Psychologie cognitive, Neurosciences et Conscience

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http://eugrafal.free.fr

1. **Introduction : l’expérience consciente comme objet d’étude scientifique**
2. **Quelle(s) méthode(s) pour étudier la conscience ?**
3. **La théorie de la non-unité de la conscience**
4. **La théorie de l’espace de travail global (global workspace theory)**
5. **Certaines personnes en état de comas végétatif sont-elles conscientes ?**
6. **Nos décisions conscientes peuvent-elles être influencées par des stimuli non perçus consciemment ?**

1. Introduction : l'expérience consciente comme objet d'étude scientifique

Le problème de la conscience

- **On a longtemps considéré qu'elle était hors de portée de l'investigation empirique :**
  - phénomène **privé, subjectif**. Comment mesurer objectivement un phénomène subjectif ? (Quel effet cela fait-il d'être une chauve-souris? (*Thomas Nagel*)

- **Elle a été écartée du domaine de la science empirique, d'abord par le pouvoir religieux (menace du dogme dualiste d'une âme immortelle donnée par Dieu) ; ensuite par les écoles de pensée scientifiques qui rejetaient comme « non scientifique » tout usage de termes mentaux.**

“It is impossible to specify what it is, what it does, or why it evolved. Nothing worth reading has been written on it."

Stuart Sutherland, 1989

Les zombies philosophiques

Un zombie philosophique ne peut en rien être différencié d'un humain normal, mise à part qu'il n'a pas d'expérience consciente

Si un zombie philosophique est possible alors la conscience n'a aucune fonction, c'est un épiphénomène

« Problèmes faciles » et « problème difficile » de la conscience

Distinction introduite par le philosophe David Chalmers en 1994 (Tucson, Arizona)

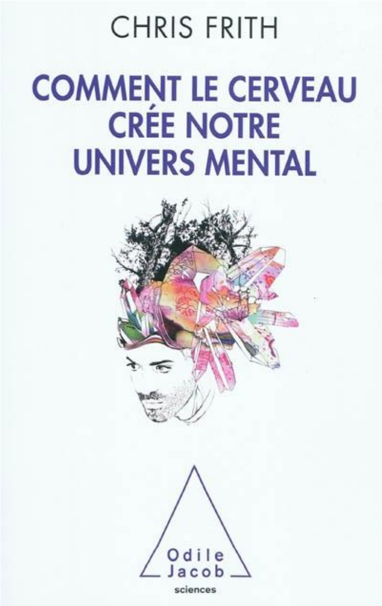
- **« Problèmes faciles »** : il fait référence à la compréhension des processus, des mécanismes, qui rendent possible la conscience.

- **« Problème difficile »** : toutes les explications sur la conscience, toutes les explications sur l'implémentation des états mentaux dans notre système nerveux (problèmes faciles) ne nous renseigneront jamais sur la dimension subjective de la conscience, sur l'effet que cela fait d'être soi et de ressentir des qualia.

Notion d' ***« explanatory gap »*** *(trou dans l'explication)*

Quelles sont les choses qui peuvent être réalisées par une créature consciente mais pas par une créature non consciente ?

- La réponse à cette question revient à déterminer la (les) fonction(s) de la conscience

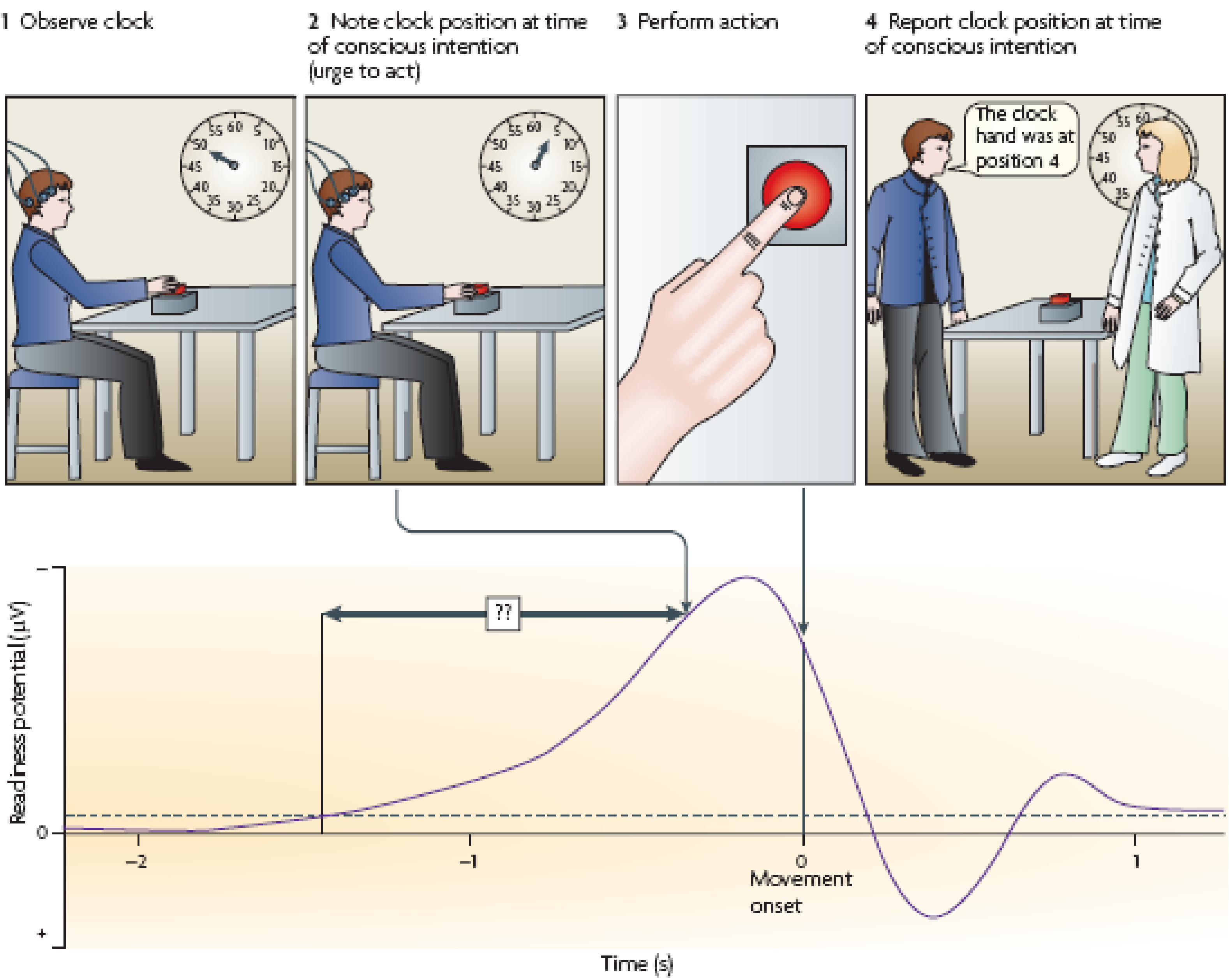


Conscience et contrôle du comportement

- Nous avons un sentiment très fort de contrôle de nos actions… Nous pensons que nos actes sont « causés » par nos intentions conscientes

- De nombreuses expériences de psychologie cognitive et de neurosciences ont montré que **la conscience a un rôle minimum dans le contrôle du comportement immédiat**

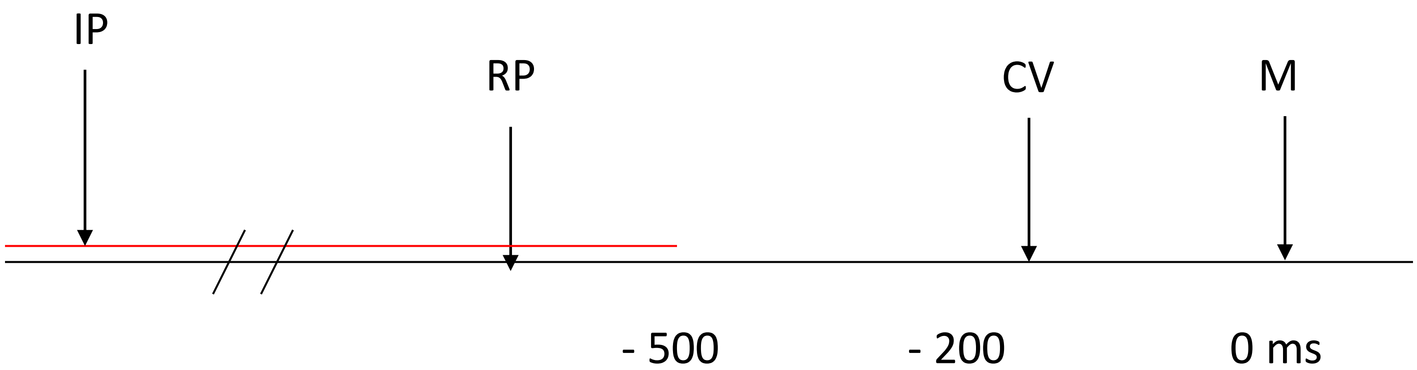
Box 1 | **Measuring conscious intention**



Le potentiel de préparation motrice

« readiness potential »

(Libet, 1983)

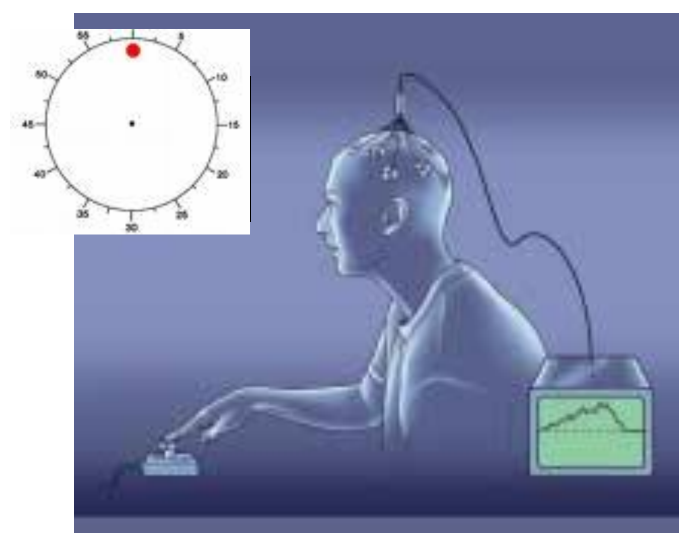


IP : intention préalable

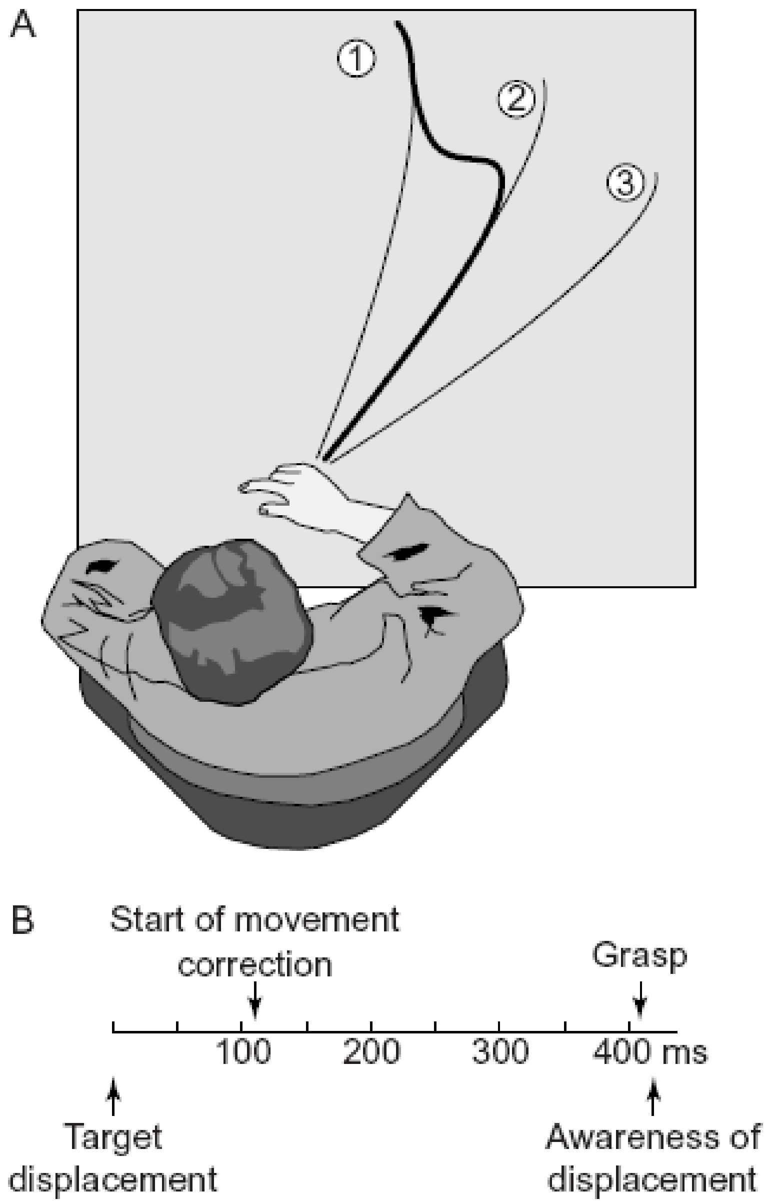
RP : readiness potential

CV : conscience de la volonté d'agir

M : Mouvement



Libet, 1983



Castiello et al., Brain, 1998

A-t-on besoin d'une délibération consciente pour prendre une décision importante ?

Devrais-je acheter cette Mercedes classe B 200 cdi de 2008 ?

On Making the Right Choice: The Deliberation-Without-Attention Effect

Ap Dijksterhuis,* Maarten W. Bos, Loran F. Nordgren, Rick B. van Baaren

Contrary to conventional wisdom, it is not always advantageous to engage in thorough conscious deliberation before choosing. On the basis of recent insights into the characteristics of conscious and unconscious thought, we tested the hypothesis that simple choices (such as between different towels or different sets of oven mitts) indeed produce better results after conscious thought, but that choices in complex matters (such as between different houses or different cars) should be left to unconscious thought. Named the "deliberation-without-attention" hypothesis, it was confirmed in four studies on consumer choice, both in the laboratory as well as among actual shoppers, that purchases of complex products were viewed more favorably when decisions had been made in the absence of attentive deliberation.

hardly developed beyond the status of "folk wisdom." It has been postulated or investigated by scientists infrequently [but see (*10–13*)]. The question addressed here is whether this view is justified. We hypothesize that it is not.

First, conscious thought does not always lead to sound choices. For example, participants who chose their favorite poster among a set of five after thorough contemplation showed less postchoice satisfaction than participants who only looked at them briefly (*14*, *15*). Furthermore, conscious deliberation can make multiple evaluations of the same object less consistent over time (*16*). Two reasons why conscious deliberation sometimes leads to poor judgments have been identified. First, consciousness has a low capacity (*17*, *18*), causing choosers to take

All participants read information about four hypothetical cars. Depending on the condition, each car was characterized by 4 attributes (simple) or by 12 attributes (complex). The attributes were either positive or negative. **One car was characterized by 75% positive attributes, two by 50% positive attributes, and one by 25% positive attributes.**

After reading the information about the four cars, participants were assigned either to a conscious thought condition or to an unconscious thought condition. In the conscious thought condition, participants were asked to think about the cars for 4 min before they chose their favorite car. **In the unconscious thought condition, participants were distracted for 4 min (they solved anagrams)** and were told that after the period of distraction they would be asked to choose the best car.

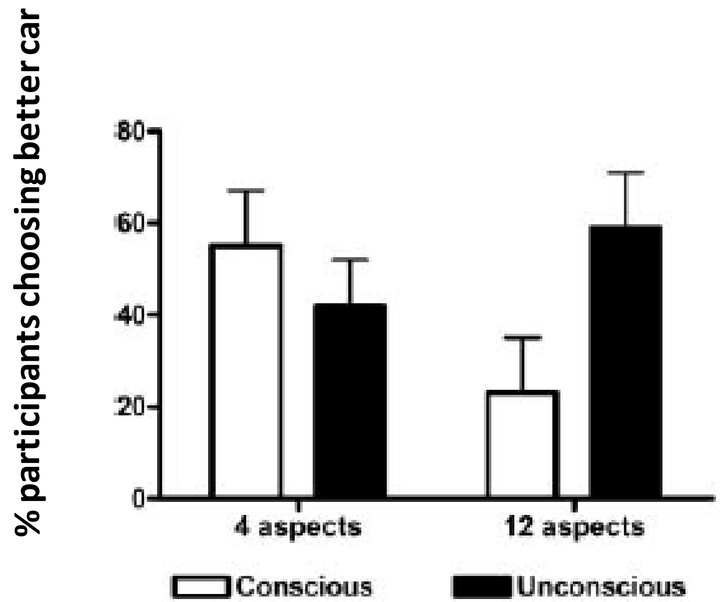
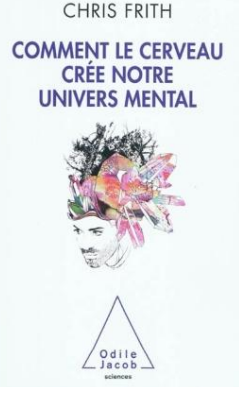
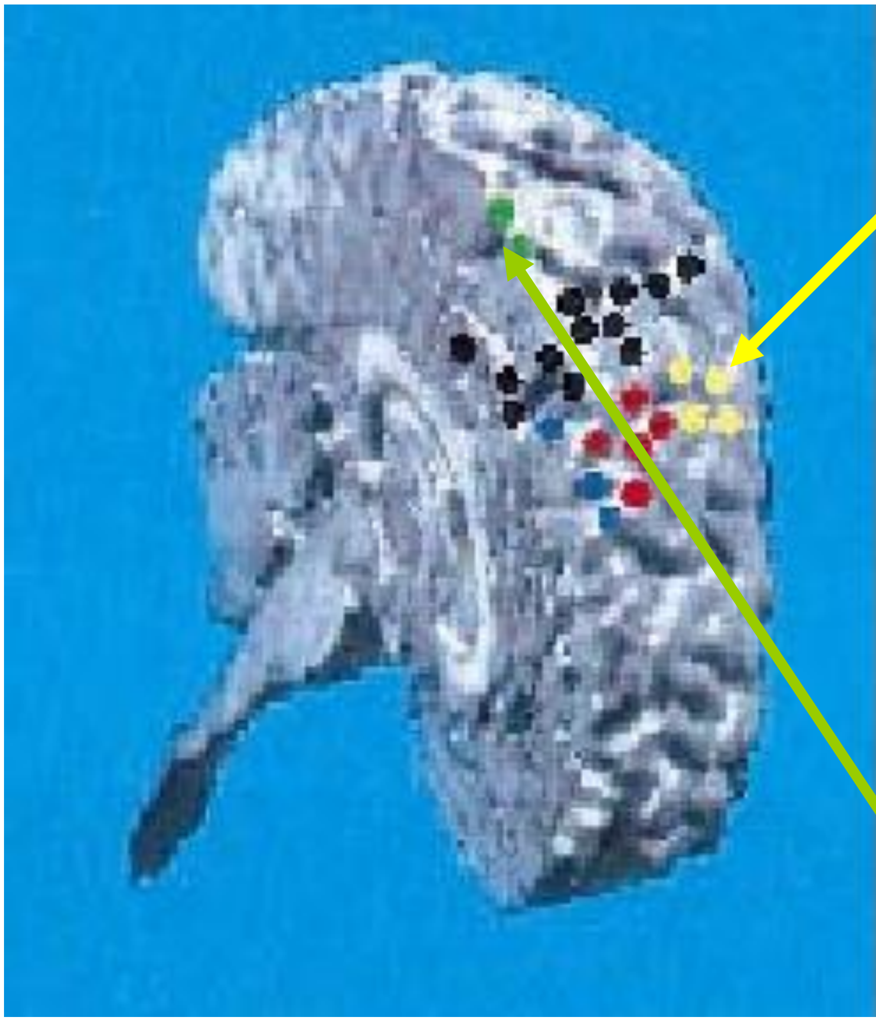


Fig. 1. Percentage of participants who chose the most desirable car as a function of complexity of decision and of mode of thought ($n = 18$ to 22 in each condition). Error bars represent the standard error.

- La conscience nous permet probablement, avant tout, d'expliquer et de justifier nos décisions (a posteriori). *Chris Frith*
  - *La conscience nous rend capable de discuter nos décisions avec les autres. Les discussions sur les prises de décision affectent le comportement des personnes*
  - *Sur le long terme, partager nos introspections sur les décisions conduit à des règles culturelles qui régulent les décisions de l'individu et du groupe*

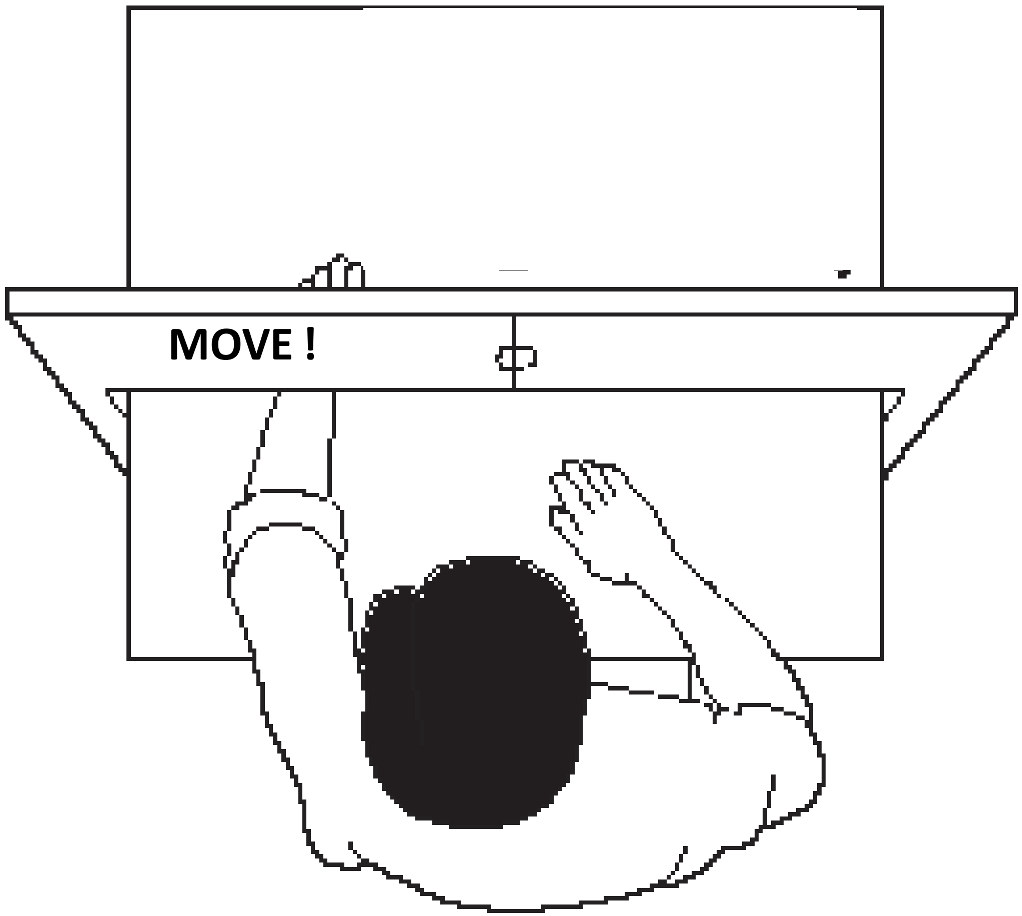


Éclats de rire induits par SE de la partie antérieure de l'AMS



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

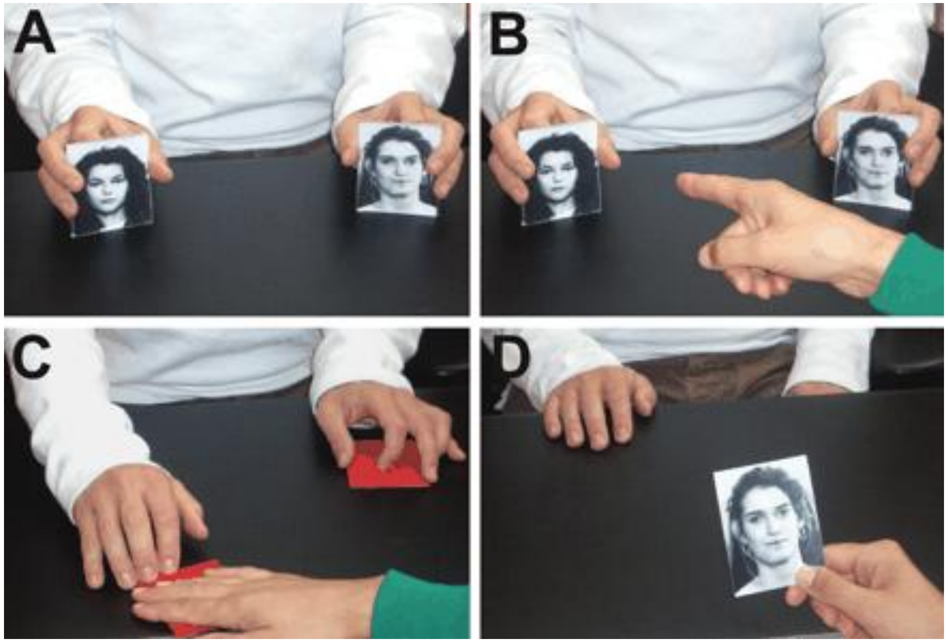
- Rires
- Interruption du langage
- Interruption de la capacité à nommer les objets
- Interruption des activités manuelles
- Mouvements impliquant les bras et les avant-bras
- Sensations de frôlement


MOVE !

Failure to Detect Mismatches Between Intention and Outcome in a Simple Decision Task

Petter Johansson,[1*] Lars Hall,[1*†] Sverker Sikström,[1] Andreas Olsson[2]

A fundamental assumption of theories of decision-making is that we detect mismatches between intention and outcome, adjust our behavior in the face of error, and adapt to changing circumstances. Is this always the case? We investigated the relation between intention, choice, and introspection. Participants made choices between presented face pairs on the basis of attractiveness, while we covertly manipulated the relationship between choice and outcome that they experienced. Participants failed to notice conspicuous mismatches between their intended choice and the outcome they were presented with, while nevertheless offering introspectively derived reasons for why they chose the way they did. We call this effect choice blindness.



Choisir

Expliquer le choix

- **Dans 20% des essais l'expérimentateur demande d'expliquer la préférence pour le visage qui n'a pas était choisi !**

- **Dans 74% des cas, la tromperie n'est pas détectée.**

Type	%		
Specific Conf.	13.3		She's radiant. I would rather have approached her at a bar than the other one. I like earrings! [M]
Detailed Conf.	17.3	She looks like an aunt of mine I think, and she seems nicer than the other one. [F]	
Emotional Conf.	9.3		Yes, well, [laughter] she looks very hot in this picture. [M]
Simple Conf.	10.8		Just a nice shape of the face, and the chin. [M]
Relational Conf.	21.3		I thought she had more personality, in a way. She was the most appealing to me. [F]
Uncertainty	11.6	Eh... I don't know. [F]	
Dynamic report	5.2		Oh, [short laughter] Why did I choose her? She looks very masculine! [M]
Original choice	11.2	Because she was smiling. [F]	

Le terme ***conscience*** est polysémique :

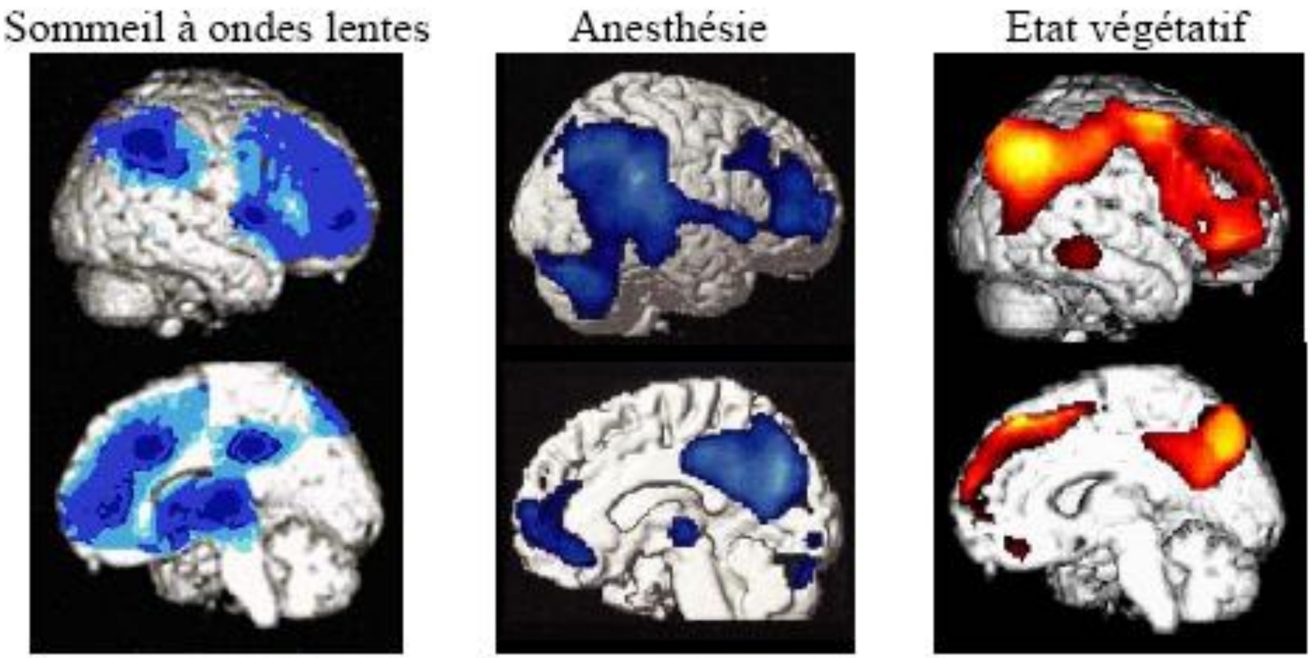
- **La conscience,** dans un usage intransitif ; **état d'éveil** : « j'ai perdu conscience » ; fait référence aux niveaux de vigilance : veille, sommeil, anesthésie, coma, état végétatif

- **La conscience d'accès :** fait référence au ***contenu*** de la conscience en tant qu'il est immédiatement disponible comme prémisse pour le raisonnement et peut jouer un rôle dans le contrôle rationnel de l'action et de la parole

- **La conscience phénoménale :** fait référence aux aspects qualitatifs de notre vie mentale (***les qualias***) ; « l'effet que cela fait » (le goût ou l'odeur du maroilles ; de ressentir une douleur ou de percevoir une couleur, …)

- **La conscience de soi :** nous disposons d'une représentation de ***soi*** qui confère une certaine unité à notre vie mentale
  - Différence soi/non-soi
  - Illusions de déplacement du soi

Réduction du métabolisme et niveau de vigilance

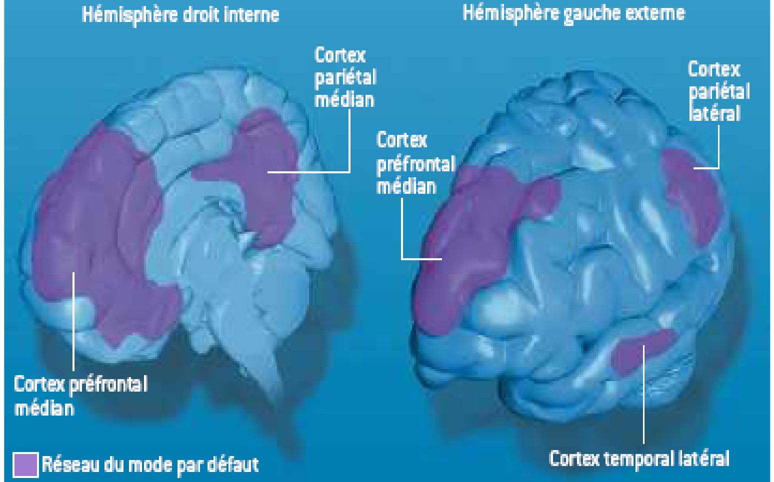


Le réseau du mode par défaut

Un ensemble de régions cérébrales qui coopèrent forme le réseau du mode par défaut. Il semble être responsable de l'essentiel de l'activité du cerveau quand il n'est pas focalisé sur une tâche particulière et jouerait un rôle essentiel dans le fonctionnement mental.

Centre de commande

Le réseau du mode par défaut implique plusieurs aires cérébrales éloignées les unes des autres.



Un chef d'orchestre du soi

Le réseau du mode par défaut jouerait le rôle d'un chef d'orchestre, émettant des signaux temporels qui coordonnent l'activité de différentes aires cérébrales. Ces indices – entre le cortex visuel – et le cortex auditif, par exemple, garantissent probablement que toutes les aires cérébrales sont prêtes à traiter de façon coordonnée les différentes composantes d'un même stimulus pour lui donner sa cohérence.

2. Quelle(s) méthode(s) pour étudier la conscience ?

La conscience comme objet d'investigation scientifique

- La conscience est « un phénomène réel, naturel, biologique, littéralement localisé dans le cerveau » (Revonsuo, 2001)

- « Les neurosciences cognitives de la conscience visent à déterminer s'il existe une forme systématique de traitement de l'information, et une classe d'états d'activité du cerveau, qui distinguent systématiquement les états que les sujets identifient comme "conscients" des autres états. » (Dehaene & Naccache, 2001)
  - Mise en corrélation psycho-neurale similaire à ce qui ce fait dans d'autres domaines de la vie mentale

La conscience comme objet d'investigation scientifique

« La première étape, cruciale, consiste à **prendre au sérieux ce que les sujets rapportent de leur introspection et de leur phénoménologie**. Ces rapports subjectifs sont les phénomènes clés qu'une neuroscience cognitive de la conscience vise à étudier. En tant que tels, ils constituent les données primaires que l'on doit mesurer et enregistrer en parallèle avec toutes les autres données physiologiques. »

(Dehaene & Naccache, 2001)

“A major part of the programme for studying the neural correlates of consciousness must be to investigate the difference between neural activities that are associated with awareness and those that are not” (*Frith et al., 1999).*

Nécessité d’identifier des contrastes minimaux entre traitements neuraux conscients et non conscients

Le masquage

- « Réduction de la visibilité d'un stimulus présenté brièvement (la *cible) par un* second stimulus, également bref et adjacent dans l'espace et dans le temps » Définition (Breitmeyer et Ogmen, 2006)

- Exemples de masquage :

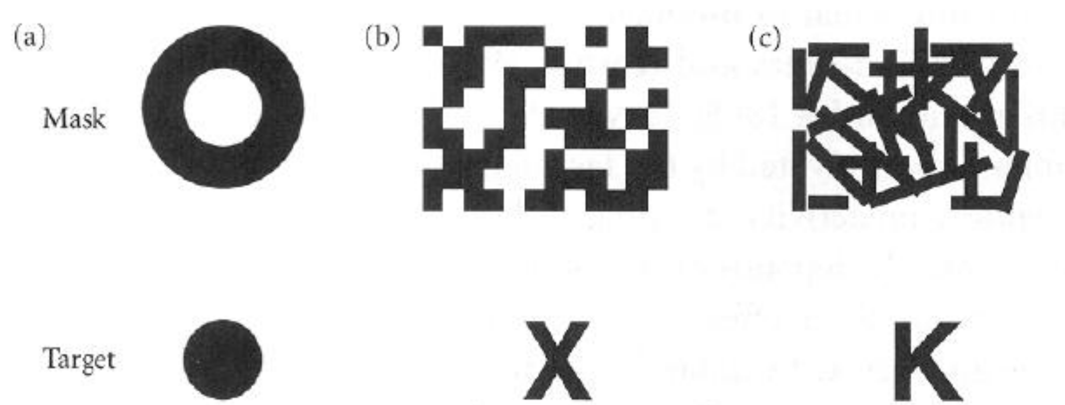


Fig. 2.1 Examples of target and mask stimuli typically used in (a) paracontrast and metacontrast, (b) pattern masking by noise, and (c) pattern masking by structure. (Reproduced from Breitmeyer and Ganz 1976.)

La méthode contrastive

Baars, *A cognitive theory of consciousness, 1989*

- Il s'agit de « contraster des paires d'événements similaires, mais dont l'un est conscient tandis que l'autre ne l'est pas. »

- La psychologie et la neurologie regorgent de cas où les sujets s'accordent pour considérer qu'un stimulus est ou n'est pas conscient.

Exemples :

- Stimuli présentés au seuil de masquage, ou masqués *vs* démasqués
- Cécité au changement *vs* conscience du changement
- Etats de vigilance : éveil *vs* sommeil, coma ou anesthésie
- Actions volontaires *vs* actions involontaires ou automatiques
- Vision normale *vs* vision aveugle chez les patients atteints de *blindsight*
- Chez les patients héminégligents, stimuli détectés *vs* stimuli "éteints"

3. La théorie de la non-unité de la conscience

Les expériences du groupe de Semir Zeki

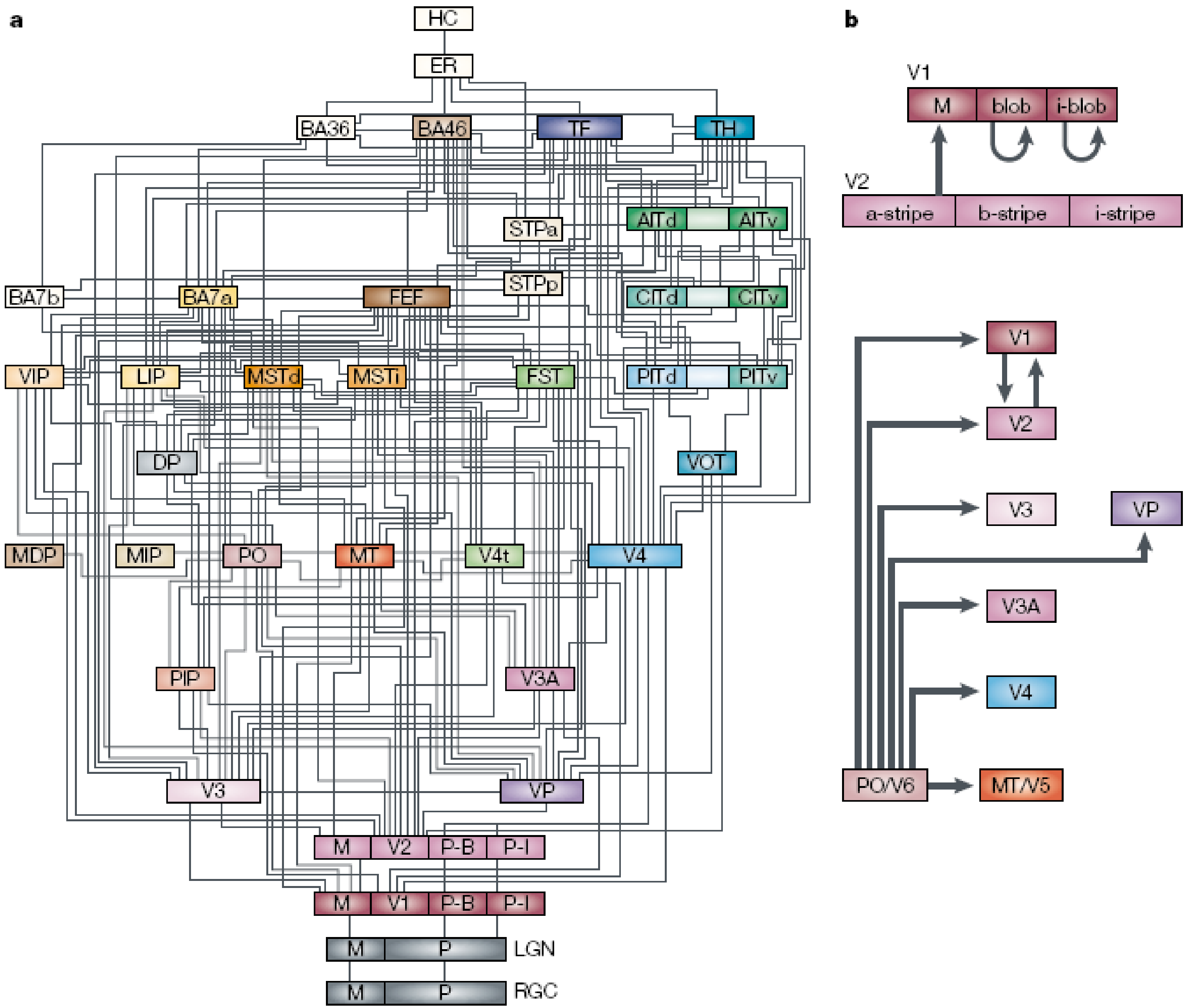
Welcome Laboratory of Neurobiology, University College London, UK

Dans les études de Zeki et coll.

Conscience = Conscience visuelle

a

b



HC
ER
BA36
BA46
TF
TH
STPa
AITd
AITv
BA7b
BA7a
FEF
STPp
CITd
CITv
VIP
LIP
MSTd
MSTi
FST
PITd
PITv
DP
VOT
MDP
MIP
PO
MT
V4t
V4
PIP
V3A
V3
VP
M
V2
P-B
P-I
M
V1
P-B
P-I
M
P
LGN
M
P
RGC
V1
M
blob
i-blob
V2
a-stripe
b-stripe
i-stripe
V1
V2
V3
VP
V3A
V4
PO/V6
MT/V5

Selon **Semir Zeki**, il existe des consciences multiples qui constituent une hiérarchie ; l'unité de la conscience est une illusion.

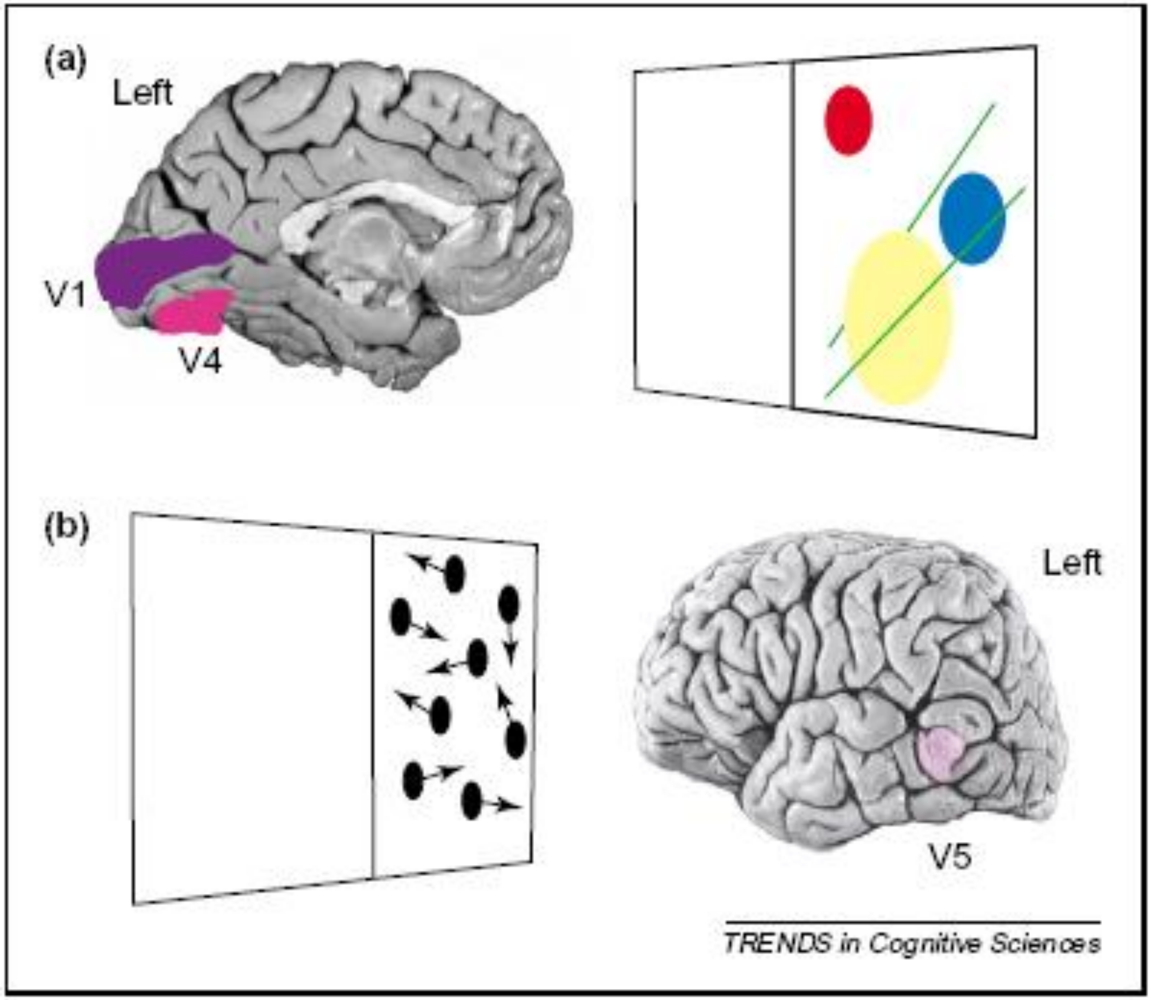
- Chaque qualia est associé à une région cérébrale qui génère une “micro-conscience”.
  - **Couleur dans V4**
  - **Mouvement dans V5**, etc

- La microconscience des différents traits d'un objet peut survenir à des moments différents. La conscience (les micro-consciences) est donc distribuée dans l'espace et le temps cérébral

- La macro-conscience résulte du liage de ces différents traits en un seul percept.

- La conscience unifiée résulte de l'intégration du percept avec la représentation du sujet en train de percevoir

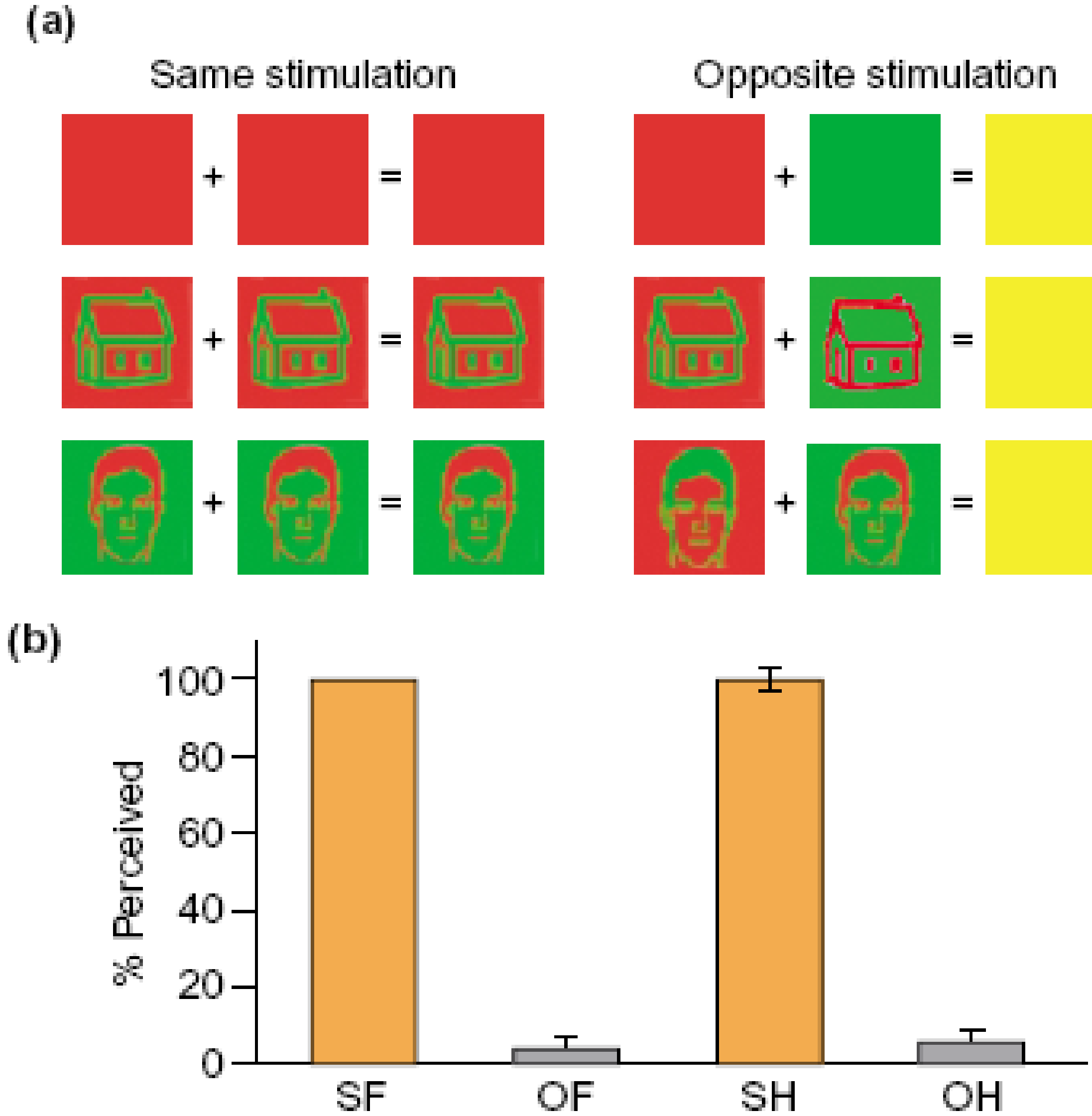
Les aires visuelles **V4** et **V5** sont spécialisées dans le traitement des couleurs et des mouvements, respectivement. Chacune reçoit des entrées en provenance du cortex visuel primaire (V1) et enregistre l'activité pertinente dans l'hémichamp contro-latéral



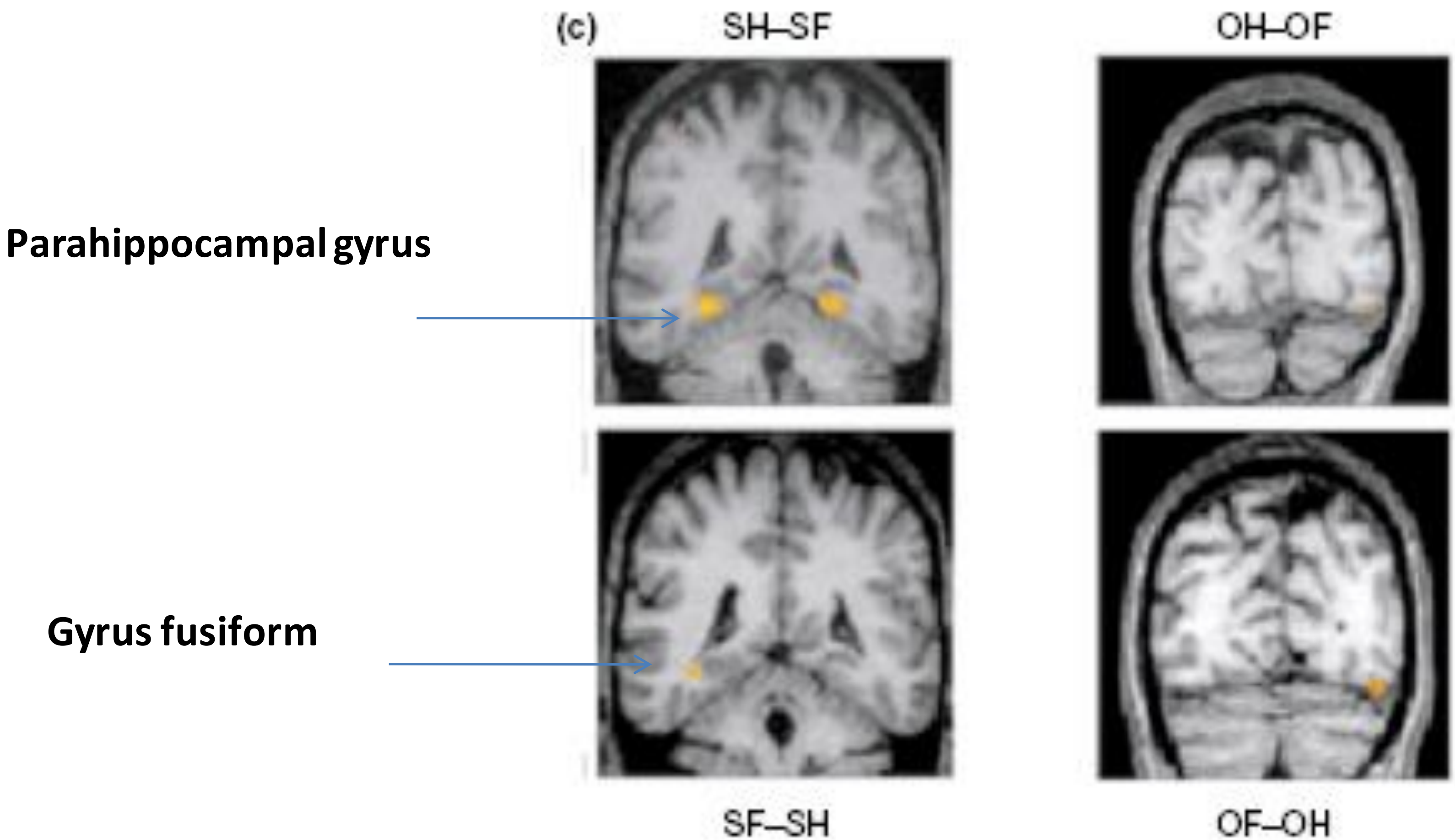
Des lésions de V4 produisent une **achromatoptie**, l'incapacité à voir les couleurs ; la vision du mouvement est préservée.

Des lésions de V5 produisent une **akinetoptie**, l'incapacité à voir le mouvement ; la vision des couleurs n'est pas affectée.

- “The **perceptual consequences** of this anatomical arrangement have been well studied in **patient GY**, blinded in one hemifield in childhood by damage to V1. Our psychophysical and imaging experiments [16,17], independently confirmed [18], have shown that, in spite of his blindness, this direct visual input to V5 [19–21] is sufficient to give GY a crude but conscious vision for fast moving, high contrast stimuli, the perception of which is mediated by V5 [17] (Fig. 2). It has also been shown that his consciousness, when visually stimulated, is visual [22].” (S. Zeki)



Moutoussis, K. and Zeki, S. (2002) The relationship between cortical activation and perception investigated with invisible stimuli. ***PNAS*** 99, 9527–9532



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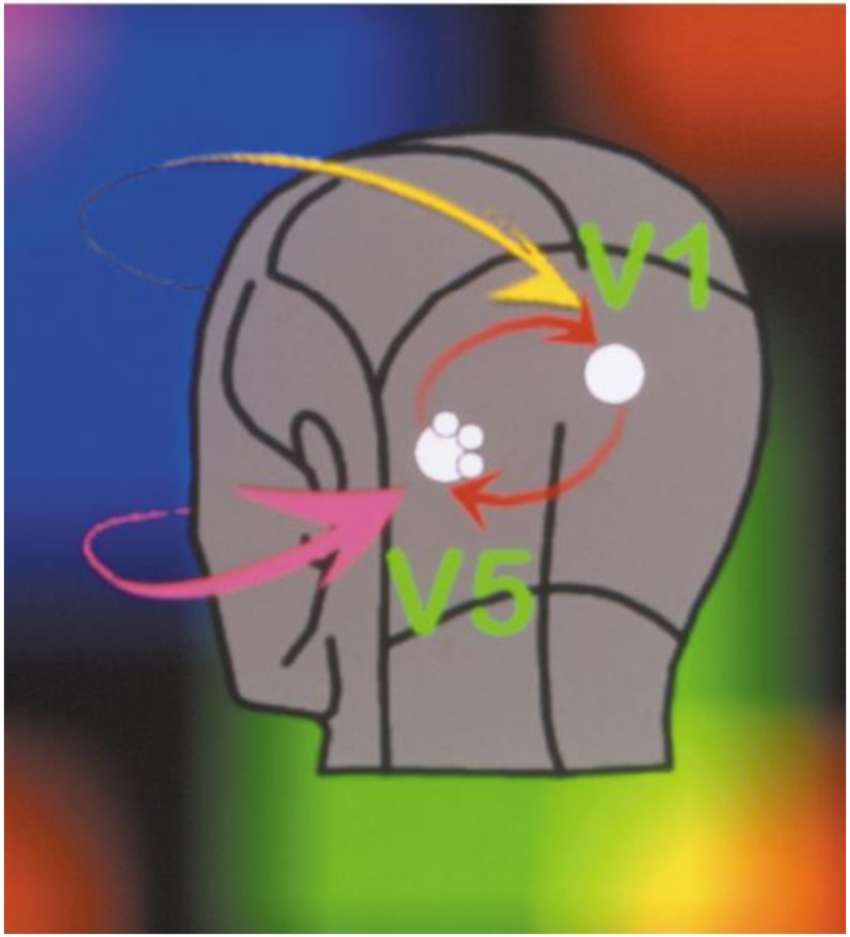


« L'activité dans une aire cérébrale spécialisée conduit à la vision consciente et son absence (ou une activité plus basse) dans la même aire corrèle avec une absence d'expérience consciente. » S. Zeki. ***TICS***, 2003

The dynamics of object-selective activation correlate with recognition performance in humans

Kalanit Grill-Spector[1,5], Tammar Kushnir[2], Talma Hendler[3] and Rafael Malach[4]

To investigate the relationship between perceptual awareness and brain activity, we measured both recognition performance and fMRI signal from object-related areas in human cortex while images were presented briefly using a masking protocol. Our results suggest that recognition performance is correlated with selective activation in object areas. Selective activation was correlated to object naming when exposure duration was varied from 20 to 500 milliseconds. Subjects' recognition during identical visual stimulation could be enhanced by training, which also increased the fMRI signal. Overall, the correlation between recognition performance and fMRI signal was highest in occipitotemporal object areas (the lateral occipital complex).

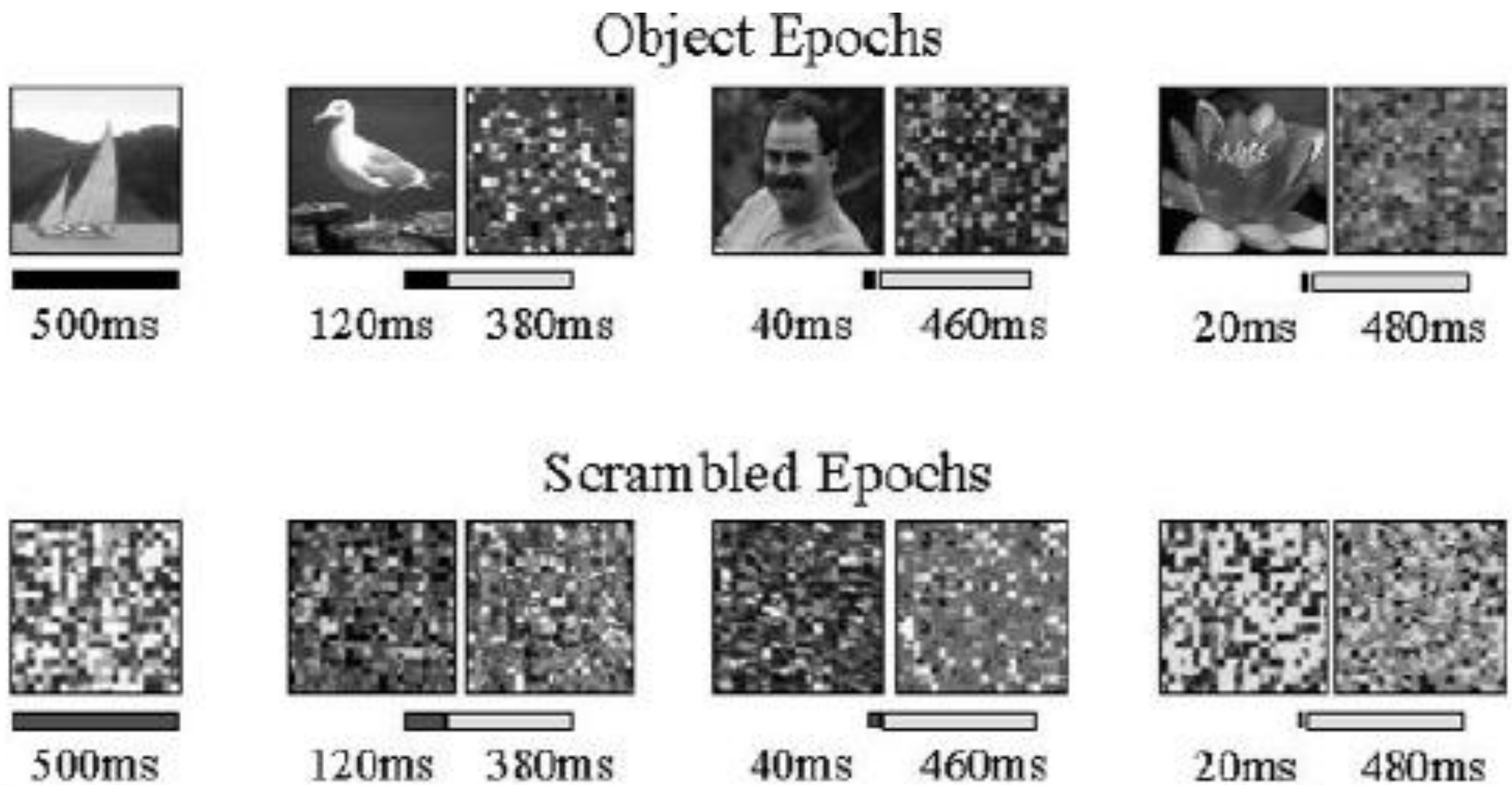


Fig. 1. Masking experiment. Subjects were presented with images of objects (top) or of scrambled objects (bottom) for 20, 40, 120 or 500 ms, followed by a mask created by randomly scrambling the images. Subjects were instructed to covertly name the stimuli. This task becomes very difficult as the stimulus duration decreases.

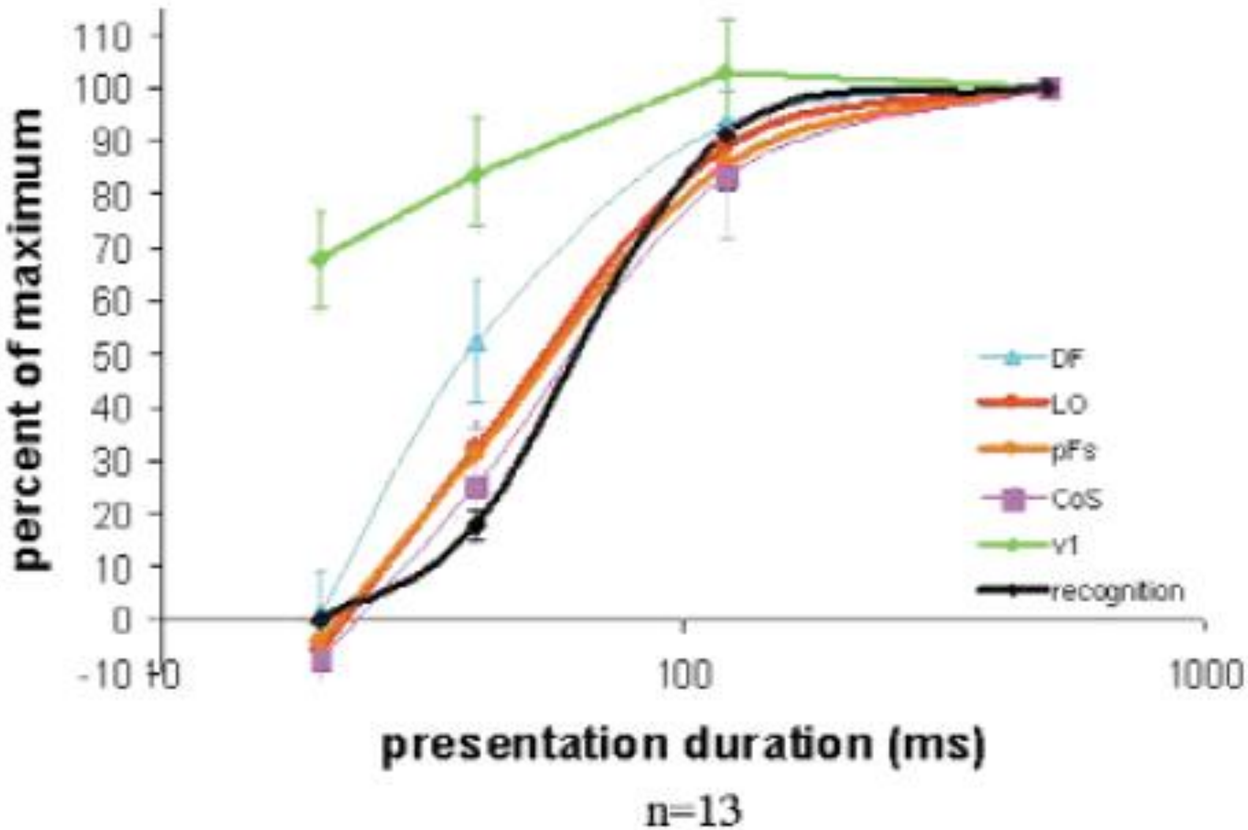


Fig. 3. Sensitivity of recognition and fMRI activation to object duration. To bring recognition and fMRI signal to a common scale, we calculated the ratio of activation and recognition compared to the maximum, obtained at an image presentation duration of 500 ms. *x*-axis, image duration on a logarithmic scale; error bars, s.e.m. Graphs indicate average of 13 subjects, except V1, for which there were 6 subjects. Solid black line, normalized recognition performance. LO, lateral occipital; pFs, posterior fusiform; CoS, collateral sulcus; DF, dorsal foci. V1, primary visual cortex.

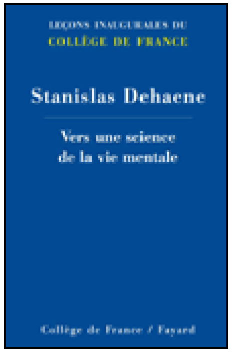
4. La théorie de l’espace de travail global (global workspace theory)

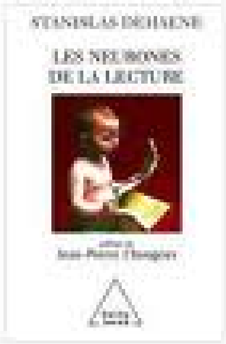
Les expériences du groupe de Semir Zeki

Welcome Laboratory of Neurobiology, University College London, UK

- **Bernard Baars** a introduit (début des années 1980) le modèle de l'espace de travail global.
  - Selon Baars, il existe un espace de travail où l'information traitée par les circuits spécialisés est rendue accessible à l'ensemble de la population neuronale du cerveau.

Stanislas Dehaene

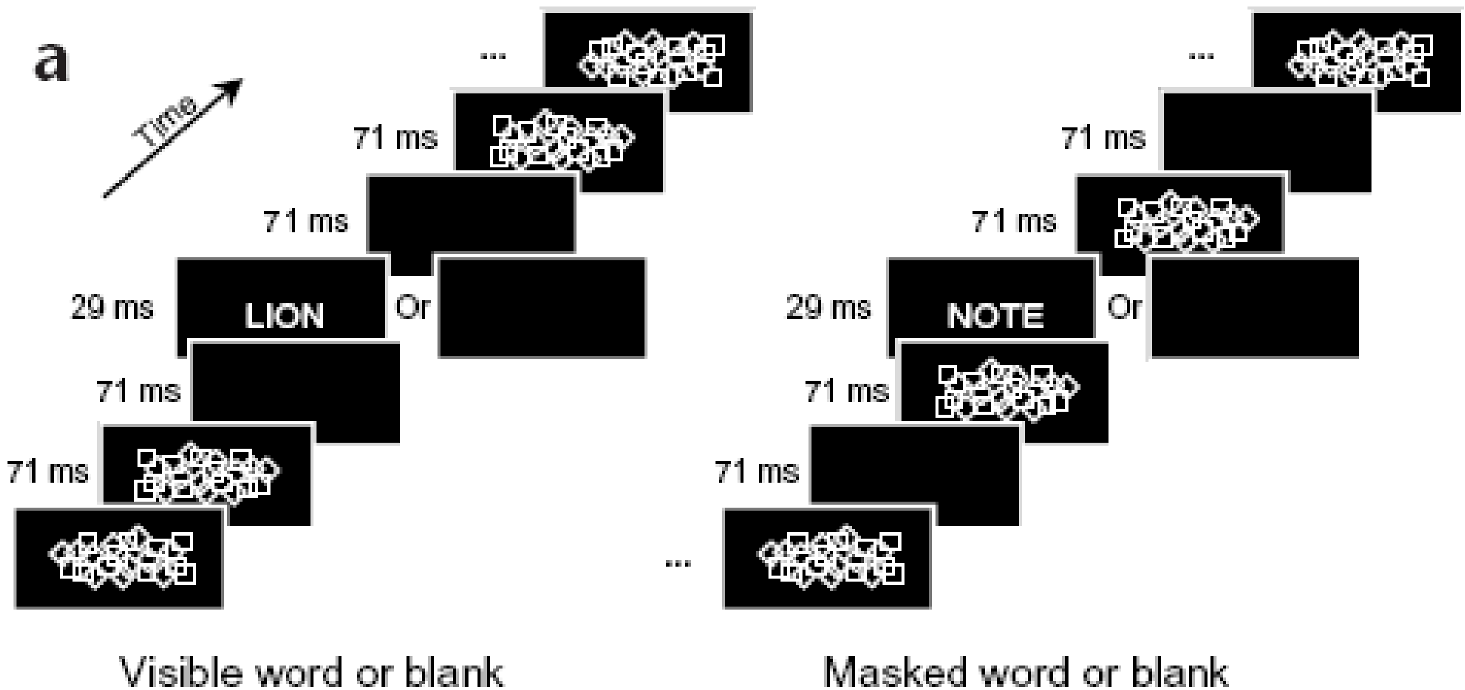




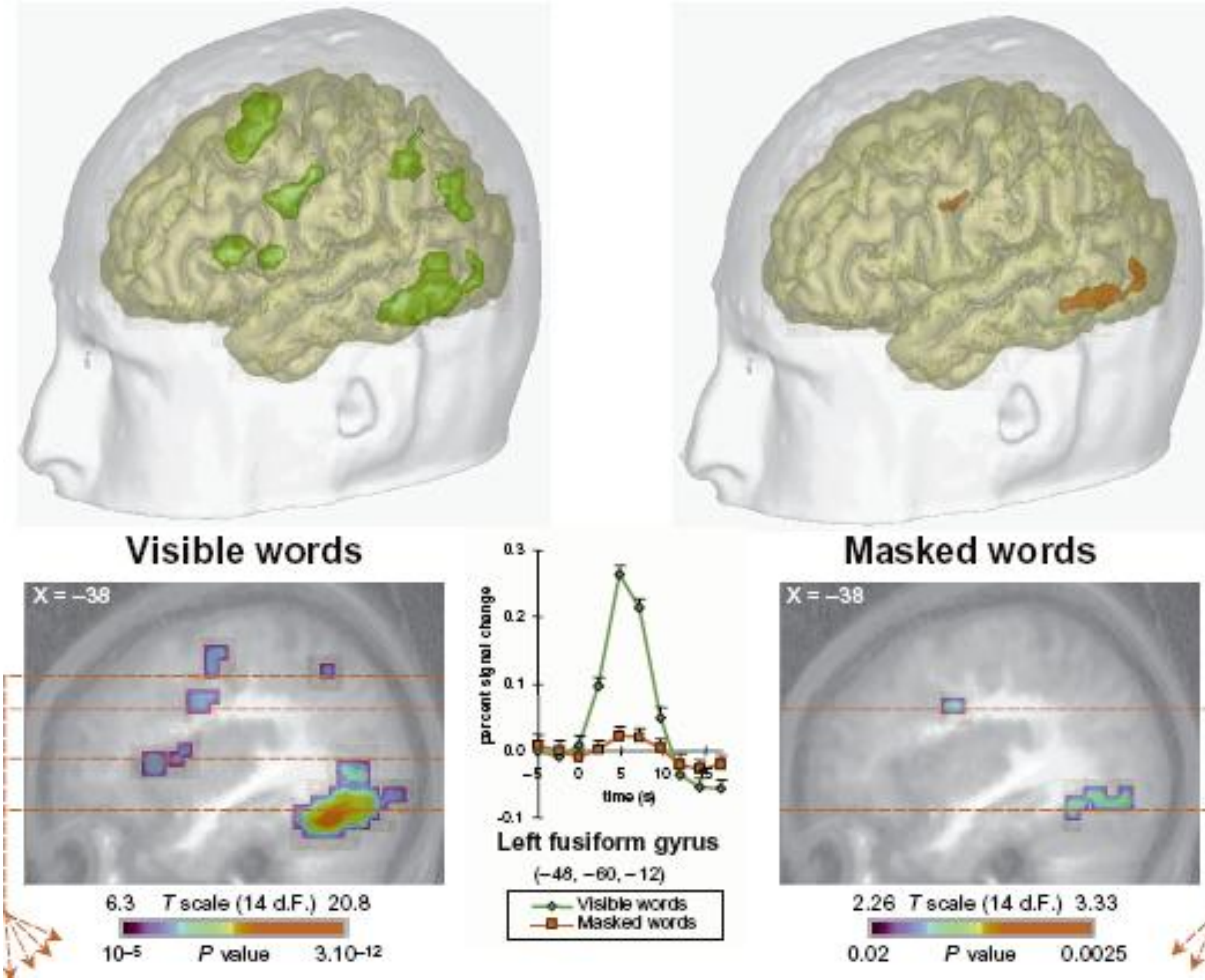
37 mots visibles, 37 invisibles

- 90,2% de mots détectés («vu»)
- 88,9% correctement nommés

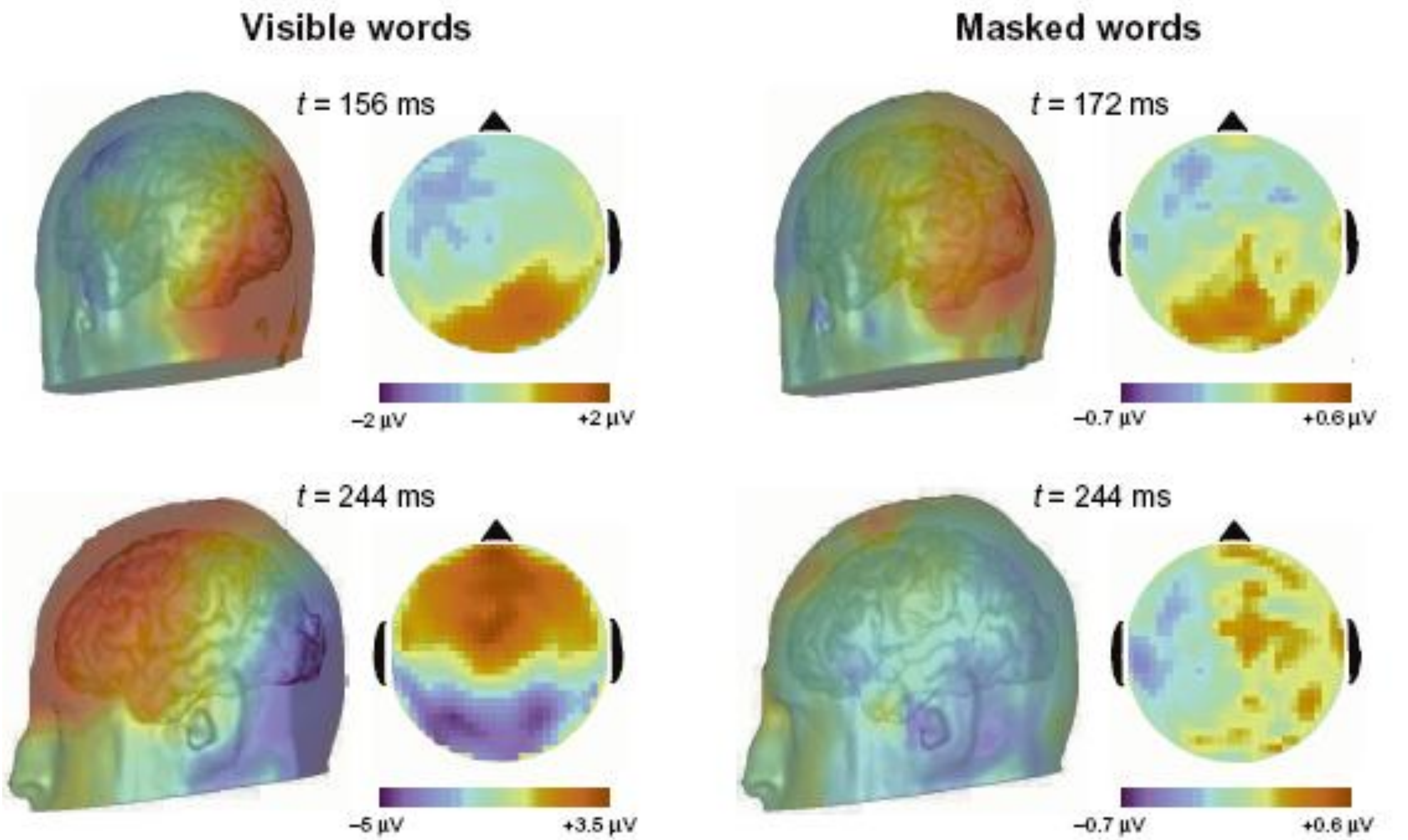
- 99,3% de mots pas détectés («non vu»)
- 99,95% pas nommés



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



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



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

Neural Correlates of Perceptual Rivalry in the Human Brain

Erik D. Lumer,* Karl J. Friston, Geraint Rees

When dissimilar images are presented to the two eyes, perception alternates spontaneously between each monocular view, a phenomenon called binocular rivalry. Functional brain imaging in humans was used to study the neural basis of these subjective perceptual changes. Cortical regions whose activity reflected perceptual transitions included extrastriate areas of the ventral visual pathway, and parietal and frontal regions that have been implicated in spatial attention; whereas the extrastriate areas were also engaged by nonrivalrous perceptual changes, activity in the frontoparietal cortex was specifically associated with perceptual alternation only during rivalry. These results suggest that frontoparietal areas play a central role in conscious perception, biasing the content of visual awareness toward abstract internal representations of visual scenes, rather than simply toward space.

Lumer et al. SCIENCE VOL. 280

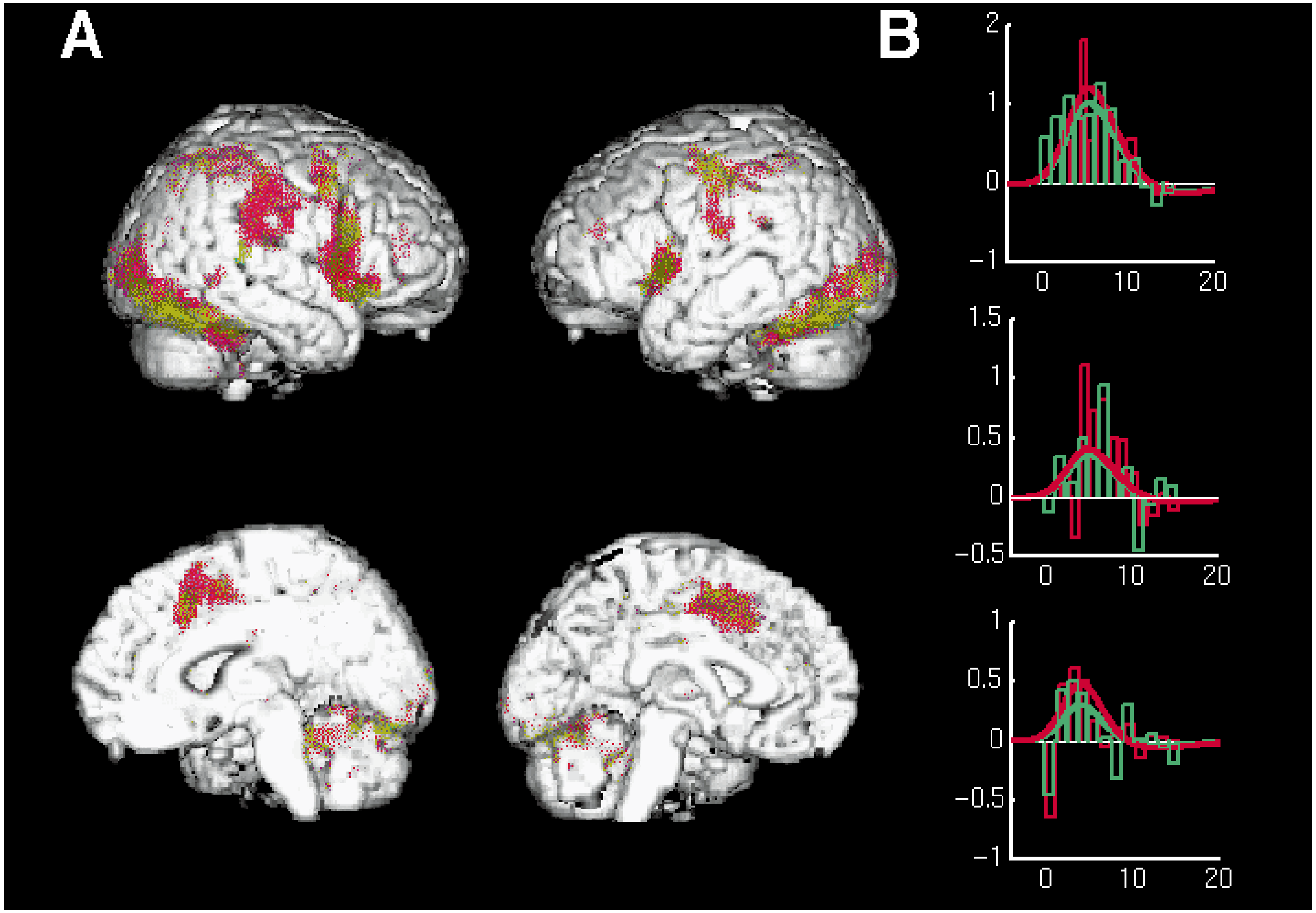


Fig. 2. Event-related activity during rivalry and replay conditions. (**A**) Four views of the medial and lateral surfaces of a rendering of the T1-weighted anatomical template image in Talairach space, on which are superimposed areas where evoked activity was specifically related to perceptual transitions in either the rivalry condition (red) or the replay condition (green). A statistical threshold of $Z = 3.09$ (corresponding to $P < 0.001$, uncorrected) was used for display purposes; peaks of activation reaching statistical significance after correction for multiple comparisons ($P < 0.05$) are listed in Table 1. The areas modulated by perception during both rivalrous and replay viewing, and the bilateral symmetry of the evoked activity are apparent. (**B**) Illustrative postevent histograms of the modulation of activity produced by transition events in rivalry (red) and replay (green) conditions from three different subjects. The evoked activity (percent change in BOLD contrast) is shown as a function of postevent time (in seconds) for each subject, with the fitted models of hemodynamic response function superimposed in solid lines. The modulation of activity shown here is taken from a voxel in right anterior fusiform gyrus ($x = 33$ mm, $y = -45$ mm, $z = -21$ mm; $Z = 8.10$, $P < 0.001$ corrected).

Behavioral/Systems/Cognitive

Distributed and Antagonistic Contributions of Ongoing Activity Fluctuations to Auditory Stimulus Detection

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Recent studies have shown that ongoing activity fluctuations influence trial-by-trial perception of identical stimuli. Some brain systems seem to bias toward better perceptual performance and others toward worse. We tested whether these observations generalize to another as of yet unassessed sensory modality, audition, and a nonspatial but memory-dependent paradigm. In a sparse event-related functional magnetic resonance imaging design, we investigated detection of auditory near-threshold stimuli as a function of prestimulus baseline activity in early auditory cortex as well as several distributed networks that were defined on the basis of resting state functional connectivity. In accord with previous studies, hits were associated with higher prestimulus activity in related early sensory cortex as well as in a system comprising anterior insula, anterior cingulate, and thalamus, which other studies have related to processing salience and maintaining task set. In contrast to previous studies, however, higher prestimulus activity in the so-called dorsal attention system of frontal and parietal cortex biased toward misses, whereas higher activity in the so-called default mode network that includes posterior cingulate and precuneus biased toward hits. These results contradict a simple dichotomic view on the function of these two latter brain systems where higher ongoing activity in the dorsal attention network would facilitate perceptual performance, and higher activity in the default mode network would deteriorate perceptual performance. Instead, we show that the way in which ongoing activity fluctuations impact on perception depends on the specific sensory (i.e., nonspatial) and cognitive (i.e., mnemonic) context that is relevant.

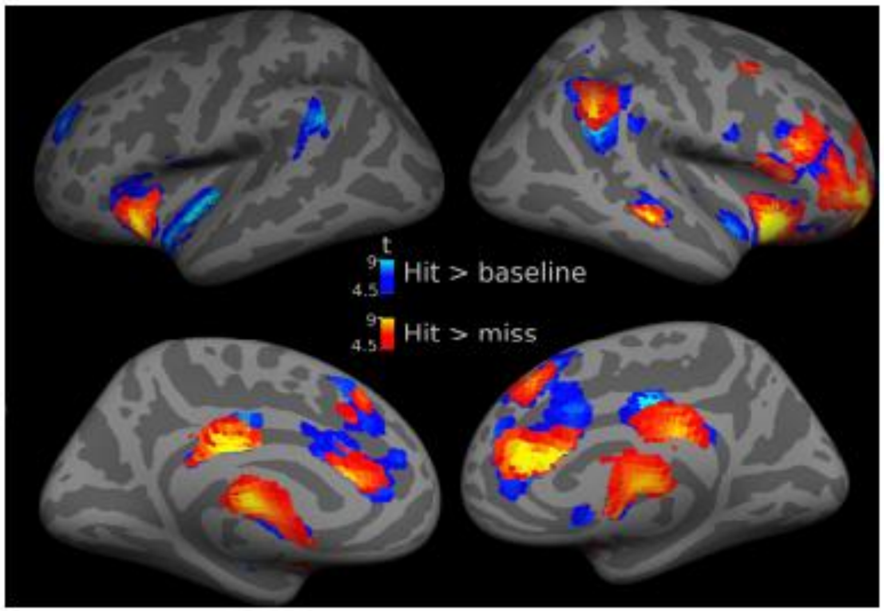

Figure 2. Spatial distribution of evoked cortical responses during successful stimulus detection. Activations evoked in hit trials versus baseline are shown in cold colors (for details, compare supplemental Table 1, available at www.jneurosci.org as supplemental material). A direct comparison of greater responses during hits than misses (warm colors) revealed a very similar activation pattern. Threshold height $p < 0.05$ corrected at the cluster level using an auxiliary (uncorrected) voxel threshold of $p < 0.0001$. Group results ($n = 11$) are superimposed onto the lateral and medial aspects of an inflated cortical surface of a canonical average brain.

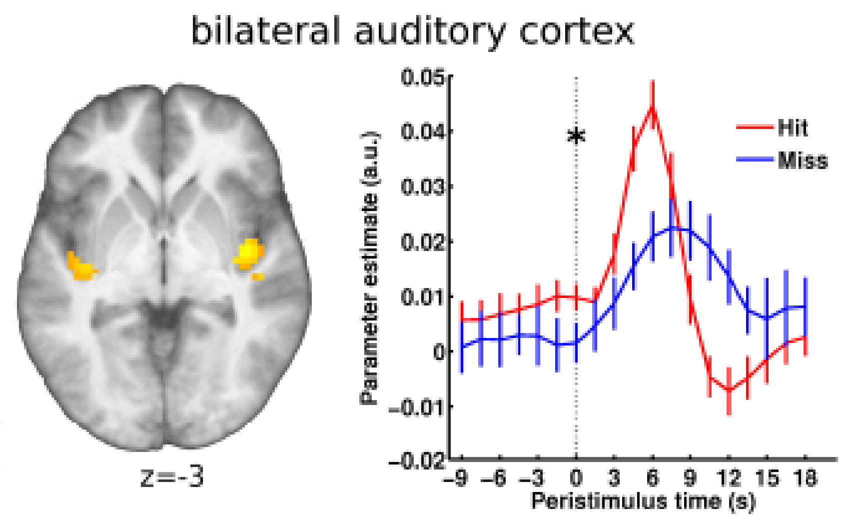

Figure 3. Prestimulus fMRI time courses from bilateral auditory cortex. Left, Map of activation evoked by the near-threshold stimulus (independent of percept) assessed in a group analysis. This map served as the basis for subject-by-subject definition of the auditory ROI (shown on the group's average brain; threshold height $p < 0.001$ uncorrected; see Materials and Methods for details). Right, In accord with our previous findings, we tested the effect of prestimulus activity at time point 0 s and found significantly higher activity preceding hits than misses (as indicated by an asterisk). Error bars indicate ±SEM.

Neural correlate of subjective sensory experience gradually builds up across cortical areas

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Contributed by Ranulfo Romo, July 13, 2006

When a sensory stimulus is presented, many cortical areas are activated, but how does the representation of a sensory stimulus evolve in time and across cortical areas during a perceptual judgment? We investigated this question by analyzing the responses from single neurons, recorded in several cortical areas of parietal and frontal lobes, while trained monkeys reported the presence or absence of a mechanical vibration of varying amplitude applied to the skin of one fingertip. Here we show that the strength of the covariations between neuronal activity and perceptual judgments progressively increases across cortical areas as the activity is transmitted from the primary somatosensory cortex to the premotor areas of the frontal lobe. This finding suggests that the neuronal correlates of subjective sensory experience gradually build up across somatosensory areas of the parietal lobe and premotor cortices of the frontal lobe.

detection | perception | psychophysics | somatosensory

Recent studies combining psychophysical and neurophysiological experiments in behaving monkeys have provided insights into which attributes of the neuronal responses evoked

a mechanical stimulator probe vibrated or not by pressing one of two push buttons with the free hand (Fig. 1*a*). Stimuli were sinusoidal of varied amplitude across trials, had a fixed frequency of 20 Hz, and were delivered to the glabrous skin of one fingertip of the restrained hand. Stimulus-present trials were interleaved with an equal number of stimulus-absent trials in which no mechanical vibrations were delivered. Because of task design, the monkeys' responses could be classified into four types: hits and misses in the stimulus-present condition, and correct rejections and false alarms in the stimulus-absent condition (Fig. 1*b*). Detection performance was calculated from the behavioral responses (Fig. 1*c*). We recorded from single neurons in several cortical areas of the parietal and frontal lobes while monkeys performed the sensory detection task (Fig. 1*d*).

Neural Responses Across Cortical Areas During the Detection Task. We found that the activity evoked by the vibrotactile stimulus is distributed from early somatosensory cortices to a large number of areas, including association and motor areas. Fig. 2*a* shows that the majority of the recorded neurons across cortical areas

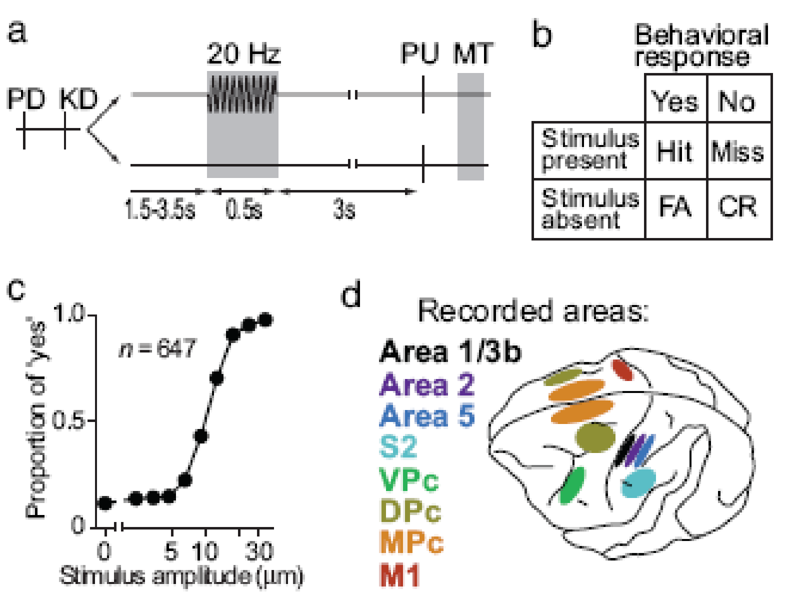


Fig. 1. Detection task. (*a*) Trials began when the stimulator probe indented the skin of one fingertip of the restrained right hand (probe down, PD). The monkey then placed its left hand on an immovable key (key down, KD). After a variable prestimulus period (uniformly distributed from 1.5 to 3.5 s), on half of the randomly selected trials, a vibratory stimulus (20 Hz, 0.5 s) was presented. Then, after a fixed delay period (3 s), the stimulator probe moved up (probe up, PU), indicating to the monkey that it could make the response movement (MT) to one of two response push buttons. The button pressed indicated whether or not the monkey felt the stimulus ("yes" and "no" responses, respectively). (*b*) Depending on whether the stimulus was present or absent and on the behavioral response, the trial outcome was classified as a hit, miss, correct rejection (CR), or false alarm (FA). Trials were pseudorandomly chosen; 90 trials were stimulus-absent (amplitude 0), and 90 trials were stimulus-present with varying amplitudes (nine amplitudes with 10 repetitions each; 2.3–34.6 μm). (*c*) Psychometric detection curve obtained by plotting the proportion of "yes" responses as a function of stimulus amplitude in logarithmic abscissa (*n* = number of runs; a run consists of 180 trials, 90 stimulus-absent and 90 stimulus-present trials). (*d*) Recorded cortical areas include 1/3b, 2, 5, secondary somatosensory cortex (S2), and ventral premotor cortex (VPc) on the left hemisphere; dorsal premotor cortex (DPc) and MPc bilaterally; and primary motor cortex (M1) on the right hemisphere.

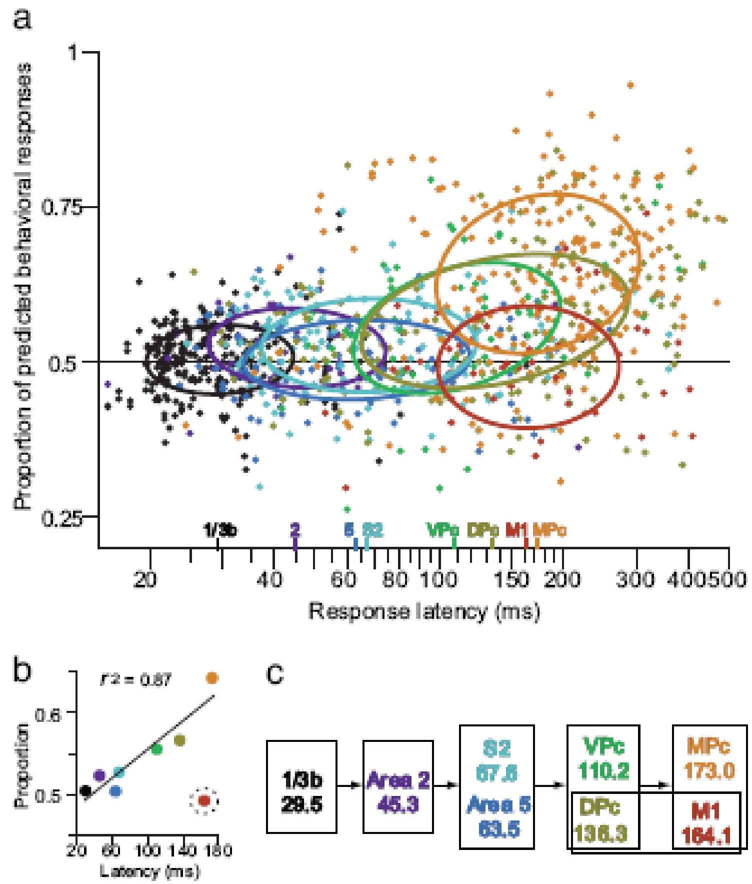
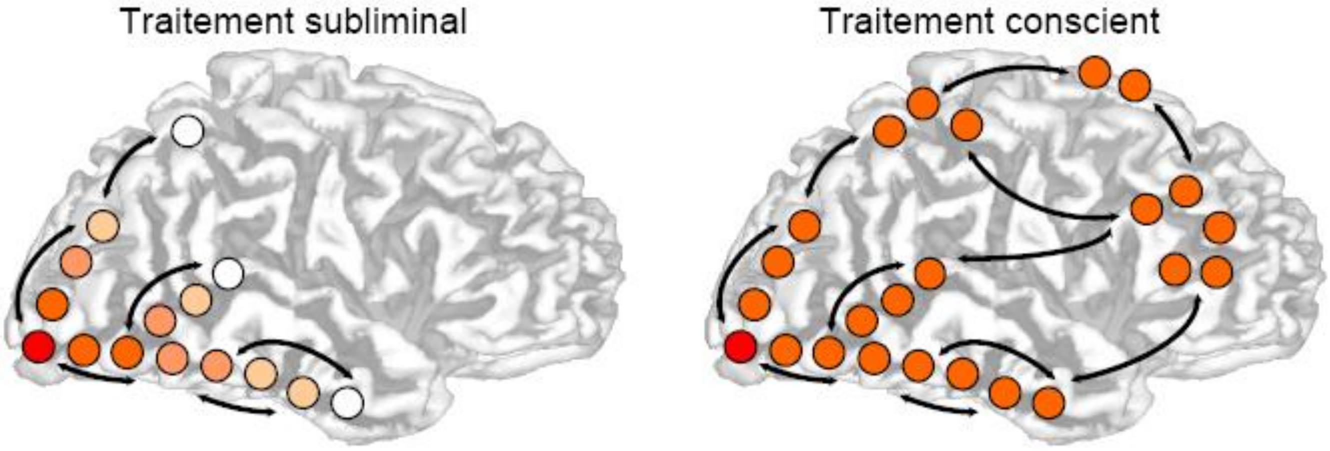
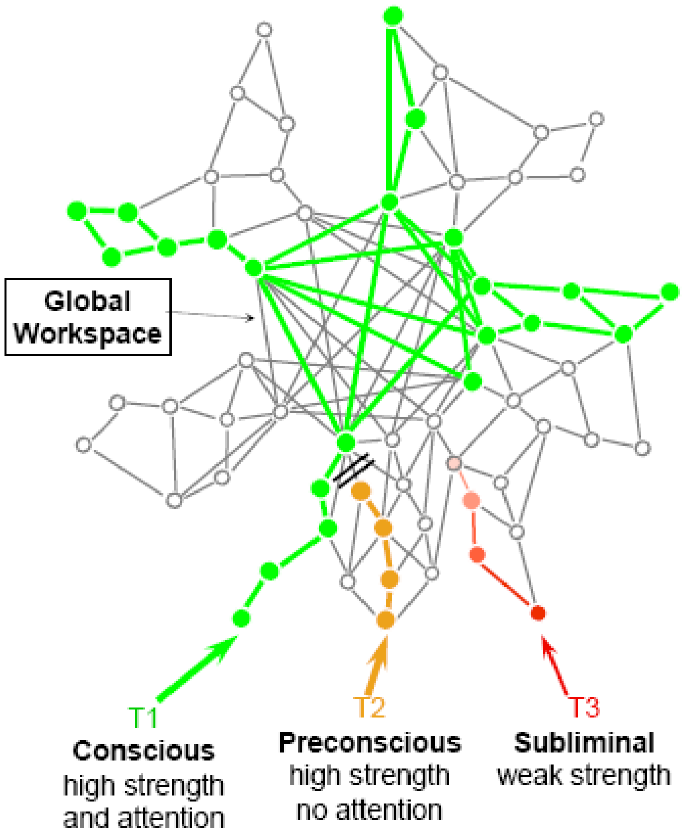


Fig. 4. Timing and strength of perceptual decision signals across cortical areas. (*a*) Choice-probability indices for individual neurons (mean value: hits vs. misses and correct rejections vs. false alarms) plotted as a function of the response latency for each cortical area (colors are as in Fig. 1*d*). Neurons from each area were fitted with two-dimensional Gaussians. Color markings at the abscissa indicate the mean response latency for each cortical area. (*b*) Mean choice-probability index for each area plotted as a function of the mean response latency. A linear fit shows how the choice-probability index increasingly grows as a function of latency (M1 neurons were excluded from the fit; red dot and dotted circle). (*c*) Recorded areas grouped into five processing stages by analysis of variance of response latencies. Each rectangle groups the areas with latencies that were statistically indistinguishable from each other.

Bases neurales de la conscience (en IRMf)





Bases neurales de l'expérience consciente

- Amplification de l'activation sensorielle
- Progression de l'activation vers des régions sensorielles plus antérieures
- Activation additionnelle de régions très distribuées du cortex préfrontal et pariétal inférieur
- Mise en corrélation de ces régions à longue distance

5. Certaines personnes en état de coma végétatif sont-elles conscientes ?

Caractéristiques de différents états de conscience altérée

État	Critères diagnostique	EEG	FDG-PET
Mort cérébrale			
	absence d'éveil absence de conscience absence de fonctions respiratoires perte des réflexes du tronc cérébral	isoélectrique	aucune activité
Coma			
	absence d'éveil absence de conscience fonction respiratoire variable présence variable des réflexes du tronc cérébral aucune production de sons	ralentissement généralisé important	40 à 50 % diminution
État végétatif			
	éveil (ouverture spontanée des yeux) absence de conscience souvent fonction respiratoire préservée préservation des réflexes du tronc cérébral parfois verbalisations non significatives	ralentissement généralisé important	50 à 60 % diminution (zones associatives)
État de conscience minimale			
	éveil (ouverture spontanée des yeux) conscience minimale (réponse inconsistante à un ordre verbal) fonction respiratoire préservée préservation des réflexes du tronc cérébral verbalisations possibles mais élémentaires	ralentissement généralisé	20 à 40 % diminution
Locked-in syndrome			
	éveil (ouverture spontanée des yeux) conscient (communication par mouvements des yeux) souvent fonction respiratoire préservée préservation des réflexes du tronc cérébral verbalisations impossibles (anarthrie) tétraplégie	normal	activité normale

« Après avoir exclu une dépression des fonctions cérébrales par des substances pharmacologiques ou toxiques ou par une hypothermie, un diagnostic définitif peut être établi après une période de 6 à 24 heures. »

Lésions = soit lésions diffuses et bilatérales du cortex cérébral, soit lésion de la substance réticulée du tronc cérébral.

Lésions = soit atteinte globale du cortex ou de la matière blanche, soit lésion thalamique bilatérale avec préservation de la substance réticulée

Lésions = soit atteinte globale du cortex ou de la matière blanche, soit lésion thalamique bilatérale avec préservation de la substance réticulée

Lésion du tronc cérébral, le plus souvent au niveau de la protubérance, avec préservation de la substance réticulée.

Schnakers, Majerus & Laureys, *Réanimation*, 2004

Box 3 | **Criteria for the vegetative state**

The criteria listed here comprise the guidelines of the US Multi-Society Task Force on Persistent Vegetative State[53].

- No evidence of awareness of self or environment and an inability to interact with others
- No evidence of sustained, reproducible, purposeful or voluntary behavioural responses to visual, auditory, tactile or noxious stimuli
- No evidence of language comprehension or expression
- Intermittent wakefulness manifested by the presence of the sleep–wake cycle
- Sufficiently preserved hypothalamic and brainstem autonomic functions to permit survival with medical and nursing care
- Bowel and bladder incontinence
- Variably preserved cranial nerve and spinal reflexes

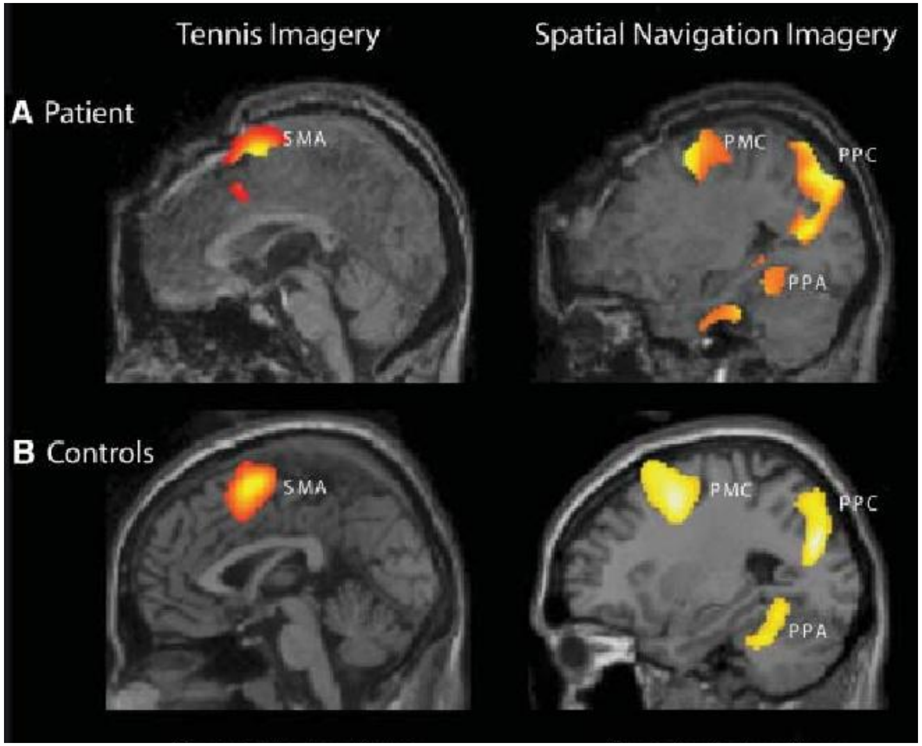


Fig. 1. We observed supplementary motor area (SMA) activity during tennis imagery in the patient and a group of 12 healthy volunteers (controls). We detected parahippocampal gyrus (PPA), posterior parietal-lobe (PPC), and lateral premotor cortex (PMC) activity while the patient and the same group of volunteers imagined moving around a house. All results are thesholded at $P <$ 0.05 corrected for multiple comparisons. *X* values refer to distance in mm from the midline in stereotaxic space (SOM text).

Owen et al., (2006). Detecting Awareness in the Vegetative State, ***Science***, 313, 1402.

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Willful Modulation of Brain Activity in Disorders of Consciousness

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BACKGROUND

The differential diagnosis of disorders of consciousness is challenging. The rate of misdiagnosis is approximately 40%, and new methods are required to complement bedside testing, particularly if the patient's capacity to show behavioral signs of awareness is diminished.

METHODS

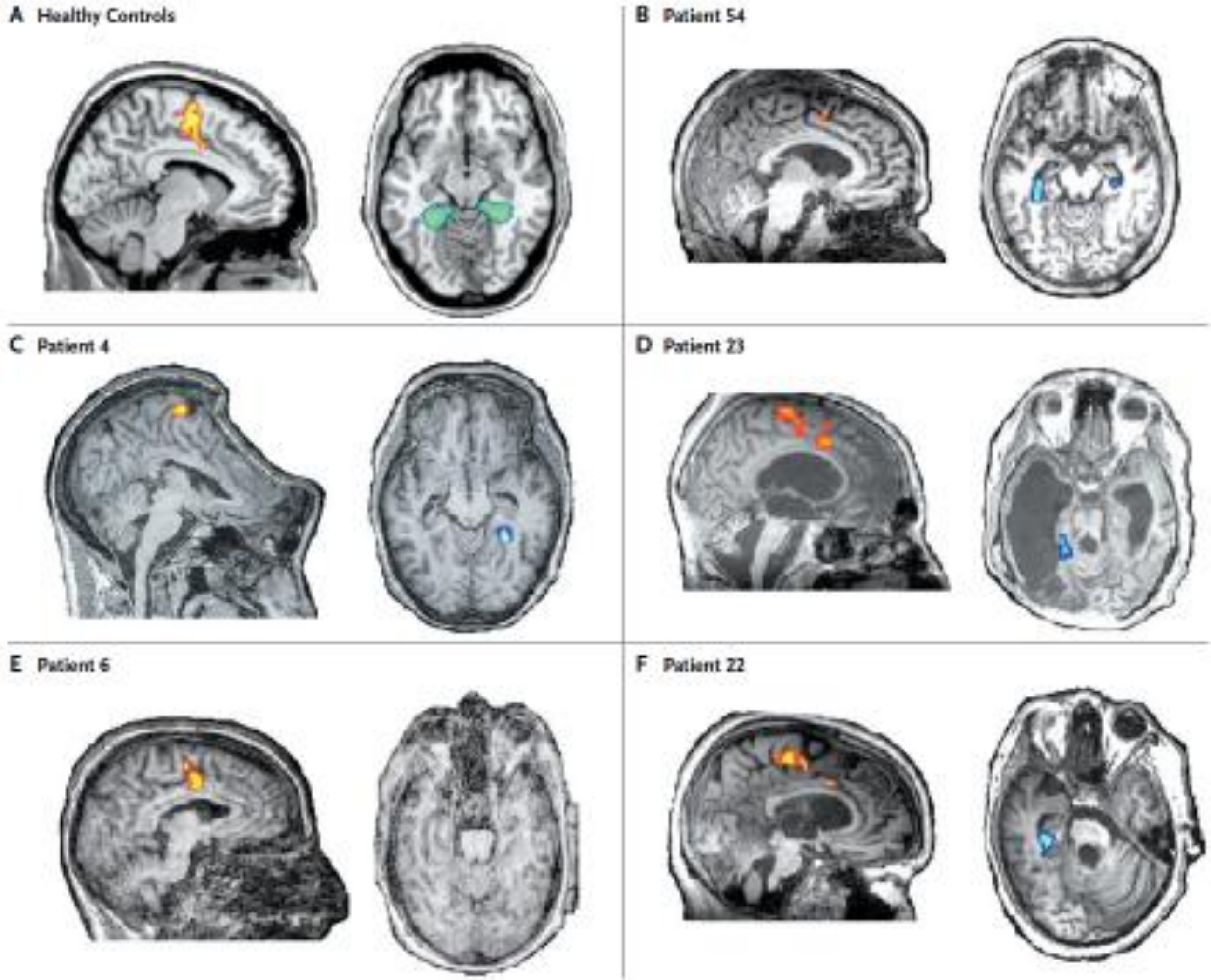
At two major referral centers in Cambridge, United Kingdom, and Liege, Belgium, we performed a study involving 54 patients with disorders of consciousness. We used functional magnetic resonance imaging (MRI) to assess each patient's ability to generate willful, neuroanatomically specific, blood-oxygenation-level–dependent responses during two established mental-imagery tasks. A technique was then developed to determine whether such tasks could be used to communicate yes-or-no answers to simple questions.

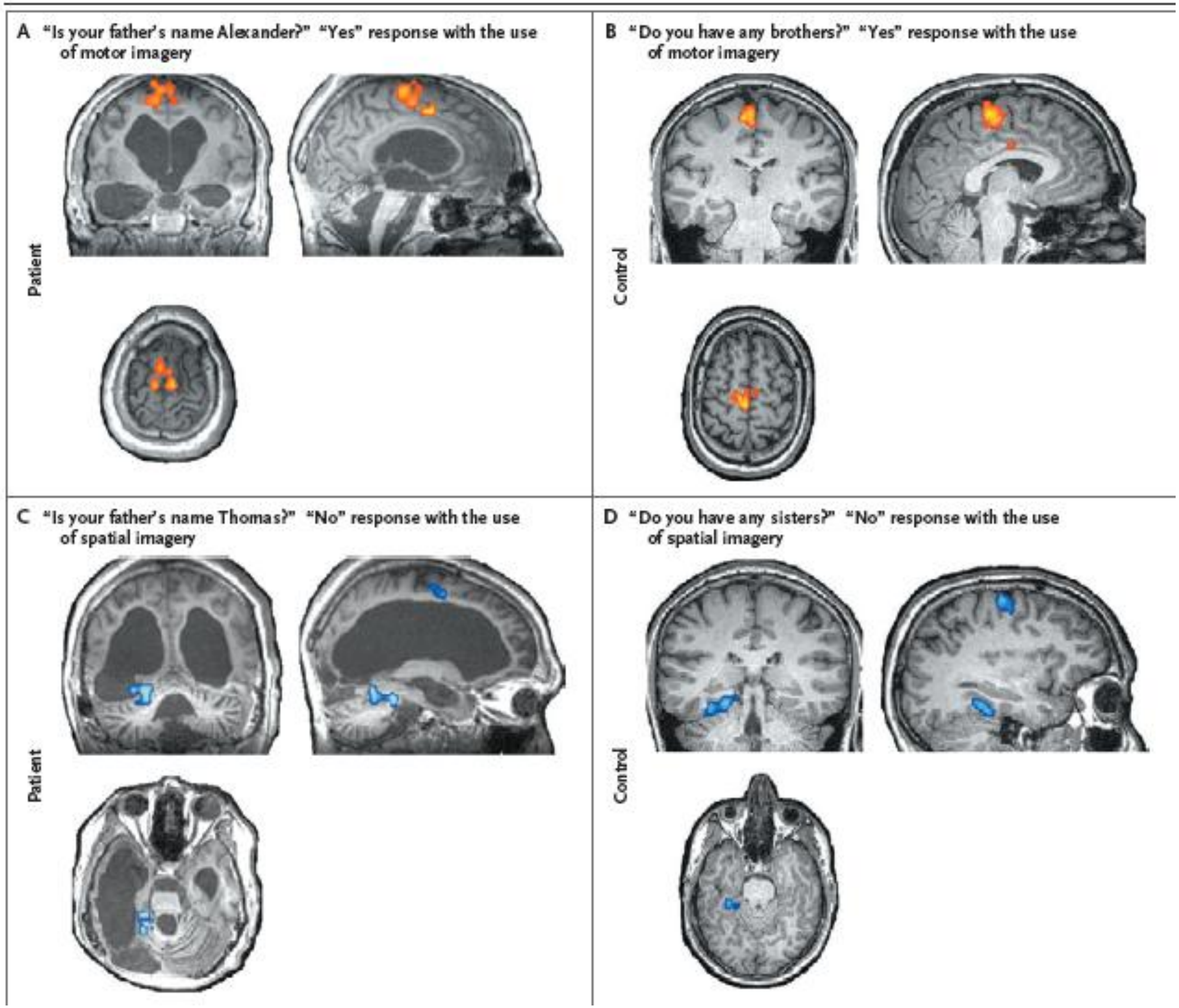
RESULTS

Of the 54 patients enrolled in the study, 5 were able to willfully modulate their brain activity. In three of these patients, additional bedside testing revealed some sign of awareness, but in the other two patients, no voluntary behavior could be detected by means of clinical assessment. One patient was able to use our technique to answer yes or no to questions during functional MRI; however, it remained impossible to establish any form of communication at the bedside.

CONCLUSIONS

These results show that a small proportion of patients in a vegetative or minimally conscious state have brain activation reflecting some awareness and cognition. Careful clinical examination will result in reclassification of the state of consciousness in some of these patients. This technique may be useful in establishing basic communication with patients who appear to be unresponsive.


A Healthy Controls
B Patient 54
C Patient 4
D Patient 23
E Patient 6
F Patient 22



A "Is your father's name Alexander?" "Yes" response with the use of motor imagery
Patient
B "Do you have any brothers?" "Yes" response with the use of motor imagery
Control
C "Is your father's name Thomas?" "No" response with the use of spatial imagery
Patient
D "Do you have any sisters?" "No" response with the use of spatial imagery
Control