Méthodes en psychologie

Les méthodes d'investigation du cerveau en Psychologie

Gilles Lafargue

gilles.lafargue@gmail.com

- **Objectif général de la psychologie :**
  - Mieux comprendre le comportement et le fonctionnement psychique de l’être humain

- Les outils/méthodes d’investigation du cerveau contribuent à l’atteinte de l’objectif général de la psychologie. De façon générale, ils contribuent à **naturaliser l’esprit**.

Différentes catégories d'outils/méthodes

- Mesurer des indices comportementaux, cognitifs… et les confronter à des lésions, des dysfonctionnements, des caractéristiques anatomiques du cerveau

- Perturber l'activité neuronale du cerveau

- Enregistrer **directement** ou **indirectement** l'activité neuronale du cerveau

Quelques repères historiques

1861 : Corrélation anatomo-clinique (Aire de Broca)

1914 : apparition de phosphènes par application d'un champ magnétique sur le scalp

1929 : Premier EEG (Hans Berger)

1937 : stimulation électrique directe du cortex moteur et du cortex somatosensoriel (Penfield & Boldrey)

1968 : Premières mesures en MEG

1972 : Tomographie par Emission de Positons (TEP)

1980 - 89 : Essor de la TEP

1990 : Apparition de l'IRM fonctionnelle (IRMf)

1991: Apparition de l'IRM du tenseur de diffusion (DTI)

1. Mesurer des indices comportementaux chez des personnes présentant des lésions ou dysfonctionnements du cerveau

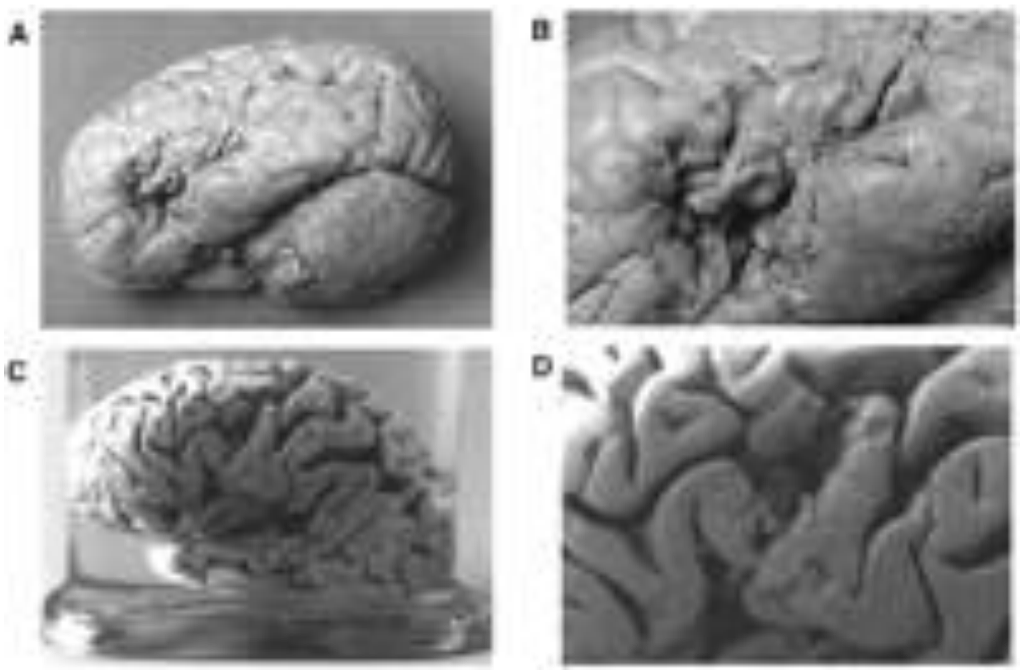
La méthode anatomo-clinique (la neuropsychologie)

- Confronter systématiquement des phénomènes pathologiques (aphasie, prosopagnosie, syndrome de Capgras, héminégligence, amnésie …) et des sites anatomiques lésionnels

- Par extension, confronter des performances comportementales, cognitives… et des données d'anatomie cérébrale chez le sujet valide

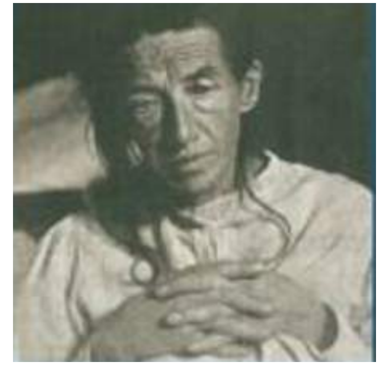
La méthode anatomo-clinique

- Cette méthode a été initialement appliquée sur les cerveaux de patients décédés.



D'après Dronkers et al., Brain 2007

Aloys Alzheimer (1864-1915)



Auguste D ; publication de 1906

dégénérescence fibrillaire

Symptômes / dégénérescence de systèmes anatomo-physiologiques / histologie de la dégénérescence

CORTEX 46 (2010) 691–699

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/cortex

Clinical neuroanatomy

Anatomic dissection of the inferior fronto-occipital fasciculus revisited in the lights of brain stimulation data☆

Juan Martino[a], *Christian Brogna*[b], *Santiago G. Robles*[c], *Francesco Vergani*[d] and *Hugues Duffau*[c,e,*]

[a] *Department of Neurosurgery, Hospital Universitario Marqués de Valdecilla, Santander, Cantabria, Spain*
[b] *Department of Neuroscience – Neurosurgery, Sapienza University of Rome, Italy*
[c] *Department of Neurosurgery, Hôpital Gui de Chauliac, CHU Montpellier, France*
[d] *Department of Neurosurgery, Università degli studi di Milano-Bicocca, San Gerardo Hospital, Monza (Milan), Italy*
[e] *Institut of Neuroscience of Montpellier, INSERM U583, France*

ARTICLE INFO

Article history:
Received 13 December 2008
Reviewed 26 March 2009
Revised 26 March 2009
Accepted 13 July 2009
Action editors Dominic H. ffytche, Marco Catani
Published online 29 August 2009

Keywords:
Inferior fronto-occipital fasciculus
Fiber dissection
Intraoperative electrical stimulation
Semantic system
Subcortical connectivity

ABSTRACT

Despite electrostimulation studies of the white matter pathways, supporting the role of the inferior fronto-occipital fasciculus (IFOF) in semantic processing, little is known about the precise anatomical course of this fascicle, especially regarding its exact cortical terminations. Here, in the lights of these new functional data, we dissected 14 post-mortem human hemispheres using the Klingler fiber dissection technique, to study the IFOF fibers and to identify their actual cortical terminations in the parietal, occipital and temporal lobes. We identified two different components of the IFOF: (i) a superficial and dorsal subcomponent, which connects the frontal lobe with the superior parietal lobe and the posterior portion of the superior and middle occipital gyri, (ii) a deep and ventral subcomponent, which connects the frontal lobe with the posterior portion of the inferior occipital gyrus and the posterior temporo-basal area. Thus, our results are in line with the hypothesis of the functional role of the IFOF in the semantic system, by showing that it is mainly connected with two areas involved in semantics: the occipital associative extrastriate cortex and the temporo-basal region. Further combined anatomical (dissection and Diffusion Tensor Imaging) and functional (intraoperative subcortical stimulation) studies are needed, to clarify the exact participation of each IFOF subcomponent in semantic processing.

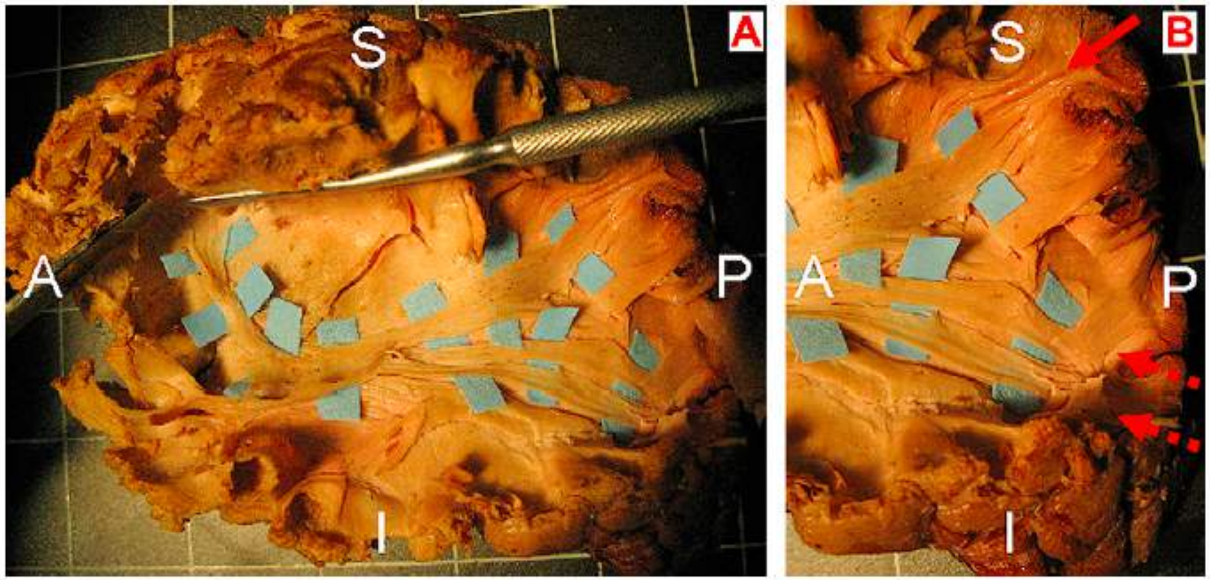


Fig. 3 – (A) Dissection of the superficial and dorsal subcomponents of the IFOF. Small pieces of blue paper have been placed between the superficial portion of the IFOF and the deeper structures, to demonstrate that the fibers of the fascicle were completely dissected and isolated from the surrounding fiber tracts. This superficial portion of the IFOF, at the ventral part of the external capsule, has an inferior and posterior orientation. It crosses the anterior portion of the temporal isthmus, passing above the anterior portion of the roof of the temporal horn, and then it turns superiorly passing underneath the posterior insula. Finally it joins the sagittal stratum in the superior portion of the lateral surface of the atrium to reach the parietal and occipital lobes. (B) Enlarged view of the cortical terminations of the superficial and dorsal portion of the IFOF. It is connected with the cortex of the superior parietal lobe (full red arrow), and with the posterior portion of the superior and middle occipital gyri (dotted red arrows). A = anterior, P = posterior, S = superior and I = inferior.

La méthode anatomo-clinique

- Elles peut maintenant être appliquée sur les images neuro-anatomiques des cerveaux de patients (et sujets sains) vivants (IRM cérébrale anatomique et fonctionnelle).

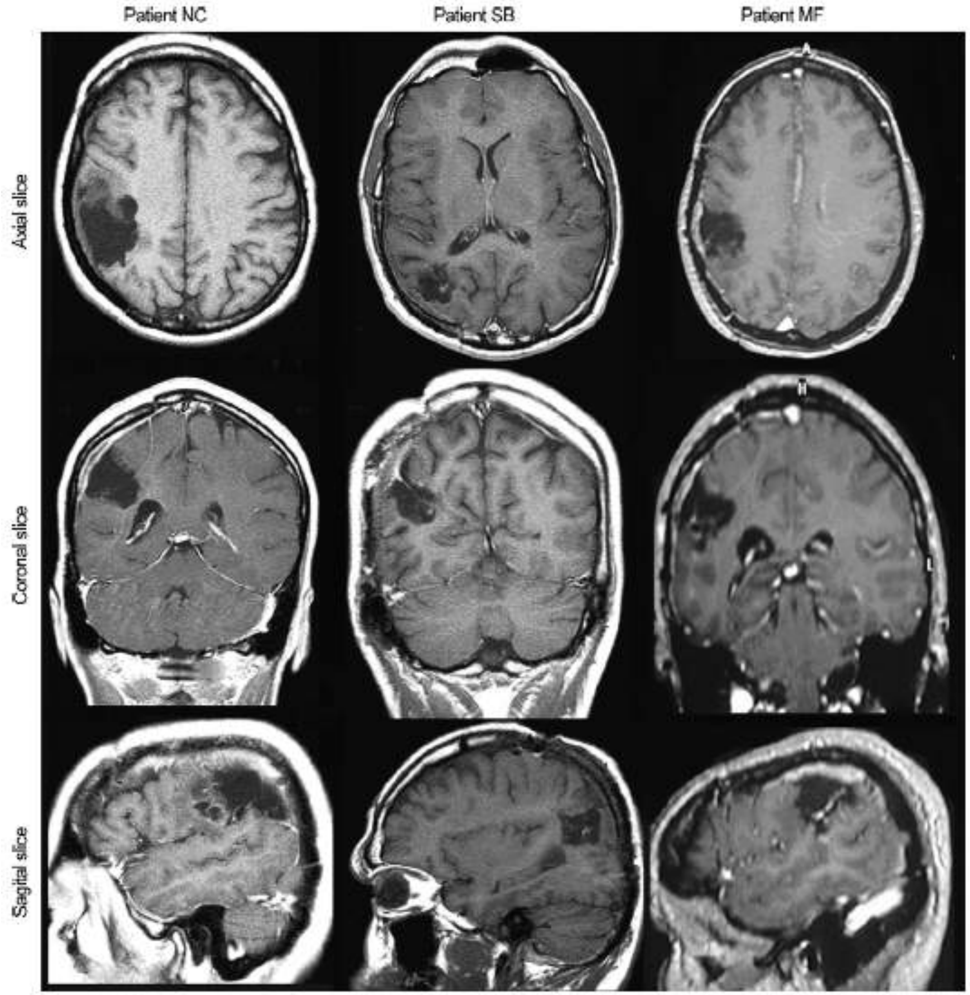


Fig. 1. Post-operative anatomical MRI of the patients confirms the resection of right IPL in the three patients.

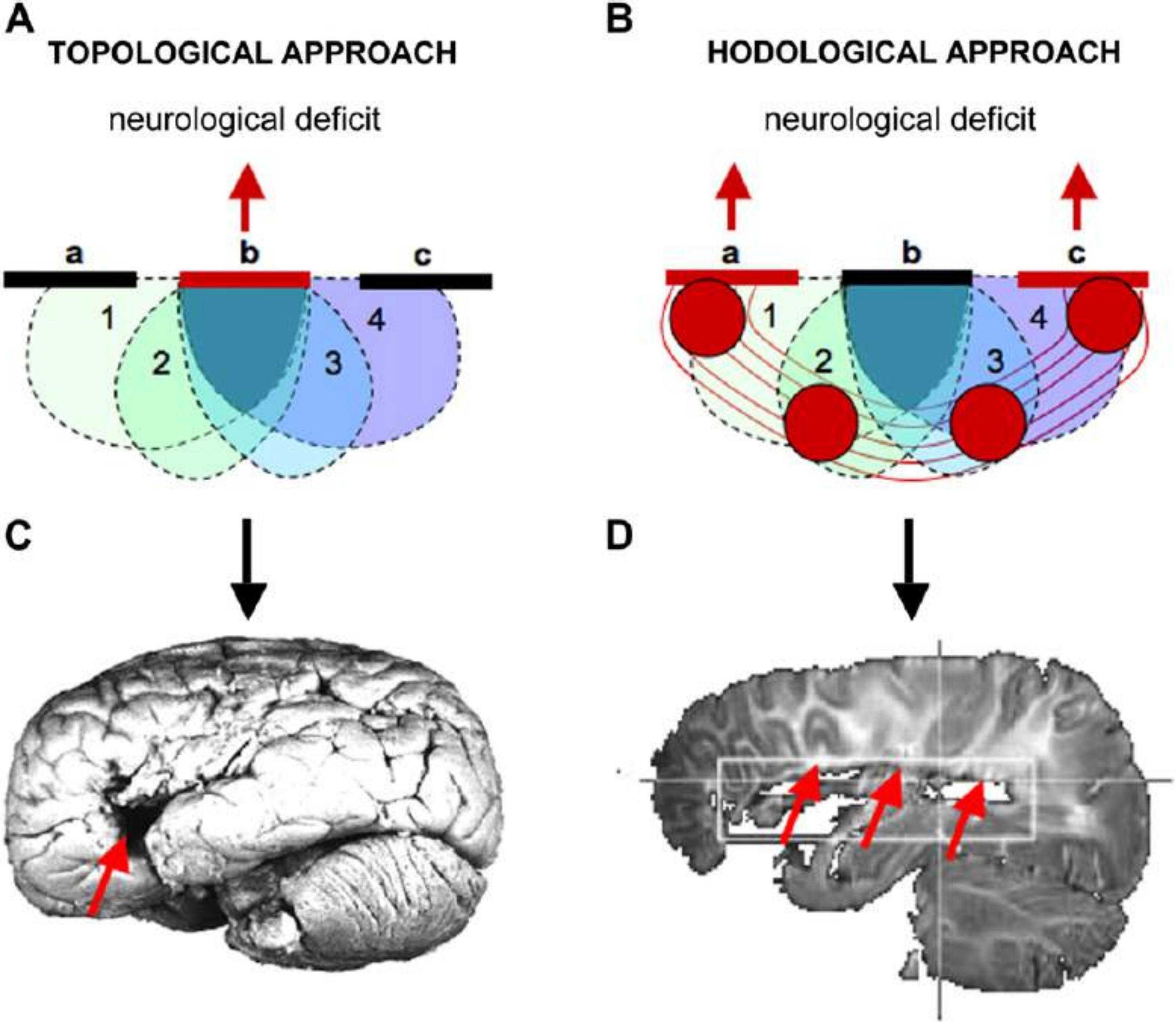
Lafargue & Duffau, *Neuropsychologia*; 2008.

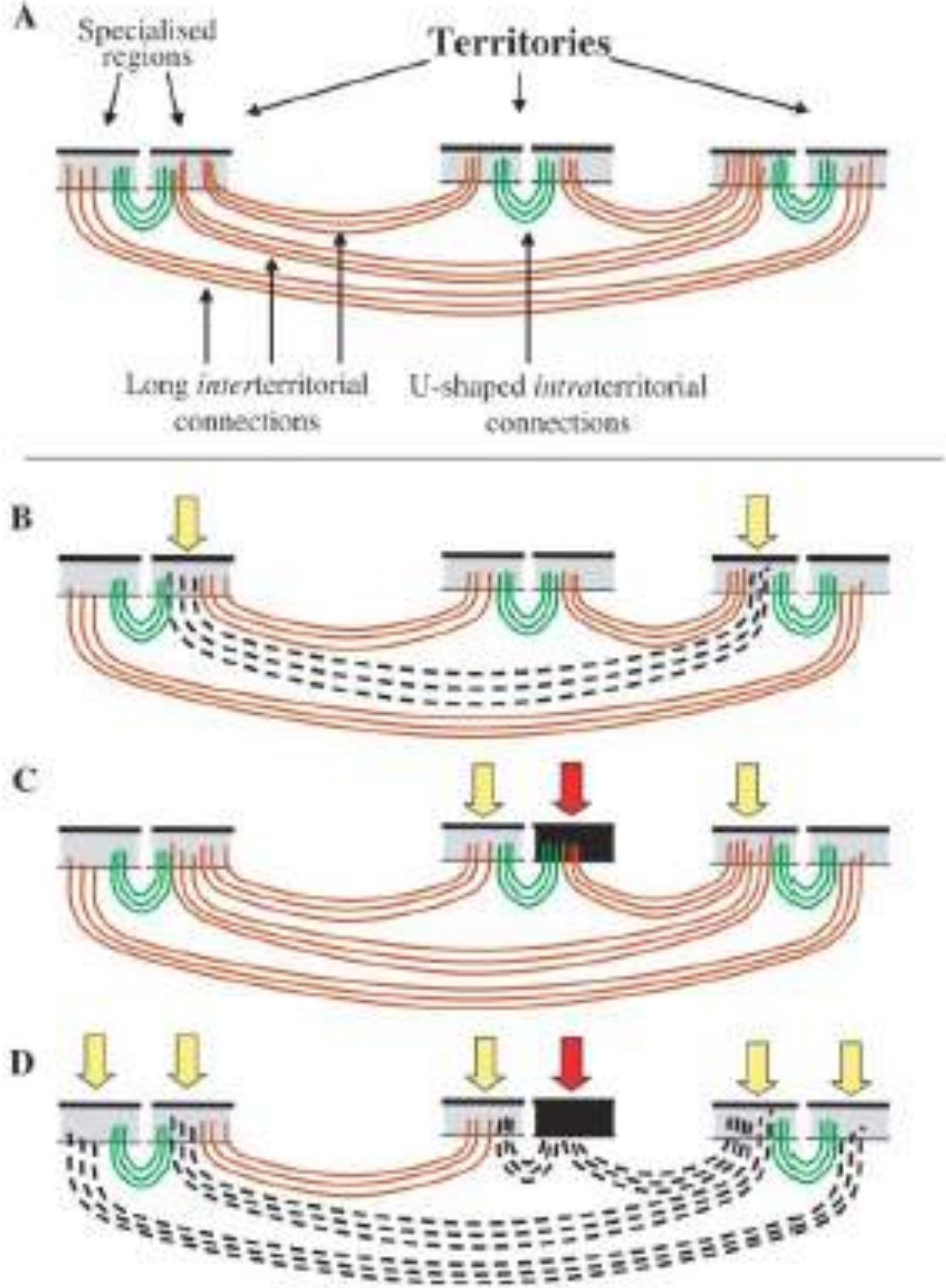
La méthode anatomo-clinique

- Pathologies neurodégénératives, accidents vasculaires cérébraux, tumeurs cérébrales, traumatismes crâniens, ...

La méthode anatomo-clinique

- Le problème de l’interprétation des données


A
TOPOLOGICAL APPROACH
neurological deficit
a
b
c
1
2
3
4
B
HODOLOGICAL APPROACH
neurological deficit
a
b
c
1
2
3
4
C
D


A
Specialised regions
Territories
Long *inter*territorial connections
U-shaped *intra*territorial connections
B
C
D

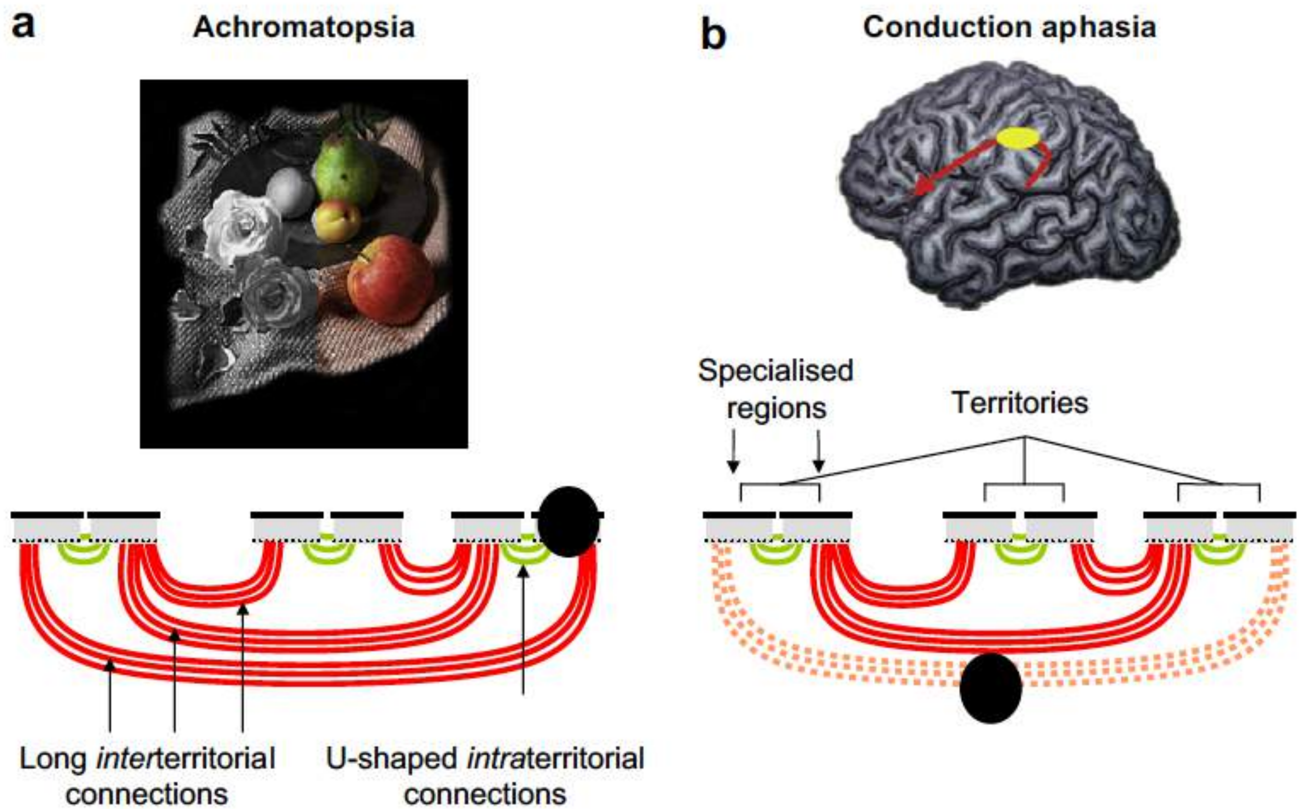
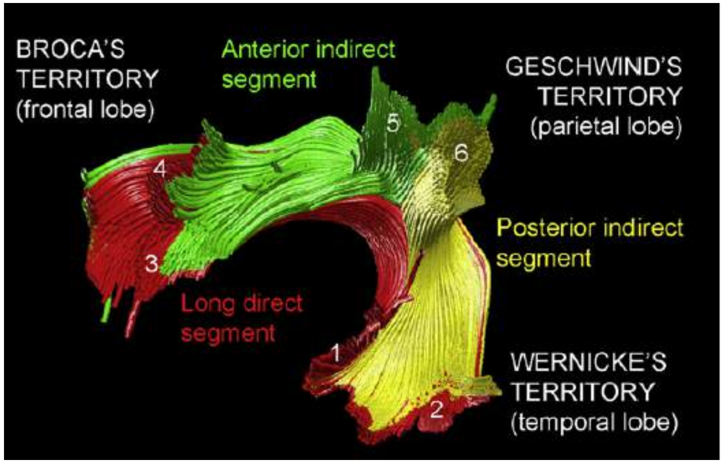


Fig. 1 – The hodotopic framework. Specialised cortical regions (grey) are connected through U-shaped fibres (green) to form territories. Territories are connected by associative fibre tracts (red). (a) Prototypical topological disorder hemi-achromatopsia is caused by a localised cortical lesion (black circle). (b) Prototypical hodological disorder conduction aphasia is caused by a lesion of associative white matter tracts (black circle = lesion; dashed red lines = hodological dysfunction within the lesioned pathway).



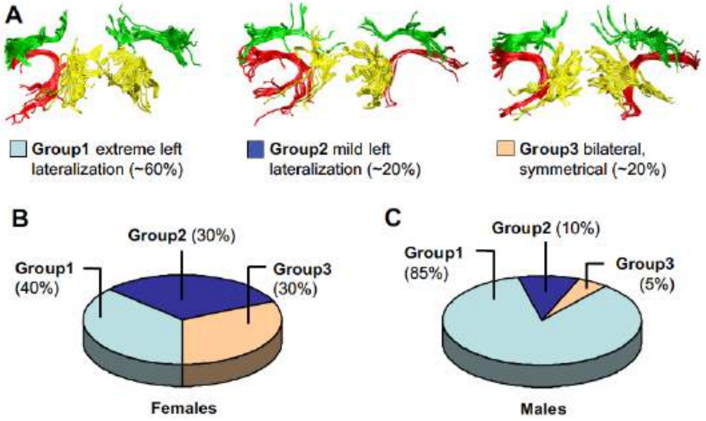


Fig. 6 – Distribution of the pattern of lateralization of the long segment in the normal population and between genders (mod. from Catani et al., 2007).

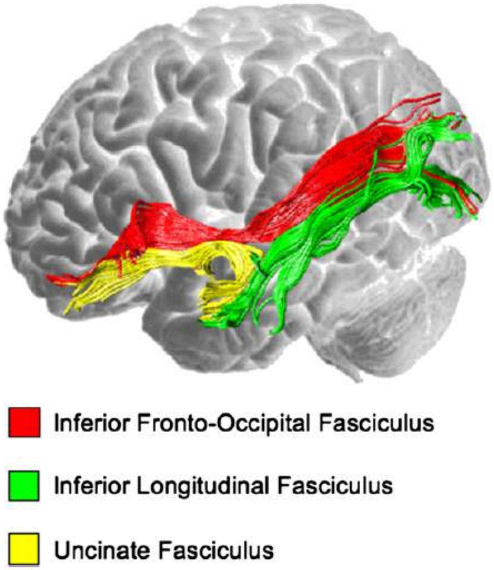


Fig. 7 – Tractography reconstruction of the ventral pathways of the left hemisphere.

Behavioral/Systems/Cognitive

Rich-Club Organization of the Human Connectome

Martijn P. van den Heuvel[1] and Olaf Sporns[2]
[1]Department of Psychiatry, University Medical Center Utrecht, Rudolf Magnus Institute of Neuroscience, 3508 GA Utrecht, The Netherlands, and
[2]Department of Psychological and Brain Sciences and Program in Cognitive Science, Indiana University, Bloomington, Indiana 47405

The human brain is a complex network of interlinked regions. Recent studies have demonstrated the existence of a number of highly connected and highly central neocortical hub regions, regions that play a key role in global information integration between different parts of the network. The potential functional importance of these "brain hubs" is underscored by recent studies showing that disturbances of their structural and functional connectivity profile are linked to neuropathology. This study aims to map out both the subcortical and neocortical hubs of the brain and examine their mutual relationship, particularly their structural linkages. Here, we demonstrate that brain hubs form a so-called "rich club," characterized by a tendency for high-degree nodes to be more densely connected among themselves than nodes of a lower degree, providing important information on the higher-level topology of the brain network. Whole-brain structural networks of 21 subjects were reconstructed using diffusion tensor imaging data. Examining the connectivity profile of these networks revealed a group of 12 strongly interconnected bihemispheric hub regions, comprising the precuneus, superior frontal and superior parietal cortex, as well as the subcortical hippocampus, putamen, and thalamus. Importantly, these hub regions were found to be more densely interconnected than would be expected based solely on their degree, together forming a rich club. We discuss the potential functional implications of the rich-club organization of the human connectome, particularly in light of its role in information integration and in conferring robustness to its structural core.

Utilisation de la théorie des graphes

Rich-club organization

Graph metrics. Graph theory was used to examine the topology of the reconstructed brain networks. Characteristic measures of network organization were computed, including the (node-specific) degree k, clustering coefficient, characteristic path length, betweenness centrality, normalized clustering coefficient and normalized path length (both normalized relative to a set of 100 comparable random graphs), global efficiency, assortativity, and modularity. Graph metrics were computed using the Brain Connectivity Toolbox as described previously (Rubinov and Sporns 2010). The centerpiece of the present paper is the investigation of rich clubs of hub nodes, which we examine by computing the rich-club coefficients $\Phi(k)$ across a range of degree k of the networks.

Unweighted network. For a given M, the degree of each node i in the network was determined, counting the number of links that node i shared with k other nodes in the network. All nodes that showed a number of connections of $\leq k$ were removed from the network. For the remaining network, the rich-club coefficient $\Phi(k)$ was computed as the ratio of connections present between the remaining nodes and the total number of possible connections that would be present when the set would be fully connected. Formally, the rich-club coefficient $\Phi(k)$ is given by the following (Zhou and Mondragon, 2004; Colizza et al., 2006; McAuley et al., 2007):

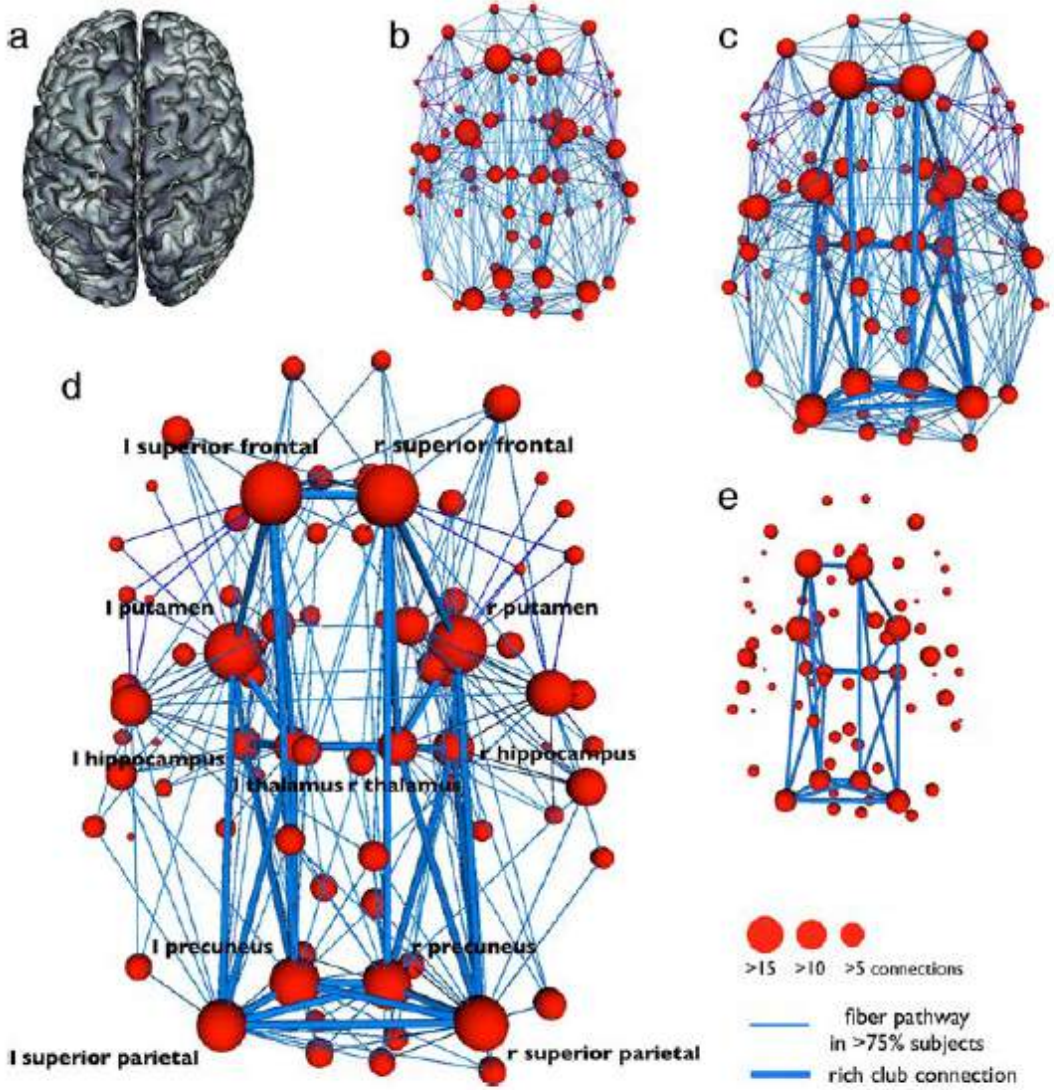


Figure 4. Rich-club regions and connections. The figure shows rich-club regions and connections of the group-averaged connectome (unweighted, $k = 17$; Fig. 3*a*). Size of nodes reflect their number of connections, with bigger nodes representing more densely connected regions. ***a***, Anatomical perspective. ***b***, Group-averaged connectome. ***c***, Group connectome with rich-club connections marked in dark blue. ***d***, Connections between rich-club regions (dark blue) and connections from rich-club nodes to the other regions of the brain network (light blue). The figure shows that almost all regions of the brain have at least one link directly to the rich club. ***e***, Rich-club connections.

- **Utilisation des paradigmes de la psychologie cognitive chez le patients et le sujets sains**
  - Taux d'erreurs
  - Temps de réaction

- **Confronter des performances à des données d'anatomie cérébrale**

Pergamon

Neuropsychologia, Vol. 33, No. 6, pp. 661–674, 1995

0028–3932/95 $9.50+0.00

0028–3932(95)00002–X

FACE PERCEPTION AND WITHIN-CATEGORY DISCRIMINATION IN PROSOPAGNOSIA

MARTHA J. FARAH,*† KAREN L. LEVINSON† and KAREN L. KLEIN‡

†University of Pennsylvania, Philadelphia, Pennsylvania, U.S.A.; and ‡Carnegie Mellon University, Pittsburgh, Pennsylvania, U.S.A.

(*Received* 23 *October* 1992; *accepted* 7 *November* 1994)

Abstract—Prosopagnosics are impaired at face recognition, but unimpaired, or relatively less impaired, at common object recognition. It has been suggested that this dissociation results simply from the greater difficulty of face recognition compared to object recognition, or from the greater need to discriminate visually similar members of a single category in face recognition compared to object recognition. We tested these hypotheses using the performance of normal subjects in an 'old/new' recognition paradigm to establish the true relative difficulty of face and object recognition, and required both normal subjects and a prosopagnosic subject to discriminate both faces and visually similar exemplars of nonface object categories. In two different experiments, the prosopagnosic patient performed disproportionately poorly with faces. These results disconfirm the hypotheses described above, and imply that prosopagnosia is an impairment of a specialized form of visual recognition that is necessary for face recognition and is not necessary, or less necessary, for the recognition of common objects.

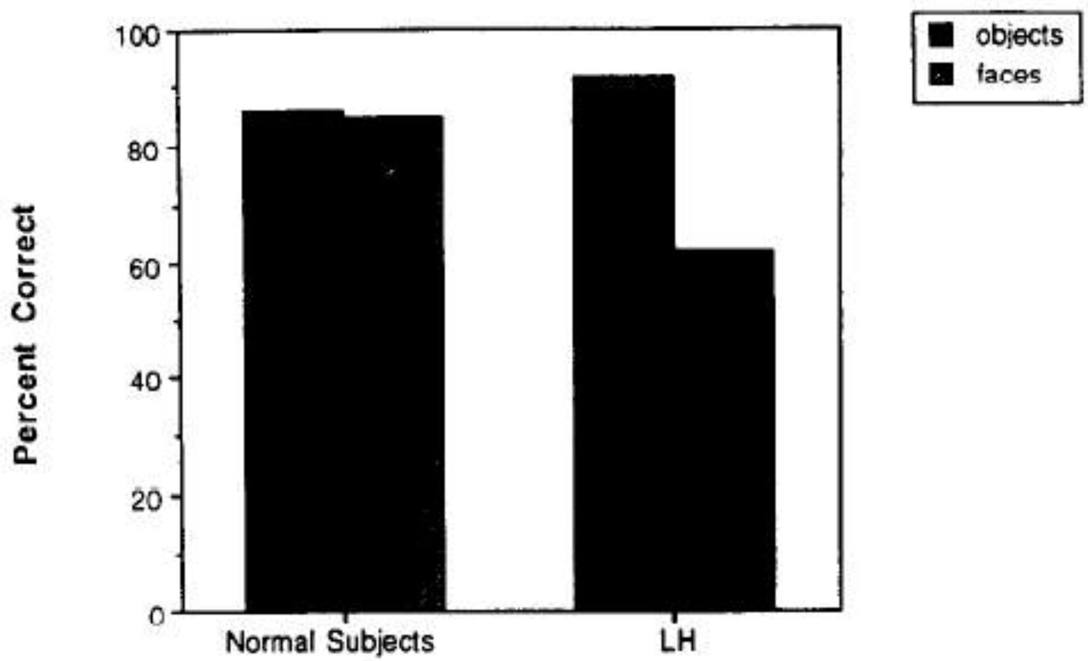
Subjects

Ten normal subjects were recruited from the Psychology Department subject pool at Carnegie-Mellon University. These subjects were undergraduates enrolled in Psychology courses, who were participating for course credit.

The prosopagnosic subject was LH, a 40yr-old man who has been prosopagnosic since an **automobile accident 20 yr earlier**. When tested during his recovery, his **verbal IQ was 132** and his performance IQ was 93. His main residual impairment is in face recognition. **He is profoundly prosopagnosic, unable to recognize friends, neighbours or even his wife and children without extra-facial cues. His recognition of real objects and pictures is only mildly impaired, and his recognition of printed words is good.**

Brain damage from the accident and subsequent surgery consists of **bilateral occipitotemporal lesions**, and right frontal and anterior temporal lesions.

Première phase : on présente des photos d'objets au sujet
Deuxième phase : on présente des photos (une par une), le sujet doit dire si elles sont nouvelles ou déjà vues



Pergamon

0042-6989(94)00273-8

Vision Res. Vol. 35, No. 14, pp. 2089–2093, 1995

0042-6989/95 $9.50 + 0.00

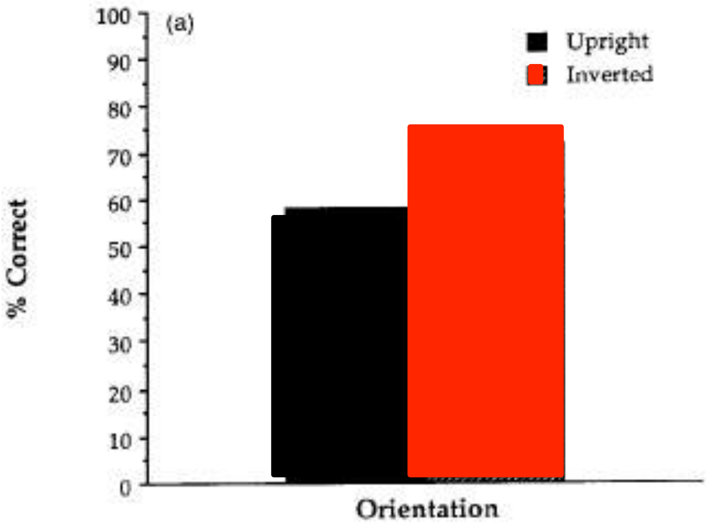
The Inverted Face Inversion Effect in Prosopagnosia: Evidence for Mandatory, Face-specific Perceptual Mechanisms

MARTHA J. FARAH,* KEVIN D. WILSON,* H. MAXWELL DRAIN,† JAMES R. TANAKA‡

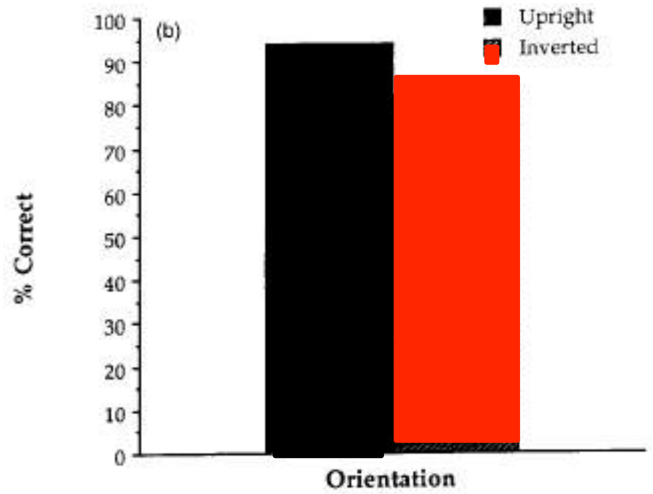
Received 6 December 1993; in revised form 14 September 1994

Does the human visual system contain a specialized system for face recognition, not used for the recognition of other objects? This question was addressed using the "face inversion effect" which refers to the loss of our normal proficiency at face perception when faces are inverted. We found that a prosopagnosic subject paradoxically performed better at matching inverted faces than upright faces, the opposite of the normal "face inversion effect". The fact that his impairment was most pronounced with the stimuli for which normal subjects show the greatest proficiency in face perception provides evidence of a neurologically localized module for upright face recognition in humans. An additional implication of these data is that specialized systems may control behavior even when they are malfunctioning and therefore maladeaptive, consistent with the mandatory operation of such systems according to the "modularity" hypothesis of the cognitive architecture.

Face inversion Face recognition Modularity Prosopagnosia



LH



Sujets contrôles

- Effet classique d’inversion des visages pour les sujets contrôles
- Effet d’inversion inversé pour LH


L'étude de Warrington (1993)

La prosopagnosie est-elle assimilable à une discrimination intra-catégorielle difficile ?

L'étude de Warrington (1993)

La prosopagnosie est-elle assimilable à une discrimination intra-catégorielle difficile ?

Figure 5.36 Les déficits de reconnaissance portant spécifiquement sur les visages ne peuvent pas être attribués au fait que les visages constituent une discrimination intra-catégorielle difficile. Un éleveur de moutons, W.J., présentait des déficits dans la reconnaissance de visages célèbres, mais reconnaissait ses propres moutons ou des moutons non familiers avec plus d'exactitude que des sujets contrôles. Dans une tâche de discrimination de visages, on montre aux sujets trois visages, en leur demandant de monter du doigt celui qui leur est familier. Dans cet exemple, le visage familier était celui de Norman Tebbit, un politicien bien connu des populations britanniques), de l'époque de Margaret Thatcher. Les visages de droite et de gauche étaient inconnus du sujet. Les moutons appartiennent à l'élevage de W.J. Un groupe contrôle a été constitué avec des sujets choisis sur la base de l'expérience professionnelle antérieure de W.J. ; un autre groupe fut constitué avec des sujets ayant une expérience de l'élevage de moutons. Reproduit, avec autorisation, de McNeil et Warrington (1993).

Relating Introspective Accuracy to Individual Differences in Brain Structure

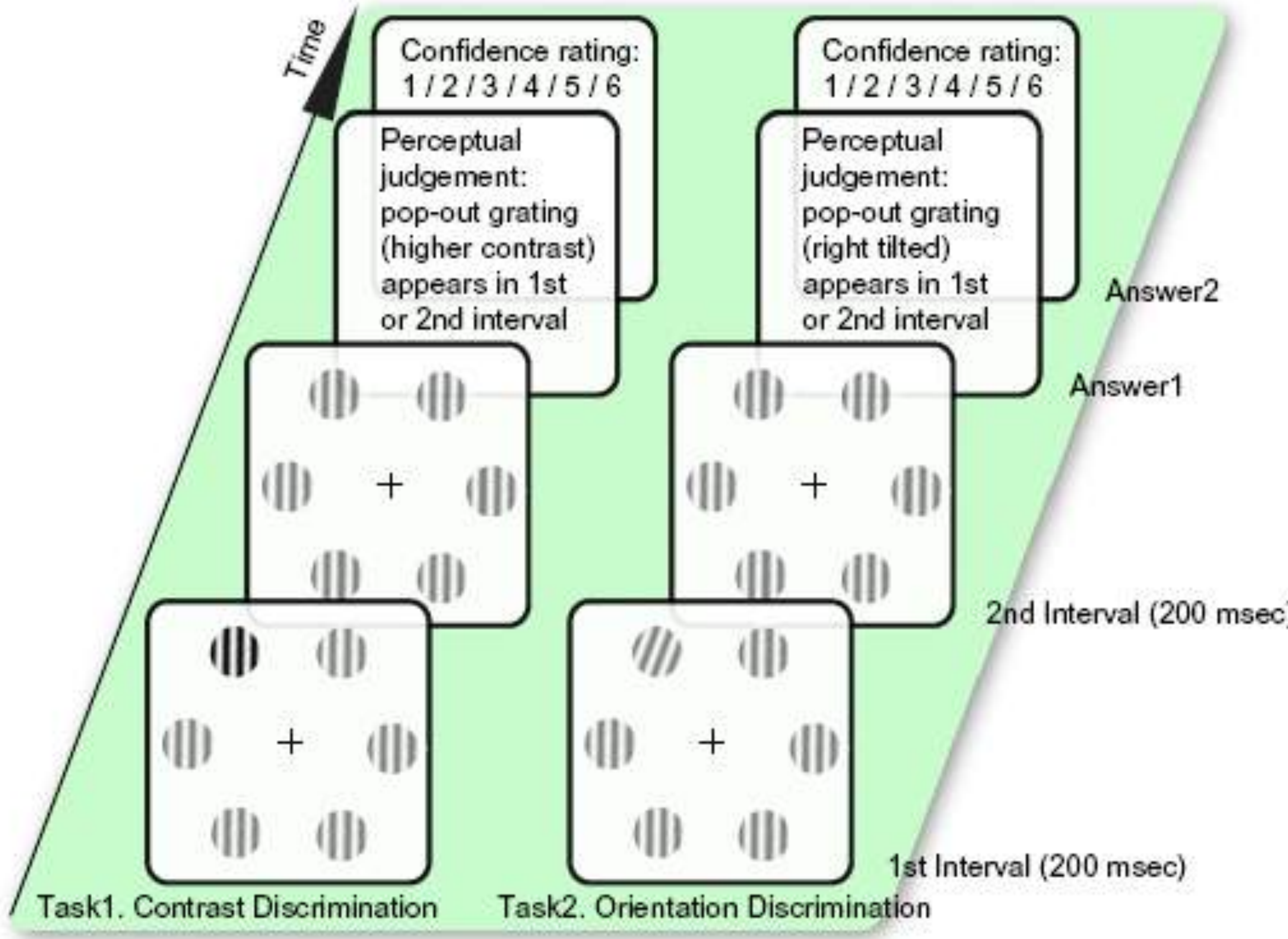
Stephen M. Fleming,[1*†] Rimona S. Weil,[1,2*] Zoltan Nagy,[1] Raymond J. Dolan,[1] Geraint Rees[1,2]

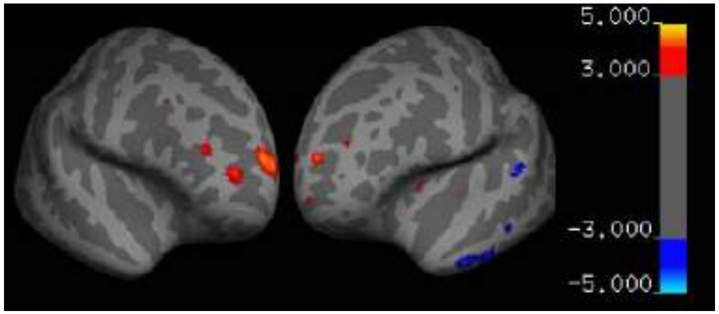
The ability to introspect about self-performance is key to human subjective experience, but the neuroanatomical basis of this ability is unknown. Such accurate introspection requires discriminating correct decisions from incorrect ones, a capacity that varies substantially across individuals. We dissociated variation in introspective ability from objective performance in a simple perceptual-decision task, allowing us to determine whether this interindividual variability was associated with a distinct neural basis. We show that introspective ability is correlated with gray matter volume in the anterior prefrontal cortex, a region that shows marked evolutionary development in humans. Moreover, interindividual variation in introspective ability is also correlated with white-matter microstructure connected with this area of the prefrontal cortex. Our findings point to a focal neuroanatomical substrate for introspective ability, a substrate distinct from that supporting primary perception.

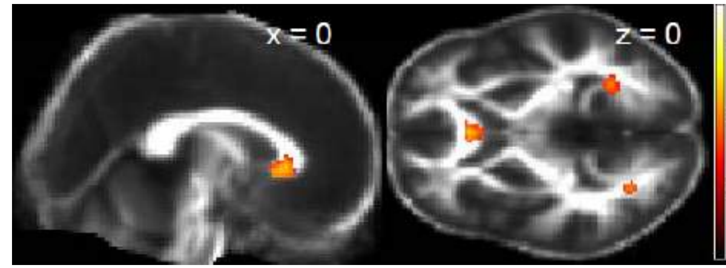
SCIENCE VOL 329 17 SEPTEMBER 2010

- Etude sur les bases cérébrales des capacités d'introspection (métacognitives)
  - Degré de confiance qu'on accorde à une décision

a


Time
Confidence rating:
1 / 2 / 3 / 4 / 5 / 6
Perceptual judgement: pop-out grating (higher contrast) appears in 1st or 2nd interval
Confidence rating:
1 / 2 / 3 / 4 / 5 / 6
Perceptual judgement: pop-out grating (right tilted) appears in 1st or 2nd interval
Answer2
Answer1
2nd Interval (200 msec)
1st Interval (200 msec)
Task1. Contrast Discrimination
Task2. Orientation Discrimination





- La compétence métacognitive des participants est corrélée avec la quantité de matière grise dans le cortex préfrontal rostral droit, **aire 10** de Brodmann, et avec la densité de matière blanche dans la région rostrale du corps calleux

-Cette région du corps calleux est connectée à l'aire 10

-L'aire 10 joue un rôle clé dans les capacités d'introspection

- **Utilisation de données psychométriques chez le patients et le sujets sains… et les confronter à des données d’anatomie cérébrale**

Research Article

ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
21(6) 820–828

DOI: 10.1177/0956797610370159
http://pss.sagepub.com
SAGE

Testing Predictions From Personality Neuroscience: Brain Structure and the Big Five

Colin G. DeYoung[1], Jacob B. Hirsh[2], Matthew S. Shane[3], Xenophon Papademetris[4], Nallakkandi Rajeevan[4], and Jeremy R. Gray[4]
[1]University of Minnesota; [2]University of Toronto; [3]The Mind Research Network, Albuquerque, New Mexico; and [4]Yale University

Abstract

We used a new theory of the biological basis of the Big Five personality traits to generate hypotheses about the association of each trait with the volume of different brain regions. Controlling for age, sex, and whole-brain volume, results from structural magnetic resonance imaging of 116 healthy adults supported our hypotheses for four of the five traits: Extraversion, Neuroticism, Agreeableness, and Conscientiousness. Extraversion covaried with volume of medial orbitofrontal cortex, a brain region involved in processing reward information. Neuroticism covaried with volume of brain regions associated with threat, punishment, and negative affect. Agreeableness covaried with volume in regions that process information about the intentions and mental states of other individuals. Conscientiousness covaried with volume in lateral prefrontal cortex, a region involved in planning and the voluntary control of behavior. These findings support our biologically based, explanatory model of the Big Five and demonstrate the potential of personality neuroscience (i.e., the systematic study of individual differences in personality using neuroscience methods) as a discipline.

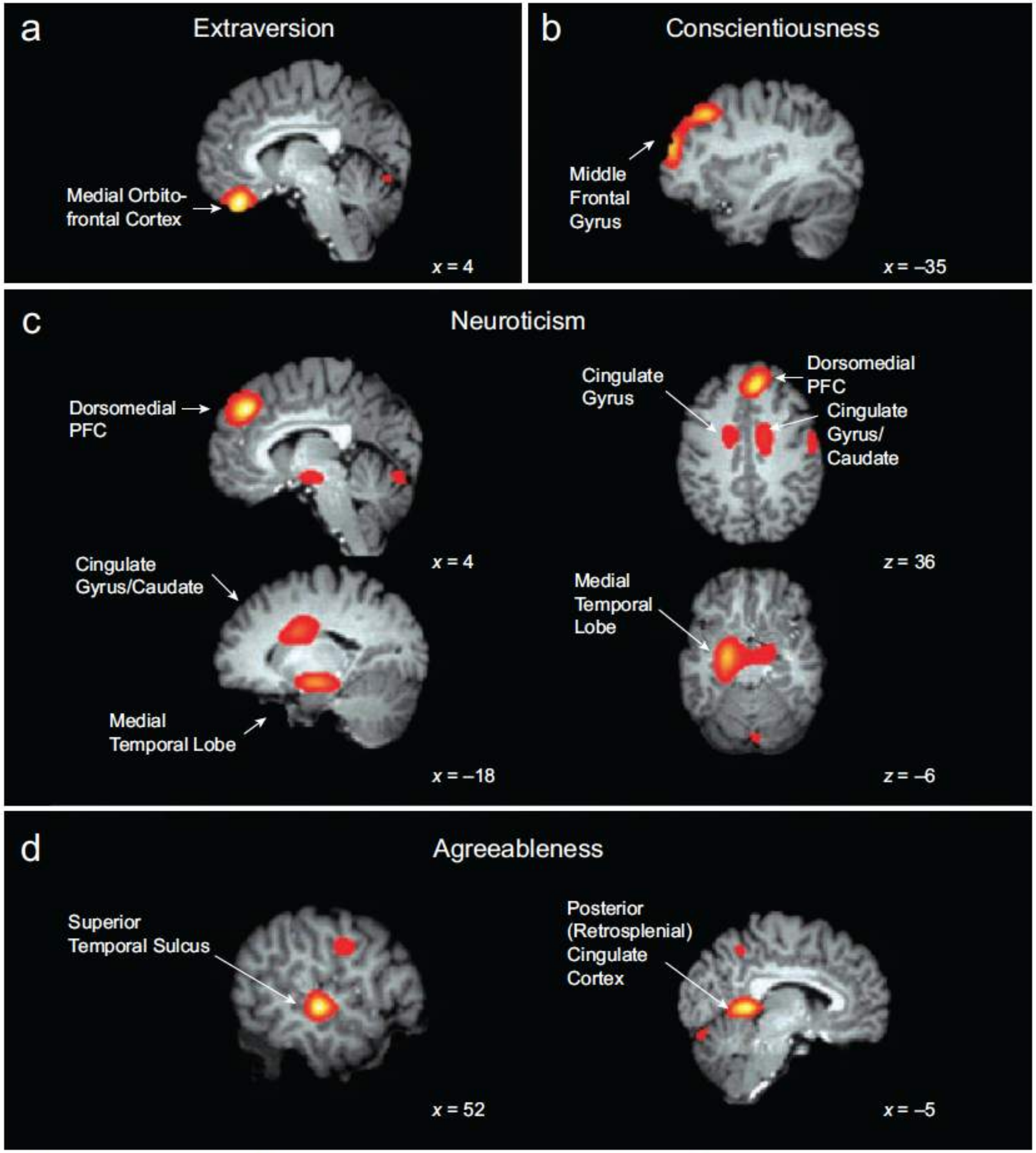


Fig. 1. Brain regions in which local volume was significantly associated with (a) Extraversion, (b) Conscientiousness, (c) Neuroticism, and (d) Agreeableness, as hypothesized (see also Table 1). Coordinates indicate the locations of the brain slices. Color is related to effect size, with lighter color signifying a larger effect, and darker color signifying a smaller effect. PFC = prefrontal cortex.

Brain Advance Access published February 10, 2014
doi:10.1093/brain/awt370

BRAIN
A JOURNAL OF NEUROLOGY

Inferring a dual-stream model of mentalizing from associative white matter fibres disconnection

Guillaume Herbet,[1,2,3] Gilles Lafargue,[4,5] François Bonnetblanc,[6,7,8] Sylvie Moritz-Gasser,[1,9] Nicolas Menjot de Champfleur[10] and Hugues Duffau[1,2]

1 Department of Neurosurgery, Gui de Chauliac hospital, F-34295 Montpellier, France
2 Institute for Neuroscience of Montpellier, INSERM 1051, Hôpital Saint Eloi, F-34091 Montpellier, France
3 University of Montpellier 1, F-34967 Montpellier, France
4 Functional Neuroscience and Pathologies Laboratory, EA-4559, Lille Nord de France University, F-59120 Loos, France
5 Department of Psychology, Lille Nord de France University (Lille3), F-59653 Villeneuve d'Ascq, France
6 Cognition, Action and Sensorimotor Plasticity Lab, INSERM U-1093, UFR STAPS, F-27877 Dijon, France
7 University of Montpellier 2, LIRMM, DEMAR team, CNRS, INRIA, F-34095 Montpellier, France
8 University Institute of France, F-75005 Paris, France
9 Department of Neurology, Gui de Chauliac hospital, F-34295 Montpellier, France
10 Department of Neuroradiology, Gui de Chauliac hospital, F-34295 Montpellier, France

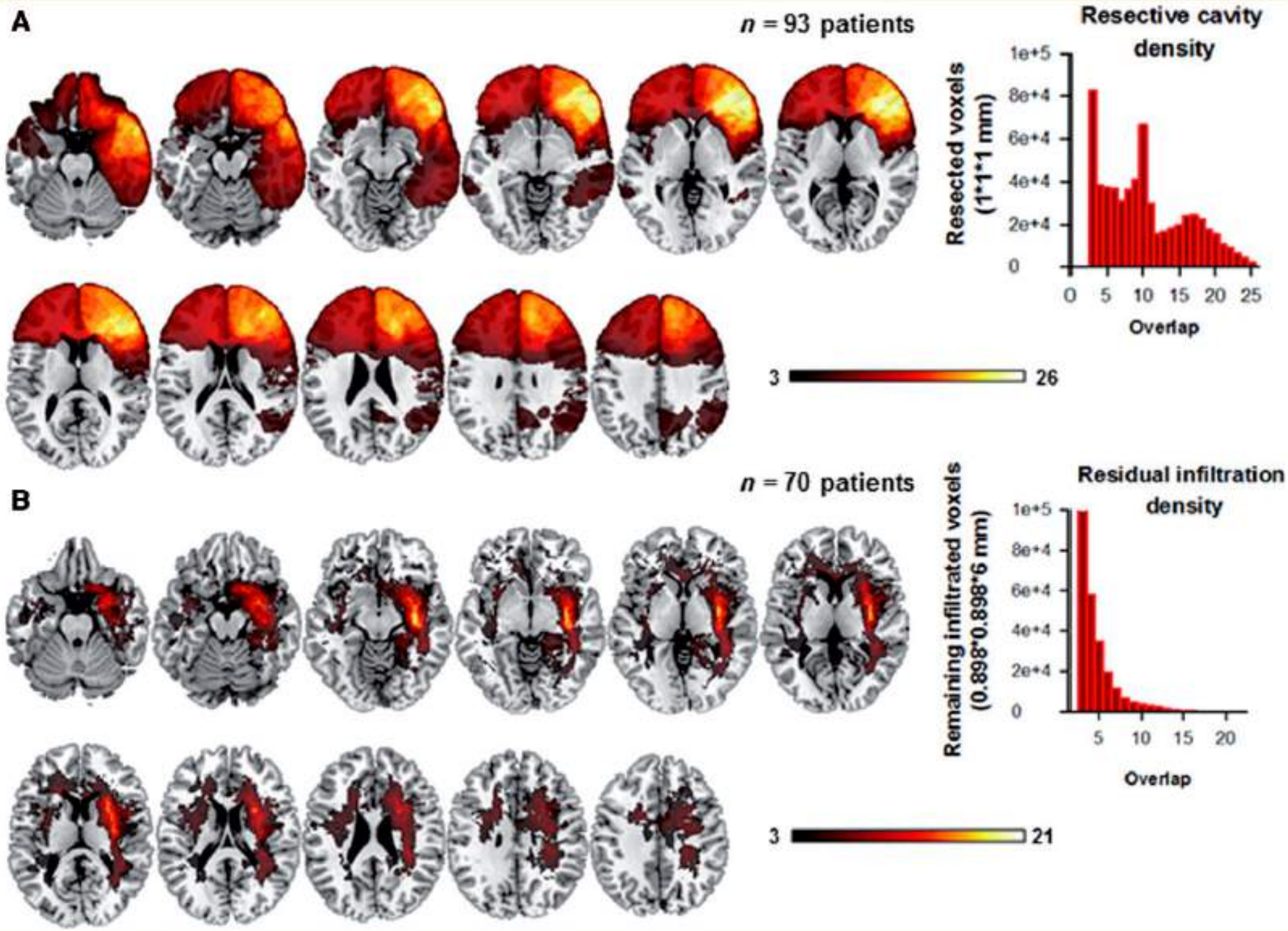


Figure 1 Lesion overlap maps for all patients. (**A**) Resection cavity overlaps ($n = 93$). The pars triangularis of the right frontal gyrus was the region with the greatest overlap ($n = 26$). (**B**) Residual lesion infiltration overlaps ($n = 70$). As expected, the residual infiltrations were located on the trajectory of the associative white matter fasciculi. The greatest degree of overlap occurred in the white matter fibres of the right inferior occipito-frontal fasciculus ($n = 21$). Histograms represent lesion density plots (i.e. the number of overlapping voxels).

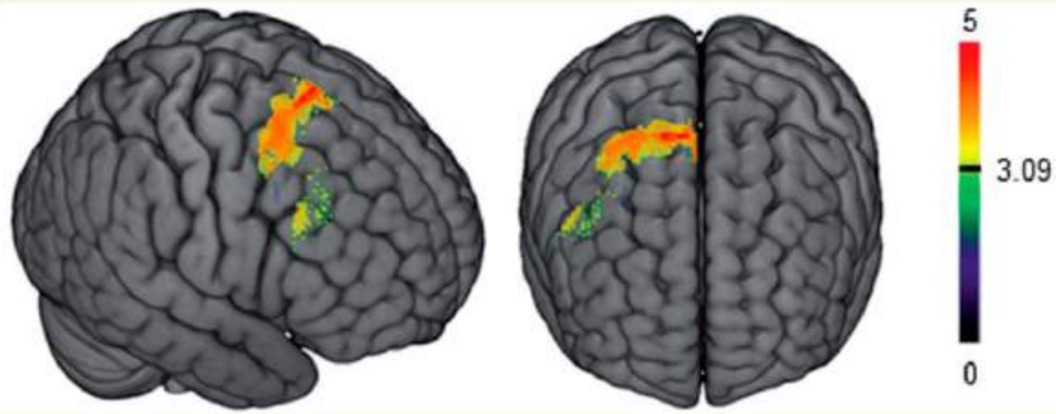


Figure 2 Damage to the supplementary motor area and dorsal premotor cortex is associated with impaired accuracy in inference-based mentalizing. The statistical map is thresholded at $P < 0.001$ uncorrected and rendered in three dimensions. Only significant voxels are shown. This lesion-symptom analysis was performed on the difference in error rate between the mentalizing condition (intention attribution) and the control condition (physical causality), after removing unwanted variance associated with nuisance variables (age, premorbid IQ, lesion volume and time since surgery).

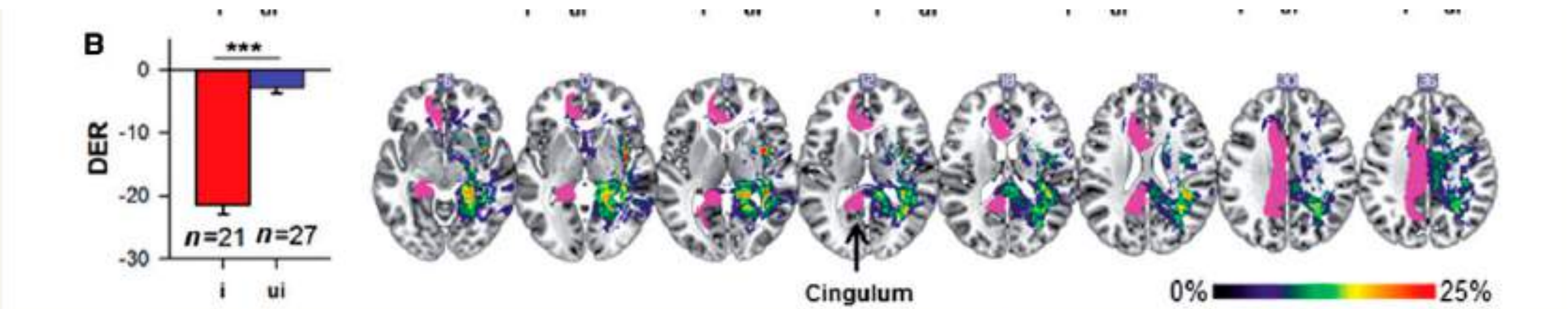


Figure 5 Damage to the right cingulum is specifically associated with decreased high-level mentalizing accuracy. (**A**) Patients with an impaired differential error rate were more likely to have infiltration in the right cingulum than patients with a normal differential error rate ($P = 0.03$, see also Table 2). Subtraction plot: patients with impaired performance were more likely to have infiltration in the cingulum and in white matters fibres constituting the temporo-parieto-occipital junction. The bar indicates increasing frequency. The left cingulum is plotted as a visual point of reference. IFOF = inferior fronto-occipital fasciculus; ILF = inferior longitudinal fasciculus; UF = uncinate fasciculus; AF = arcuate fasciculus; lSLF = lateral superior longitudinal fasciculus.

2. Perturber l'activité neuronale du cerveau (sain ou lésé)

2.1 La stimulation magnétique transcrânienne (TMS)

Magnuson CE, Stevens HC. (1914). Visual sensations created by a magnetic field. Philosoph Mag, 28, 188–207

Barker AT, Jalinous R, Freeston IL., (1985). Non-invasive magnetic stimulation of human motor cortex, *The Lancet* , 1, 8437, 1985, p. 1106–1107

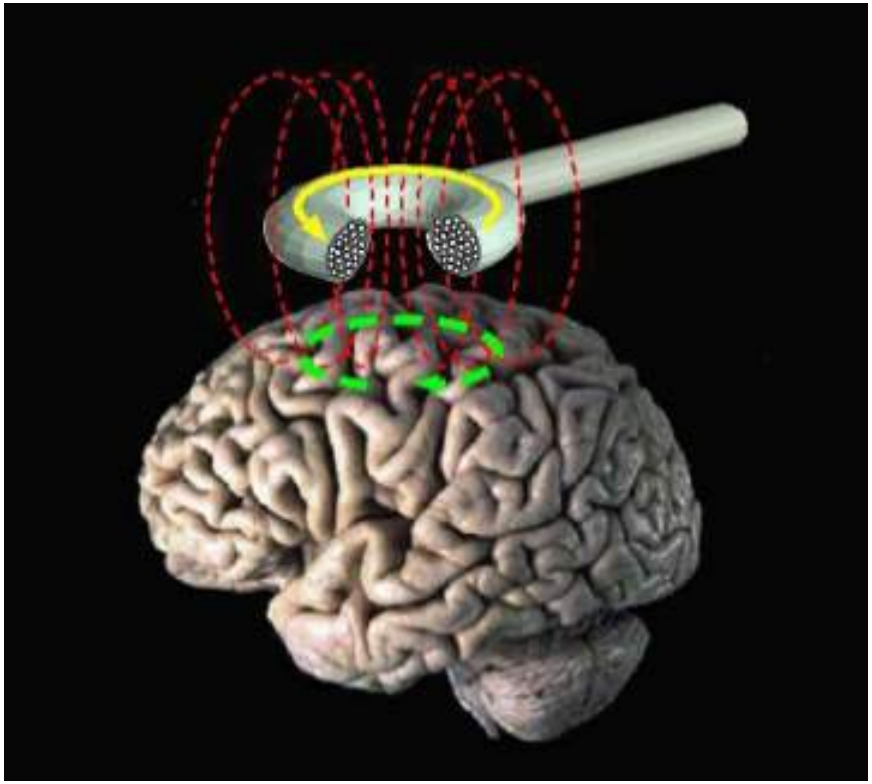
Principe de Faraday (1)

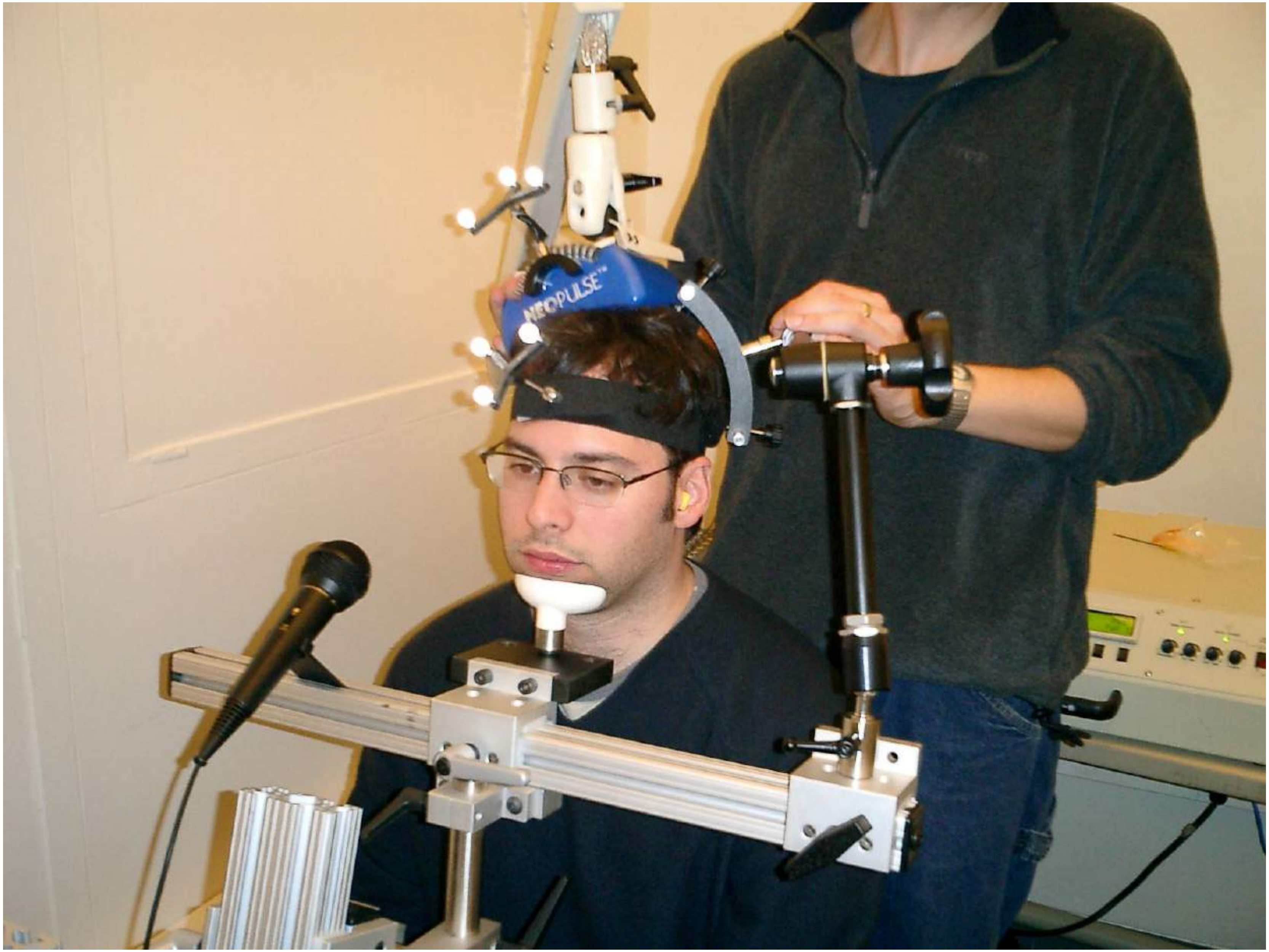
Lorsqu’un courant électrique passe dans un conducteur, ce courant génère un champ magnétique qui à son tour induit un courant secondaire dans tout conducteur à sa portée.

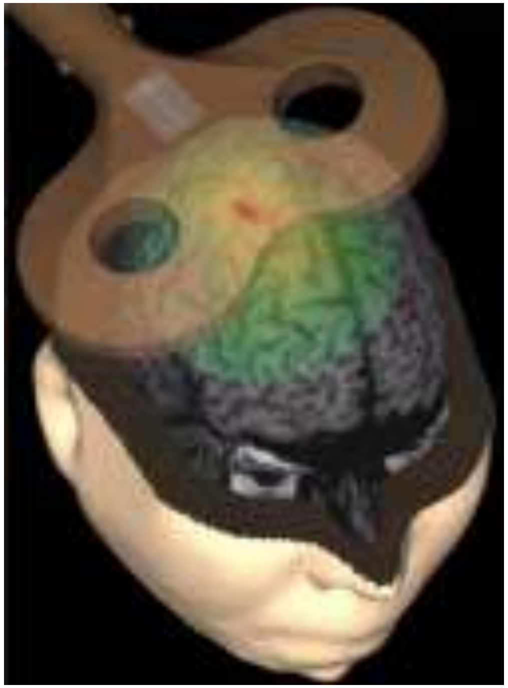
Principe de Faraday (2)

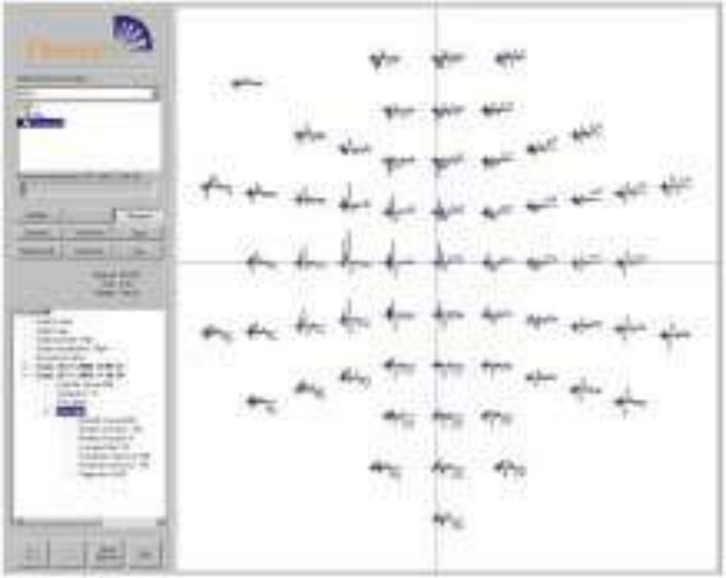
En TMS, la seconde bobine est remplacée par le tissu cérébral

- un <u>courant de forte intensité</u> (environ 8kA) est délivré sur une <u>période de temps très brève</u> (environ 1 ms)
- le courant génère un champ magnétique qui induit un champ électrique suffisant pour dépolariser la membranes des neurones stimulés




NEOPULSE™





Plateforme de TMS stéréotaxique couplant la TMS, un système de neuro-navigation et l'enregistrement EEG

Différents modes de stimulation

- TMS unique

- La rTMS
  - basses fréquences (<1Hz)
  - hautes fréquences (>1Hz)

TMS et Neuropsychologie ?

La TMS permet d'interférer avec le fonctionnement normal d'une aire corticale au cours d'une opération cognitive déterminée.

Pourquoi interférer avec le fonctionnement normal du cerveau ?

- pour étudier activement la relation entre l'activité corticale localisée et le comportement humain
- pour déterminer comment interagissent les différentes régions cérébrales

Principe

- Brouiller momentanément l’activité d’une région définie du cerveau et demander au sujet d'effectuer une tâche.

- **Si la région dérangée est nécessaire pour faire la tâche, la performance doit être inférieure à sa performance habituelle.**

Current Biology *17*, 1568–1573, September 18, 2007 DOI 10.1016/j.cub.2007.07.063

Report

TMS Evidence for the Involvement of the Right Occipital Face Area in Early Face Processing

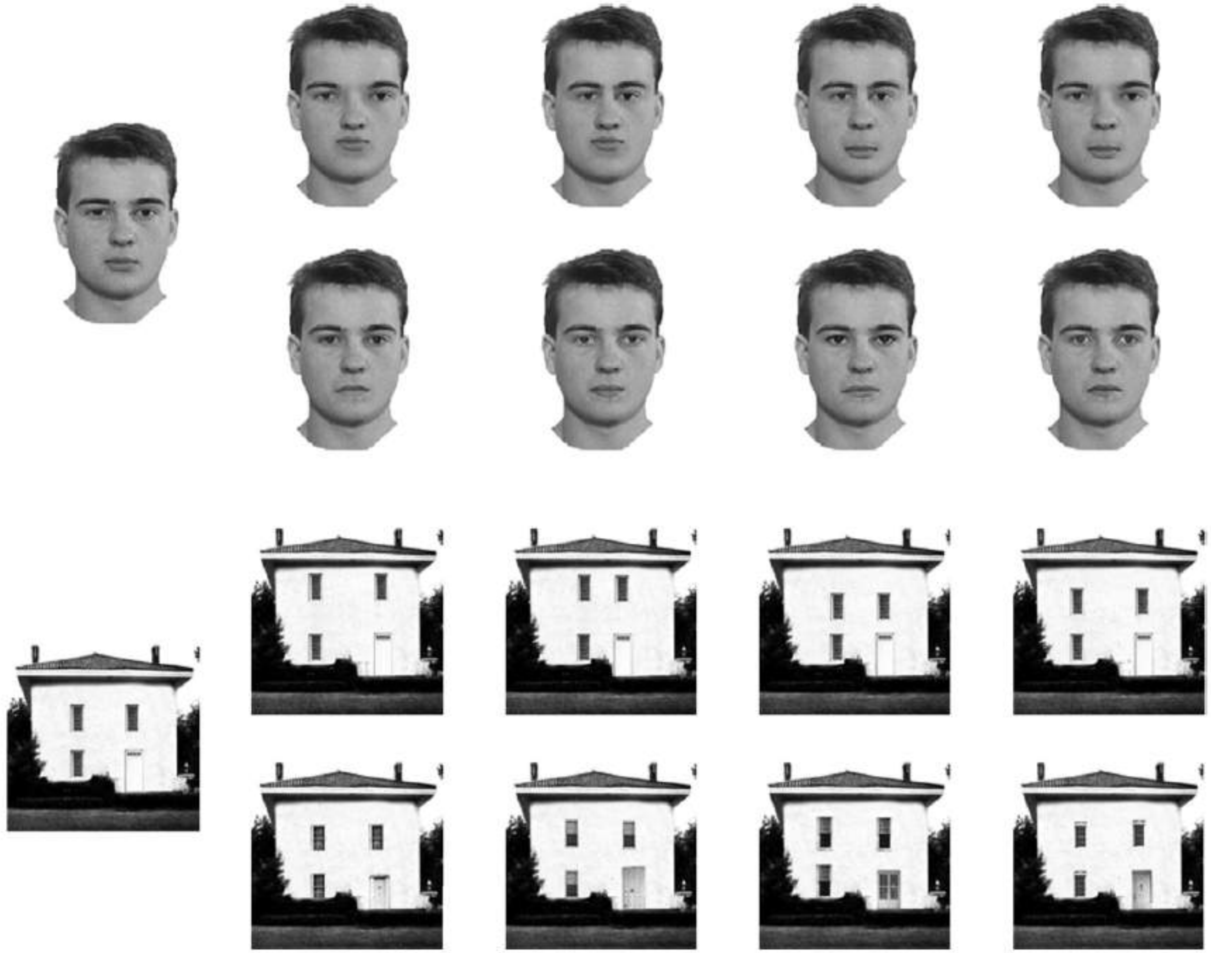


Figure 1. Examples of the Closely Matched Face and House Stimuli

Faces: Two sets of stimuli were generated from an image of a male face. For the spacing set, four faces were constructed by varying the distance between the two eyes and between the mouth and the nose (see Figure 4). For the part set, the two eyes and the mouth were replaced in each of the four faces by eyes and mouths from different faces.

Houses: House stimuli were created with a method similar to that used for the face stimuli. For the spacing set, four houses were constructed by manipulating the location of the windows and the door. For the part set, the windows and the door were replaced by windows and a door with the same shape but different internal features.

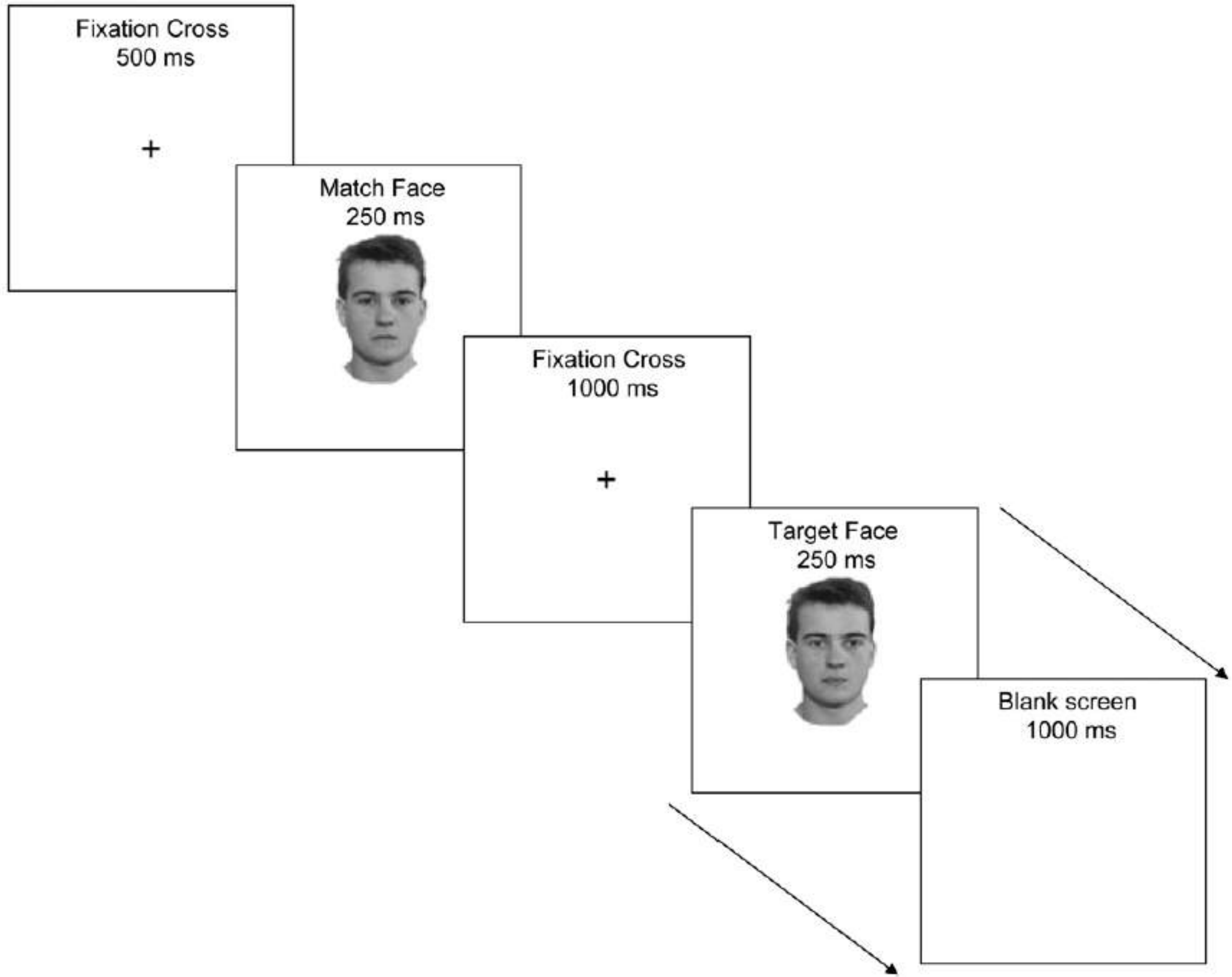
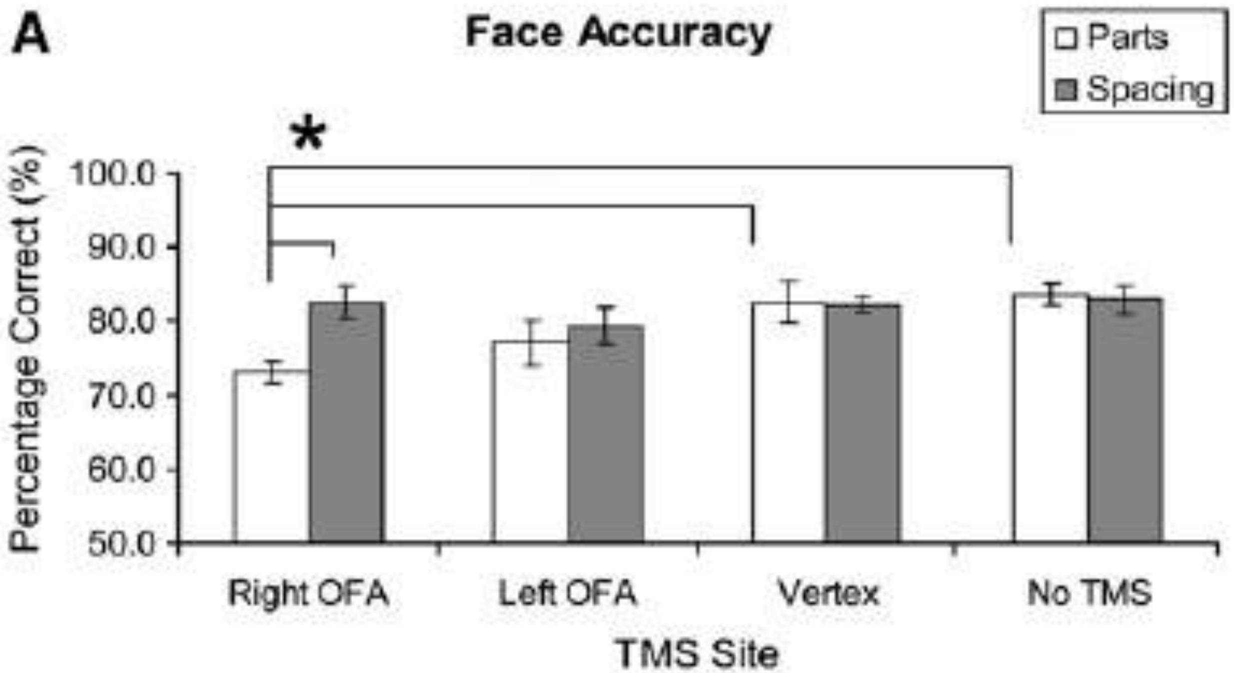


Figure 4. Trial Procedure for Experiments 1, 2, and 3

Timeline of the experimental procedure for experiment 1, experiment 2, and experiment 3 (an example of face-part stimuli is shown). TMS protocol for experiments 1 and 2: 10 Hz for 500 ms; TMS protocol for experiment 3: double-pulse TMS, 40 ms apart delivered at 20 and 60 ms, 60 and 100 ms, 100 and 140 ms, 130 and 170 ms, 170 and 210 ms, 210 and 250 ms.


A
Face Accuracy
Parts
Spacing
*
Percentage Correct (%)
100.0
90.0
80.0
70.0
60.0
50.0
Right OFA
Left OFA
Vertex
No TMS
TMS Site

doi:10.1093/scan/nsm036

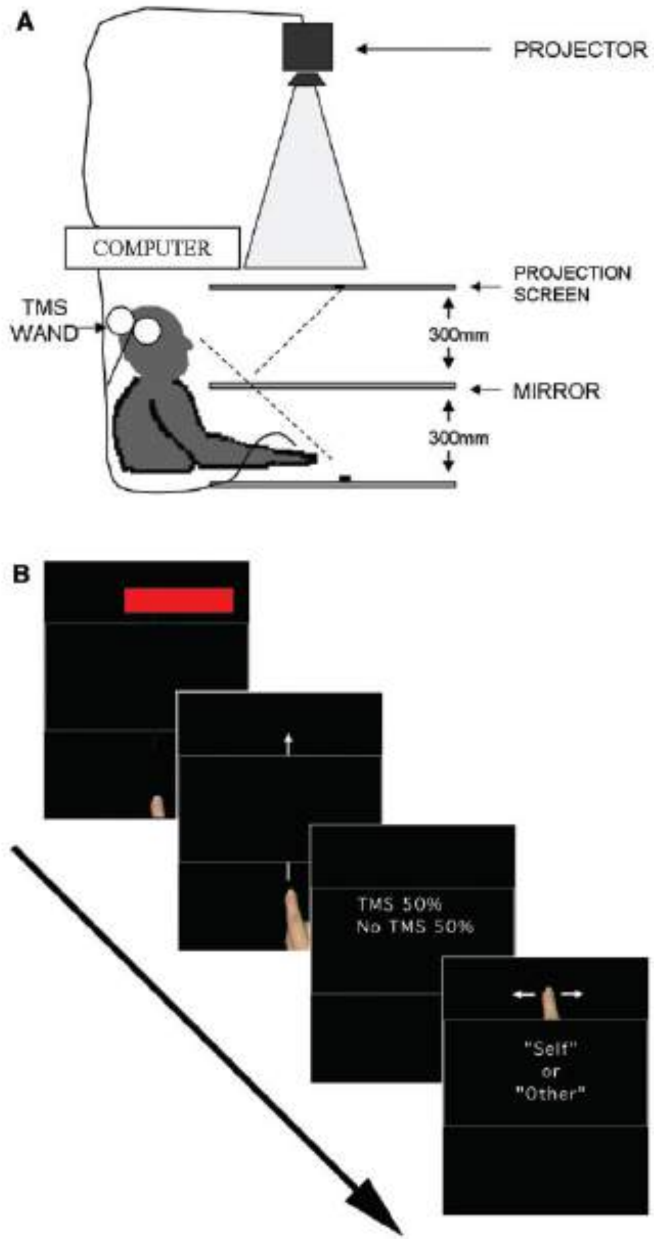
SCAN (2008) 3, 26–32

Misattribution of movement agency following right parietal TMS

Catherine Preston, and Roger Newport
School of Psychology, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

Single pulse transcranial magnetic stimulation (TMS) was used to disrupt the right inferior parietal lobe (rIPL) whilst neurologically intact participants made self/other judgments about whole arm reaching movements. Visual feedback of a physically coincident virtual hand was perturbed or left unperturbed (randomly) while TMS was delivered to either the rIPL or the vertex (blocked). Visual feedback of the virtual hand was veridical until the hand became occluded by a virtual bar approximately half way through the movement. TMS was delivered on 50% of trials at random during occlusion of the hand. The position of the virtual hand relative to the real hand was also perturbed during occlusion of the virtual hand on 50% of trials at random. At the end of the reach participants were required to make a verbal judgment as to whether the movement they had seen was *self* (unperturbed) or *other* (perturbed). The results revealed that when TMS was applied over rIPL, participants were more likely to misattribute agency to the computer, making more *other* responses for both perturbed and unperturbed trials. These findings highlight the role of a parietal neural comparator as a low-level mechanism in the experience of agency.

Keywords: agency attribution; inferior parietal lobe; transcranial magnetic stimulation; self-awareness; social cognition


A
PROJECTOR
COMPUTER
PROJECTION SCREEN
TMS WAND
300mm
MIRROR
300mm
B
TMS 50%
No TMS 50%
"Self"
or
"Other"

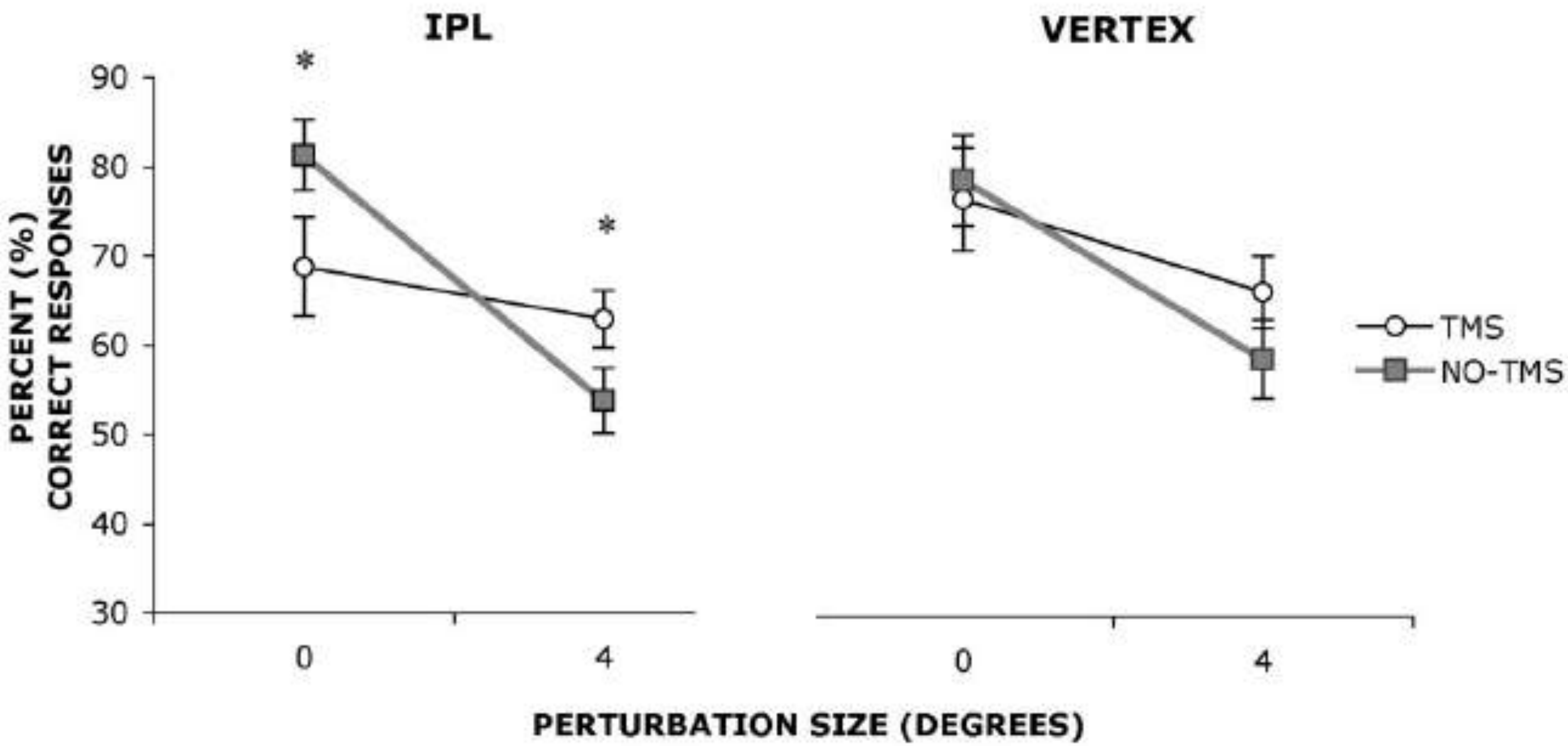


Fig. 2 Percent correct responses for zero-degree (self) and four-degree (other) perturbations when TMS was delivered (open circles) or not delivered (filled squares) over rIPL (left figure) or vertex (right figure). Asterisks denote significant differences revealed by planned comparisons.

Pourquoi des « pseudo lésions » ?

- Les chercheurs peuvent manipuler à leur guise **le lieu**, **la taille** et surtout **le moment d'apparition** de la lésion virtuelle (ou pseudo-lésion).

- L'information chronométrique permet d'**établir à quel moment** différentes régions cérébrales contribuent à un comportement donné.

Avantage par rapport à la neuropsychologie classique

- Le cerveau endommagé est en réorganisation depuis des semaines, des mois, voire des années.
  - Le sujet cérébro-lésé a pu acquérir un large répertoire de stratégies compensatoires
    - Étudie-t-on la fonction de la structure endommagée ou la capacité d’autres circuits corticaux à prendre en charge cette fonction ?

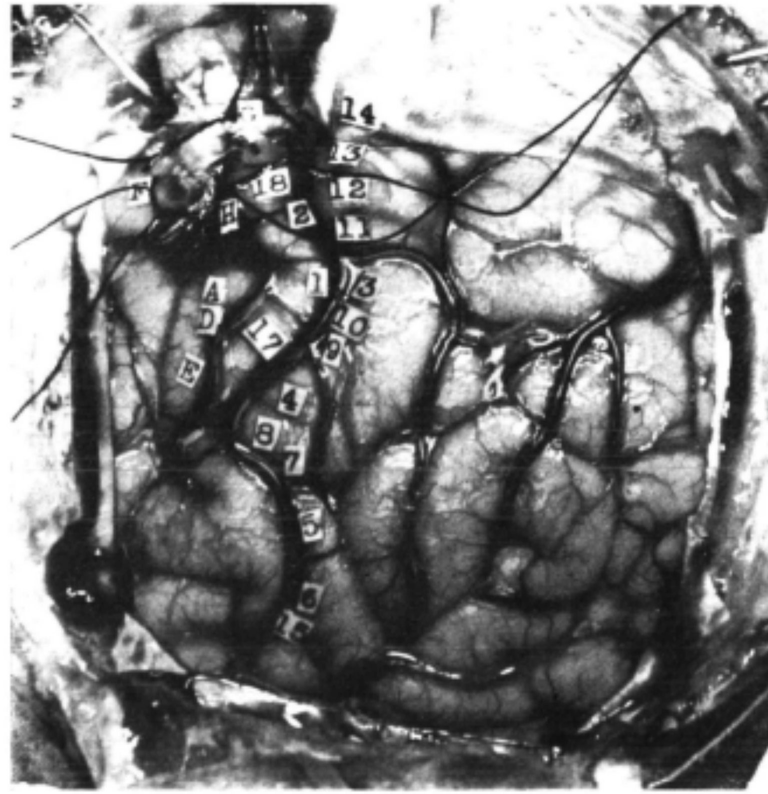
Quelles sont les limites ?

- Problème de localisation spatiale
  - Voir plus haut la diapositive : « plateforme de TMS stéréotaxique couplant la TMS, un système de neuro-navigation et l'enregistrement EEG »

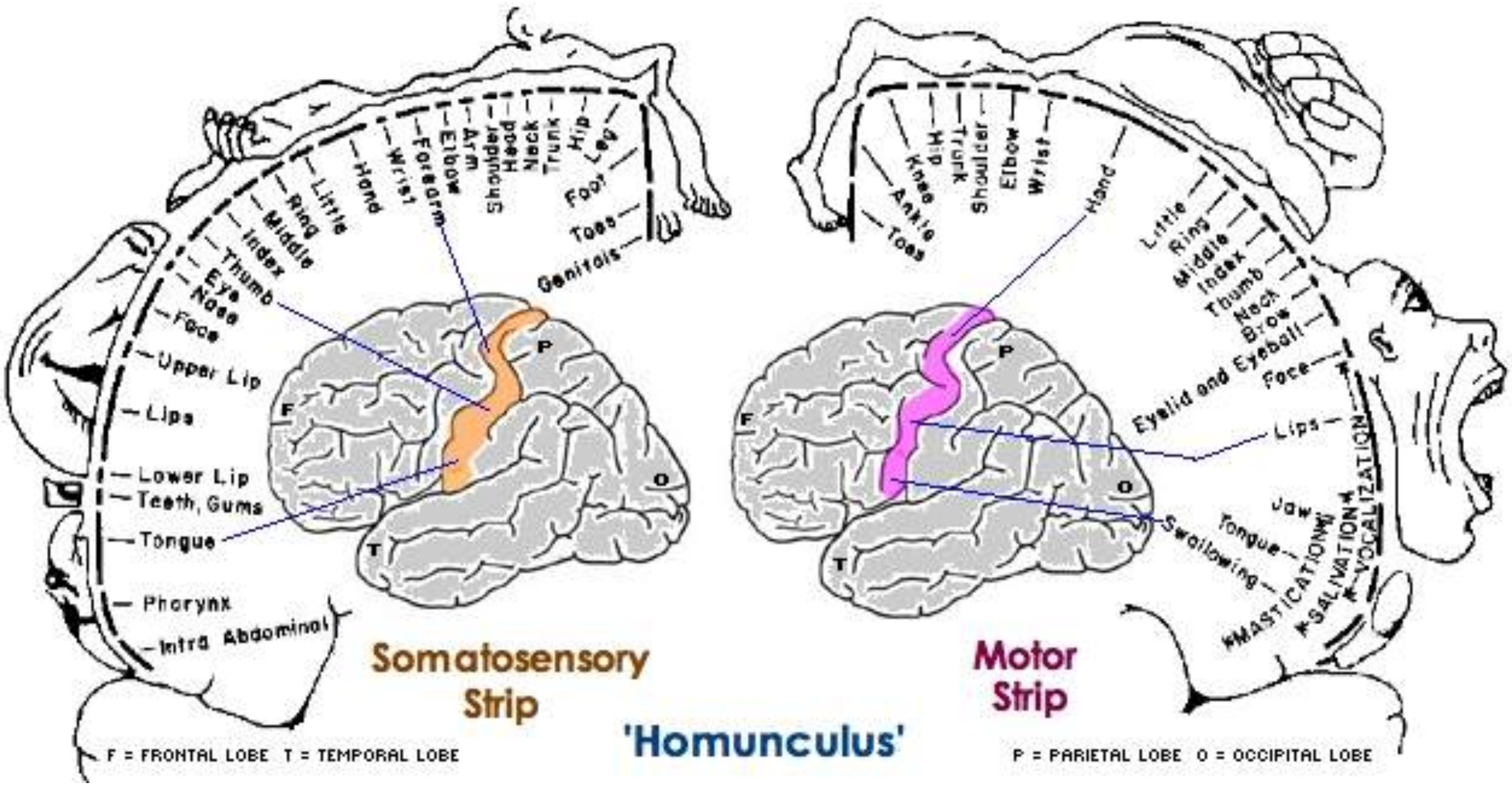
- **Problèmes éthiques**

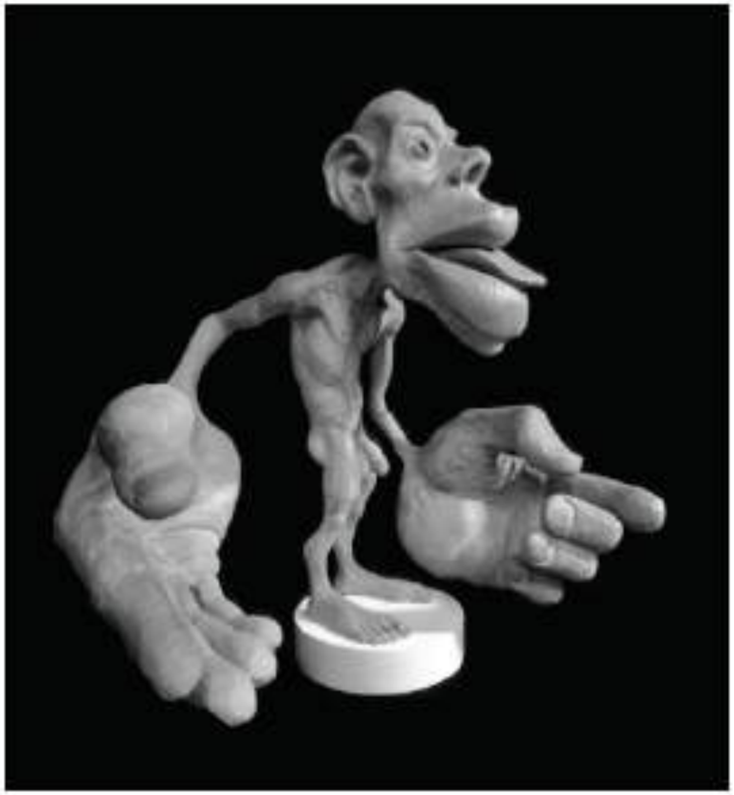
2.2 La stimulation électrique directe du cerveau (SED)

Wilder Penfield
(1891-1976)



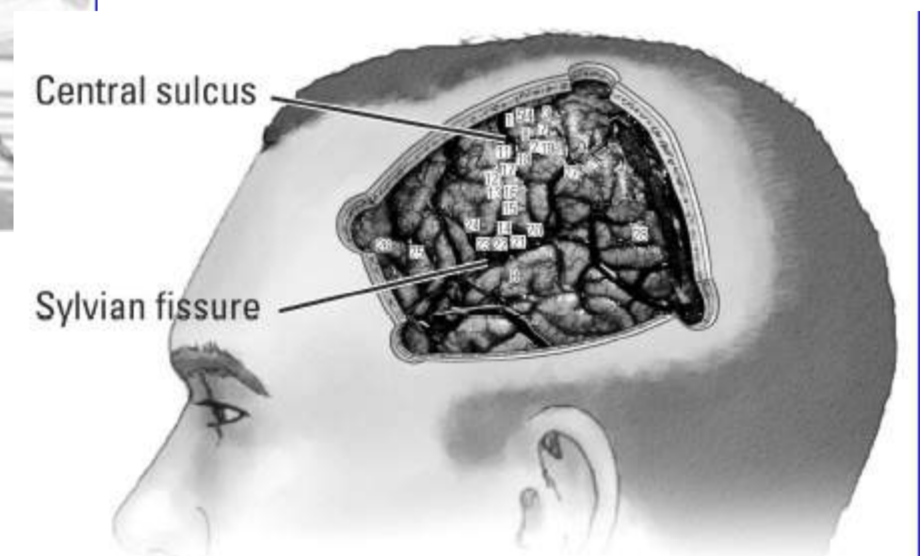
Penfield & Boldrey, 1937


Little
Ring
Middle
Index
Thumb
Eye
Nose
Face
Upper Lip
Lips
Lower Lip
Teeth, Gums
Tongue
Pharynx
Intra Abdominal
Hand
Wrist
Forearm
Elbow
Arm
Shoulder
Head
Neck
Trunk
Hip
Leg
Foot
Toes
Genitals
F
P
T
O
Somatosensory Strip
Toes
Ankle
Knee
Hip
Trunk
Shoulder
Elbow
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Neck
Brow
Eyelid and Eyeball
Face
Lips
Jaw
Tongue
Swallowing
MASTICATION
SALIVATION
VOCALIZATION
Motor Strip
'Homunculus'
F = FRONTAL LOBE T = TEMPORAL LOBE
P = PARIETAL LOBE O = OCCIPITAL LOBE

Ce à quoi nous ressemblerions si nos membres avaient une taille proportionnelle à celle des régions cérébrales correspondantes (perception, gauche; action, droite)

Identification des aires du langage et du contrôle moteur



SED permet de tester les fonctions en temps réel durant l'opération

- Fonctions somatosensorielles
  - Mouvements involontaires ; Dysesthesies (sensations anormales: diminution ou exagération de la sensibilité ; sensations de douleurs engourdissent, picotements, brûlures)

- Langage spontané, dénomination, compréhension, lecture, écriture, bilinguisme, calcul, mémoire, processus visuospatiaux,…..

30 SEPTEMBER 2005 VOL 309 SCIENCE www.sciencemag.org

Direct Evidence for a Parietal-Frontal Pathway Subserving Spatial Awareness in Humans

Michel Thiebaut de Schotten,[1] Marika Urbanski,[1] Hugues Duffau,[2] Emmanuelle Volle,[1,3] Richard Lévy,[1,4] Bruno Dubois,[1,4] Paolo Bartolomeo[1,4*]

Intraoperative electrical stimulation, which temporarily inactivates restricted regions during brain surgery, can map cognitive functions in humans with spatiotemporal resolution unmatched by other methods. Using this technique, we found that stimulation of the right inferior parietal lobule or the caudal superior temporal gyrus, but not of its rostral portion, determined rightward deviations on line bisection. However, the strongest shifts occurred with subcortical stimulation. Fiber tracking identified the stimulated site as a section of the superior occipitofrontal fasciculus, a poorly known parietal-frontal pathway. These findings suggest that parietal-frontal communication is necessary for the symmetrical processing of the visual scene.

CAL: partie caudale du lobe temporal droit

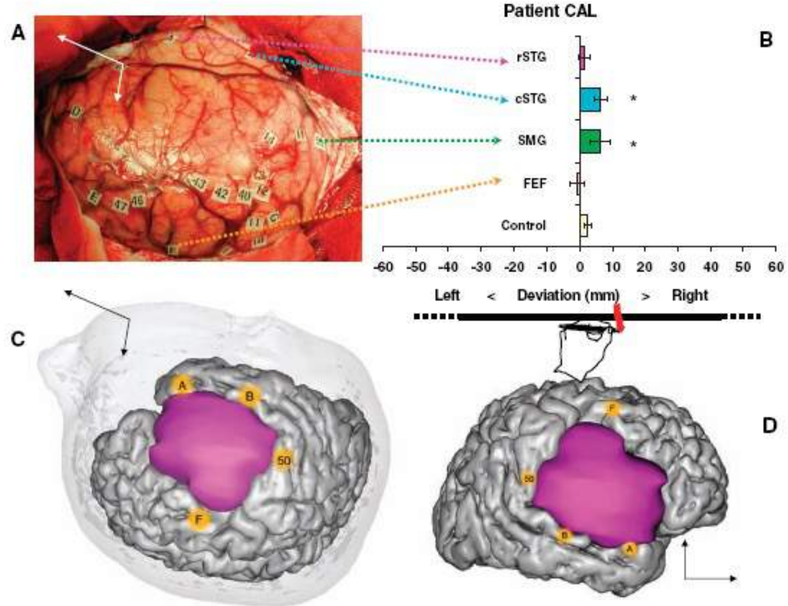


Fig. 1. Performance of patient CAL. (A) The surgical field. (B) Mean deviation (in millimeters) with 95% confidence intervals during stimulation of the rostral part of the superior temporal gyrus (rSTG, label A; $n = 4$), of the caudal part of the STG (cSTG, label B; $n = 2$), of the supramarginal gyrus (SMG, label 50; $n = 4$), of the frontal eye field (FEF, label F; $n = 5$), and of control neighboring regions (superior frontal gyrus, medial frontal gyrus, precentral gyrus, postcentral gyrus, and tumor, $n = 16$). $^*P < 0.05$ (two-tailed) as compared to controls' performance (32). (C) Three-dimensional reconstruction of the tumor mass (in purple) and of the stimulated regions (in yellow). (D) Lateral view.

42: partie sup du faisceau occipito-frontal qui connecte les lobes parietal et frontal

SB: lobule pariétal inf droit

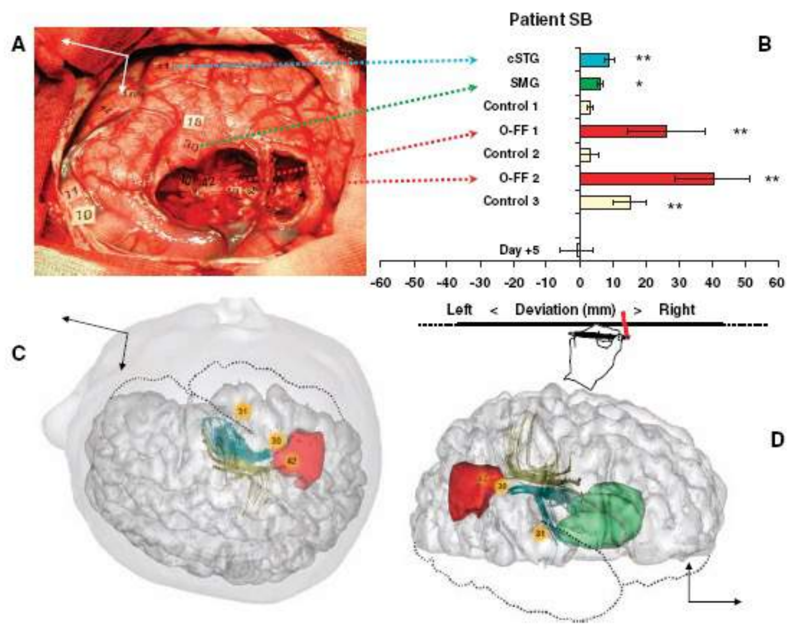


Fig. 2. Performance of patient SB. (A) The surgical field. (B) Mean deviation (in millimeters) with 95% confidence intervals during stimulation of the caudal part of the STG (cSTG, label 31; $n = 6$), of the supramarginal gyrus (SMG, label 30; $n = 4$), of the superior occipitofrontal fasciculus (label 42) during (O-FF 1; $n = 4$) and after tumor resection (O-FF 2, $n = 4$), and of control neighboring regions (postcentral gyrus, lateral occipital gyri, and tumor) before resection (control 1, $n = 27$), during resection (control 2, $n = 38$), and after resection (control 3, $n = 12$). Performance 5 days after surgery is also shown (day +5). $^*P < 0.05$, $^{**}P < 0.01$ (both two-tailed) as compared to controls' performance (32). (C) Three-dimensional reconstruction of the surgical resection (in red) and of the stimulated regions (in yellow), showing their relationships with the superior occipitofrontal fasciculus (in yellow) and the superior longitudinal fasciculus (in blue) (18). The head of the caudate nucleus and the putamen are shown in green. (D) Lateral view.

The Journal of Neuroscience, November 1991, 11(11): 3656–3666

Functional Organization of Human Supplementary Motor Cortex Studied by Electrical Stimulation

Itzhak Fried,[1] Amiram Katz,[1] Gregory McCarthy,[1,2] Kimberlee J. Sass,[1] Peter Williamson,[1,2] Susan S. Spencer,[1] and Dennis D. Spencer[1]

[1]Section of Neurosurgery and Department of Neurology, Yale University School of Medicine, New Haven, Connecticut 06510 and [2]Neurology Service and Neuropsychology Laboratory, Veterans Administration Medical Center, West Haven, Connecticut 06516

The presence of somatotopic organization in the human supplementary motor area (SMA) remains a controversial issue. In this study, subdural electrode grids were placed on the medial surface of the cerebral hemispheres in 13 patients with intractable epilepsy undergoing evaluation for surgical treatment. Electrical stimulation mapping with currents below the threshold of afterdischarges showed somatotopic organization of supplementary motor cortex with the lower extremities represented posteriorly, head and face most anteriorly, and the upper extremities between these two regions. Electrical stimulation often elicited synergistic and complex movements involving more than one joint. In transitional areas between neighboring somatotopic representations, stimulation evoked combined movements involving the body parts represented in these adjacent regions. Anterior to the supplementary motor representation of the face, vocalization and speech arrest or slowing of speech were evoked. Various sensations were elicited by electrical stimulation of SMA. In some cases a preliminary sensation of "urge" to perform a movement or anticipation that a movement was about to occur were evoked. Most responses were contralateral to the stimulated hemisphere. Ipsilateral and bilateral responses were elicited almost exclusively from the right (nondominant) hemisphere. These data suggest the presence of combined somatotopic organization and left–right specialization in human supplementary motor cortex.

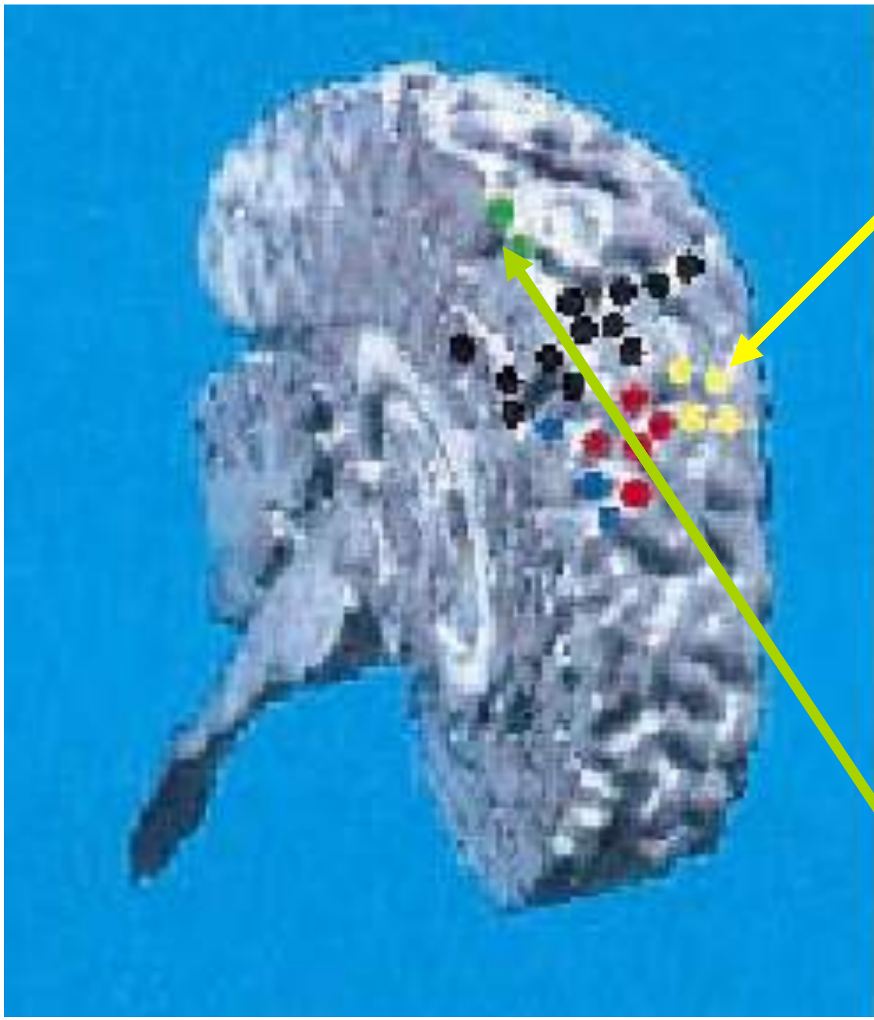
L'intention motrice

Expérience consciente de la volonté d'effectuer un mouvement précis

déclenchée par le neuro-chirurgien

Fried et al. (1991). Direct stimulation of the supplementary motor area in man. A strip of electrodes is used to stimulate the cerebral cortex as part of pre-operative procedure before neurosurgery for severe epilepsy. When the SMA (electrodes outlined in red) was stimulated, subjects reported the sensation of an urge to move their limbs. More intense stimulation at the same locations provoked physical movements of the corresponding limb

Éclats de rire induits par SE de la partie antérieure de l'AMS



- Rires
- Interruption du langage
- Interruption de la capacité à nommer les objets
- Interruption des activités manuelles
- Mouvements impliquant les bras et les avant-bras
- Sensations de frôlement

Fried et al. (1998). Electrical current stimulates laughter, ***Nature***, 391, 650.

Disrupting posterior cingulate connectivity disconnects consciousness from the external environment

Guillaume Herbet [a,b,c,*], Gilles Lafargue [d], Nicolas Menjot de Champfleur [b,e], Sylvie Moritz-Gasser [b,f], Emmanuelle le Bars [b,e], François Bonnetblanc [g,h], Hugues Duffau [a,b]

[a] *Department of Neurosurgery, Montpellier University Medical Center, Montpellier 34295, France*
[b] *Institute for Neuroscience of Montpellier, INSERM U-1051, Hôpital Saint Eloi, Montpellier 34298, France*
[c] *University of Montpellier 1, Montpellier 34967, France*
[d] *Functional Neuroscience and Pathologies Lab, EA-4559, Université Lille Nord de France, Loos 59120, France*
[e] *Department of Neuroradiology, Montpellier University Medical Center, Montpellier 34295, France*
[f] *Department of Neurology, Montpellier University Medical Center, Montpellier 34295, France*
[g] *Cognition, Action and Sensorimotor Plasticity Lab, INSERM U-1093, UFR STAPS, Dijon 21078, France*
[h] *University of Montpellier 2, LIRMM, DEMAR Team, CNRS, INRIA, Montpellier 34095, France*

ARTICLE INFO

Article history:
Received 21 November 2013
Received in revised form
5 January 2014
Accepted 27 January 2014
Available online 4 February 2014

Keywords:
Posterior cingulate
Precuneus
External awareness
Consciousness disorders
Electrical stimulations

ABSTRACT

Neurophysiological and neuroimaging studies including both patients with disorders of consciousness and healthy subjects with modified states of consciousness suggest a crucial role of the medial posteroparietal cortex in conscious information processing. However no direct neuropsychological evidence supports this hypothesis and studies including patients with restricted lesions of this brain region are almost non-existent. Using direct intraoperative electrostimulations, we showed in a rare patient that disrupting the subcortical connectivity of the left posterior cingulate cortex (PCC) reliably induced a breakdown in conscious experience. This acute phenomenon was mainly characterized by a transient behavioral unresponsiveness with loss of external connectedness. In all cases, when he regained consciousness, the patient described himself as in dream, outside the operating room. This finding suggests that functional integrity of the PPC connectivity is necessary for maintaining consciousness of external environment.

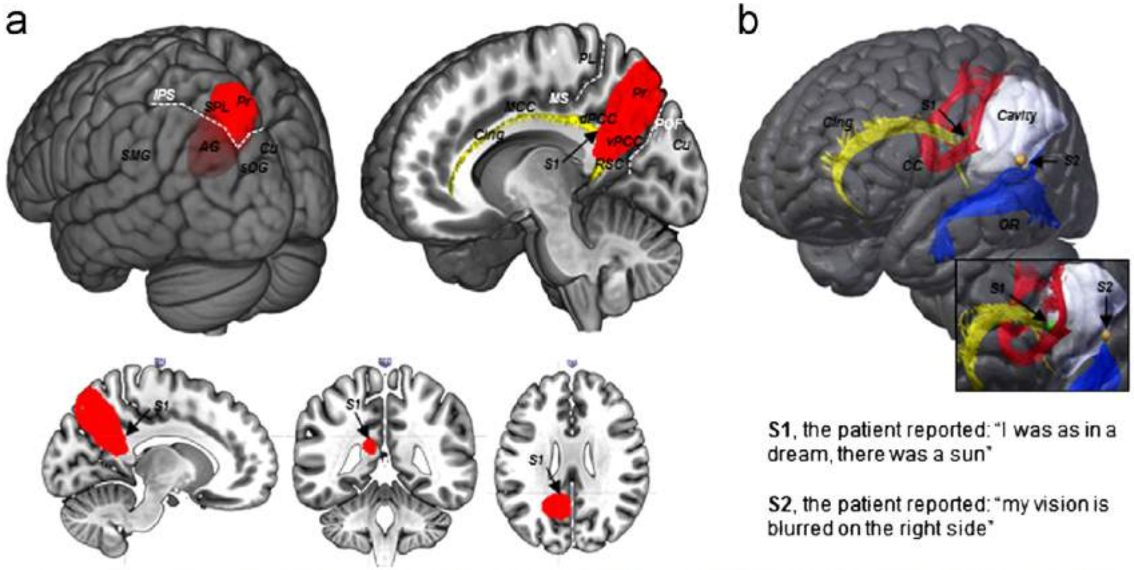


Fig. 1. Anatomical location of the "dream-like state" stimulation. (a) Location of the stimulation relative to the resective cavity. The "dream-like state" stimulation (S1) was applied on the white matter underlying the left posterior cingulate (black arrow, MNI coordinates: −12, −44, 27). (b) Tractography reconstruction. Whereas the "dream-like state" stimulation (S1) was identified close to the cingulum, the "visual blur" stimulation was identified close to optic radiations (S2). Pr=precuneus, PL=paracentral lobule, vPCC=ventral posterior cingulate cortex, dPCC=dorsal posterior cingulate cortex, MCC=middle cingulate cortex, RSC=retrosplenial cortex, SPL=Superior parietal lobule, Cu=cuneus, AG=angular gyrus, SMG=supramarginal gyrus, IPS=intraparietal sulcus, SOG=superior occipital gyrus, MS=marginal sulcus, POF=parieto-occipital fissure, Cing=cingulum, CC=corpus callosum, OR=optic radiations.

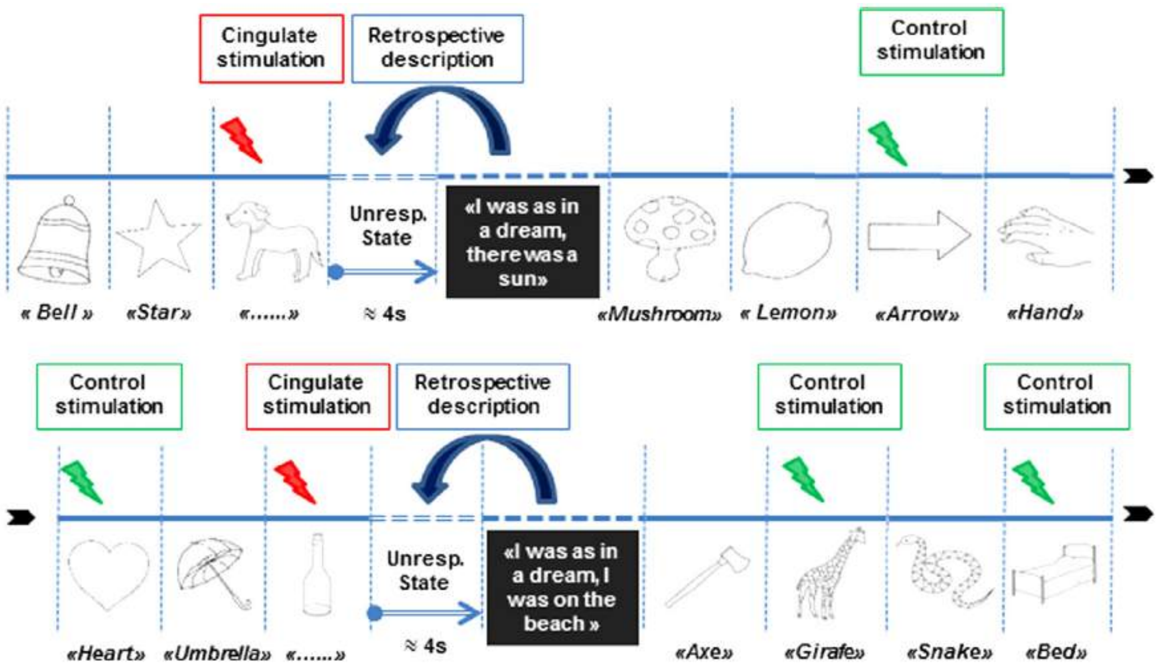


Fig. 2. Schematic description of the intraoperative protocol. Each responsive stimulation (red lightning; three stimulations sum-total applied on the same anatomical location) was followed by two no responsive control stimulations (green lightning; six stimulations sum-total applied on the anatomical space surrounding the responsive site, with a minimal distance of 5 mm that corresponds to the spatial resolution of the bipolar electrode). Note that the same protocol was applied regarding the "visual blur" phenomenon. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Enregistrer **directement** ou **indirectement** l'activité neuronale du cerveau

3.1 Enregistrement (direct) de l'activité de neurones uniques chez le sujet humain éveillé

nature Vol 435|23 June 2005|doi:10.1038/nature03687

LETTERS

Invariant visual representation by single neurons in the human brain

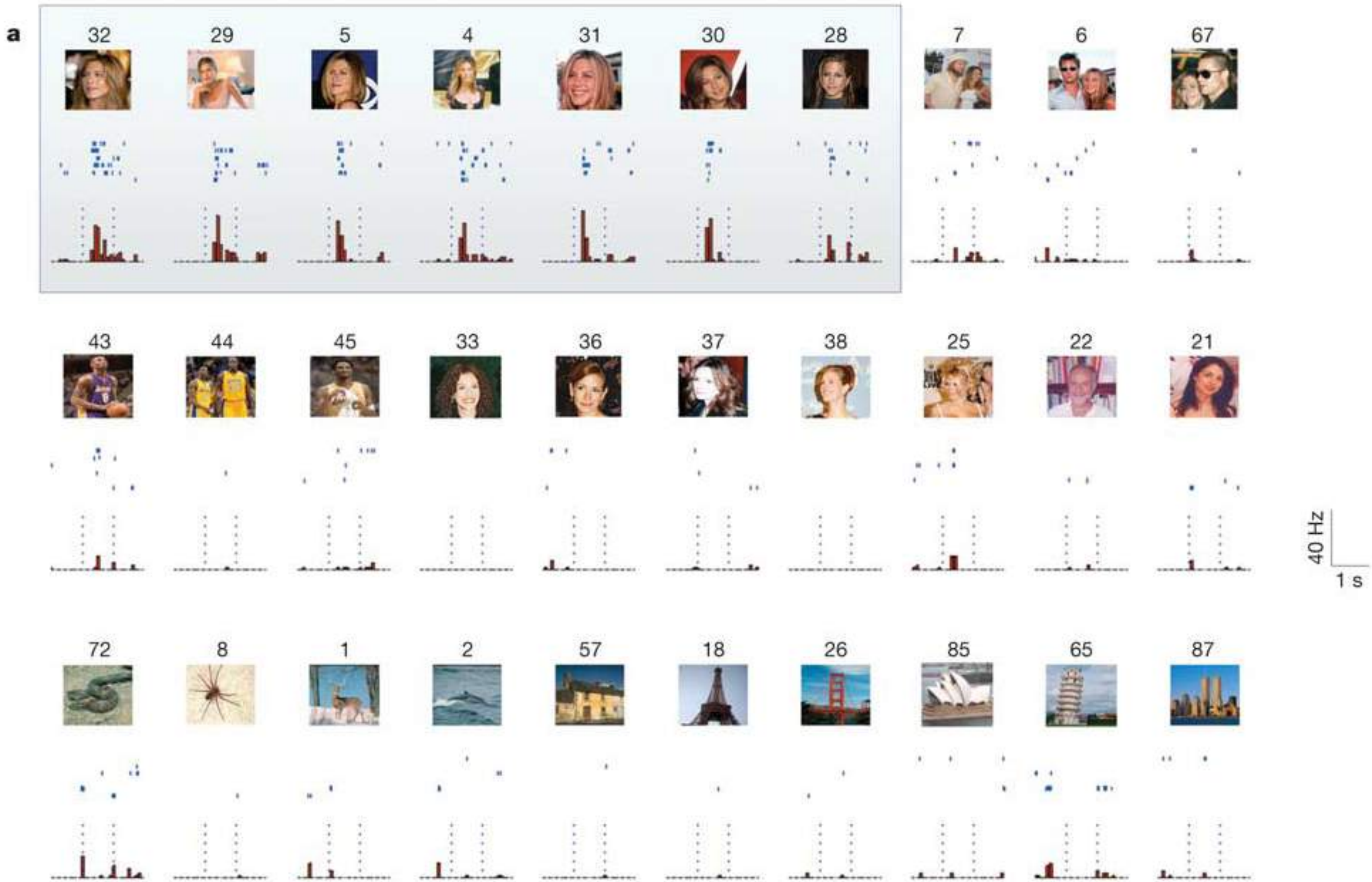
R. Quian Quiroga[1,2]†, L. Reddy[1], G. Kreiman[3], C. Koch[1] & I. Fried[2,4]

It takes a fraction of a second to recognize a person or an object even when seen under strikingly different conditions. How such a robust, high-level representation is achieved by neurons in the human brain is still unclear[1–6]. In monkeys, neurons in the upper stages of the ventral visual pathway respond to complex images such as faces and objects and show some degree of invariance to metric properties such as the stimulus size, position and viewing angle[2,4,7–12]. We have previously shown that neurons in the human medial temporal lobe (MTL) fire selectively to images of faces, animals, objects or scenes[13,14]. Here we report on a remarkable subset of MTL neurons that are selectively activated by strikingly different pictures of given individuals, landmarks or objects and in some cases even by letter strings with their names. These results suggest an invariant, sparse and explicit code, which might be important in the transformation of complex visual percepts into long-term and more abstract memories.

patient. The mean number of images in the screening session was 93.9 (range 71–114). The data were quickly analysed offline to determine the stimuli that elicited responses in at least one unit (see definition of response below). Subsequently, in later sessions (testing sessions) between three and eight variants of all the stimuli that had previously elicited a response were shown. If not enough stimuli elicited significant responses in the screening session, we chose those stimuli with the strongest responses. On average, 88.6 (range 70–110) different images showing distinct views of 14 individuals or objects (range 7–23) were used in the testing sessions. Single views of random stimuli (for example, famous and non-famous faces, houses, animals, etc) were also included. The total number of stimuli was determined by the time available with the patient (about 30 min on average). Because in our clinical set-up the recording conditions can sometimes change within a few hours, we always tried to perform the testing sessions shortly after the screening

- Au cours du bilan pré-chirurgical, certains patients épileptiques sont implantés à l'aide d'électrodes intra-cérébrales. Certaines de ces électrodes sont munies à leur extrémité de microélectrodes (permettant ainsi de recueillir l'activité de neurones uniques chez un sujet humain conscient.)

  - ➢Cet outil exceptionnel permet d'enregistrer chaque potentiel d'action d'un neurone cortical tandis que le sujet se livre à telle ou telle tâche expérimentale. En moyennant l'activité recueillie à travers plusieurs essais, on peut extraire la réponse moyennée de ce neurone.



Réponse d'un neurone unique hippocampique à des photographies. Ce neurone répond exclusivement à la comédienne Jennifer Aniston ; il ne décharge pas en réponse à d'autres visages féminins, masculins ou à d'autres stimuli.

3.2 Enregistrement direct de l'activité de populations de neurones

A direct intracranial record of emotions evoked by subliminal words

Lionel Naccache[*,†,‡,§], Raphaël Gaillard[*,†], Claude Adam[‡], Dominique Hasboun[‡], Stéphane Clémenceau[¶], Michel Baulac[‡], Stanislas Dehaene[*], and Laurent Cohen[*,‡]

[*]Institut National de la Santé et de la Recherche Médicale, Unité 562, Institut Fédératif de Recherche 49, Commissariat à l'Energie Atomique/Département de la Recherche Médicale/Direction des Sciences du Vivant, 91401 Orsay Cedex, France; and Departments of [†]Clinical Neurophysiology, [‡]Neurology, and [¶]Neurosurgery, Hôpital de la Salpêtriere, 47 Boulevard de l'Hôpital, Institut Fédératif de Recherche 70, 75013 Paris Cedex, France

Edited by Edward E. Smith, Columbia University, New York, NY, and approved April 5, 2005 (received for review January 21, 2005)

A classical but still open issue in cognitive psychology concerns the depth of subliminal processing. Can the meaning of undetected words be accessed in the absence of consciousness? Subliminal priming experiments in normal subjects have revealed only small effects whose interpretation remains controversial. Here, we provide a direct demonstration of semantic access for unseen masked words. In three epileptic patients with intracranial electrodes, we recorded brain potentials from the amygdala, a neural structure that responds to fearful or threatening stimuli presented in various modalities, including written words. We show that the subliminal presentation of emotional words modulates the activity of the amygdala at a long latency (>800 ms). Our result indicates that subliminal words can trigger long-lasting cerebral processes, including semantic access to emotional valence.

amygdala | semantic | visual masking

words "smut" and "bile" as negative, the subliminal prime "smile" primed the negative response, not the positive one. This result suggests that the priming effect, in this particular situation, was not due to a subliminal access to semantics. Rather, subjects had learned to respond rapidly to fragments of the target strings with specific left or right key presses, and this sensorimotor learning generalized to other primes made of the same fragments (7).

Currently, the single category of words for which a convincing set of reports demonstrated nonconscious semantic processing, including generalization to novel primes, are number words (8–11). For nonnumerical words, although many important studies have suggested subliminal access to semantics (1, 12, 13), there is yet no uncontroversial evidence that fulfills the two criteria outlined above, namely convincing proof of lack of conscious perception and rejection of the direct sensorimotor specification hypothesis. The interpretation of this absence of

- Chez des patients épileptiques implantés ou chez des patients souffrant de maladie de Parkinson, il est possible d'enregistrer à l'aide d'électrodes intra-cérébrales l'activité correspondant à l'activité sommée de populations de neurones .

  - « C 'est ainsi, par exemple, qu'on a pu enregistrer la réponse neurale de l'amygdale, une structure impliquée dans la perception des émotions. En présentant des mots à forte valence émotionnelle (ex : « MORT », « PEUR », « VIOL »,…) ou des mots neutres (ex : « TABLE », COUSIN, « VOILE »), il a été observé que l'activité de l'amygdale était modulée par ce paramètres sémantique qu'est la valence émotionnelle du mot. »

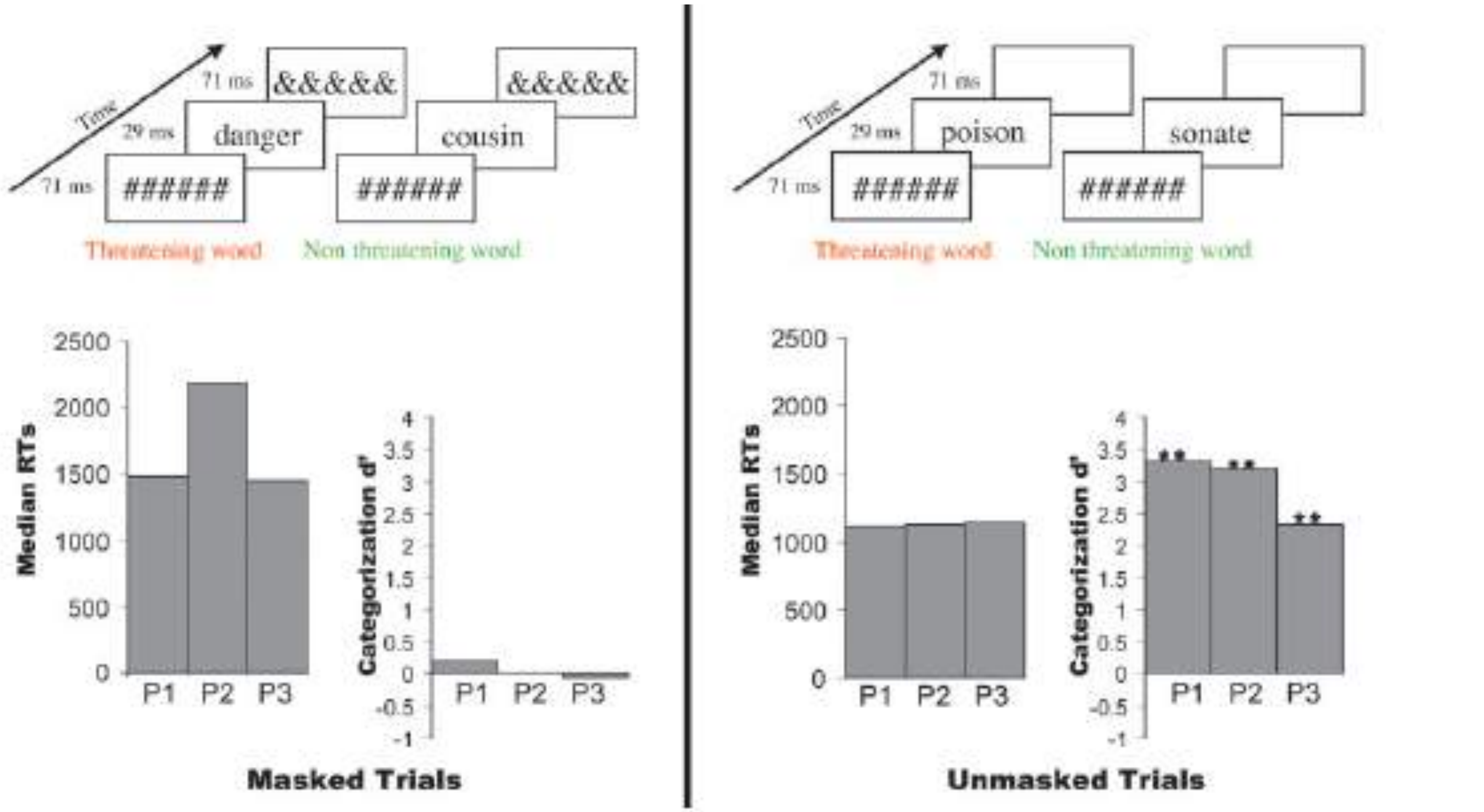


Fig. 1. Experimental paradigm and behavior. Subjects categorized a 29-ms flashed word as either threatening or neutral. Each word was preceded by a 71-ms mask made of six hash-mark symbols. Masked words were followed by 71-ms ampersands postmask, whereas, on visible trials, no postmask was presented. Reaction times (RTs, in ms) were longer for masked than for unmasked words in the three patients. Although objective word emotional valence categorization assessed by signal detection theory d' was excellent for unmasked words (**, $P < 0.01$ in χ^2 tests), it dropped to chance level for masked words in each of the three patients.

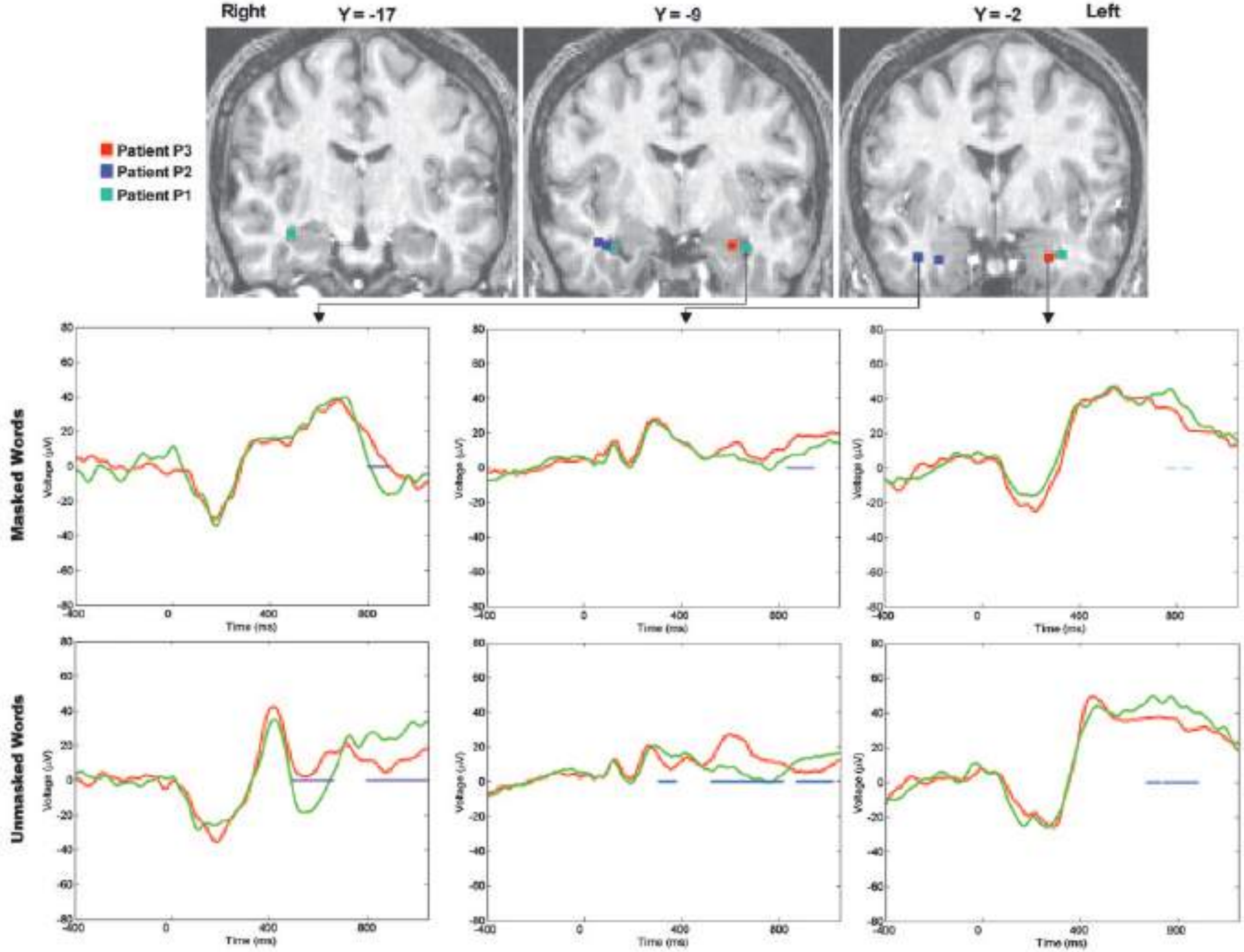
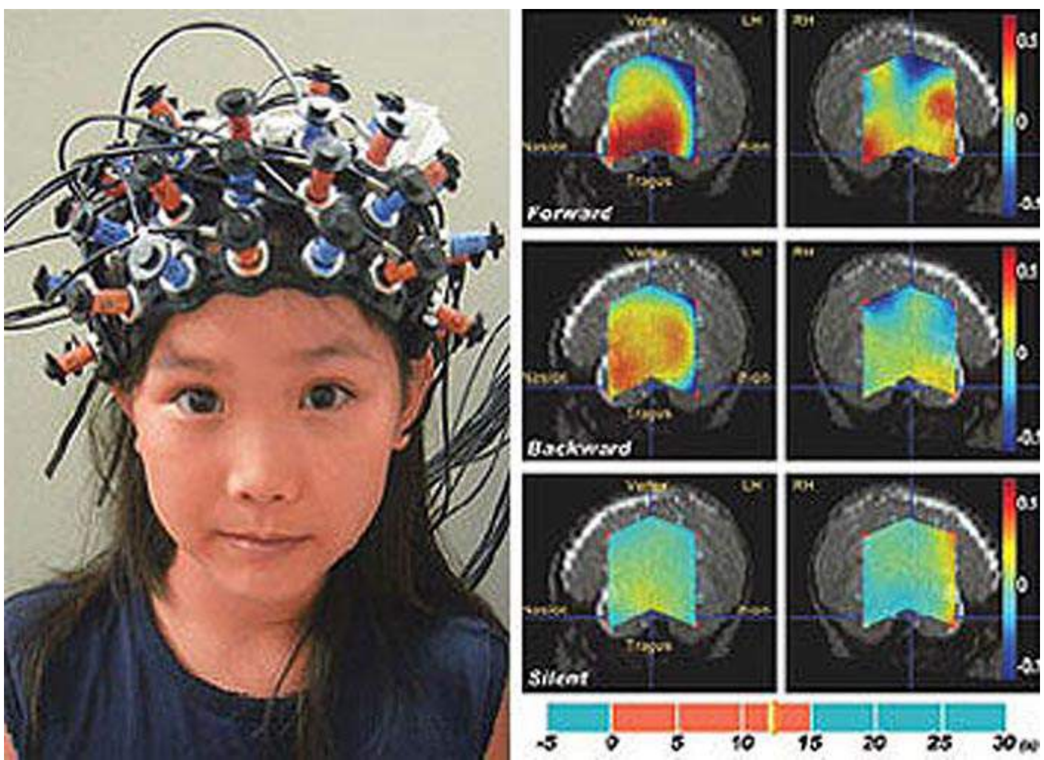


Fig. 2. Effects of threat recorded in the amygdala for nonconscious and conscious words. (*Top*) Three coronal slices of P1 normalized brain with the locations of the 10 electrodes used to record intracranial local field potential. (*Middle* and *Bottom*) For each patient, one electrode is selected (arrows), and the corresponding ERPs are shown for threatening (red) and nonthreatening (green) words in the masked (*Middle*) and unmasked (*Bottom*) conditions. Significant differences are indicated by blue (30 successive samples with $P < 0.05$ in a bilateral t test) or cyan (15 successive samples with $P < 0.05$ in a bilateral t test) horizontal bars. In the three patients, a significant difference between threatening and nonthreatening masked words was observed ≈870 ms after word presentation. A polarity inversion for the most internal and anterior electrode (rightmost panels) tentatively suggests a generator located within the lateral amygdalar nucleus. In the three patients, unmasked words elicited earlier, more ample, and sustained responses within the same electrodes.

3.3 Enregistrement de l’activité neurale globale du cerveau

3.2.1 L’électroencéphalographie (EEG)



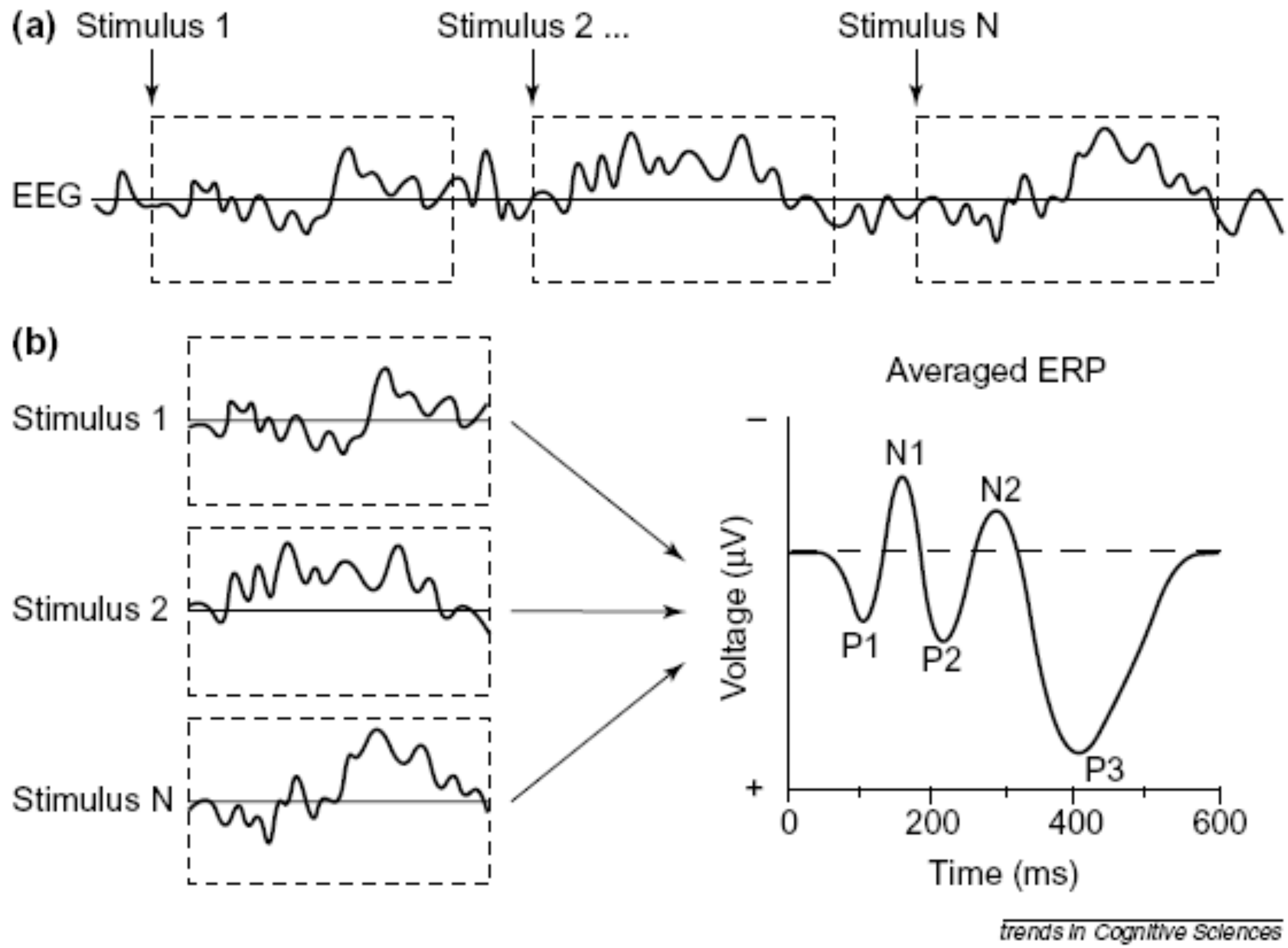


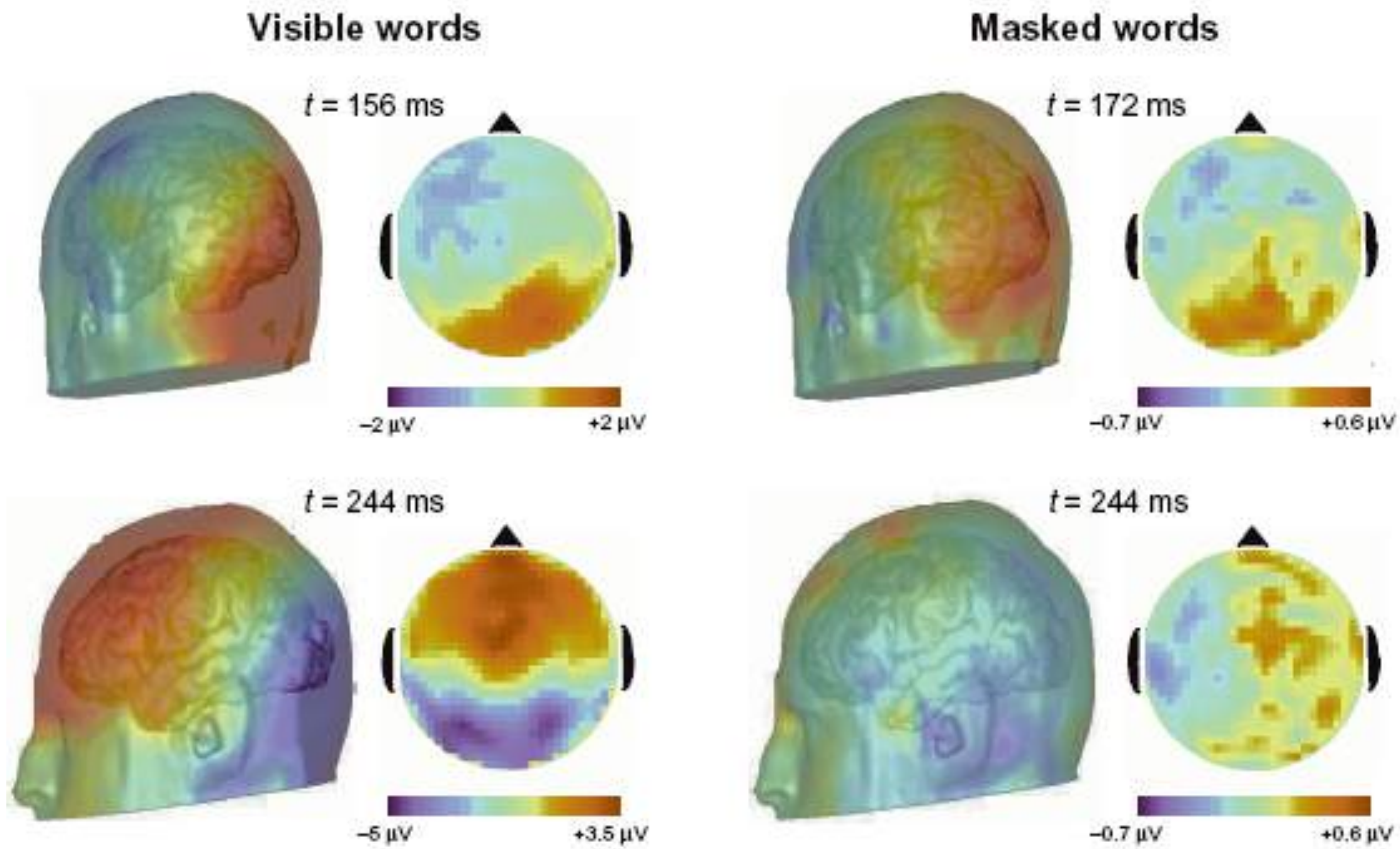
Fig. I. Extraction of the ERP waveform from the ongoing EEG. (a) Stimuli (1... N) are presented while the EEG is being recorded, but the specific response to each stimulus is too small to be seen in the much larger EEG. **(b)** To isolate the ERP from the ongoing EEG, the EEG segments following each stimulus are extracted and averaged together to create the averaged ERP waveform.

Luck, S. J., Woodman, G. F., and Vogel, E. K. (2000). Event-related potential studies of attention. Trends Cogn Sci

- Alors que l'EEG est enregistré en continu, on découpe les segments d'EEG synchronisés avec un stimulus ou une réponse comportementale, puis on réaligne ces essais et on moyenne point par point le signal EEG.

- L'hypothèse sous-jacente est qu'à chaque essai l'activité EEG comporte un faible signal reproductible (le potentiel évoqué ou évènementiel) noyé dans une activité EEG tout à fait indépendante.

- L'inspection d'un essai unique ne permet pas d'extraire le PE, mais en moyennant les essais, le rapport signal/bruit augmente, et on peut extraire le PE dont l'amplitude est souvent de l'ordre du millionième de volt, alors que l'EEG global est de l'ordre de plusieurs centaines de millivolts, soit un facteur 1000.



Dehaene et al. ***Nature Neuroscience,*** 2001

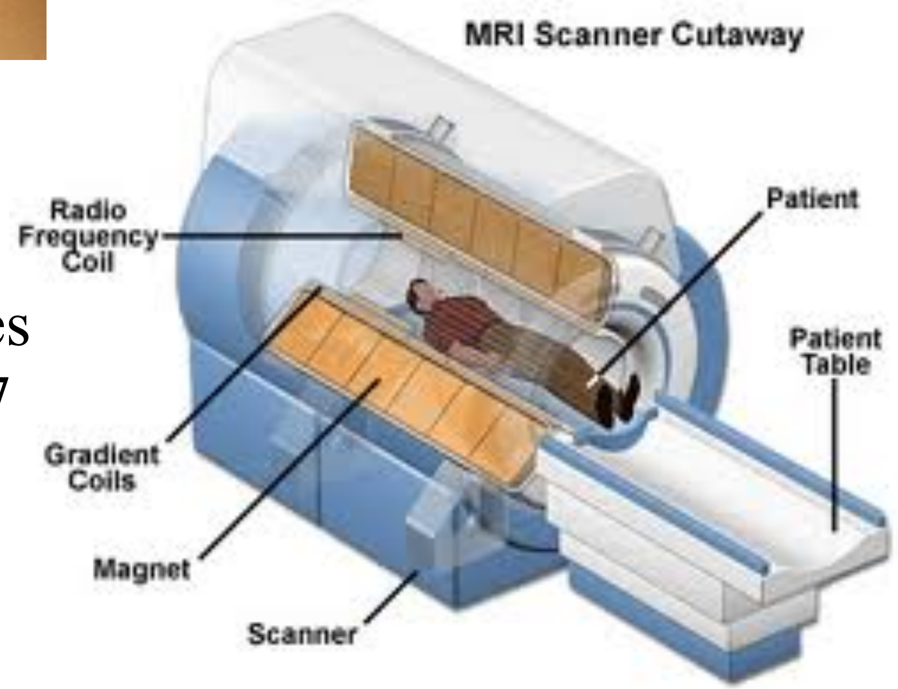
3.2.1 La magnétoencéphalographie (MEG)

- Permet de mesurer les champs magnétiques induits par les variations de potentiel électrique du cortex cérébral
  - Complémentaire de l'EEG, meilleures résolution spatiale

3.3 Enregistrement indirect de l’activité neuronale du cerveau

L’imagerie par résonnance magnétique fonctionnelle (IRMf)

- **L'imagerie par résonnance magnétique fonctionnelle (IRMf)**
  - Non invasive (pas d'injection de produit radioactif) contrairement à la TEP (tomographie à émission de positons ; injection d'un marqueur radioactif par voie sanguine)
  - Consiste à enregistrer les variations hémodynamiques dans les différentes régions cérébrales
    - La localisation s'appuie sur l'effet BOLD (blood oxygen level dependant) dû à l'aimentation de la désoxyhémoglobine contenue dans les globules rouges du sang

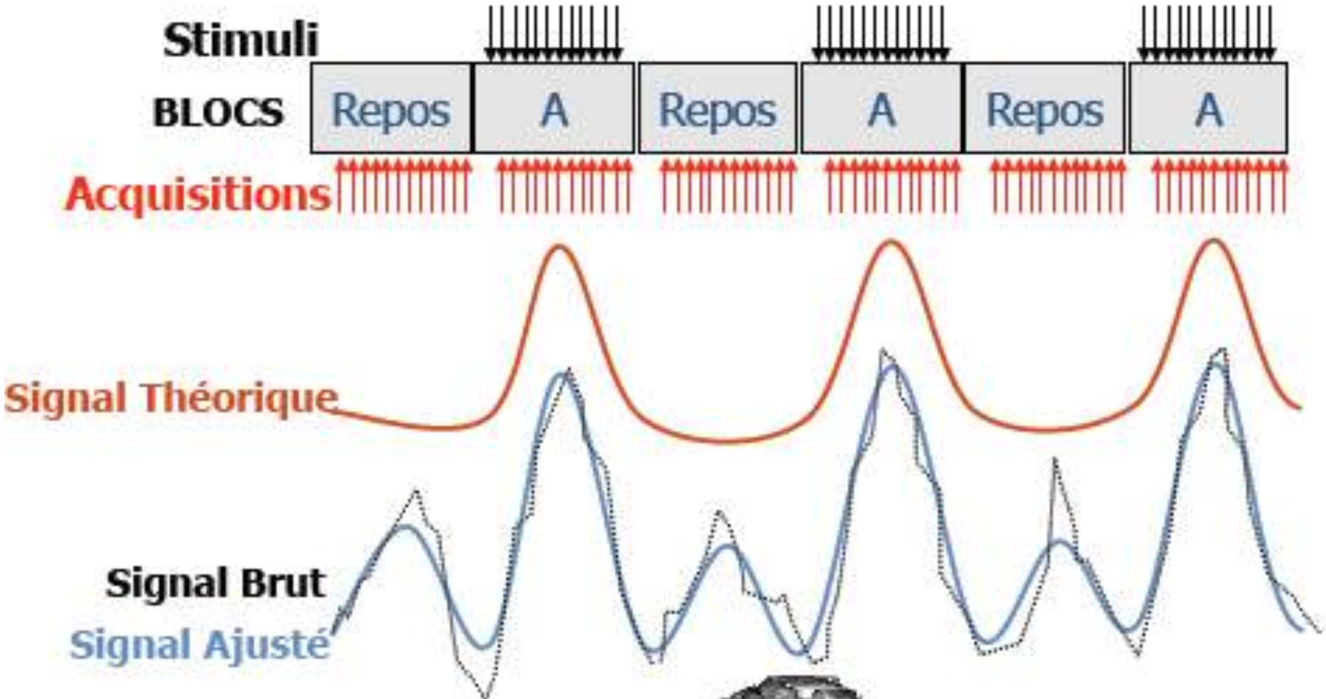


Les intensités de champs magnétiques utilisées sont comprises entre 0,1 et 7 Tesla.

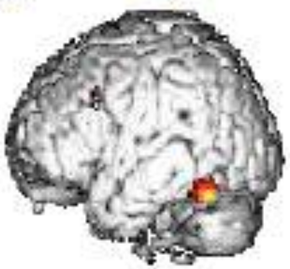
1,5 T équivaut à 30 000 fois l'intensité du champ magnétique terrestre

- **Deux types de protocoles**
  - En bloc : les activités sont organisées en blocs de quelques dizaines de secondes qui alternent à intervalles réguliers. Au sein d'un même bloc, les réponses hémodynamiques vont se chevaucher et s'accumuler avant de former un plateau.
  - Evénementiel : les activités ou stimuli sont uniques ou présentés en courtes répétitions, avec un enchaînement qui peut être pseudo-aléatoire (ce qui évite le phénomène d'anticipation), et avec mesure possible de la performance de la réponse (délai et exactitude de la réponse…). On évalue ainsi la réponse hémodynamique locale lors des différentes activités.

Imagerie Fonctionnelle cérébrale : « Block Design »



Résultat: une région qui réagit spécifiquement à la condition de stimulation A



Résolution Spatiale

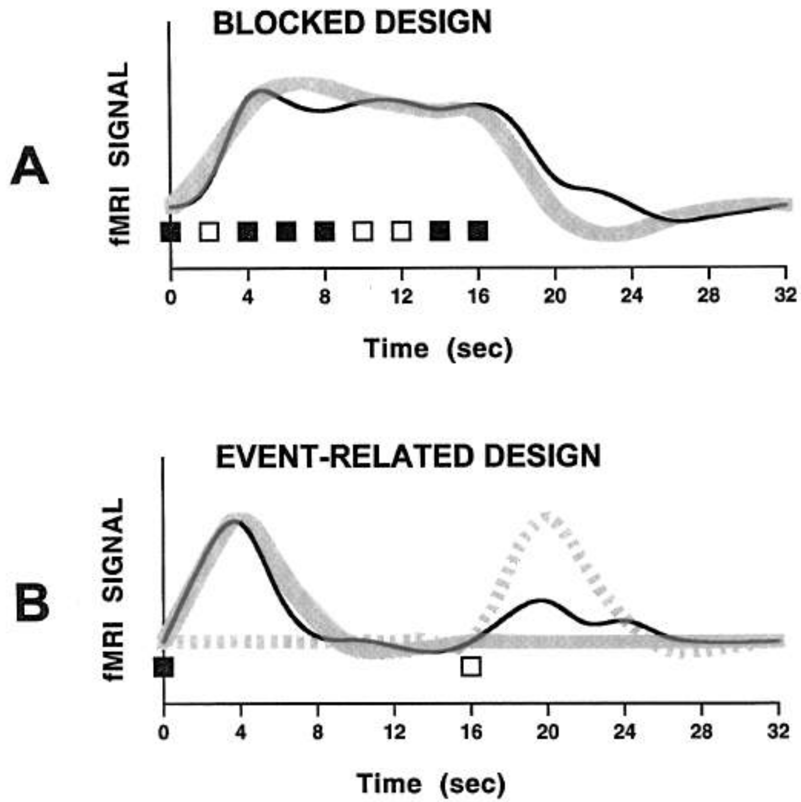
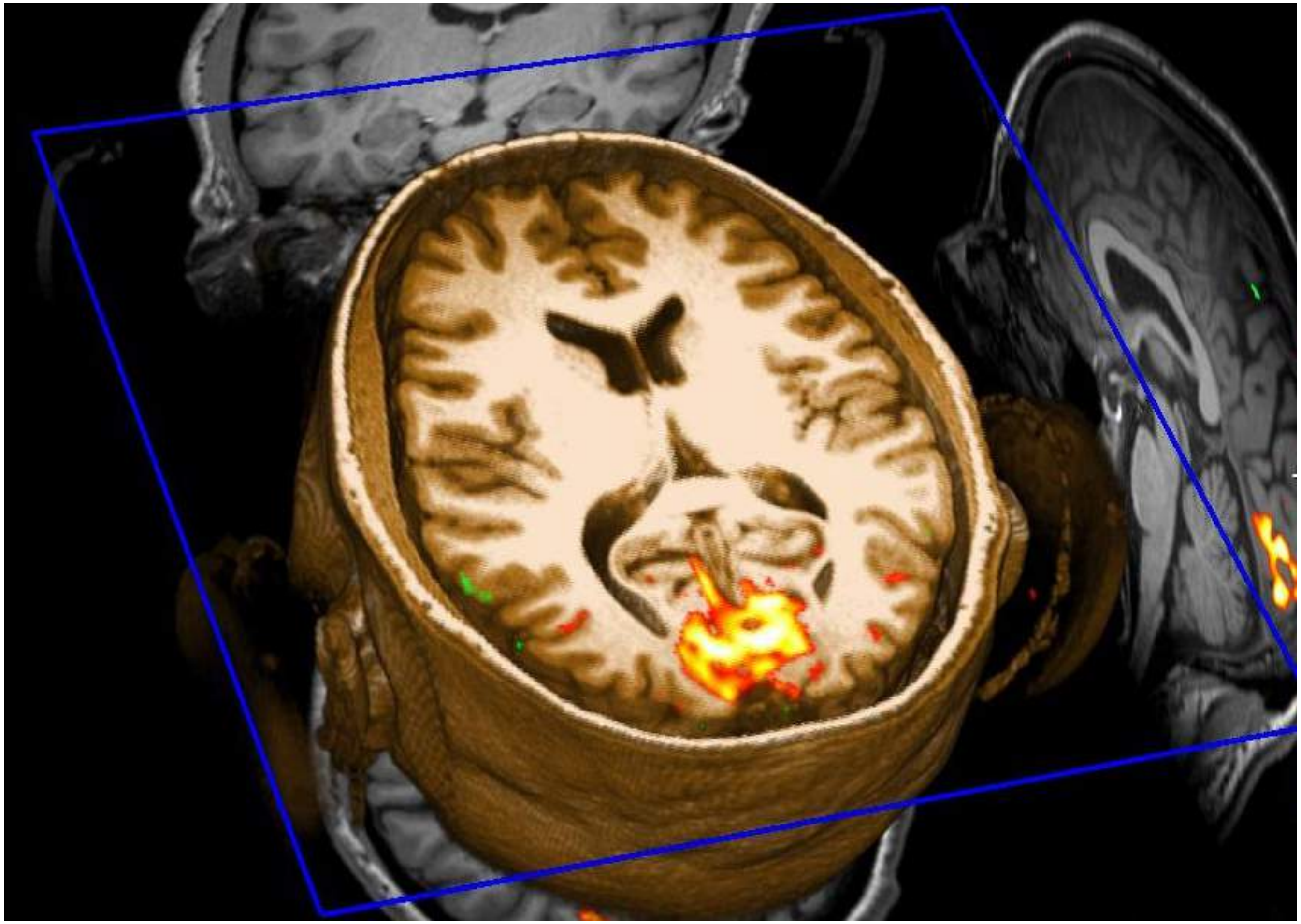


Figure 2. Schematic diagram of the differences in the design and analysis of blocked versus event-related functional magnetic resonance imaging (fMRI) designs. (A) In the blocked design, nine different trials (black and white boxes) are presented sequentially. The fMRI signal (black line) is evaluated against a boxcar (square-wave) reference function that has been smoothed to account for the physiology of the hemodynamic response (gray line). This analysis is sensitive to signal changes between the block of trials (0–16 s) versus the block of time without any trials (16–32 s). (B) In contrast, in the event-related design, one trial occurs every 16 s. The fMRI signal (black line) is evaluated against isolated representations of the hemodynamic response (gray solid line and gray dotted line). In this example, different magnitudes of neural response were produced by the two different trial types. Notably, the event-related design is capable of distinguishing the two types of responses because of the temporal separation of the individual trials and the use of covariates that model only one trial type (gray solid line) or another (gray solid line).

D’après d’Esposito et al., 1999



- Les points forts

- Bonne résolution spatiale (~ 1 mm^3)

- Les points faibles

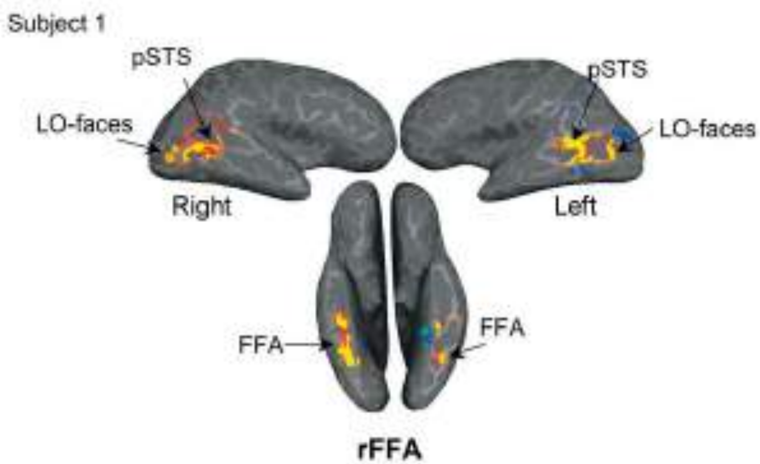
- Coût élevé
- Mauvaise résolution temporelle (~ 1 seconde)
- Position à l'intérieur du scanner
- Immobilité absolue nécessaire
- Bruit

nature neuroscience

The fusiform face area subserves face perception, not generic within-category identification

Kalanit Grill-Spector[1], Nicholas Knouf[2] & Nancy Kanwisher[2]

The function of the fusiform face area (FFA), a face-selective region in human extrastriate cortex, is a matter of active debate. Here we measured the correlation between FFA activity measured by functional magnetic resonance imaging (fMRI) and behavioral outcomes in perceptual tasks to determine the role of the FFA in the detection and within-category identification of faces and objects. Our data show that FFA activation is correlated on a trial-by-trial basis with both detecting the presence of faces and identifying specific faces. However, for most non-face objects (including cars seen by car experts), within-category identification performance was correlated with activation in other regions of the ventral occipitotemporal cortex, not the FFA. These results indicate that the FFA is involved in both detection and identification of faces, but that it has little involvement in within-category identification of non-face objects (including objects of expertise).



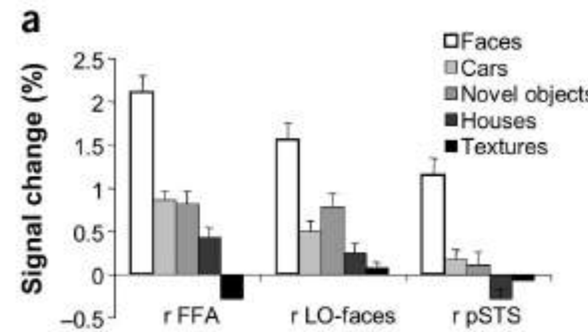
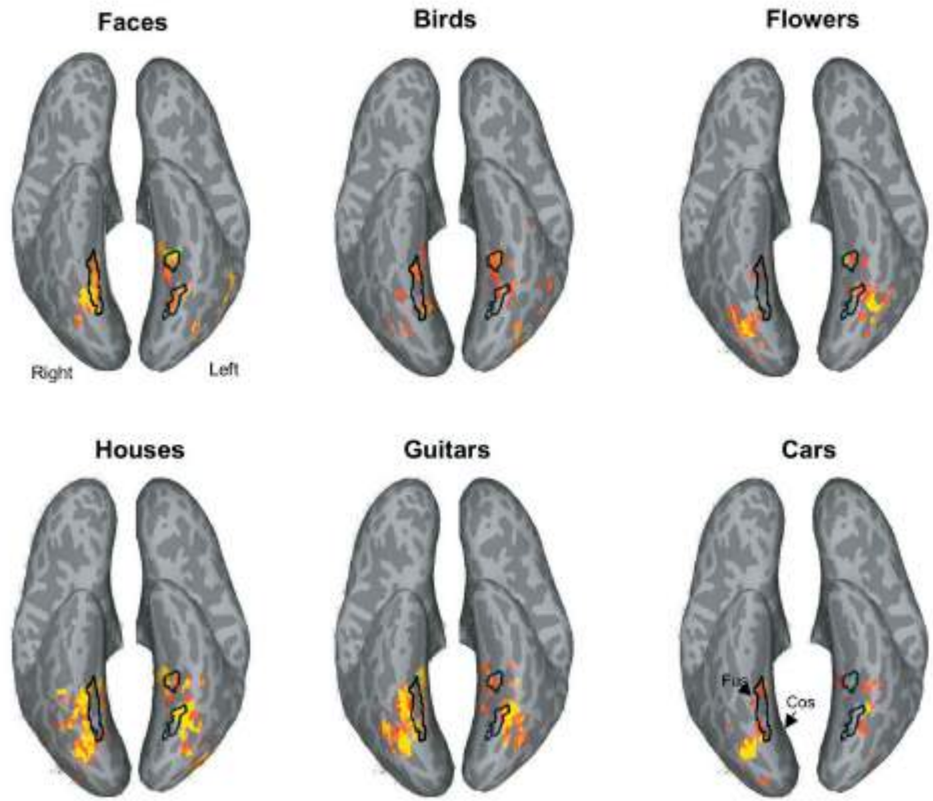
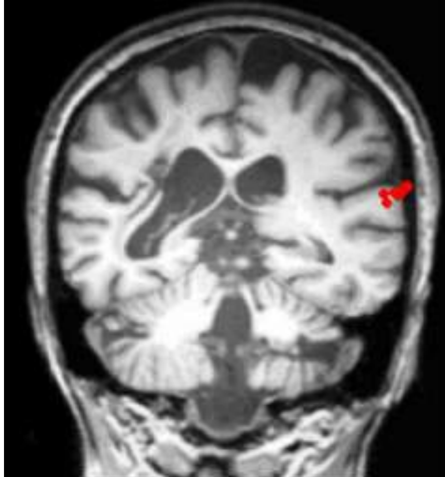


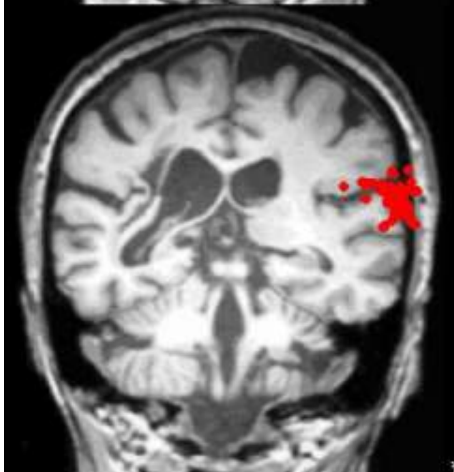
Figure 2 Right FFA hemodynamic response in face experiments. (**a**) Face-selective regions in one representative subject. Face-selective regions (yellow) were defined as regions that respond more strongly to faces than houses, cars and novel objects ($P < 10^{-4}$) at the voxel level. Blue voxels indicate voxels that passed the opposite contrast. Face-selective ROIs: (i) fusiform face area (FFA; Talairach coordinates (*x, y, z*) for the center of the FFA: right, 39 ± 3, −40 ±7, −16 ± 5; left, −37 ± 4, −42 ± 7, −16 ± 5), (ii) face-selective region in the lateral occipital cortex (LO-faces; right, 45 ± 5, −70 ± 3, 2 ± 9; left, −48 ± 3, −76 ± 6, 6 ± 3) and (iii) posterior STS (pSTS; right, 56 ± 3, −53 ± 4, 8 ± 7). (**b–d**) Right FFA (rFFA)

Figure 3 Involvement of face-selective regions of interest in face detection and face identification. (**a**) Average amplitude of activation (five subjects) in the localizer scan in three face-selective ROIs in the right hemisphere. (**b**)

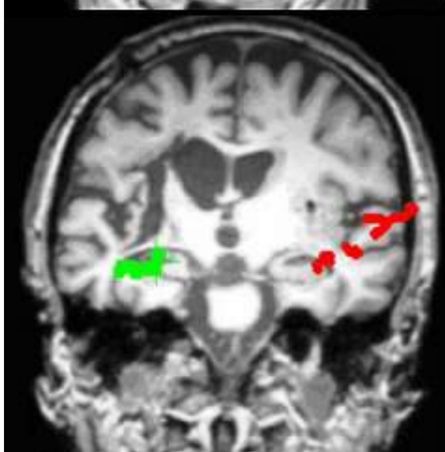

Faces
Birds
Flowers
Right
Left
Houses
Guitars
Cars
Fus
Cos



Time 1 –Just prior to language therapy. There is no activation within the left hemisphere during a language comprehension and memory task. All activation is confined to areas of the right hemisphere that are homotopic to pre-stroke language areas suggesting re-organization of language comprehension to the right hemisphere



Time 2 –Just after language therapy that resulted in significant improvement in comprehension. There continues to be no activation within the left hemisphere during a language comprehension and memory task. Right hemisphere activation has increased in the same areas that were active before therapy.



Time 3 –Three months after therapy. There is now activation within left hemisphere memory areas during a language comprehension and memory task. Right hemisphere activation continues to be present. Together the data suggest: (1) possible reorganization of language function to the right hemisphere after stroke, (2) increase in this activation associated with improvement in comprehension due to therapy, and (3) some resumption of verbal memory function within the left hemisphere within 3 months of therapy.

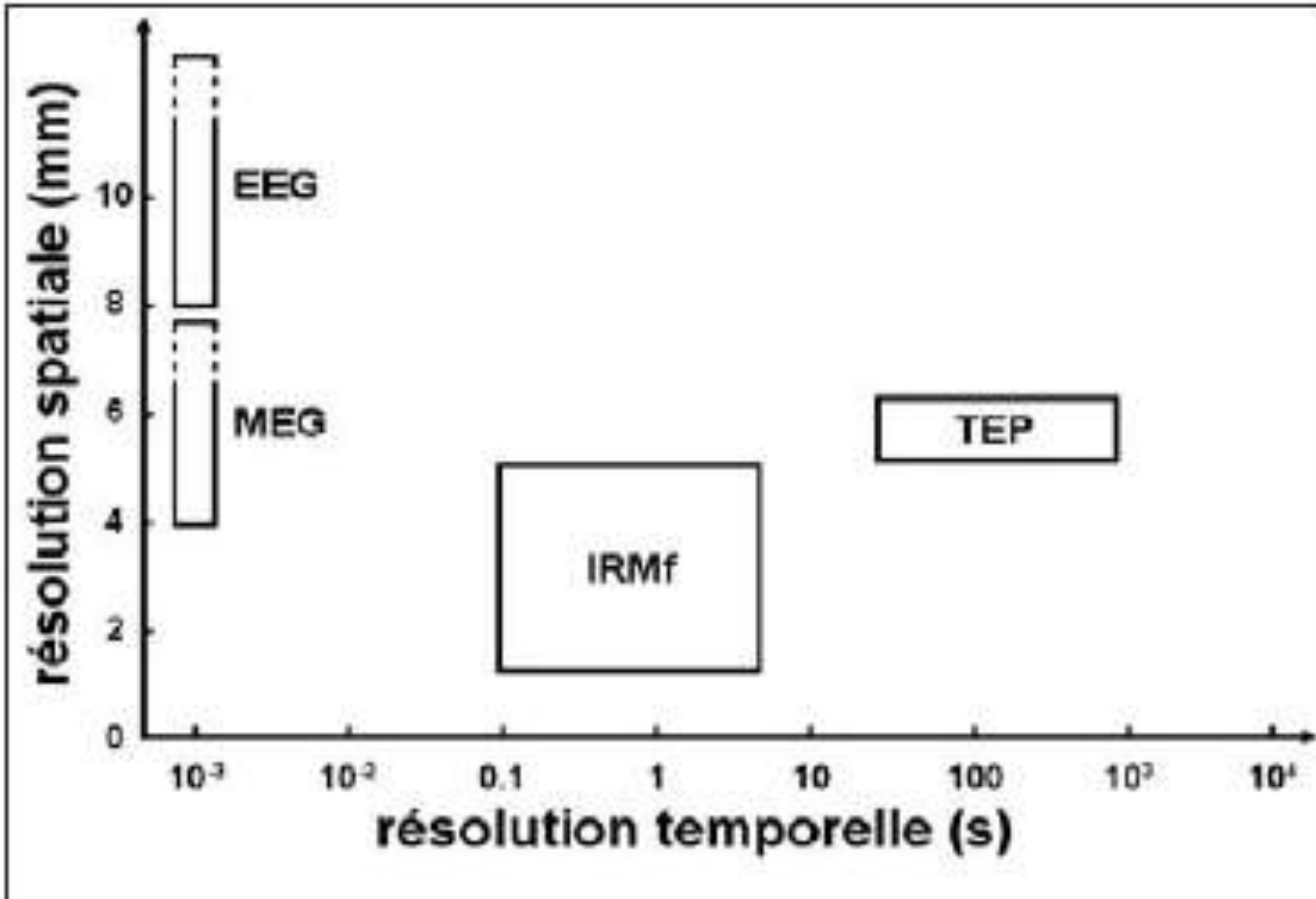


Figure 2. Résolutions temporelle et spatiale des techniques d'imagerie fonctionnelle cérébrale les plus communément utilisées. Adapté de Laureys et al (2002) (13).

Merci !