



Reprezentarea cerebrală a limbajului. Aportul Imagisticii prin Rezonanta Magnetica Nucleara functională (IRMf)

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Plan

- Metode de neuroimagingistica
- IRMf: Consideratii metodologice si practice
- Reprezentare cerebrală a limbajului
- IRMf: Studii de cartografie a limbajului

Plan

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Metode de neuroimagistica

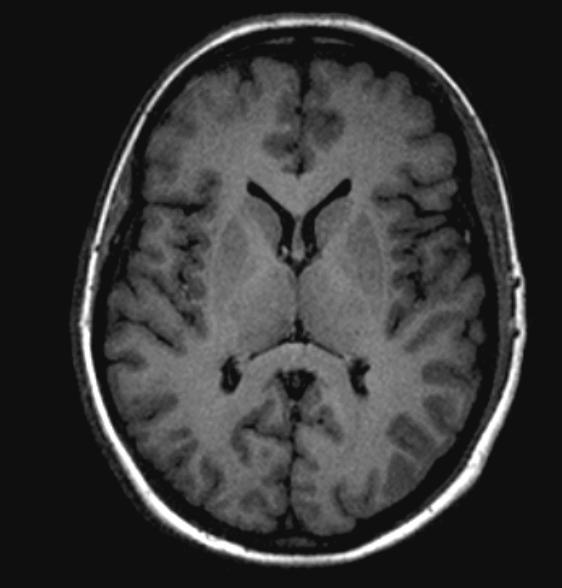
- De tip structural (morfologic)
 - Tomografia CT
 - Imagistica prin Rezonanta Magnetica (IRM)
- De tip functional:
 - DIRECTE
 - Electrofiziologie
 - Electro-encefalografie
 - Magneto-encefalografie
 - INDIRECTE
 - Medicina Nucleara
 - Tomografia prin Emisie de Positroni
 - Tomographia Mono-photonique
 - Imagistica prin Rezonanta Magnetica Nucleare funtionala (IRM)

Plan

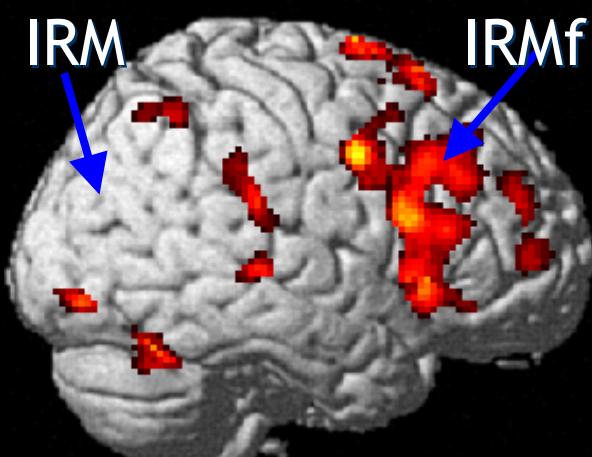
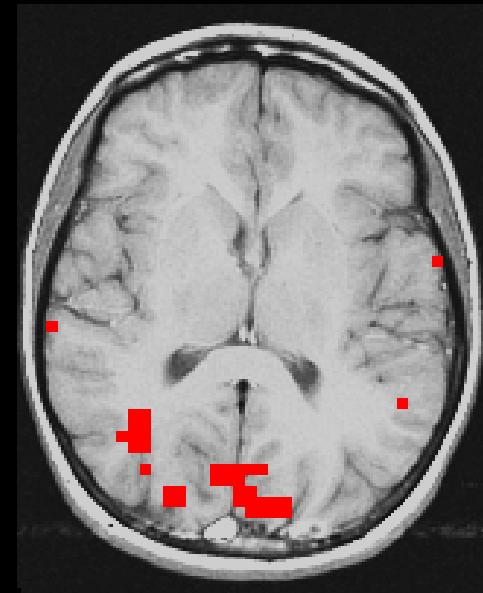
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IRM vs IRMf

IRM exploreaza anatomia



IRMf exploreaza functia



IRMf cartografie functională

- **Neinvaziva** - nu necesita injectare de produs de contrast; traserul este « endogen » (Hb)
- **Indirectă** - masoara variatia debitului sanguin local si a oxigenarii sangvine
- **Anatomo-functională** - Permite obtinerea concomitenta a imaginilor anatomice si functionale cerebrale

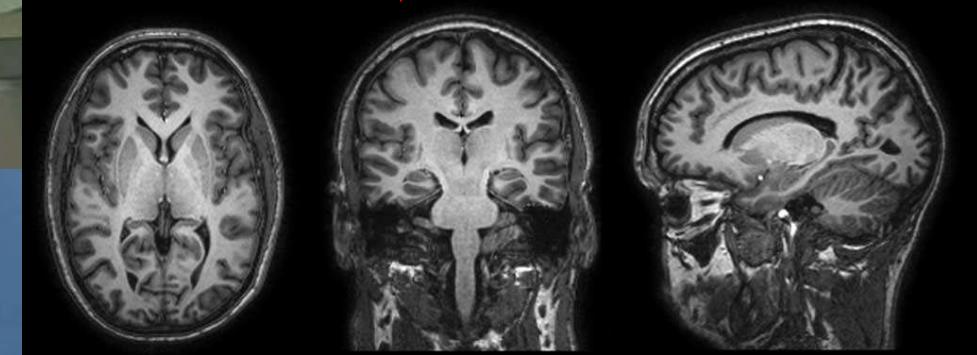
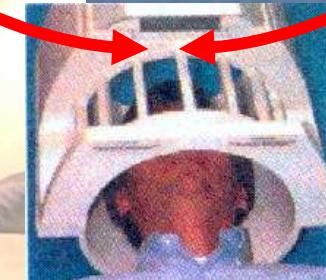
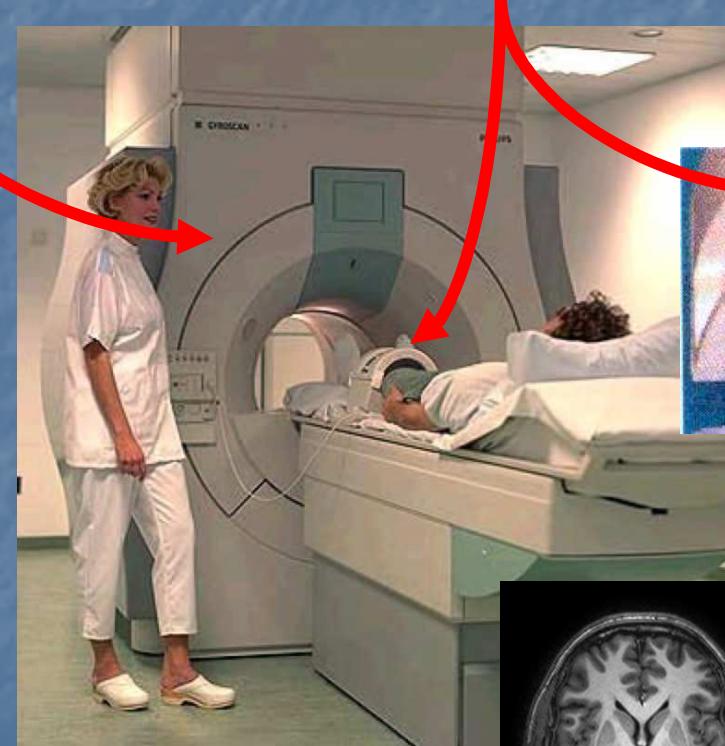
IRM

RMN: Rezonanta Magnetica Nucleara

Magnetisation
Polarisation
Magnetic field

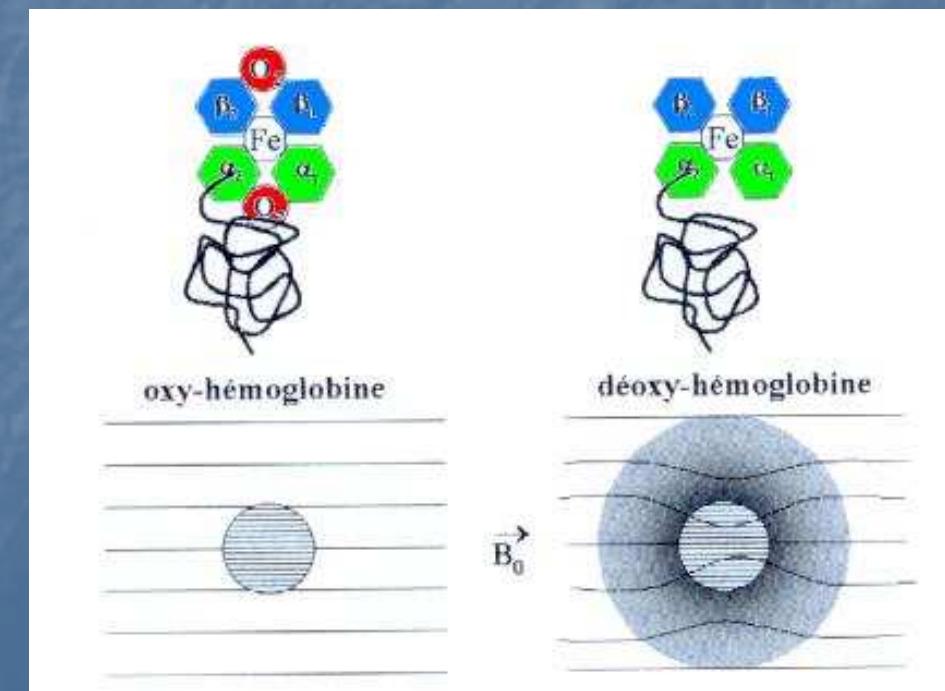
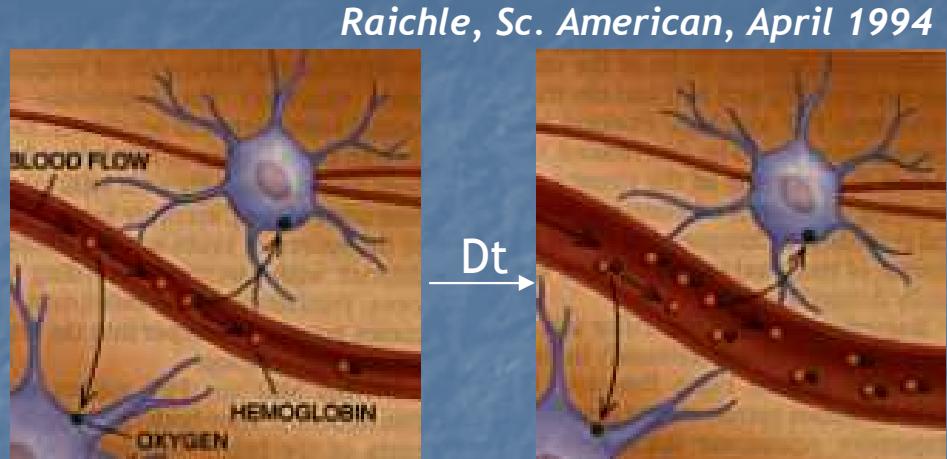
Resonance
Depolarisation
RF

Relaxation
Repolarisation
FID



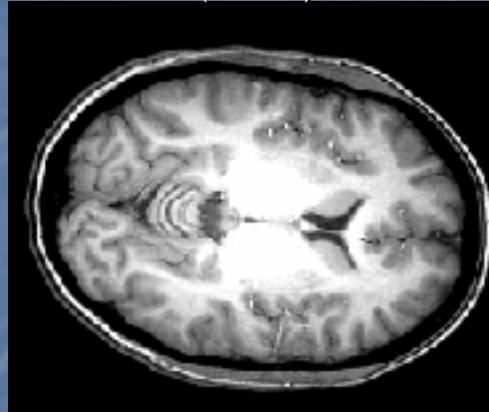
IRMf BOLD (Blood Oxygen Level Dependent)

- Evaluare indirectă a activității neuronale :
 - Variatie locală de debit sanghin
 - Variatie locală de oxigenare sanghina



IRM

RS +++
(1 mm)



1 imagine în 10 min

IRMf

RS-
(~3 mm)



Imagini multiple la
fiecare 2 s

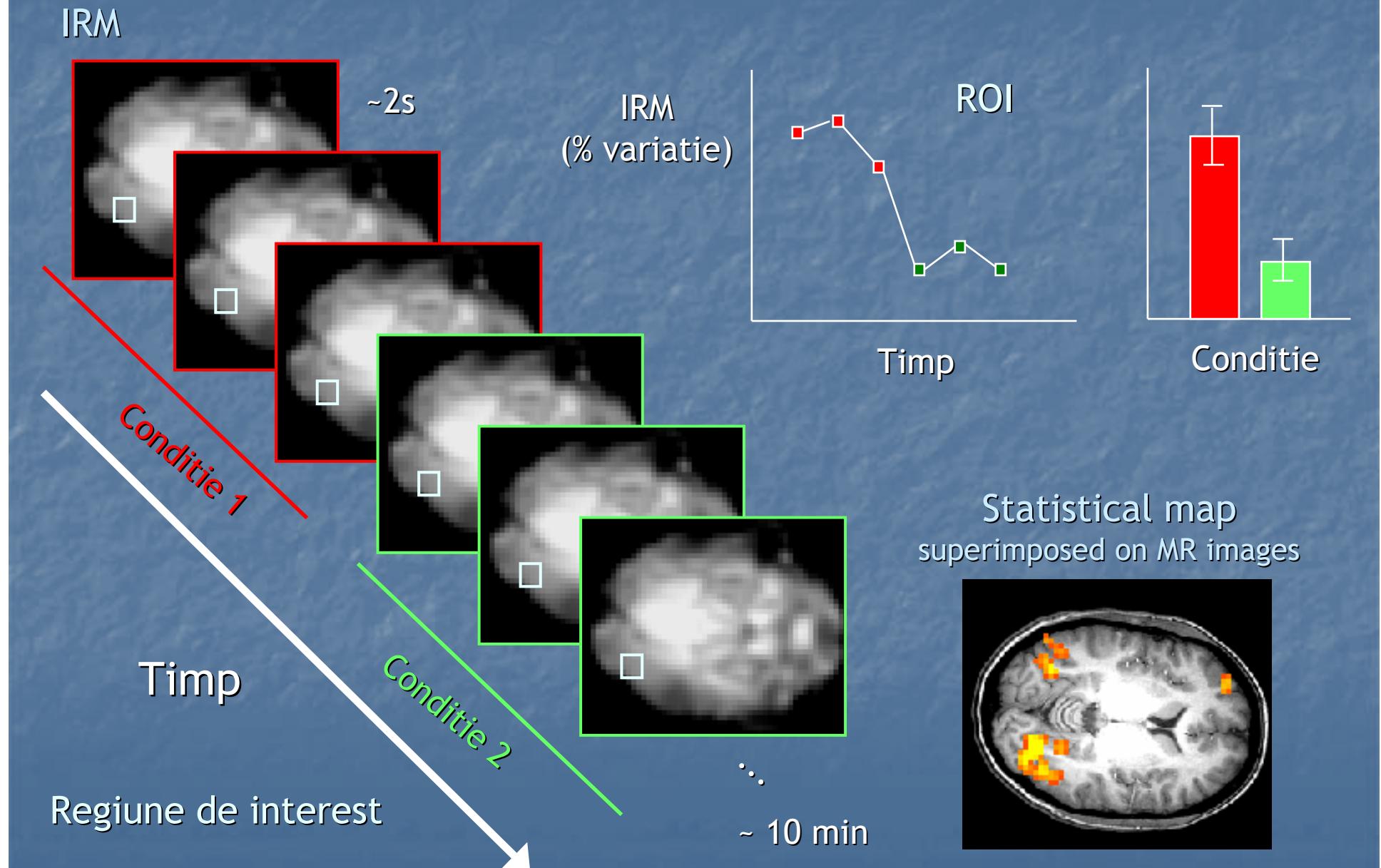
IRMF - Stimulus



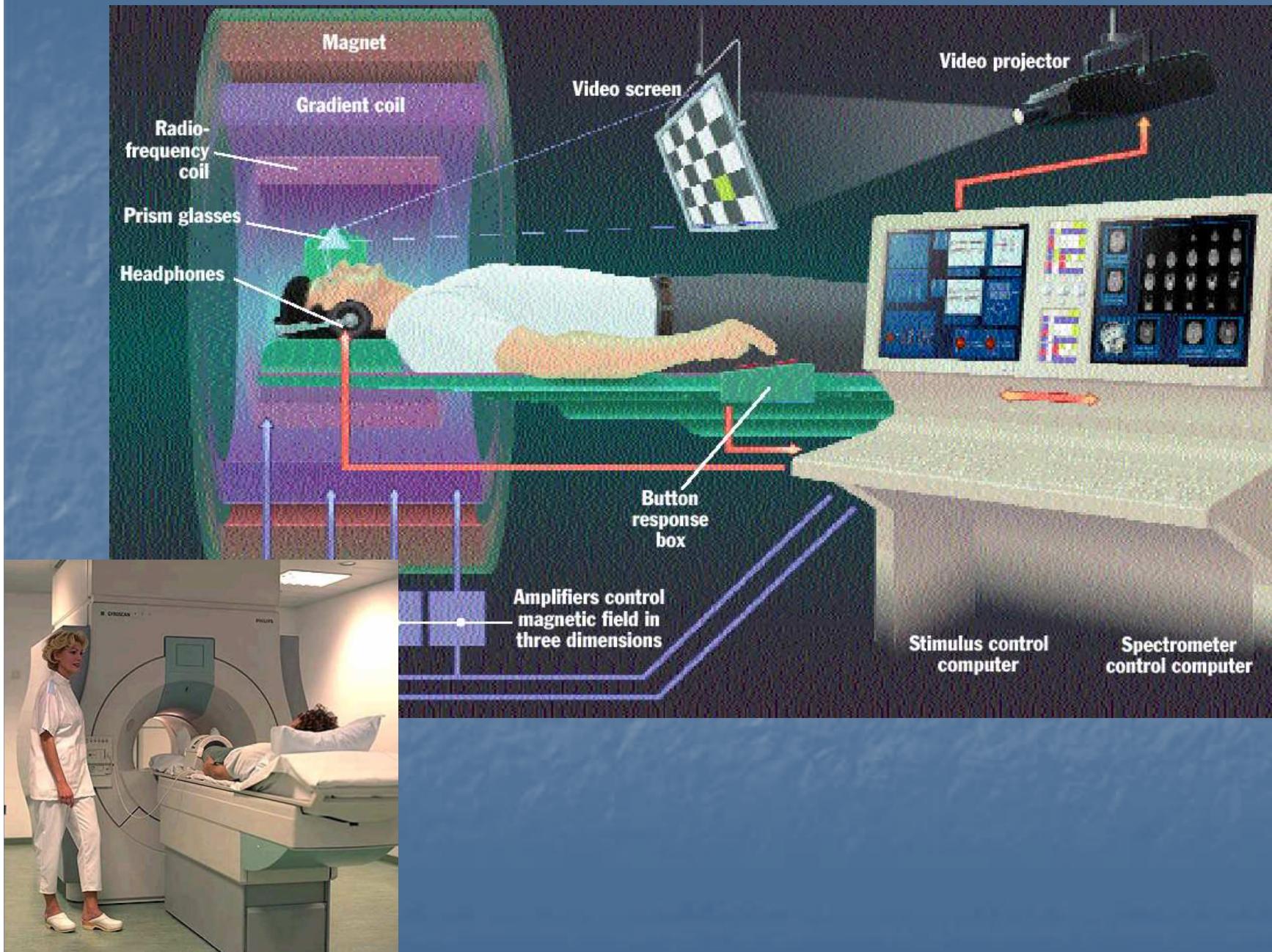
↑ act. neuronale → ↑ O₂ sănge → ↑ semnal RMN

IRMF necesita stimulare cerebrală internă sau externă!

IRMf - cartografie funcională

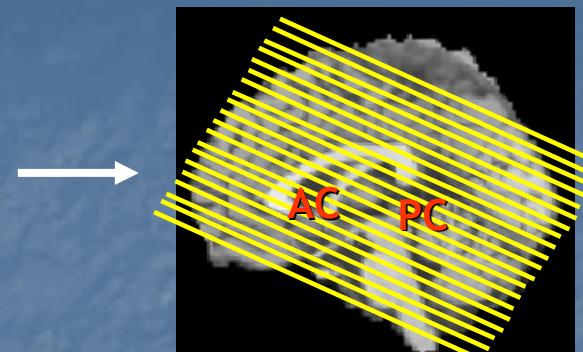
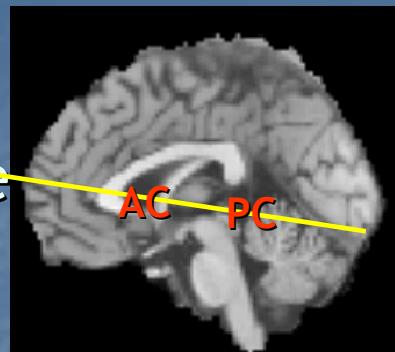


Echipament de stimulare cerebrală

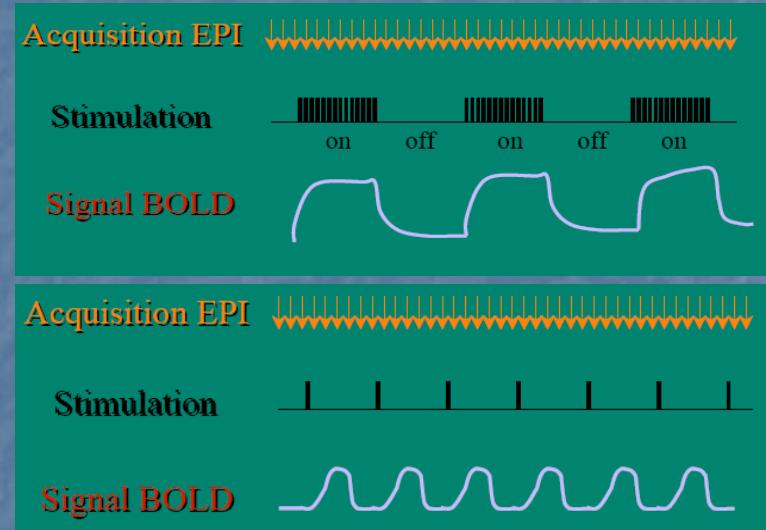
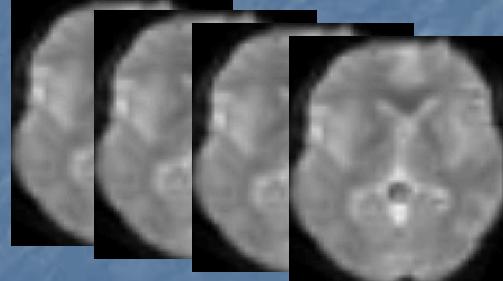


IRMf - consideratii practice

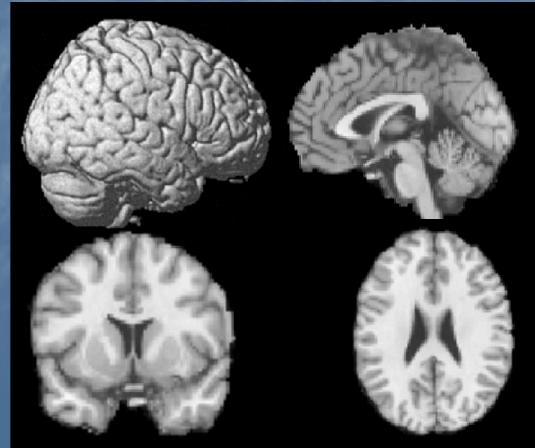
Scan pozitionare



Scan functional
Paradigma de activare



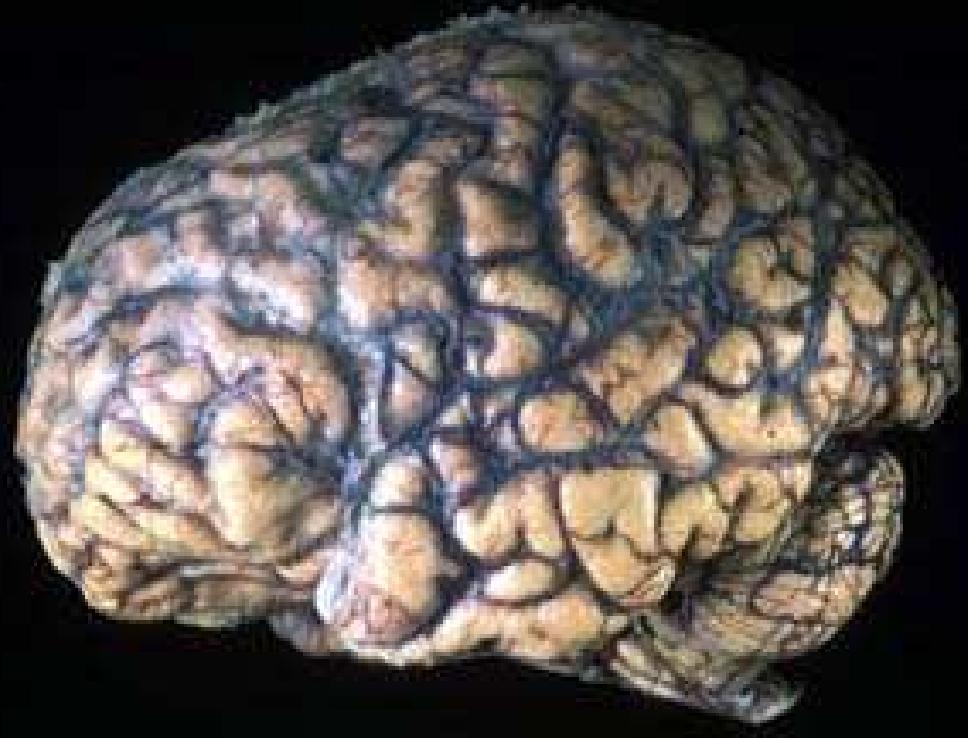
Scan anatomic



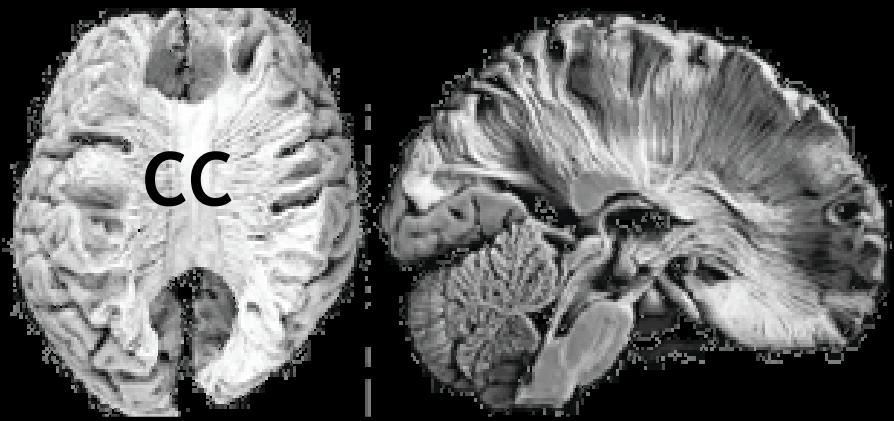
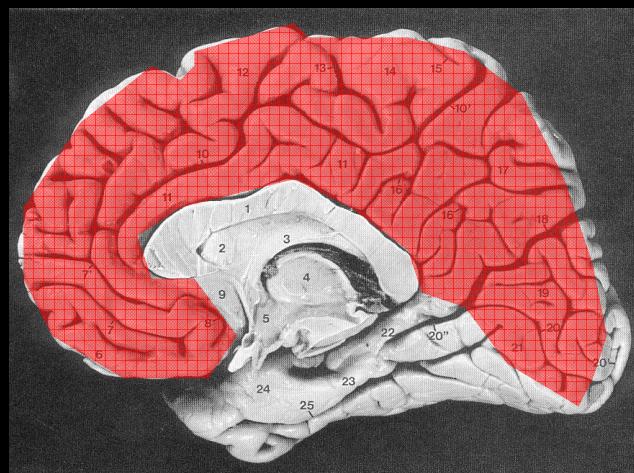
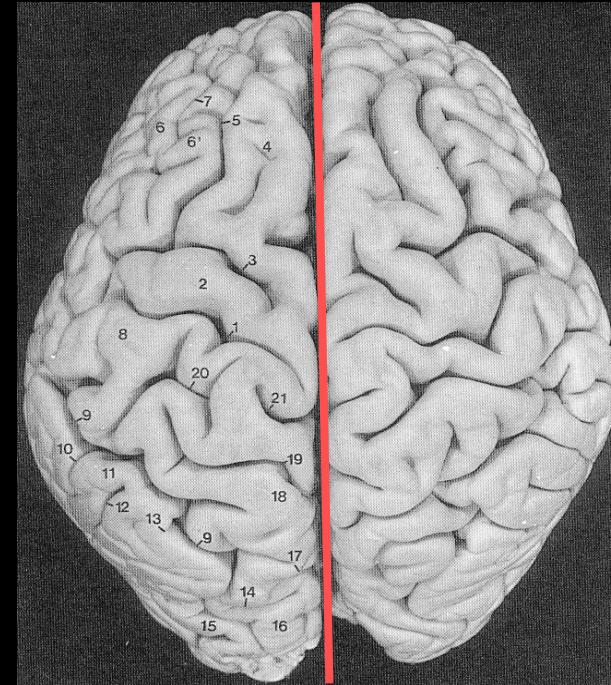
Plan

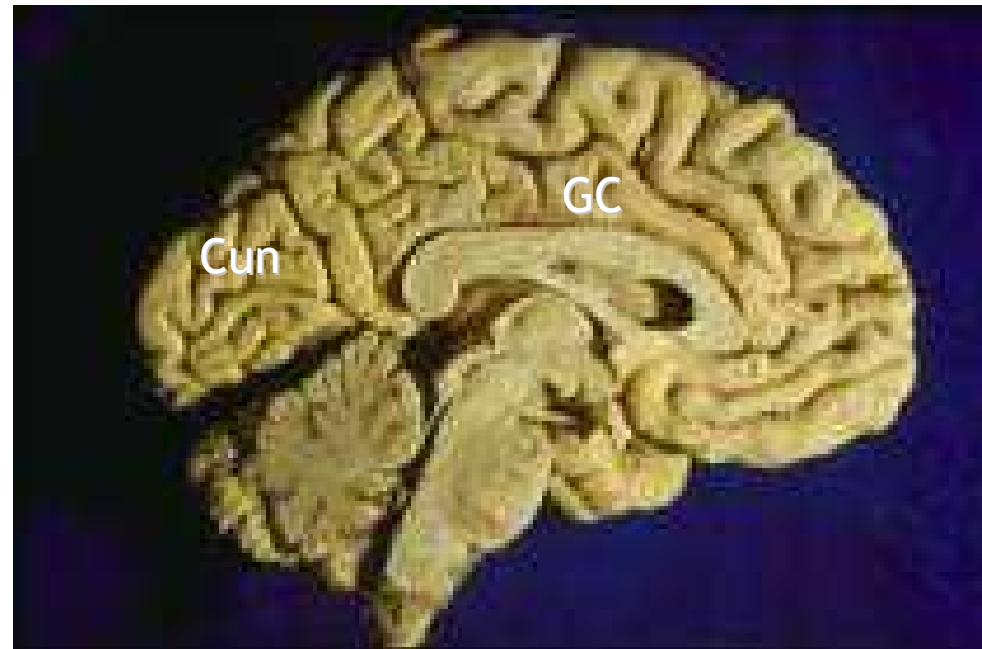
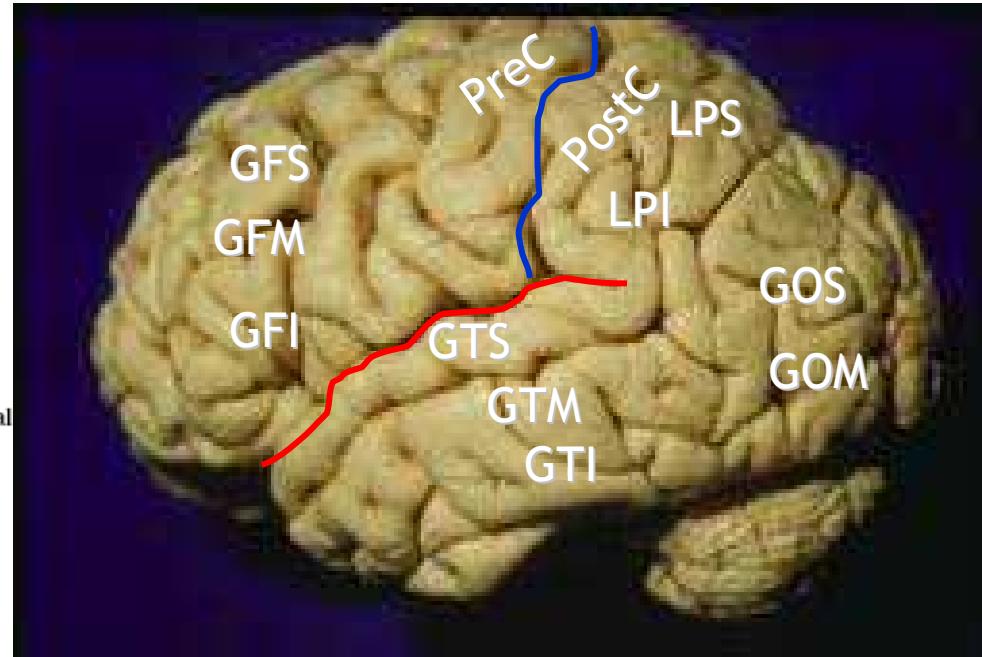
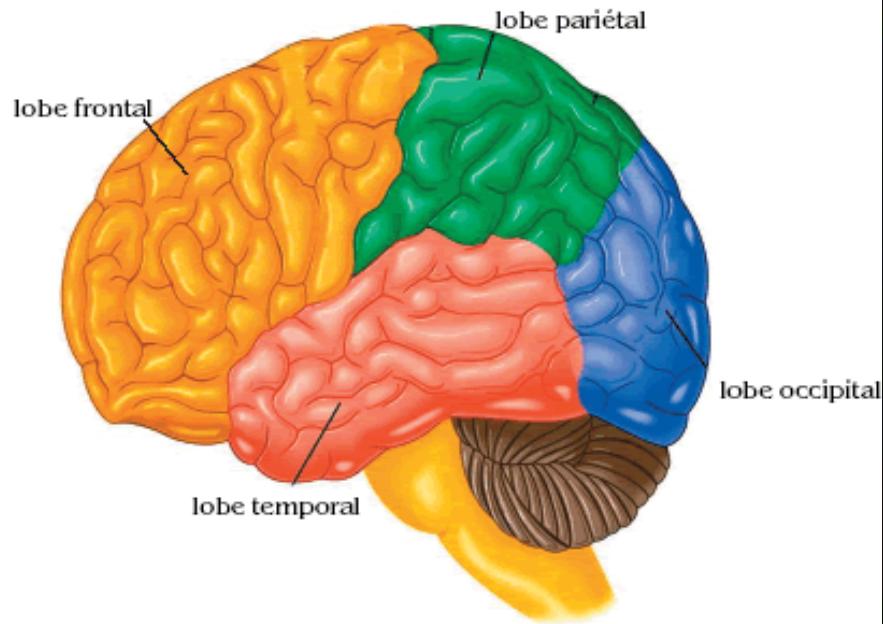
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Encefal

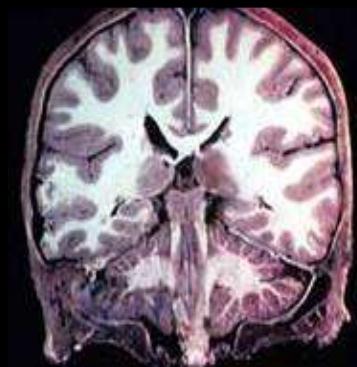


Creier = 2 EC



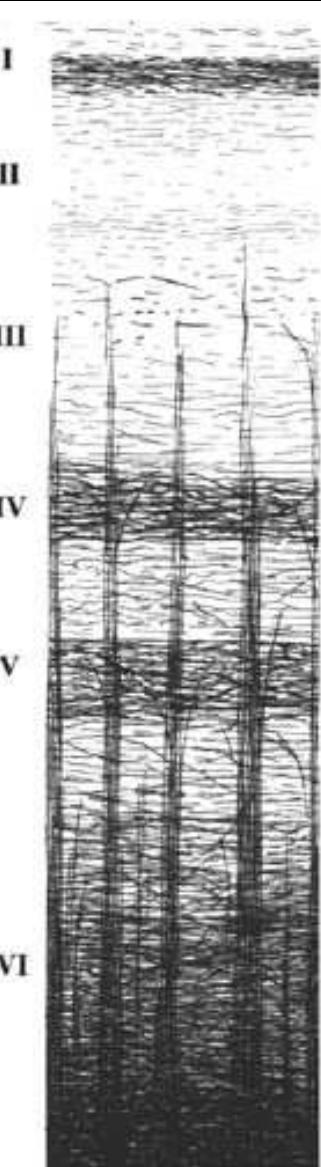
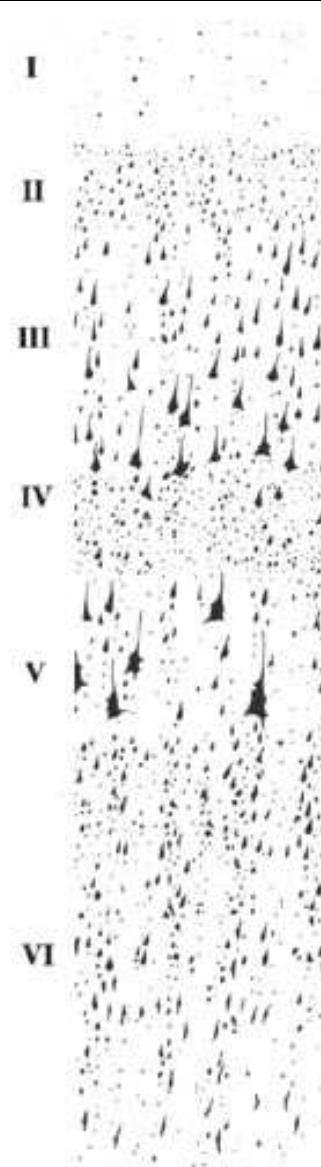
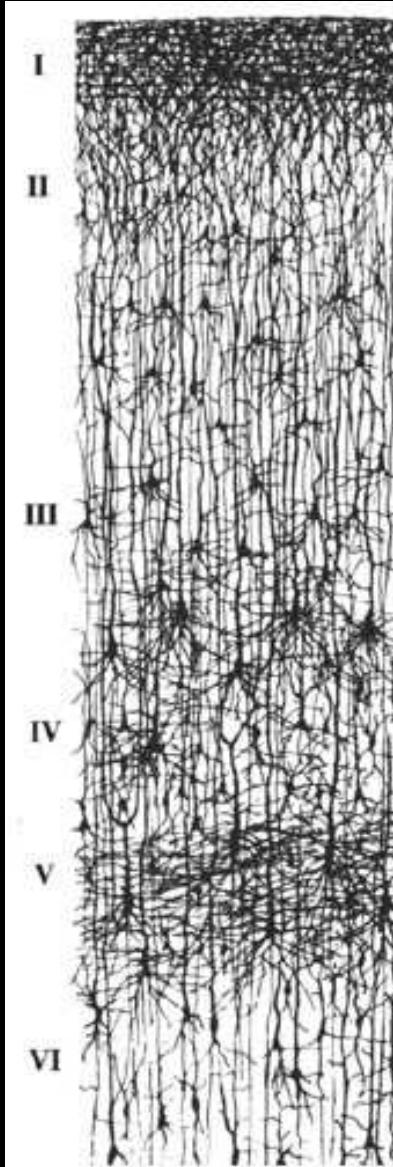


Cortex cerebral

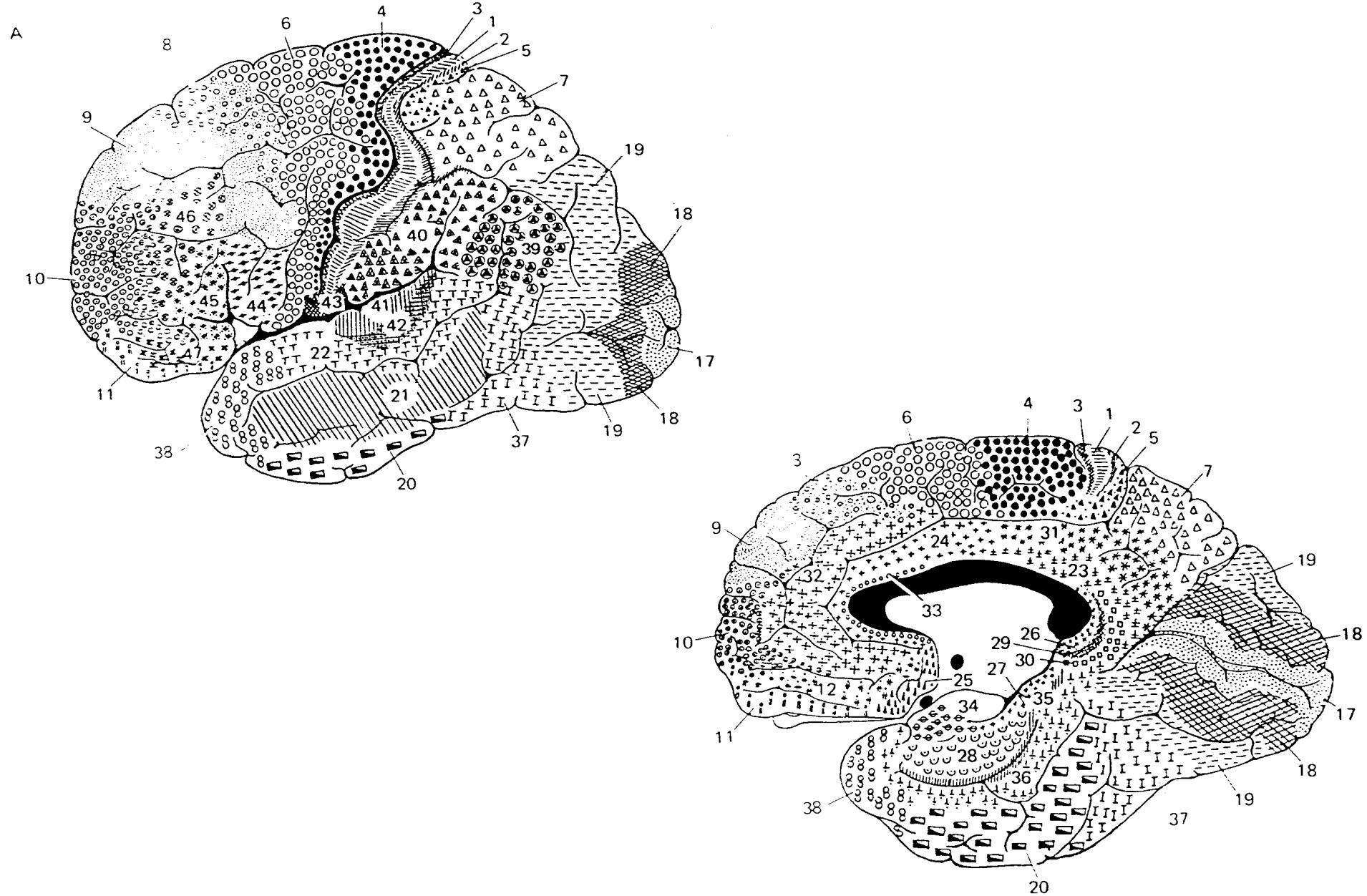


Cortex - 6 straturi

- I. Molecular
- II. Granular extern
- III. Piramidal extern
- IV. Granular intern
- V. Piramidal intern
- VI. Fuziform



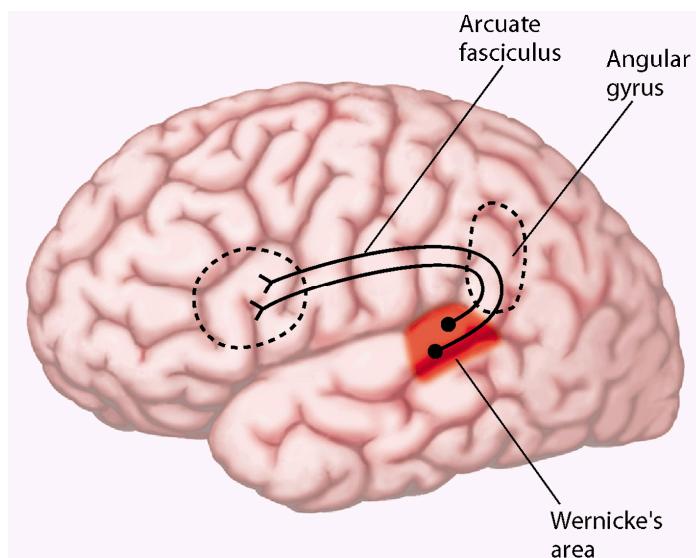
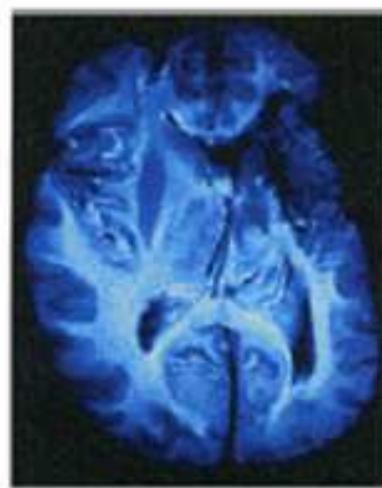
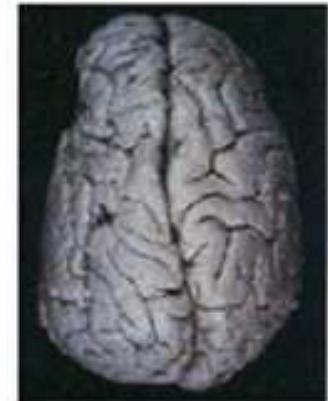
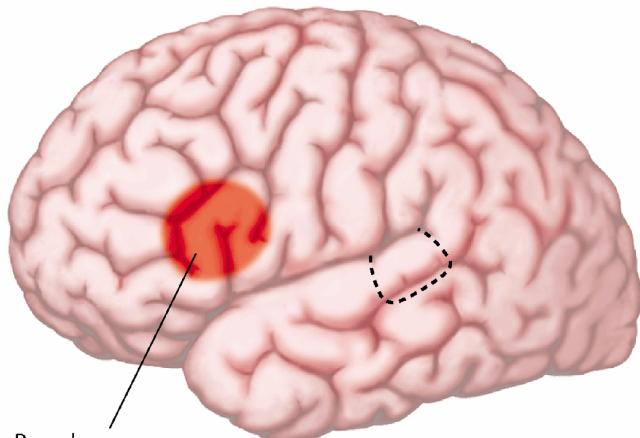
Proprietati citoarhitectonice - Brodmann



LIMBAJ - functie cognitiva complexa

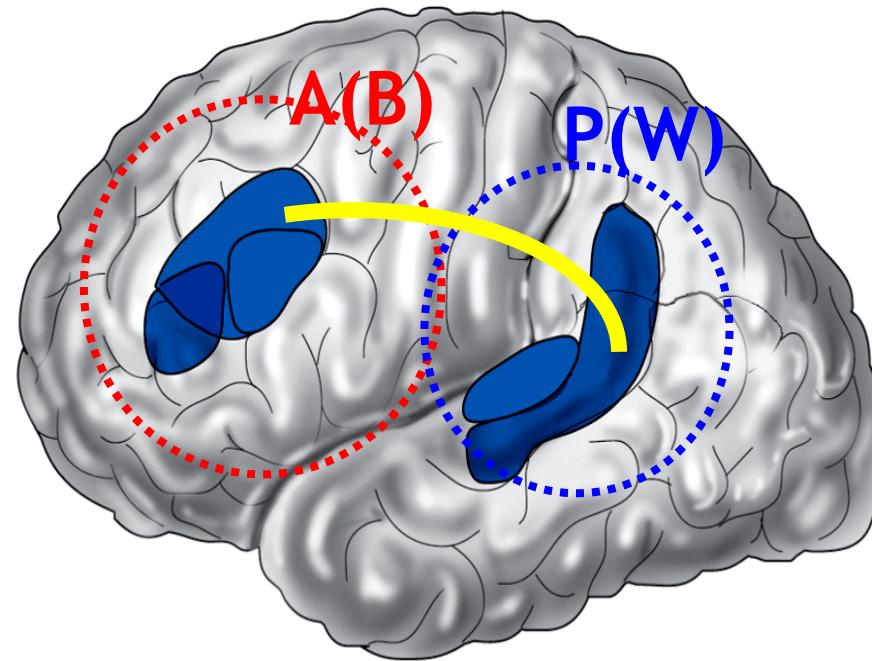
- Specializare emisferica - relativa
- Specializare regională - retele de regiuni cerebrale
 - Productie vs. Decodaj verbal
 - Vorbit vs. Scris
 - Procese lingvistice: orthografie, fonologie, semantica, sintaxa, prozodie

SPECIALIZARE EMISFERICA

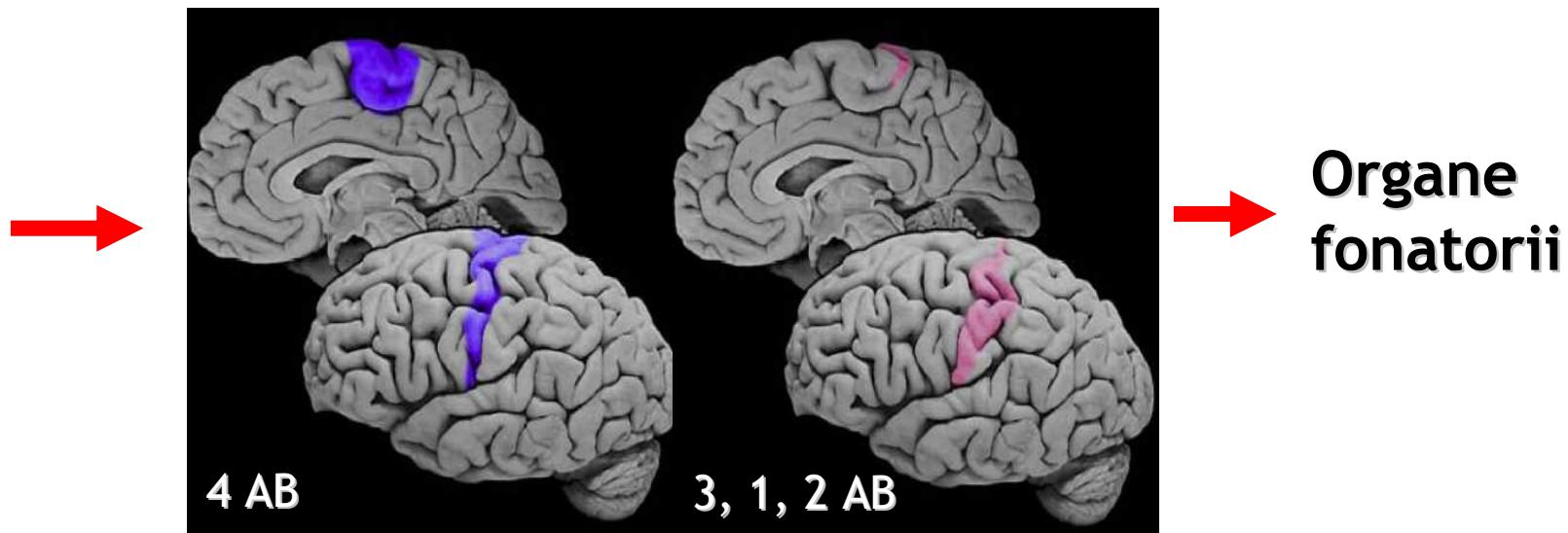
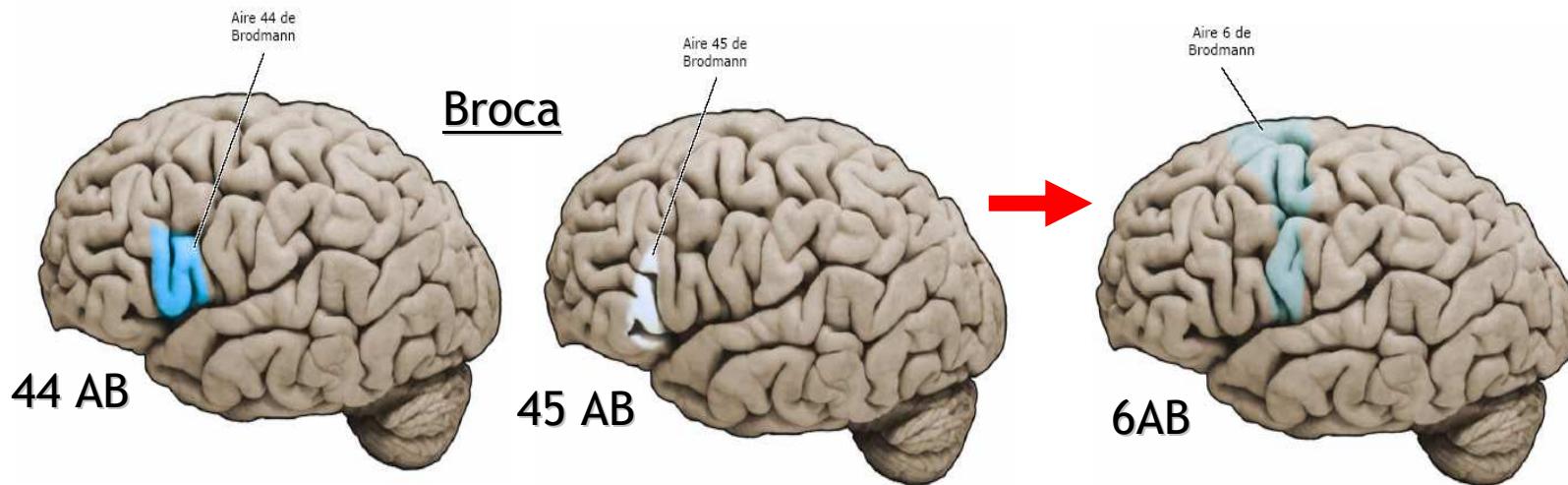


Sistem anterior (Broca) PRODUCTIE VERBALA

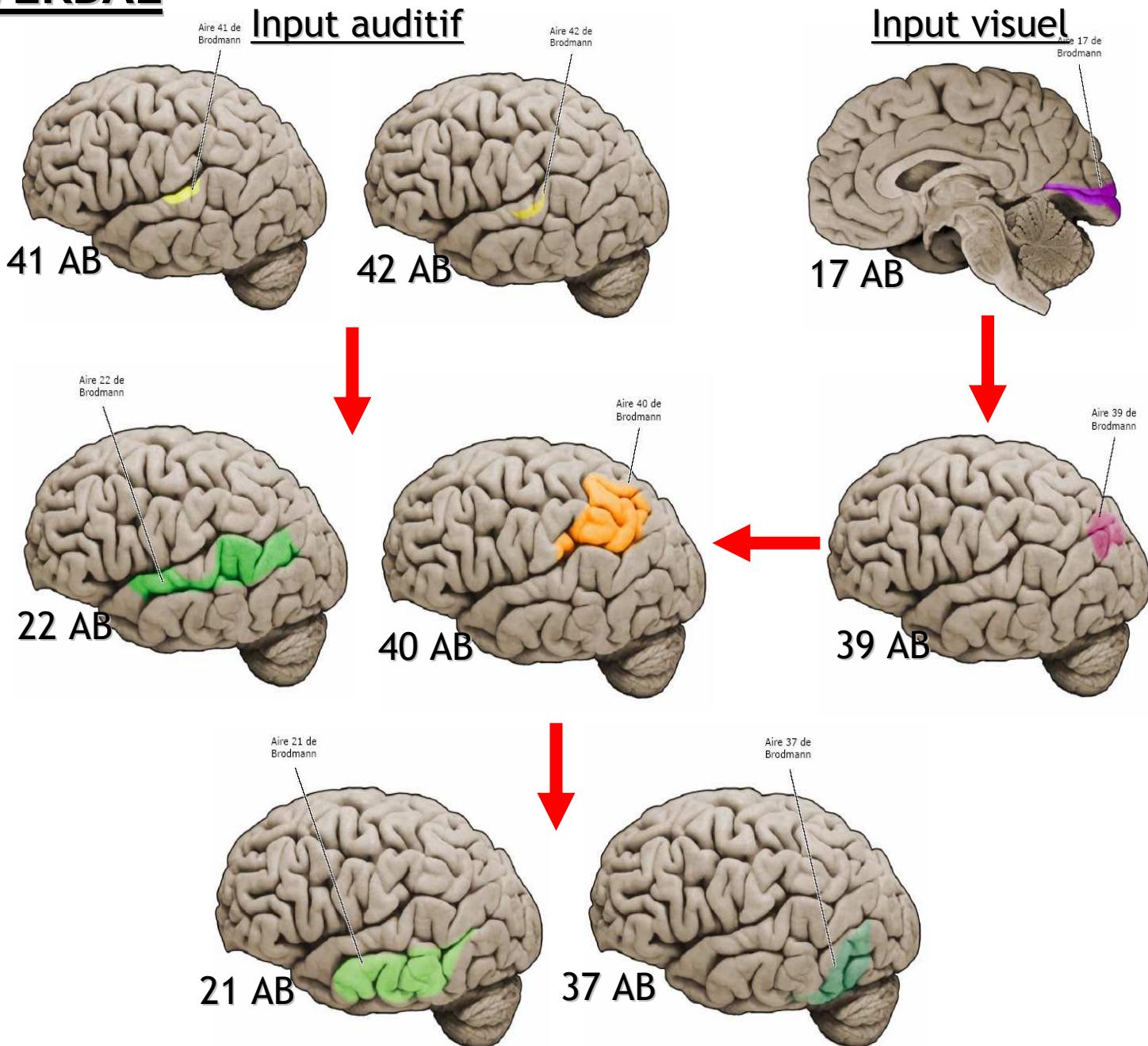
Sistem posterior (Wernicke) DECODAJ VERBAL

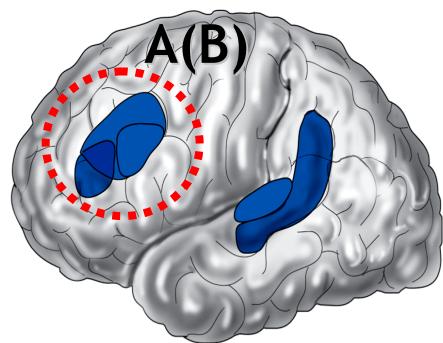
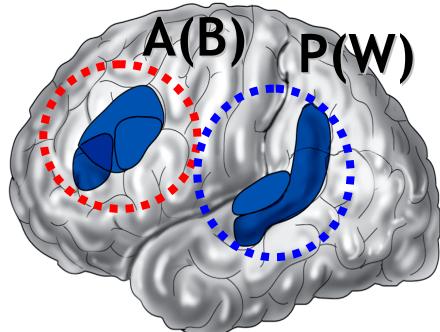


PRODUCTIE VERBALA

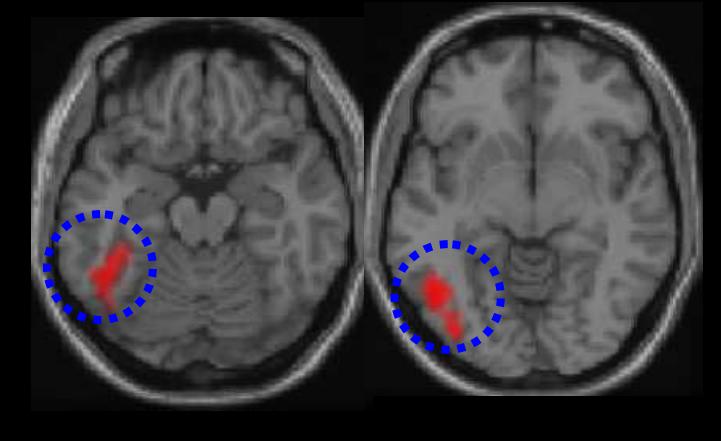
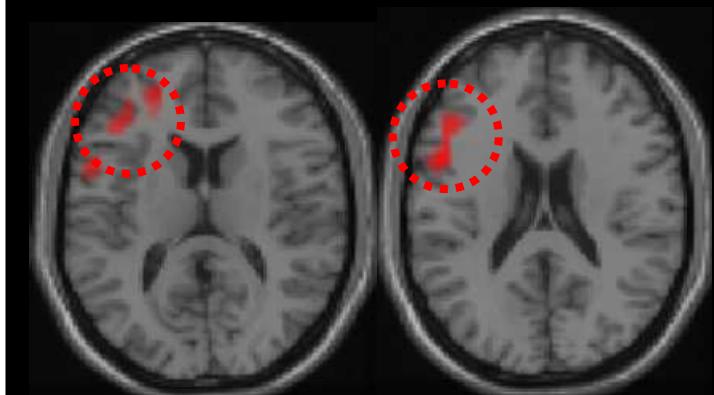
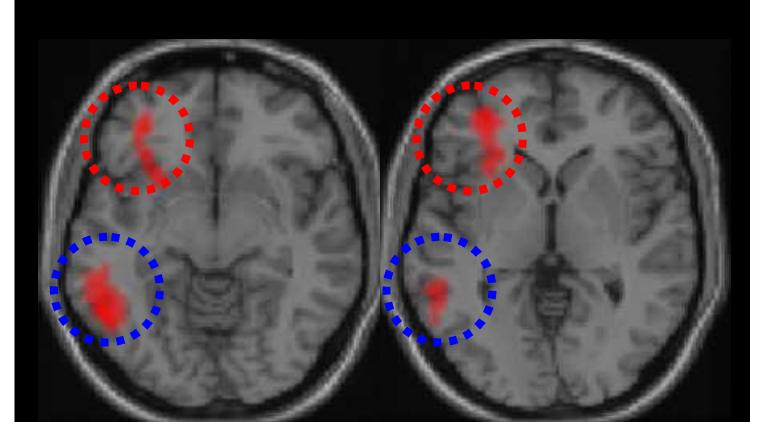
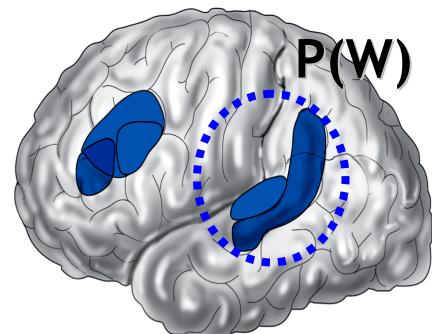


DECODAJ VERBAL





- Specializare emisferica
- Specializare regionala



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STUDII IRMf EPILEPSIE

SCOP:

- Evaluare pre-chirurgicală a reprezentării cerebrale cognitive (limbaj)
- Reorganizare cerebrală (plasticitate)

Epilepsie FOCALA si FARMACO-REZISTENTA

Epilepsie

= boala neurologica, expresia unei disfunctionari cerebrale, acute si tranzitorii, a activitatii electrice cerebrale, tradusa clinic prin repetitia crizelor de epilepsie (crize comitiale)

Tipuri

Epilepsie generalizata - zona epileptogena neidentificata

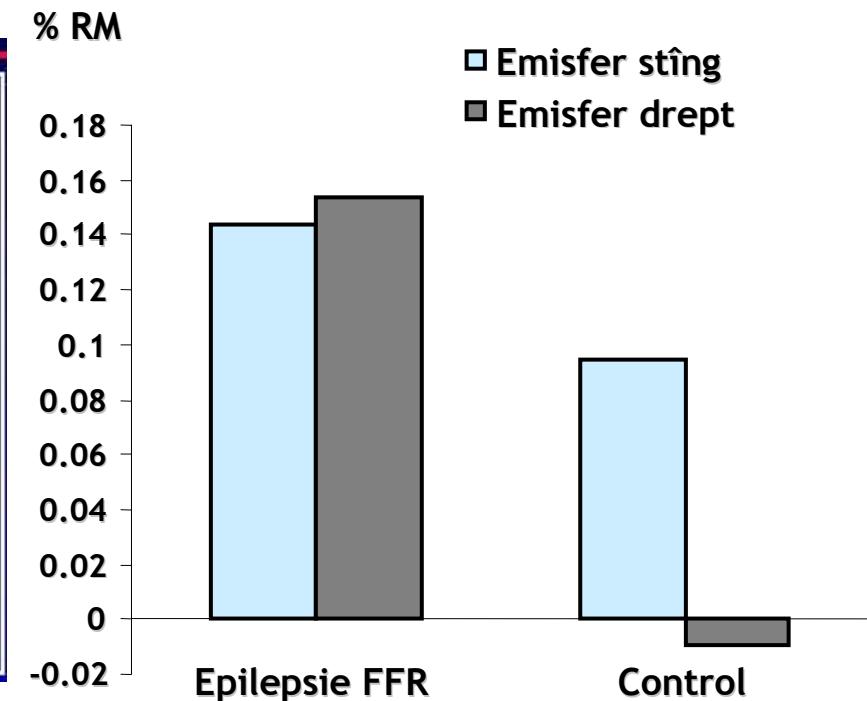
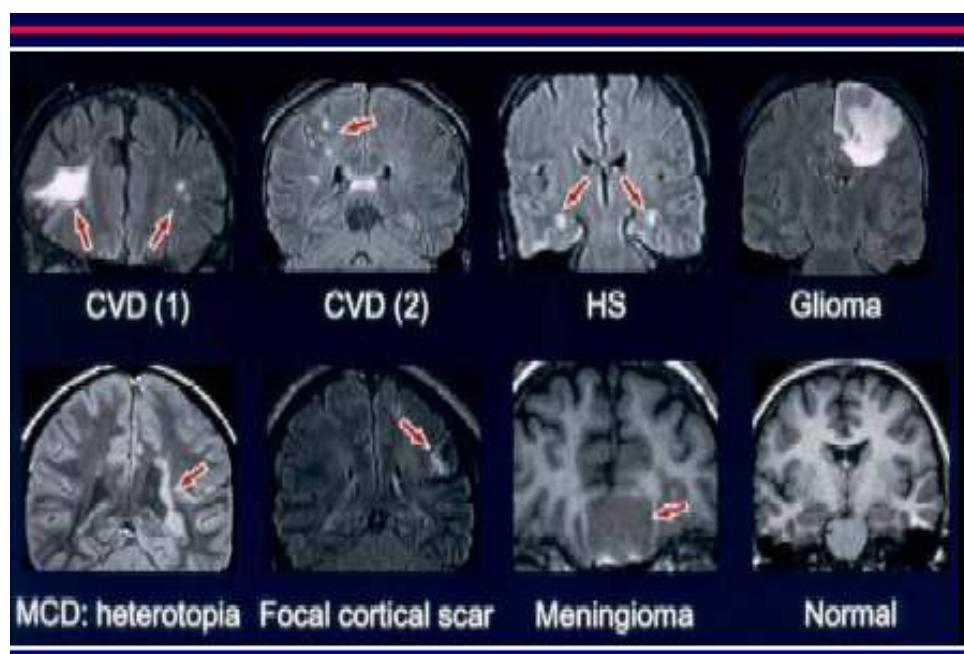
- crize tonico-clonice
- absente epileptice

Epilepsie focala - zona epileptogena identificata

EPILEPSIE

CARACTERISTICI RETELE LIMBAJ

- Specializare emisferică - atipica
- Incidenta crescută de reorganizare cerebrală
Pre +/- chirurgie

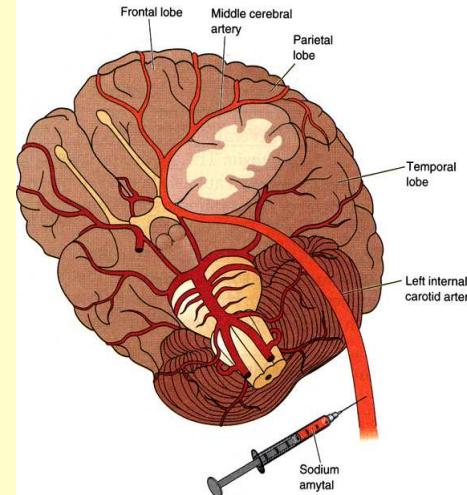


IN PRACTICA

Epilepsie focală
si FR

ZE:
VEEG, IRM,
TEP,SPECT..

SH + Cartografie cerebrală



Wada

.....

SEC

Chirurgie



IN PRACTICA

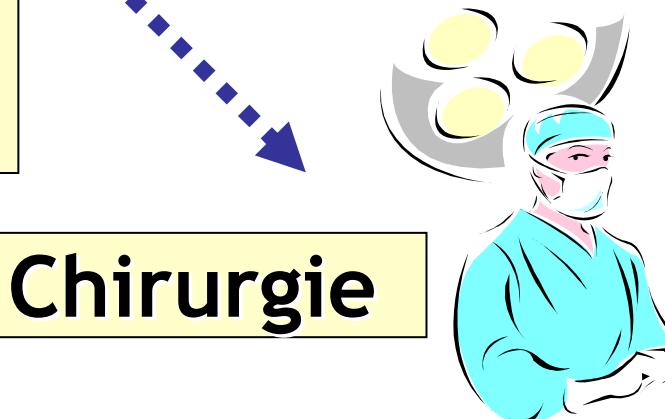
Epilepsie focală
și FR

????

IRM funcțională

EZ:
VEEG, IRM,
TEP, SPECT

Chirurgie



PARTICULARITATI ALE EXPLORARII IRMf LA PACIENTI (analiza individual!)

- **Exercitiul de activare** - apropiat, scurta durata, evaluare comportamentală...
- **Design experimental** - robustete statistica
- **Metoda prelucrare date** si de cuantificare a SE
- **Validare experimentală** - subiecti “control”

PROBLEMATICA GENERALA

Functii: LIMBAJ - MEMORIE EPISODICA

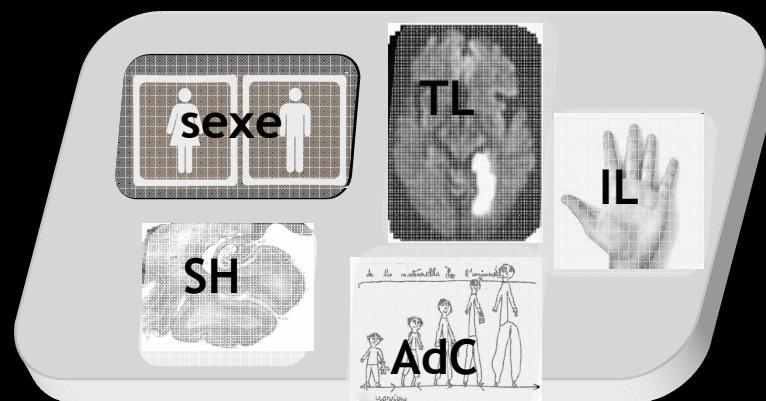
Psy Cognitiva et Neuropsihologie → Ø Déficits

PLASTICITATE CEREBRALA?

Neuroanatomie functională - Psychologie Cognitivă
Neuropsihologie

↓
Cercetare fundamentală

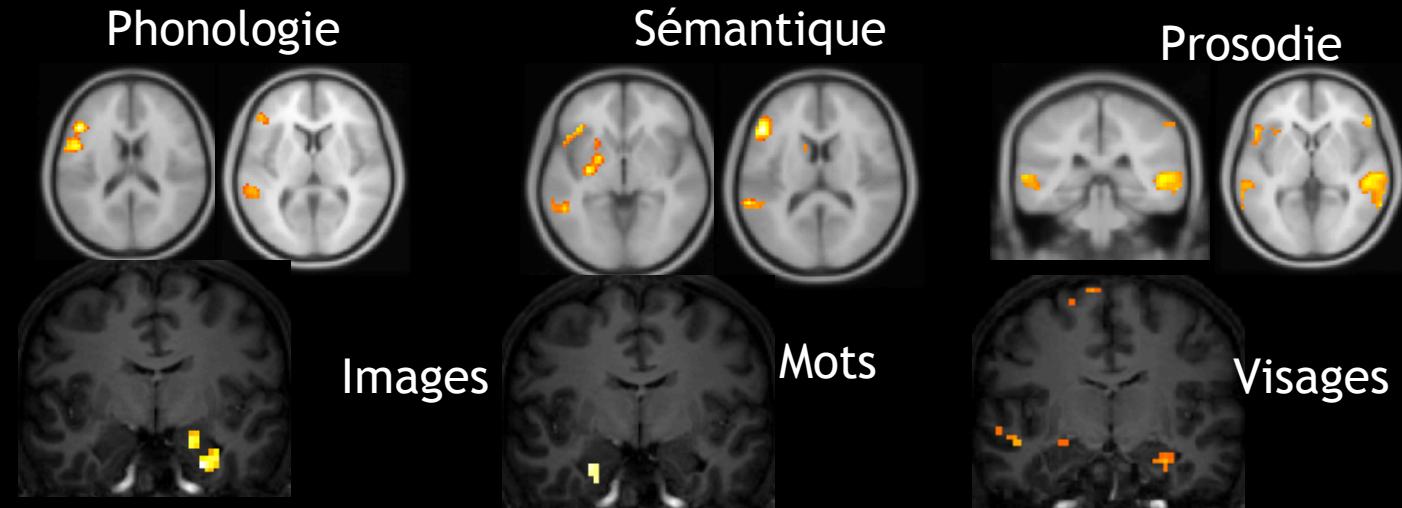
↓
Aplicatie clinica



Organisation anatomo-fonctionnelle : sujets témoins

- Spécialisation inter - et intra- hémisphérique (cartographie)

▪ Langage



▪ Mémoire Episodique

- Variabilité inter-individuelles (préférence manuelle, genre, etc.)

Réorganisation anatomo-fonctionnelle : patients

Témoins



Patients
pré-chirurgie

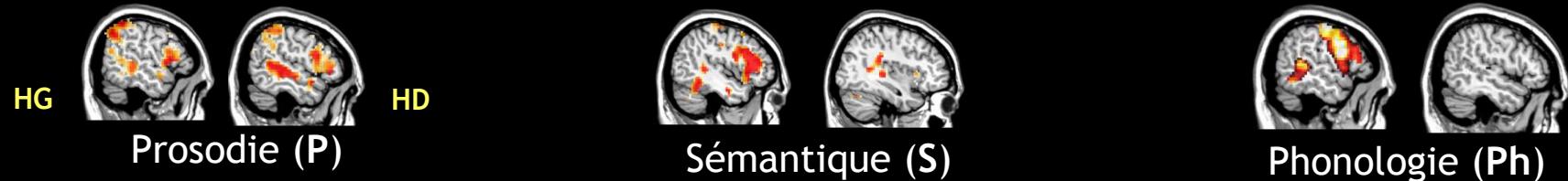


Patients
post-chirurgie

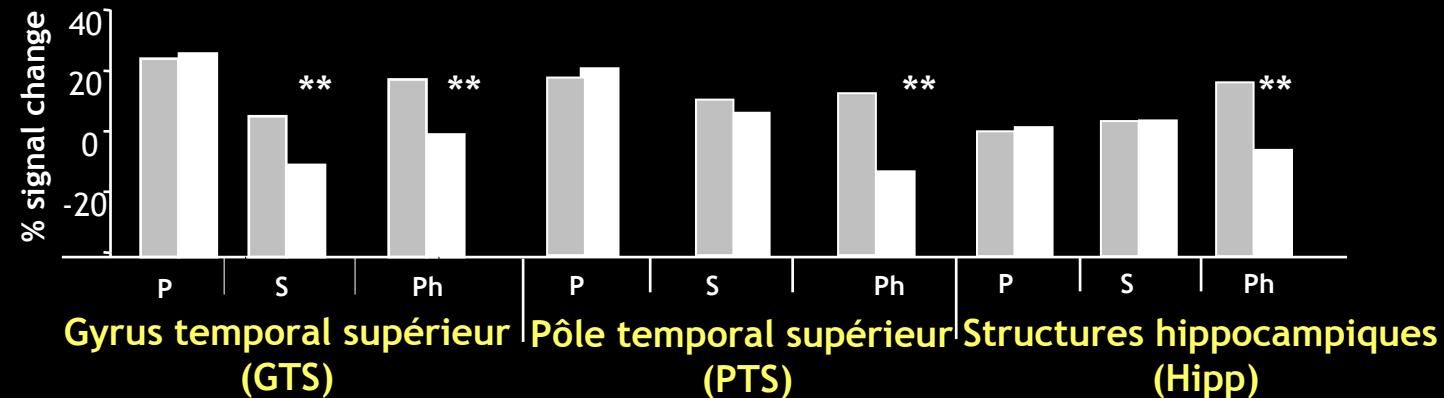
Perrone et al. 2009; Cousin, Perrone et al. 2009; Perrone et al., 2010 (soumis); Perrone et al. en préparation

Exemple résultats cartographie langage

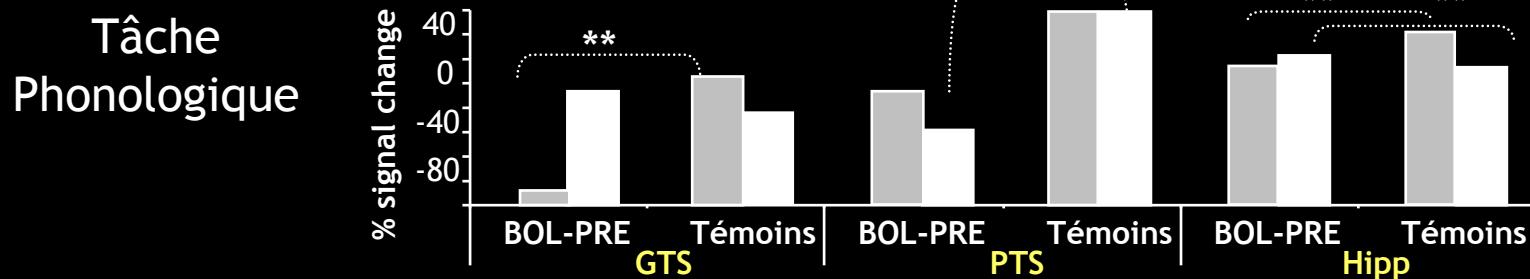
- Spécialisation hémisphérique en fonction de la tâche



- Spécialisation hémisphérique en fonction de la ROI et de la tâche



- Spécialisation hémisphérique en fonction de la ROI et de la condition pathologique

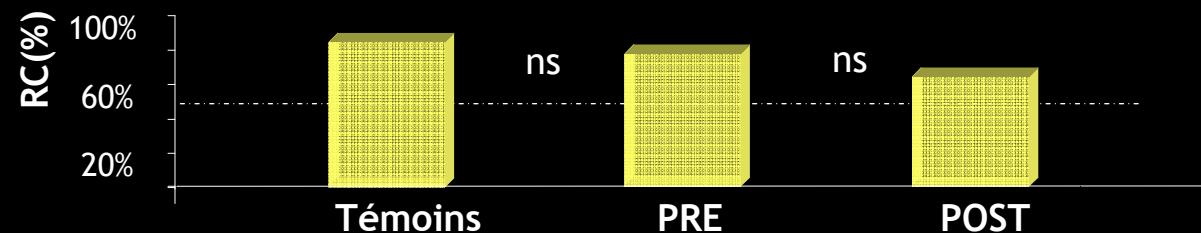


Exemple résultats cartographie langage

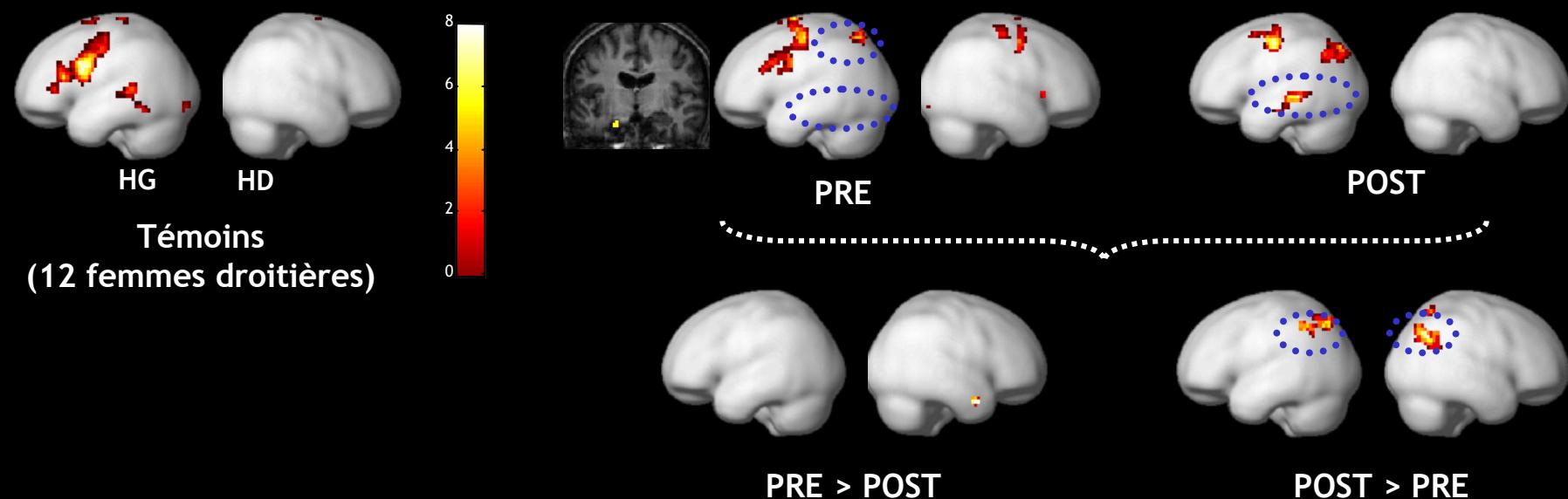
Cas CS : F 23 ans (DC 18 a); ZE - temporelle interne gauche

Bilan neuropsychologique: droitière (inventaire d'Edinburgh), Q.I.V (Binois et Pichot) : 72

Résultats comportementaux :



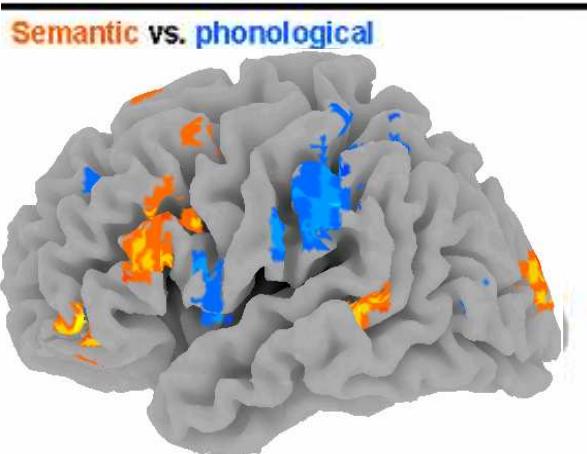
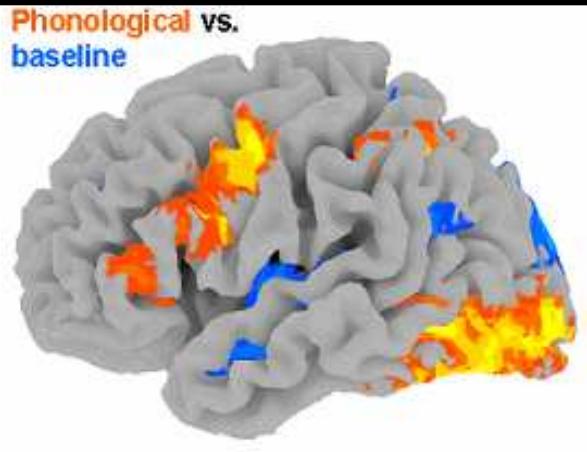
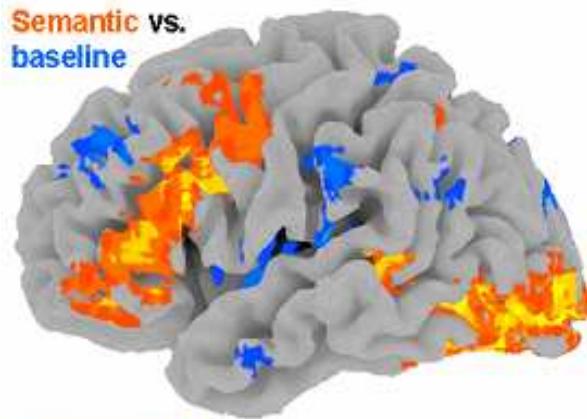
Résultats neuroimagerie :



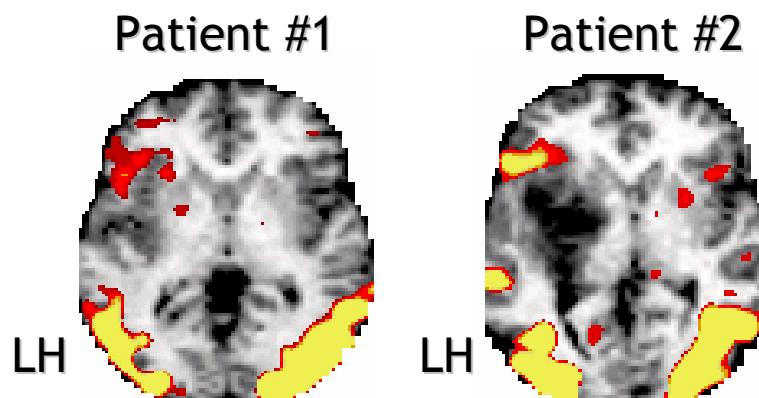
IRMf - specializare emisferica

Paradigma “bloc”
8 scans/subject
12 liste/scan
16 cuvinte/lista

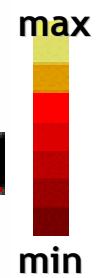
A	SENS	2 sec	RIMA	2 sec
	glove	560 ms	bog	560 ms
	finger	560 ms	hog	560 ms
	shake	560 ms	fog	560 ms
	palm	560 ms	log	560 ms
	thumb	560 ms	smog	560 ms
C	
	+	12.5 s	+	12.5 s



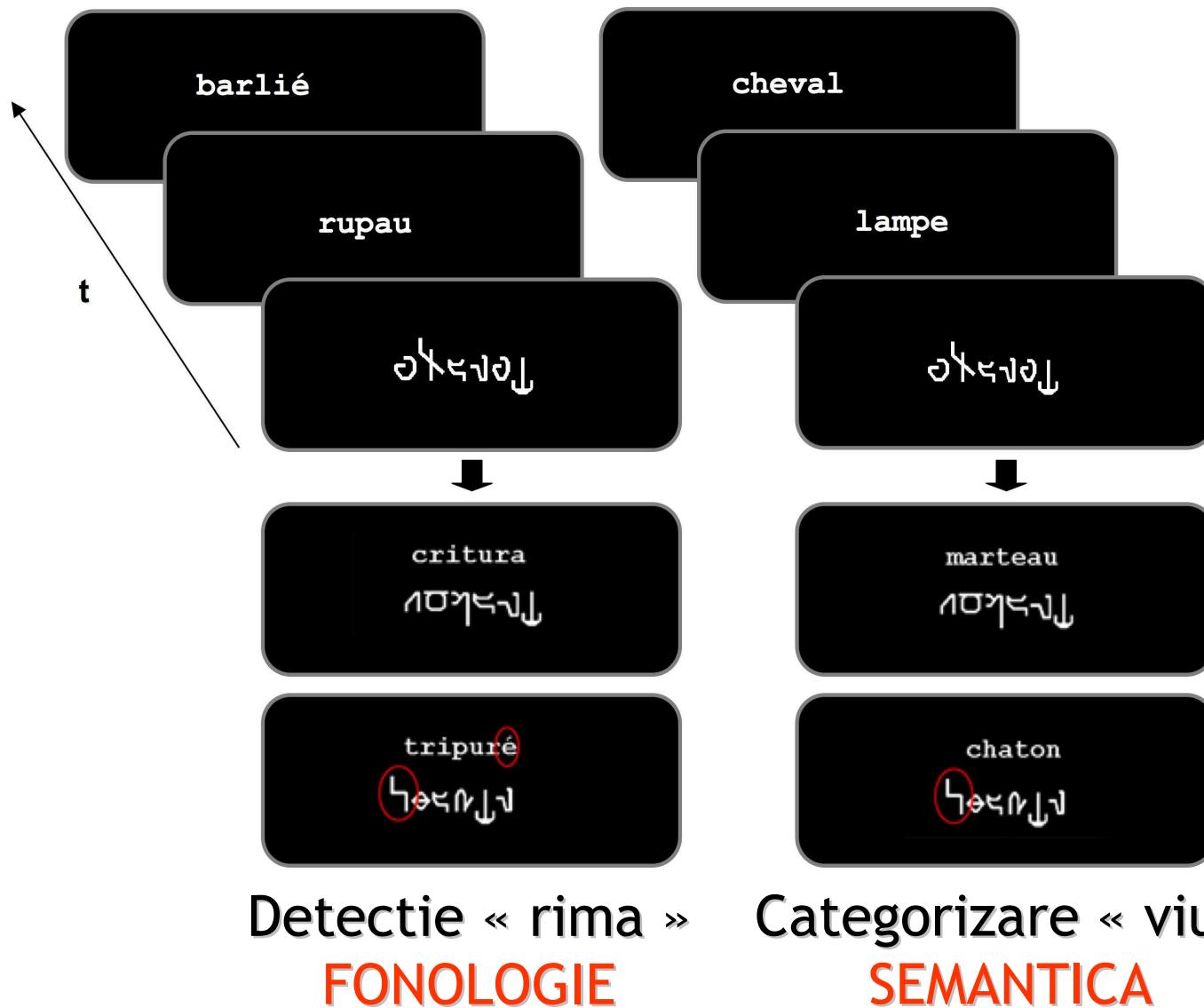
McDermott et al, Neuropsychologia 2003
Baciu et al, Epilepsy & Behaviour, 2003
Baciu et al, Neuroradiology, 2005



Baciu et al, Neuroradiology, 2005



IRMf - specializare regională - operații lingvistice



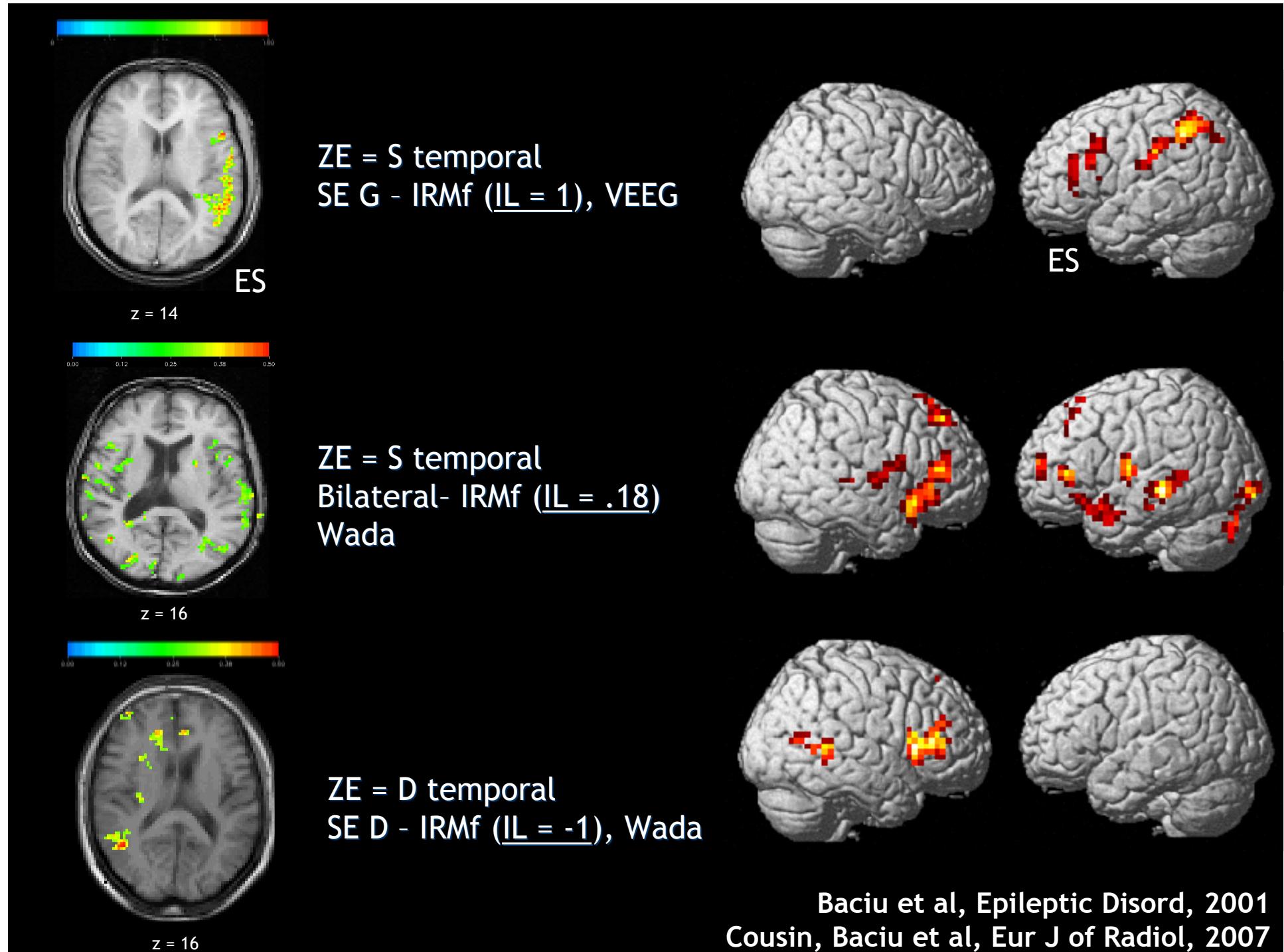




Fig. 1. MR (T₂ weighted) coronal slice obtained before the first surgery (1998) in D.C. The image is presented in radiological convention (i.e., the left hemisphere is on the right side of the image). The tumor cavity (ganglioglioma), situated within the left superior and middle frontal gyrus, is indicated by the red arrow. After tumor resection, the seizures recurred. Invasive monitoring for resection of the seizure focus was performed in 2002. A larger region situated within the middle frontal gyrus was removed (with motor cortex as the posterior boundary and inferior frontal gyrus as the inferior border).

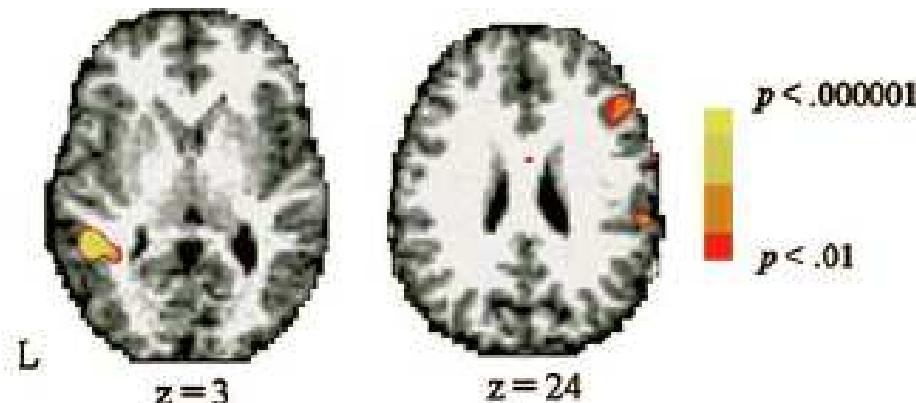
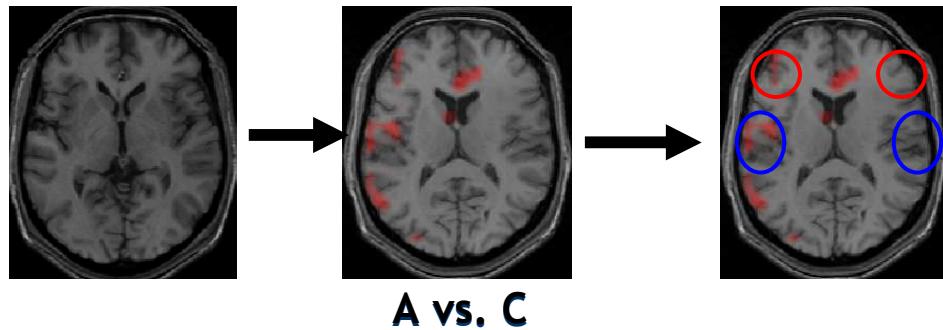


Fig. 2. Representative functional maps obtained by using fMRI in D.C. when comparing lexical processing (i.e., meaning and rhyme processing combined) with fixation. The images are presented in neurological convention (i.e., the left hemisphere is on the left side of the image). Significant activation ($P < 0.01$, $z \geq 2.58$; uncorrected z map, positives only displayed) was obtained within left middle temporal cortex and within right inferior frontal cortex.

Cuantificarea predominantei emisferice

1. Calcul Indice de lateralitate



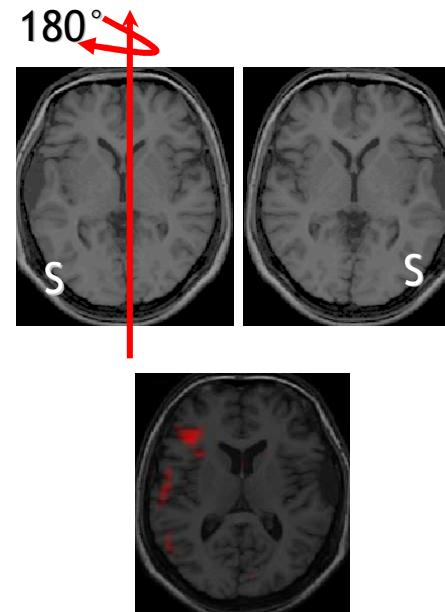
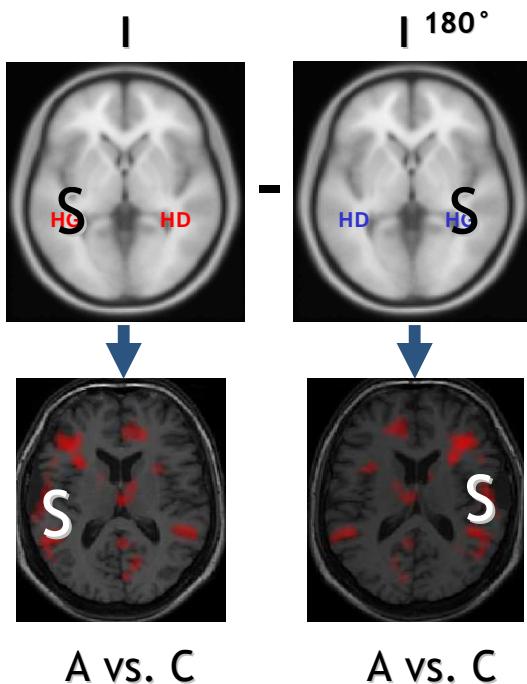
$$IL = \frac{(n \text{ FS} + n \text{ TS}) - (n \text{ FD} + n \text{ TD})}{(n \text{ FS} + n \text{ TS}) + (n \text{ FD} + n \text{ TD})}$$

IL > 0 = ES

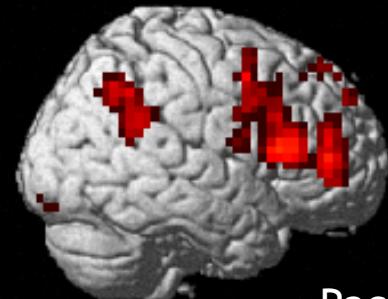
IL < 0 = ED

IL = 0 = RB

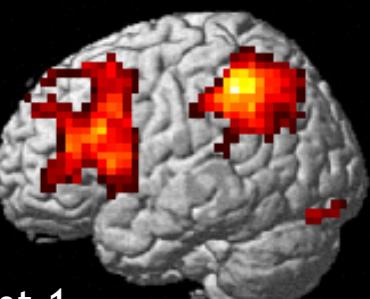
2. Metoda “flip”



A vs C



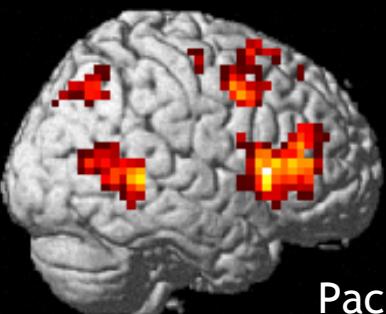
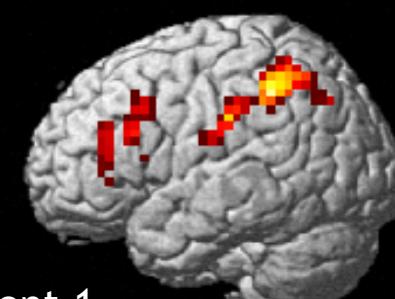
Pacient 1



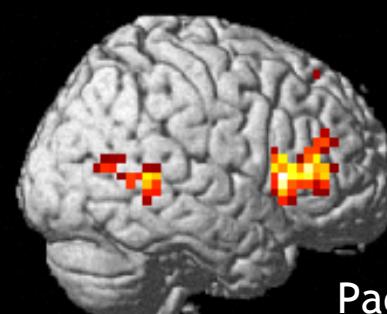
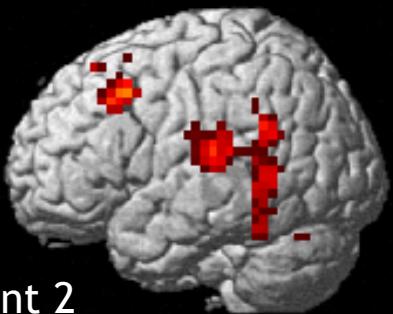
A vs. C₁ vs. T vs. C₁ 180°



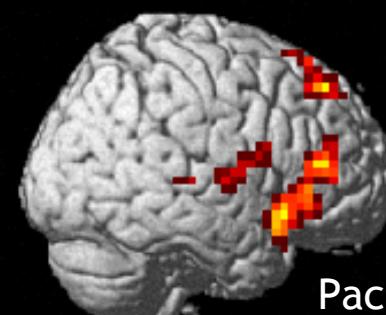
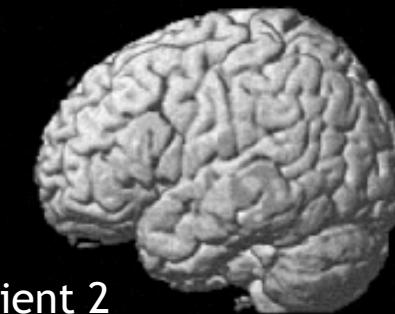
Pacient 1



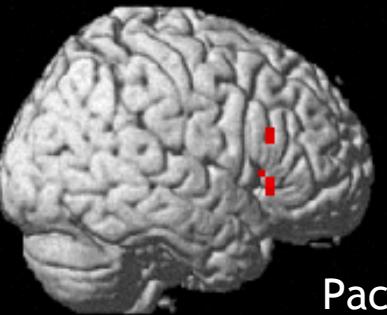
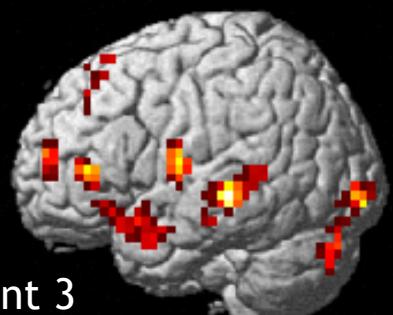
Pacient 2



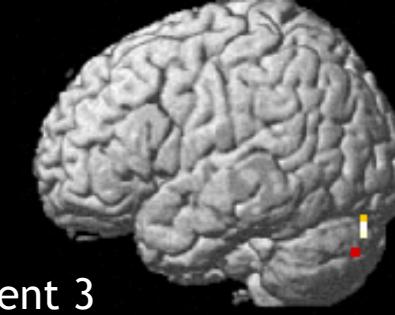
Pacient 2



Pacient 3



Pacient 3



T vs C

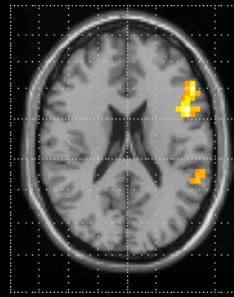


RH

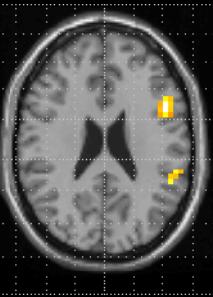


LH

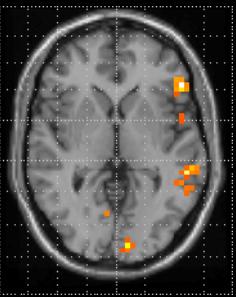
$z = 20\text{mm}$



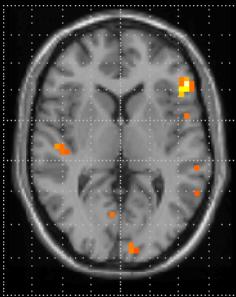
$z = 24\text{mm}$



$z = 0\text{mm}$

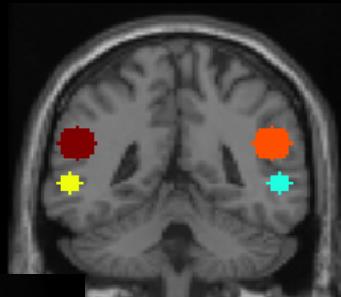


$z = 4\text{mm}$

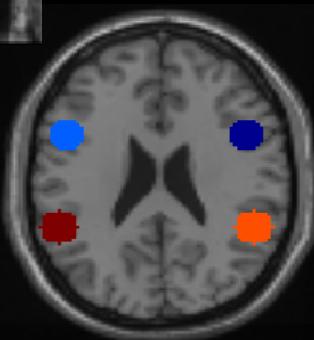
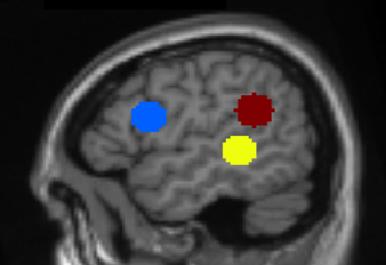


Analiza ROIs

10 mm radius

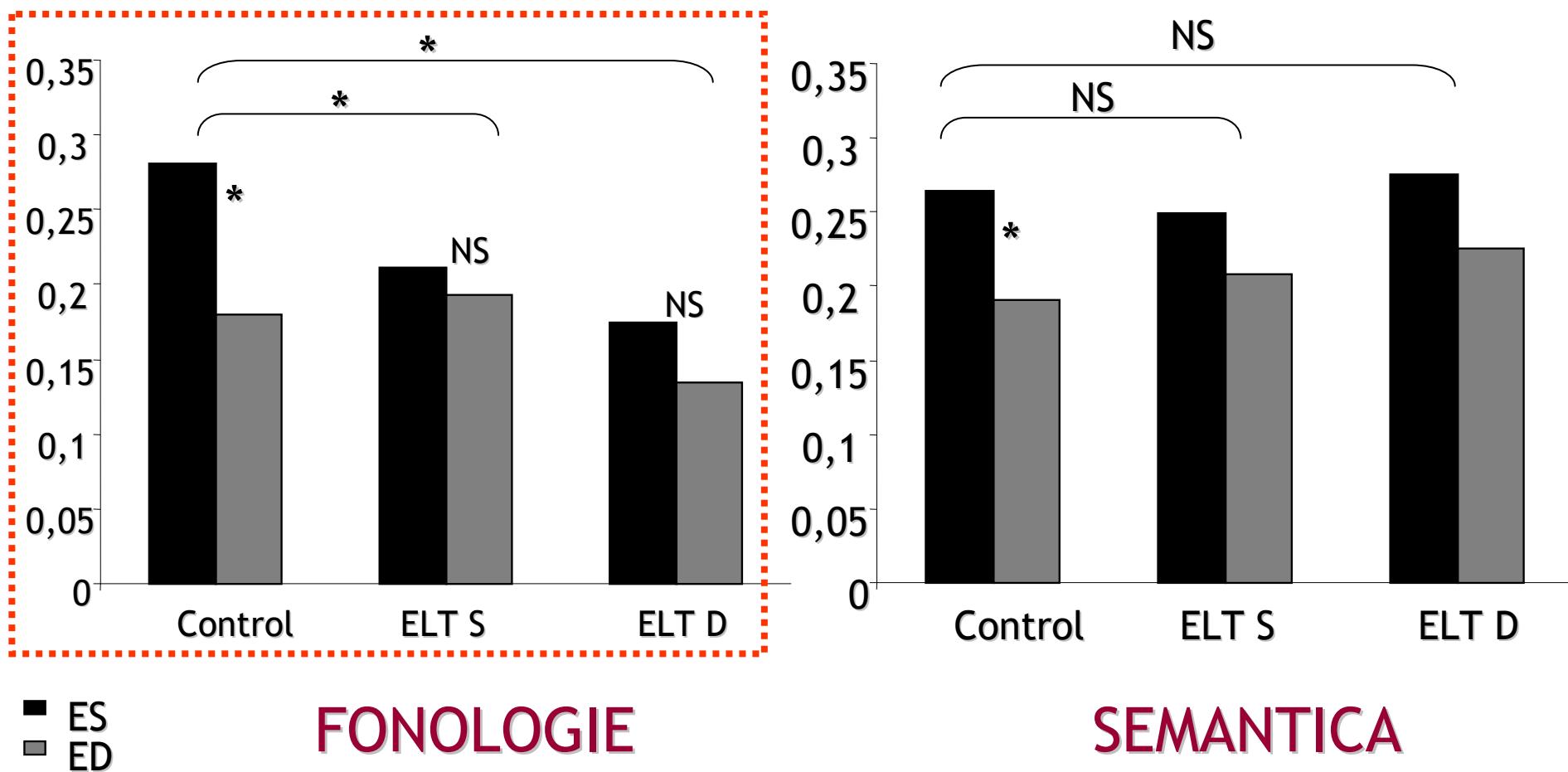


- ■ IPL L/R (BA 39/40), $x y z$, $-/+52 -44 24$
- ■ MSTG L/R (BA 21/22), $x y z$, $-/+56 -36 0$
- ■ IFG L/R (BA 44/45), $x y z$, $-/+48 12 20$



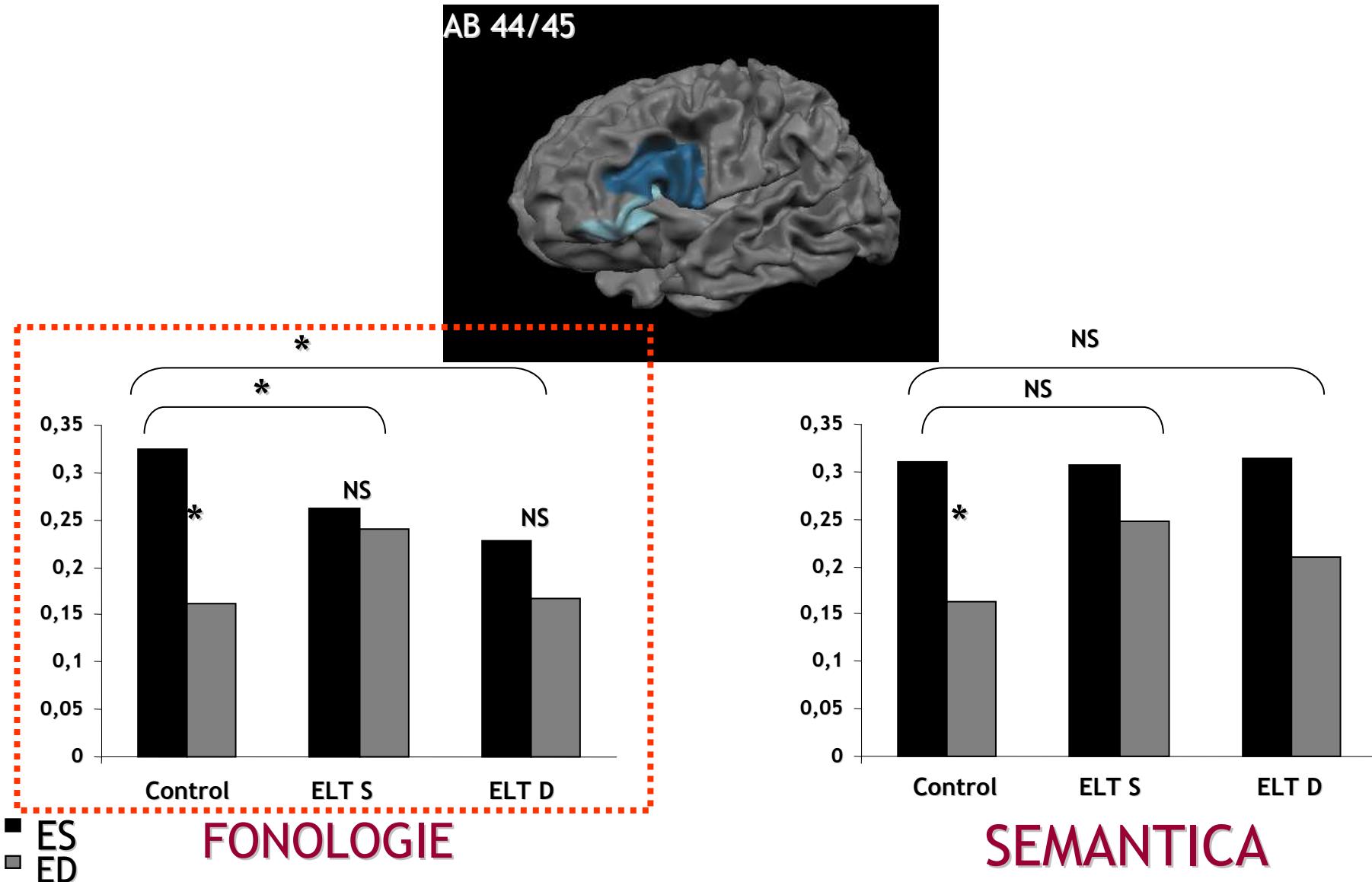
Nivel emisferic

Tip subiect x Localizare ZE x Operatie lingvistica



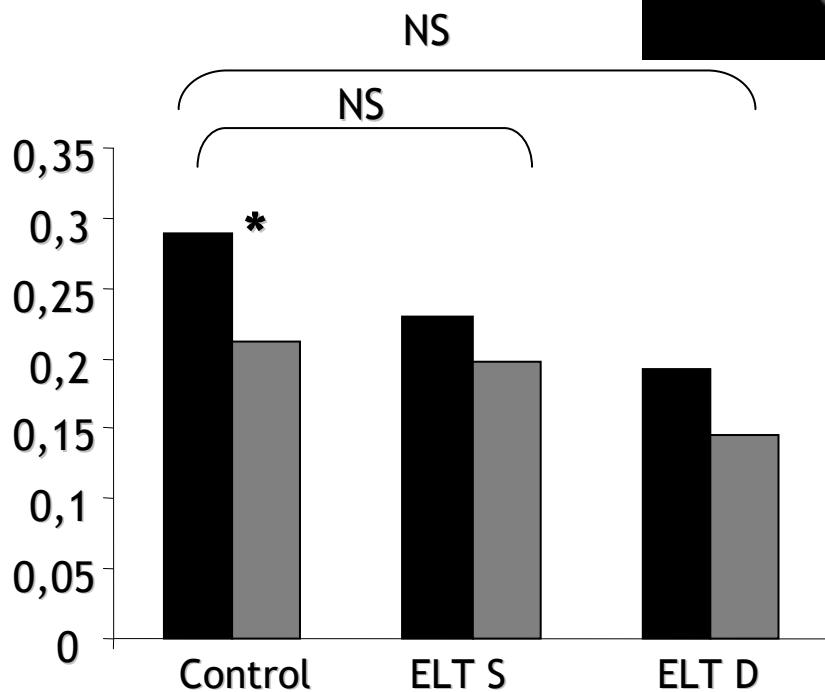
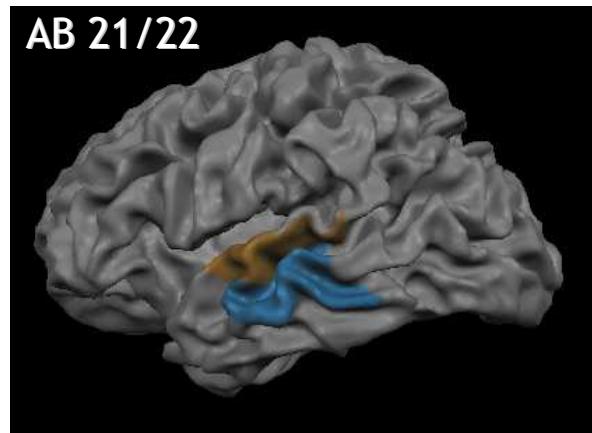
Nivel regional FRONTAL

Tip subiect x Localizare ZE x Operatie lingvistica



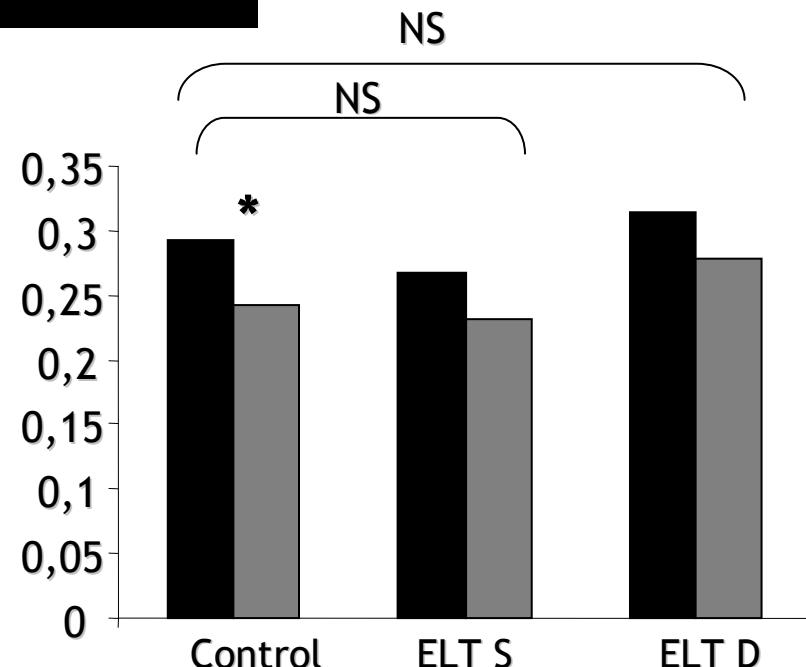
Nivel regional TEMPORAL

Tip subiect x Localizare ZE x Operatie lingvistica



■ ES
■ ED

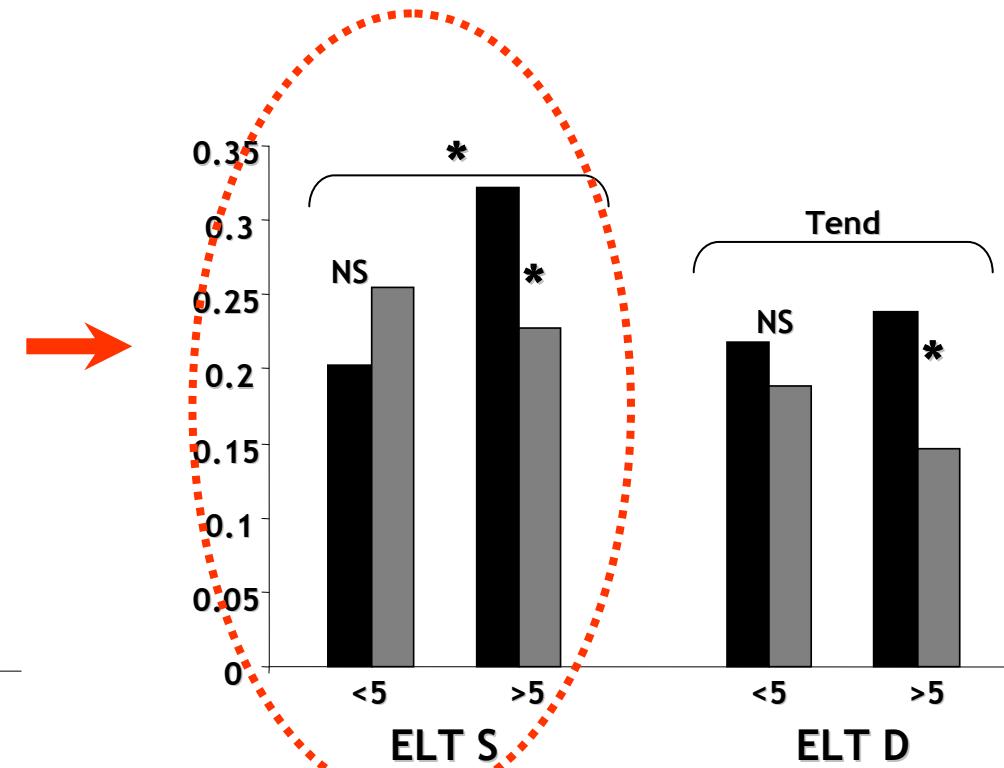
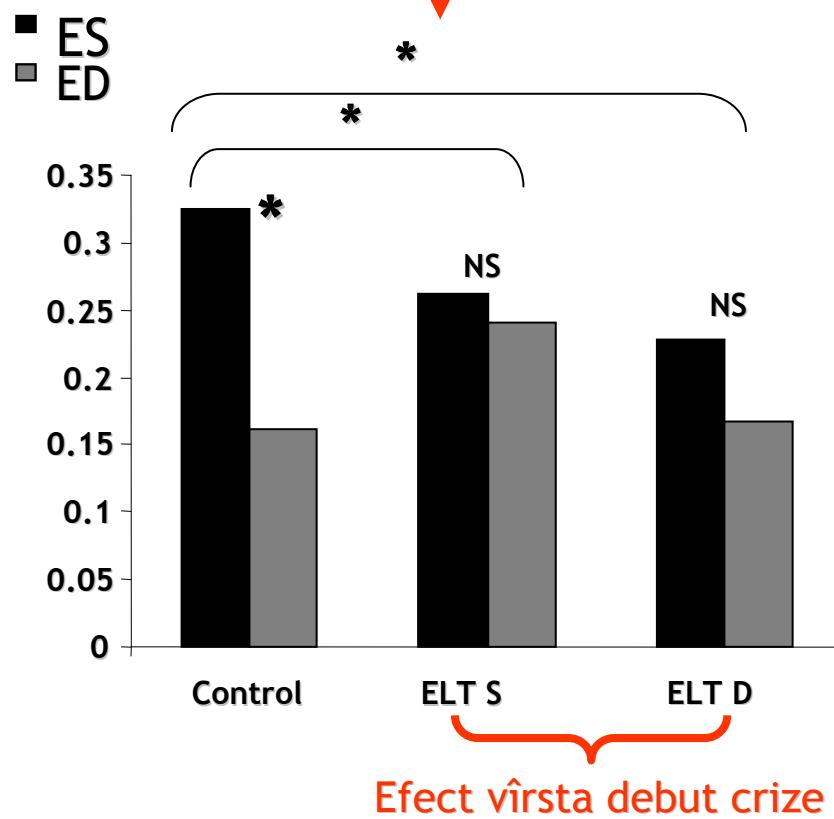
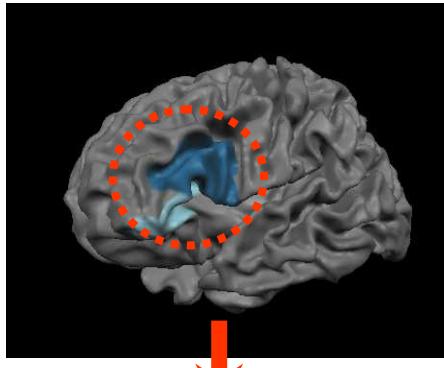
FONOLOGIE



SEMANTICA

Nivel regional FRONTAL si FONOLOGIE

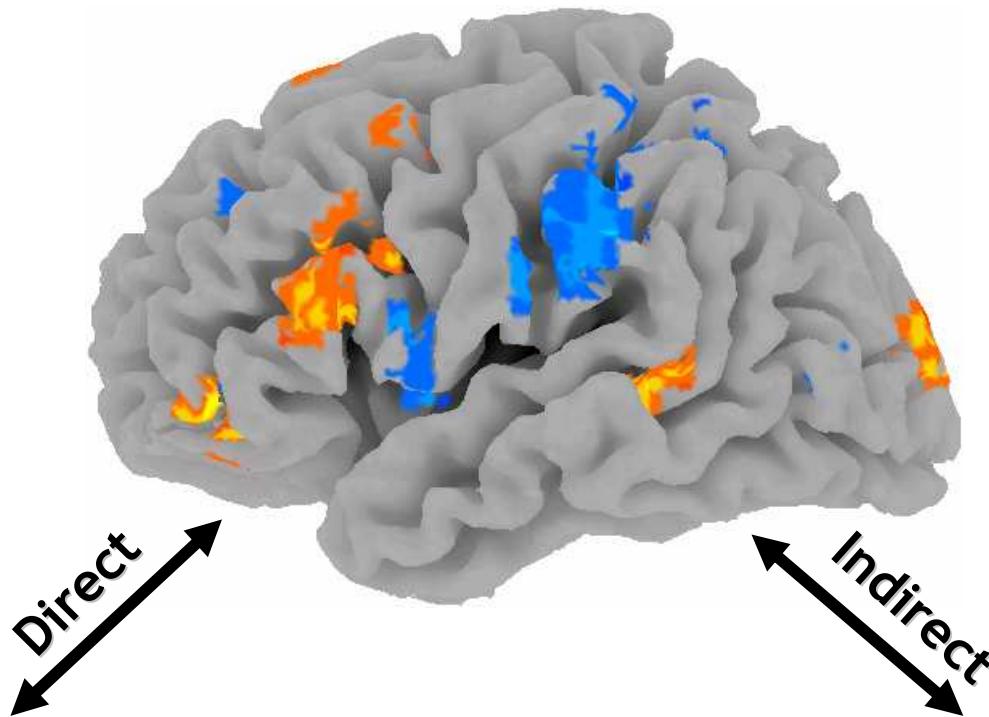
Tip subiect x Localizare ZE x Operatie lingvistica x Vîrsta debut crize



Regiunile cerebrale « active » cu
IRMf

reprezinta

Regiuni esentiale ale limbajului ?

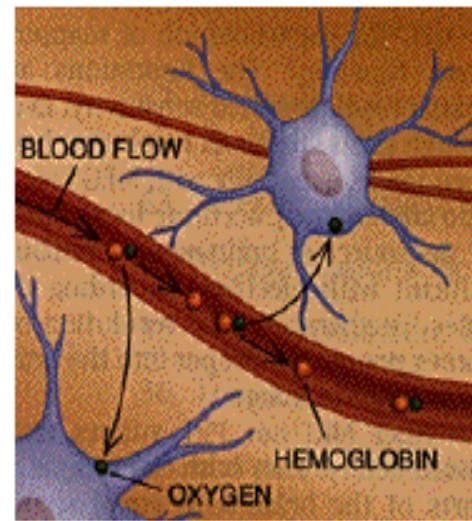


Direct

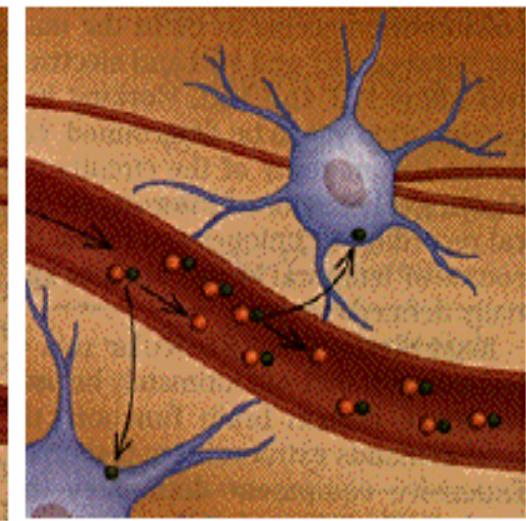
Indirect



SEC



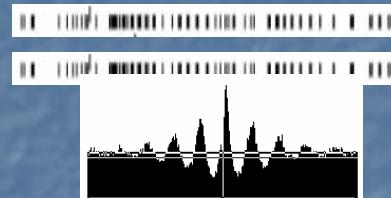
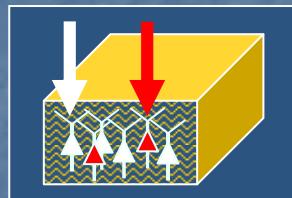
IRMf



Induced Gamma Responses : a simplified time line

1990

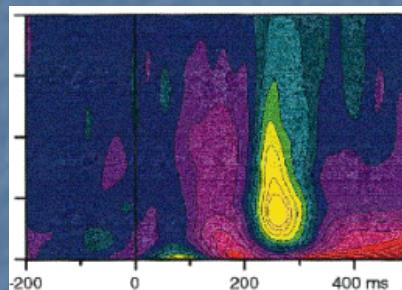
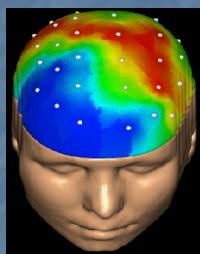
↑
animals



Rougeul-Buser
Gray and Singer, 1989
...

1995

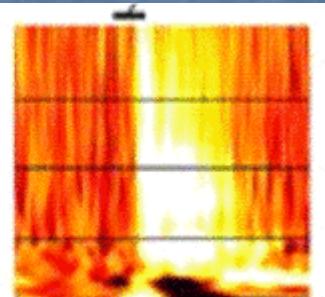
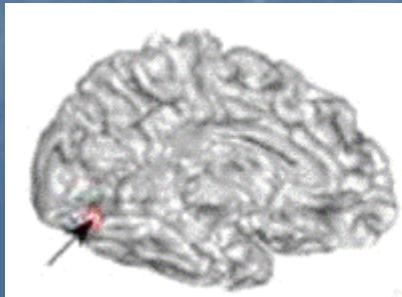
↑
scalp EEG



Tallon-Baudry et al, ...
1996, 1997,

2000

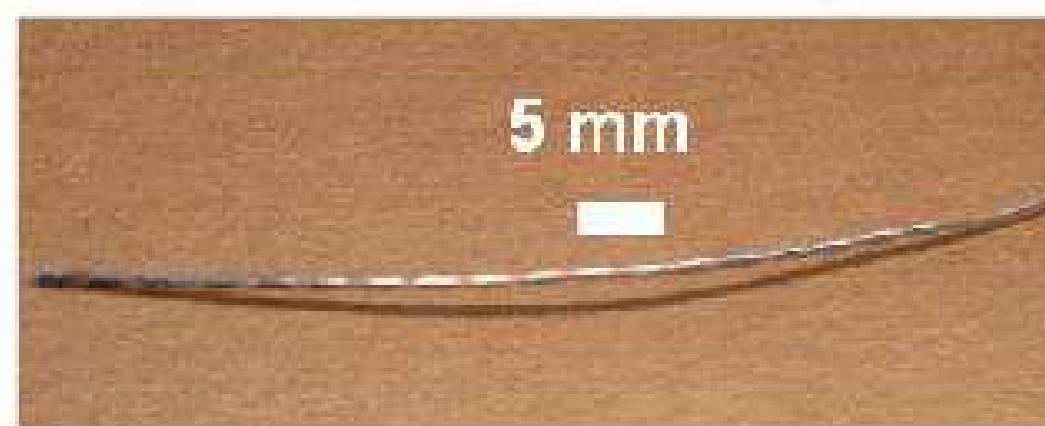
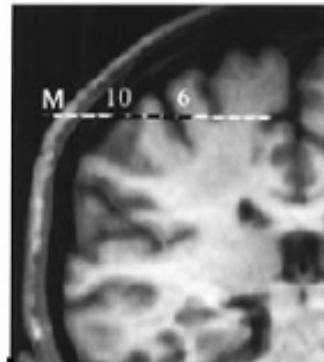
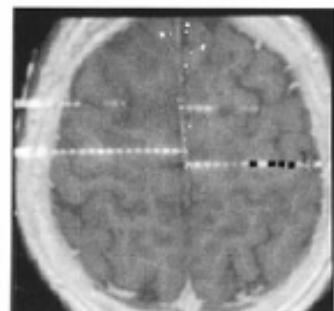
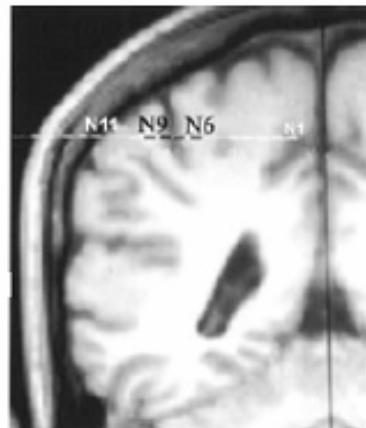
↑
sEEG



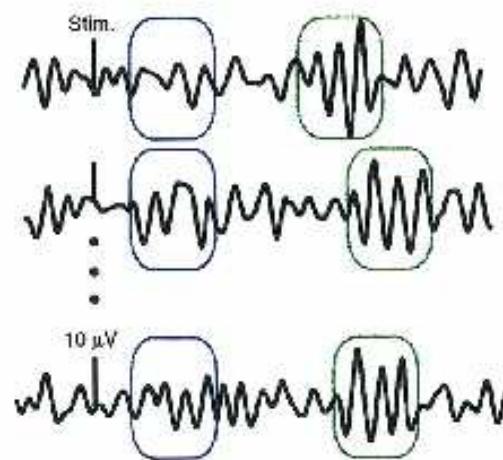
Lachaux et al, 1999
Crone et al., 1999

SEEG/iEEG

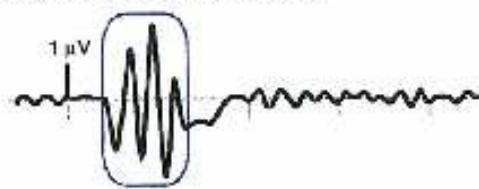
SEEG = spatio-temporal cartography of the epileptogenic network



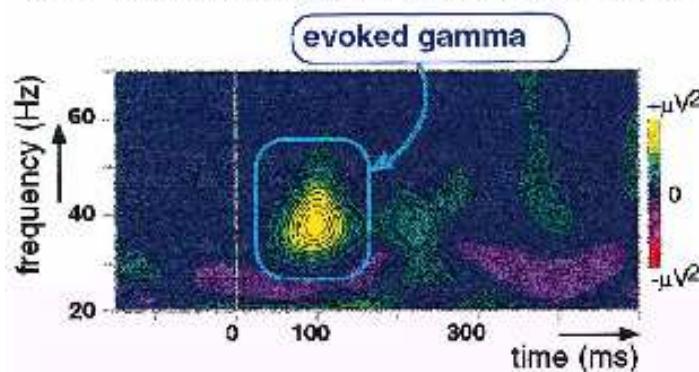
A Single-trials



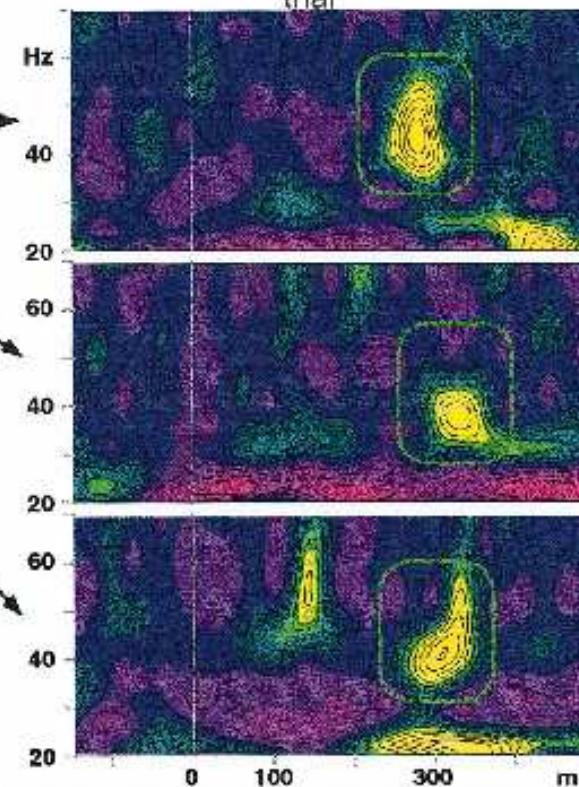
B Time average : evoked potential



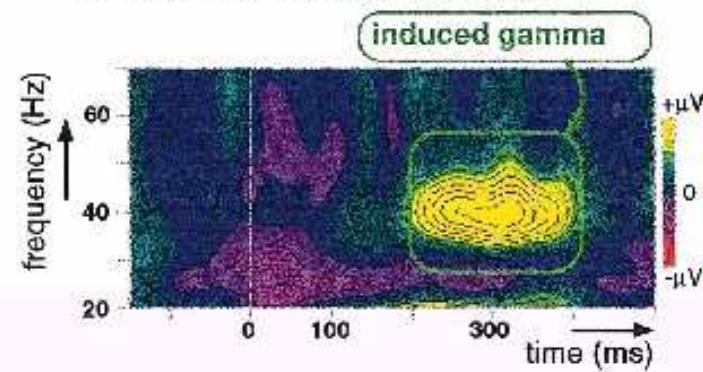
C Time-frequency power of the evoked potential



D Time-frequency power of each single trial



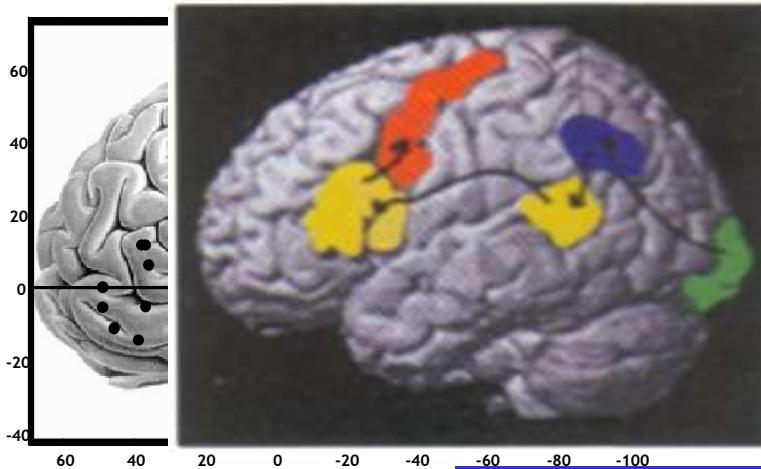
E Time-frequency power average



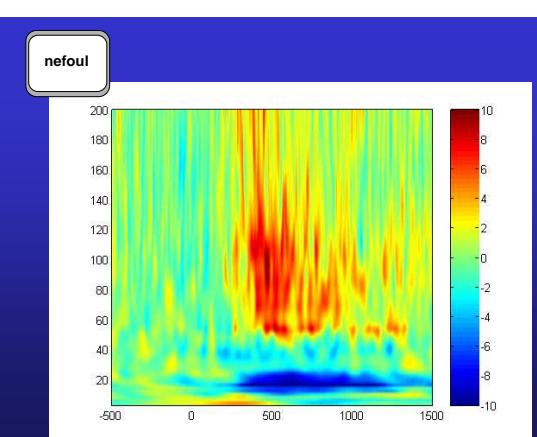
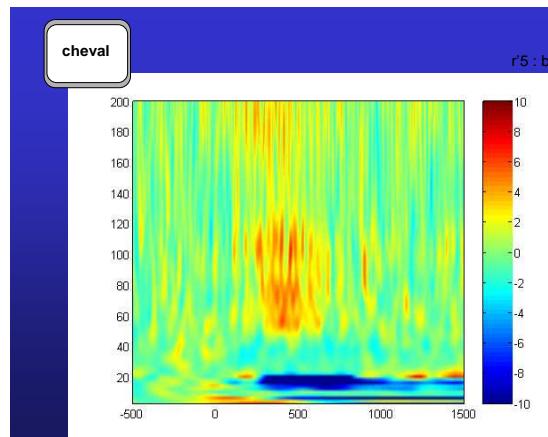
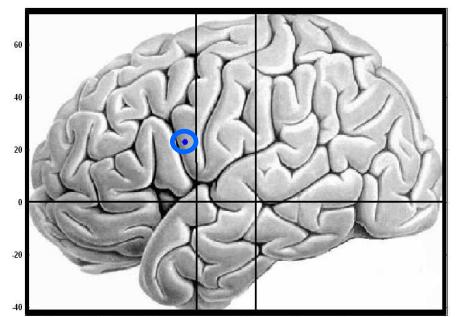
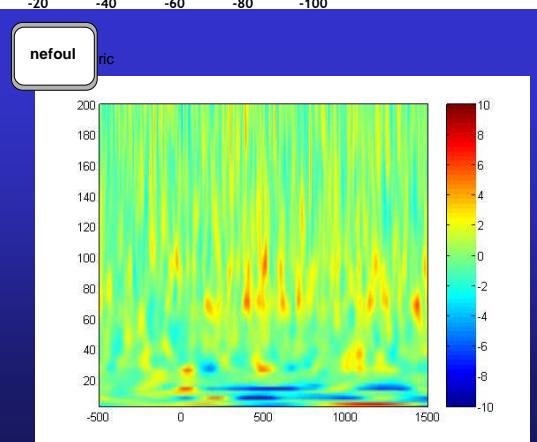
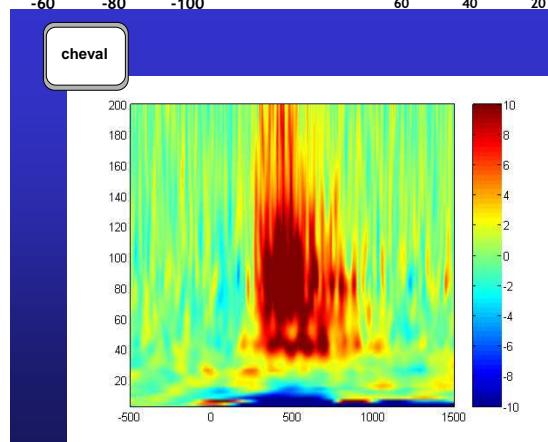
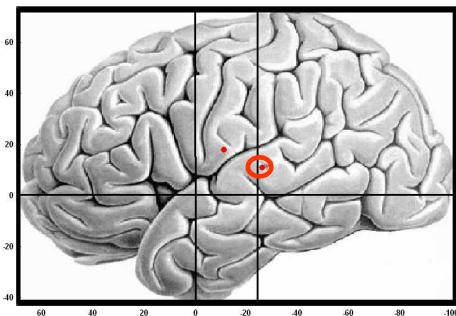
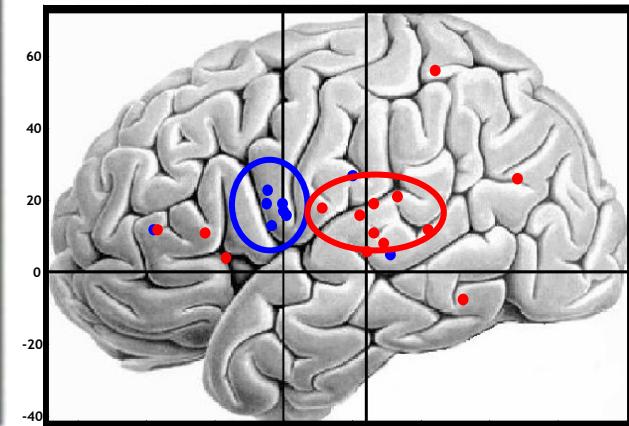
Cognitive activity = Cognitive EP frequency >40 Hz

Tallon-Baudry et al., 1999

Electrodes



Seman > Phono Phono > Seman





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Jeff Ojemann
Neurochirurg



Lorella Minotti
Neurolog



JP Lachaux
Cercetator Neuroștiinte



Jason Watson
Psiholog