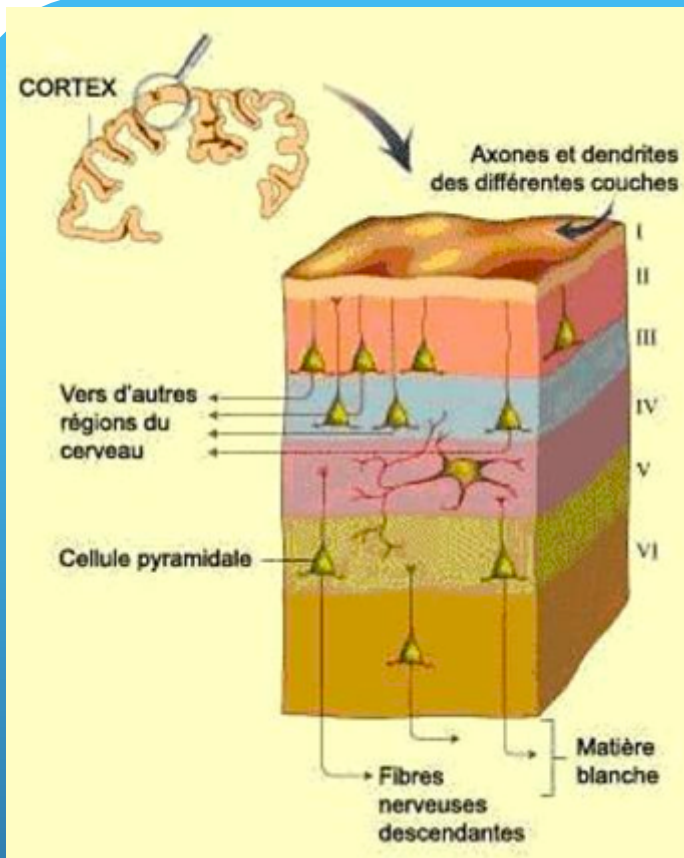


# Cerveau, intelligence, précocité où en est-on des connaissances neuroscientifiques?

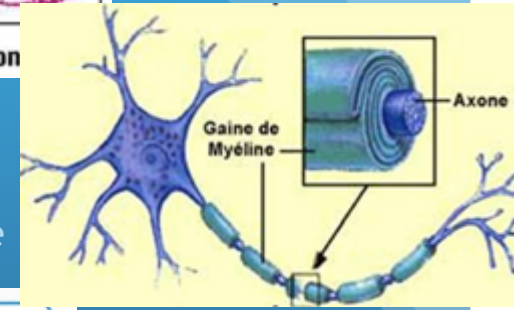
Michel Habib, neurologue  
CHU de Marseille

# Un bref panorama des études récentes cerveau/précocité

- Avant l'avènement de l'imagerie fonctionnelle (~<1995)
  - Notions sur la taille du cerveau, du cortex, de l'hippocampe..., et leur corrélation avec le QI
  - Notions assez générales sur des particularités de la transmission de l'influx électrique (EEG, potentiels évoqués)
- Depuis l'apparition de l'imagerie fonctionnelle (PET, IRMf++)
  - Nombreuses études comparant l'activation cérébrale lors de tâche à fort ou faible « poids facteur g » (g-loaded)
  - Quelques études comparant précisément précoces et témoins à intelligence standard
  - Très rares études consacrées aux précoces avec difficultés
- Apport plus prometteur de l'imagerie morphologique
  - études transversales de la maturation du cortex
  - Études de connectivité entre régions distantes

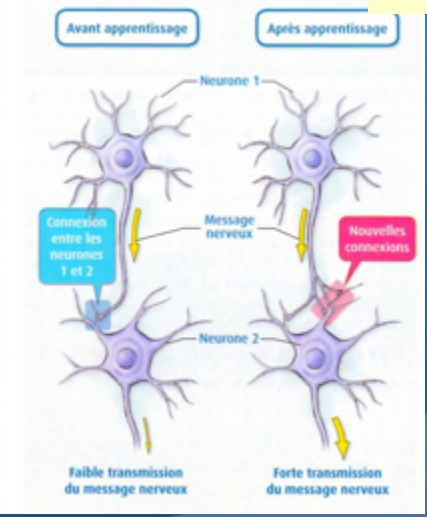
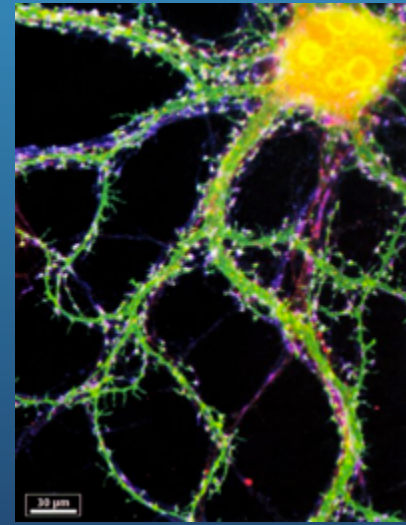


Prolifération dendritique : atteint son maximum vers 2 ans + gaine de myéline



Cortex cérébral : neurones, axones, dendrites, synapses

Apprentissage : synapses se créent, s'éliminent, se modifient

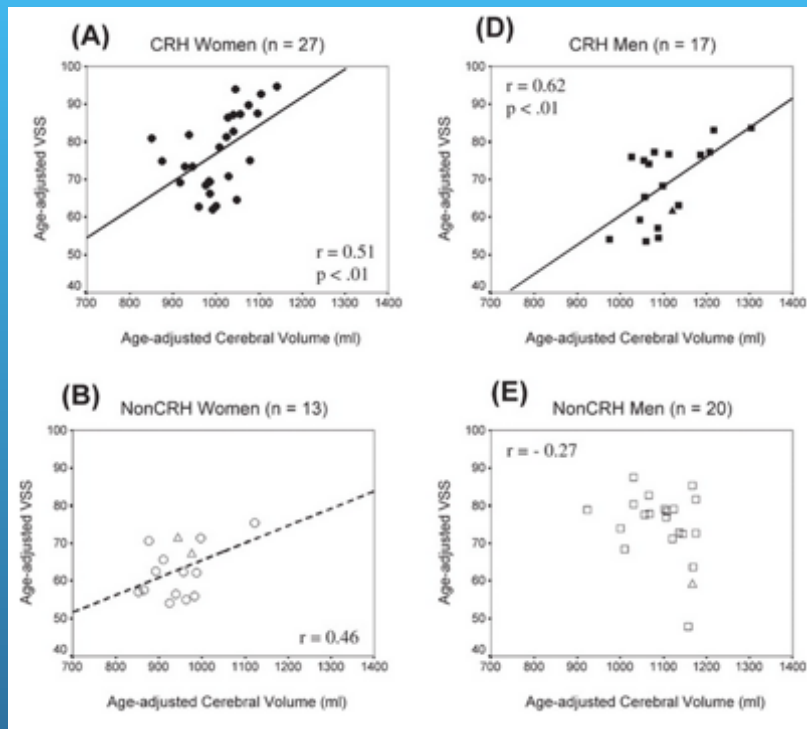


# Intelligence et volume cérébral : quelles relations?

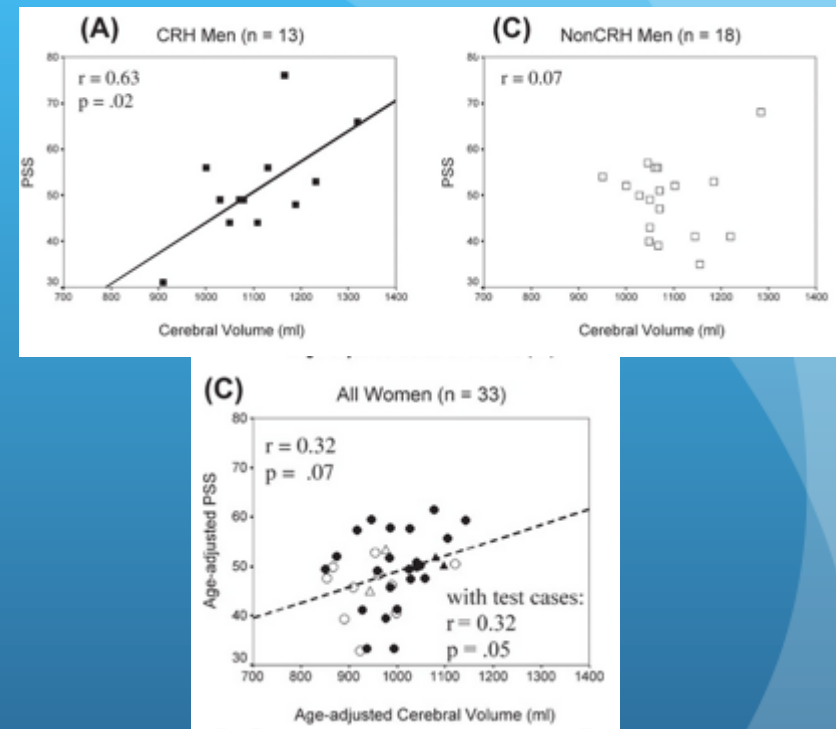
- Une méta-analyse de 37 études avec un nombre total de 1530 participants. Conclusion : « Ce rapport résout définitivement le débat ouvert il y a 169 ans : il est clair que l'intelligence et le volume cérébral sont positivement corrélés».
- Plus précisément, les résultats de cette étude étaient triples :
  - 1) la corrélation moyenne est de 0,33 (ce qui est relativement faible) ;
  - 2) cette corrélation est plus forte pour les individus de sexe féminin (0,40) ; et
  - 3) elle ne change pas avec l'âge.

McDaniel MA. Big-brained people are smarter: a meta-analysis of the relationship between in vivo brain volume and intelligence. *Intelligence*. 2005;33:337-346.

# Intelligence et volume cérébral : effet de la latéralisation hémisphérique



Verbal IQ vs. total cerebral volume



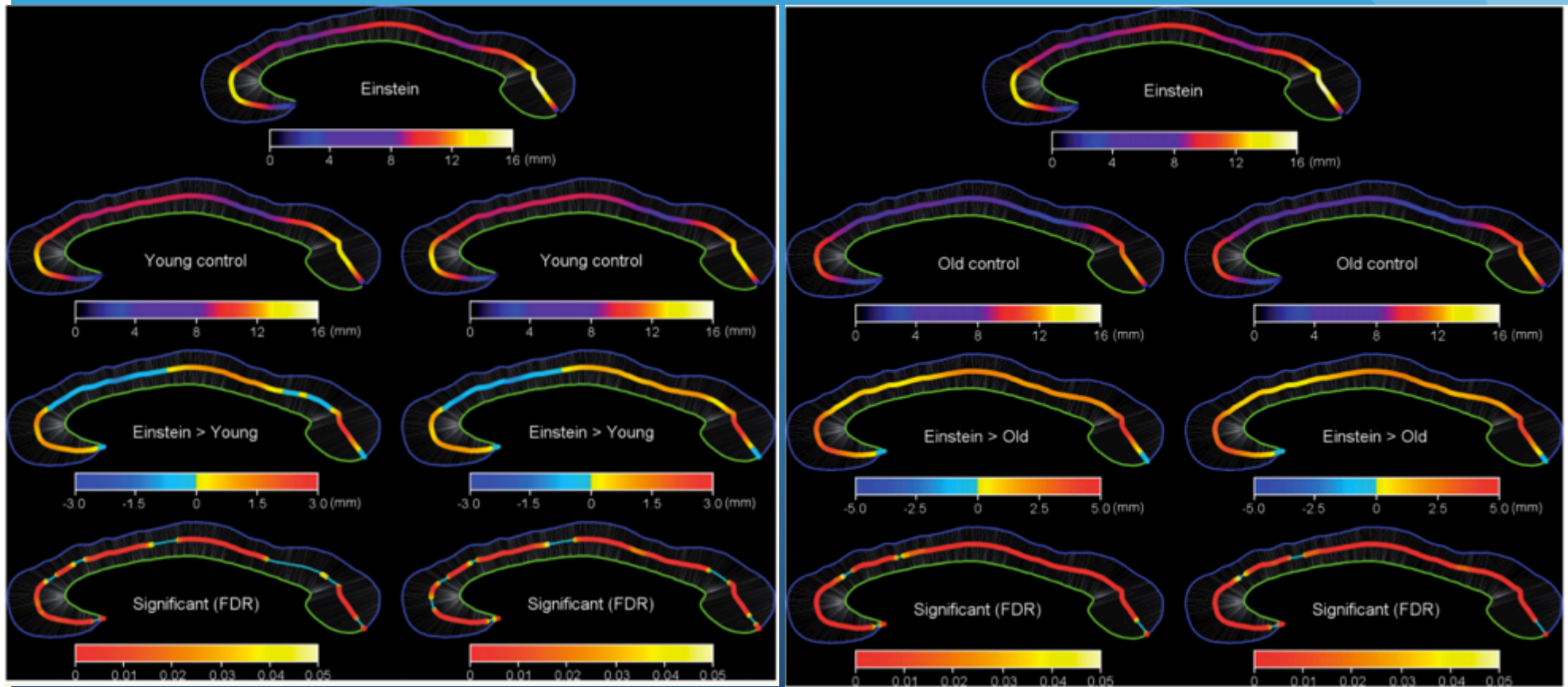
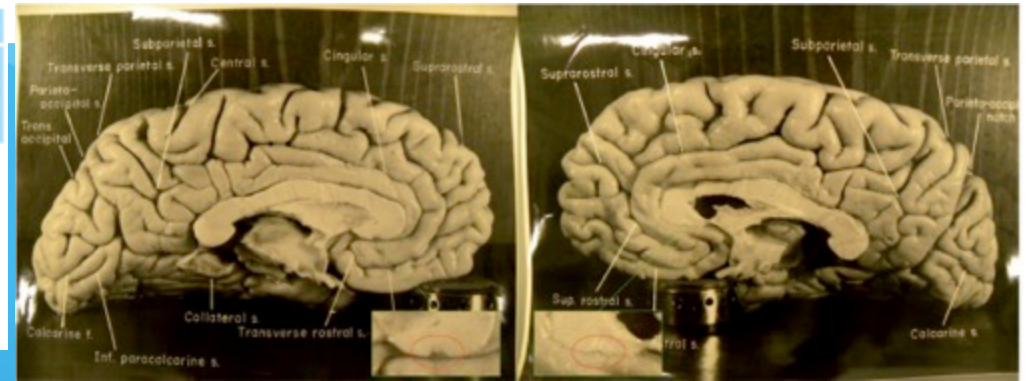
Perform. IQ vs. total cerebral volume

S. F. Witelson, H. Beresh, D. L. Kigar. (2006). Intelligence and brain size in 100 postmortem brains: sex, lateralization and age factors. [Brain](#). 129(Pt 2):386-98.

## LETTER TO THE EDITOR

The corpus callosum of Albert Einstein's brain: another clue to his high intelligence?

Weiwei Men,<sup>1</sup> Dean Falk,<sup>2,3</sup> Tao Sun,<sup>4</sup> Weibo Chen,<sup>1</sup> Jianqi Li,<sup>1</sup> Dazhi Yin,<sup>1</sup> Lili Zang<sup>1</sup> and Mingxia Fan<sup>1</sup>



# Neuromythology of Einstein's brain



Terence Hines

Psychology Department, Pace University, Pleasantville, NY, United States  
Neurology Department, New York Medical College, Valhalla, NY, United States

## ARTICLE INFO

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## ABSTRACT

The idea that the brain of the great physicist Albert Einstein is different from "average" brains in both cellular structure and external shape is widespread. This belief is based on several studies examining Einstein's brain both histologically and morphologically. This paper reviews these studies and finds them wanting. Their results do not, in fact, provide support for the claim that the structure of Einstein's brain reflects his intellectual abilities.

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frontiers in  
**EVOLUTIONARY NEUROSCIENCE**

**ORIGINAL RESEARCH ARTICLE**

published: 04 May 2009  
doi: 10.3389/neuro.18.003.2009



## New information about Albert Einstein's brain

**Dean Falk\***

*Department of Anthropology, Florida State University, Tallahassee, FL, USA*

doi:10.1093/brain/aws295

Brain 2013; 136; 1304–1327 | 1304

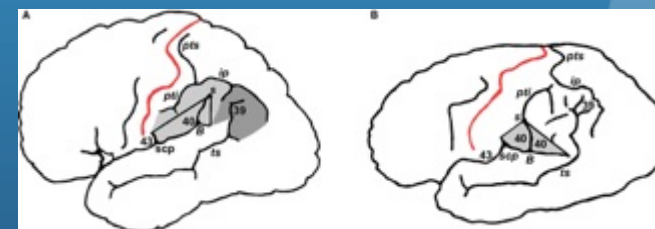
**BRAIN**

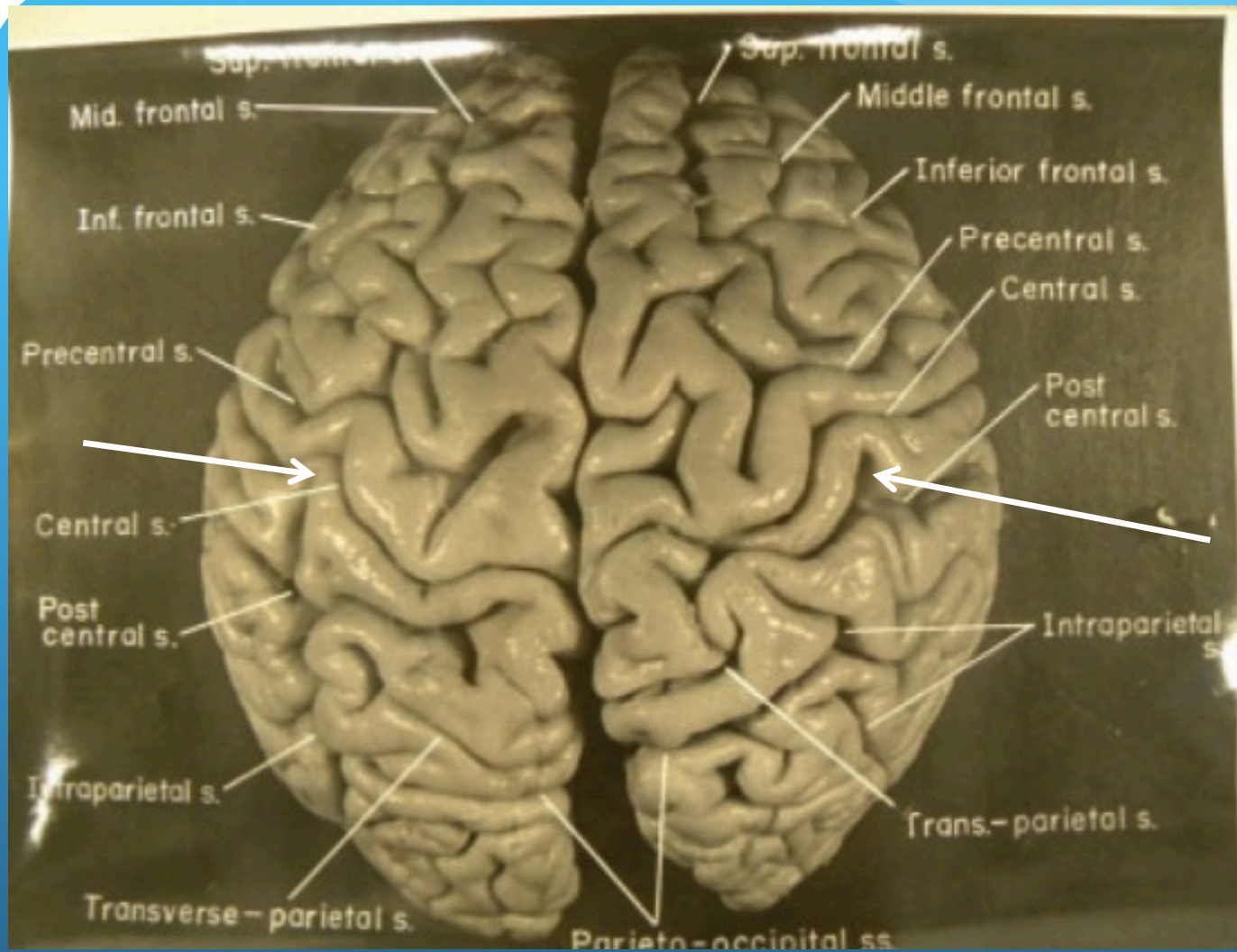
A JOURNAL OF NEUROLOGY

**OCCASIONAL PAPER**

## The cerebral cortex of Albert Einstein: a description and preliminary analysis of unpublished photographs

Dean Falk,<sup>1,2</sup> Frederick E. Lepore<sup>3,4</sup> and Adrienne Noe<sup>5</sup>



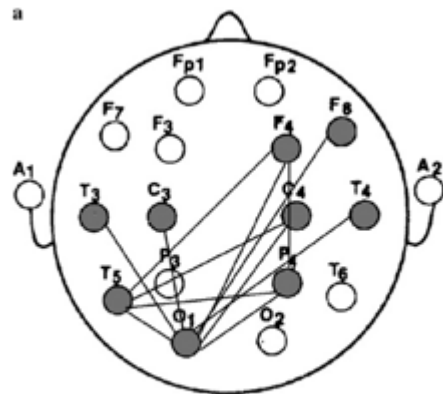




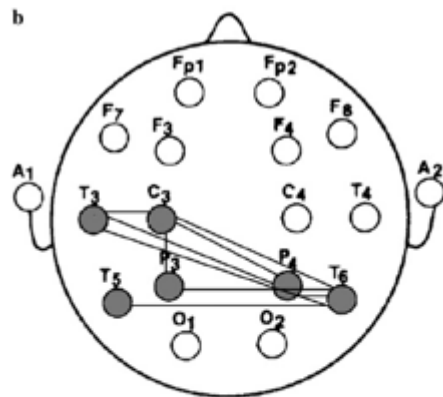
# Differences in brain information transmission between gifted and normal children during scientific hypothesis generation

Seung-Hyun Jin <sup>a</sup>, Yong-Ju Kwon <sup>b,\*</sup>, Jin-Su Jeong <sup>b</sup>, Suk-Won Kwon <sup>b</sup>, Dong-Hoon Shin <sup>b</sup>

control



gifted



Les HPI utilisent préférentiellement les régions postérieures de leur cerveau, et distribuent leurs ressources cognitives plus efficacement

Fig. 1. *t*-map describing all the pairs where higher A-CMI values (paired test,  $P < .05$ ) are observed in hypothesis generation condition: (a) the normal children and (b) the gifted children, as compared to A-CMI values at a resting state. The straight line indicates the bi-directionally increased A-CMI values.

Après placement des électrodes sur le scalp, les enfants devaient lire une série de questions puis formuler une explication causale à partir des questions évoquées. Les résultats ont été obtenus après une analyse multivariée des A-CMI (averaged cross mutual information): "In contrast to normal children, gifted children showed increased A-CMI values between the left temporal and central, between the left temporal and parietal, and between the left central and parietal locations while generating a hypothesis. These results suggested that gifted children more efficiently distribute the cognitive resources essential to cope with hypothesis generation."

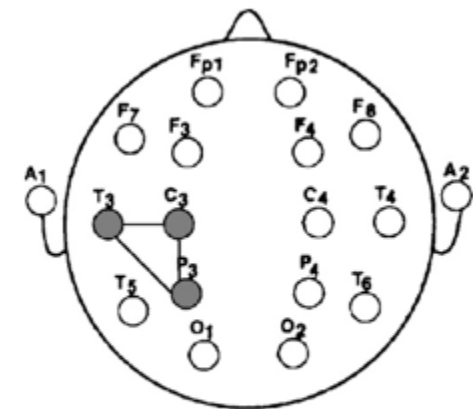


Fig. 2. *t*-map describing all the pairs where the gifted children have higher A-CMI values (unpaired *t*-test,  $P < .05$ ) than the normal children. The straight line indicates the bi-directionally increased A-CMI values.

# DECISION LEXICALE

**AVION**

*Mot*

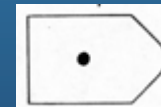
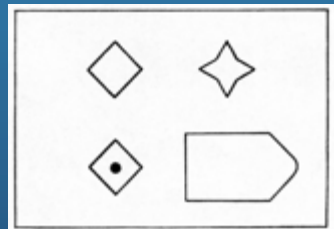
**NOAGE**

*Pseudo-mot*

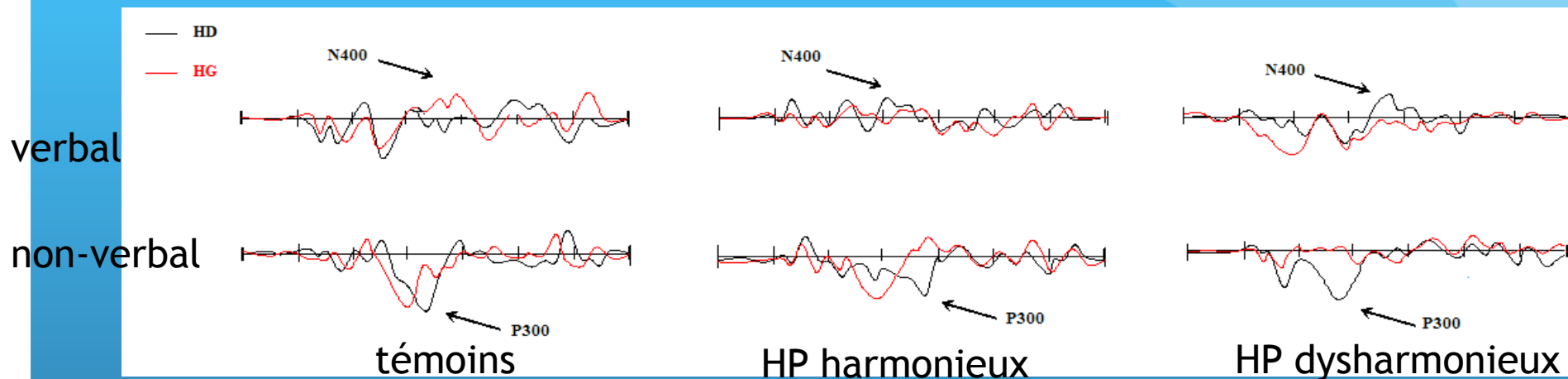
**WXPT**

*Non-mot*

## COMPLETEMENT D'UNE MATRICE



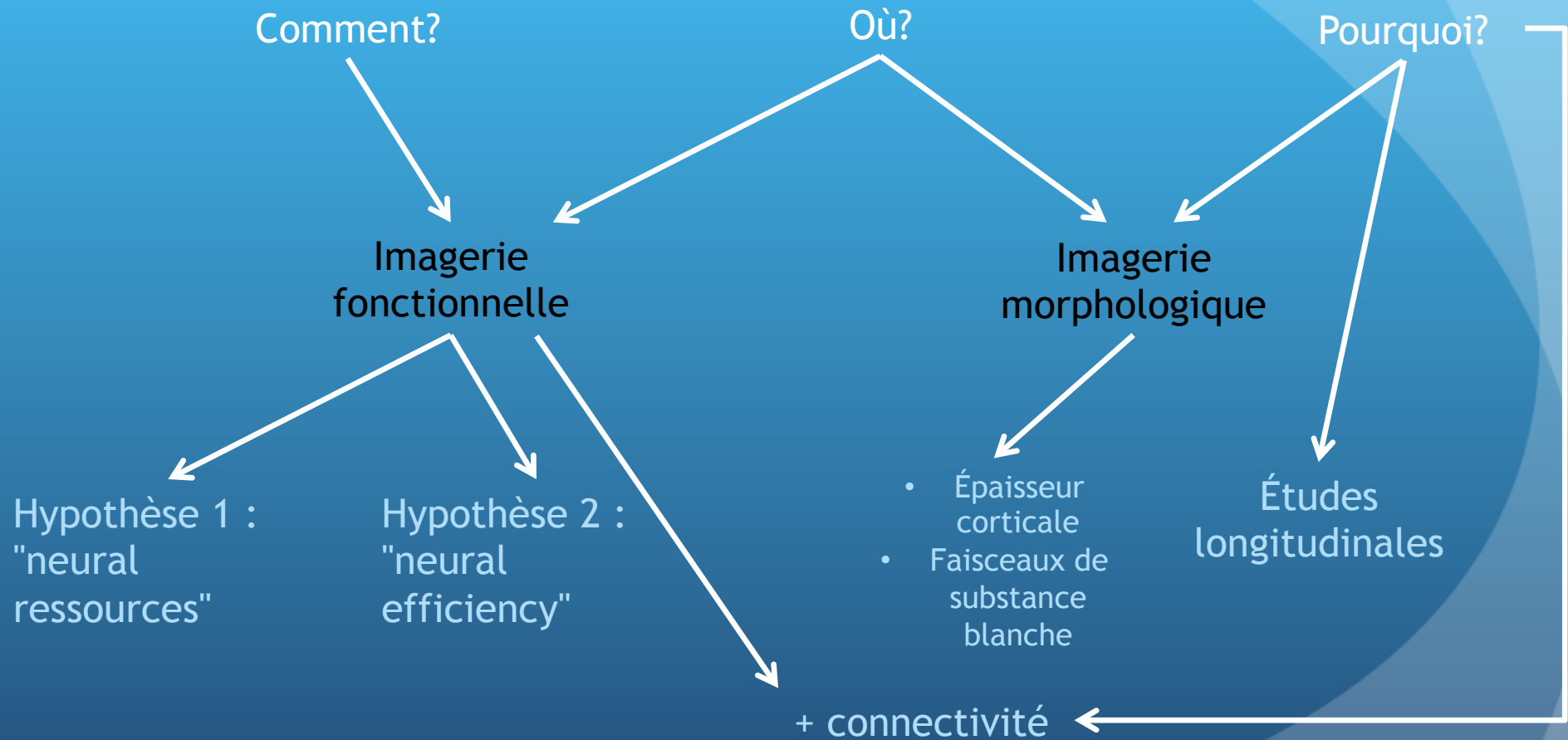
Exemples de PE enregistrés lors des tâches de décision lexicale et de complèment de matrice chez des enfants (contrôle, intellectuellement précoces harmonieux et dysharmonieux)



*les enfants ayant une importante différence entre leurs performances verbales et pragmatiques dont témoigne le profil dysharmonieux du Q.I. auraient tendance à surengager l' hémisphère cérébral droit aux dépens du gauche quel que soit le type de tâche. Les enfants ayant un profil harmonieux de performances cognitives auraient, quant à eux, tendance à engager leurs deux hémisphères à la fois dans les tâches verbales et non verbales.*

**Magnié M.N., Caro C., Faure F. (2003). Hemispheric specialisation in giftedness: psychometric, behavioral and electrophysiological investigation. Sixth IBRO World Congress of Neuroscience, Prague, Czech Republic, July 10<sup>th</sup> - 15<sup>th</sup>, 2003**

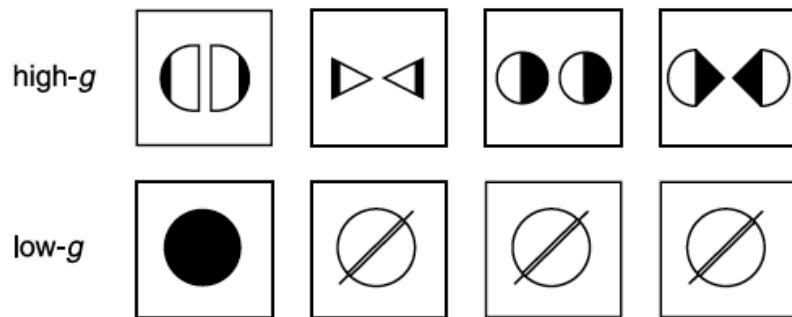
# Imagerie cérébrale : questions et hypothèses



# A Neural Basis for General Intelligence

John Duncan,<sup>1\*</sup> Rüdiger J. Seitz,<sup>2</sup> Jonathan Kolodny,<sup>1</sup>  
 Daniel Bor,<sup>1</sup> Hans Herzog,<sup>3</sup> Ayesha Ahmed,<sup>1</sup> Fiona N. Newell,<sup>1</sup>  
 Hazel Emslie<sup>1</sup>

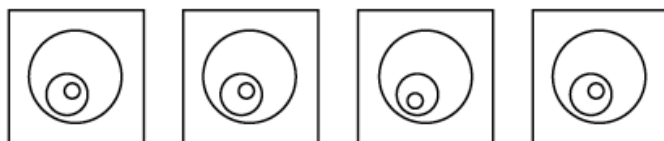
## A Spatial



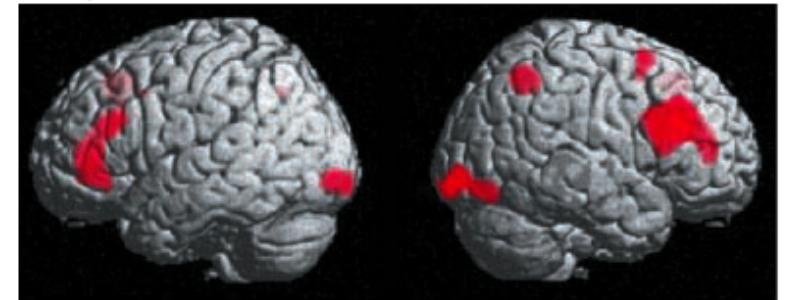
## B Verbal

high- <i>g</i>	L H E C	D F I M	T Q N K	H J M Q
low- <i>g</i>	O P Q S	G H I J	L M N O	I J K L

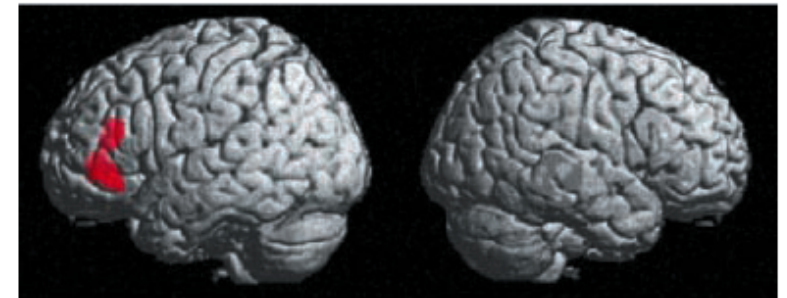
## C Circles



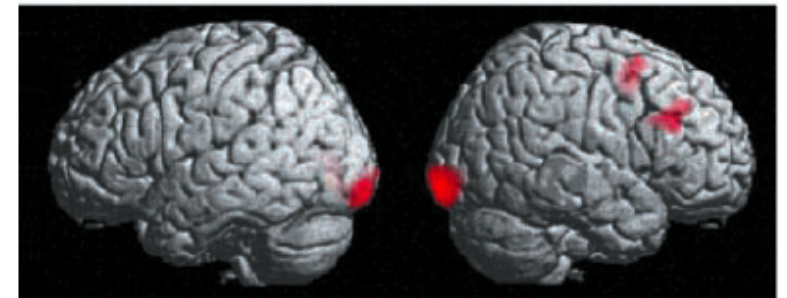
## A Spatial



## B Verbal



## C Circles

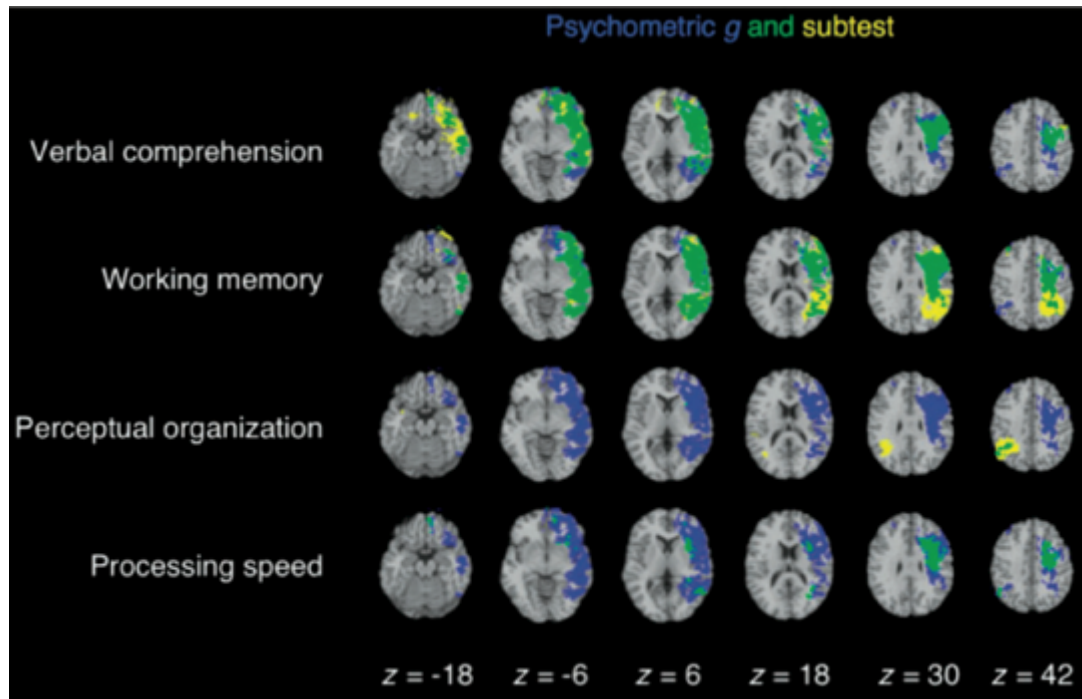


Duncan et al. :

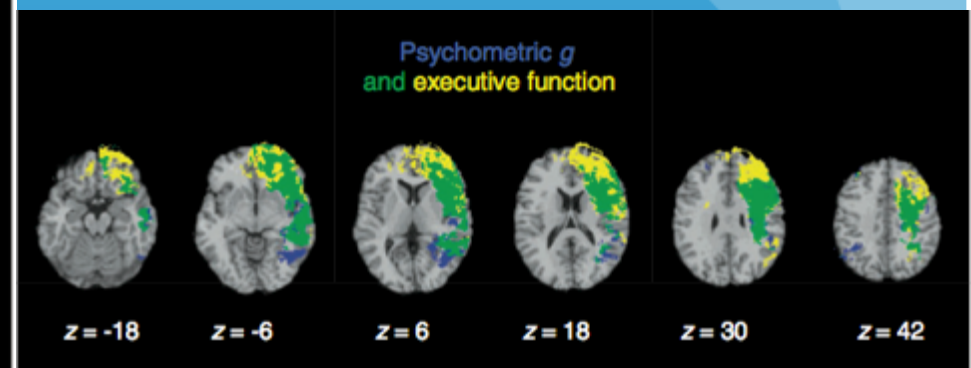
"Such results argue strongly against the possibility that high-g tasks are associated with diffuse neural recruitment"

## An integrative architecture for general intelligence and executive function revealed by lesion mapping

Aron K. Barbey,<sup>1,2,3,4,5</sup> Roberto Colom,<sup>6</sup> Jeffrey Solomon,<sup>7</sup> Frank Krueger,<sup>8</sup> Chad Forbes<sup>9</sup> and Jordan Grafman<sup>10</sup>



The information processing architecture of general intelligence, therefore, remains the focus of ongoing research and debate, with investigators proposing that psychometric *g* embodies a single cognitive ability implemented within processing networks of the prefrontal cortex (Duncan et al., 2000; Duncan, 2010) or derives instead from multiple cognitive operations that engage a distributed system of functionally specialized cortical regions (



We observed a significant effect on *g* and executive function with lesions in left hemispheric white matter sectors, including the superior longitudinal/arcuate fasciculus, which connect frontal and parietal cortices. Despite its distributed nature, the neural sub- strates of *g* and executive function were remarkably circumscribed, concentrated in the core of white matter and comprising a narrow subset of regions associated with performance on individual WAIS and D-KEFS subtests.

## Neural correlates of superior intelligence: Stronger recruitment of posterior parietal cortex

Kun Ho Lee,<sup>a,\*</sup> Yu Yong Choi,<sup>a,c</sup> Jeremy R. Gray,<sup>b</sup> Sun Hee Cho,<sup>c</sup> Jeong-Ho Chae,<sup>d</sup> Seungheun Lee,<sup>c</sup> and Kyungjin Kim<sup>a</sup>

Investigation des bases neurales de la douance intellectuelle en comparant

- un groupe d'intelligence supérieure (n = 18, RAPM moy =  $33.9 \pm 0.8$ , >99%)
- un groupe témoin (n = 18, RAPM moy =  $22.8 \pm 1.6$ , 60%) from local high schools in Korea
- age moy =  $16.5 \pm 0.8$ ).

Acquisition fMRI lors de la réalisation de deux tâches (high and low g-loadings).

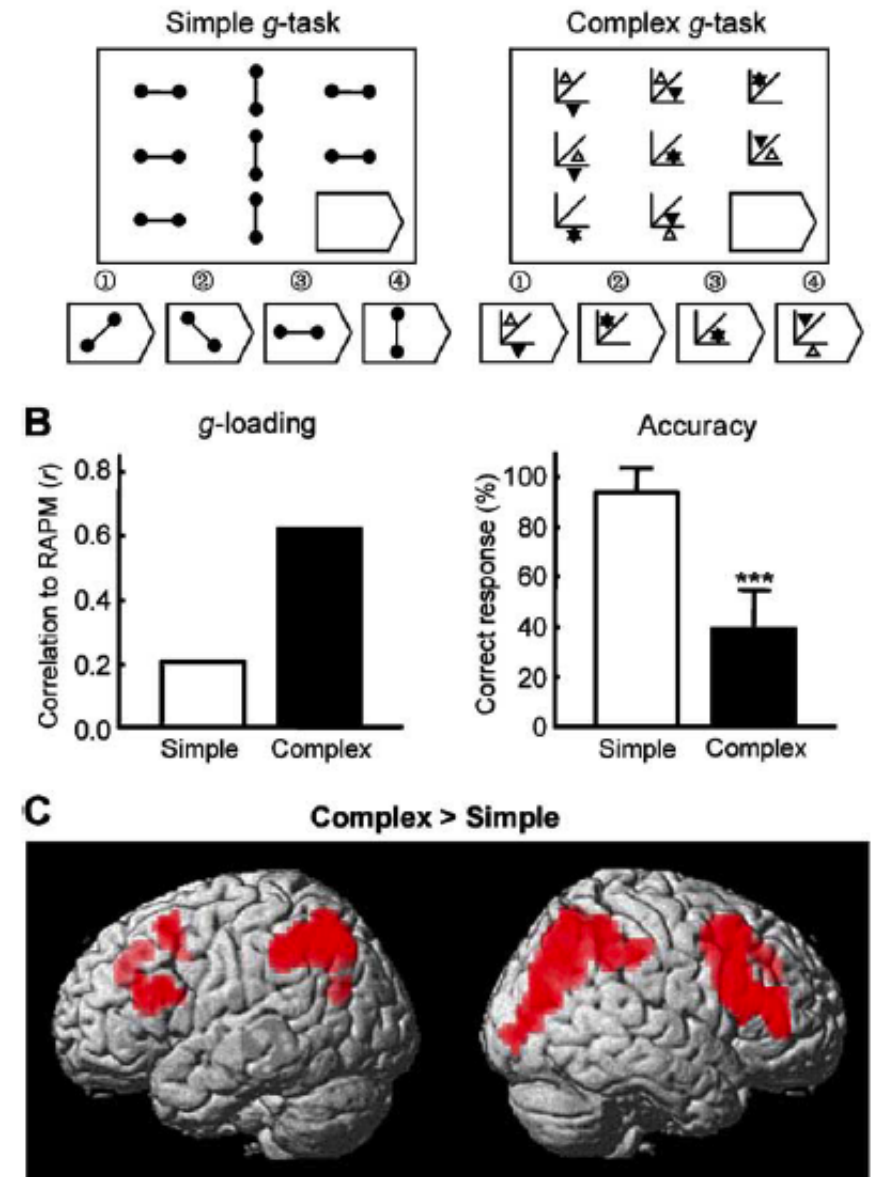
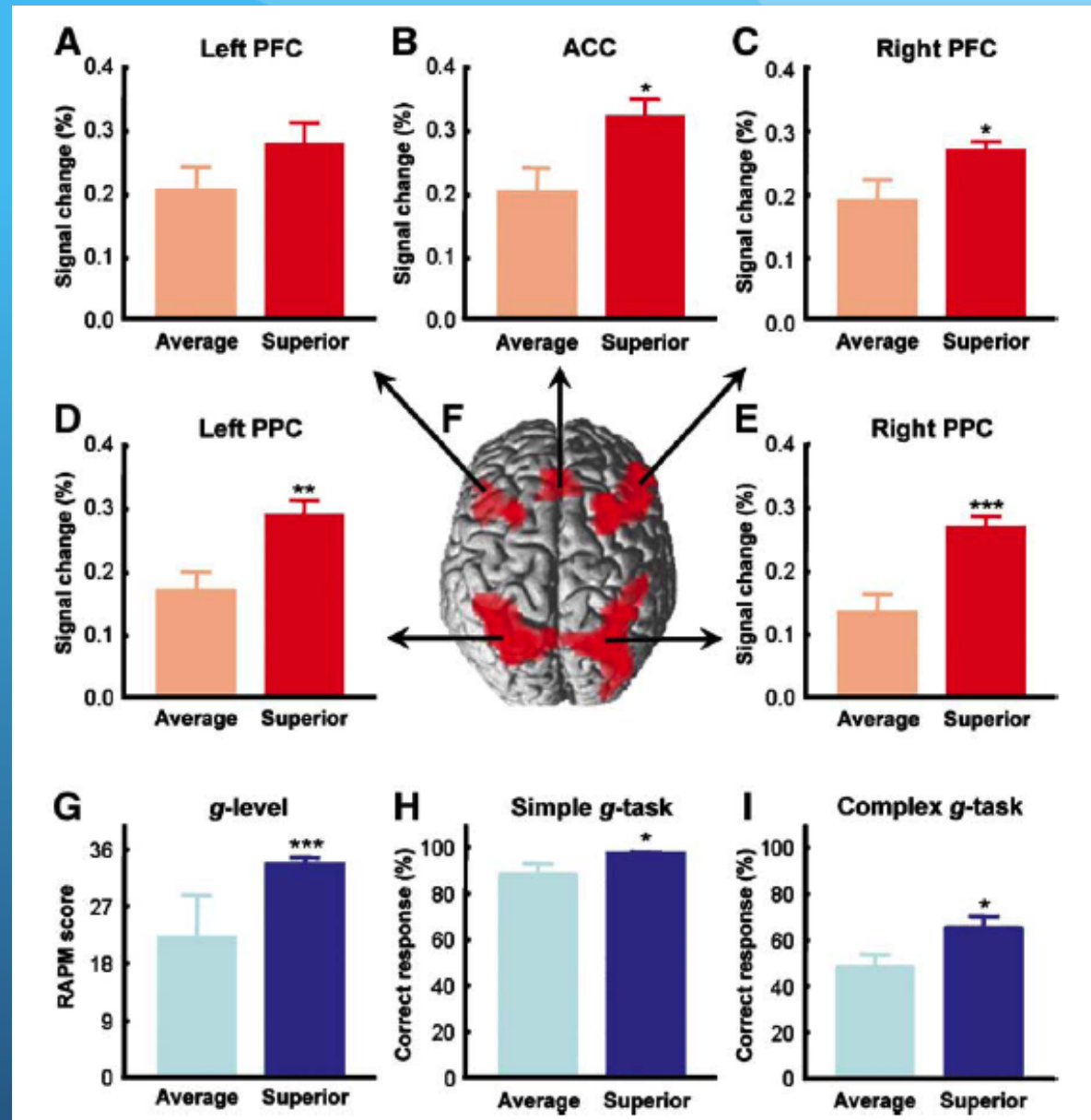


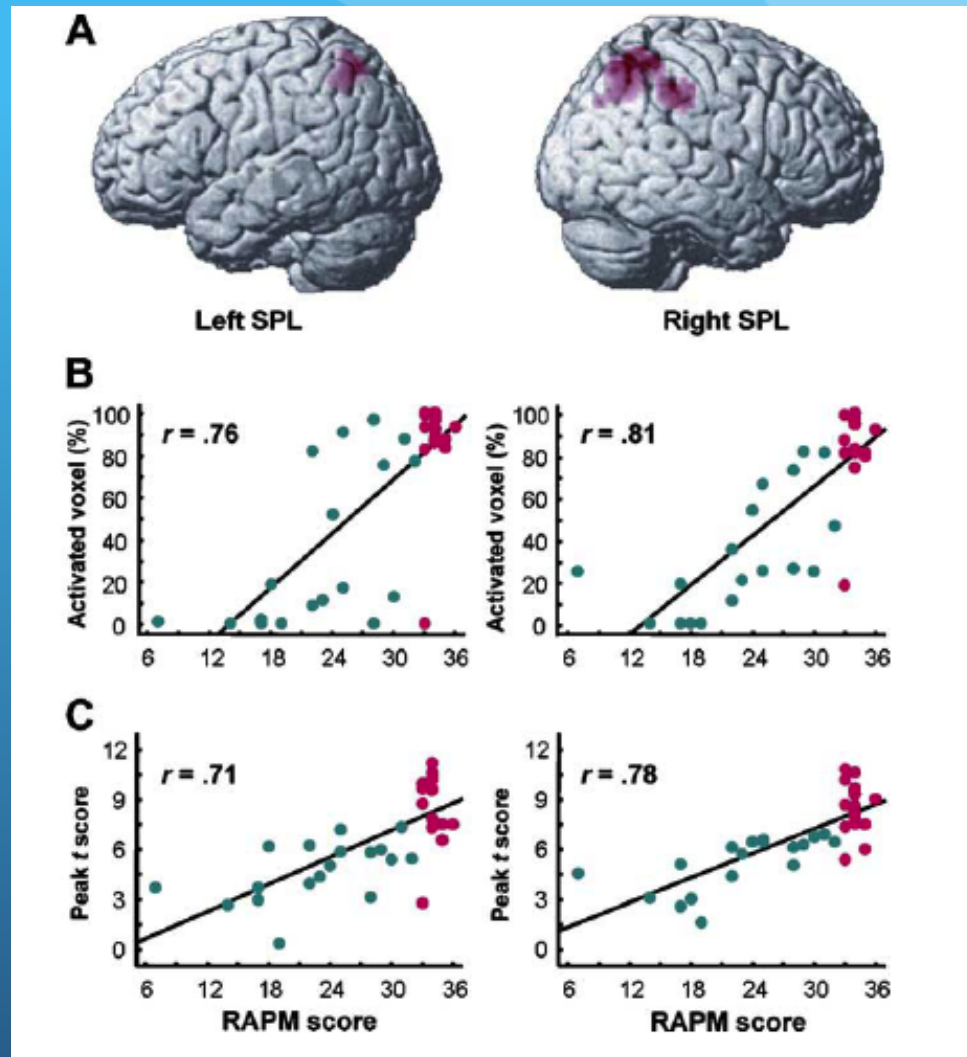
Fig. 1. Behavioral tasks and g-related neural network. (A) Example task



Différences d'activations régionales entre les groupes précoce et 'average'  
Surtout significatif dans les deux régions pariétales



g-level-related neural substrates  
and correlation of their  
activations  
with individual differences in g



*We reviewed the state-of-the-art based on 37 studies and proposed a specific neuro-anatomical model of intelligence with testable predictions*

# The Parieto-Frontal Integration Theory (P-FIT) of intelligence: Converging neuroimaging evidence

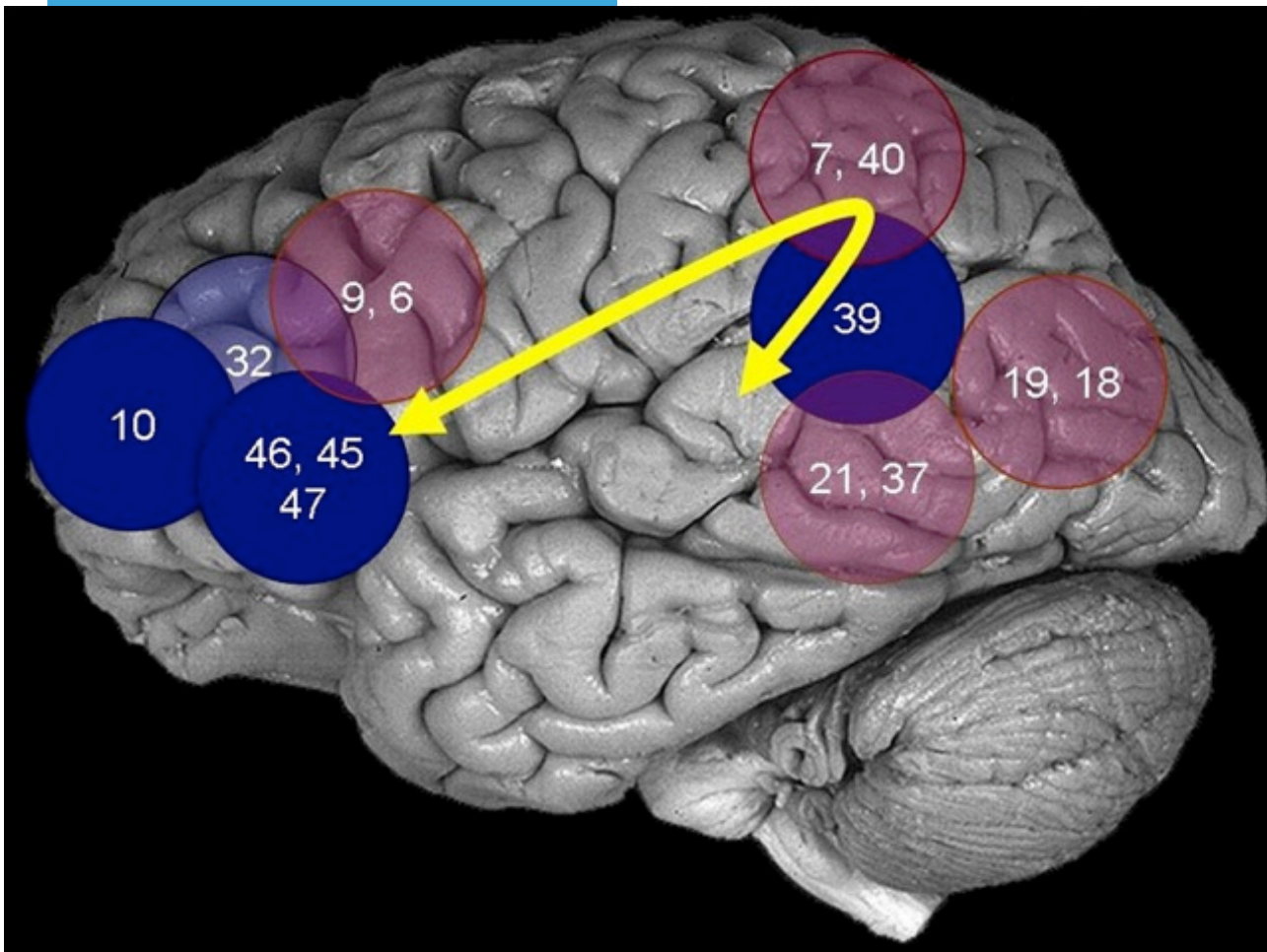


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neurology/haier/haier.html



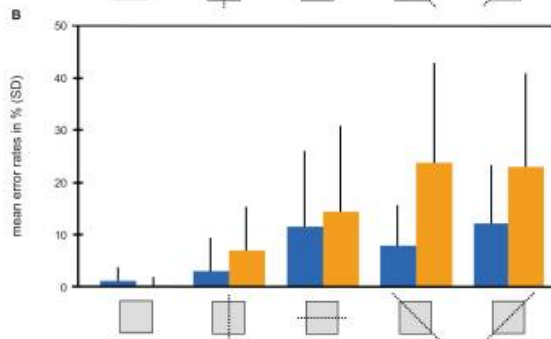
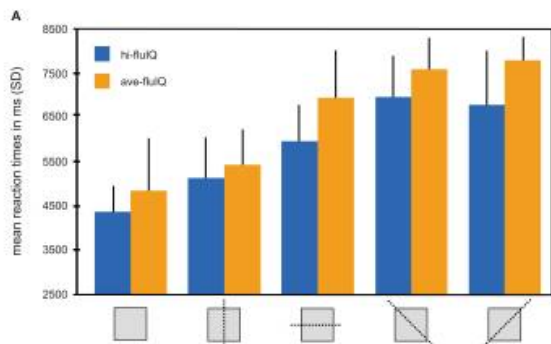
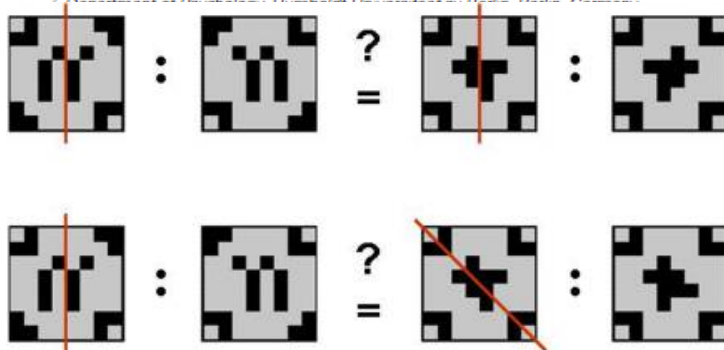
*The major challenge was the negative view many people held of intelligence tests, but this has changed dramatically as more imaging research shows that the test scores are related to the brain.*

# Fluid intelligence allows flexible recruitment of the parieto-frontal network in analogical reasoning

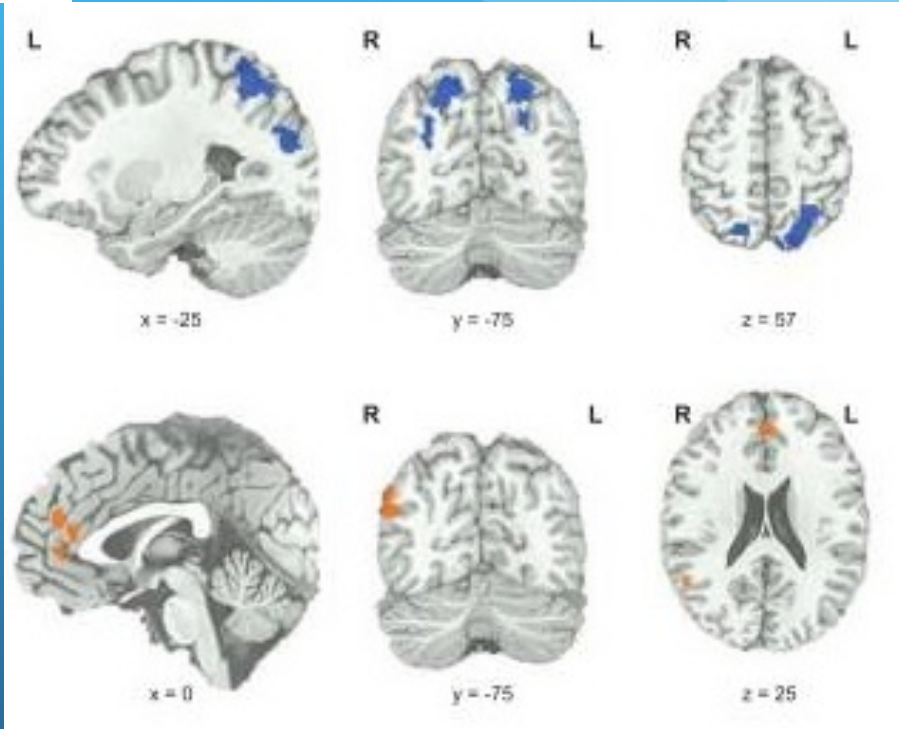
Franziska Preusse<sup>1,2,3\*</sup>, Elke van der Meer<sup>2,3</sup>, Gopikrishna Deshpande<sup>4,5</sup>, Frank Krueger<sup>6</sup> and Isabell Wartenburger<sup>1,3,7</sup>

<sup>1</sup> Department of Neurology, Berlin Neuroimaging Center, Charité – Universitätsmedizin Berlin, Berlin, Germany

<sup>2</sup> Department of Psychology, Humboldt University Berlin, Berlin, Germany



Main effect of fluid intelligence for hi-fluIQ > ave-fluIQ



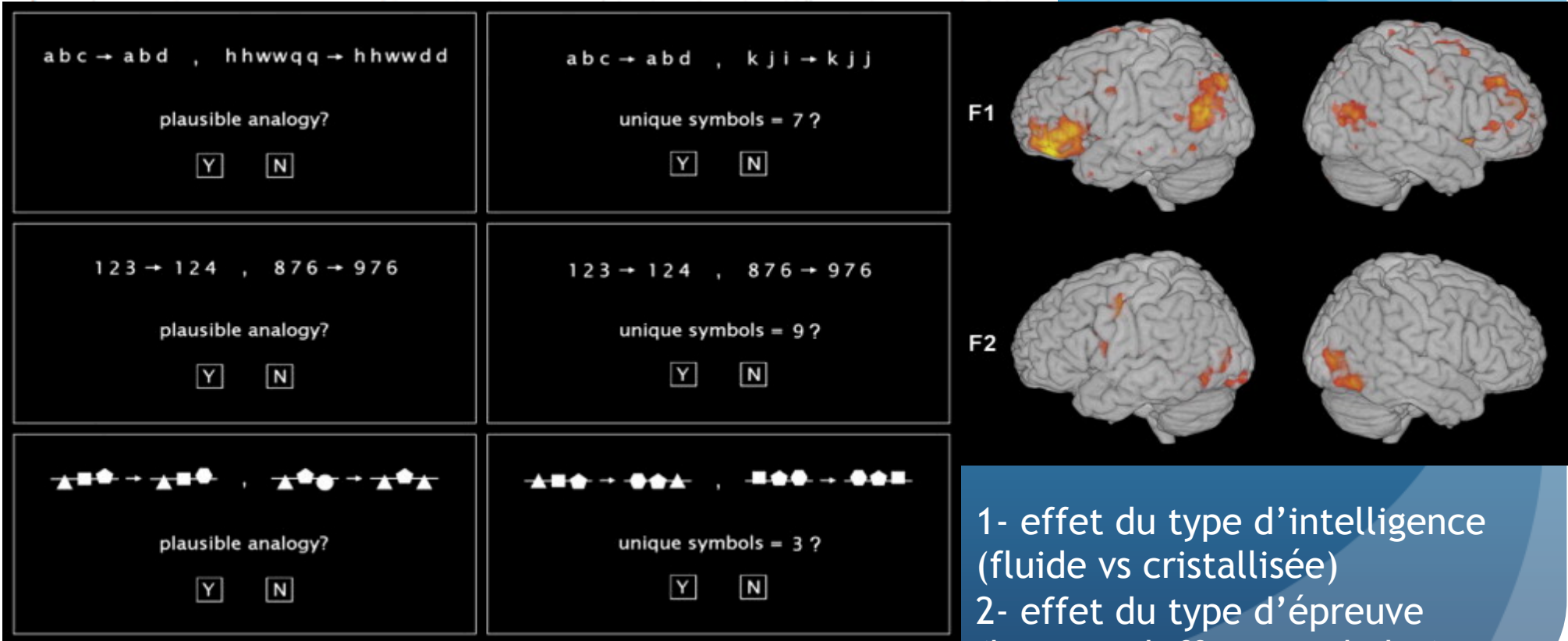
Main effect of fluid intelligence for ave-fluIQ > hi-fluIQ



## Functional neural correlates of fluid and crystallized analogizing

John G. Geake<sup>a,b,d,\*</sup>, Peter C. Hansen<sup>a,b,c</sup>

<sup>a</sup> Department of Physiology, Anatomy and Genetics, University of Oxford, UK



1- effet du type d'intelligence (fluide vs cristallisée)  
2- effet du type d'épreuve (lettres, chiffres, symboles)

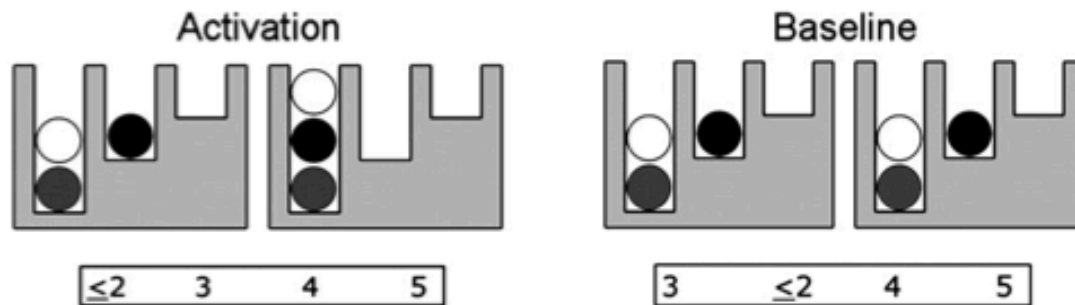


Mathematically gifted adolescents use more extensive and more bilateral areas of the fronto-parietal network than controls during executive functioning and fluid reasoning tasks

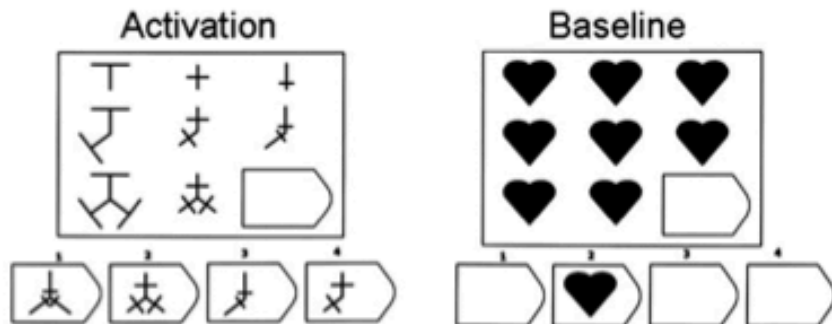
Manuel Desco <sup>a,b,c</sup>, Francisco J. Navas-Sanchez <sup>b,c,\*</sup>, Javier Sanchez-González <sup>c,d</sup>, Santiago Reig <sup>b,c</sup>, Olalla Robles <sup>e,f</sup>, Carolina Franco <sup>e</sup>, Juan A. Guzmán-De-Villoria <sup>b,g</sup>, Pedro García-Barreno <sup>b,c,h</sup>, Celso Arango <sup>b,e</sup>

13 math-gifted adolescents and 14 controls with average mathematical skills. Patterns of activation specific to reasoning tasks in math-gifted subjects were examined using functional magnetic resonance images acquired while the subjects were performing Raven's Advanced Progressive Matrices (RAPM) and the Tower of London (TOL) tasks

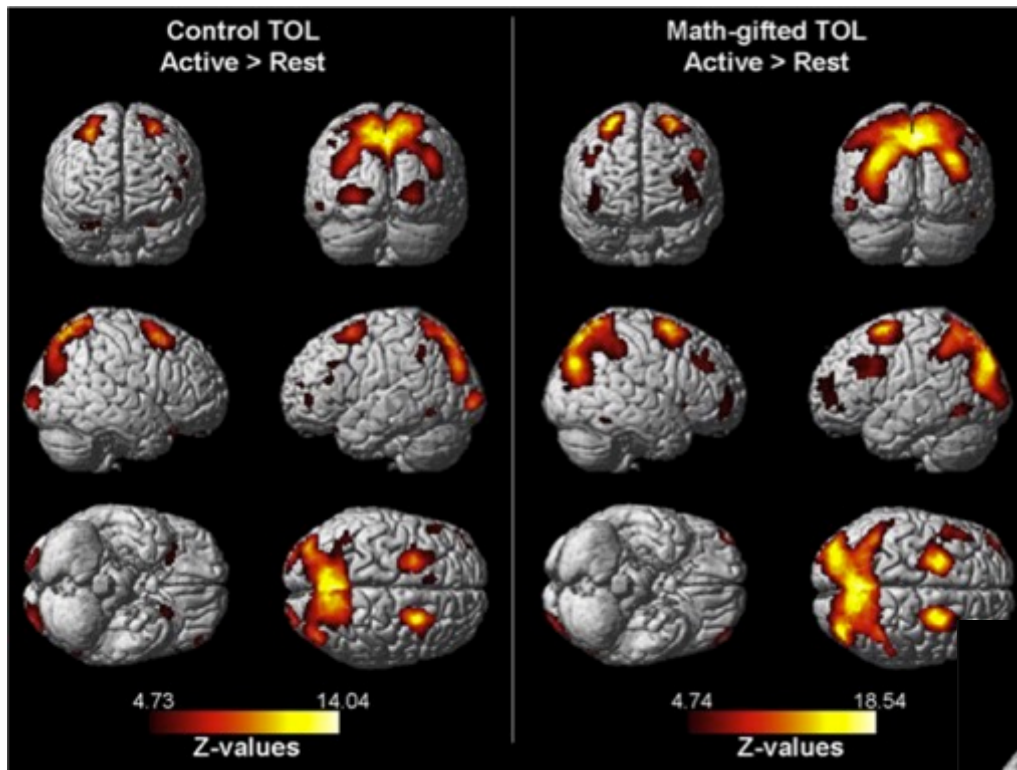
**Tower of London test**



**Raven Progressive Matrices test**

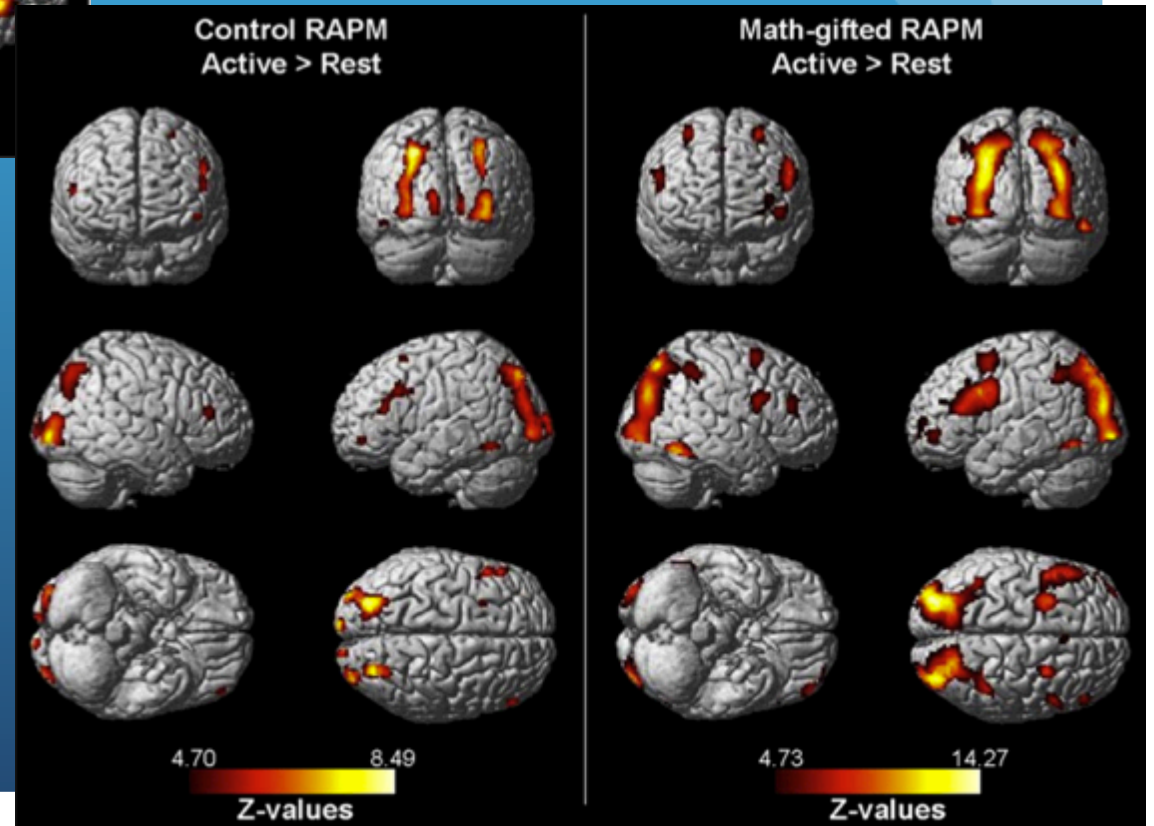


In contrast to an explanation based on neural efficiency, our study further supports this hypothesis of stronger recruitment of math-gifted children. Therefore, math-gifted subjects are qualitatively different in terms of the degree and location of activated brain regions.



Tour de Londres : plus forte activité en pariétal et frontal bilatéral chez math-gifted

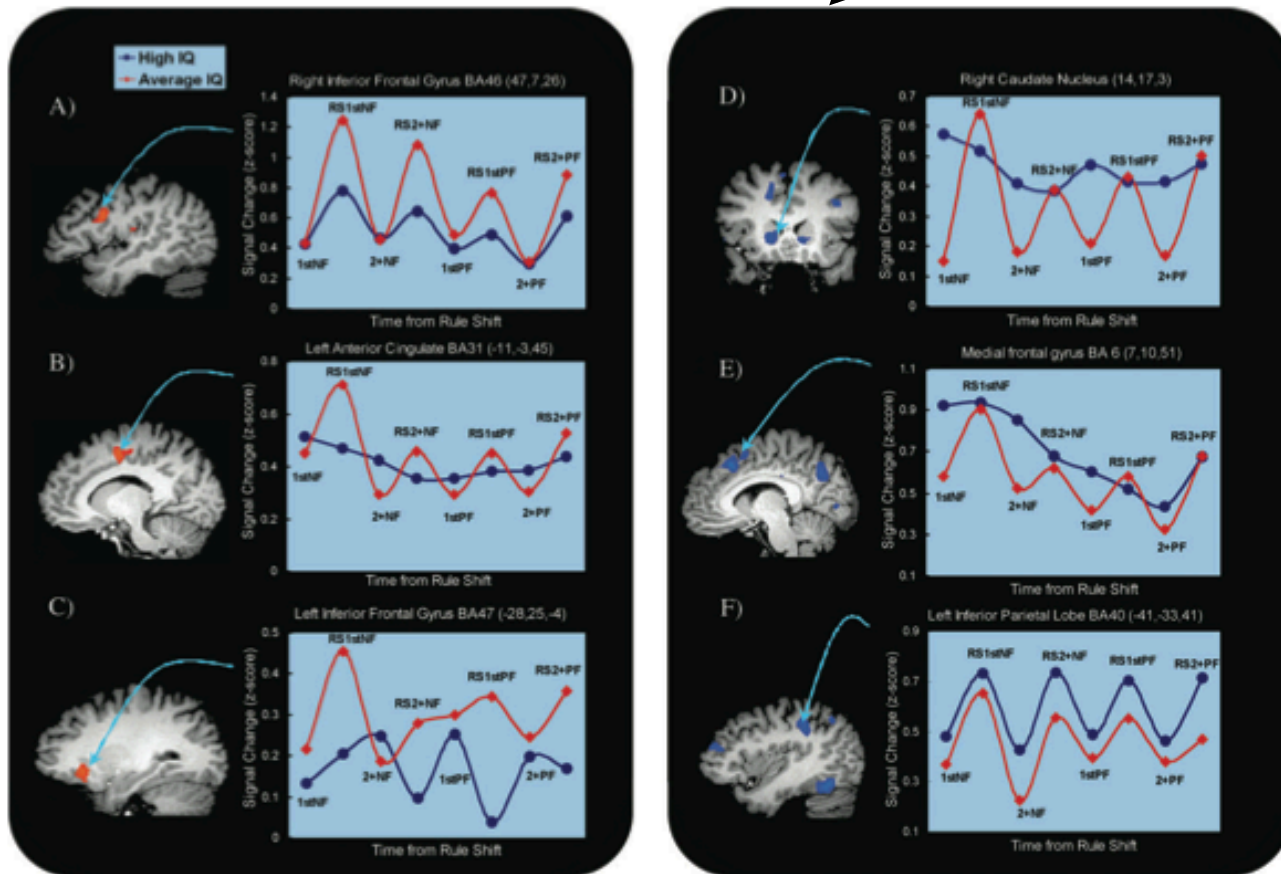
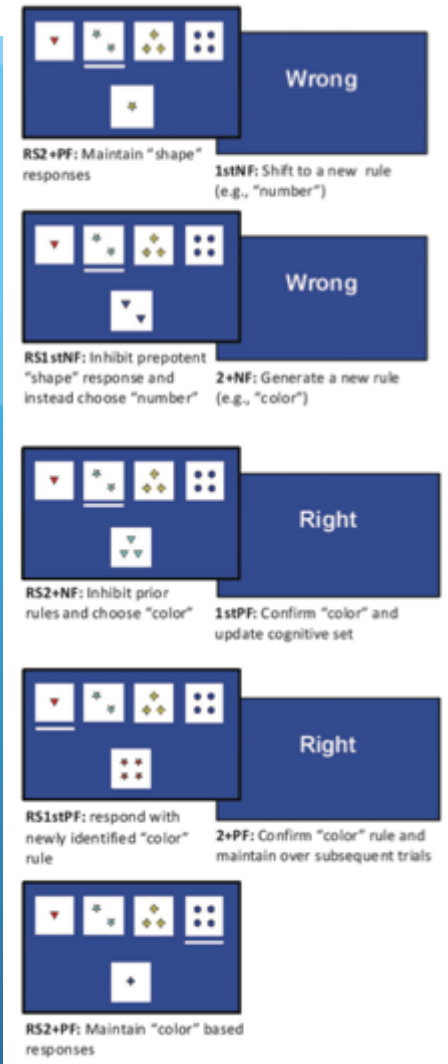
Raven's progressive matrices : activité en pariéto-occipital plus forte et plus bilatérale



## **IQ-Related fMRI Differences during Cognitive Set Shifting**

Steven Graham<sup>1,2</sup>, Jiaying Jiang<sup>1</sup>, Victoria Manning<sup>1</sup>, Ayna Baladi Nejad<sup>1</sup>, Koh Zhisheng<sup>1</sup>, Shan R. Salleh<sup>1</sup>, Xavier Golay<sup>3</sup>, Yeh Ing Berne<sup>4</sup> and Peter J. McKenna<sup>5</sup>

Test de Wisconsin : activation cérébrale lors du changement de règle (shifting)  
 Zones moins actives chez les précoces zones plus actives  
 (Lors de la sélection des réponses) (lors de la réception du feedback)



**Figure 2.** Regions of interest graphs depicting the signal change across the events from rule shift (A) right inferior frontal gyrus, (B) left anterior cingulate, (C) left inferior frontal gyrus, (D) caudate nucleus, (E) medial frontal gyrus, (F) left inferior parietal lobe.

Whether greater intelligence is associated with more or less brain activity (the "neural efficiency" debate) depends therefore on the specific component of the task being examined as well as the brain region recruited.



## Brain spontaneous functional connectivity and intelligence

Ming Song,<sup>a</sup> Yuan Zhou,<sup>a</sup> Jun Li,<sup>a</sup> Yong Liu,<sup>a</sup> Lixia Tian,<sup>c</sup> Chunshui Yu,<sup>b,\*</sup> and Tianzi Jiang<sup>a,\*</sup>

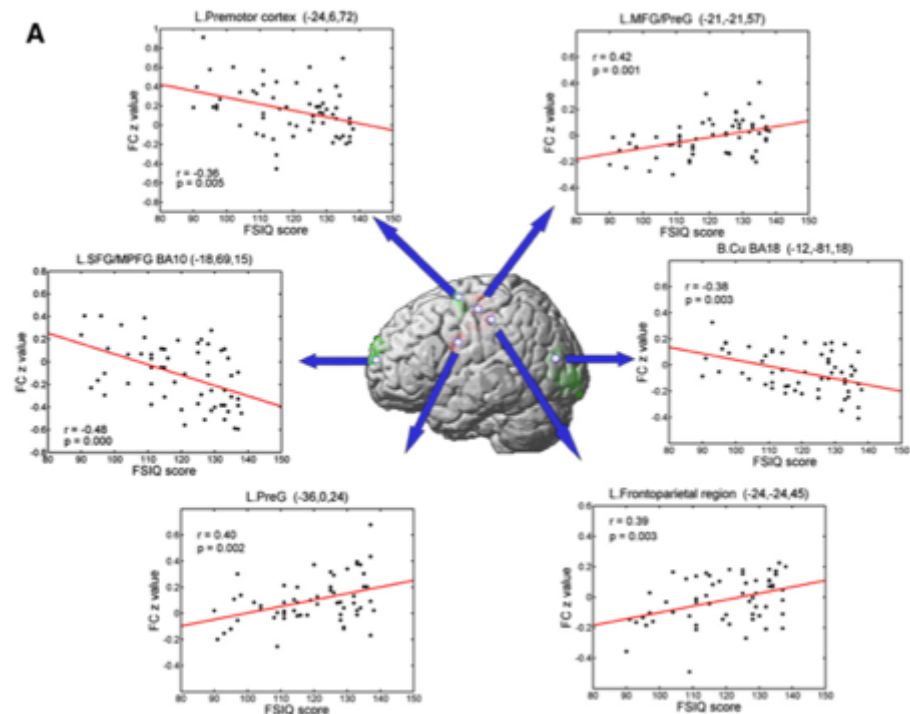
<sup>a</sup>National Laboratory of Pattern Recognition, Institute of Automation, Chinese Academy of Sciences, Beijing 100080, PR China

<sup>b</sup>Department of Radiology, Xuanwu Hospital of Capital Medical University, Beijing, 100053, PR China

<sup>c</sup>Department of Biomedical Engineering, School of Computer and Information Technology, Beijing Jiaotong University, Beijing 100044, PR China

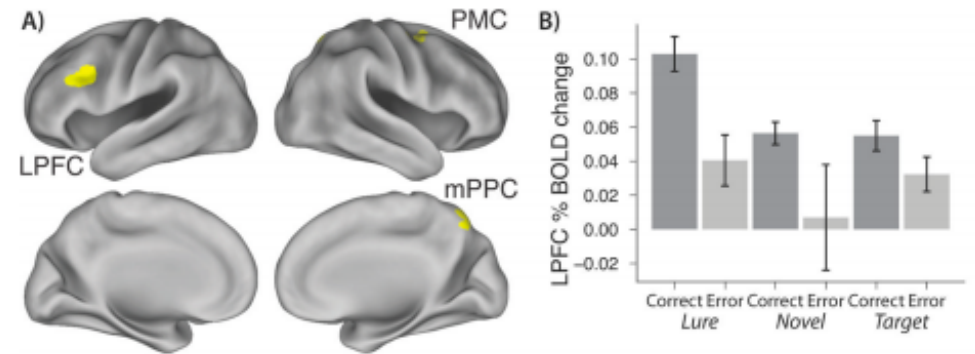
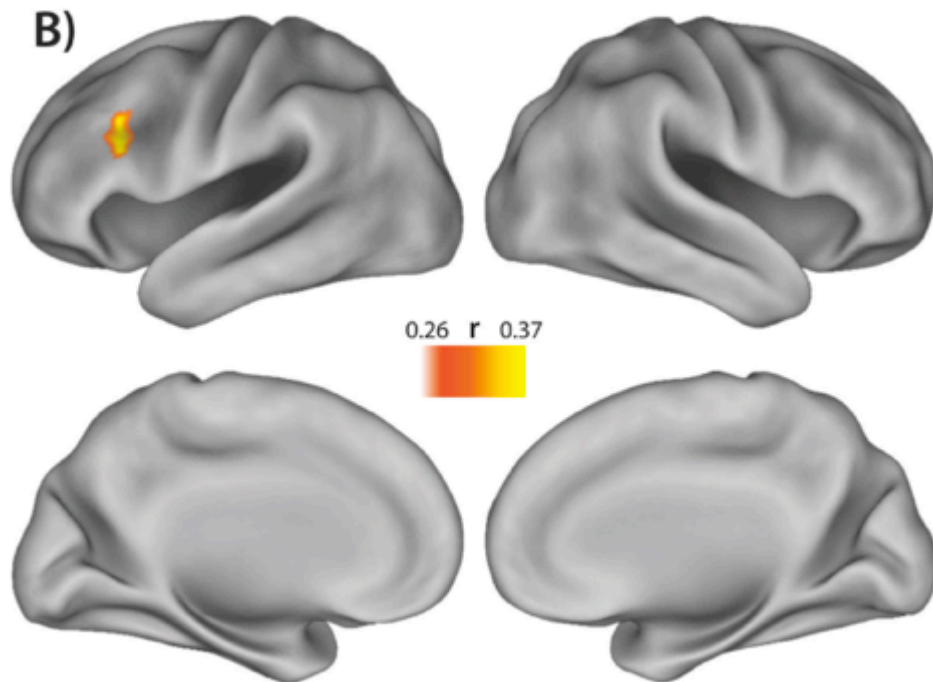
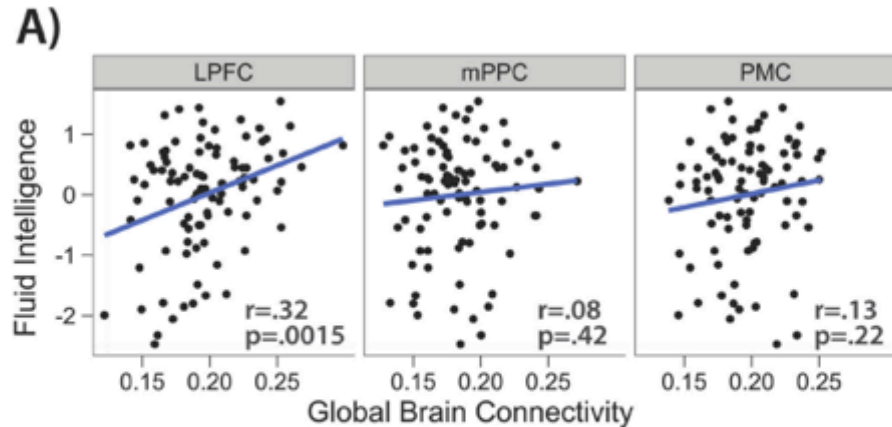
Connectivity within the frontal lobe and between the frontal and posterior brain regions were both important predictive factors for the differences in intelligence. These findings support a network view of intelligence, as suggested in previous studies.

More importantly, our findings suggest that brain activity may be relevant to the differences in intelligence even in the resting state and in the absence of an explicit cognitive demand.

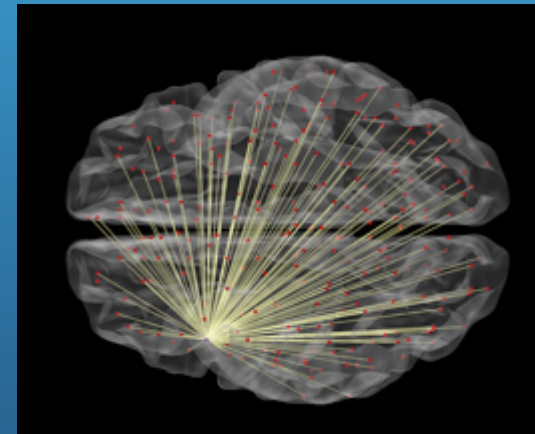


## Global connectivity of prefrontal cortex predicts cognitive control and intelligence

Michael W. Cole, Tal Yarkoni, Grega Repovs, Alan Anticevic, and Todd S. Braver



A lateral prefrontal cortex (LPFC) region's activity was found to predict performance in a high control demand working memory task, and also to exhibit high global connectivity



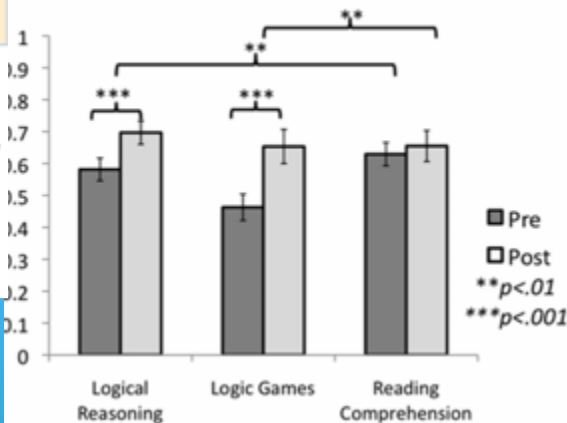
The degree of global connectivity of this same region was found correlated to a measure of fluid intelligence

**Intensive reasoning training alters patterns of brain connectivity at rest**

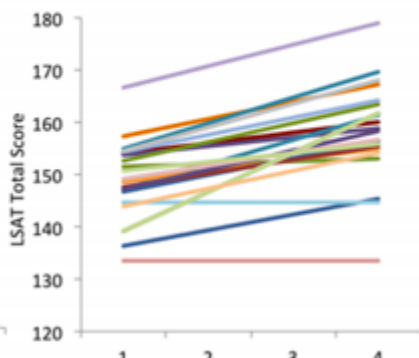
Allyson P. Mackey<sup>1</sup>, Alison T. Miller Singley<sup>2</sup>, and Silvia A. Bunge<sup>1,2</sup>  
<sup>1</sup>Helen Wills Neuroscience Institute: 132 Barker Hall, Berkeley, CA, 94720  
<sup>2</sup>Department of Psychology: 3210 Tolman Hall, Berkeley, CA, 94720

An analysis of pairwise correlations between brain regions implicated in reasoning showed that fronto-parietal connections were strengthened, along with parietal-striatal connections.

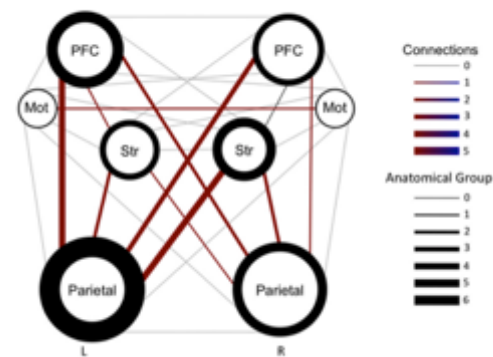
**B. LSAT Subscores**



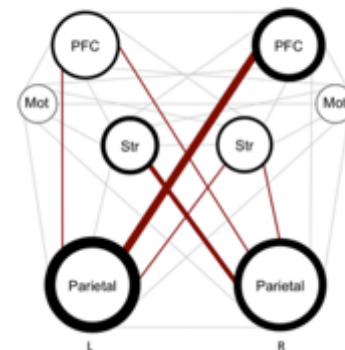
**D. LSAT Improvement Slopes**



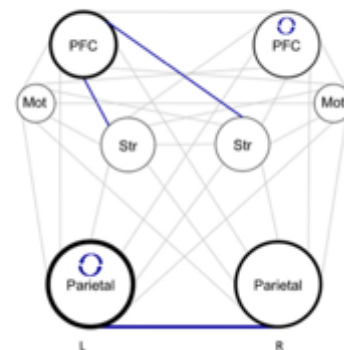
**A. Connection Changes with Training**



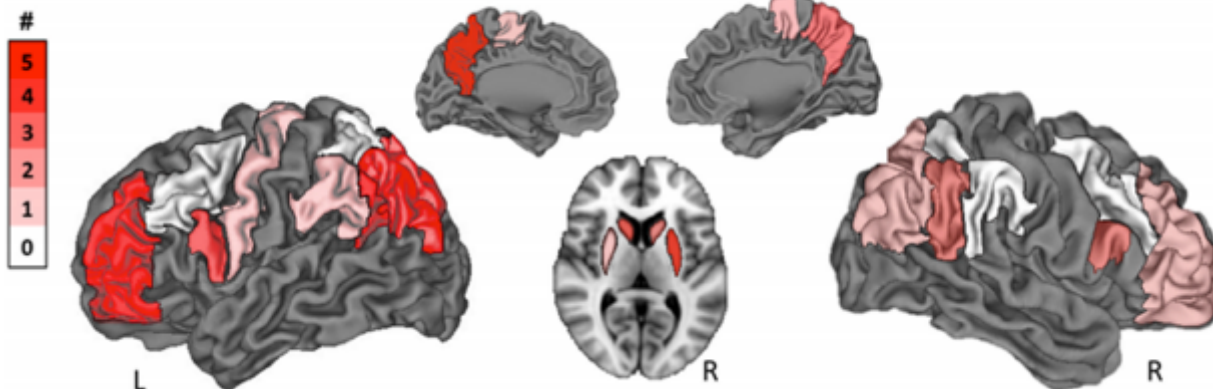
**B. Positive Correlations with LSAT Improvement**



**C. Negative Correlations with LSAT Improvement**

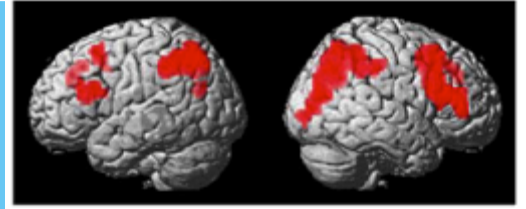


**B. Regions Showing Correlation Changes**



These findings provide strong evidence for neural plasticity at the level of large-scale networks supporting high-level cognition.

# En résumé : les données de neuro-imagerie fonctionnelle



- Montrent une convergence de résultats en faveur d'une suractivation chez l'HP d'un circuit bilatéral fronto-pariétal, dont l'activité est fortement liée au QI
- Ce circuit est non seulement suractivé lors de tâches cognitives, verbales ou non verbales, mais aussi au repos en dehors de toute tâche cognitive
- Mais ce circuit fronto-pariétal n'est pas le substrat unique de l'intelligence : un lien fort existe entre l'intelligence et le degré de connectivité globale qui caractérise certaines parties de ce circuit.
- Un entraînement intensif au raisonnement verbal est capable de modifier significativement et durablement la nature de cette connectivité fronto-pariétale, mais aussi avec les structures sous-corticales

# Imagerie morphologique

S.blanche

S. grise

DTI : tractographie

VBM : morphométrie  
voxel à voxel

Directionnalité des  
fibres blanches

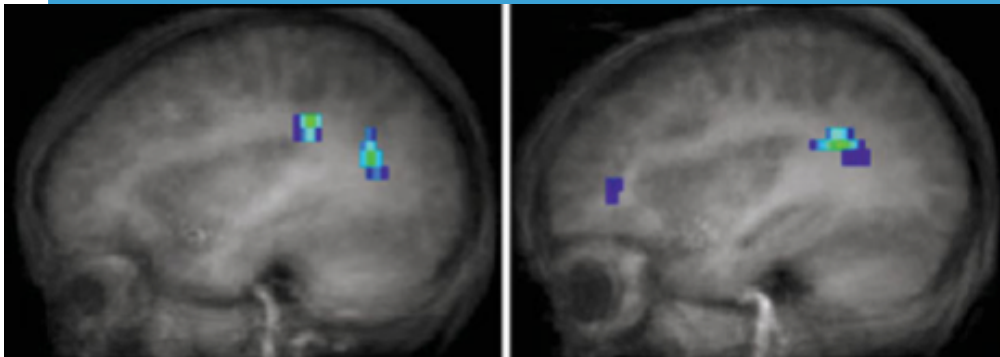
Épaisseur du cortex

connectivité

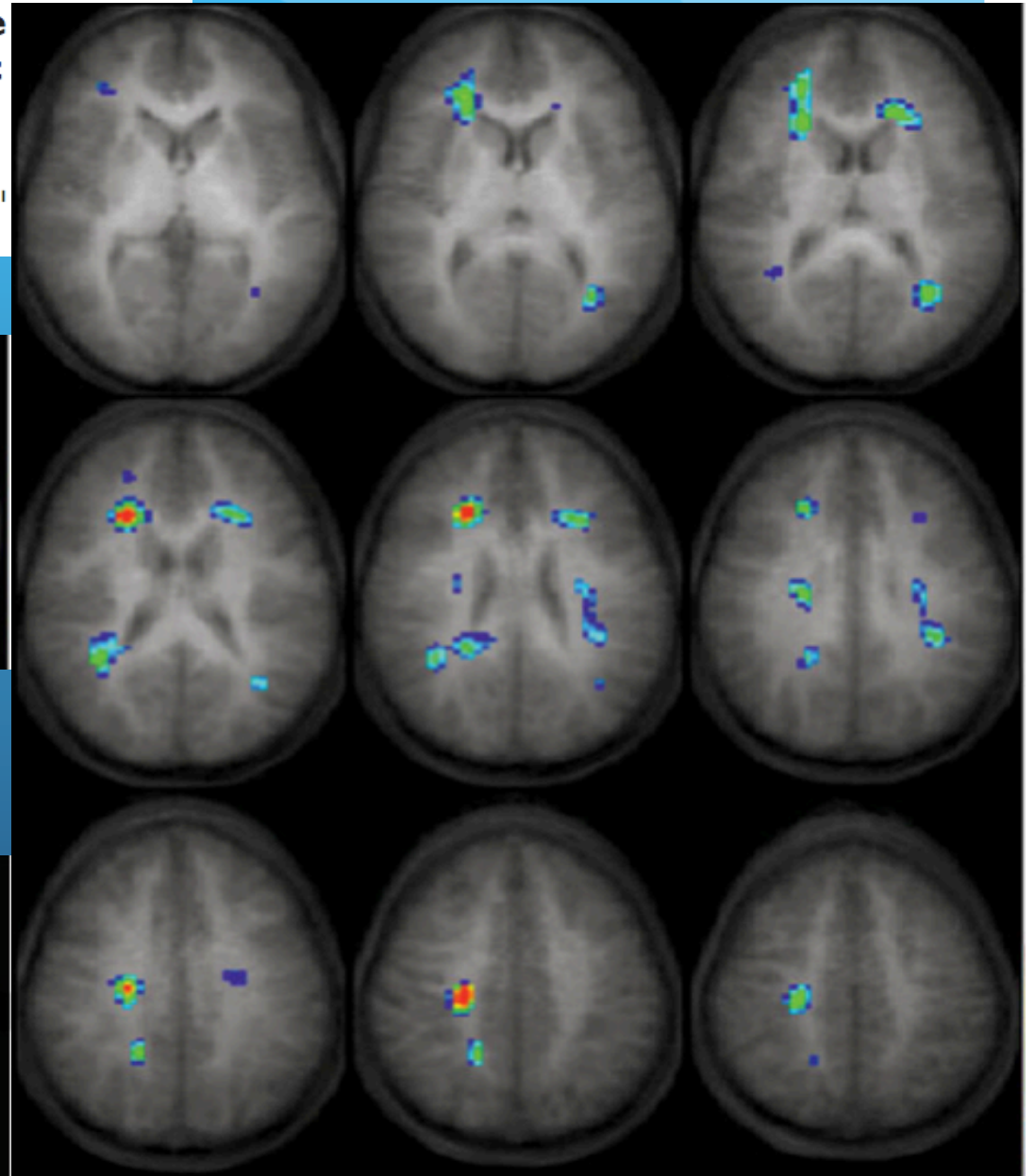
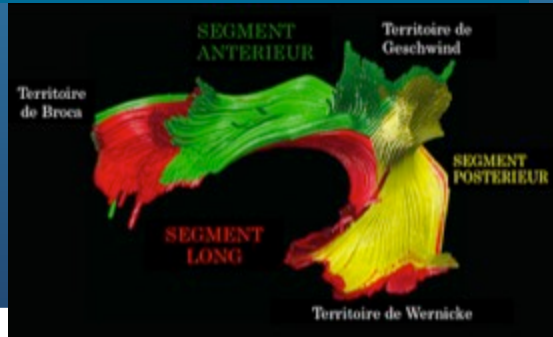
Trajectoire  
développementale

## Cognitive Functions Correlate With White Matter Architecture in a Normal Pediatric Population: A Diffusion Tensor MRI Study

Vincent J. Schmithorst,<sup>1\*</sup> Marko Wilke,<sup>1–3</sup> Bernard J. Dardzinski,<sup>1</sup> and Scott K. Holland<sup>1</sup>



Régions de corrélation positive entre anisotropie (FA) et QI total



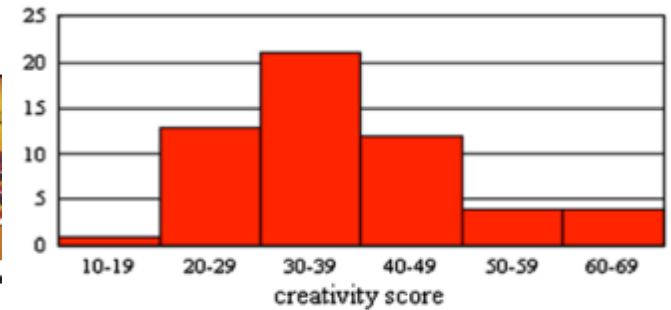
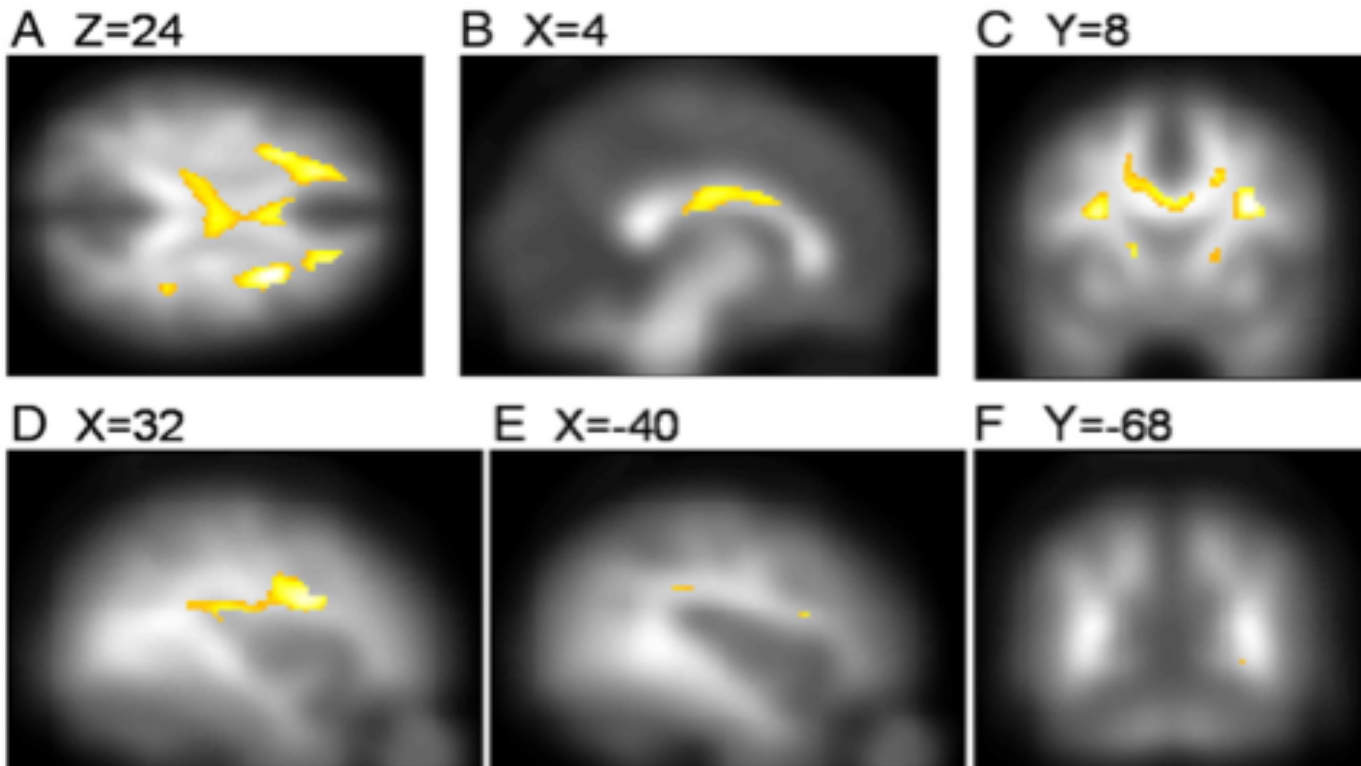


Fig. 1. Distribution of the scores from the S-A creativity test in our sample.

## White matter structures associated with creativity: Evidence from diffusion tensor imaging

Hikaru Takeuchi <sup>a,\*</sup>, Yasuyuki Taki <sup>a</sup>, Yuko Sassa <sup>a</sup>, Hiroshi Hashizume <sup>a</sup>, Atsushi Sekiguchi <sup>b</sup>, Ai Fukushima <sup>b</sup>, Ryuta Kawashima <sup>a,b,c</sup>

### Corrélation significative avec score de créativité



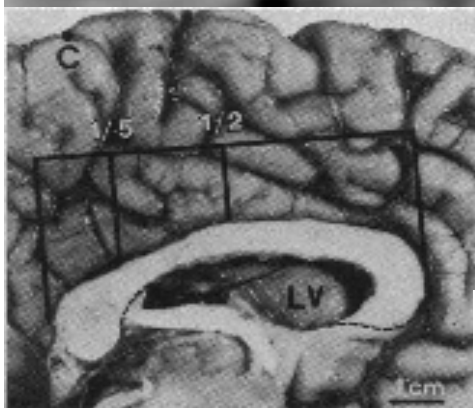
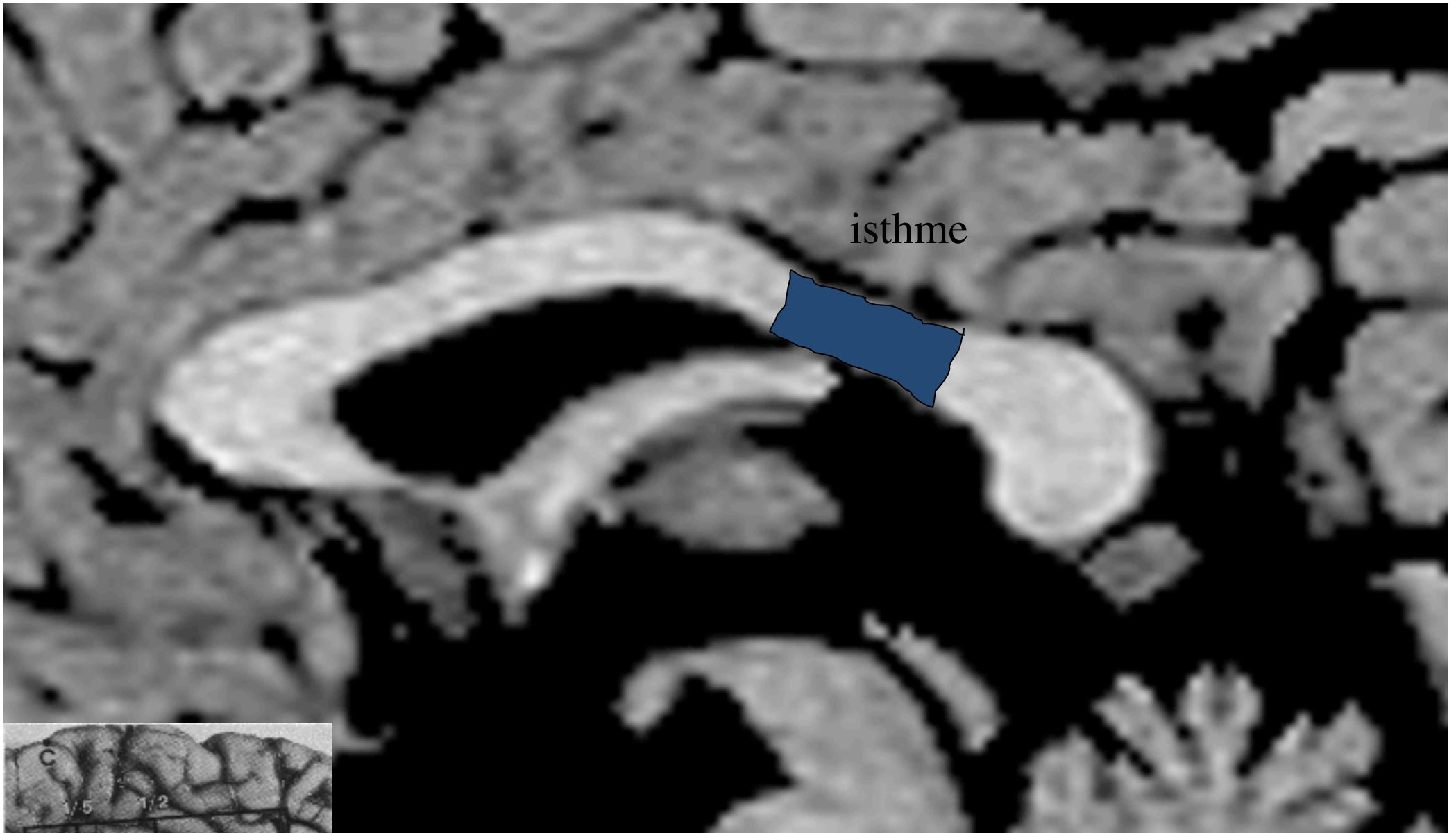
### "test de créativité (divergent thinking")

3 types de questions : "en plus de la lecture, à quoi peut servir un journal?" : ex: pour envelopper les choses

"quelles sont les caractéristiques d'un bon appareil de télé?" ex.: recevoir des émissions du monde entier'

"Qu'arriverait-il s'il n'y avait plus de souris sur terre ex.: le monde serait plus propre

On évalue : a) la fluence (aptitude à donner le plus grand nombre de réponses différentes) b) la flexibilité (aptitude à donner des réponses dans des champs différents) c) l'originalité (différence /réponses standard; d) l'élaboration : aptitude à entrer dans les détails



**The Brain Connection:  
The Corpus Callosum Is Larger in Left-Handers**

Witelson, S.F. (1985), *Science*, 229: 665-666



## Positive correlations between corpus callosum thickness and intelligence

Eileen Luders,<sup>a</sup> Katherine L. Narr,<sup>a</sup> Robert M. Bilder,<sup>b,c</sup> Paul M. Thompson,<sup>a</sup> Philip R. Szeszko,<sup>d</sup> Liberty Hamilton,<sup>a</sup> and Arthur W. Toga<sup>a,\*</sup>

<sup>a</sup>Laboratory of Neuro Imaging, Department of Neurology, UCLA School of Medicine, 635 Charles Young Drive South, Suite 225, Los Angeles, CA 90095-7334, USA

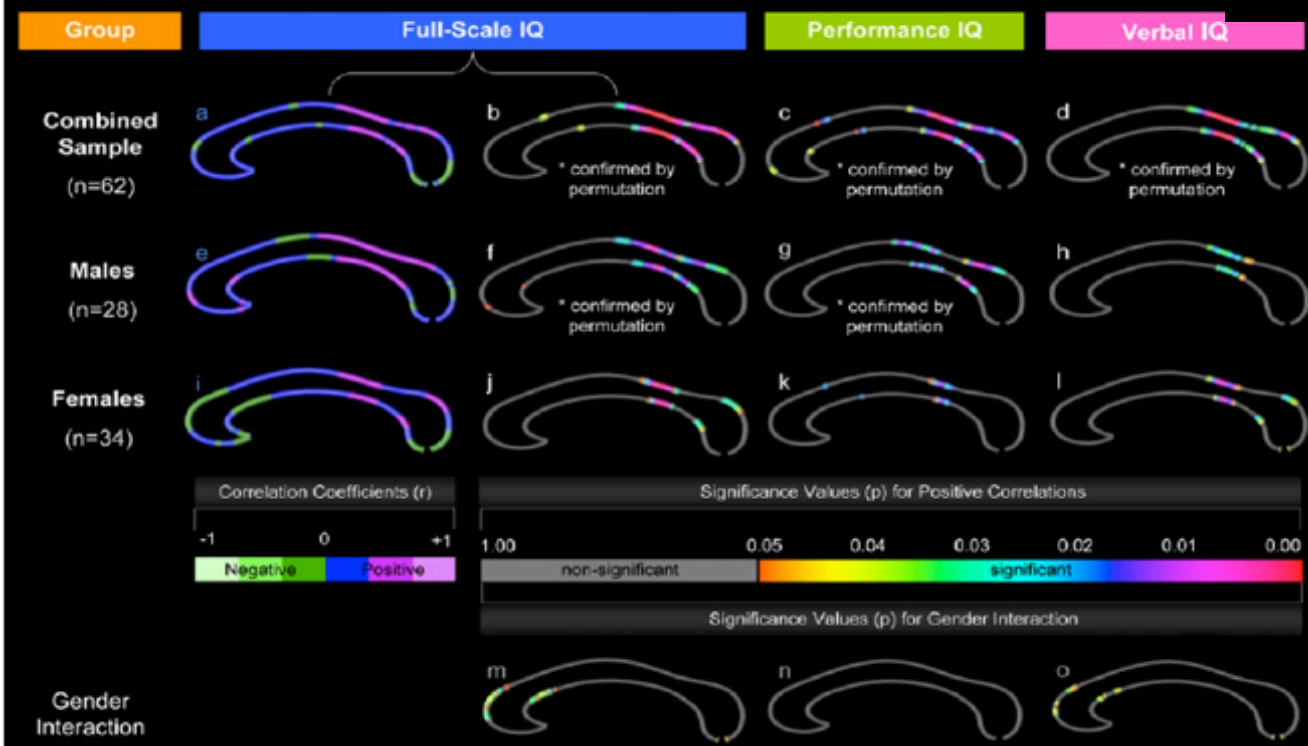
Correlations between callosal thickness and intelligence measures (corrected  $p$ -values computed by permutation testing for  $p < 0.05$ )

	Full-scale IQ	Performance IQ	Verbal IQ
Combined sample ( $n=62$ )	0.01*	0.01*	0.03*
Males ( $n=28$ )	0.03*	0.05*	0.17
Females ( $n=34$ )	0.09	0.28	0.11
Gender interaction	0.15	1.00	0.27

The asterisk (\*) denotes significant findings.



### Correlations between Callosal Thickness & Intelligence



Tronc postérieur  
 Pre-splénium  
 isthme

Corrélations positives avec QI total, QI verbal e QI performance

# White Matter Microstructure Correlates of **Mathematical Giftedness** and Intelligence Quotient

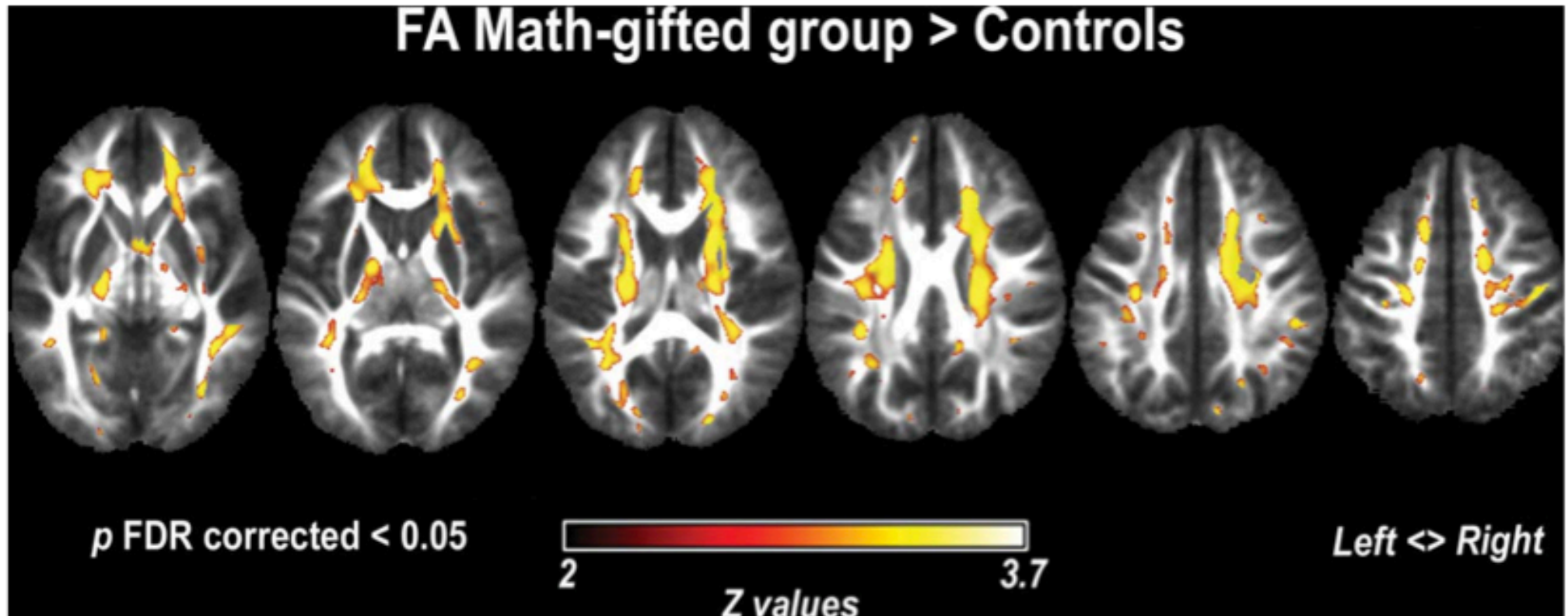
Francisco J. Navas-Sánchez,<sup>1,2\*</sup> Yasser Alemán-Gómez,<sup>1,2</sup>  
 Javier Sánchez-Gonzalez,<sup>3</sup> Juan A. Guzmán-De-Villoria,<sup>4</sup> Carolina Franco,<sup>5</sup>  
 Olalla Robles,<sup>5,6</sup> Celso Arango,<sup>2,5</sup> and Manuel Desco<sup>1,2,7</sup>

<sup>1</sup>Unidad de Medicina y Cirugía Experimental, Hospital General Universitario Gregorio Marañón, Instituto de Investigación Sanitaria Gregorio Marañón, Madrid, Spain

**TABLE I. Mean and standard deviation (SD) of demographic data for each group**

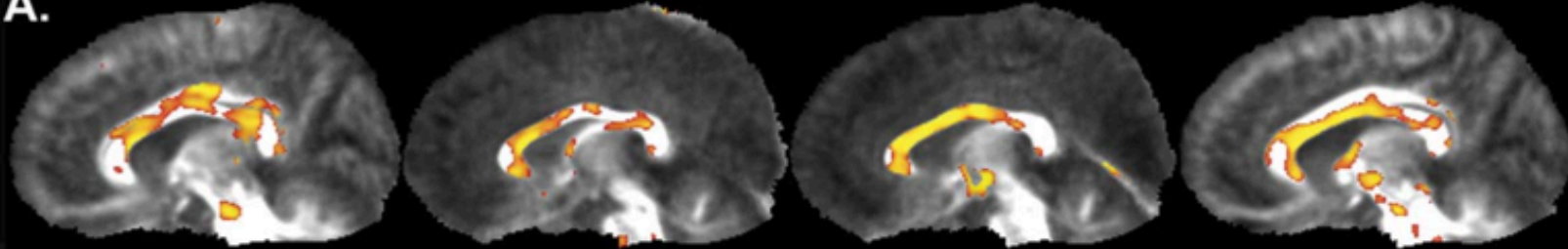
	Controls (n = 23)		Math-gifted (n = 13)		Pa
	Mean	SD	Mean	SD	
Age (years)	13.42	0.86	13.75	0.57	
Age (months)	160.91	10.31	165.01	7	
Gender (male\female)	19\4		8\5		
Handedness (right\left\mixed)	23\0\0		13\0\0		
Estimated full-scale IQ	105.48	15.71	130.77	10.68	<0.001
Verbal IQ	106.83	16.67	125.08	12.07	<0.001
Performance IQ	99.83	23.1	128.85	12.14	<0.001

<sup>a</sup> Student's *t* test of differences between groups.

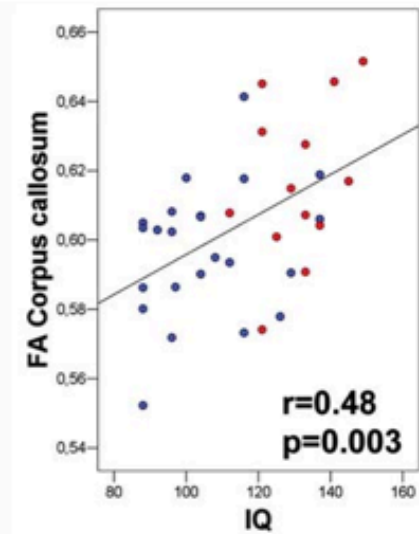
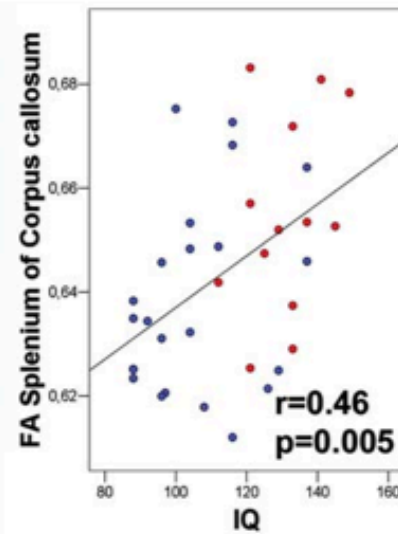
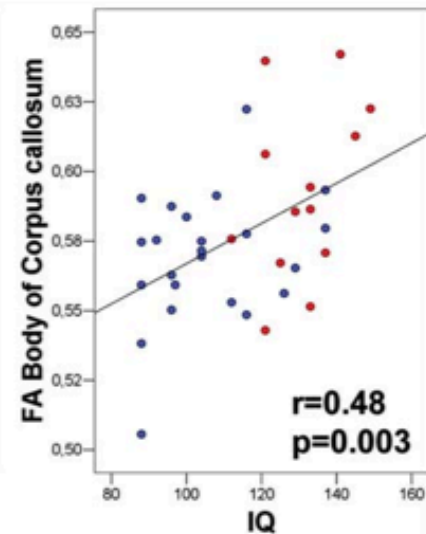
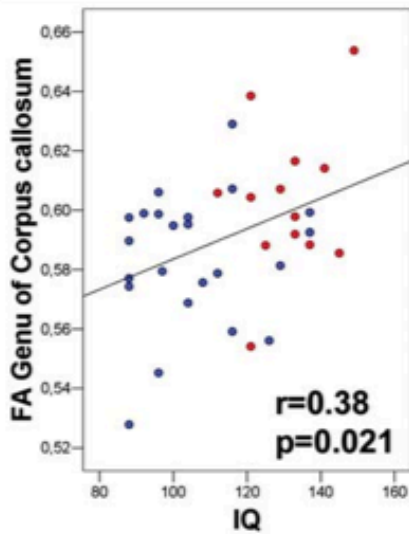
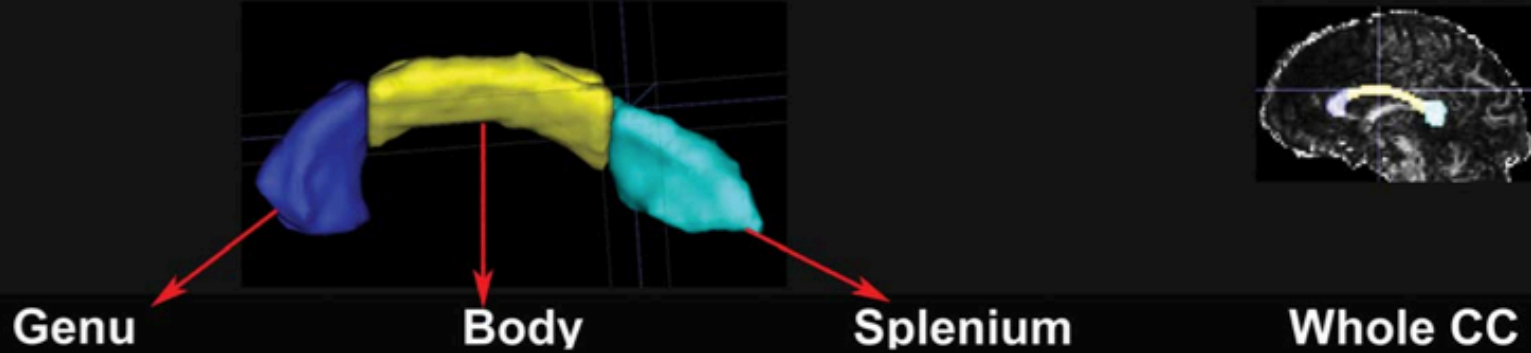


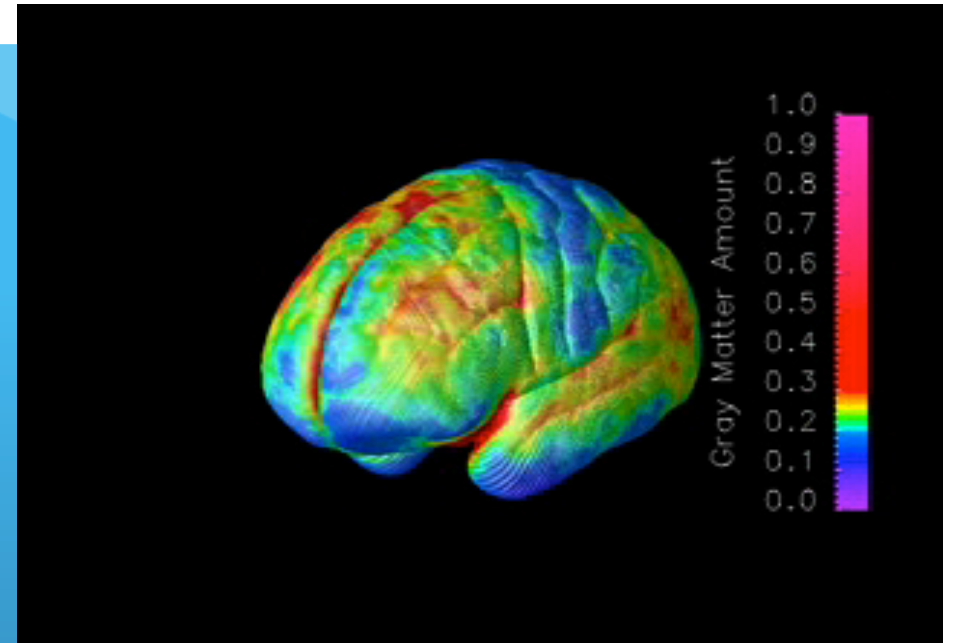
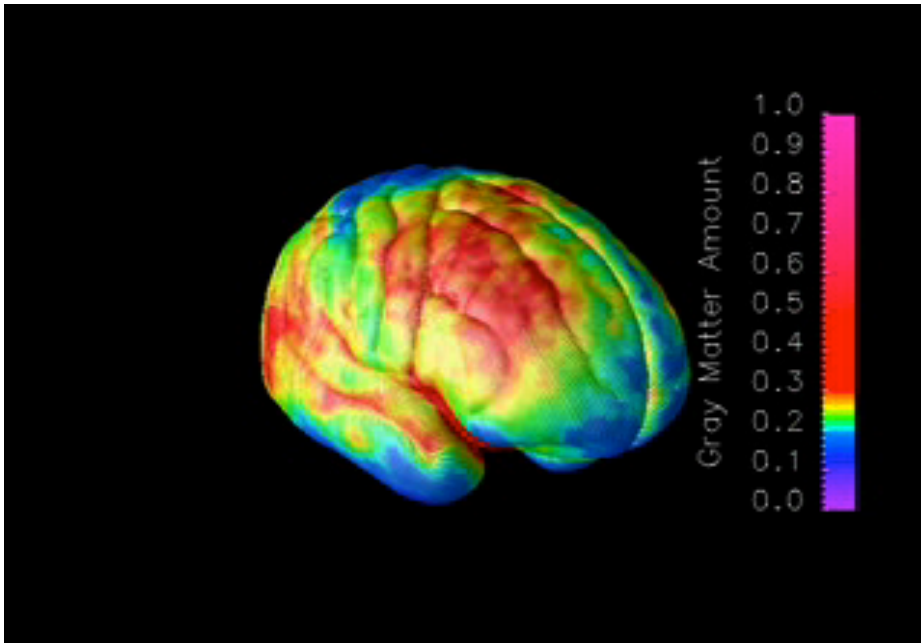
# CORRELATION FA & IQ

A.

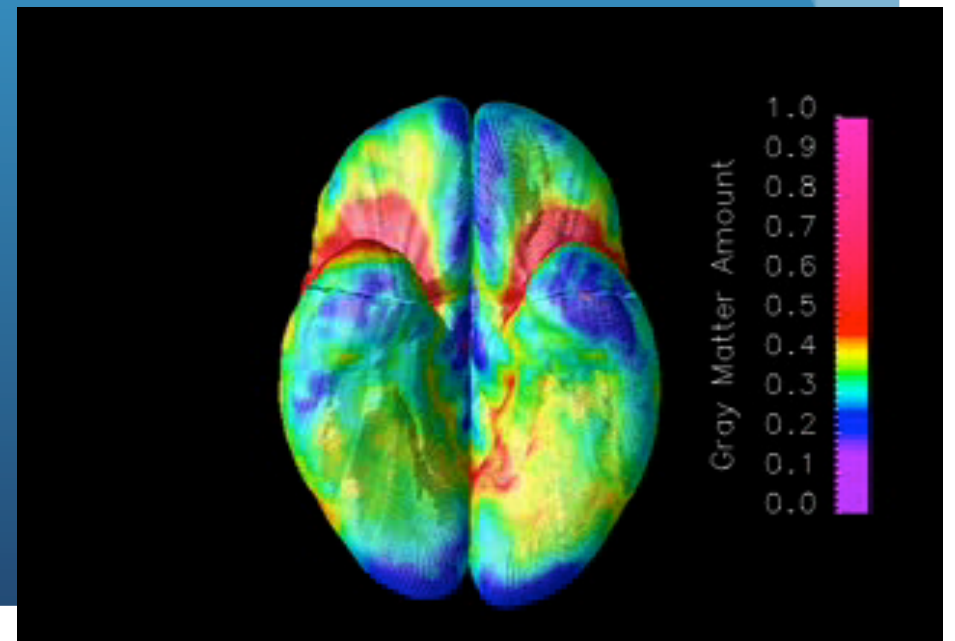
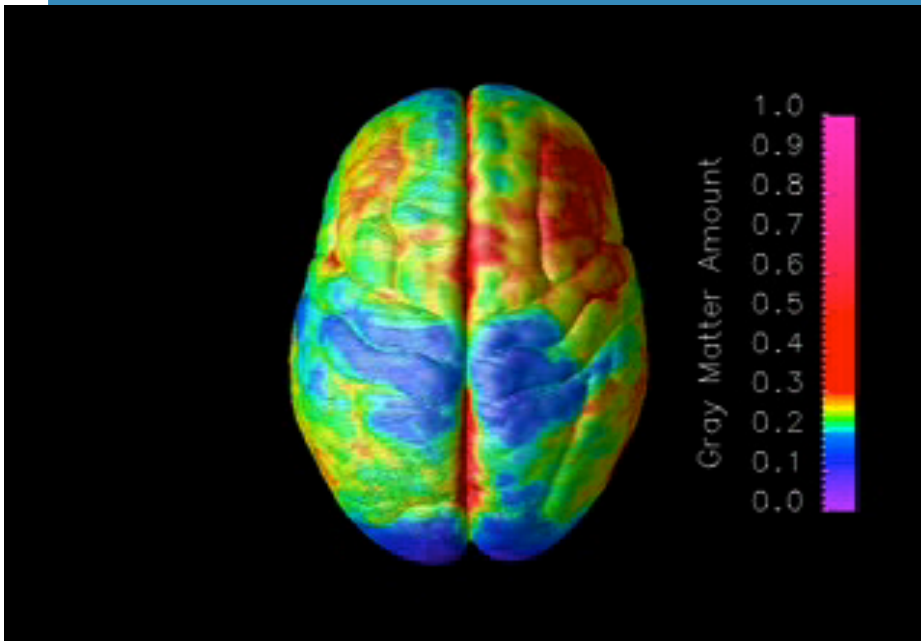


B.





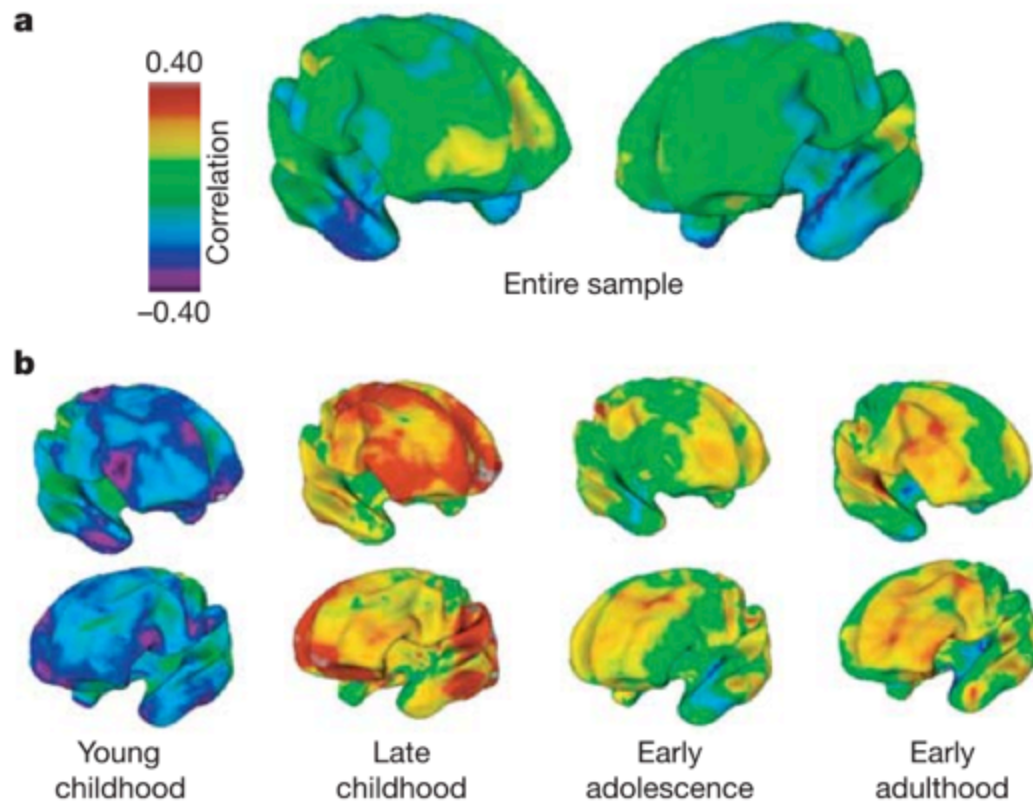
gray matter maturation over the cortical surface between ages 4 and 21 (Gogtay et al. /pnas, 2004)



## LETTERS

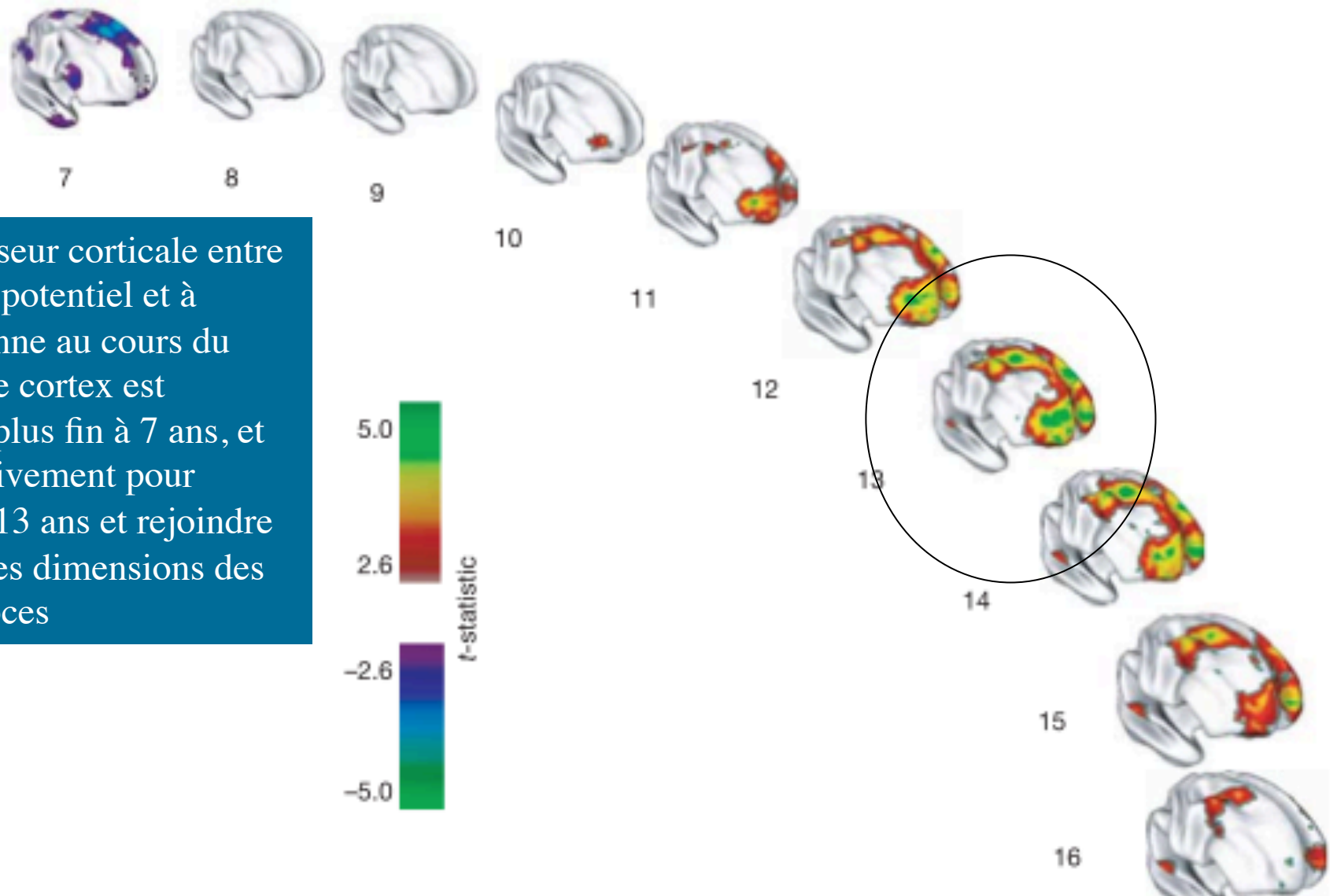
## Intellectual ability and cortical development in children and adolescents

P. Shaw<sup>1</sup>, D. Greenstein<sup>1</sup>, J. Lerch<sup>2</sup>, L. Clasen<sup>1</sup>, R. Lenroot<sup>1</sup>, N. Gogtay<sup>1</sup>, A. Evans<sup>2</sup>, J. Rapoport<sup>1</sup> & J. Giedd<sup>1</sup>



**Figure 1 | Correlations between IQ and cortical thickness. a**, Pearson's correlations for all 207 subjects were generally positive and modest

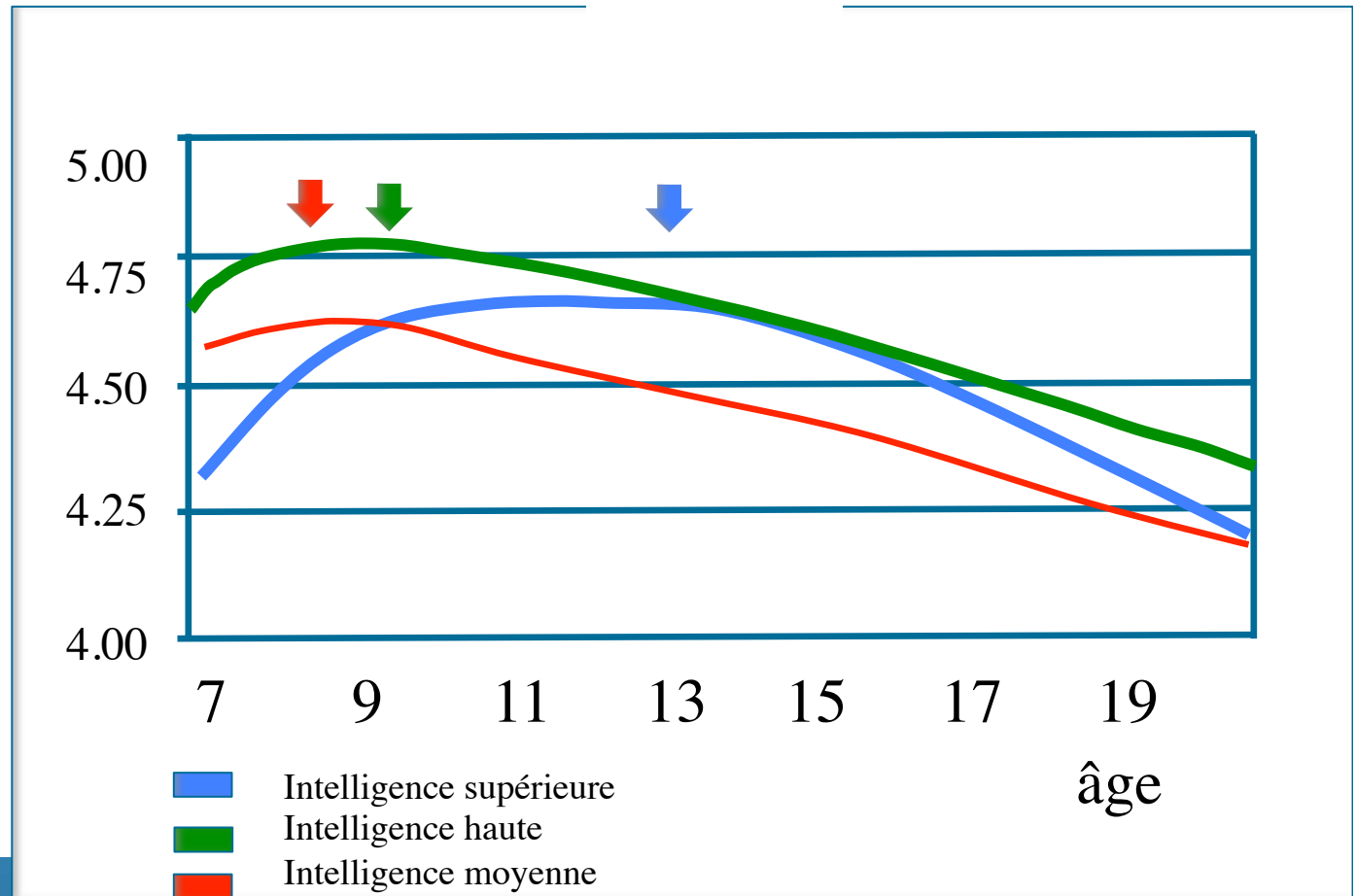
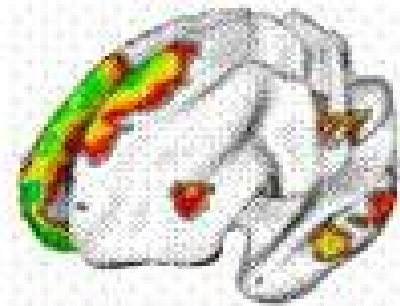
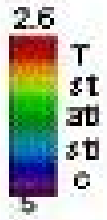
Corrélation entre l'épaisseur corticale et le QI en fonction de l'âge: corrélation négative dans la petite enfance, très positive chez les grands enfants, positive à un moindre degré à l'adolescence



Différence d'épaisseur corticale entre des enfants à haut potentiel et à intelligence moyenne au cours du développement : le cortex est significativement plus fin à 7 ans, et s'épaissit progressivement pour atteindre un pic à 13 ans et rejoindre progressivement les dimensions des témoins non précoces

**Figure 4 | Developing differences in cortical thickness between the superior and average intelligence groups.** Group differences are represented by *t*-statistics ( $t > 2.6$ ), and show that the superior intelligence group has a thinner superior prefrontal cortex at the earliest age (purple

regions). There is then a rapid increase in cortical thickness (red, green and yellow regions) in the superior intelligence group, peaking at age 13 and waning in late adolescence.



300 IRM d'enfants de 7 à 18 ans: la dynamique structurale (évolution de l'épaisseur du cortex) est différente entre enfants à haut QI (121-145) par rapport à ceux à QI supra-moyen (109-120) et moyen (83-108)  
 Donc la phase de croissance dendritique et synaptogenèse dure plus longtemps avant que ne commence la phase d'élimination des connexions superflues.

# Cognitive ability changes and dynamics of cortical thickness development in healthy children and adolescents

Miguel Burgaleta <sup>a,b</sup>, Wendy Johnson <sup>c</sup>, Deborah P. Waber <sup>d,1</sup>, Roberto Colom <sup>a,e</sup>, Sherif Karama <sup>f,g,\*</sup>

Full Scale IQ (FSIQ), Performance IQ (PIQ) and Verbal IQ (VIQ) in a representative sample of children and adolescents (n = 188, mean age = 11.59 years) assessed two years apart as part of the NIH Study of Normal Brain Development.

changes in FSIQ, PIQ, and VIQ were related to rates of cortical thinning, mainly in left frontal areas. Participants who showed reliable gains in FSIQ showed no significant changes in cortical thickness on average, whereas those who exhibited no significant FSIQ change showed moderate declines in cortical thickness. Importantly, individuals who showed large decreases in FSIQ displayed the steepest and most significant reductions in cortical thickness.

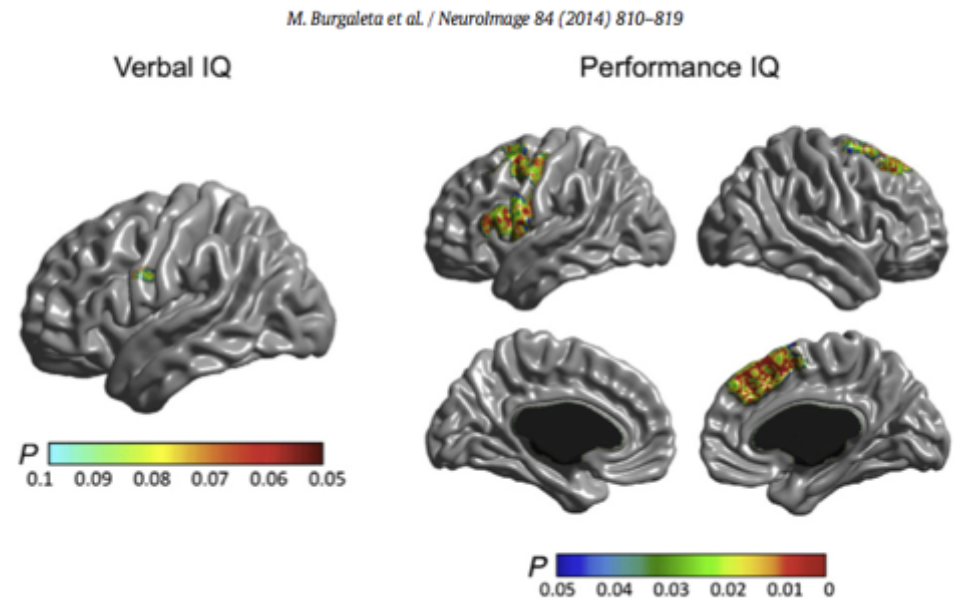
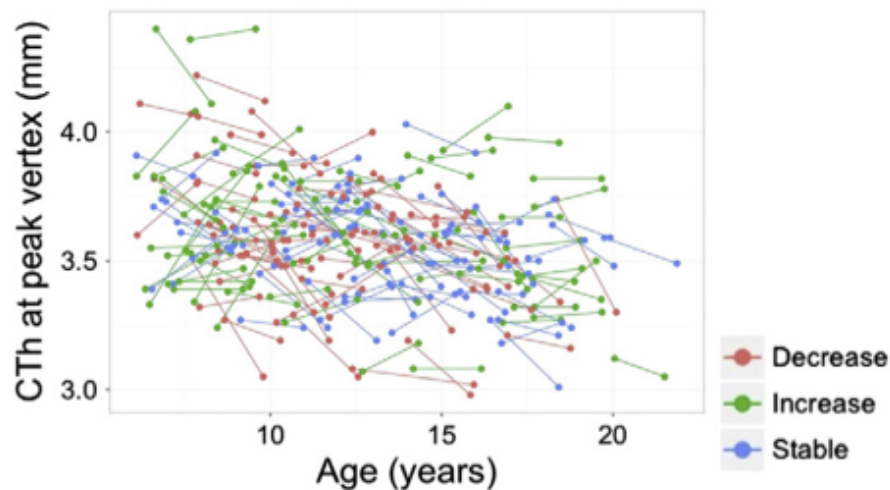


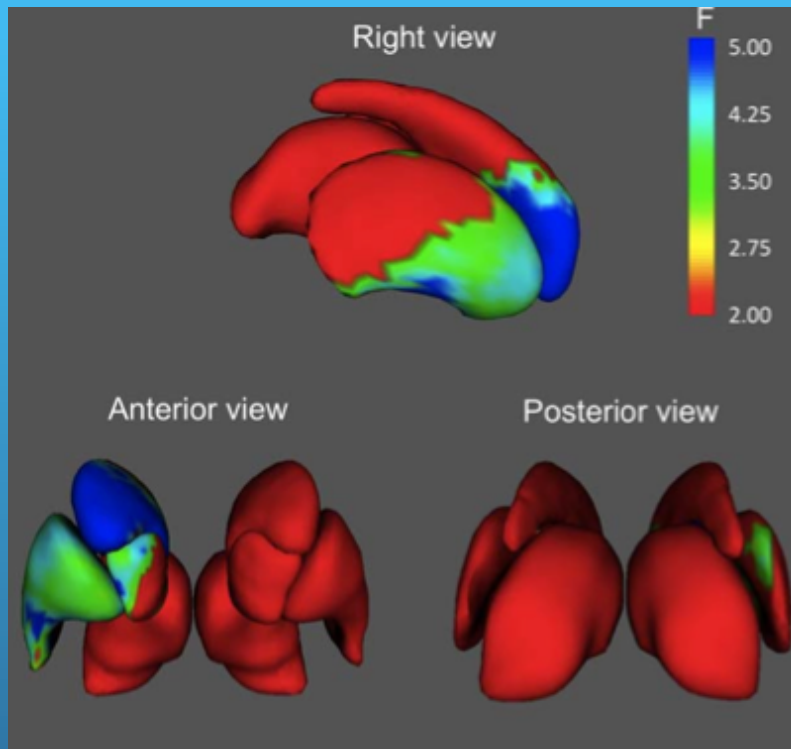
Fig. 6. Correlations between change in CTh and change in verbal IQ (left), and performance IQ (right).



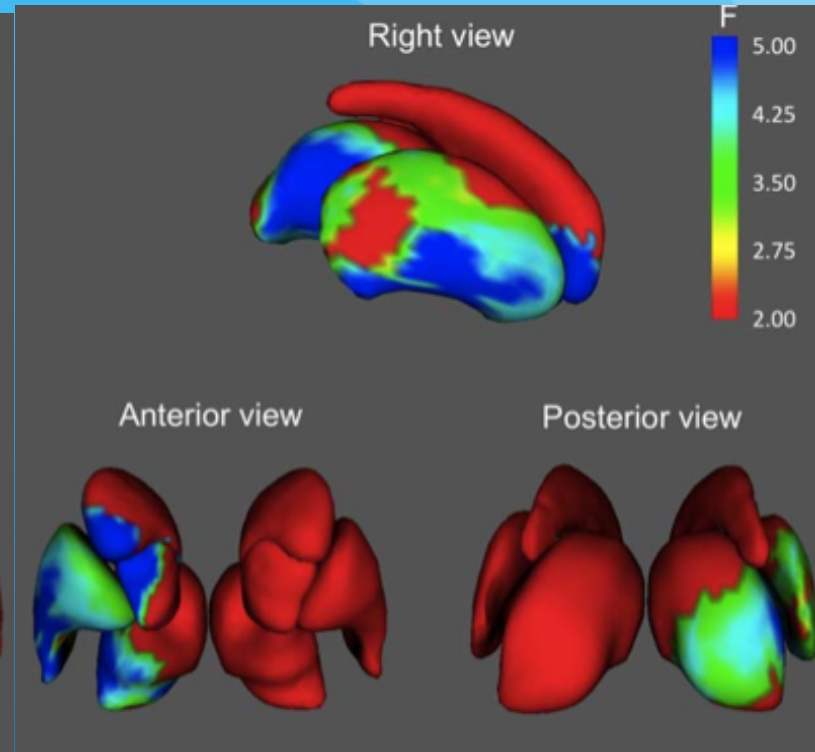
# En résumé, le cerveau de l'HP possède deux particularités

- Une plus forte densité des projections du lobe pariétal sur le cortex frontal, d'où une connectivité plus efficiente entre les régions perceptives/spatiales et les systèmes exécutifs, « expliquant » la qualité des raisonnements en particulier mathématiques
- Une plus longue période de croissance du cortex pré-frontal avant que ne débute la période d'élagage des synapses, pourrait augmenter la période critique durant laquelle s'installent des connexions cruciales, mais aussi augmenter la probabilité d'un déséquilibre interhémisphérique de l'installation de ces connexions.
- Pour certaines régions frontales, le ratio de diminution d'épaisseur serait corrélé à l'intelligence, un faible QI s'accompagnant d'un amincissement plus rapide

## Intelligence fluide



## Intelligence spatiale



mesure des différentes parties des ganglions de la base, en relation avec l'intelligence fluide (à gauche) et l'intelligence spatiale (à droite). Les différents noyaux (putamen, noyau caudé, thalamus), en particulier du côté droit, sont corrélés à ces deux types d'intelligence, mais pas à l'intelligence cristallisée, qui fait appel à des connaissances acquises (d'après Burgaleta et al., 2014).

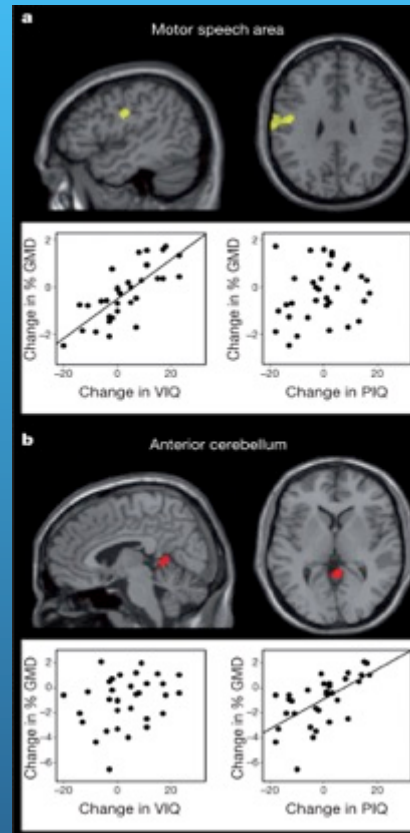
# Ramsden et al., 2011

- ont examiné 33 adolescents en bonne santé, une première fois en 2004 lorsqu'ils étaient âgés de 12 à 16 ans (14 ans en moyenne) puis une seconde fois en 2007-2008 lorsqu'ils avaient entre 15 et 20 ans (18 ans en moyenne). Leur QI verbal et non verbal a été mesuré grâce à différents tests (WISC-III à T1 et WAIS-III à T2) et ces jeunes ont subi un scanner cérébral structurel et fonctionnel par IRM lors de chaque examen. Les différents QI des participants allaient de 77 à 135 points au premier test et de 87 à 143 points au second, ce qui a confirmé le large éventail des aptitudes intellectuelles chez ces personnes.
- le QI verbal et non verbal avait considérablement varié chez les participants entre 2004 et 2008. Certains individus avaient amélioré leur performance par rapport aux jeunes de leur âge, avec une augmentation pouvant aller jusqu'à 20 points de leur QI global. Pour d'autres, en revanche, leur performance avait chuté, avec une baisse du QI pouvant atteindre également 20 points
- ces changements ne sont pas dus à une variation de la performance liée à l'humeur ou à la concentration ce jour-là, ils sont bien réels puisqu'ils sont corrélés à des changements de structure de certaines régions cérébrales.

		Age	FSIQ	VIQ	PIQ
<b>High ability (n=11)</b>					
<b>Time 1</b>	Mean (SD)	13.8 (0.9)	126 (3.8)	128 (8.8)	115 (7.4)
	Min/max	13.1/16.5	120/132	113/139	101/125
<b>Time 2</b>	Mean (SD)	17.4 (1.0)	126 (9.1)	133 (10.8)	113 (6.4)
	Min/max	16.6/20.2	110/143	117/150	98/124
<b>Change (Time 2 – Time 1)</b>	Mean (SD)	3.6 (0.1)	+0.4 (8.2)	+4.5 (9.7)	-2.1 (9.2)
	Min/max	3.5/3.7	-16/+11	-13/+17	-18/+13
<b>Average ability (n=7)</b>					
<b>Time 1</b>	Mean (SD)	14.4 (1.3)	108 (7.8)	111 (9.3)	103 (9.2)
	Min/max	13.0/16.3	94/118	100/121	90/119
<b>Time 2</b>	Mean (SD)	17.9 (1.3)	114 (10.8)	121 (14.8)	104 (11.2)
	Min/max	16.4/19.8	98/128	100/138	85/117
<b>Change (Time 2 – Time 1)</b>	Mean (SD)	3.5 (0.1)	+6.1 (9.7)	+10.3 (10.7)	+0.7 (13.7)
	Min/max	3.3/3.6	-9/+21	0/+23	-18/+17
<b>Low ability (n=14)</b>					
<b>Time 1</b>	Mean (SD)	14.1 (0.9)	101 (10.3)	101 (9.5)	102 (11.7)
	Min/max	12.6/16.0	77/114	84/115	74/116
<b>Time 2</b>	Mean (SD)	17.7 (0.9)	101 (6.8)	99 (7.8)	102 (7.4)
	Min/max	16.0/19.5	87/111	90/113	83/111
<b>Change (Time 2 – Time 1)</b>	Mean (SD)	3.6(0.2)	-0.5 (9.0)	-1.1 (9.9)	+0.1 (9.4)
	Min/max	3.3/3.9	-18/+13	-20/+17	-14/+16

Les enfants haute aptitude (QI >120)

Location of brain regions where grey matter changed with VIQ and PIQ.



S Ramsden *et al.* *Nature* 000, 1-4 (2011) doi:10.1038/nature10514

**nature**

# Association between Ability Emotional Intelligence and Left Insula during Social Judgment of Facial Emotions

Tiziana Quarto, Giuseppe Blasi, Chiara Maddalena, Giovanna Viscanti, Tiziana Lanciano, Emanuela Soleti, Ivan Mangiulli, Paolo Taurisano, Leonardo Fazio, Alessandro Bertolino, Antonietta Curci

Sixty-three healthy subjects completed a test measuring Ability EI and underwent fMRI during a social decision task (i.e. approach or avoid) about emotional faces with different facial expressions. Imaging data revealed that EI scores are associated with left insula activity during social judgment of emotional faces as a function of facial expression. Specifically, higher EI scores are associated with greater left insula activity during social judgment of fearful faces but also with lower activity of this region during social judgment of angry faces.

