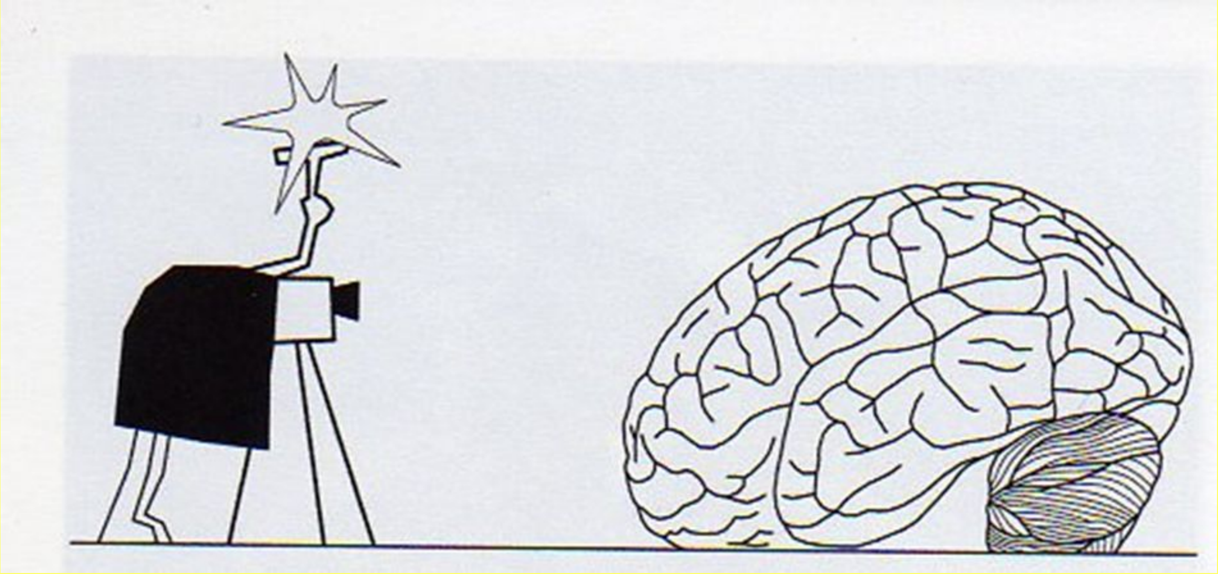
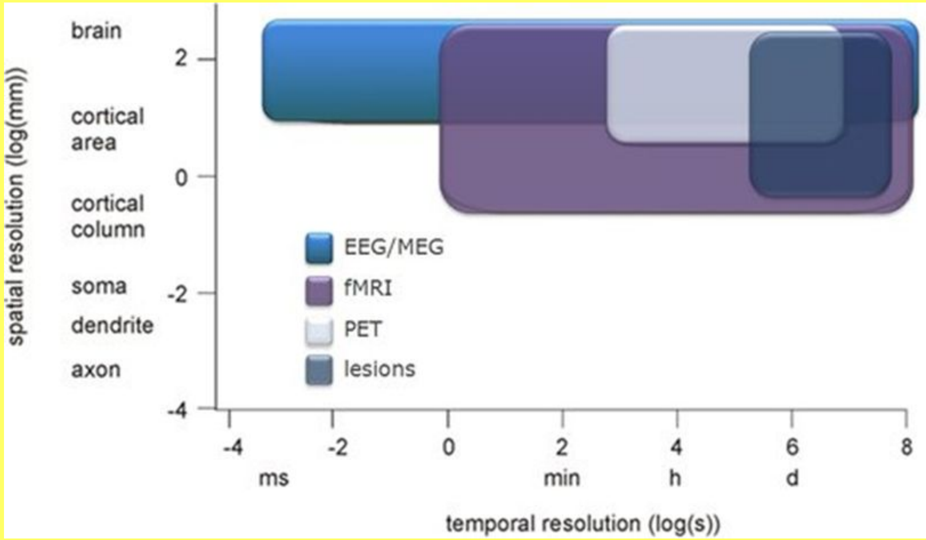
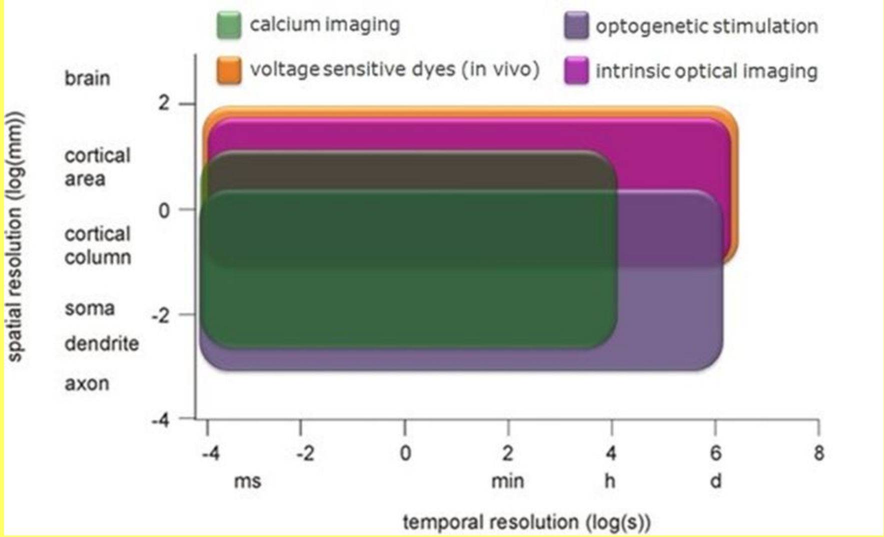
Психофизиология

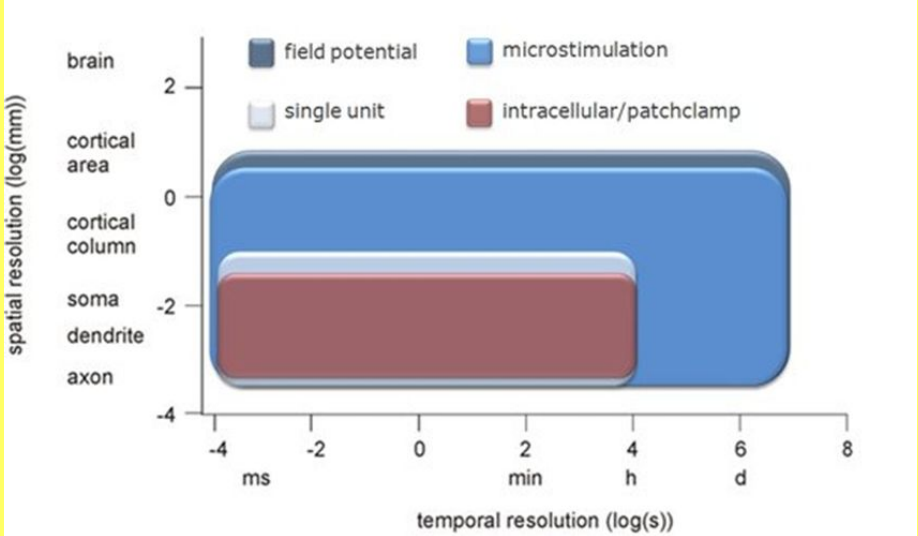
Методы
(общемозговой уровень)



Методы

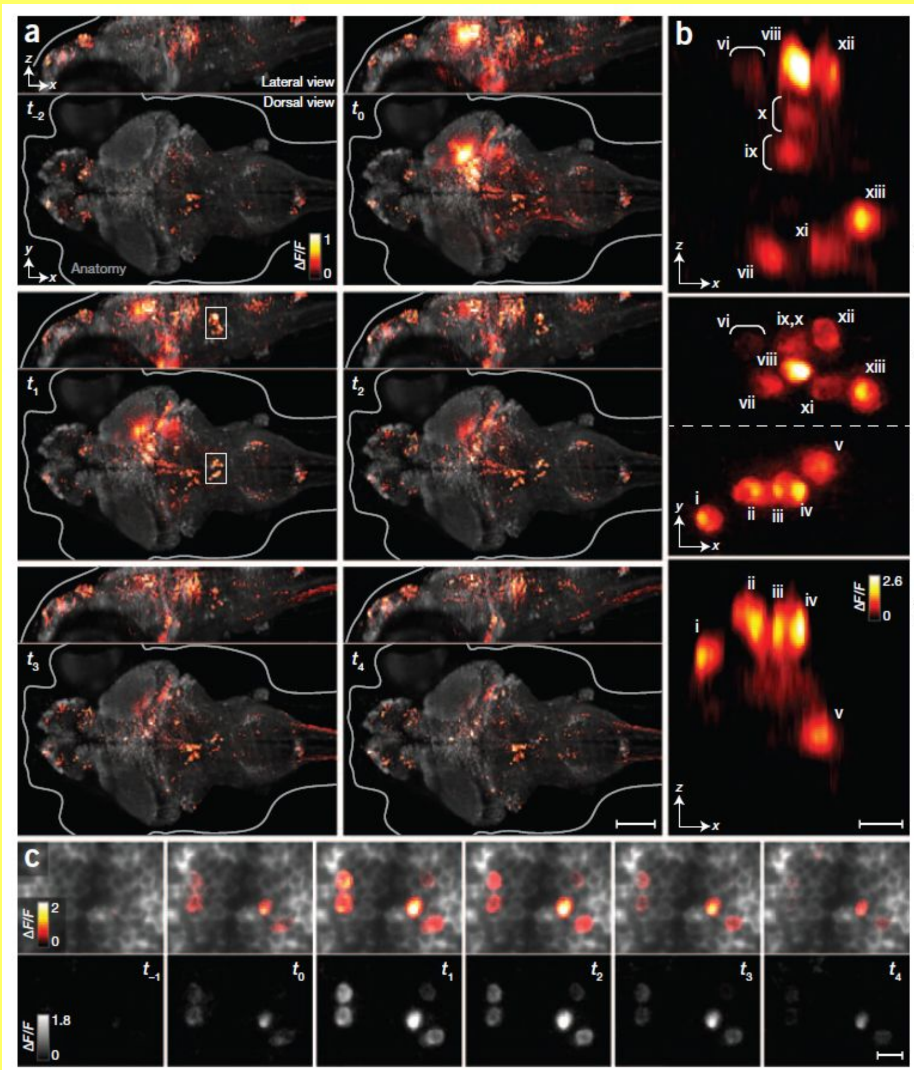

brain
cortical area
cortical column
soma
dendrite
axon
spatial resolution (log(mm))
2
0
-2
-4
-4
-2
0
2
4
6
8
ms
min
h
d
temporal resolution (log(s))
EEG/MEG
fMRI
PET
lesions

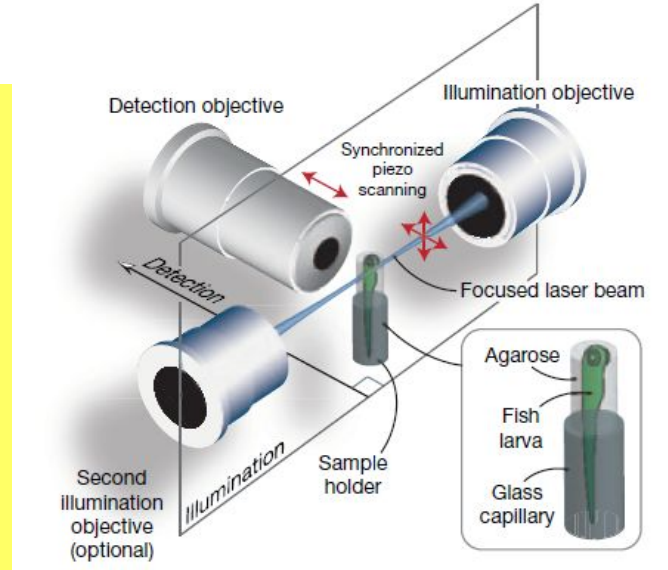

calcium imaging
optogenetic stimulation
voltage sensitive dyes (in vivo)
intrinsic optical imaging
brain
cortical area
cortical column
soma
dendrite
axon
spatial resolution (log(mm))
2
0
-2
-4
-4
-2
0
2
4
6
8
ms
min
h
d
temporal resolution (log(s))


field potential
microstimulation
single unit
intracellular/patchclamp
brain
cortical area
cortical column
soma
dendrite
axon
spatial resolution (log(mm))
2
0
-2
-4
-4
-2
0
2
4
6
8
ms
min
h
d
temporal resolution (log(s))

Whole-brain functional imaging at cellular resolution using light-sheet microscopy

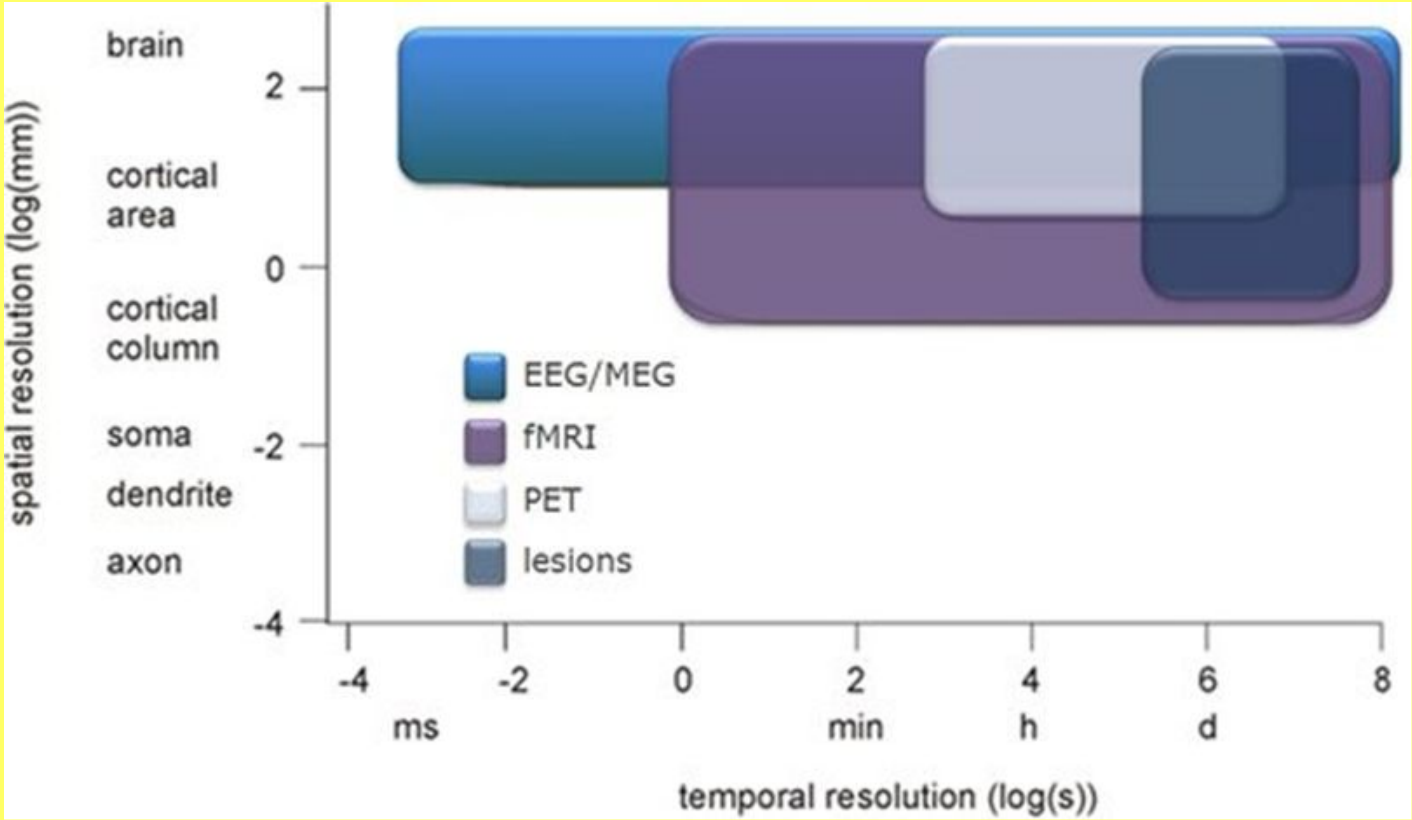
Misha B Ahrens & Philipp J Keller





Ahrens et al., 2013

Разрешение методов



3 типа методов

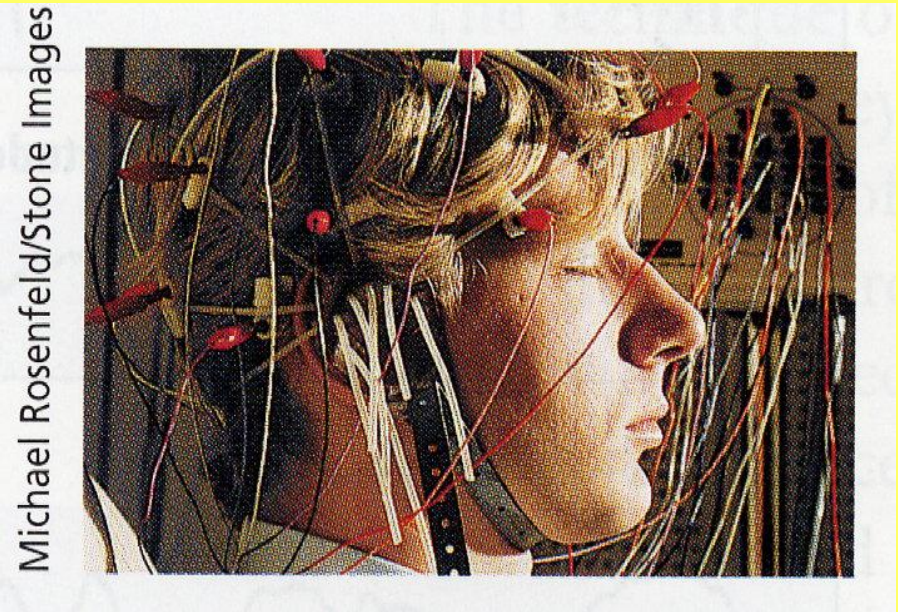
- Регистрация активности
- Воздействие
  - индукция активности
  - элиминация (подавление или «убирание») активности

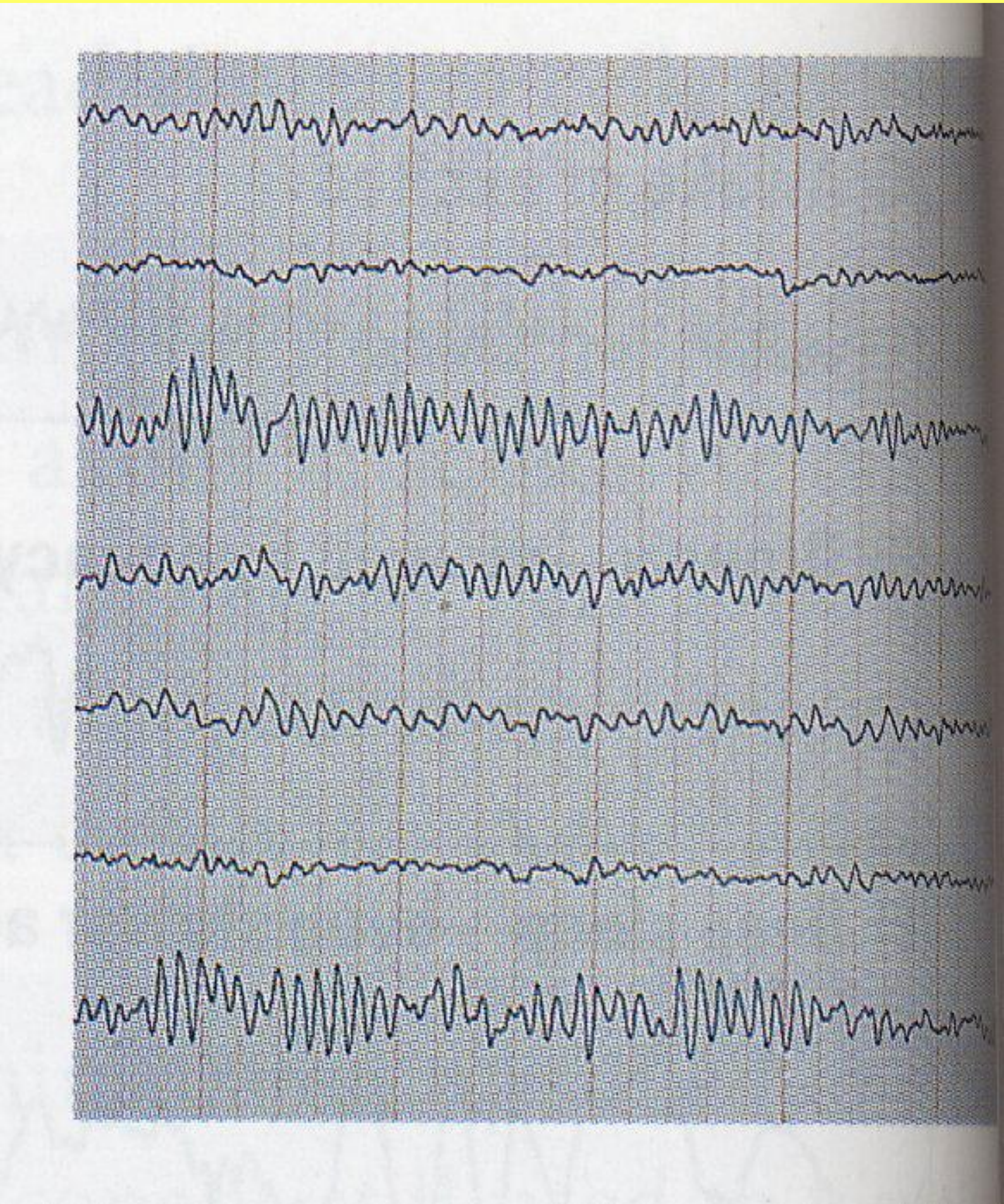
→ мозг

→ нейрон

электрические или метаболические показатели

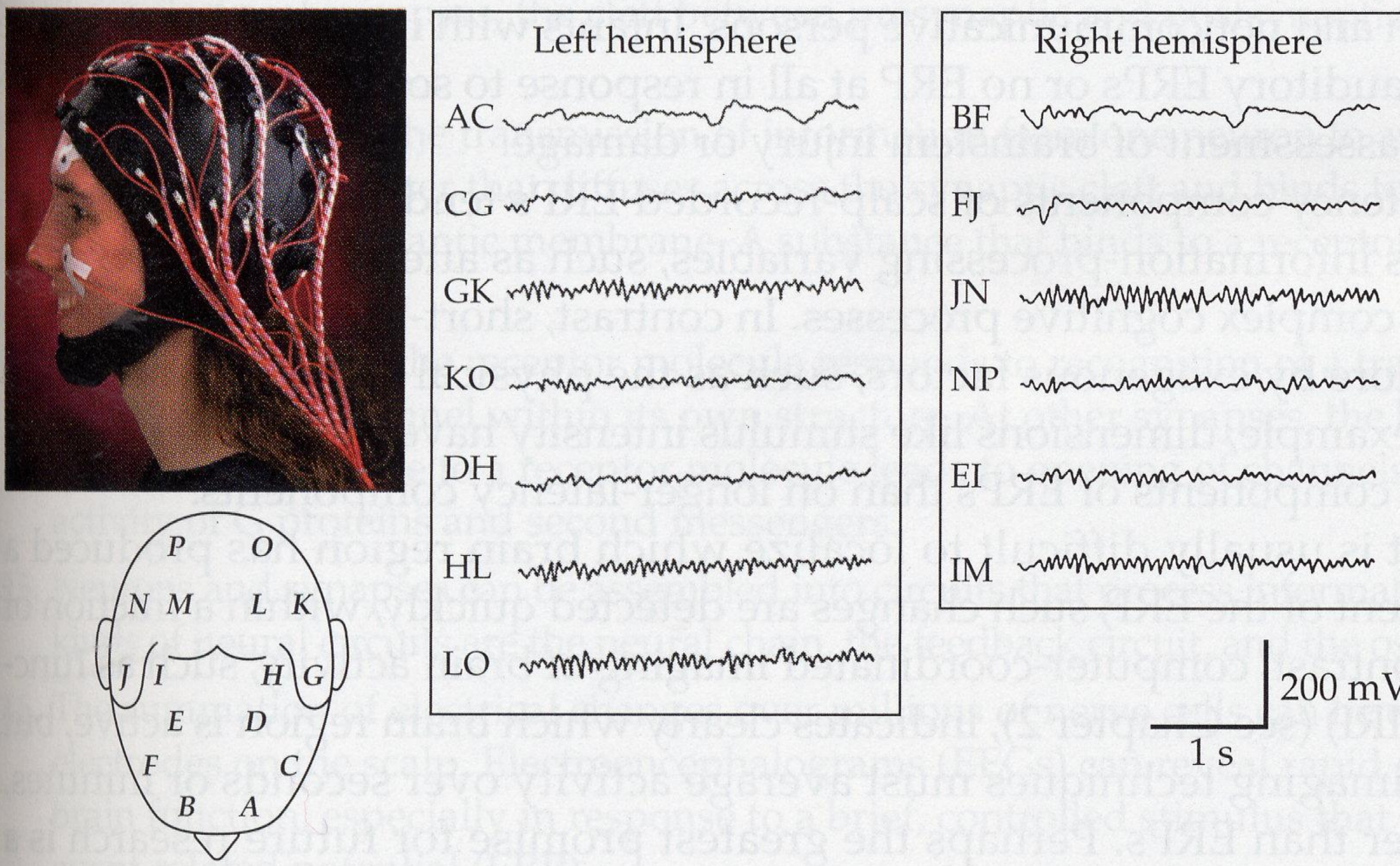
электроэнцефалография (ЭЭГ)





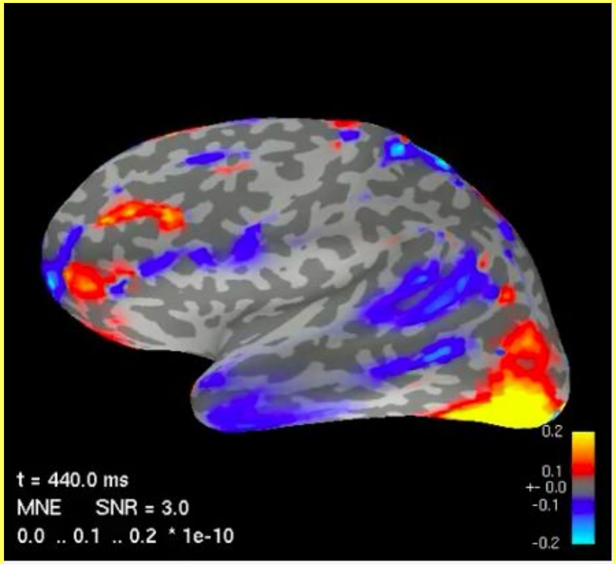
электроэнцефалография (ЭЭГ)

(*a*) **Multichannel EEG recording**



магнитоэнцефалография (МЭГ)

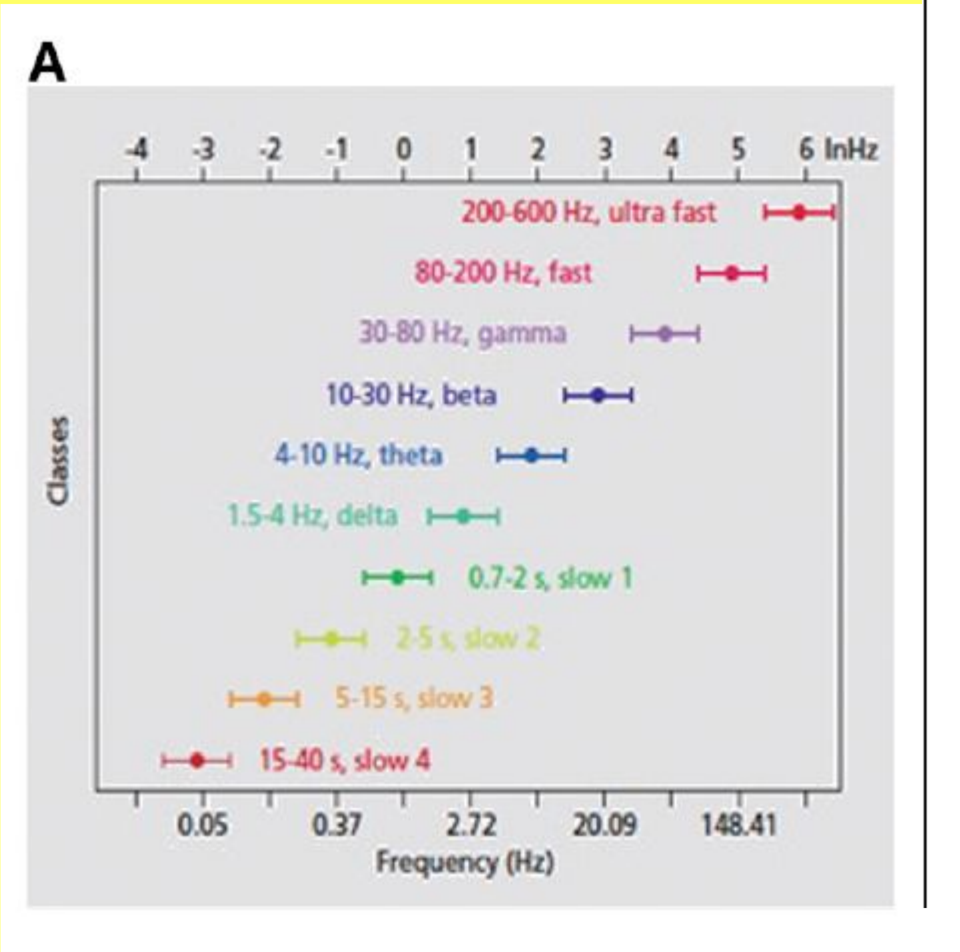
- ✔ регистрируются магнитные поля
- ✔ дополнение к ЭЭГ (направление токов)

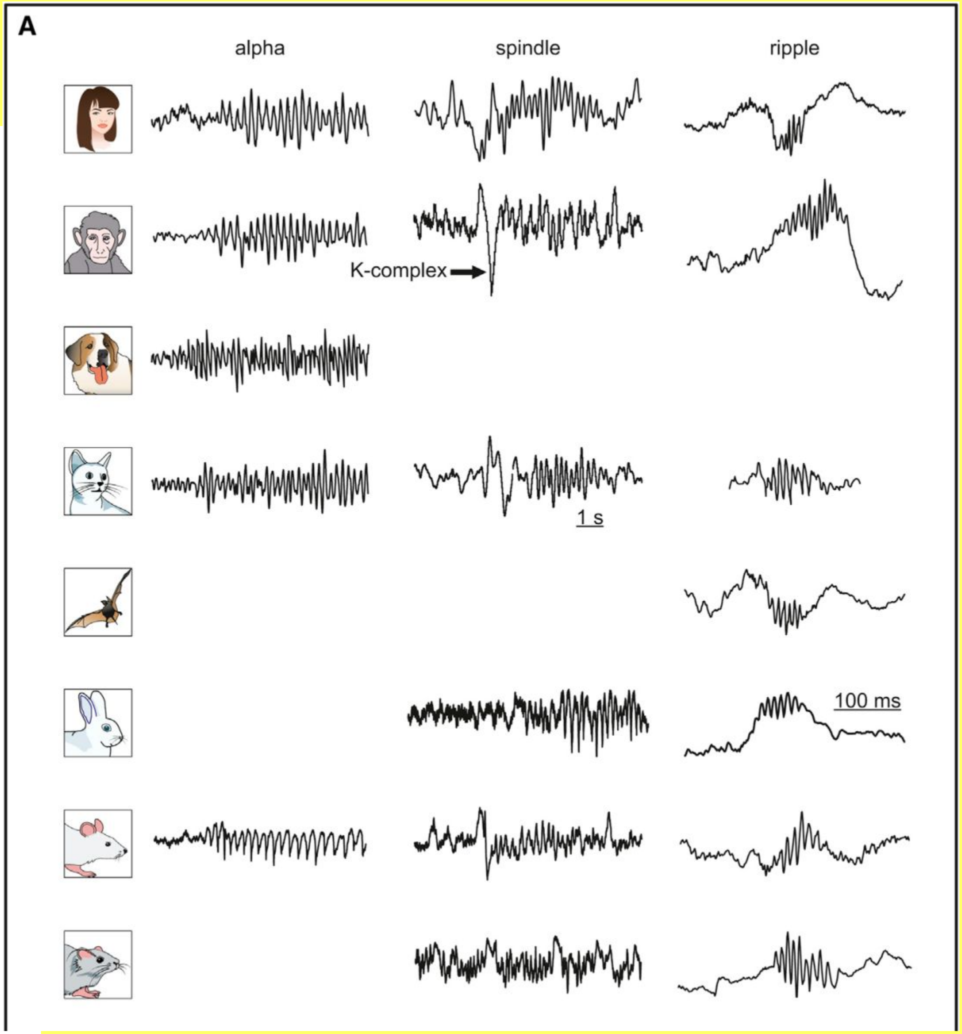


https://www.youtube.com/watch?v=dakGq0sghSI

ЭЭГ МЭГ

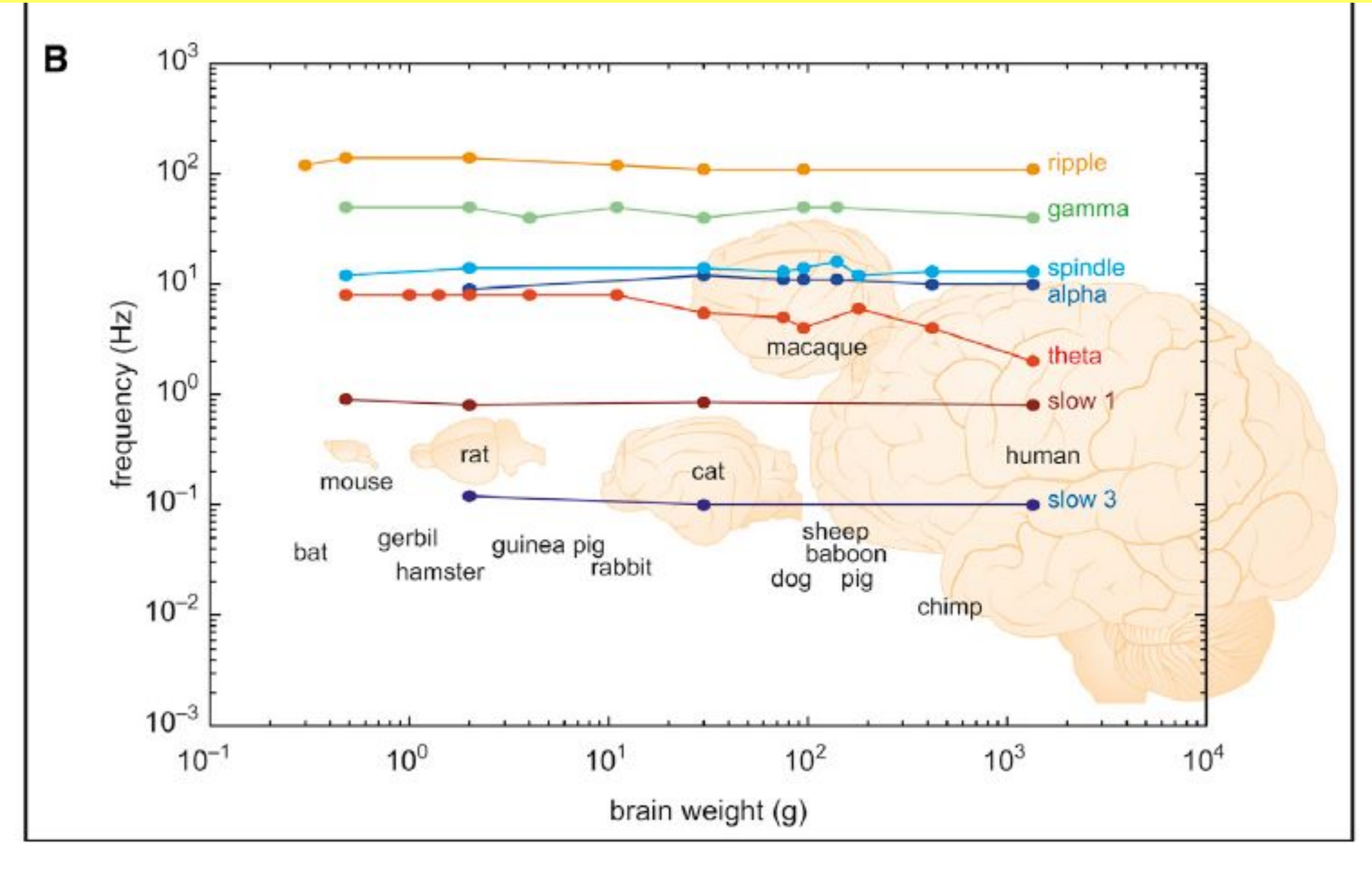
- ✔ выделение ритмических колебаний определенной частоты



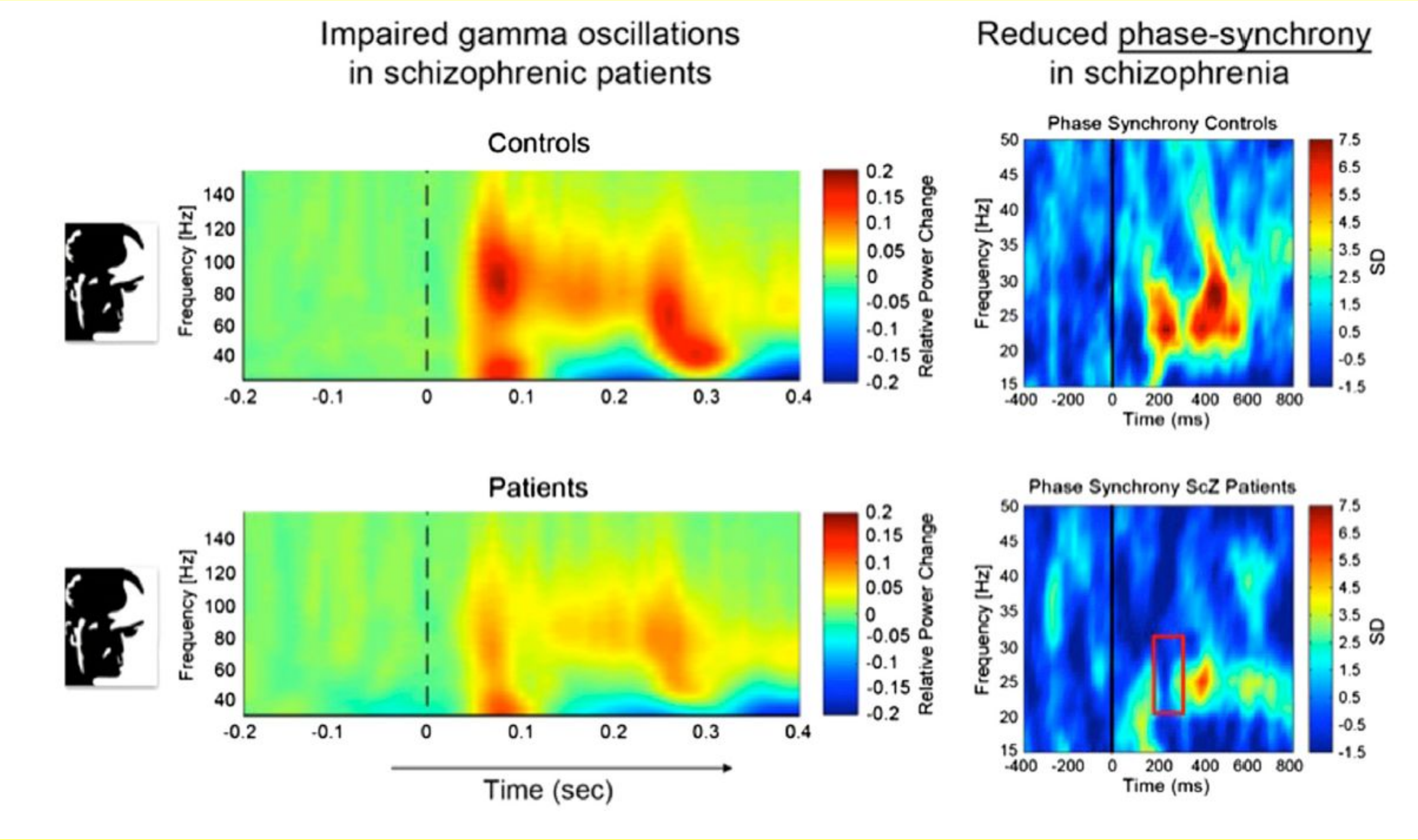


Buzsaki et al 2013

ЭЭГ МЭГ



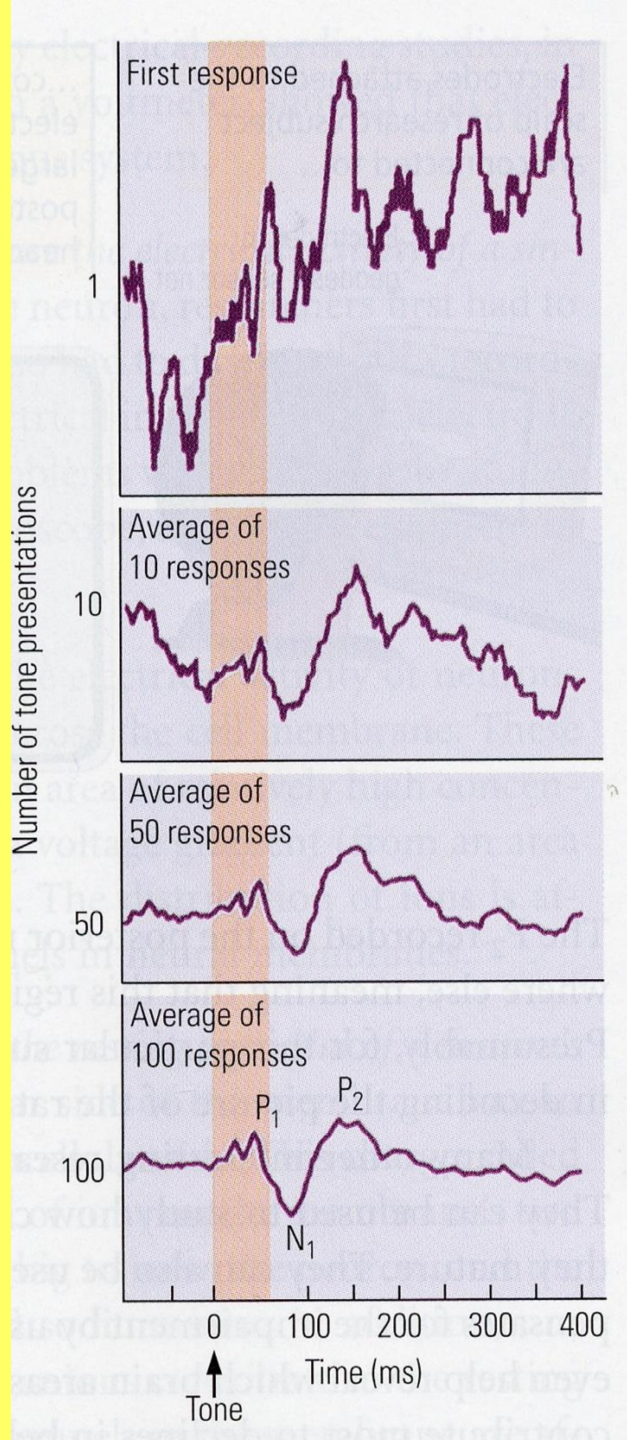
Buzsaki et al 2013



Buzsaki et al 2013

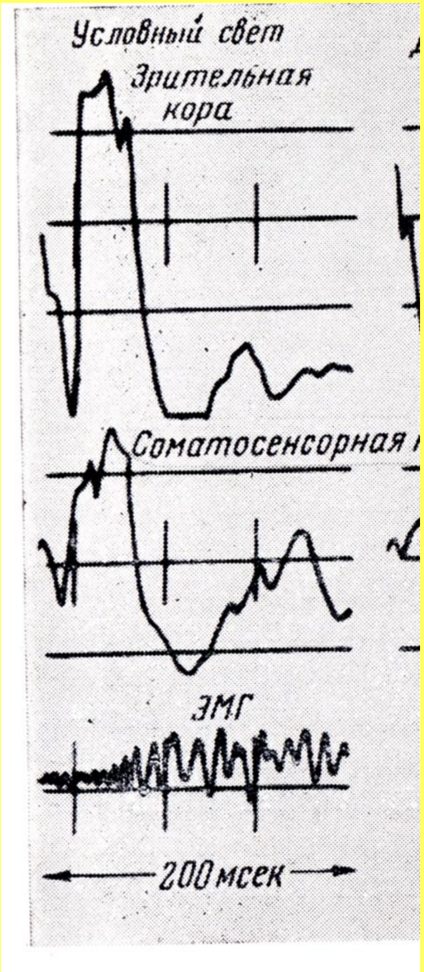
ЭЭГ

- ✔ ССП (связанные с событиями потенциалы)

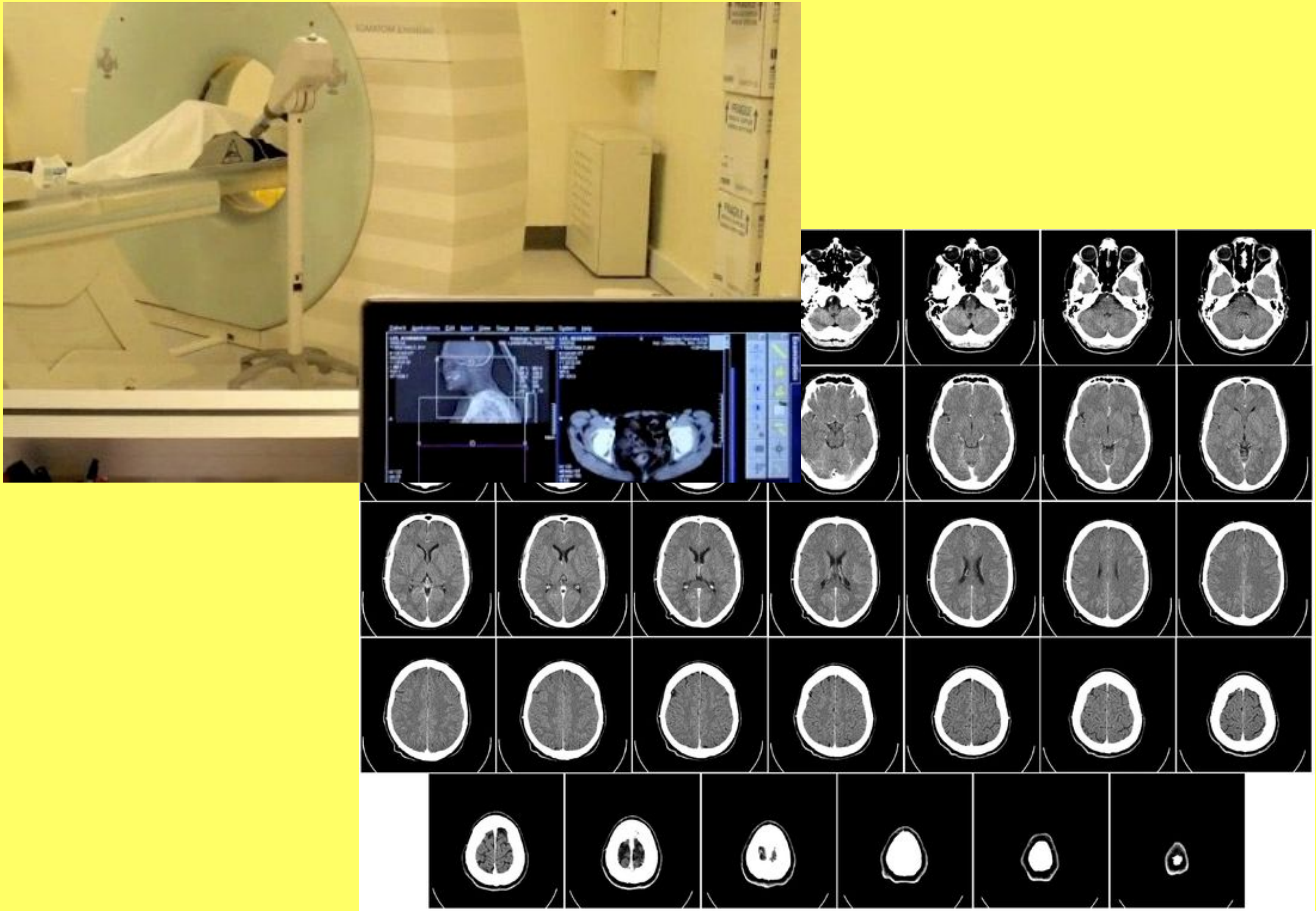


ЭЭГ

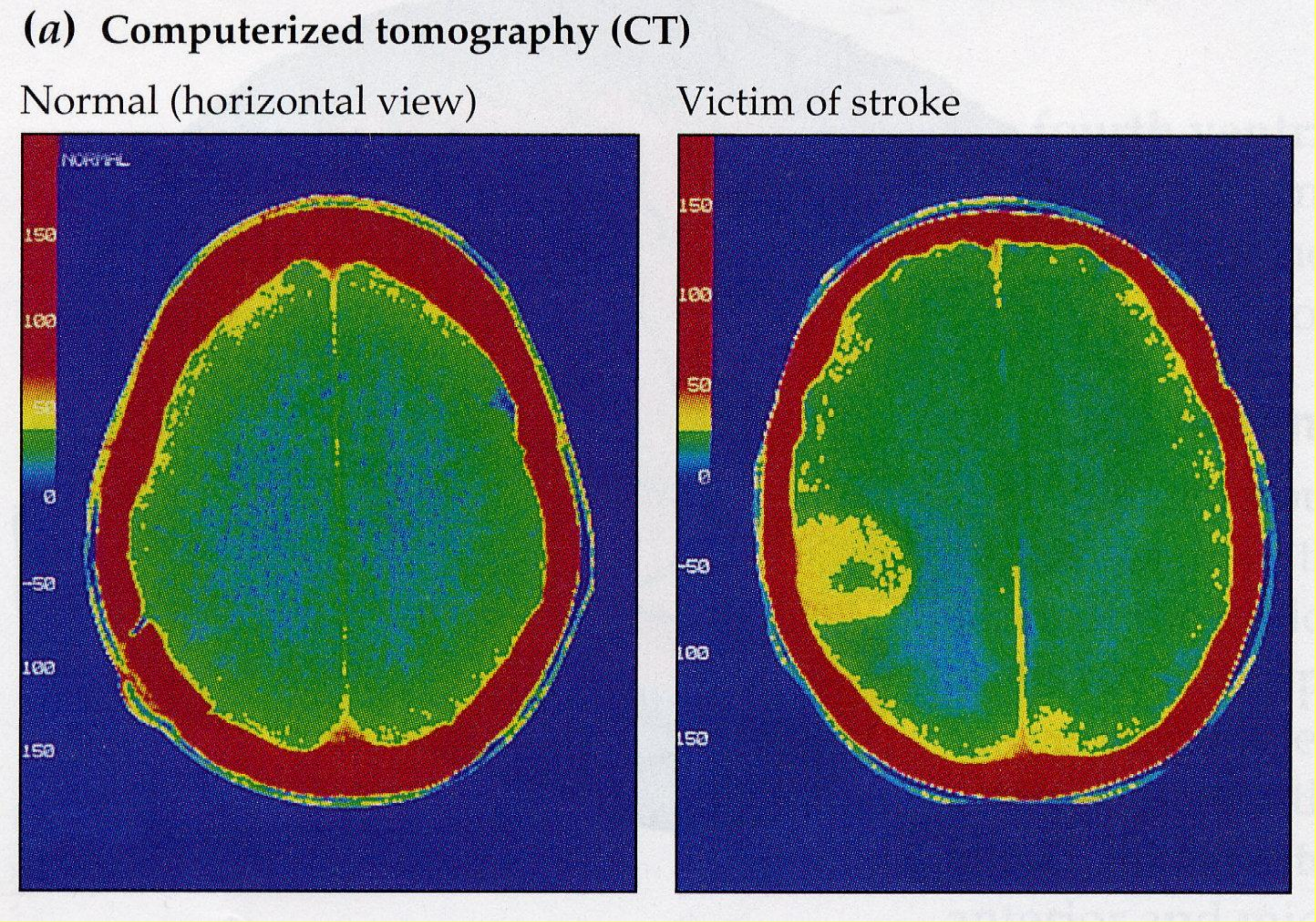
- **ССП (связанные с событиями потенциалы)**
  - вспышка света – электрокожное раздражение (Швырков, 1973)



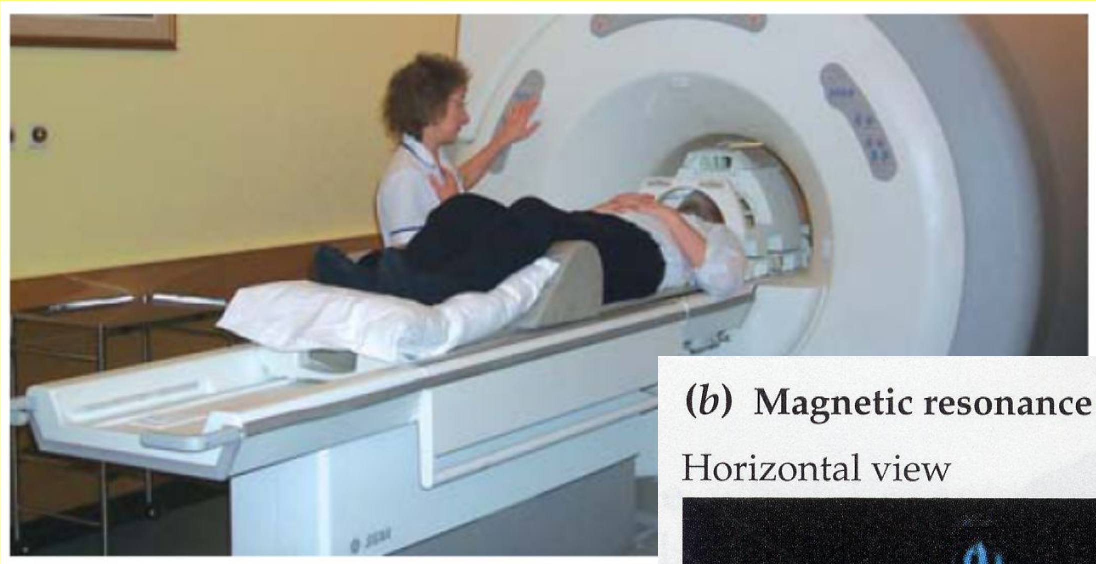
Компьютерная томография

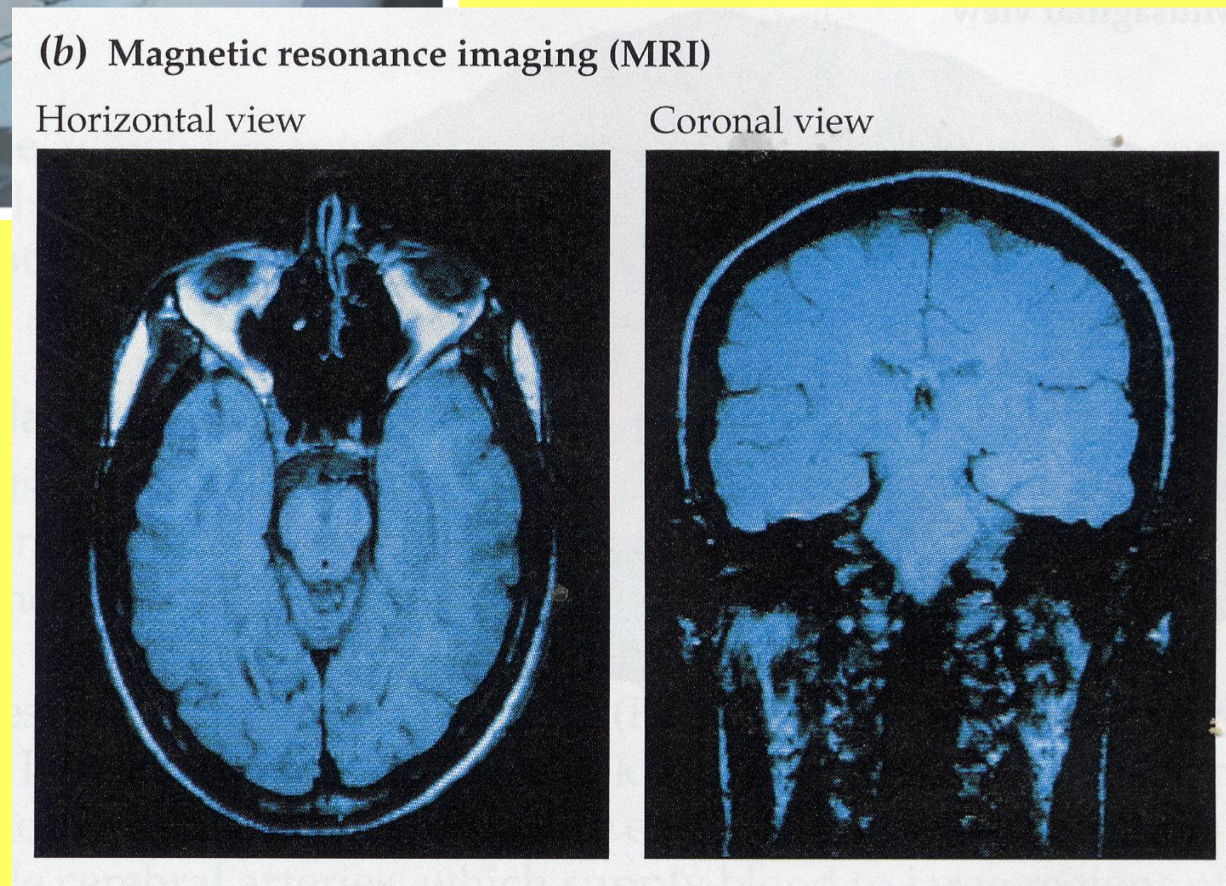


Компьютерная томография

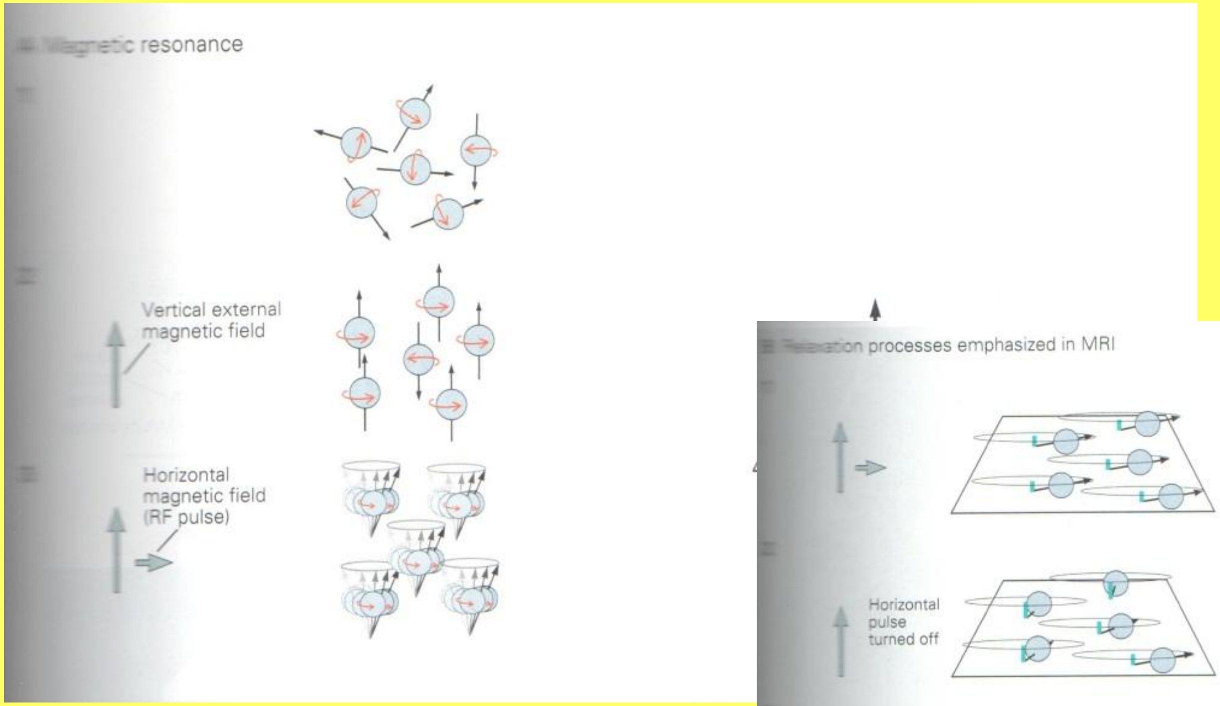


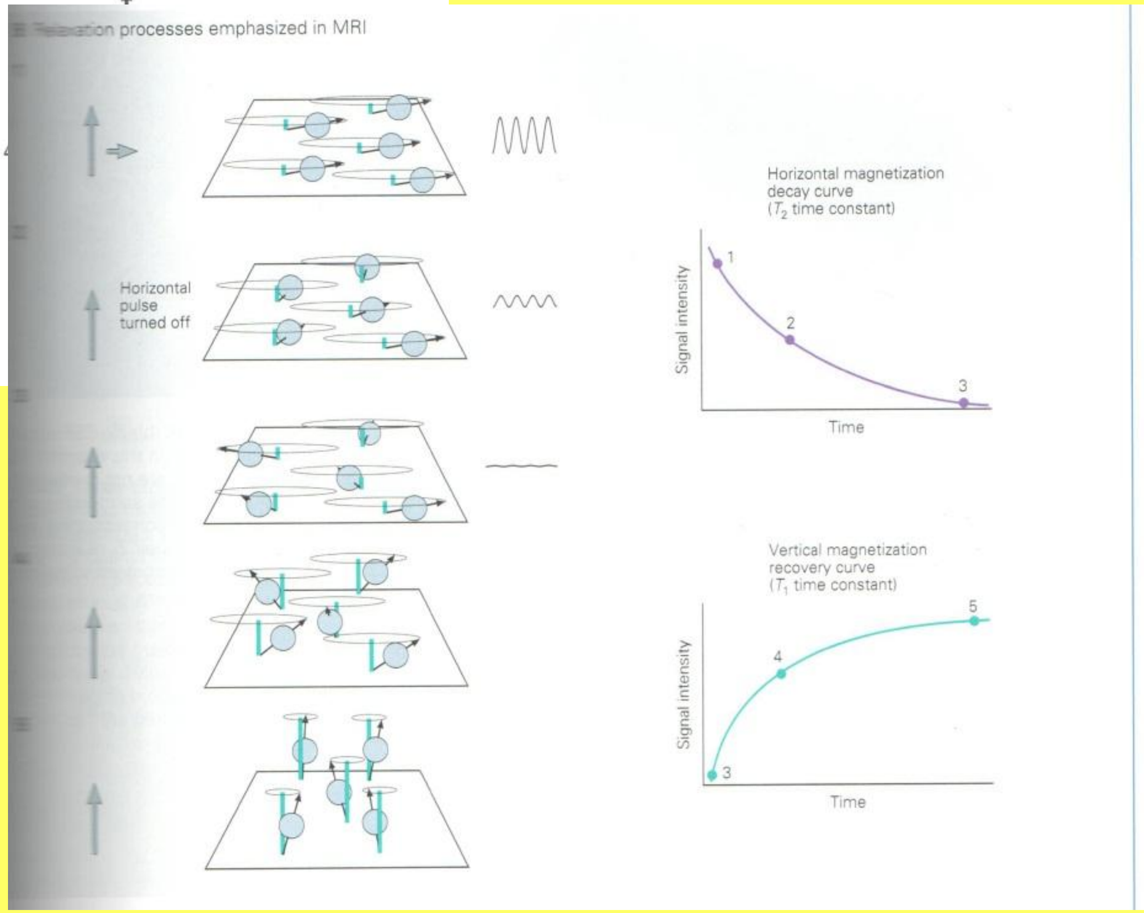
магнитно-резонансная томография





магнитно-резонансная томография





магнитно-резонансная томография

Box 19-3 Magnetic Resonance Imaging (continued)

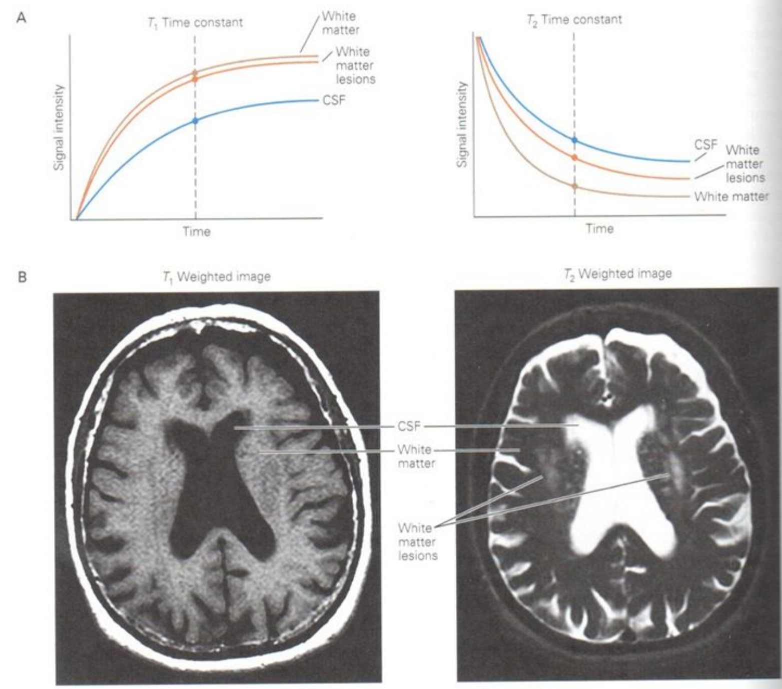


Figure 19-19 Different T_1 and T_2 time constants provide the contrast that distinguishes tissues in the MR image. T_1 and T_2 weighted images together provide a range of information about the structure of the brain.

A. The relaxation rates of cerebrospinal fluid (CSF) are slower than those of white matter for both T_1 and T_2 time constants. The CSF signal at a given point in time is weaker than that of the white matter in T_1 and stronger in T_2.

B. The resulting images show a weak (**black**) CSF signa[l] and a strong (**white**) CSF signal in T_2. In this example th[e] age reveals white matter lesions that are not prominen[t] T_1 weighted image. The lesions and the surrounding wh[ite] matter have similar T_1 rates and their corresponding sig[nals] indistinguishable. On the other hand their T_2 relaxation [rates] are more distinct, providing sufficient contrast in their si[gnals to] reveal the lesions.

Table 19-2 Time Constants (ms) of Different Tissues at a Field Strength of 1 Tesla.

Tissue	T_1	T_2
Fat	241	85
Brain, white matter	683	90
Brain, gray matter	813	100
CSF	2500	1400

функциональная магнитно-резонансная томография

Box 19-3 Magnetic Resonance Imaging (continued)

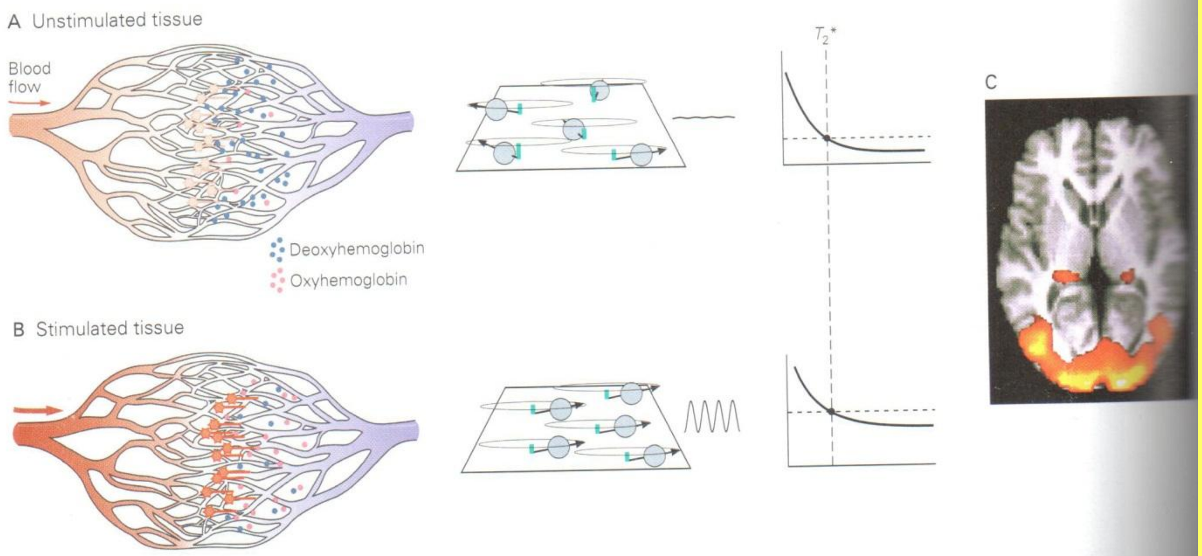


Figure 19-21 Functional MRI study of the visual cortex. Functional MRI (fMRI) locates neural activity by examining regional blood flow in the brain. In a region of neuronal activity the supply of oxygenated blood is greater than its consumption, leading to a higher than normal ratio of oxygenated to deoxygenated blood. Because the two forms of hemoglobin have different effects on the dephasing of protons, they produce different magnetic resonance signals.

A. In the unstimulated condition visual information is kept to a minimum. There is little activation of neurons; blood flow is not increased; and a relatively large proportion of the hemoglobin is in the deoxy form. Because deoxyhemoglobin promotes efficient dephasing of the rotating protons, the T_2* curve [illegible] characterizes fMRI is relatively steep and the magnetic [illegible] nance signal weak.

B. In the stimulated condition the patient is exposed to a [illegible] ing checkerboard pattern. Neurons become active; blood [illegible] increases; and the proportion of deoxyhemoglobin [illegible]. As a result, the dephasing of the protons is slower, the T_2* curve less steep, and the corresponding magnetic [illegible] signal stronger.

C. An image showing the increased signal in the visual [illegible] generated from a comparison of the images of the [illegible] and unstimulated cortex.

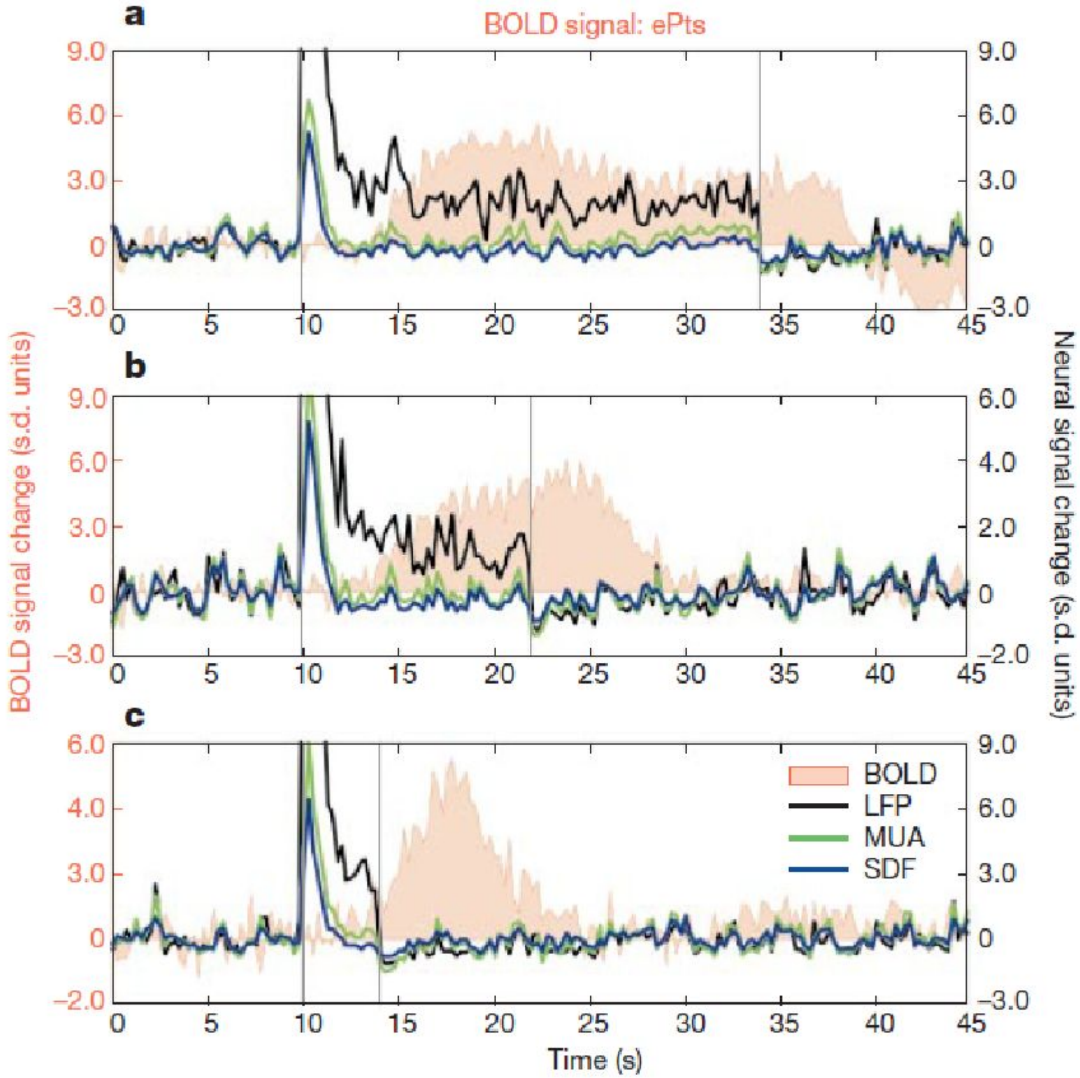
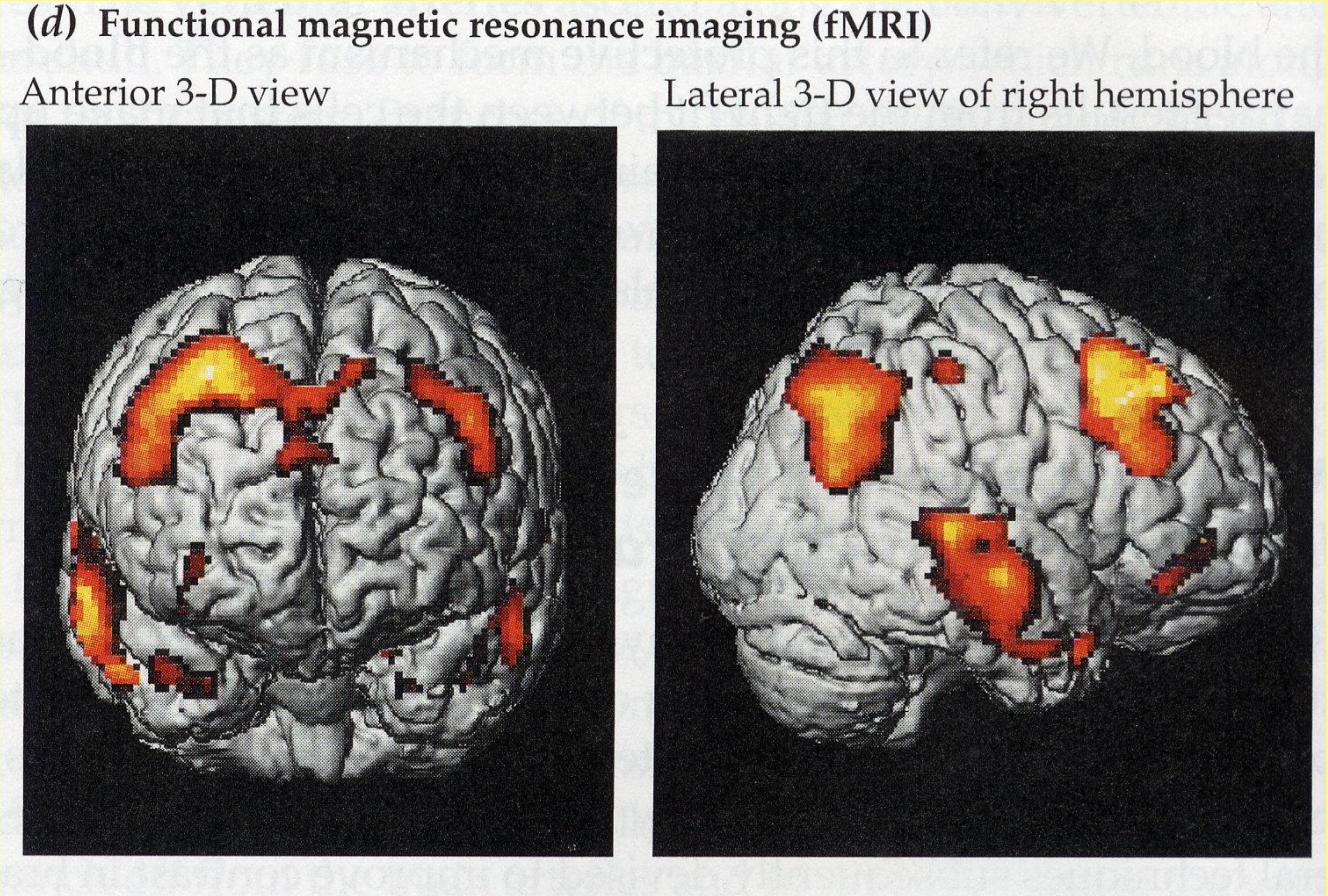


Figure 3 Simultaneous neural and haemodynamic recordings from a cortical site showing transient neural response. **a–c**, Responses to a pulse stimulus of 24, 12 and 4 s. Both single- and multi-unit responses adapt a couple of seconds after stimulus onset, with LFP remaining the only signal correlated with the BOLD response. SDF, spike-density function (see text); ePts, electrode ROI—positive time series.

Logothetis et al 2001

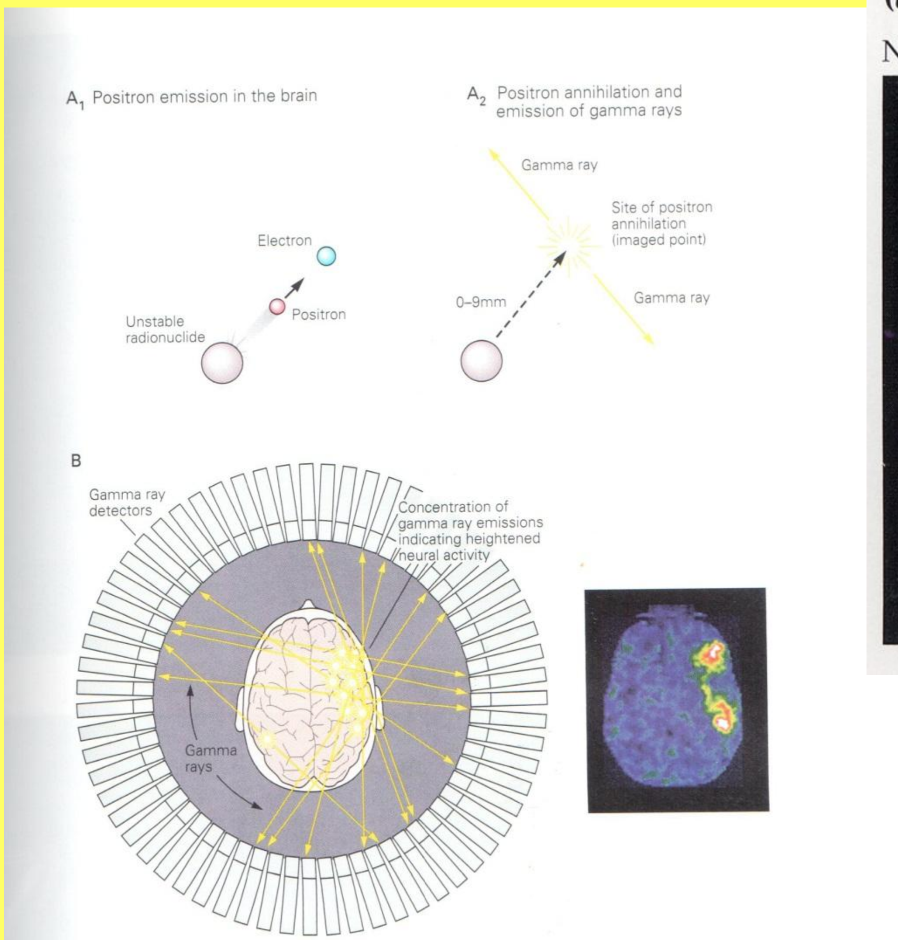
функциональная магнитно-резонансная томография

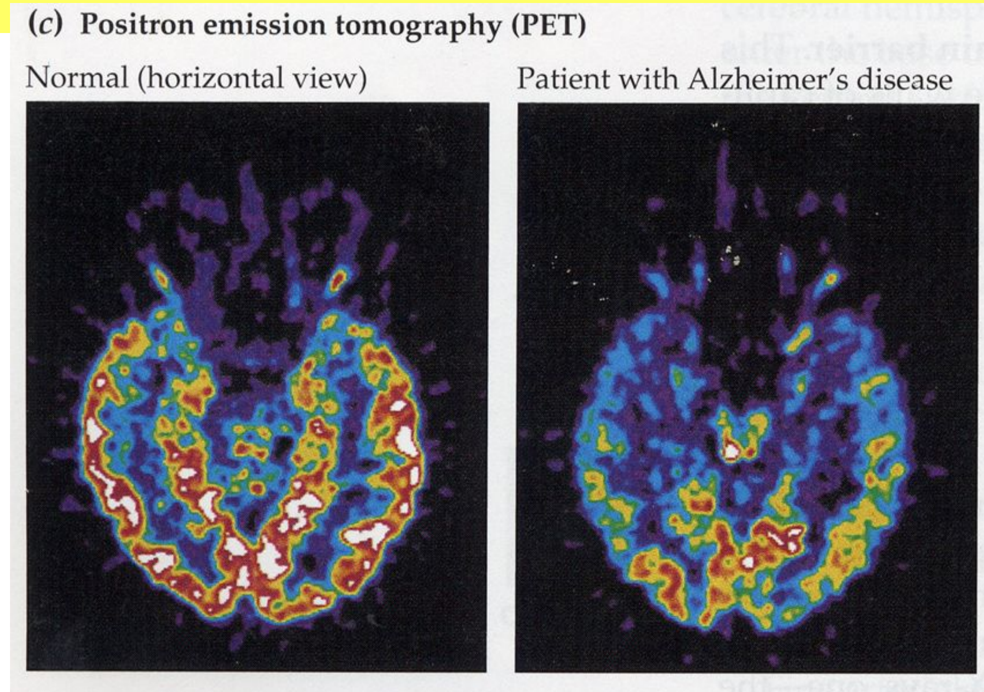


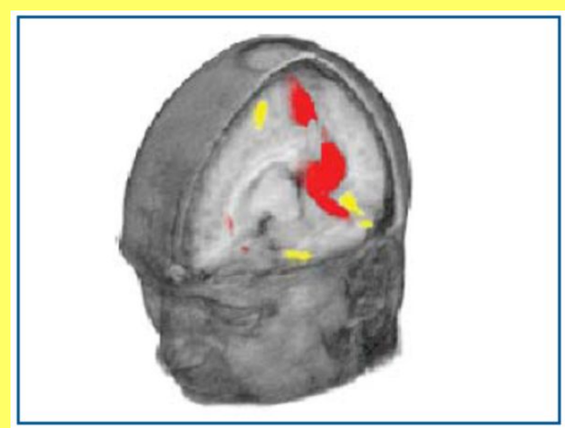
позитронно-эмиссионная томография (ПЭТ)

- ✔ регистрируются метаболическая активность
- ✔ дезоксиглюкоза в крови – увеличение концентрации изотопа
- ✔ детекторы протонов

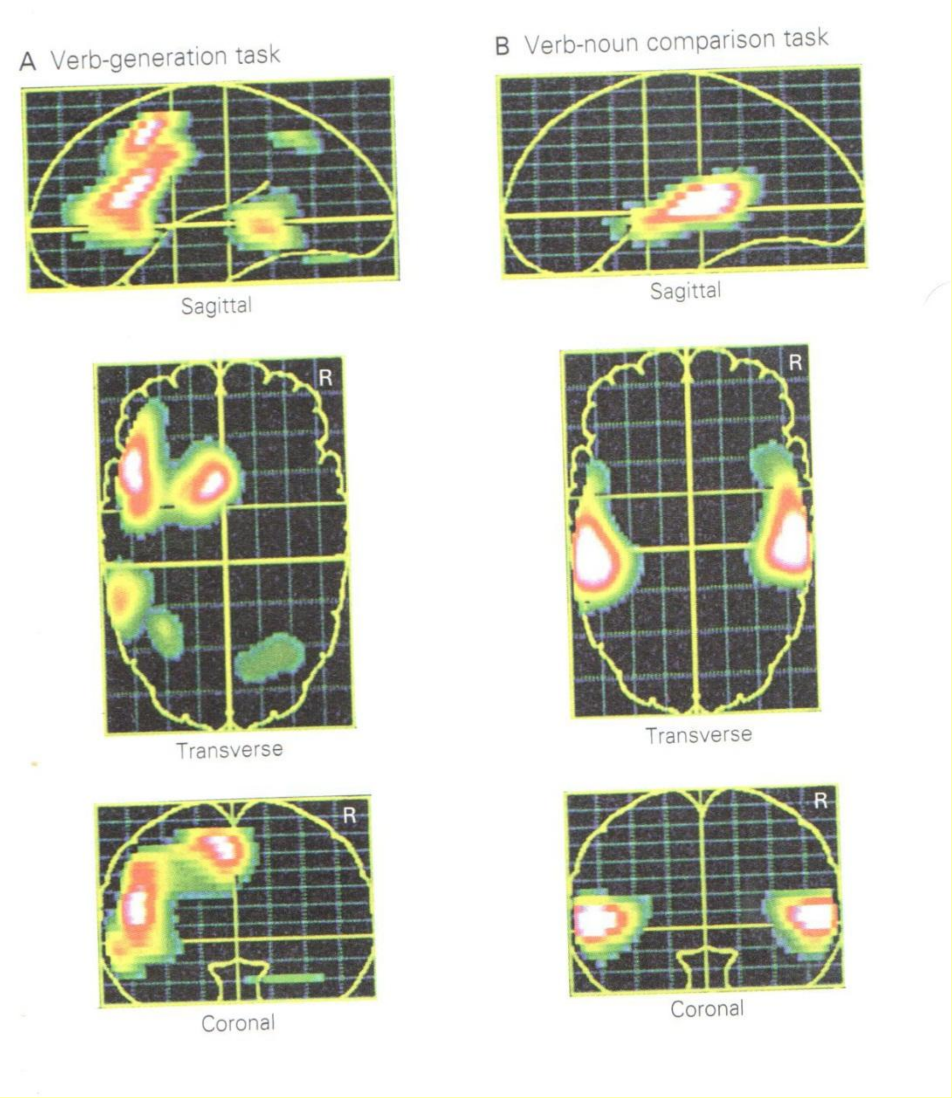
позитронно-эмиссионная томография (ПЭТ)

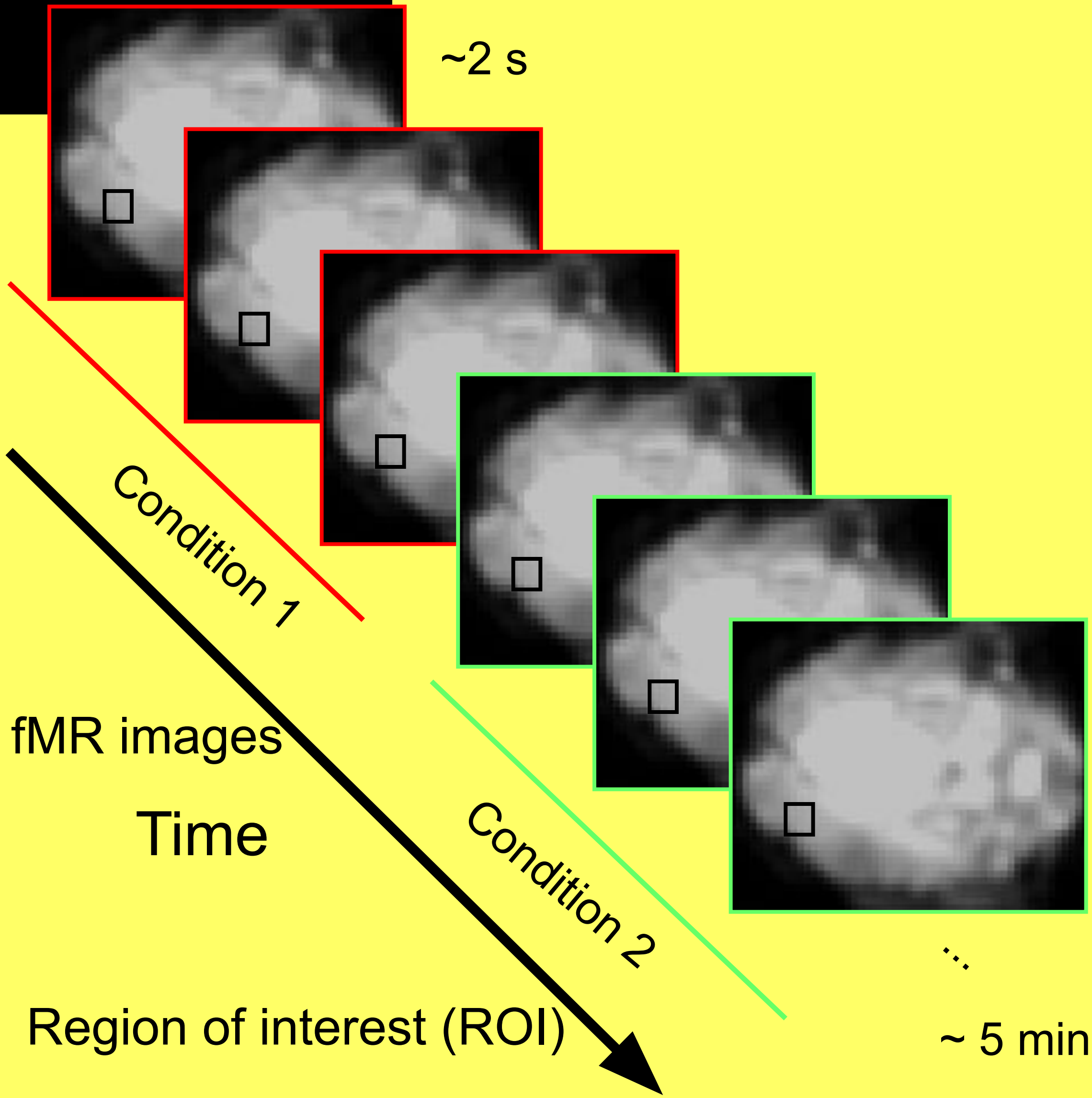




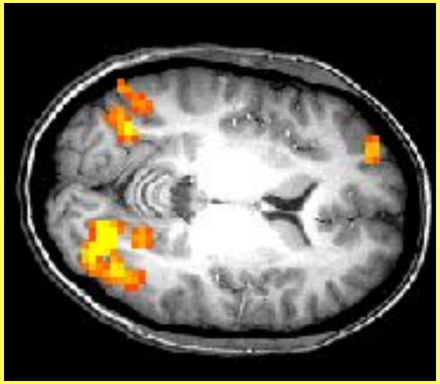


позитронно-эмиссионная томография (ПЭТ)



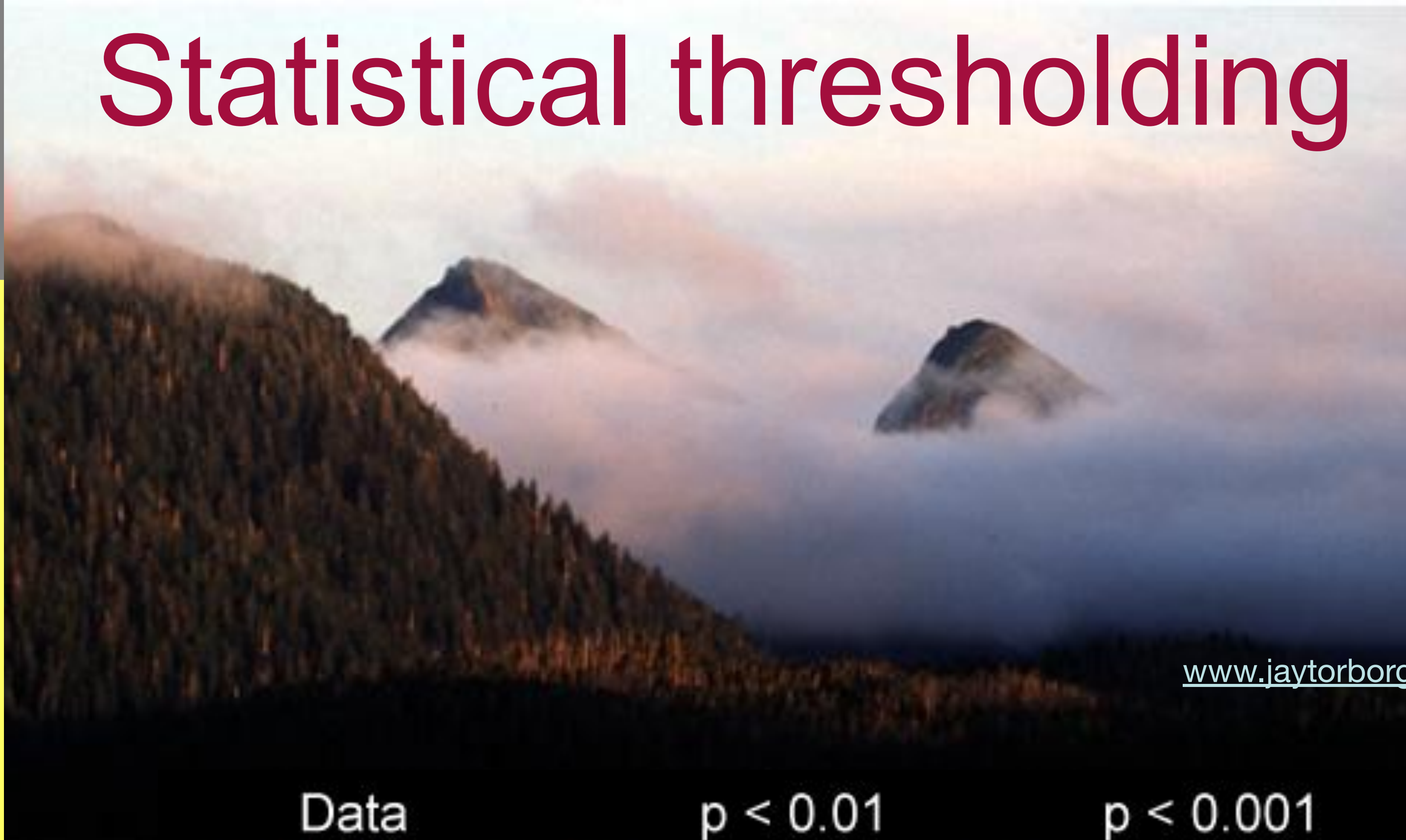


Statistical map
Superimposed on an anatomical image

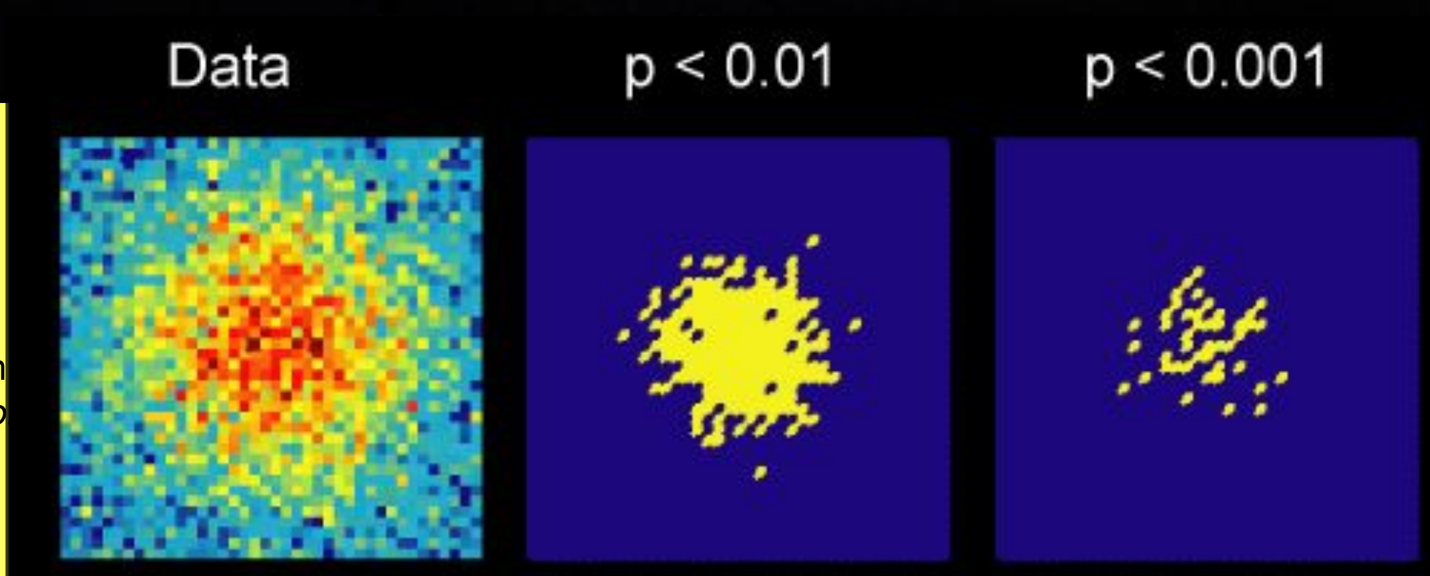


Jody Culham's website

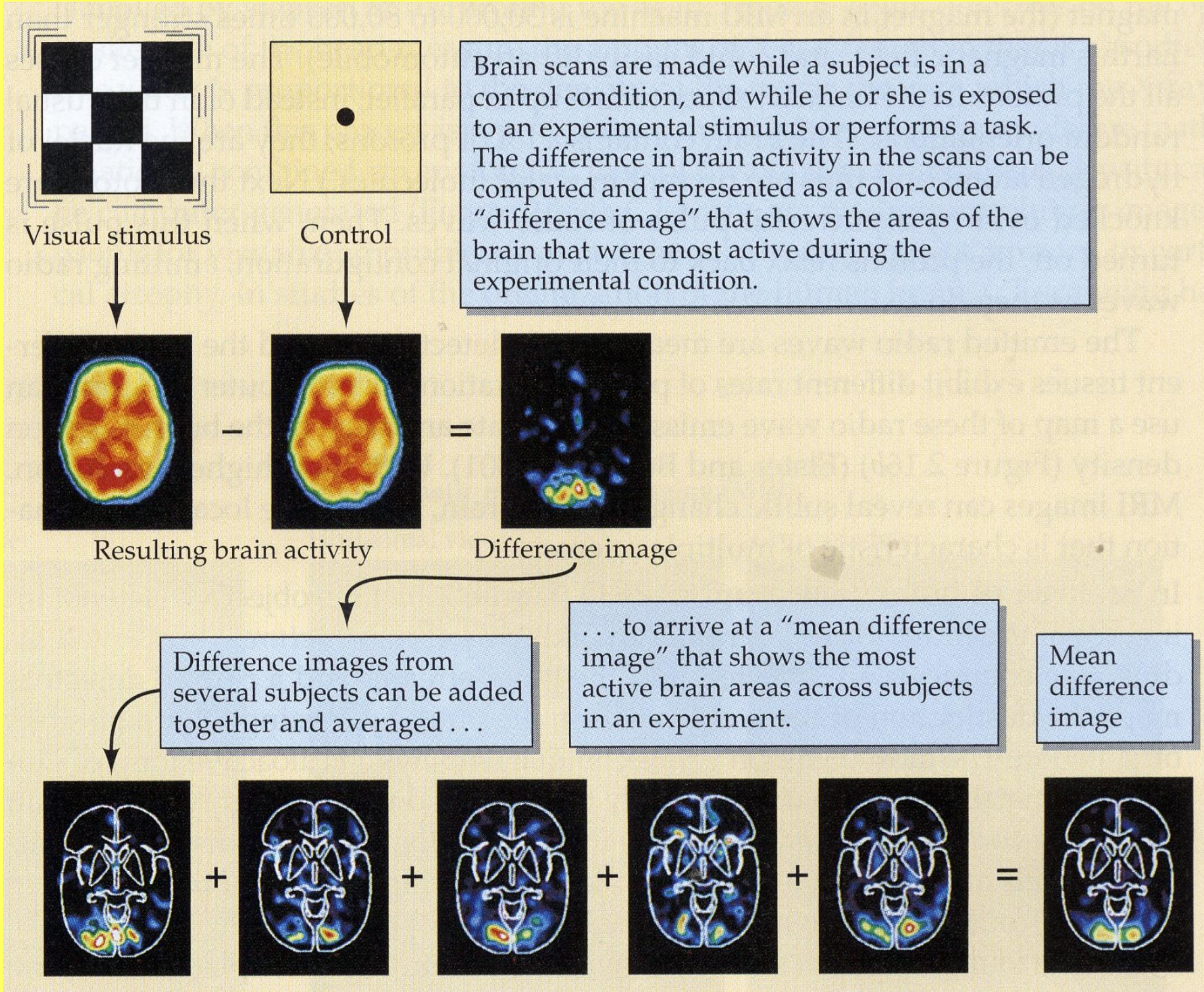
Statistical thresholding



www.jaytorborg.com

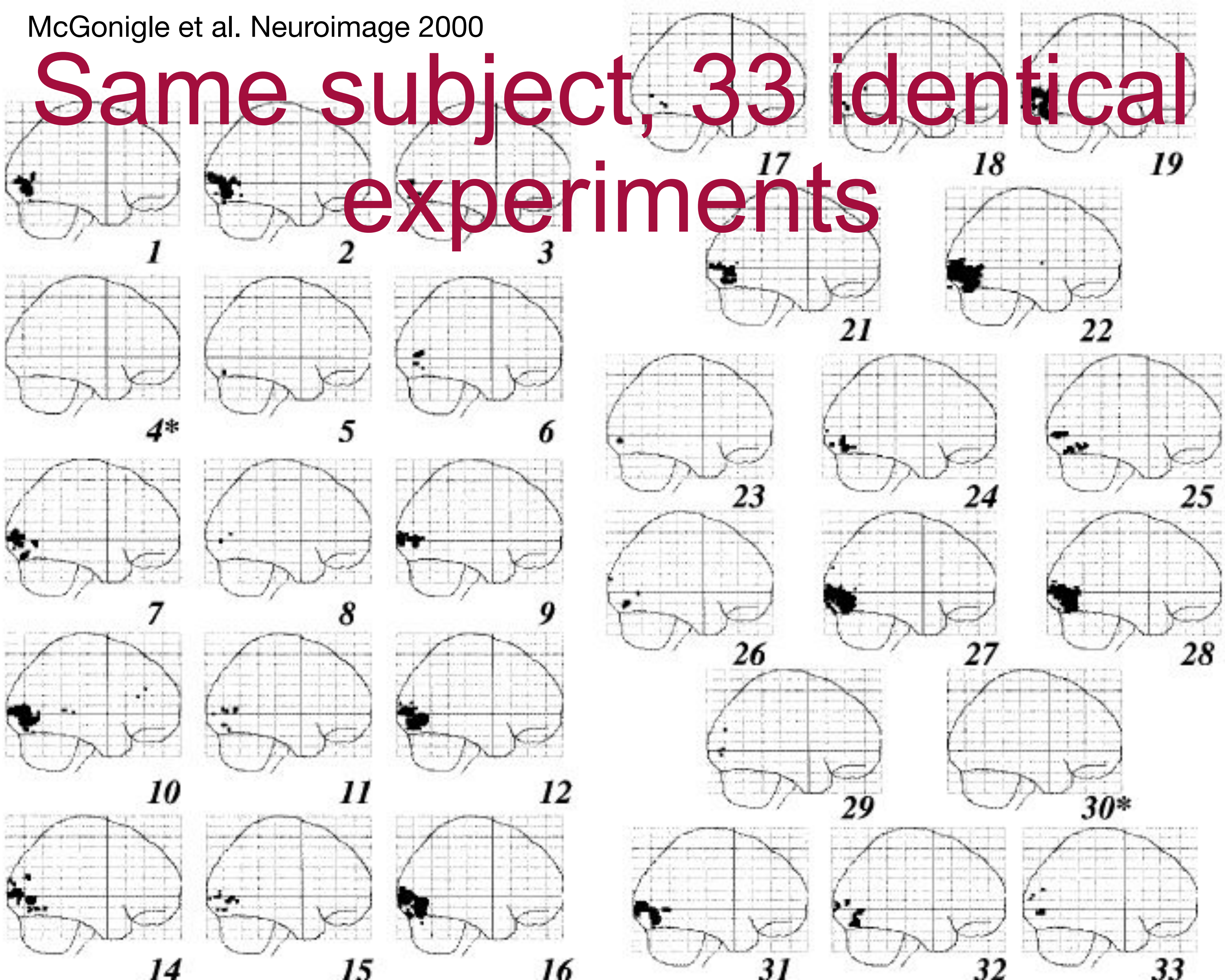


Renvall, Parkkonen
& Hari *in preparatio*


Visual stimulus
Control
Brain scans are made while a subject is in a control condition, and while he or she is exposed to an experimental stimulus or performs a task. The difference in brain activity in the scans can be computed and represented as a color-coded "difference image" that shows the areas of the brain that were most active during the experimental condition.
Resulting brain activity
Difference image
Difference images from several subjects can be added together and averaged . . .
. . . to arrive at a "mean difference image" that shows the most active brain areas across subjects in an experiment.
Mean difference image

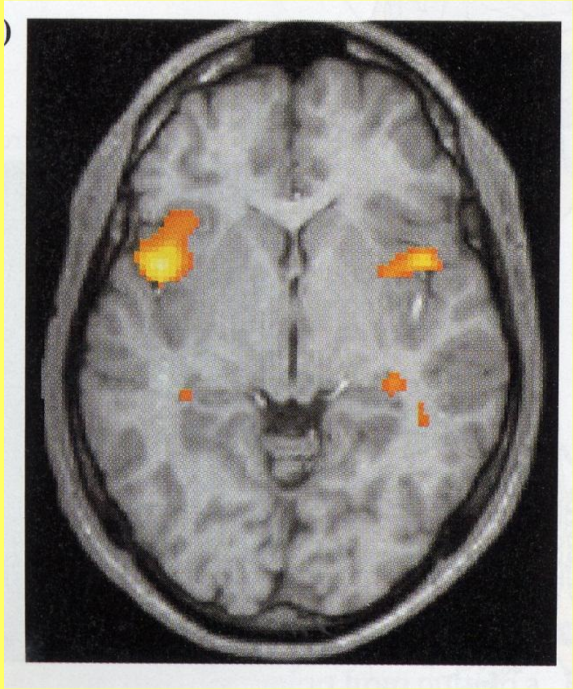
McGonigle et al. Neuroimage 2000

Same subject, 33 identical experiments



Современные методы (2)

- позитронно-эмиссионная томография или функциональный ядерно-магнитный резонанс



✔ эмоция романтической любви в передней цингулярной коре, хвостатом ядре и некоторых других структурах (Bartels & Zeki, 2000).

Активность мозга у мертвого лосося?

Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction

Craig M. Bennett[1], Abigail A. Baird[2], Michael B. Miller[1], and George L. Wolford[3]

[1] Psychology Department, University of California Santa Barbara, Santa Barbara, CA; [2] Department of Psychology, Vassar College, Poughkeepsie, NY;
[3] Department of Psychological & Brain Sciences, Dartmouth College, Hanover, NH

INTRODUCTION

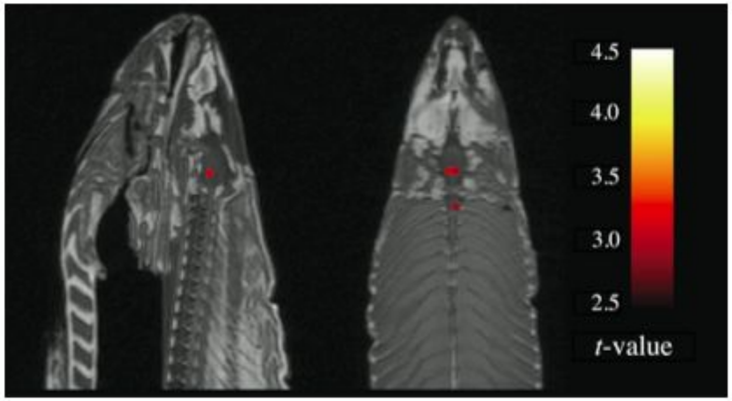
With the extreme dimensionality of functional neuroimaging data comes extreme risk for false positives. Across the 130,000 voxels in a typical fMRI volume the probability of a false positive is almost certain. Correction for multiple comparisons should be completed with these datasets, but is often ignored by investigators. To illustrate the magnitude of the problem we carried out a real experiment that demonstrates the danger of not correcting for chance properly.

METHODS

Subject. One mature Atlantic Salmon (Salmo salar) participated in the fMRI study. The salmon was approximately 18 inches long, weighed 3.8 lbs, and was not alive at the time of scanning.

Task. The task administered to the salmon involved completing an open-ended mentalizing task. The salmon was shown a series of photographs depicting human individuals in social situations with a specified emotional valence. The salmon was asked to determine what emotion the individual in the photo must have been experiencing.

GLM RESULTS

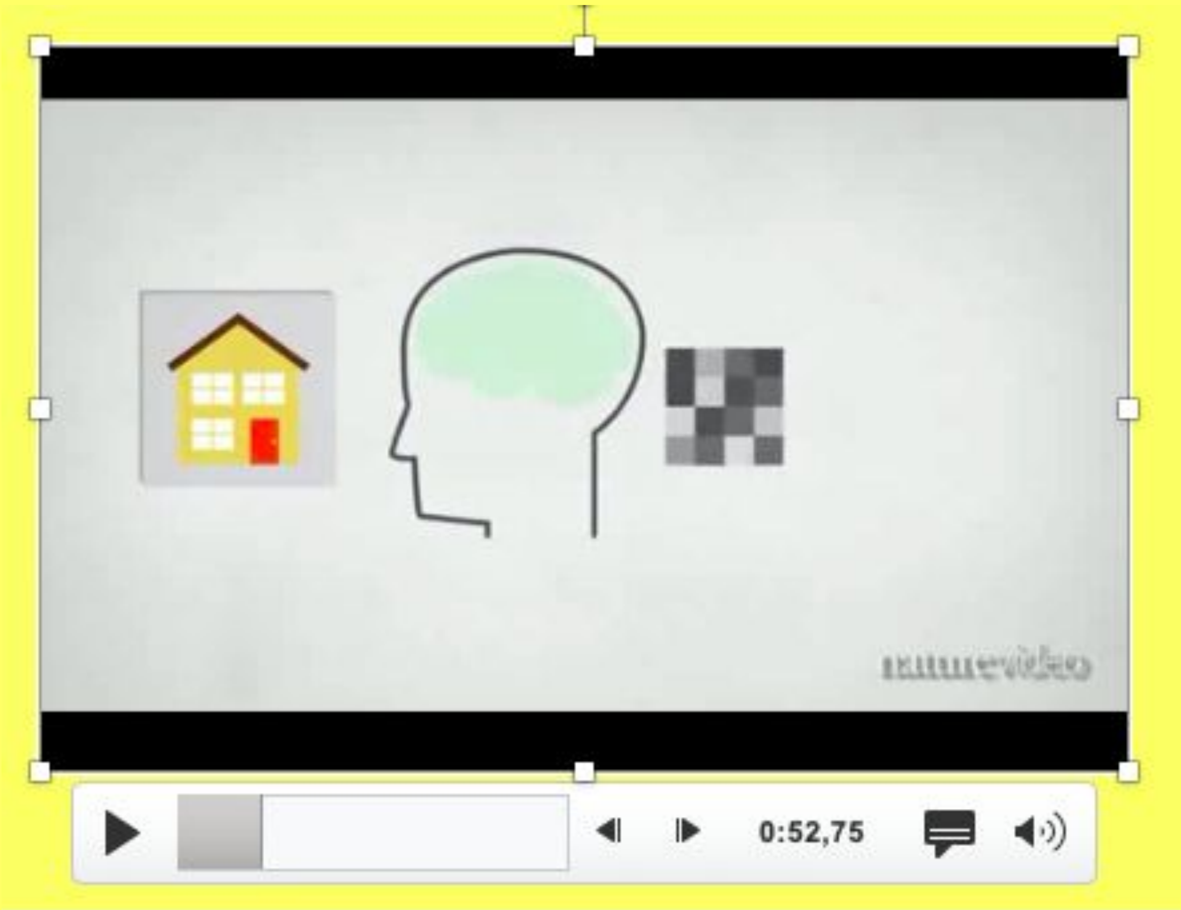


A t-contrast was used to test for regions with significant BOLD signal change during the photo condition compared to rest. The parameters for this comparison were $t(131) > 3.15$, p(uncorrected) < 0.001, 3 voxel extent threshold.

Several active voxels were discovered in a cluster located within the salmon's brain cavity (Figure 1, see above). The size of this cluster was 81 mm^3 with a

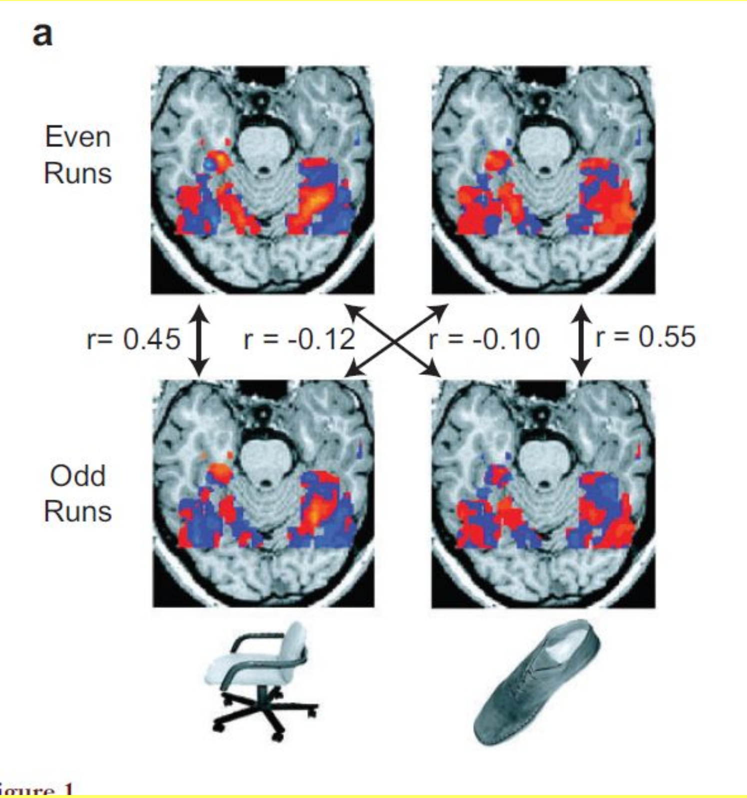
Reading Minds

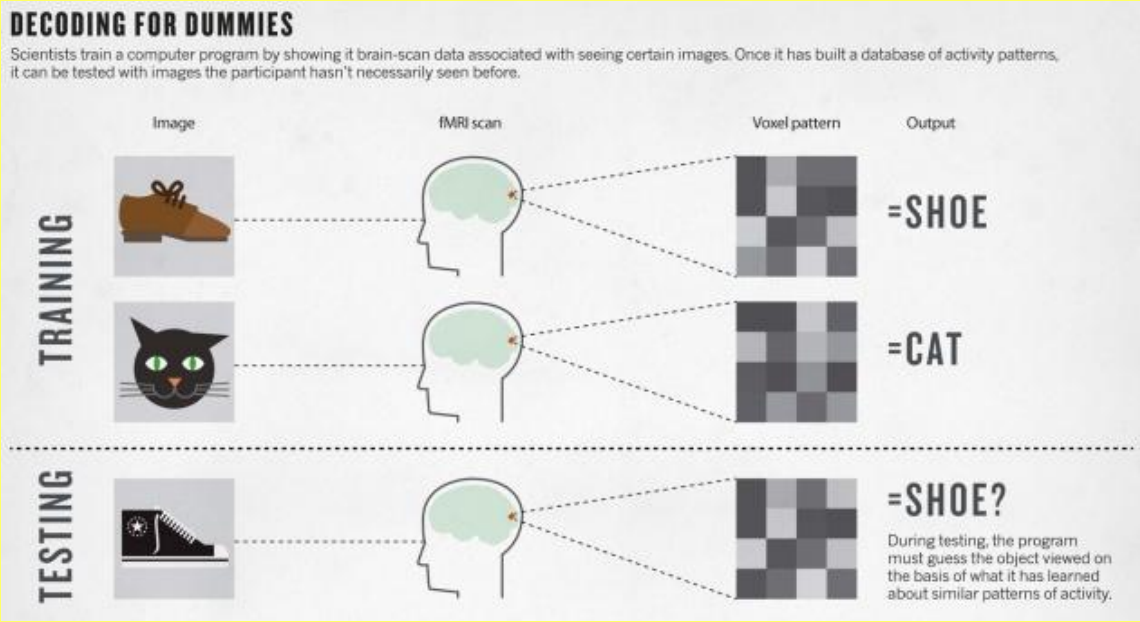
Reading Minds



https://www.youtube.com/watch?v=z8iEogscUI8

Область vs. паттерн





ЖУРНАЛ ВЫСШЕЙ НЕРВНОЙ ДЕЯТЕЛЬНОСТИ, 2017, том 67, № 4, с. 493–503

МЕТОДИКА

УДК 612.821.6

МАКЕТ УСТРОЙСТВА СЛЕЖЕНИЯ ЗА КОГНИТИВНОЙ ДЕЯТЕЛЬНОСТЬЮ ЧЕЛОВЕКА В РЕАЛЬНОМ ВРЕМЕНИ (“КОГНОВИЗОР”)

© 2017 г. И. В. Таротин[1,2], М. С. Атанов[1], Г. А. Иваницкий[1]
[1]Институт высшей нервной деятельности и нейрофизиологии РАН, Москва
[2]Московский физико-технический институт (государственный университет), Москва

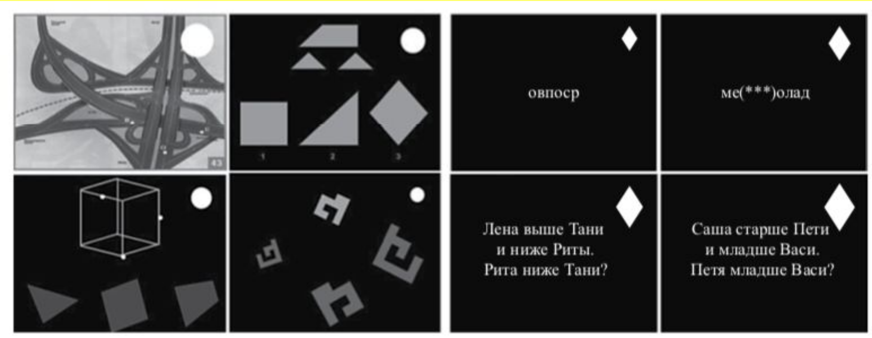
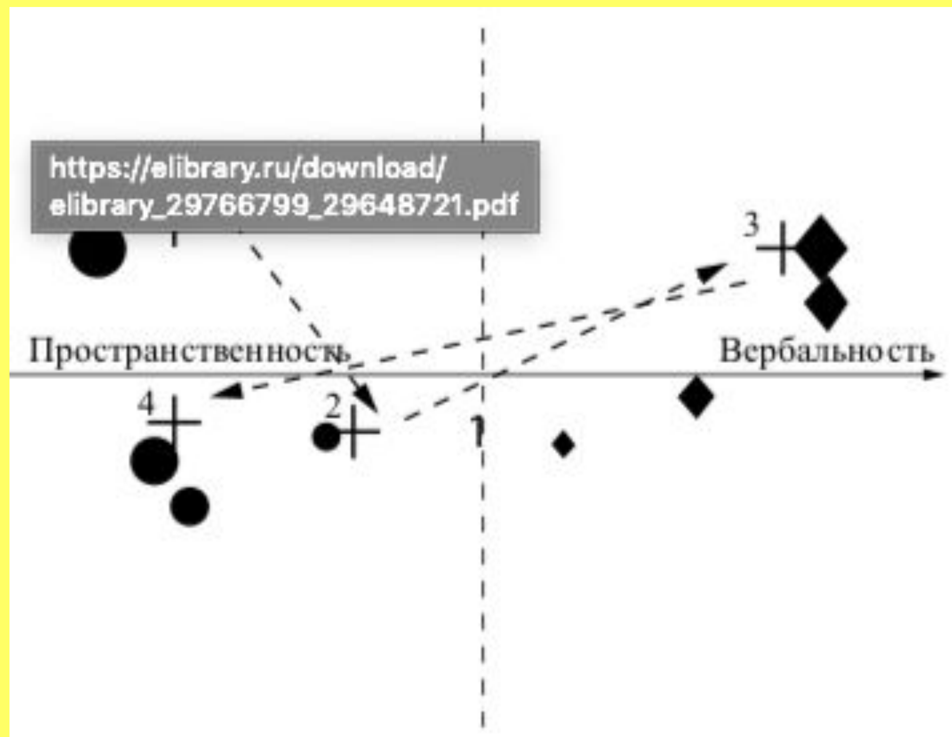
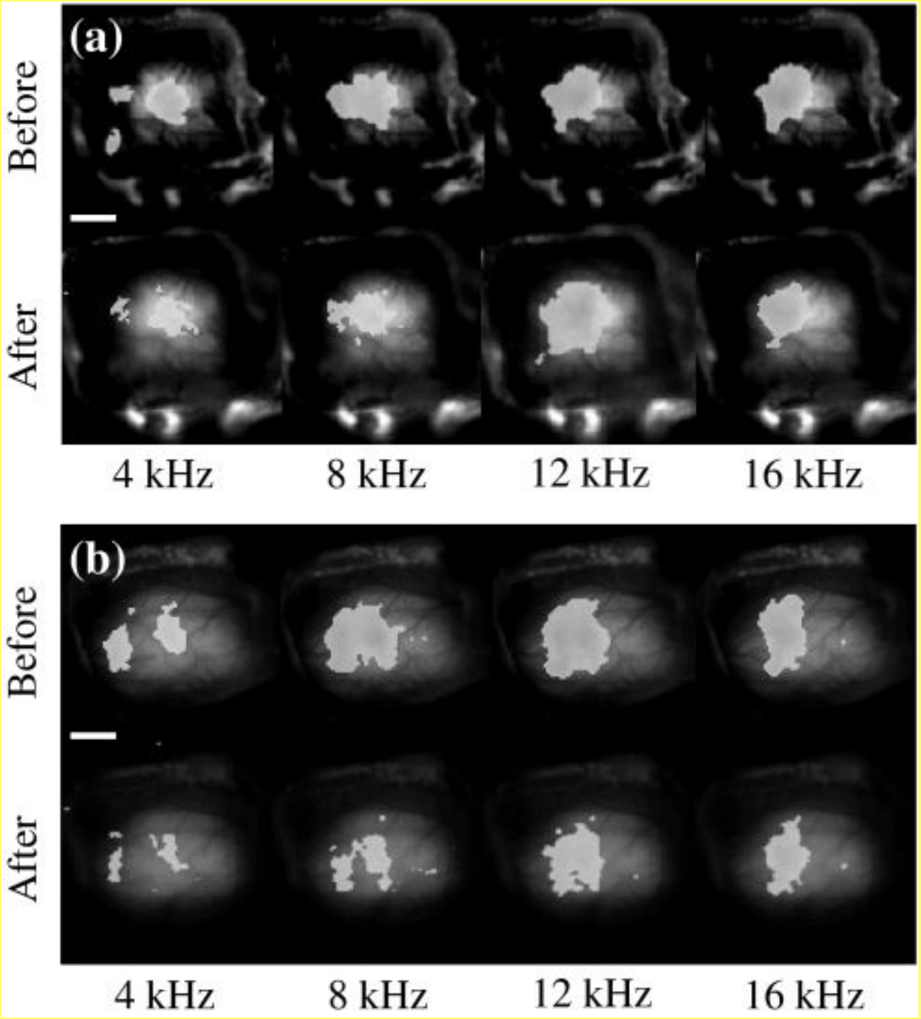


Рис. 1. Примеры задач, предъявляемых испытуемым.



Потенциал-чувствительные красители



Ide et al., 2012
(auditory cortex, fear conditioning)

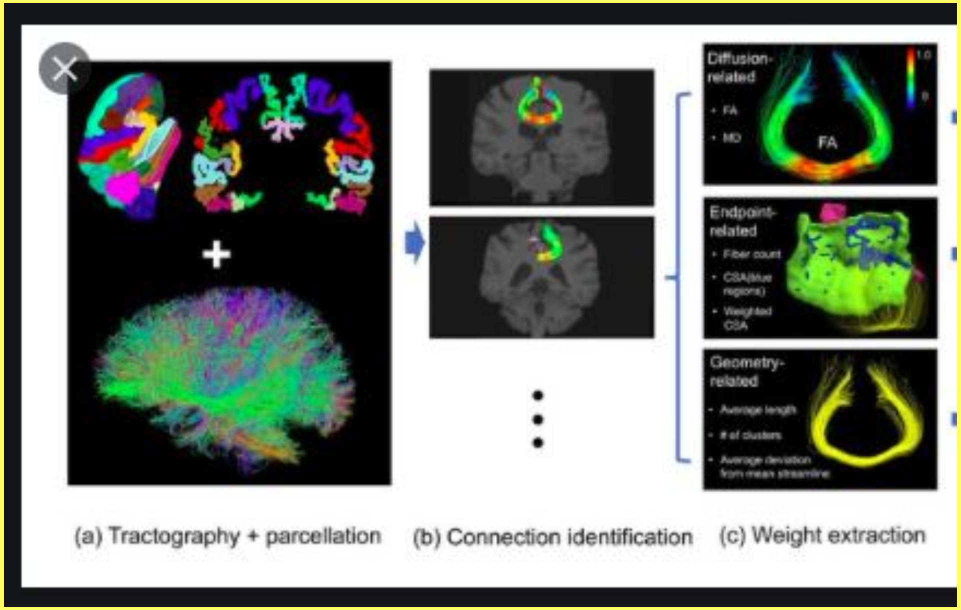
Sebastian Seung: I am my connectome

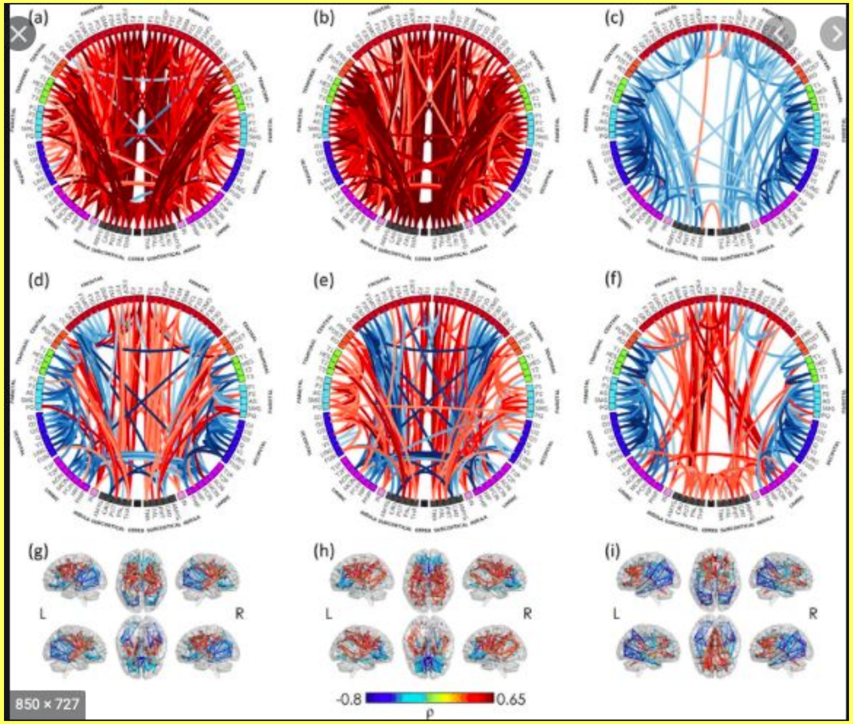
«Я – это мой Коннектом»

https://www.youtube.com/watch?v=HA7GwKXfJB0

диффузионная магнитно-резонансная томография

- полное описание структуры связей



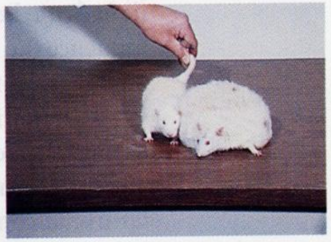


Повреждения участков мозга (Lesion)

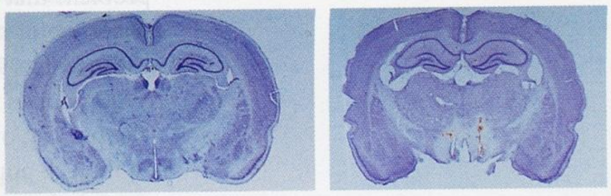
EXPERIMENT 11-1

Question: Does the hypothalamus play a role in eating?

Procedure



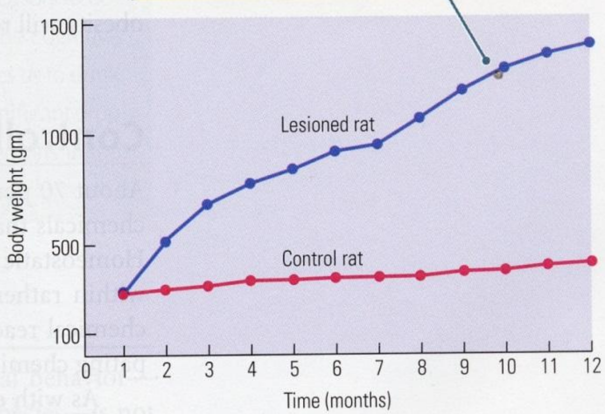
The ventromedial hypothalamus (VMH) of the rat on the right was damaged, and her body weight was monitored for a year. Her sister on the left is normal.



Intact brain of sister rat — Rat brain with lesion

Results:

The VMH-lesioned rat showed a dramatic increase in food intake and body weight.



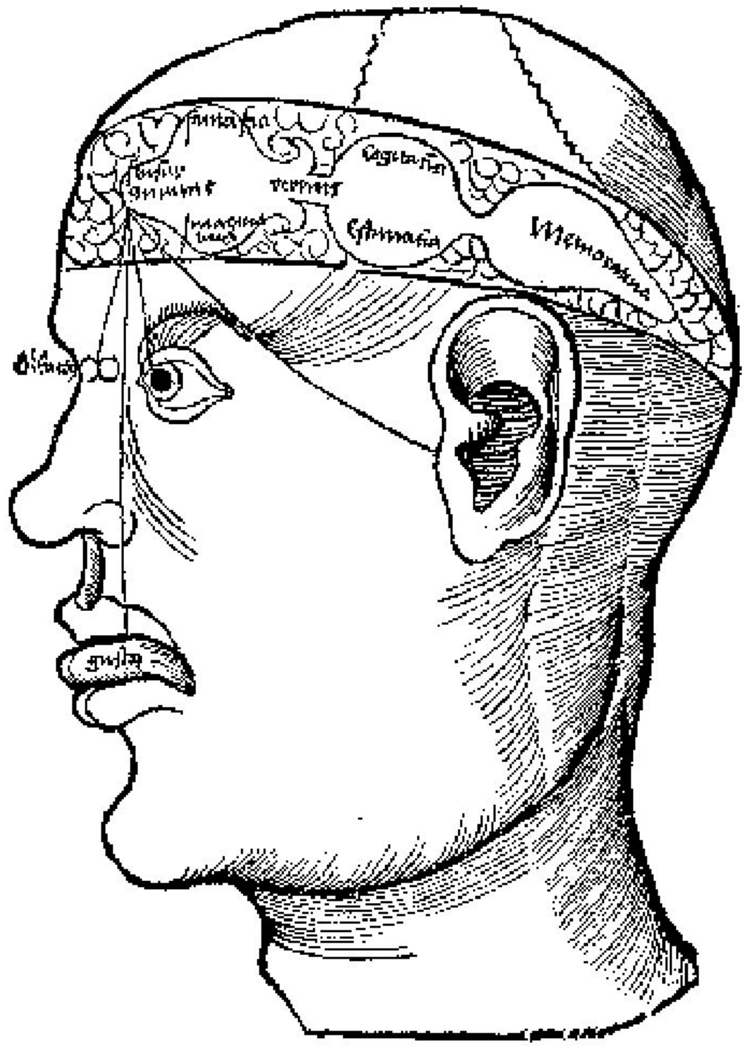
Conclusion

The VMH plays a role in controlling the cessation of eating. Damage to the VMH results in prolonged and dramatic weight gain.

История (1)

15-16 век

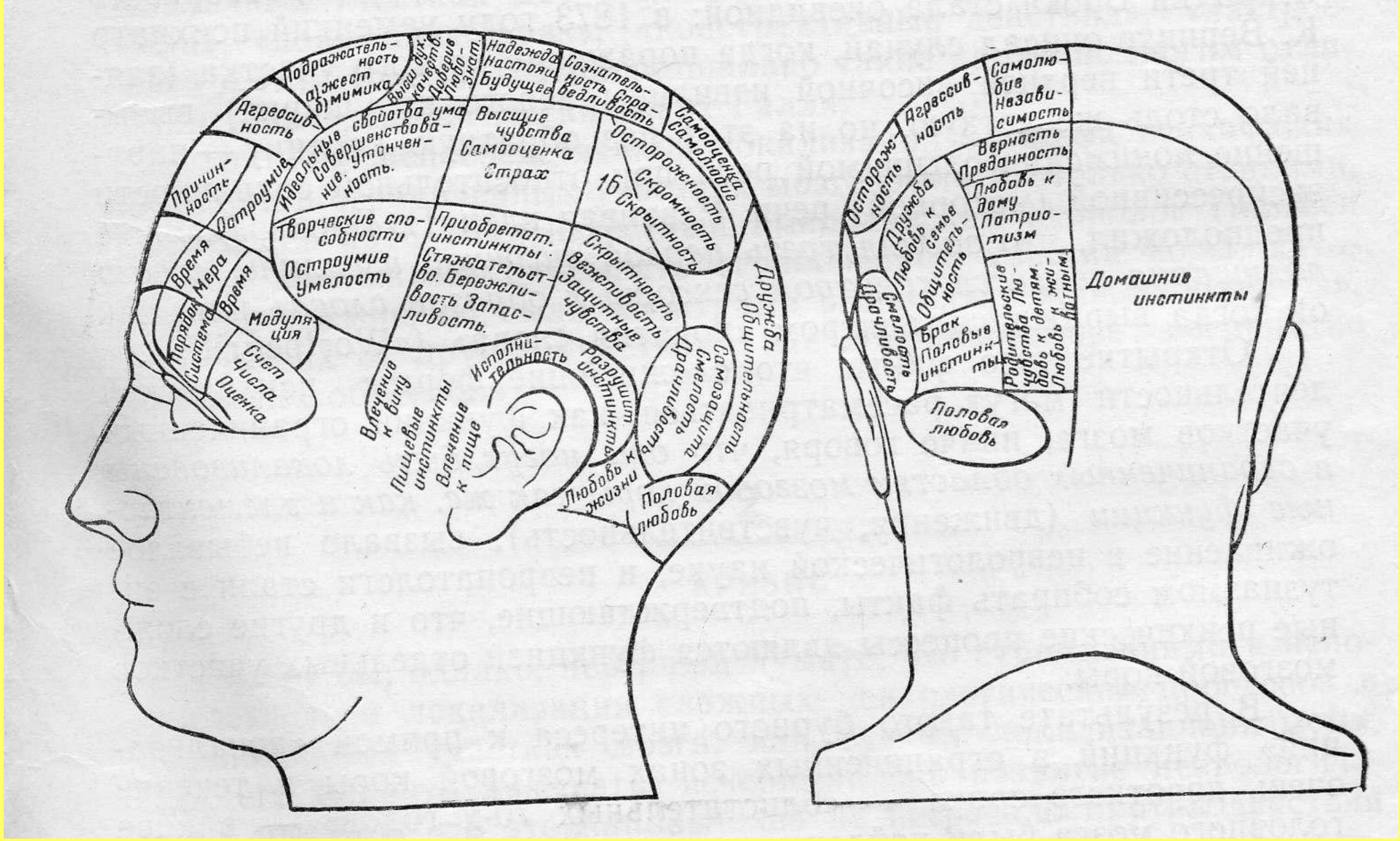
- ощущение, фантазия, воображение –
- предположение, мышление –
- память



Green, 2003

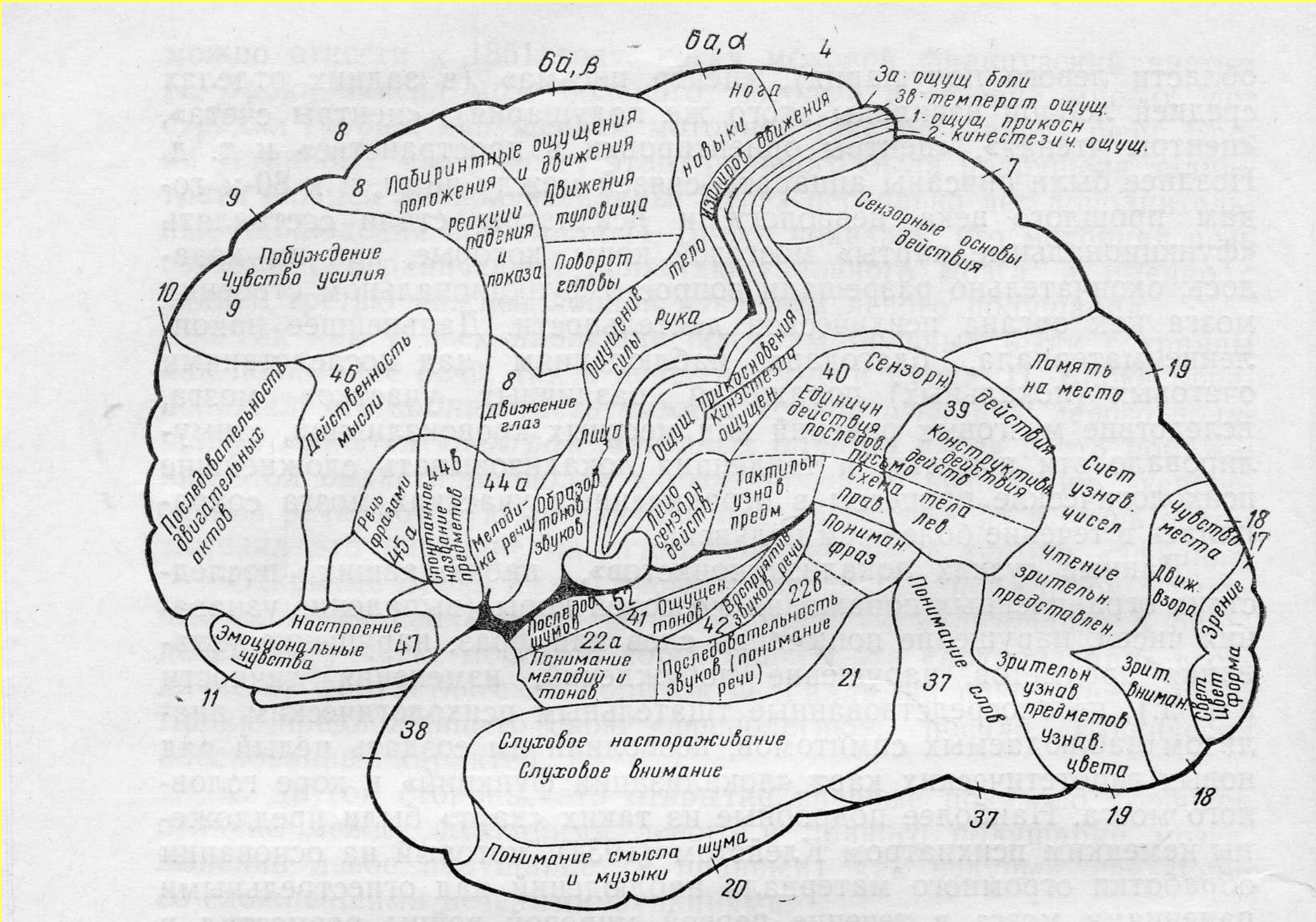
История (2)

- Френологические карты Ф. Галля (19 век)



История (3)

- Локализационная карта Клейста (1934)



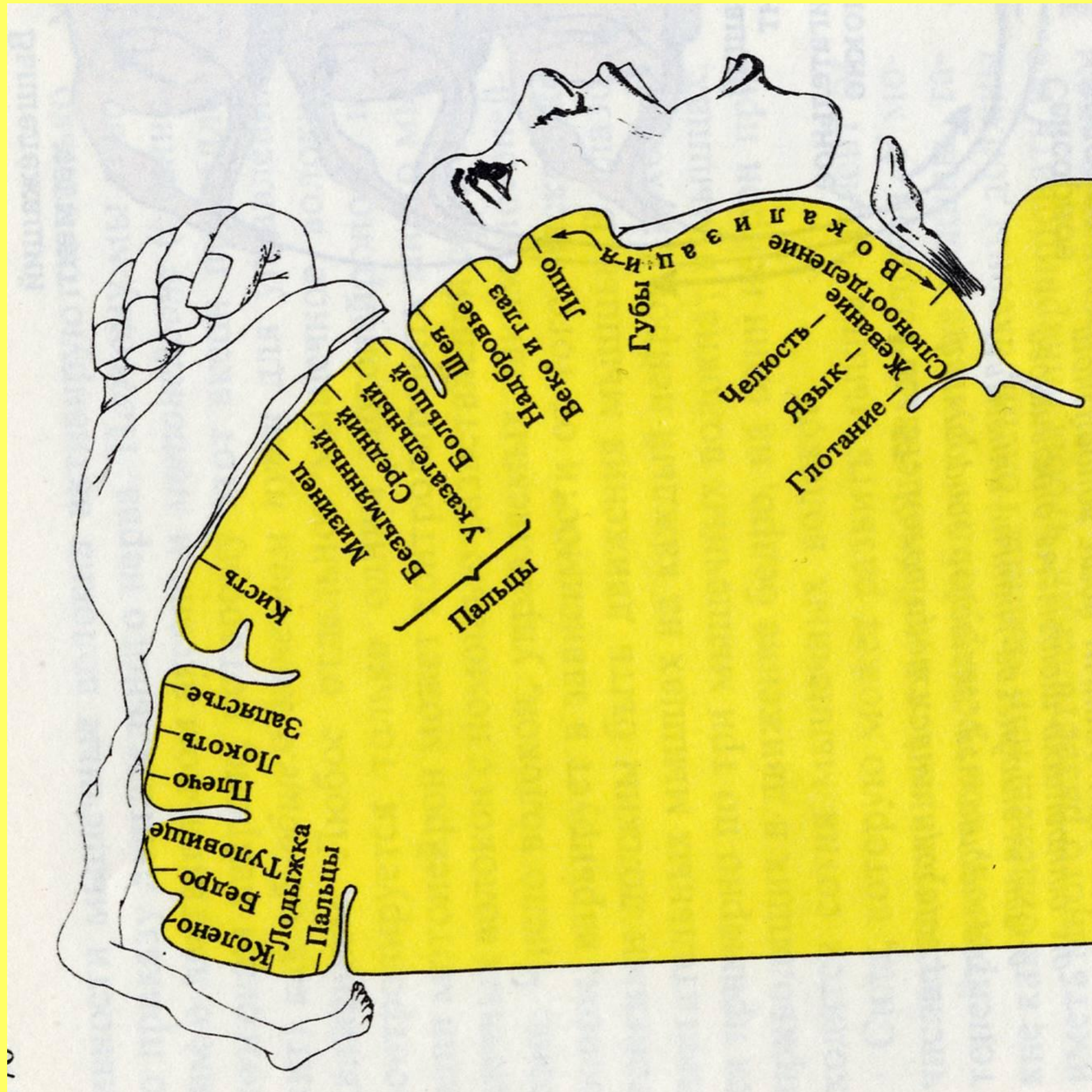
История (4)

- В.М. Бехтерев (1907) обосновывает принцип структурно-функционального подхода, изучение строения мозга в единстве с его функциями (все участки мозга имеют определенное назначение); функциональная локализация

- клинические наблюдения и разрушения
  - ✔ Брока (1861): нарушение речи
  - ✔ Вернике (1873): нарушение понимания речи
  - ✔ Lashley, 1921: эквипотенциальность мозга

Начальные методы (2)

- электрическое раздражение (Penfield, 1959)



Нейропсихология

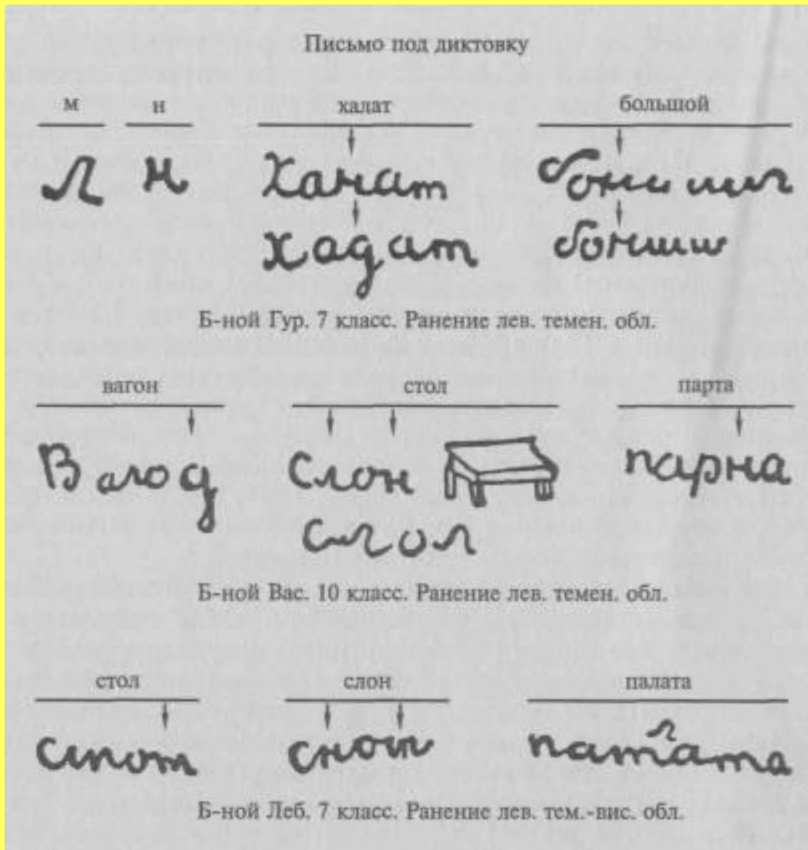
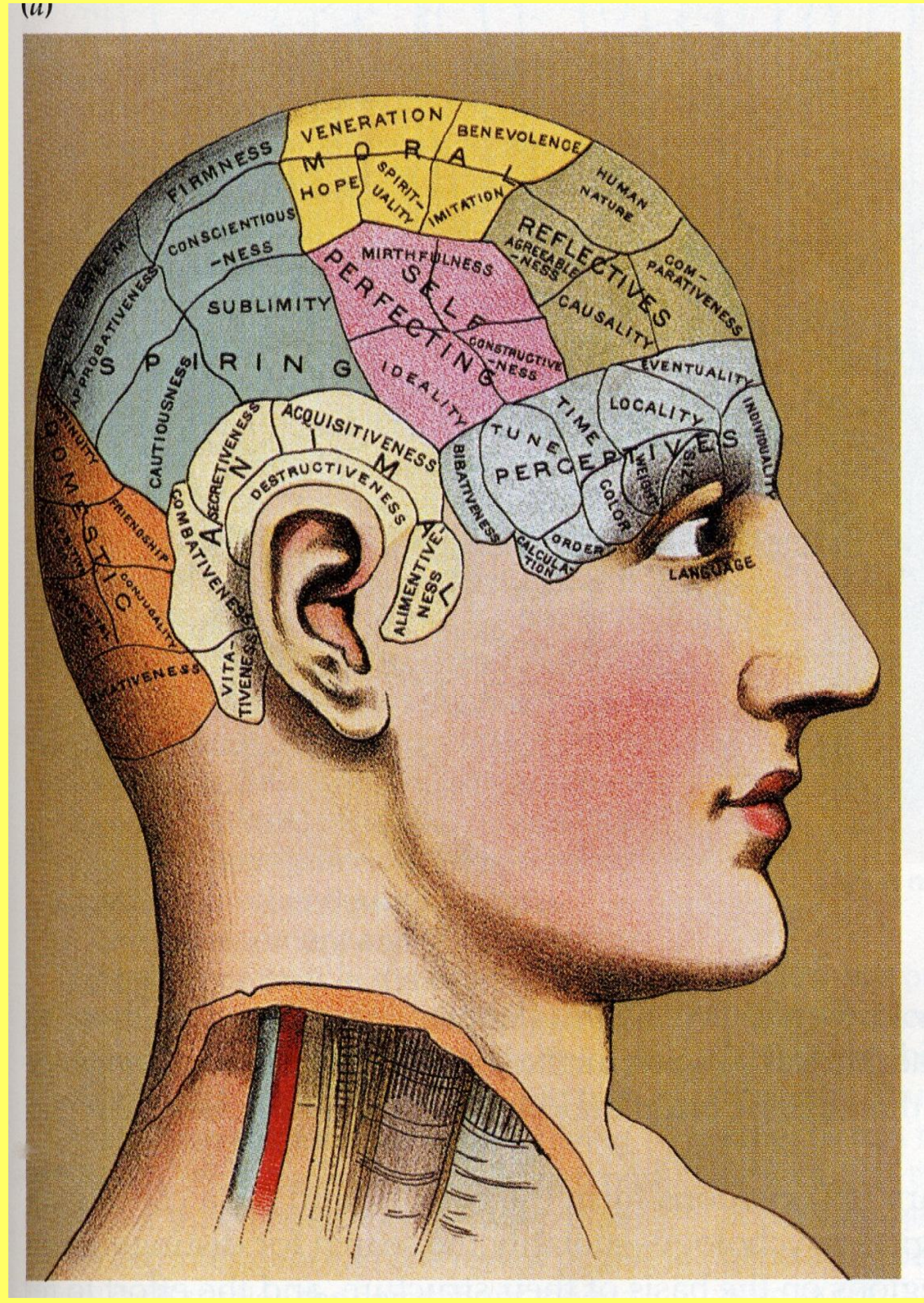
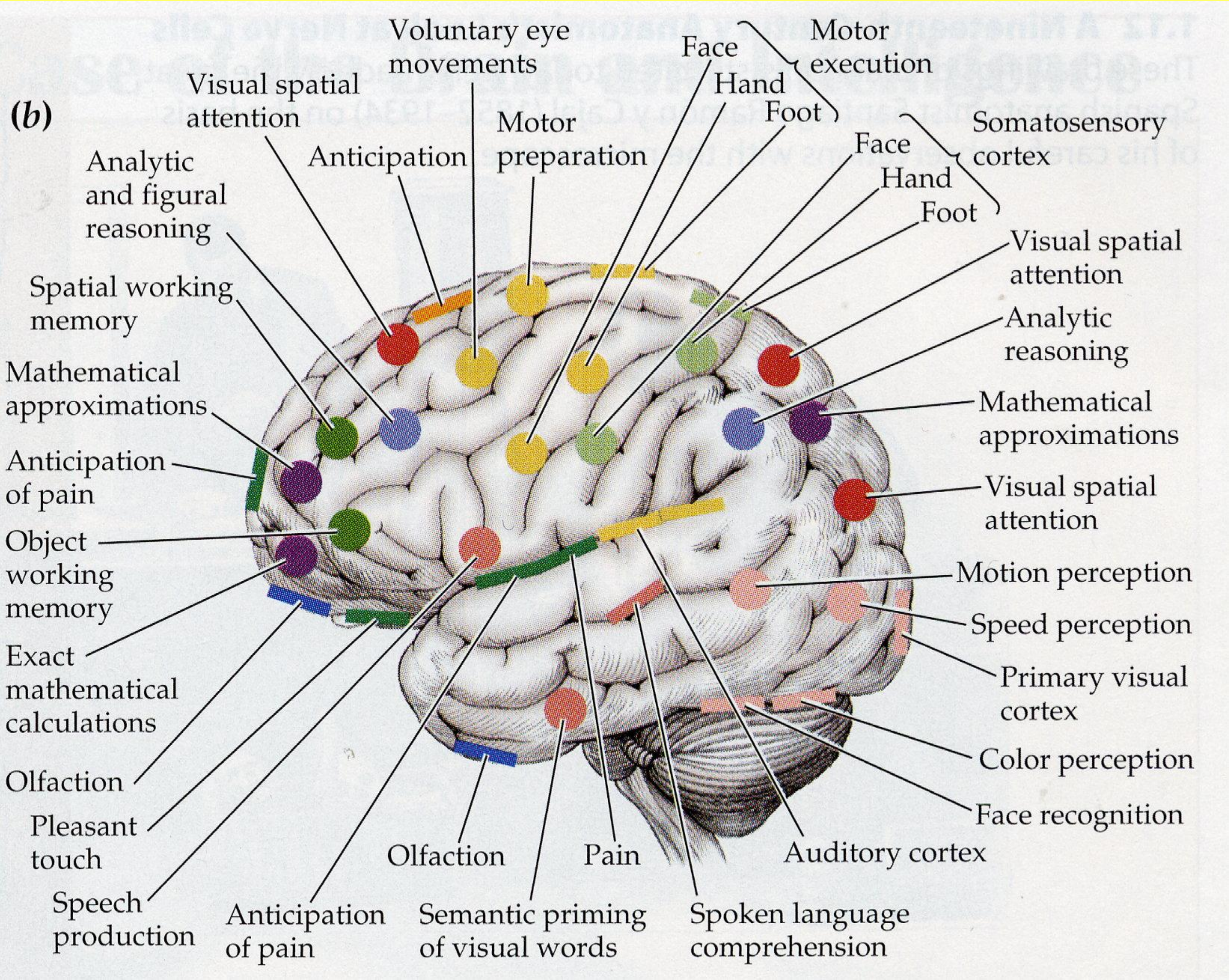


Рис. 75. Письмо больных с «афферентной моторной афазией»

Прошлое


(a)
VENERATION
BENEVOLENCE
MORAL
FIRMNESS
HOPE
SPIRIT-UALITY
IMITATION
HUMAN NATURE
CONSCIENTIOUS-NESS
MIRTHFULNESS
SELF PERFECTING
REFLECTIVES
AGREEABLE-NESS
COM-PARATIVENESS
SUBLIMITY
CAUSALITY
APPROBATIVENESS
ASPIRING
CONSTRUCTIVE-NESS
IDEALITY
EVENTUALITY
LOCALITY
TIME
INDIVIDUALITY
CAUTIOUSNESS
SECRETIVENESS
ACQUISITIVENESS
ANIMAL
DESTRUCTIVENESS
TUNE
PERCEPTIVES
BIBATIVENESS
COLOR
WEIGHT
SIZE
ORDER
CALCULATION
LANGUAGE
DOMESTIC
FRIENDSHIP
CONJUGALITY
COMBATIVENESS
ALIMENTIVENESS
VITATIVENESS

Настоящее


(b)
Voluntary eye movements
Face
Hand
Foot
Motor execution
Visual spatial attention
Motor preparation
Anticipation
Face
Hand
Foot
Somatosensory cortex
Analytic and figural reasoning
Visual spatial attention
Spatial working memory
Analytic reasoning
Mathematical approximations
Mathematical approximations
Anticipation of pain
Visual spatial attention
Object working memory
Motion perception
Speed perception
Exact mathematical calculations
Primary visual cortex
Color perception
Olfaction
Face recognition
Pleasant touch
Olfaction
Pain
Auditory cortex
Speech production
Anticipation of pain
Semantic priming of visual words
Spoken language comprehension


Расположение высших нервных центров в коре головного мозга собак (схема по И. П. Павлову)
Анализатор кожно-механических
Центр движений туловища и конечностей
Центр осязания
Центр чтения
Двигательный центр речи
Чувствительный центр речи
Центр слуха
Центр зрения
Расположение высших нервных центров в коре головного мозга человека

Проблема 1

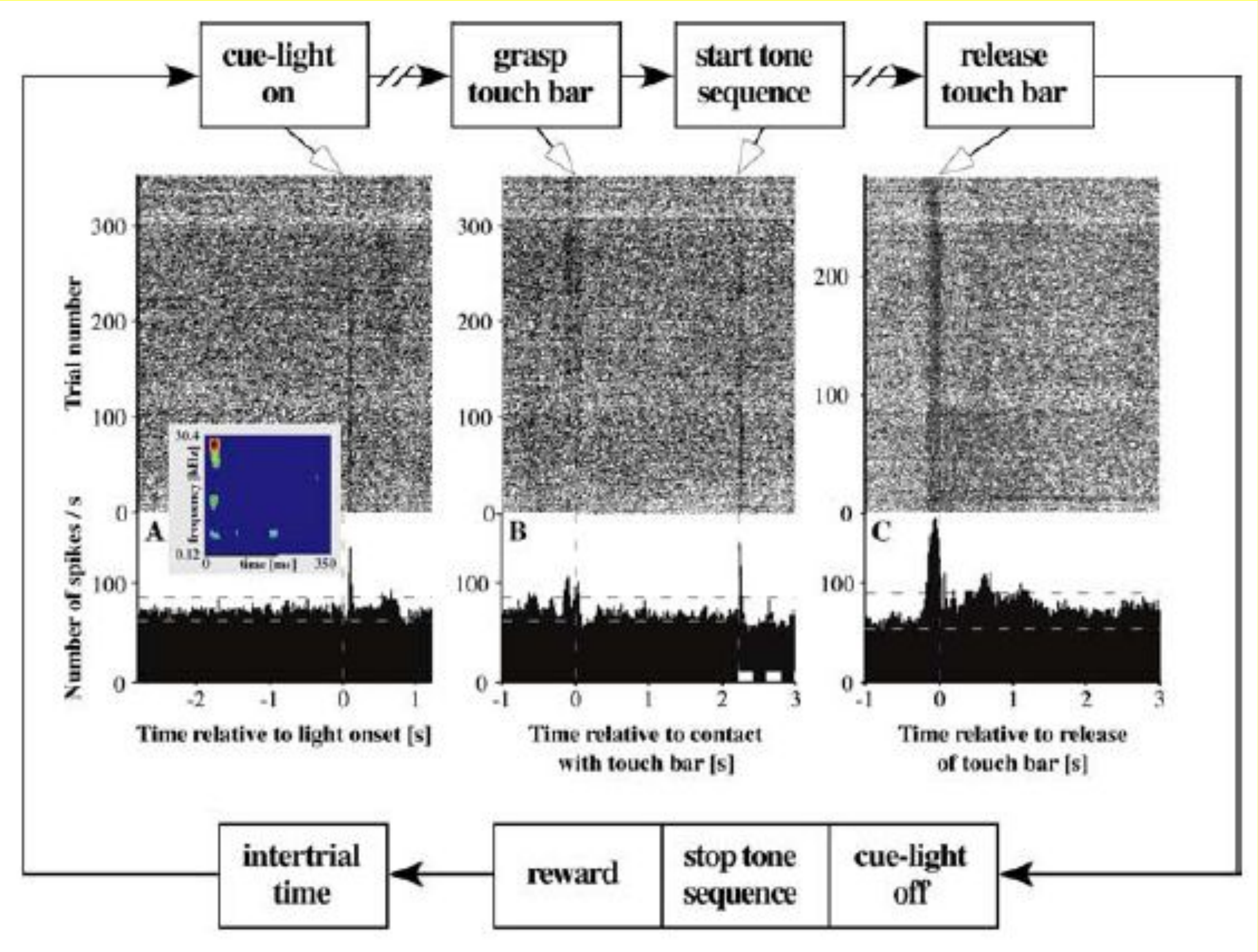
- «функция» может быть найдена не только в своем «функциональном» центре
  - у собак нарушается зрение при удалении моторной коры (Беритов, 1963; Иоффе, 1975)
  - активация нейронов не только сенсорных областей, но и моторной коры, регистрируется при предъявлении сенсорных (соматических, звуковых, зрительных) сигналов (Соколова и Липецкая, 1966; Buser et al., 1968; Ogawa, 1975 и др.)

Проблема 2

- «функциональный» центр содержит разные «функции»
  - один и тот же нейрон, например, зрительной коры, может активироваться при предъявлении соматических, вестибулярных или звуковых сигналов (Куман и Латаш, 1970)

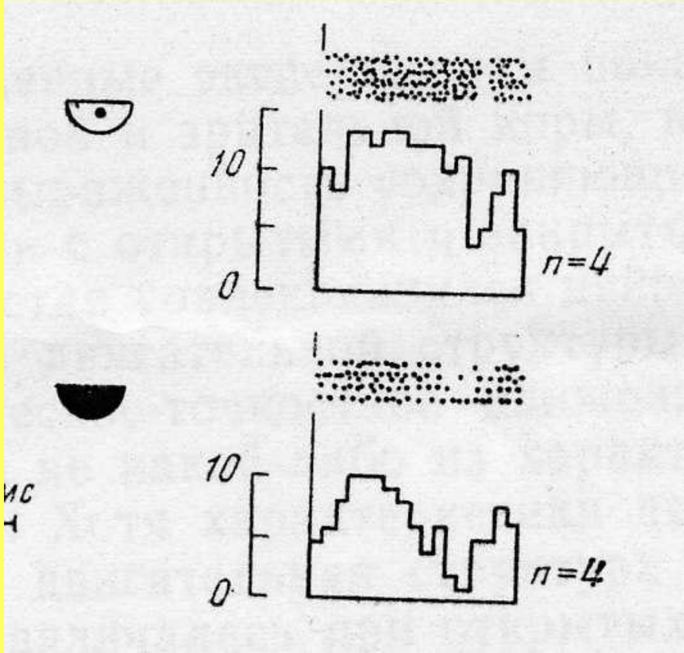
Проблема 2

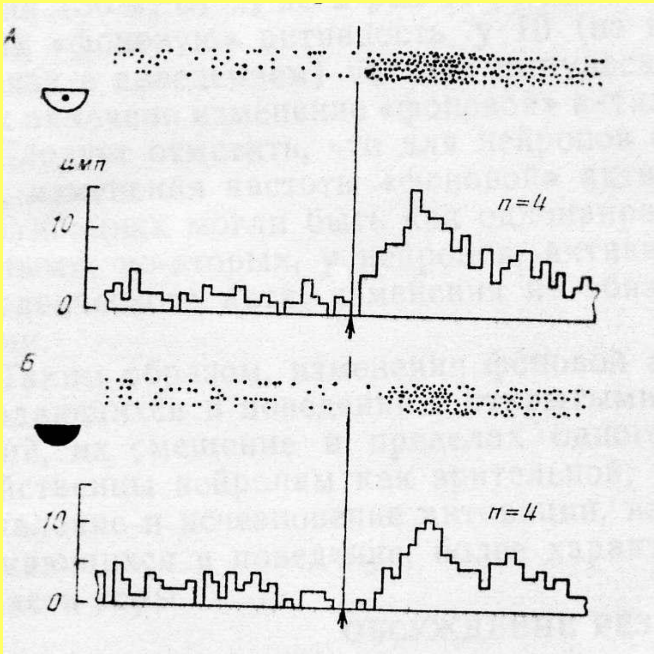
- «функциональный» центр содержит разные «функции»
  - (Brosch et al., 2005) J Neurosci



Проблема 3

- «функции нет, а активность «центра» есть»
  - Александров Ю.И. и Александров И.О. (1981)





связь с определенными этапами (подача моркови)

Повреждения участков мозга (Lesion)

Cerebral Cortex Advance Access published August 19, 2015

OXFORD

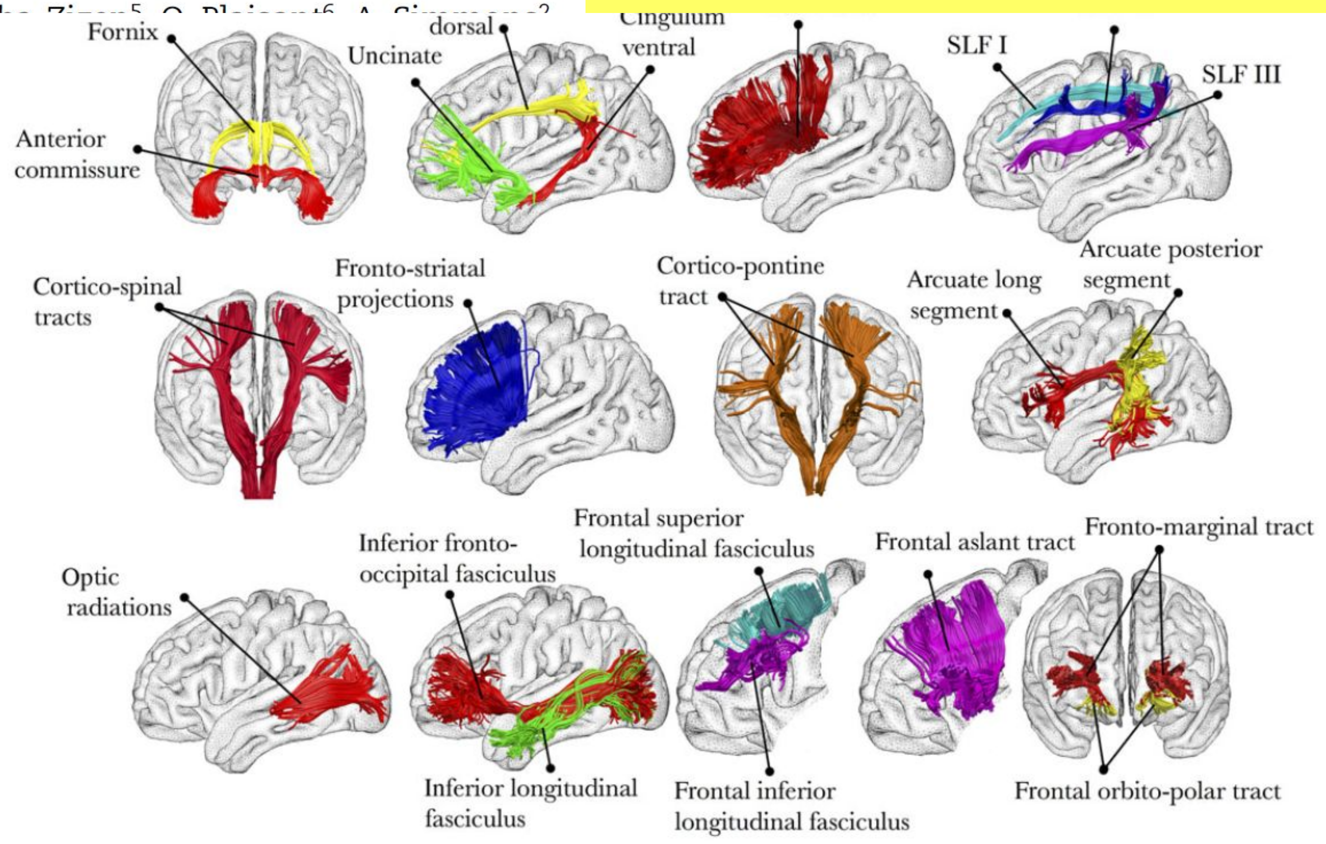
Cerebral Cortex, 2015, 1–16

doi: 10.1093/cercor/bhv173
Original Article

ORIGINAL ARTICLE

From Phineas Gage and Monsieur Leborgne to H.M.: Revisiting Disconnection Syndromes

M. Thiebaut de Schotten[1,3,4], F. Dell'Acqua[1,2], P. Ratiu[1], A. Leslie[1,2],
H. Howells[1,2], E. Cabanis[5], M. T.
N. F. Dronkers[7,8,9], S. Corkin[10], a



Cerebral Cortex Advance Access published August 19, 2015

OXFORD

Cerebral Cortex, 2015, 1–16

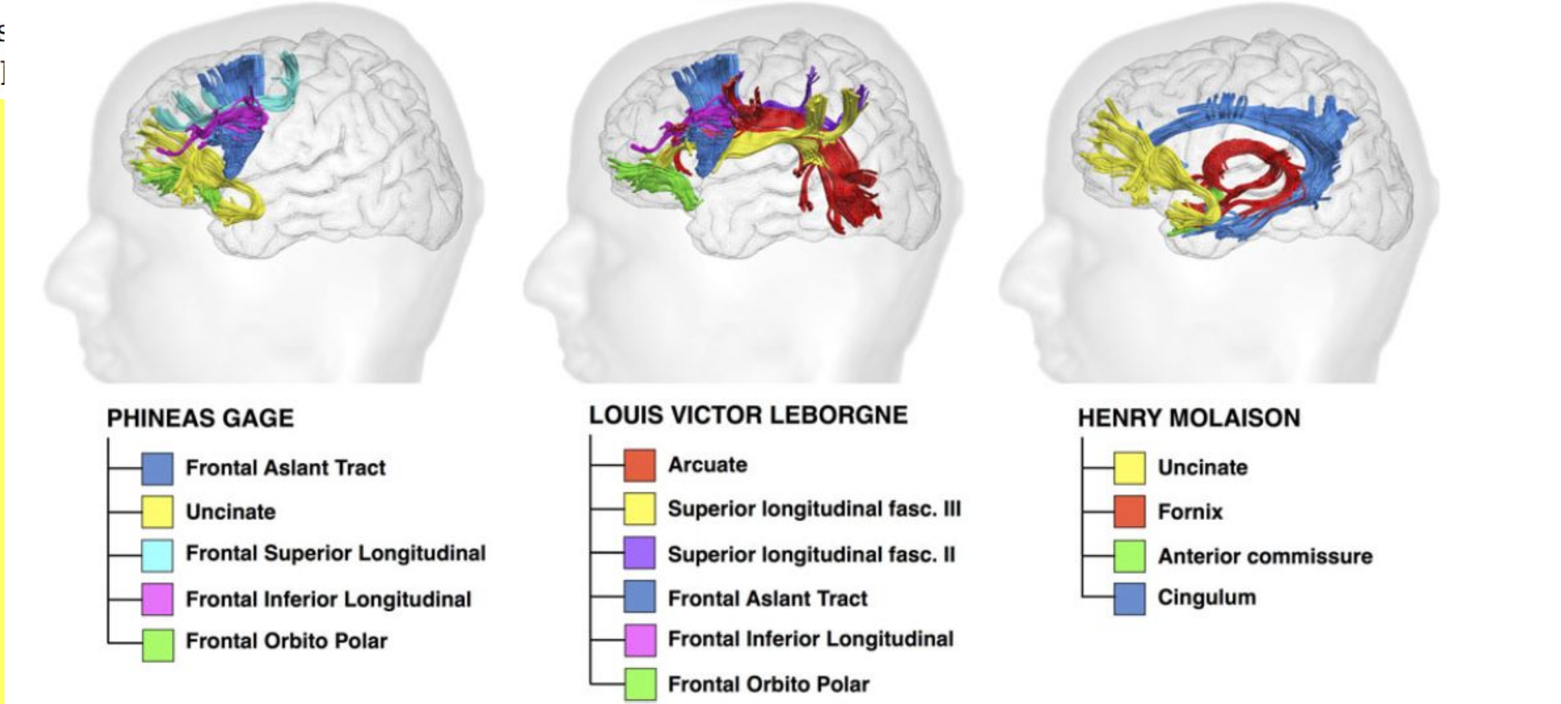
doi: 10.1093/cercor/bhv173
Original Article

Повреждения участков мозга (Lesion)

ORIGINAL ARTICLE

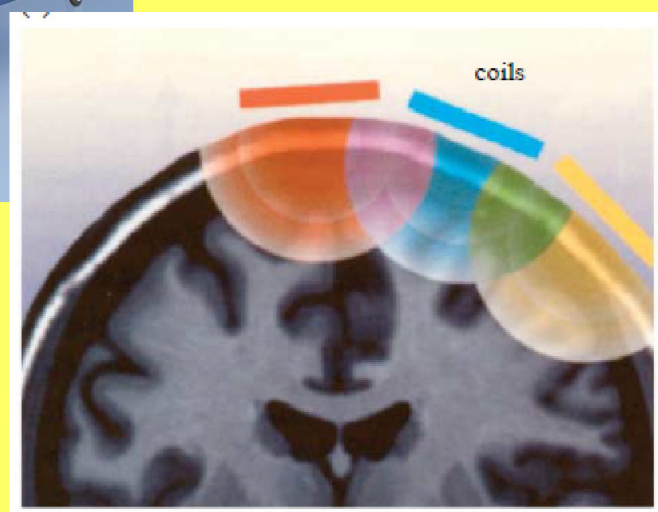
From Phineas Gage and Monsieur Leborgne to H.M.: Revisiting Disconnection Syndromes

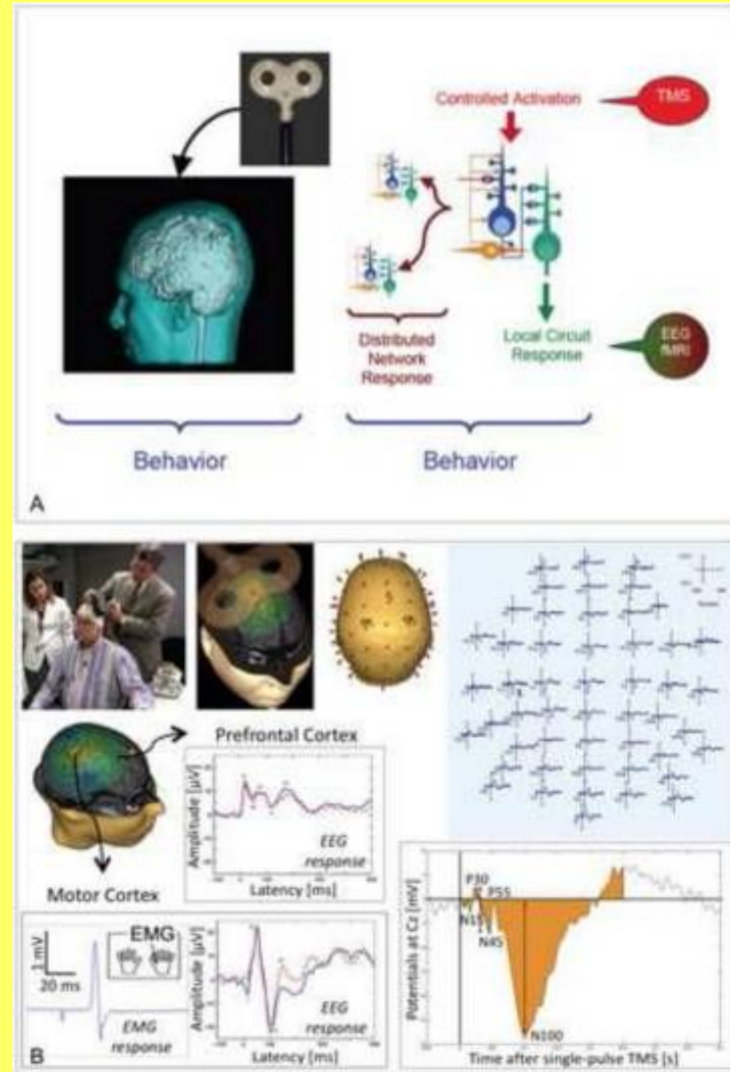
M. Thiebaut de Schotten[1,3,4], F. Dell'Acqua[1,2], P. Ratiu[1], A. Leslie[1,2],
H. Howells
N. F. Dronl



. Major tracts that were damaged in Gage (damage affected at least 30% of the tracts' volume, z-score = 1.7), in Leborgne (damage affected at least 55% of the tracts'
, z-score = 1.29), and in Molaison (damage affected at least 5% of the tracts' volume, z-score = 1.39).

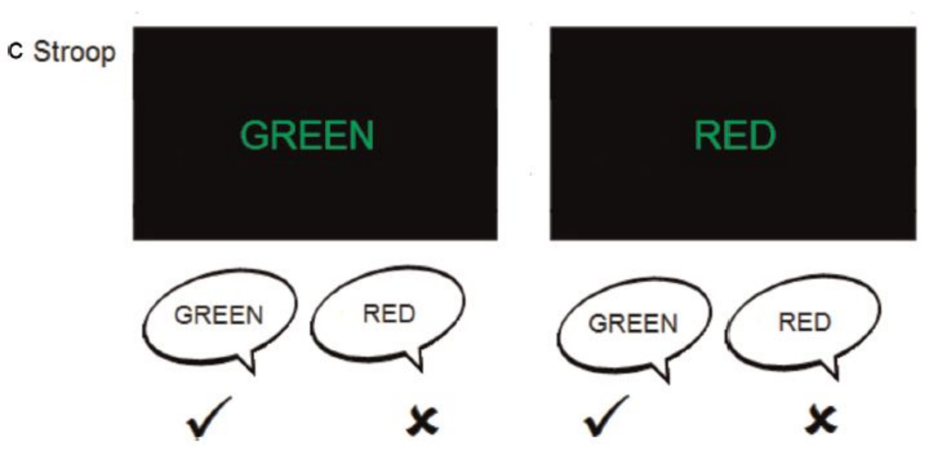
Стимуляция участков мозга





- **Транскраниальная магнитная стимуляция**

Транскраниальная магнитная стимуляция

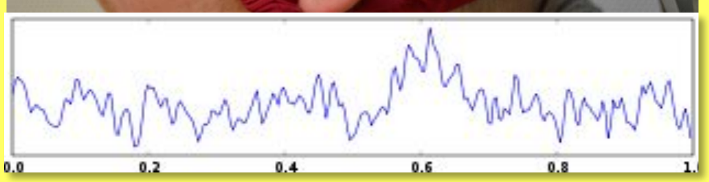


Stroop paradigm			
Hayward et al. (2004)	AAC and PAC; area 4 cm posterior to the motor vertex as control site	Four pulses; 10 Hz; 110% of individual threshold; first pulse applied 200 ms after stimulus onset	• Stroop effect abolished with TMS over AAC and PAC. • Cingulate may serve an 'evaluative' role and monitor competing behaviorally relevant information.
Hayward et al. (2007)	Medial frontal, medial parietal as control site	Four pulses; 10 Hz; 110% of individual threshold	• Stroop effect abolished with TMS over the medial frontal cortex. • No interaction between TMS and the Stroop condition occurred in regional cerebral blood flow. • Possibly limited utility of TMS for the stimulation of deep brain regions.
Boggio et al. (2005)	Left dlPFC	rTMS; 15 Hz; 110% above motor threshold; 40 trains of 5 s each; 10 daily sessions; or sham	• Performance in Stroop task improved to a comparable extent for rTMS group and a group receiving medication. • No negative effects observed after rTMS in any of the neuropsychological tests; rTMS safe to used in PD patients.
Wagner et al. (2006)	Left dlPFC	rTMS; 20 Hz; 100% of individual motor threshold; 40 trains of 2 s duration, 20 min; or sham	• No delayed effects of rTMS on performance in Stroop Test; rTMS does not produce longer-lasting impairments of executive function.

Olk et al 2015

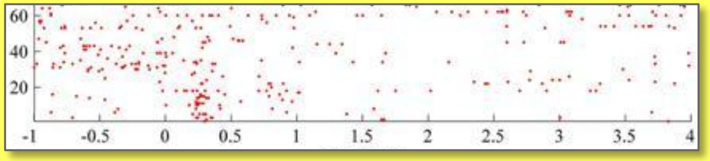
Нейроинтерфейсы мозг-компьютер: два основных подхода

Неинвазивные нейроинтерфейсы



Сигнал усреднен, зашумлен

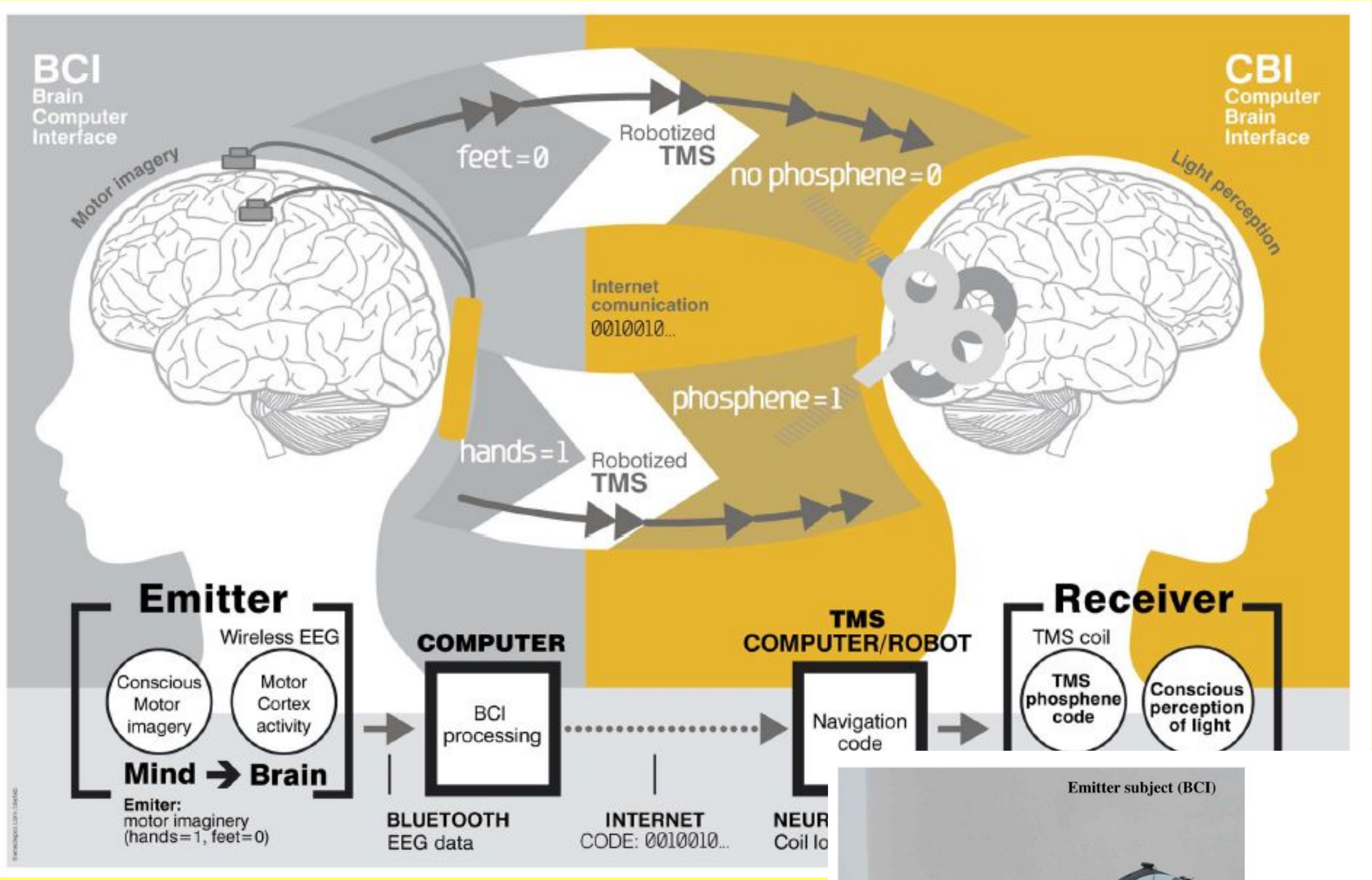
Импланитируемые нейроинтерфейсы

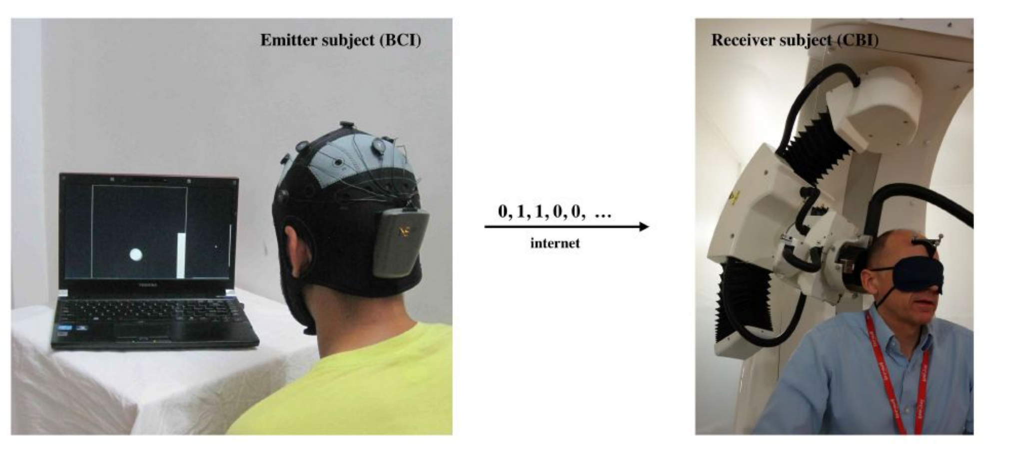


Сигнал дискретен, информативен

Интерфейсы, основанные на ЭЭГ

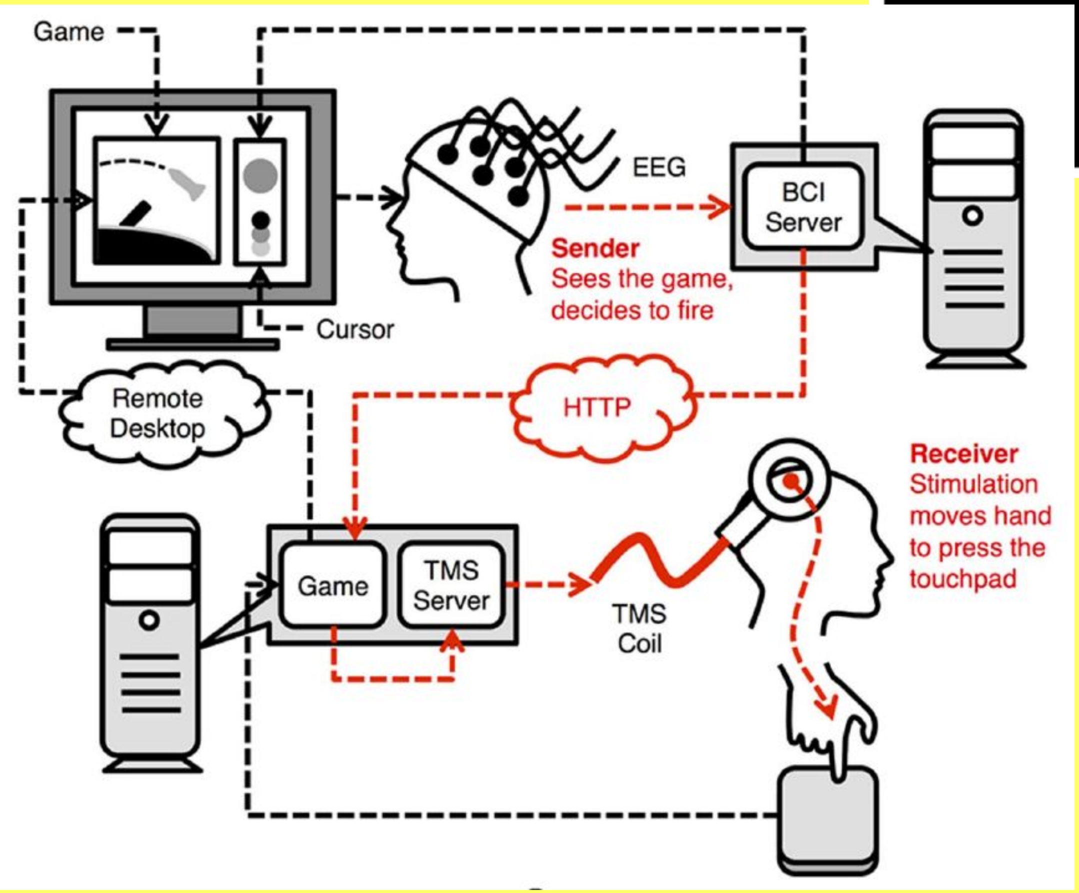
«ПЕРЕДАЧА МЫСЛЕЙ»





Grau et al 2014

«ПЕРЕДАЧА МЫСЛЕЙ»



Rao et al 2014

SCIENTIFIC REPORTS

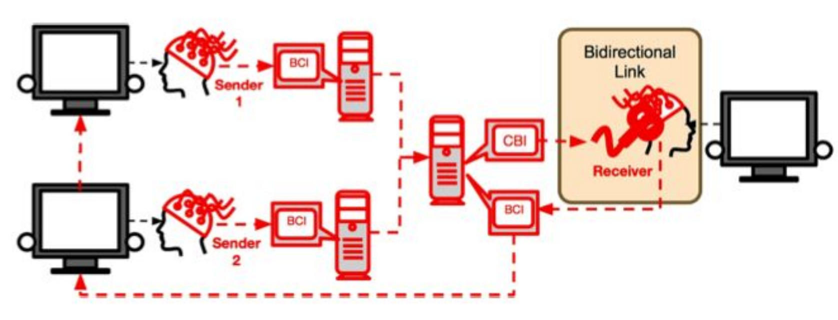
OPEN

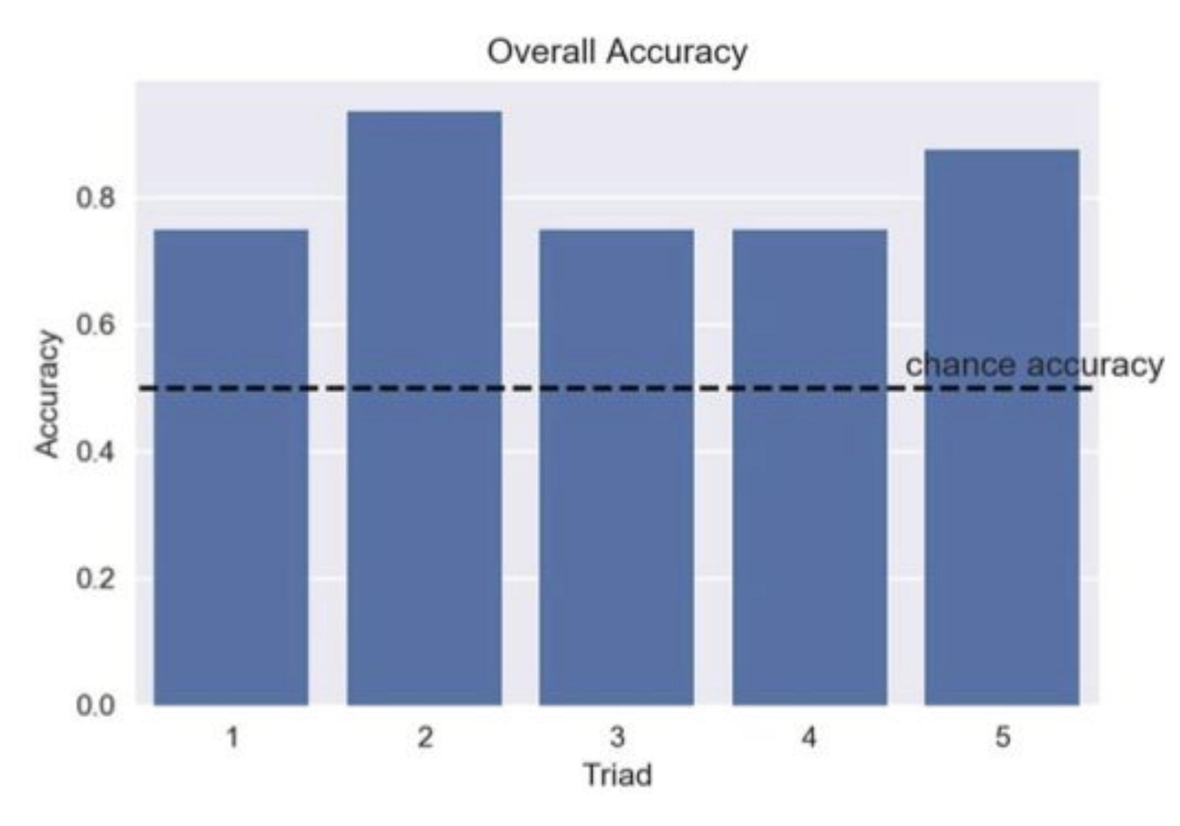
BrainNet: A Multi-Person Brain-to-Brain Interface for Direct Collaboration Between Brains

Received: 15 October 2018
Accepted: 20 March 2019
Published online: 16 April 2019

Linxing Jiang[1], Andrea Stocco[2,3,6,7], Darby M. Losey[4,5], Justin A. Abernethy[2,3], Chantel S. Prat[2,3,6,7] & Rajesh P. N. Rao[1,6,7]

We present BrainNet which, to our knowledge, is the first multi-person non-invasive direct brain-to-brain interface for collaborative problem solving. The interface combines electroencephalography (EEG) to record brain signals and transcranial magnetic stimulation (TMS) to deliver information noninvasively





3 типа методов

- Регистрация активности
- Воздействие
  - индукция активности
  - элиминация (подавление или «убирание») активности

мозг

нейрон

электрические или метаболические показатели