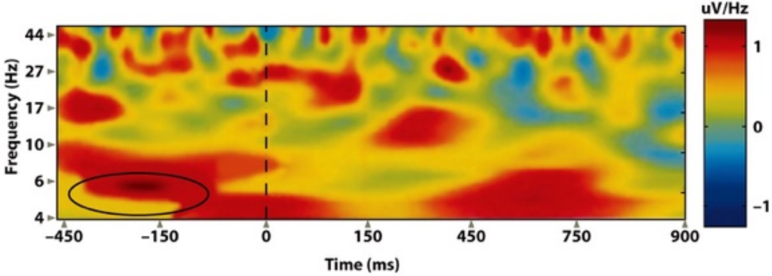
(Hagoort, Brown, & Groothusen, 1993)

Semantic Processing and the N400 Wave



(Friederici, 2011)

Time-frequency analysis

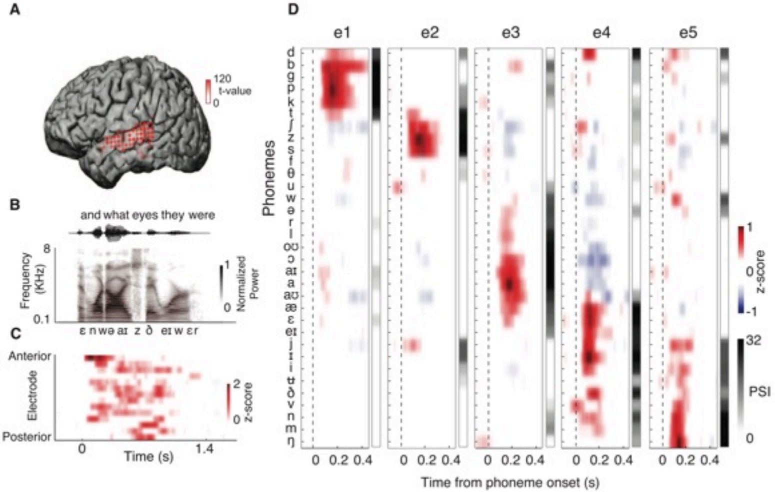


(Addante, Watrous, Yonelinas, Ekstrom, & Ranganath, 2011)

Studying Neural function

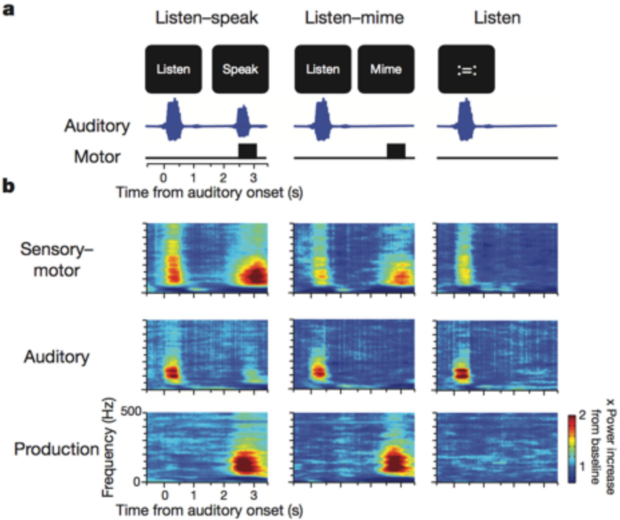
Electrocortogram

Electrocortogram



(Mesgarani, Cheung, Johnson, & Chang, 2014)

Electrocortogram



(Cogan et al., 2014)

The complexity of neural signals

- 一个神经元可以有多达 1.5×10^4 个突触连接；
- 大脑皮层共包含约 2×10^{10} 个神经元细胞；
- 大脑皮层总共约有 2.4×10^{14} 个突触连接；
- 大脑皮层面积约 2.5×10^5 平方毫米；
- 每平方毫米大约有 10^5 个神经元和 10^9 个突触连接；

Analyzing the Brain Structure

Structural Analysis of the Brain

Structural Analysis of the Brain

- Computed Tomography (CT, 计算机断层扫描)

Structural Analysis of the Brain

- Computed Tomography (CT, 计算机断层扫描)
- Magnetic Resonance Imaging (MRI, 磁共振成像)

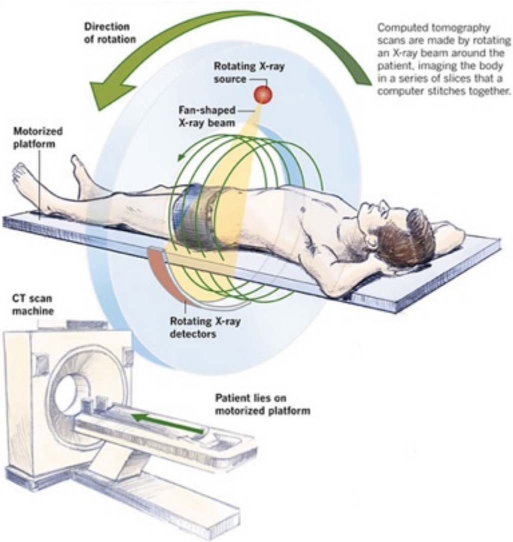
Structural Analysis of the Brain

- Computed Tomography (CT, 计算机断层扫描)
- Magnetic Resonance Imaging (MRI, 磁共振成像)
- Diffusion Tensor Imaging (DTI, 扩散张量成像)

Analyzing the Brain Structure

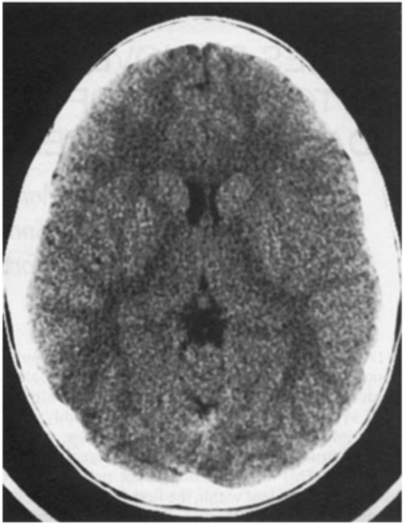
Computed tomography (CT)

Computed tomography (CT)



(Brenner & Hall, 2007)

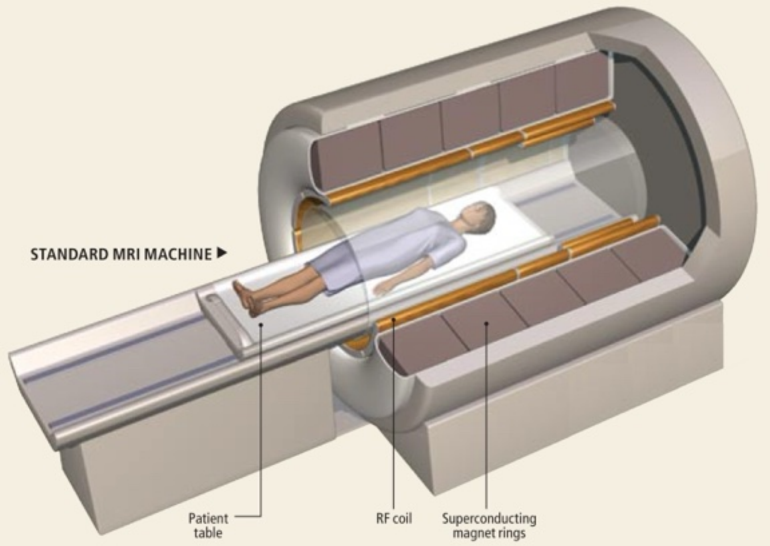
Computed tomography (CT)



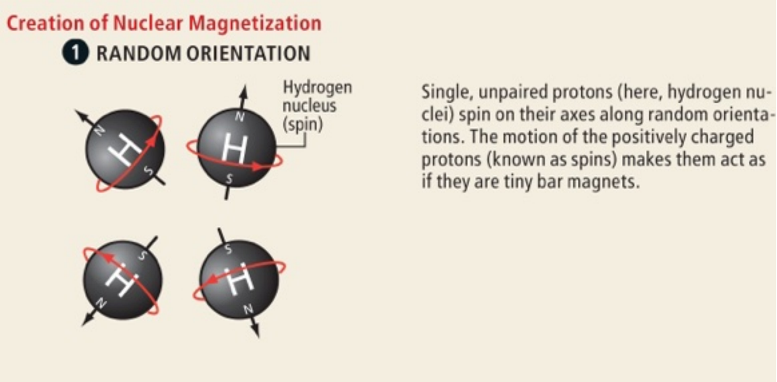
Analyzing the Brain Structure

Magnetic Resonance Imaging

Magnetic Resonance Imaging

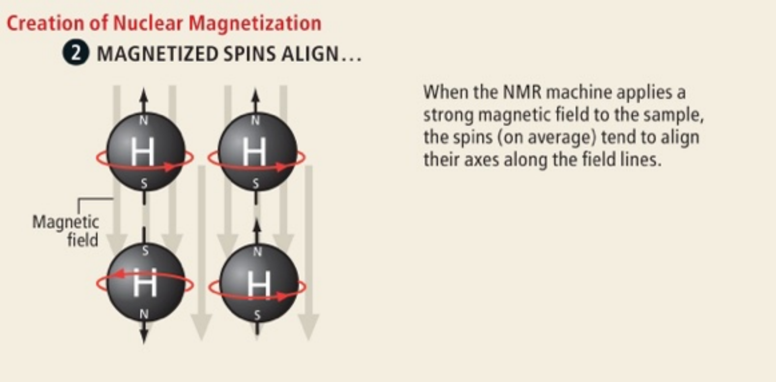


Magnetic Resonance Imaging



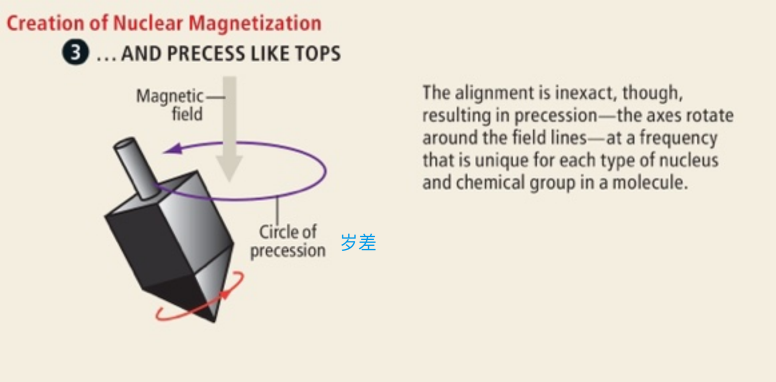
(Blümich, 2008)

Magnetic Resonance Imaging

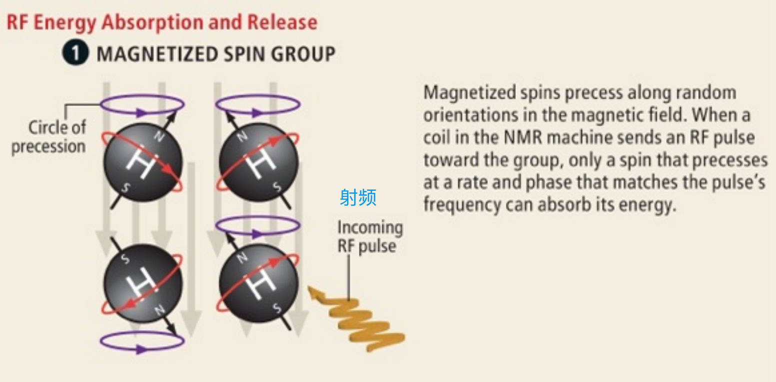


(Blümich, 2008)

Magnetic Resonance Imaging

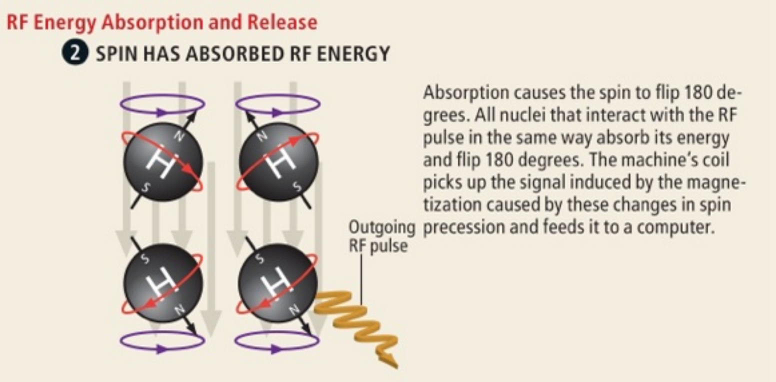


(Blümich, 2008)



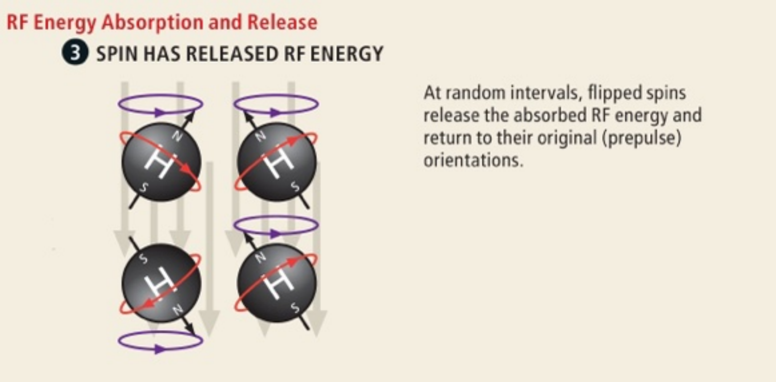
(Blümich, 2008)

Magnetic Resonance Imaging



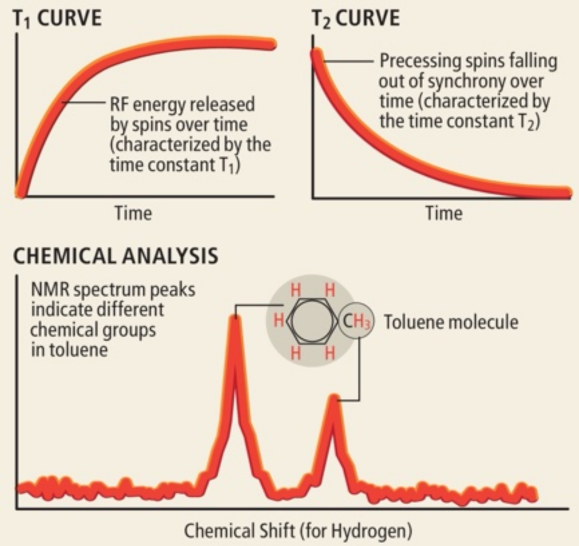
(Blümich, 2008)

Magnetic Resonance Imaging



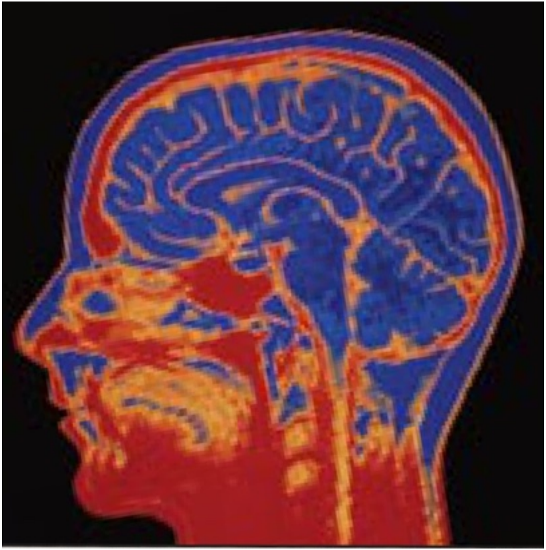
(Blümich, 2008)

Magnetic Resonance Imaging



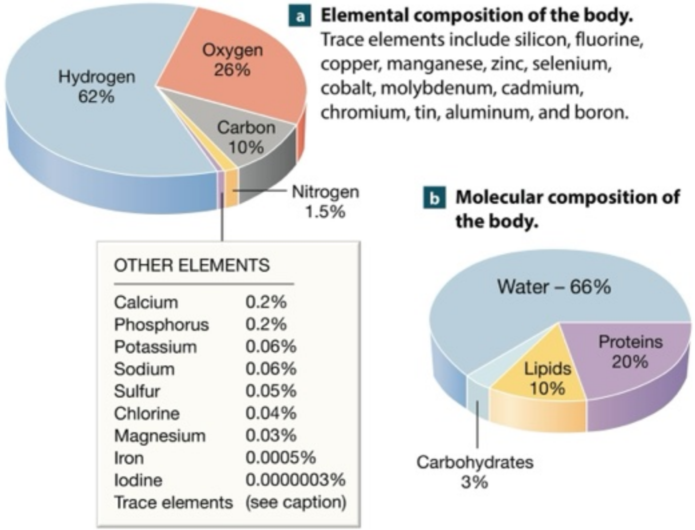
 (Blümich, 2008)

Magnetic Resonance Imaging



(Blümich, 2008)

Elemental composition of the body

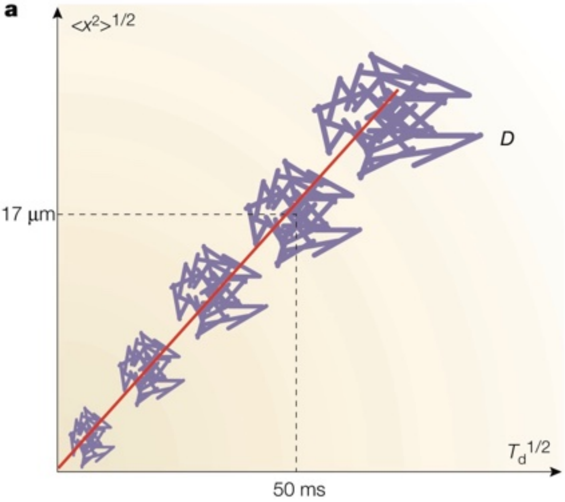


 (Martini et al., 2015, p.5)

Analyzing the Brain Structure

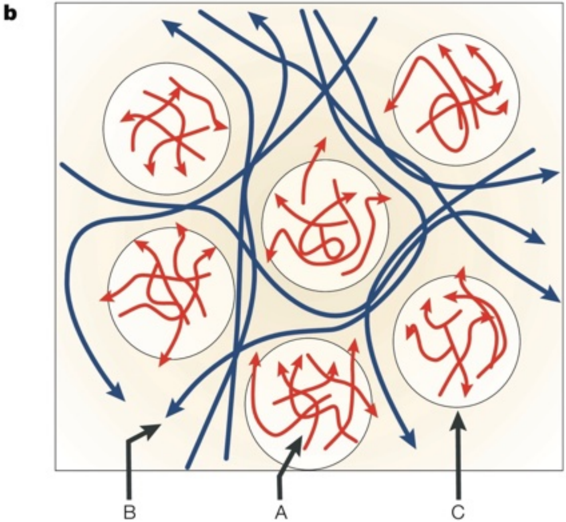
Diffusion Tensor Imaging

Diffusion Tensor Imaging

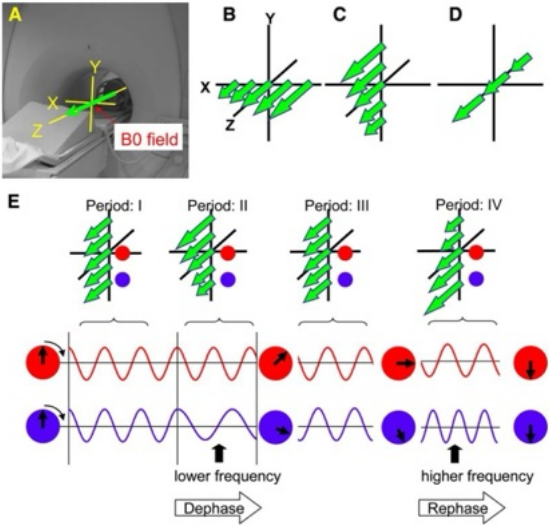


(Le Bihan, 2003)

Diffusion Tensor Imaging

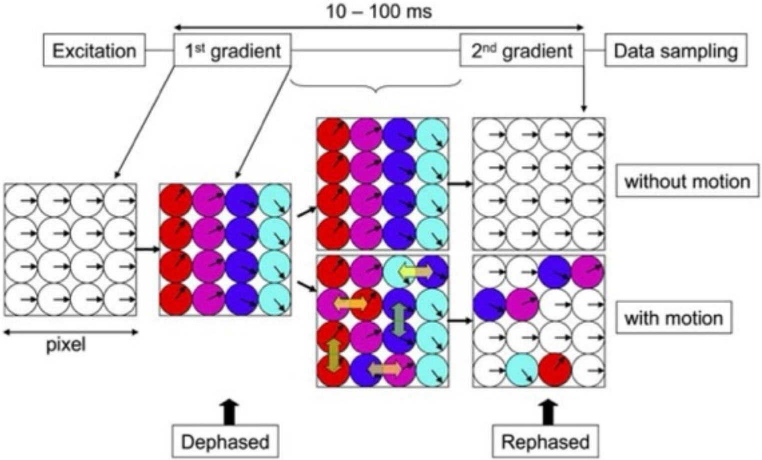


Diffusion Tensor Imaging



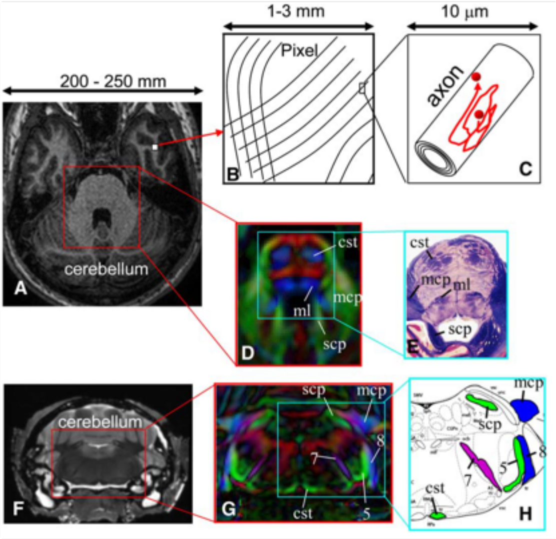
(Mori & Zhang, 2006)

Diffusion Tensor Imaging

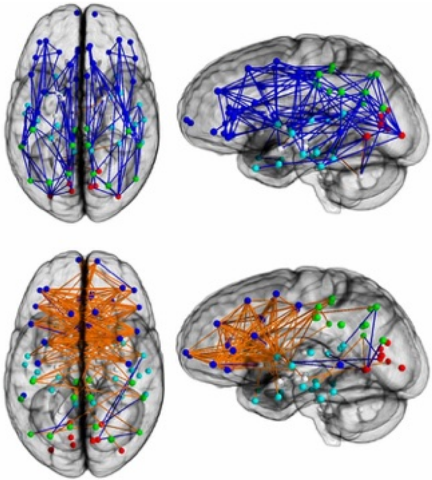


(Mori & Zhang, 2006)

Diffusion Tensor Imaging

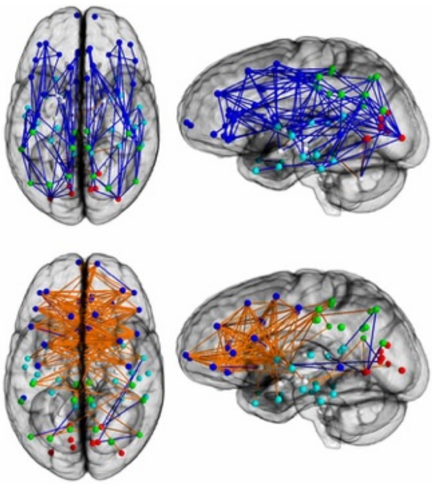


Diffusion Tensor Imaging: Sex differences



(Ingalhalikar et al., 2013)

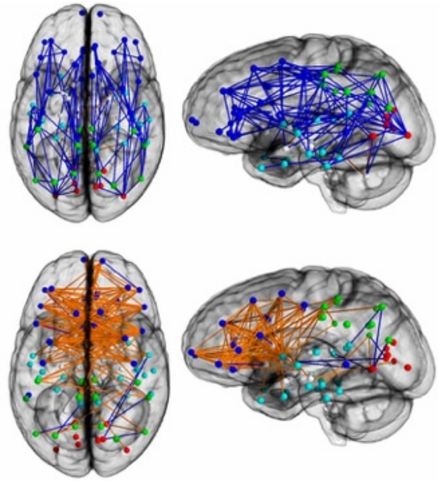
Diffusion Tensor Imaging: Sex differences



Male

(Ingalhalikar et al., 2013)

Diffusion Tensor Imaging: Sex differences



Male

Female

(Ingalhalikar et al., 2013)

Neuroimaging: Function + Structure

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- Positron Emission Tomography (PET, 正电子断层扫描术)

Neuroimaging: Function + Structure

- Positron Emission Tomography (PET, 正电子断层扫描术)
- functional Magnetic Resonance Imaging (fMRI, 功能性磁共振成像)

Neuroimaging: Function + Structure

- Positron Emission Tomography
  (PET, 正电子断层扫描术)
- functional Magnetic Resonance Imaging
  (fMRI, 功能性磁共振成像)
- functional near-infrared spectroscopy
  (fNIRS, 功能近红外光谱成像技术)

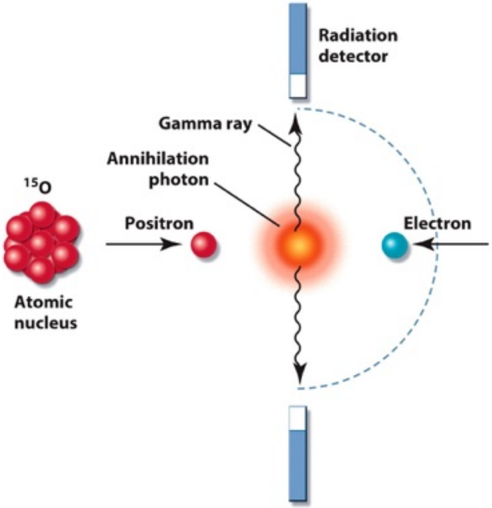
Neuroimaging: Function + Structure

Positron Emission Tomography

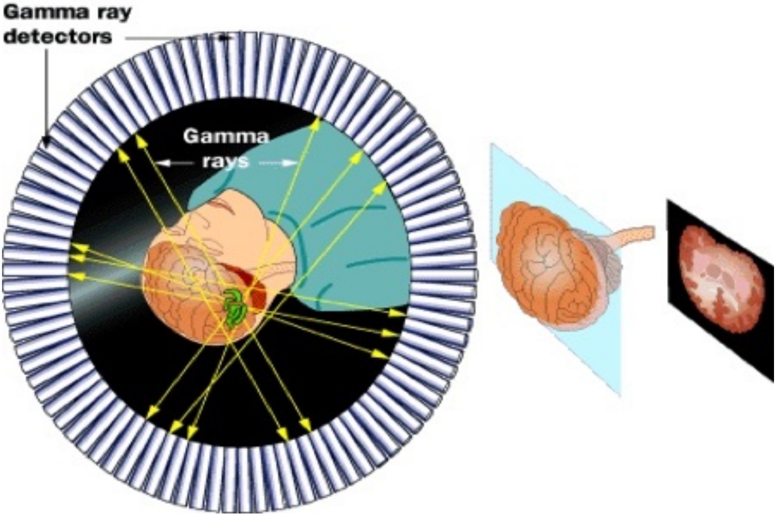
Positron Emission Tomography

Positron Emission Tomography

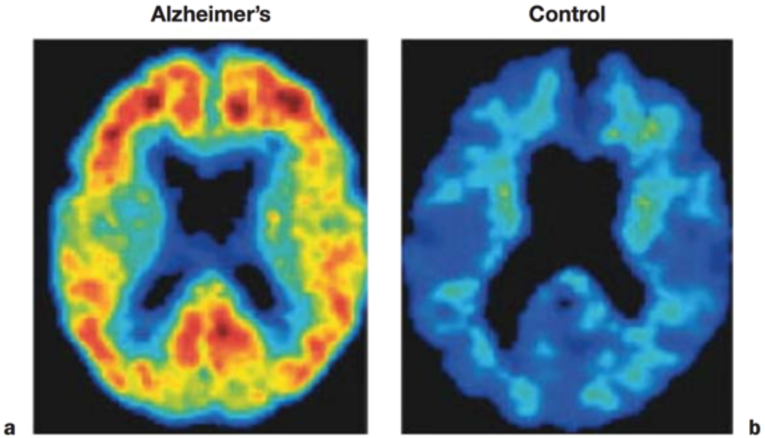
Positron Emission Tomography



Positron Emission Tomography



Using PiB to look for signs of Alzheimer's disease



(Vitali, Migliaccio, Agosta, Rosen, & Geschwind, n.d.)

Neuroimaging: Function + Structure

Functional Magnetic Resonance Imaging

BOLD signals

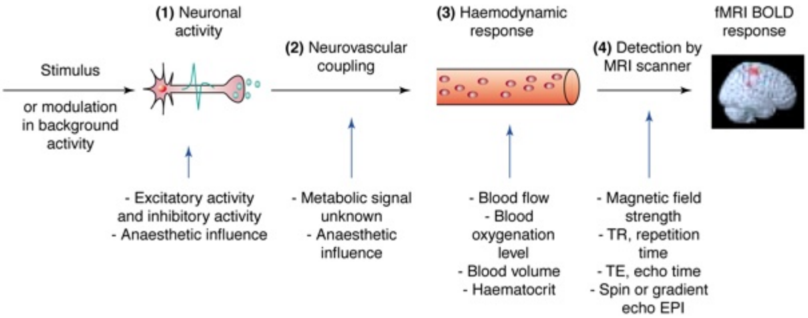
BOLD signals

- Deoxygenated hemoglobin (脱氧血红蛋白) is paramagnetic (i.e., weakly magnetic in the presence of a magnetic field), whereas oxygenated hemoglobin (含氧血红蛋白) is not.

BOLD signals

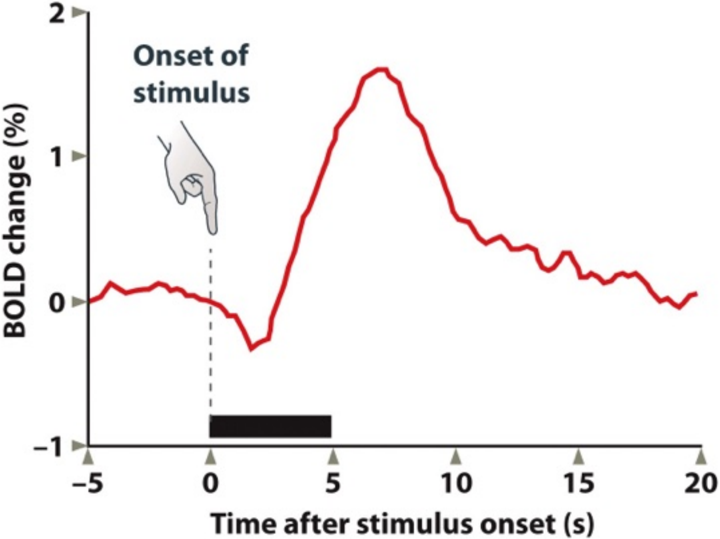
- Deoxygenated hemoglobin (脱氧血红蛋白) is paramagnetic (i.e., weakly magnetic in the presence of a magnetic field), whereas oxygenated hemoglobin (含氧血红蛋白) is not.
- fMRI detectors measure the ratio of oxygenated to deoxygenated hemoglobin; this value is referred to as the blood oxygen level–dependent (血氧水平依赖), or BOLD.

Functional Magnetic Resonance Imaging

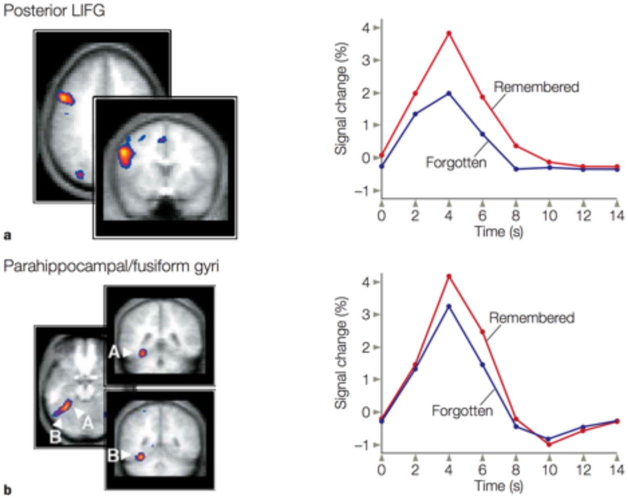


(Arthurs & Boniface, 2002)

Stimulus and BOLD signals



Encode or retrieve

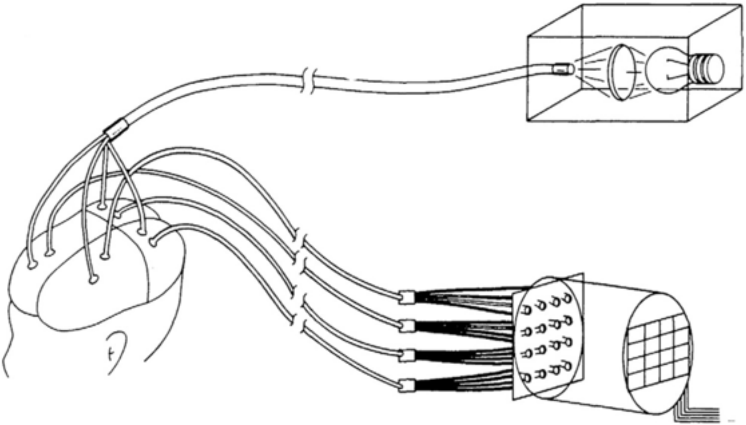


(A. D. Wagner et al., 1998)

Neuroimaging: Function + Structure

functional Near-Infrared Spectroscopy

functional Near-Infrared Spectroscopy



(Ferrari & Quaresima, 2012)

functional Near-Infrared Spectroscopy

functional Near-Infrared Spectroscopy

- fNIRS is a non-invasive imaging method involving the quantification of chromophore concentration resolved from the measurement of near infrared (NIR) light attenuation or temporal or phasic changes.

functional Near-Infrared Spectroscopy

- fNIRS is a non-invasive imaging method involving the quantification of chromophore concentration resolved from the measurement of near infrared (NIR) light attenuation or temporal or phasic changes.
- NIR spectrum light takes advantage of the optical window in which skin, tissue, and bone are mostly transparent to NIR light in the spectrum of 700-900 nm, while hemoglobin (oxy-Hb) and deoxygenated-hemoglobin (deoxy-Hb) are stronger absorbers of light.

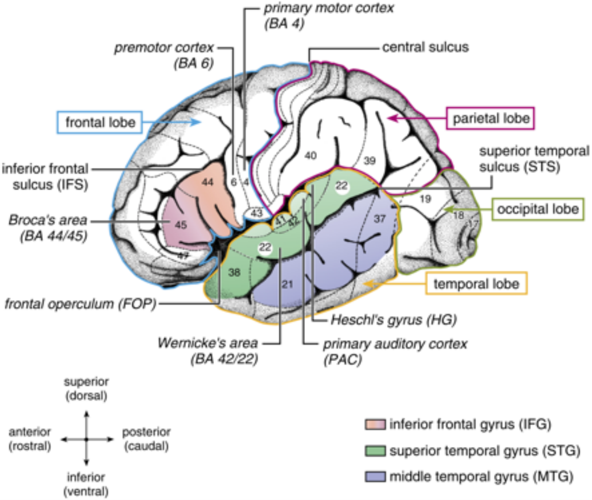
functional Near-Infrared Spectroscopy

- Differences in the absorption spectra of deoxy-Hb and oxy-Hb allow the measurement of relative changes in hemoglobin concentration through the use of light attenuation at multiple wavelengths.

Neuroimaging: Function + Structure

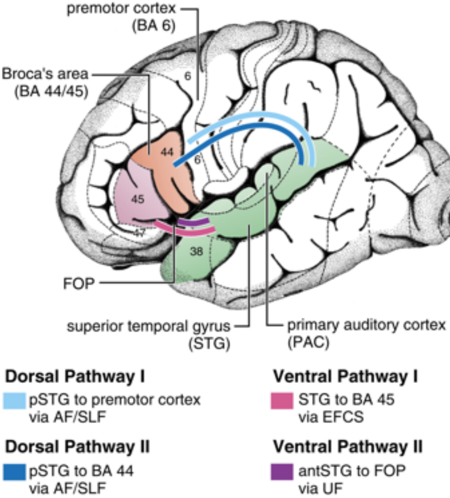
Applying to language

The left hemisphere



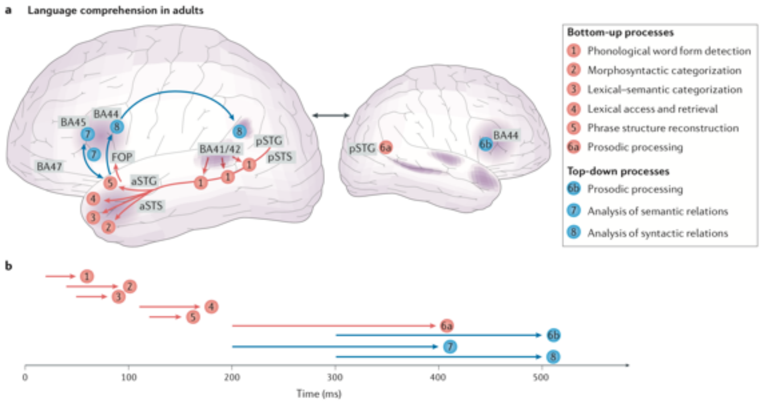
(Friederici, 2011)

Structural connectivities



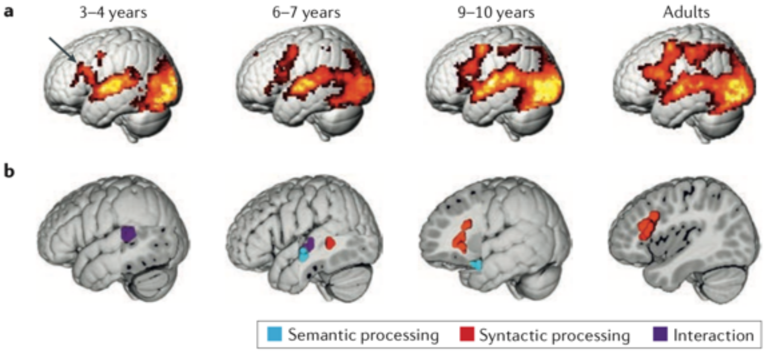
(Friederici, 2011)

The adult auditory language comprehension network



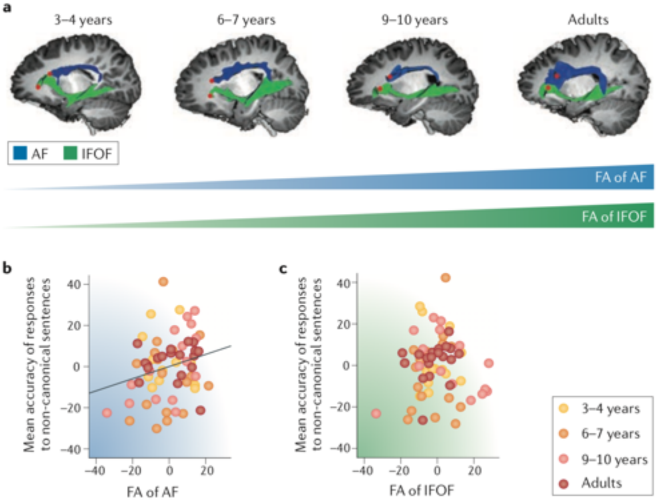
(Skeide & Friederici, 2016)

The segregation of syntax from semantics



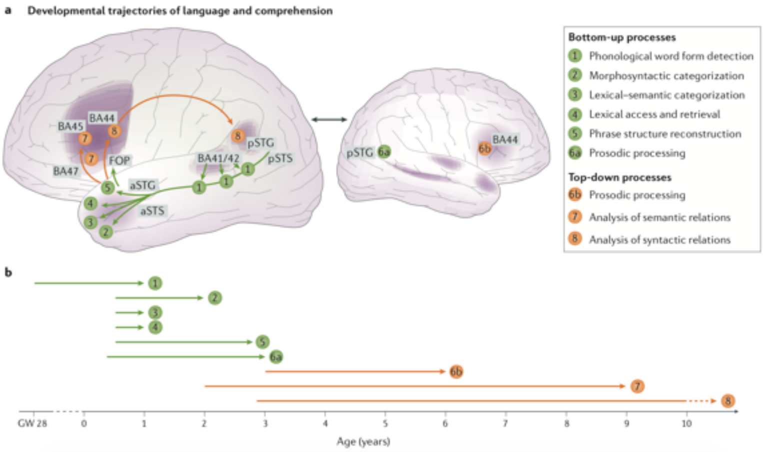
(Skeide & Friederici, 2016)

The ontogenetic emergence of complex syntax



(Skeide & Friederici, 2016)

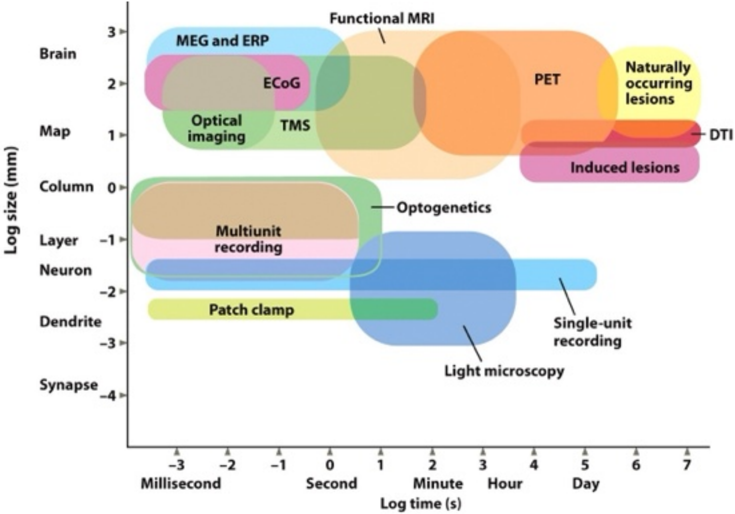
The evolving cortical circuit



(Skeide & Friederici, 2016)

Summary

Summary



(Gazzaniga et al., 2014, p.116)

Thank you

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