

Neuropsychologie et précocité intellectuelle

Michel Habib

Centre référent des troubles
d'apprentissage

AP-HM

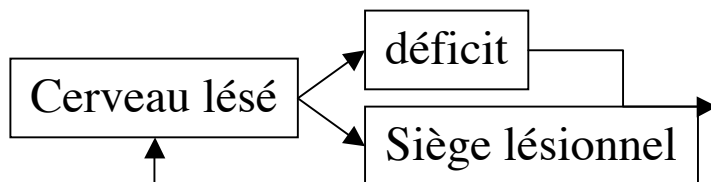
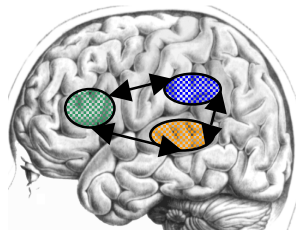


NEUROPSYCHOLOGIE : DEFINITION ET CADRE CONCEPTUEL

Discipline clinique et scientifique qui étudie les liens entre le cerveau et les fonctions mentales

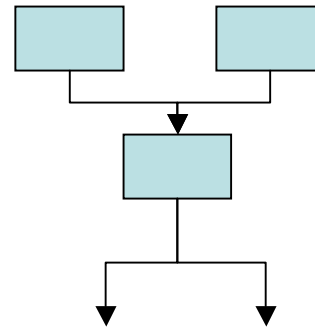
Méthode anatomo-clinique

Relation structure fonction



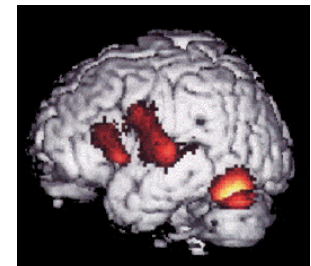
Approche cognitive

Architecture fonctionnelle

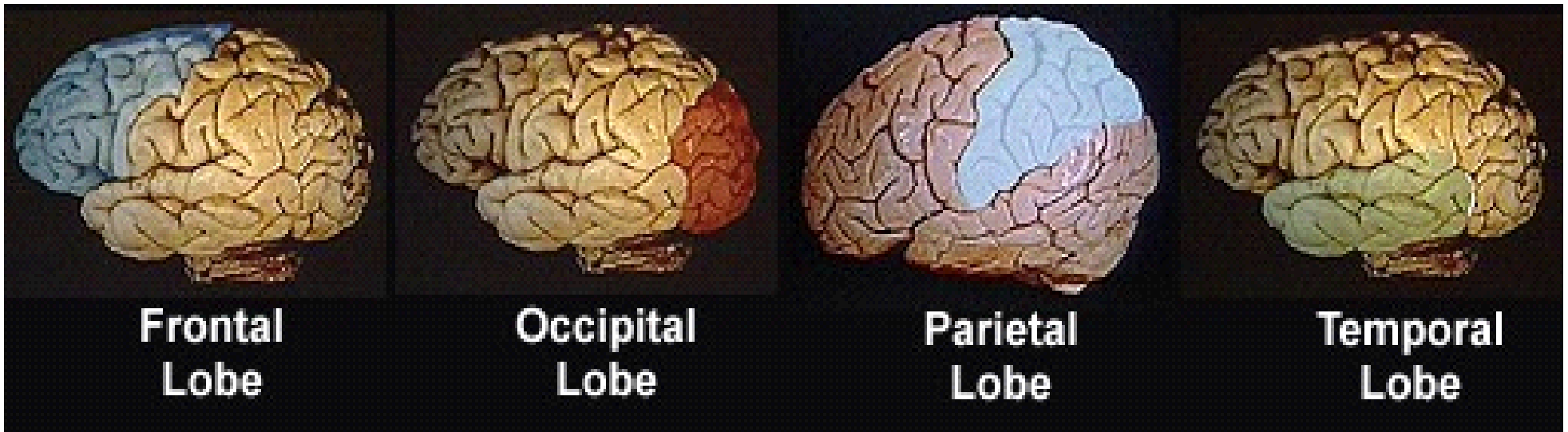
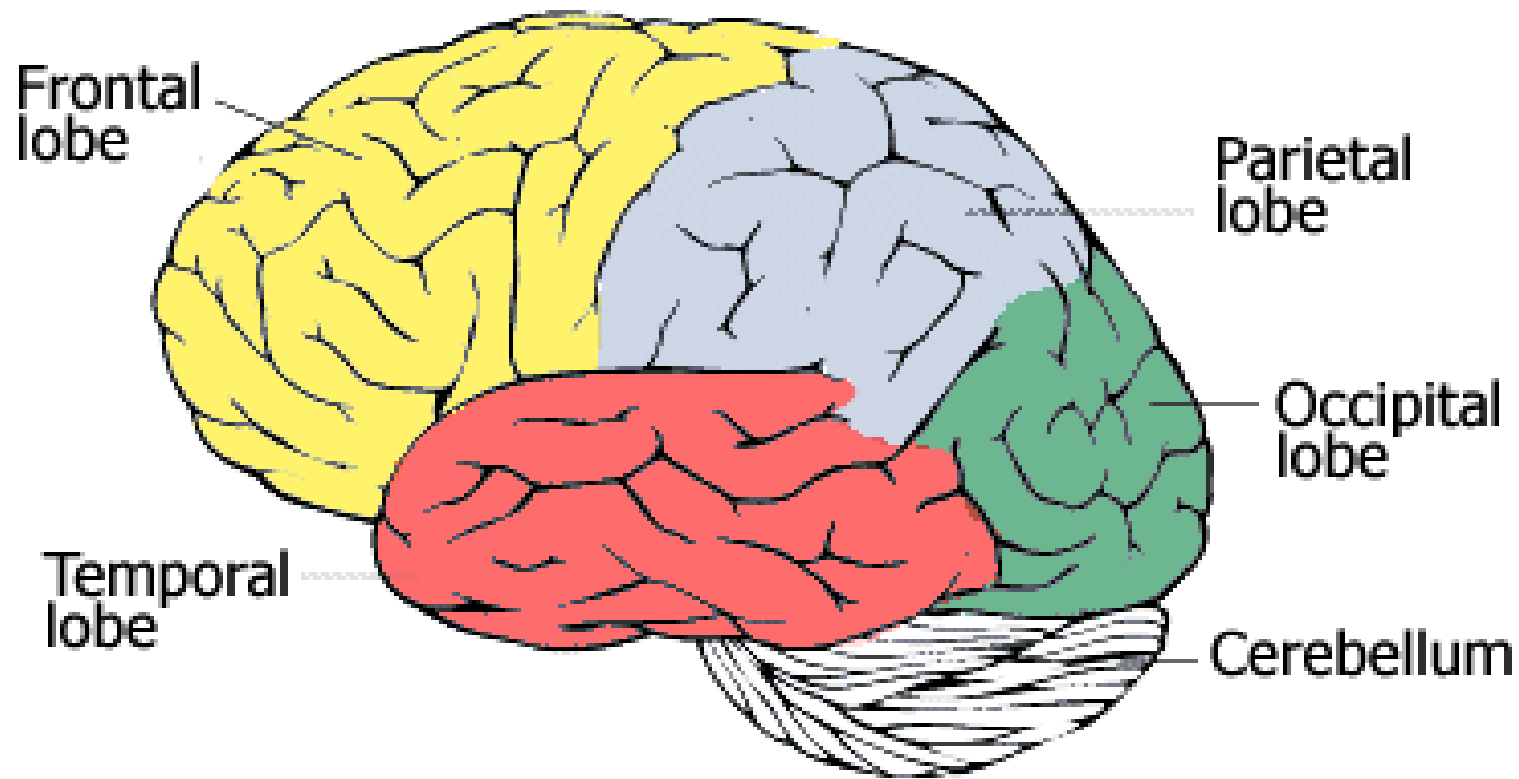


Imagerie fonctionnelle

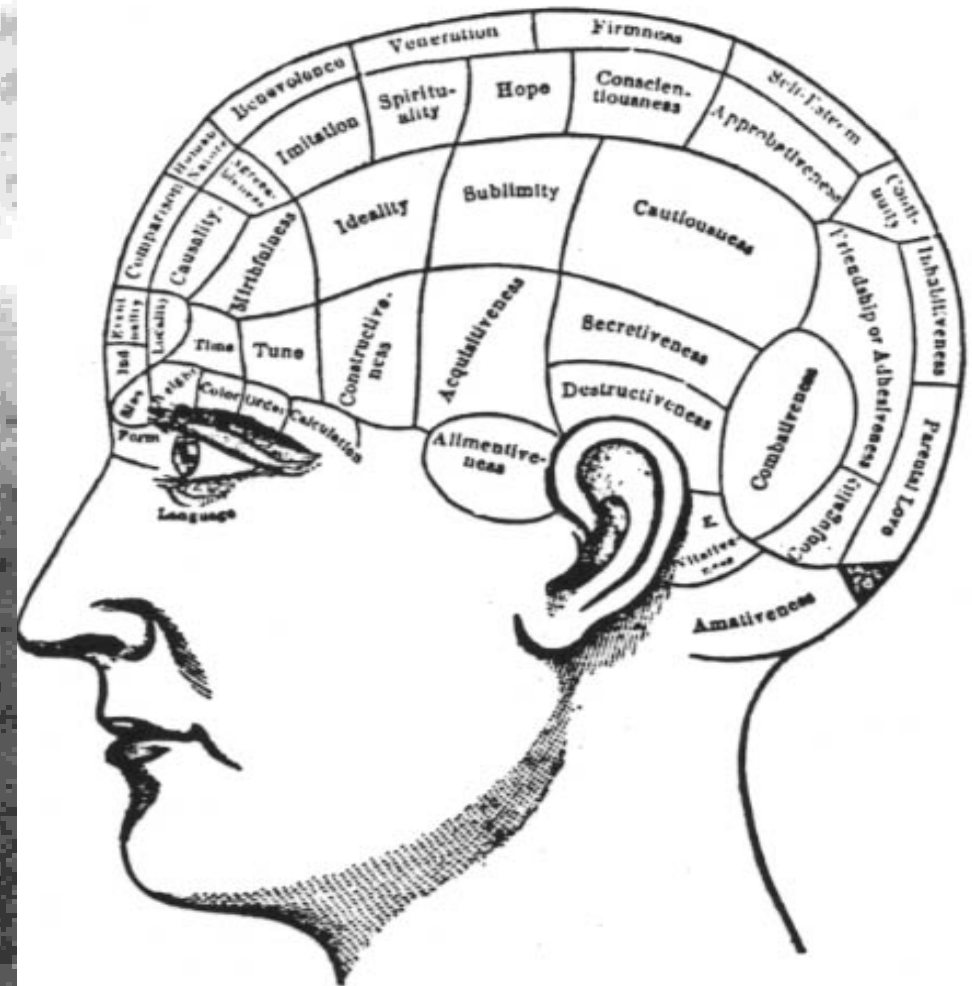
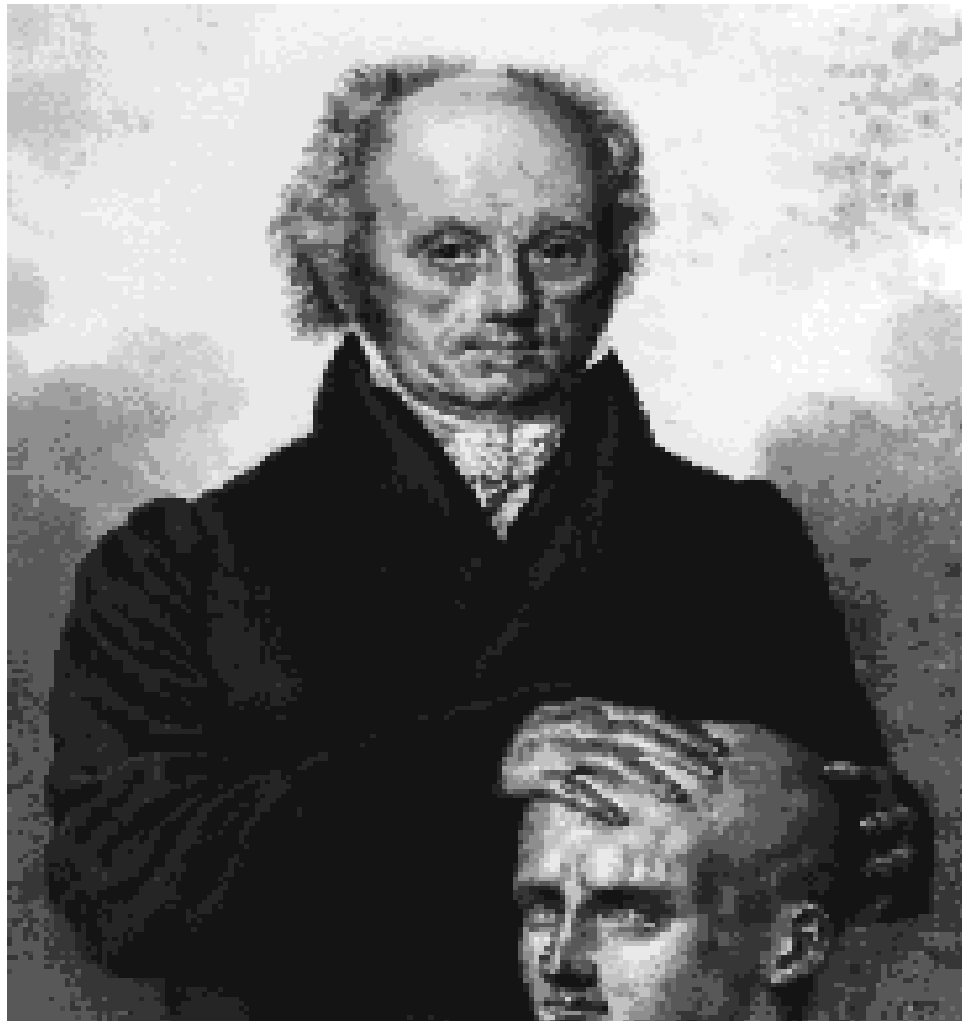
Anatomie fonctionnelle



Cerveau sain

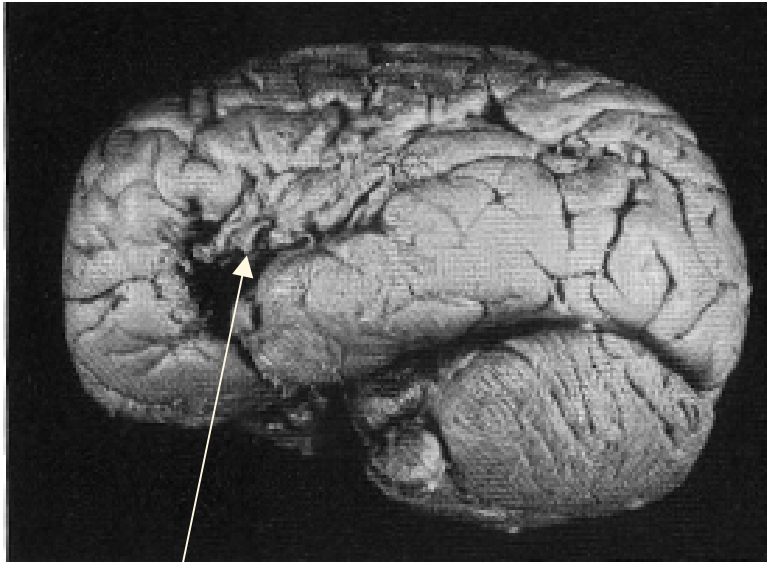


Franz Joseph Gall (1758-1828)

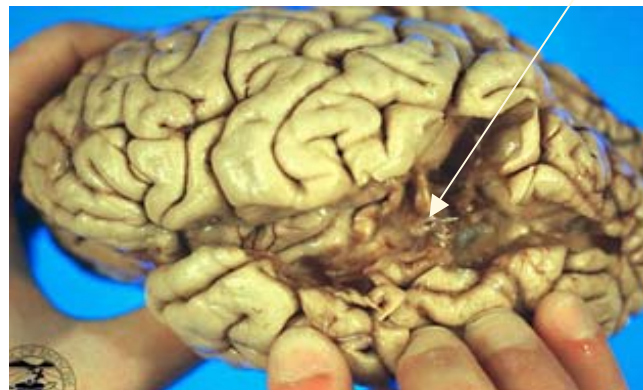




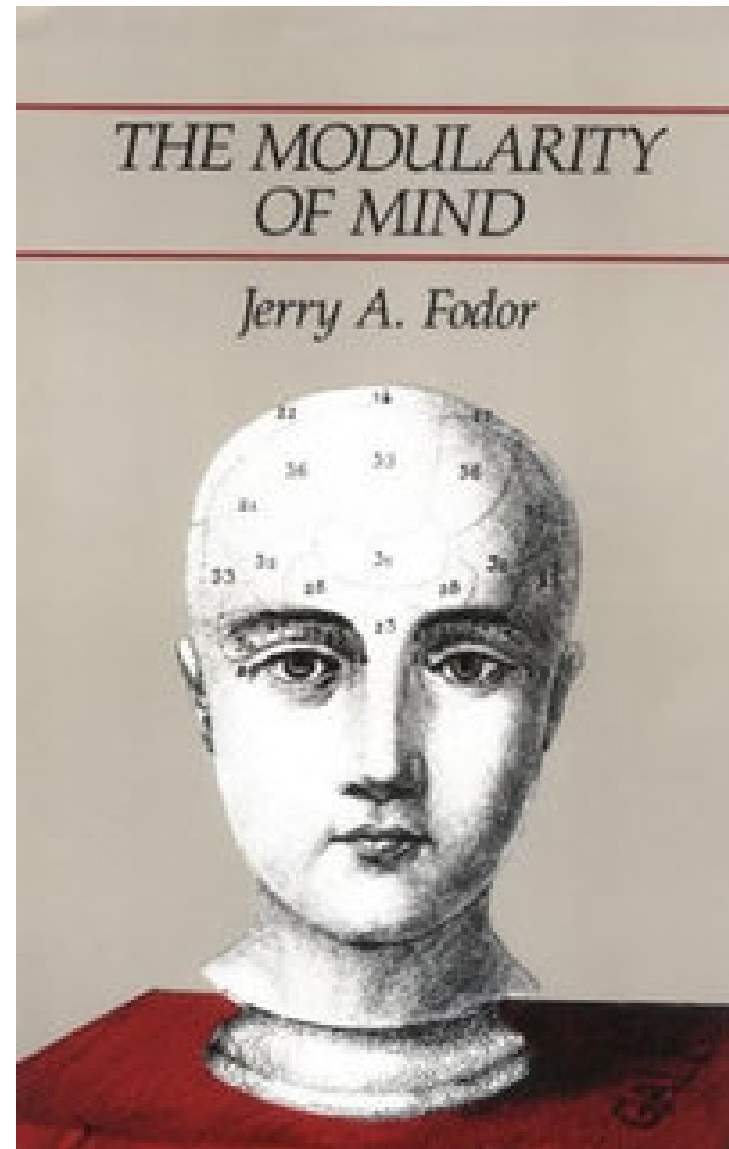
Paul Broca

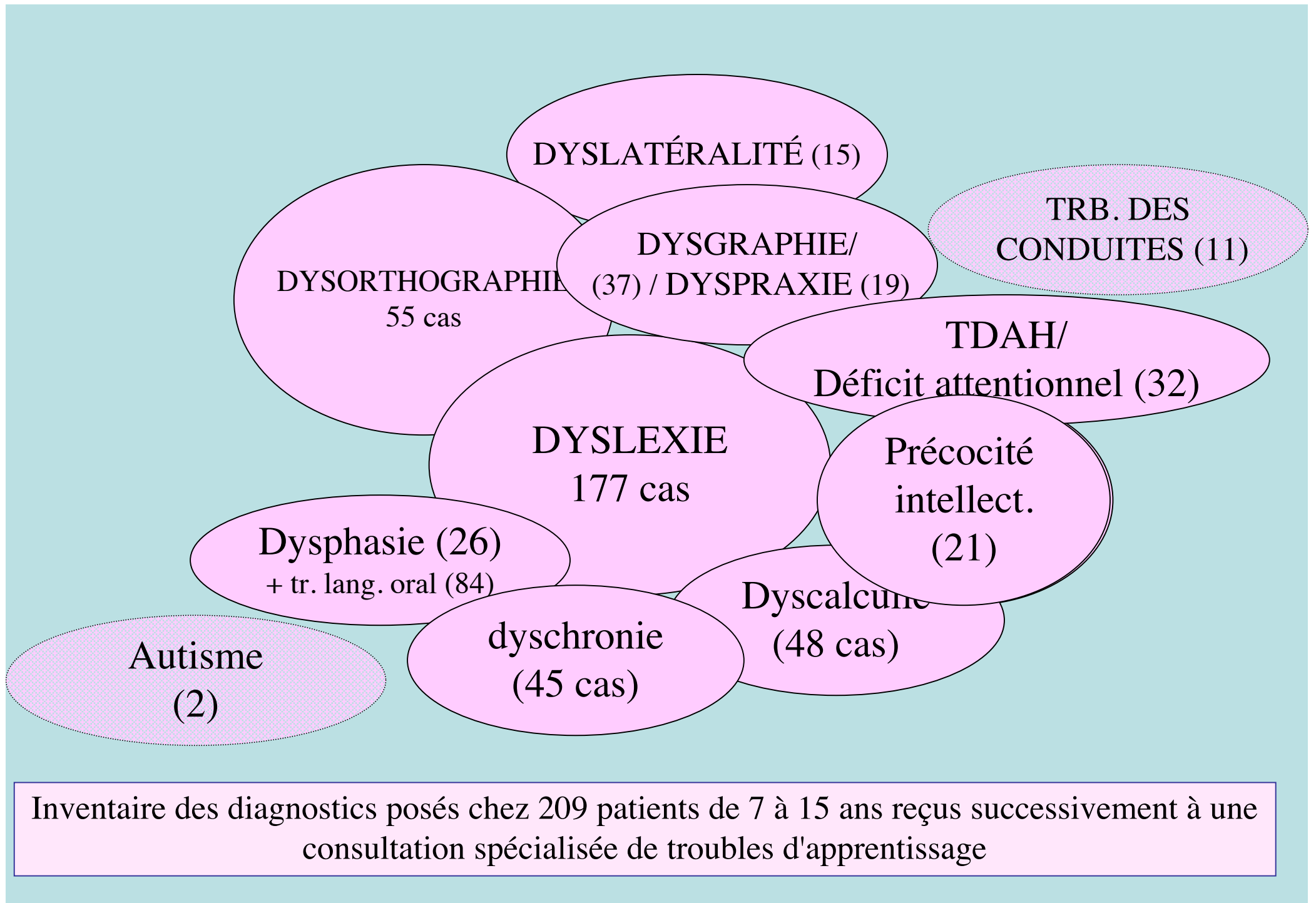


Karl Wernicke

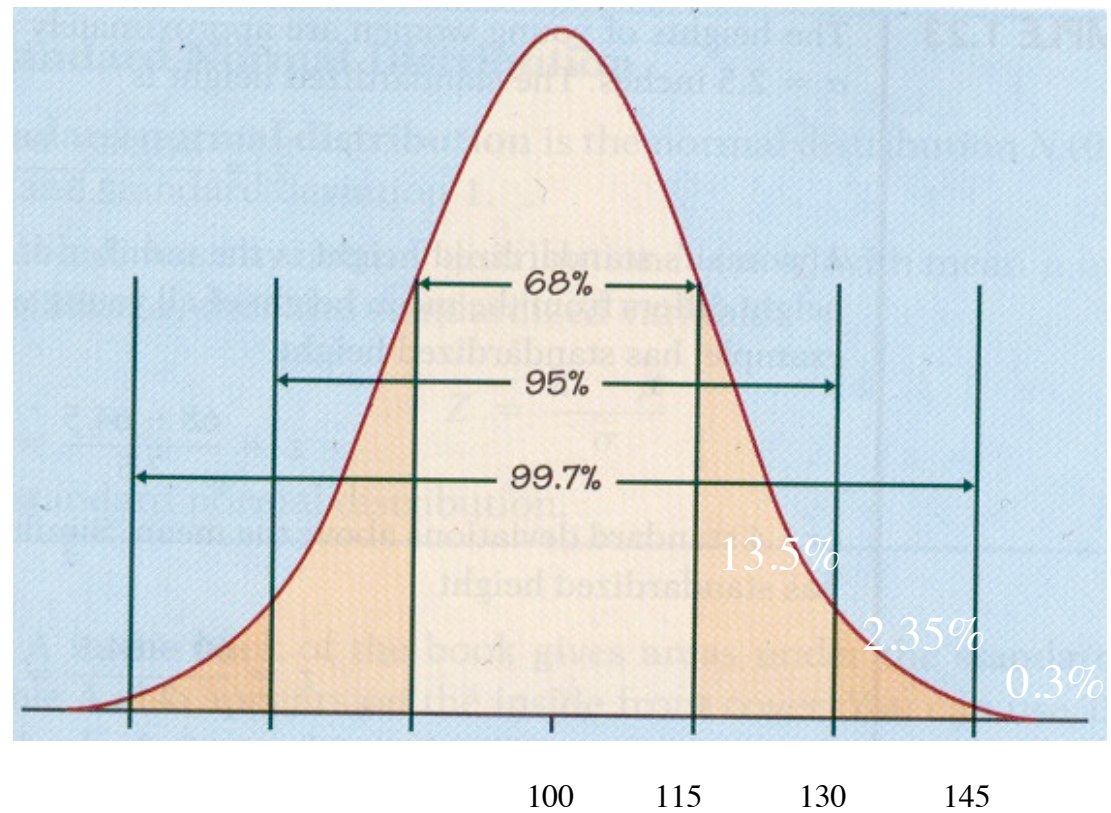


We may usefully think of the language faculty, the number faculty, and others, as "mental organs," analogous to the heart or the visual system or the system of motor coordination and planning (J.A. Fodor, 1983)





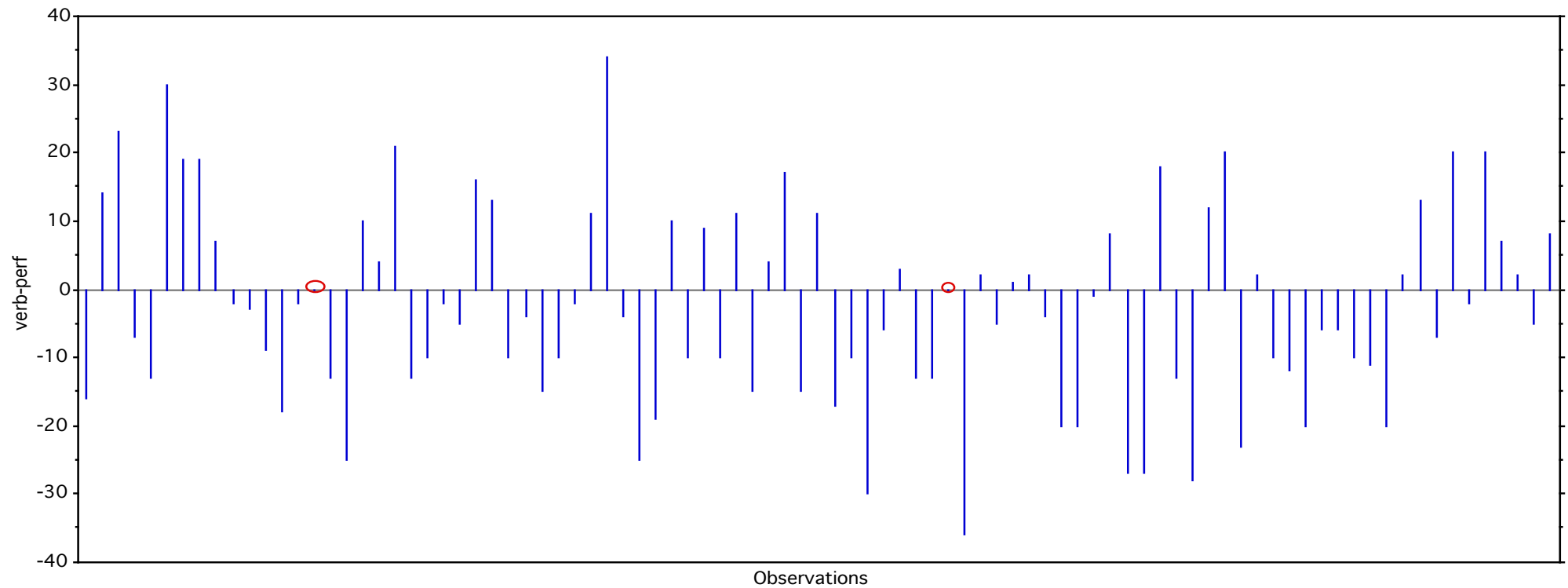
Distribution "normale"



Precocité : théorique < à 2% / observé : $21/209 = >10\%$

verb > perf :
N= 35

$\mu=12\pm 8.2$

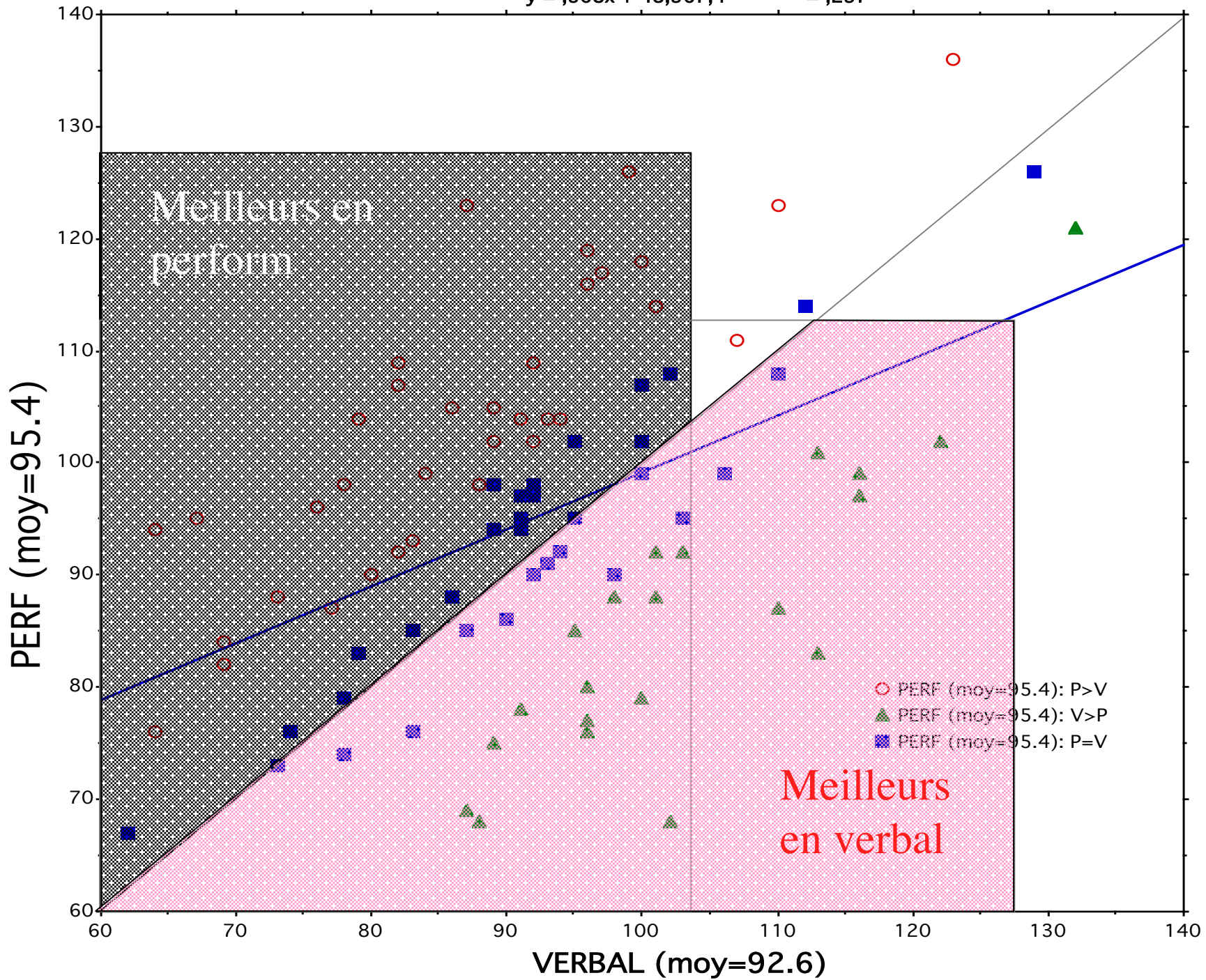


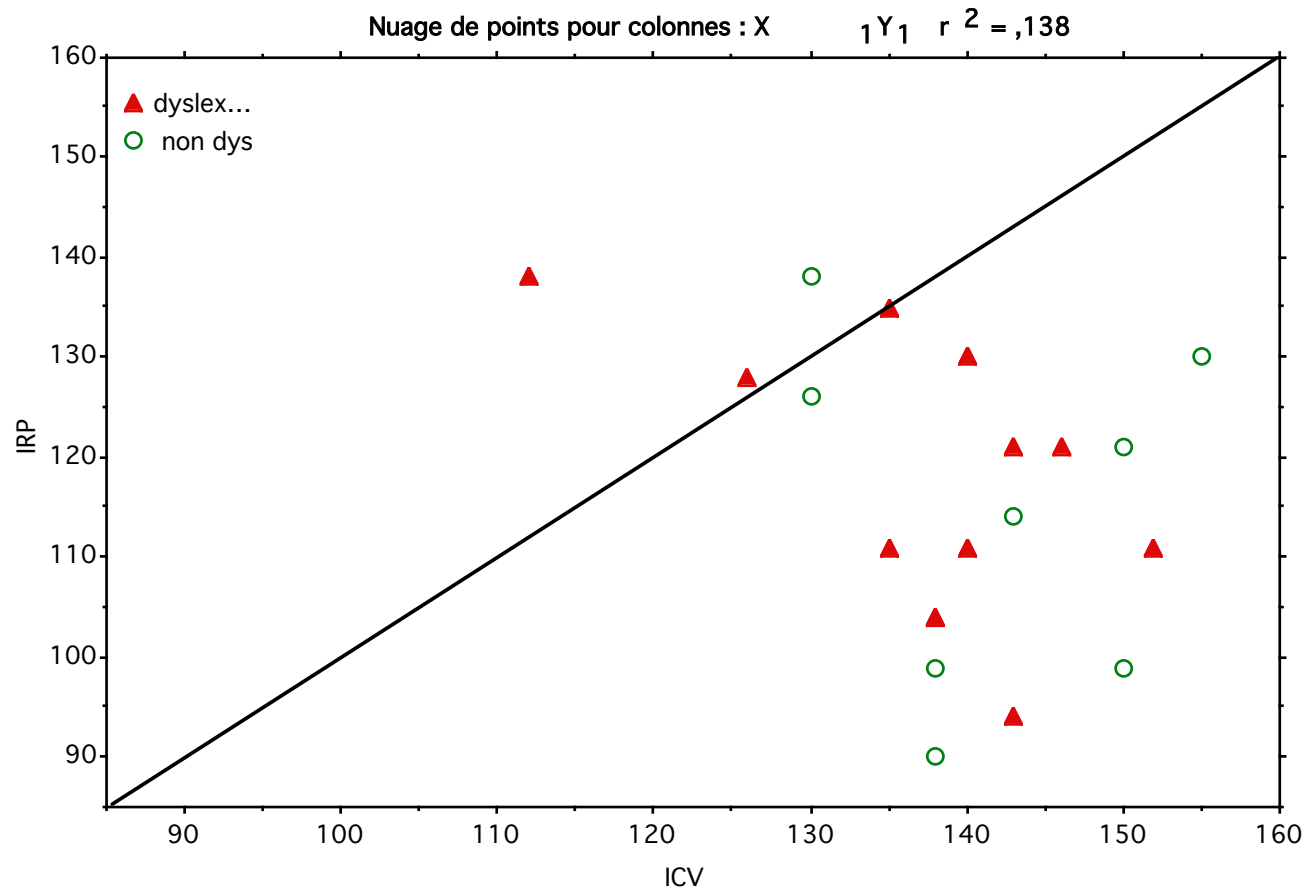
perf > verb N= 54

$\mu=-12\pm 8.3$

différence verb - non verb : N=91

$y = ,508x + 48,367, r^2 = ,237$



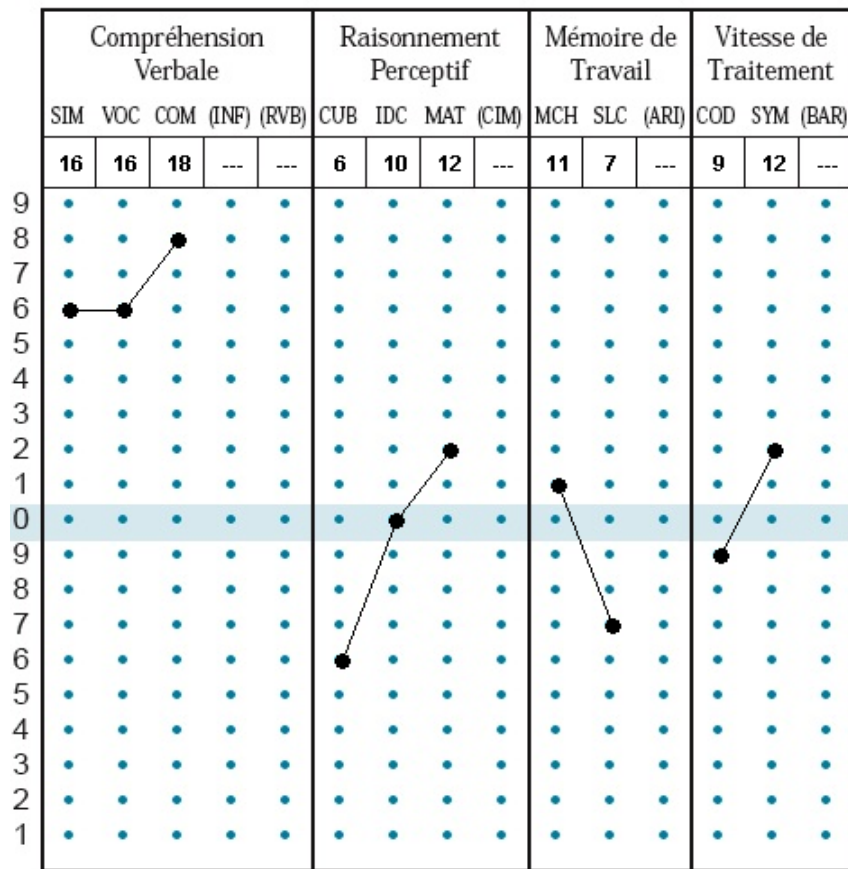


profil cognitif de 20 enfants à fort potentiel intellectuel en
 difficulté scolaire (dont 12 en difficulté de lecture)

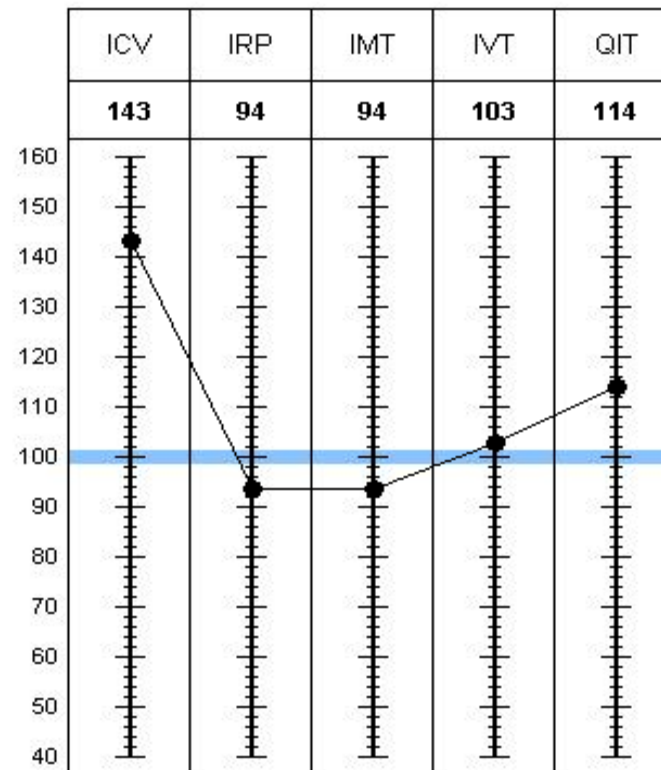
Guillaume : 13 ans 11 mois – 4e

Tenue du crayon acquise difficilement, aime dessiner mais n'aime pas écrire.
 Dyslexie Visuelle partiellement résolue au cours du CP. Difficultés en géométrie.
 TB mémoire visuelle. Difficultés graphomotrices

Profil des notes standard



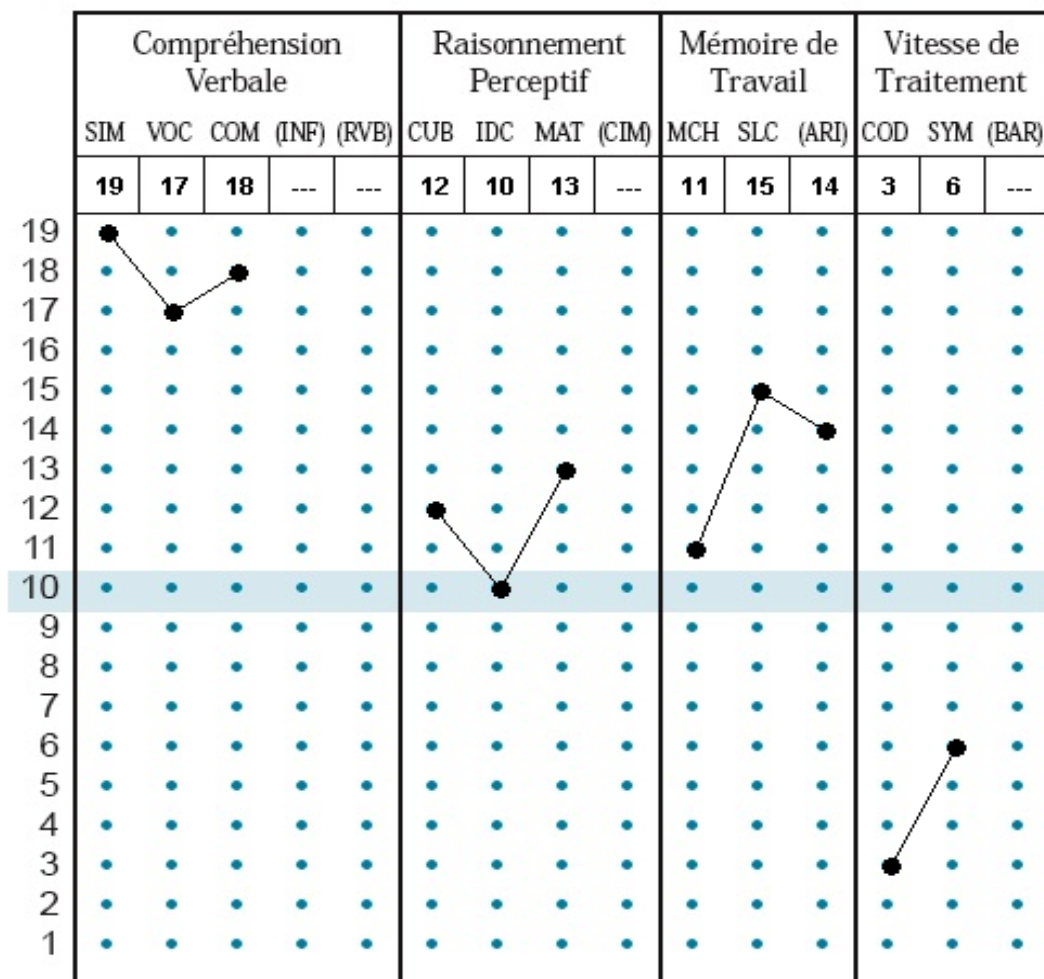
Profil des notes composites



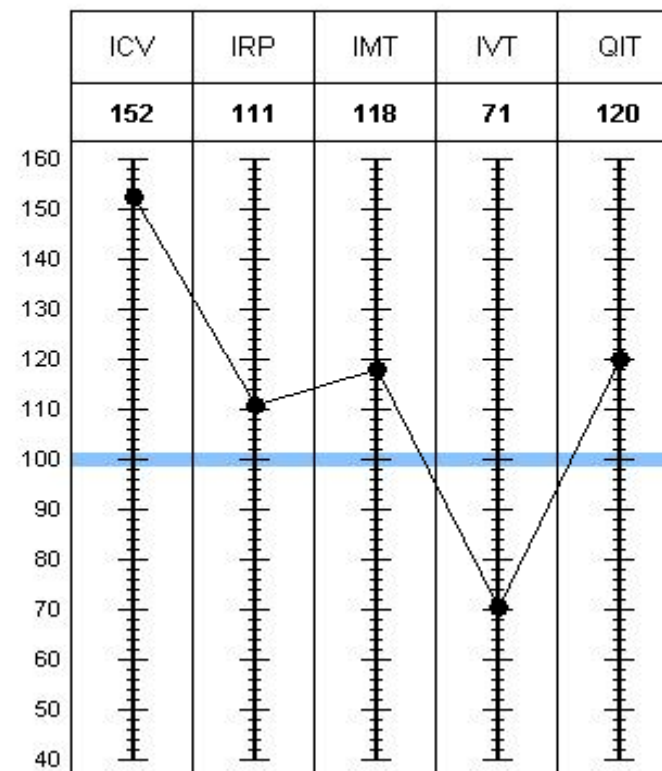
Benjamin : 16 ans 8 mois. 1e S

Pas de retard moteur ni langage. Lenteur à l'habillage. Dyschronie importante. N'arrive pas à terminer ses devoirs. Pas de dysgraphie. Bilan ortho : lenteur de lecture significative

Profil des notes standard



Profil des notes composites



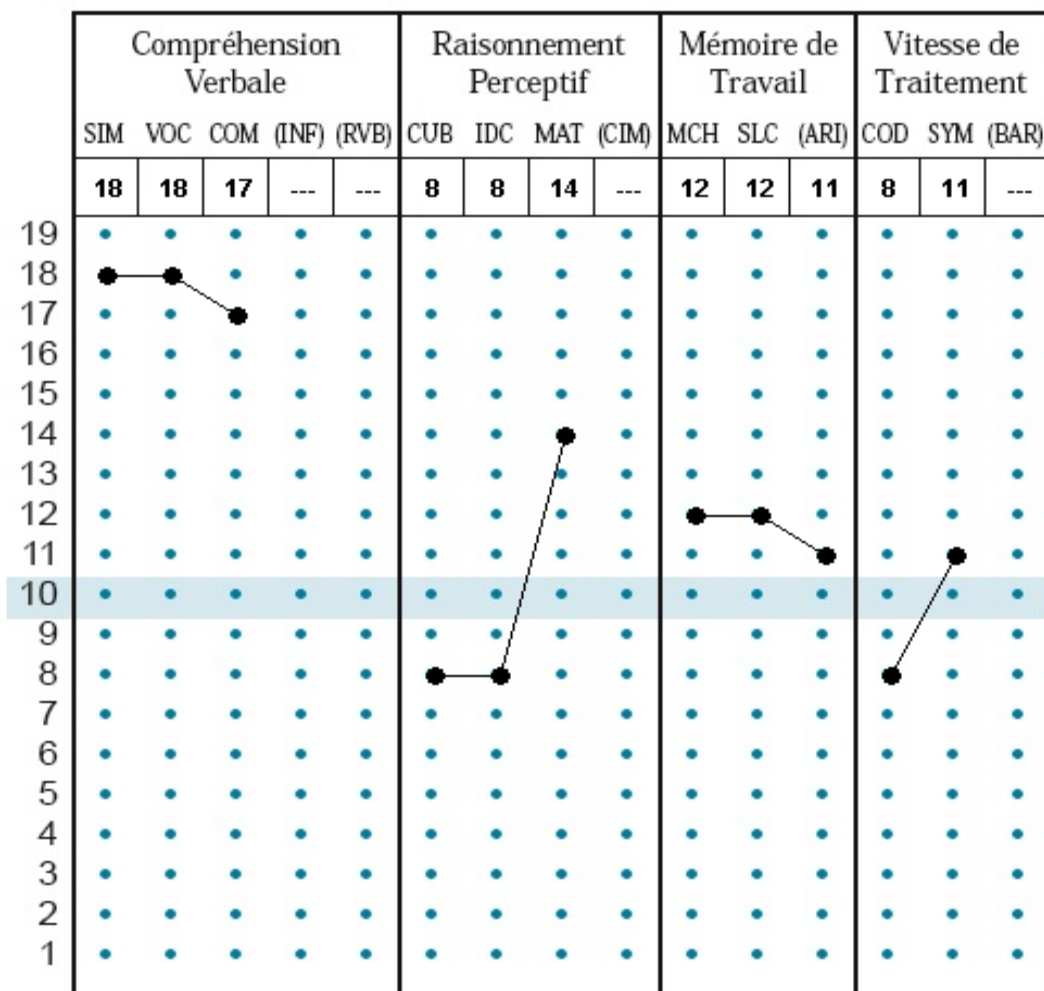
Conclusion (1)

- Le profil des enfants à haut potentiel en difficulté est différent de celui de la majorité des dyslexiques
- Il est caractérisé par un écart moyen de plus de 20 points en faveur de l'indice de compréhension verbale, suggérant un excellent raisonnement verbal et un profil relatif de dyspraxie ou de "syndrome hémisphérique droit"
- Cette association entre un déficit (relatif) dans un domaine des fonctions cognitives et à l'opposé un talent exceptionnel dans un autre suggère un facteur variation (probablement génétique) capable d'avoir des effets opposés sur des systèmes cérébraux différents
- Cette organisation cérébrale particulière résulterait dans des "styles cognitifs" singuliers impliquant des circuits hémisphériques spécifiques.

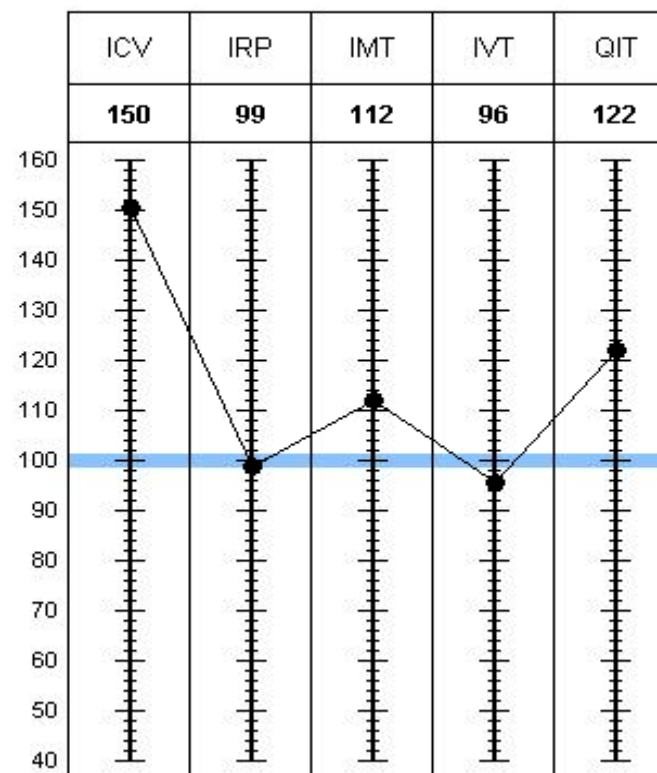
Lolita : 6 ans 11 mois. CE1.aucun retard ni moteur ni langage ni écriture. Lecture acquise après un mois de CP. S'ennuie en classe, turbulente.

Difficultés en mathématiques.

Profil des notes standard

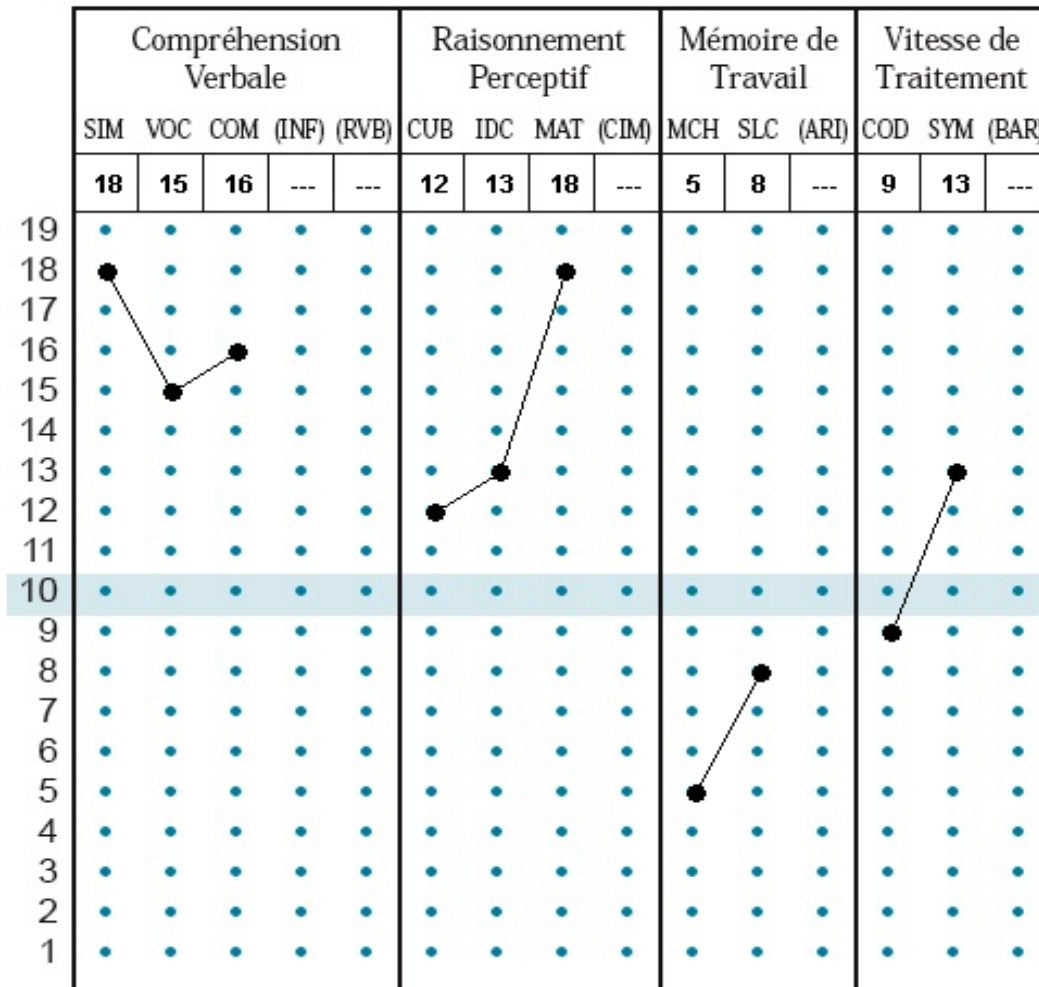


Profil des notes composites

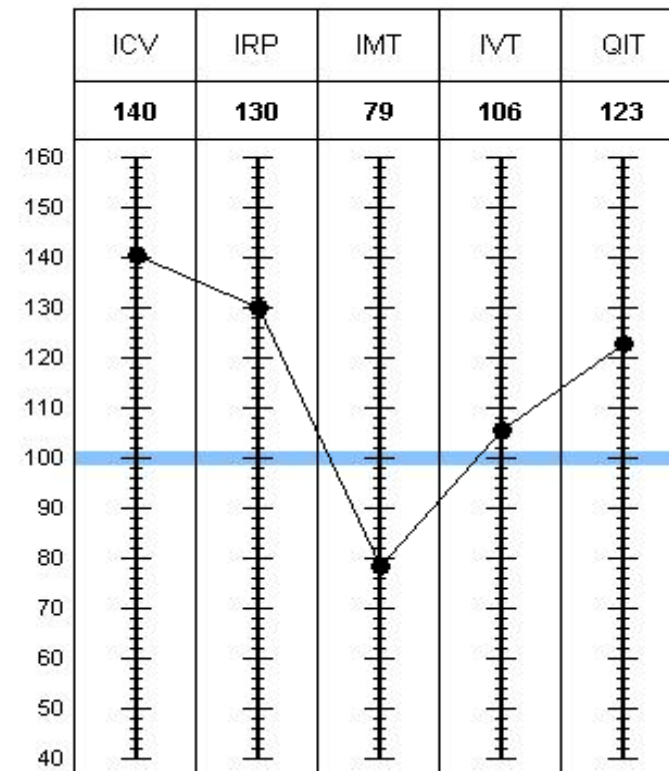


Léonard : 11 ans. CM2. Retard de langage. Quelques difficultés temporelles et pour s'habiller (faire ses lacets). Lecture non acquise en fin de CP.. Orthophonie : trouble phonologique et dysorthographe sévère

Profil des notes standard



Profil des notes composites



	Jamais	Rarement	Parfois	Souvent	Très souvent
1- Il (Elle) se souvient difficilement des jours / mois / année que nous sommes.					
2- Il (Elle) confond les moments de la journée matin / après-midi / soirée.					
3- Un événement qui est survenu le matin, il (elle) peut le placer la veille.					
4- Pour un événement qui est survenu il y a quelques jours, il (elle) peut dire : "il y a très longtemps".					
5- Il lui est difficile de comprendre les relations existantes entre les membres de la famille : grands-parents, tantes, neveux, beau-frère.					
6- Il (Elle) a du mal à comprendre les notions de hier, demain ou après-demain.					
7- Il (Elle) a des difficultés à li l'heure sur un cadran.					
8- Il (Elle) se trompe lorsque il (elle) doit évaluer la durée d'un film, la durée d'une activité, voire même la durée d'une nuit de sommeil.					
9- Vous avez besoin de lui donner des indices pour qu'il (elle) se repère dans une semaine (lundi : école ; mercredi : activités extra-scolaires ; dimanche : repos ...).					

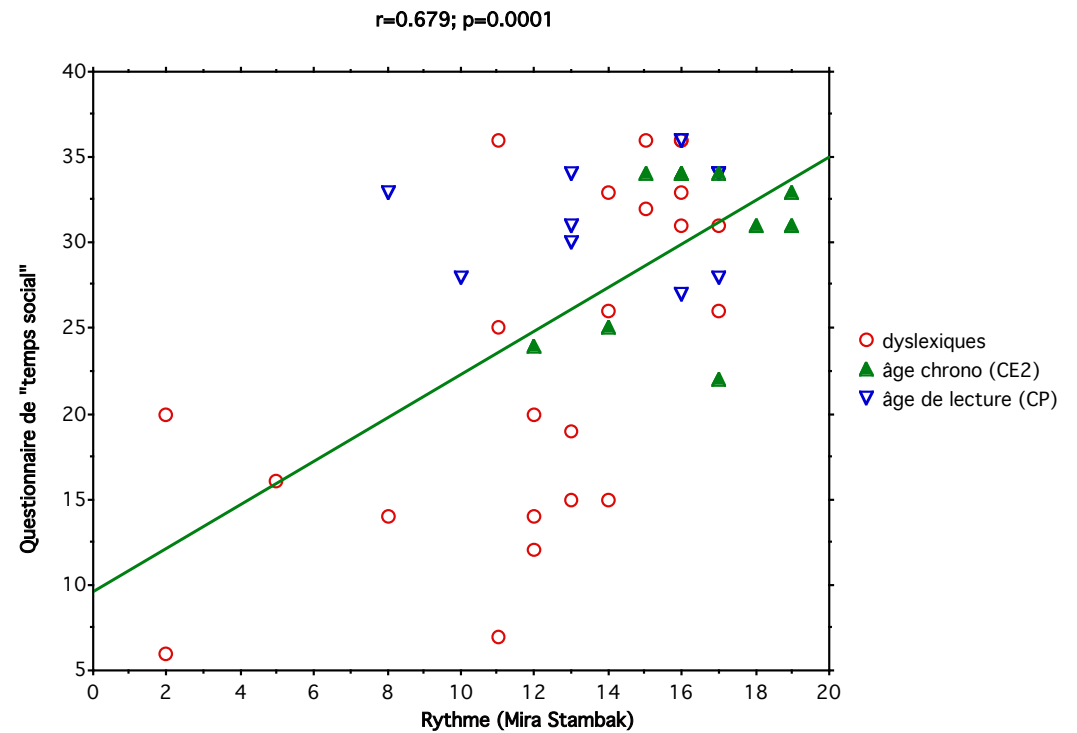
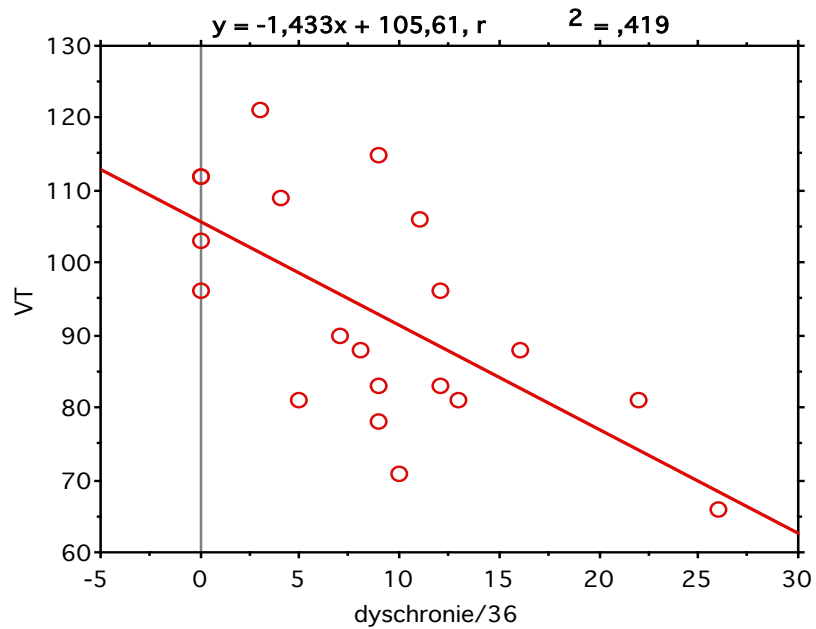


Figure 3 : corrélation chez 23 enfants dyslexiques et 20 témoins (appariés en âge de lecture : CP ou selon l'âge chronologique : CE2) entre la performance à un test d'imitation de rythmes et le résultats d'un questionnaire de « temps social » (Daffaure et al., 2002).

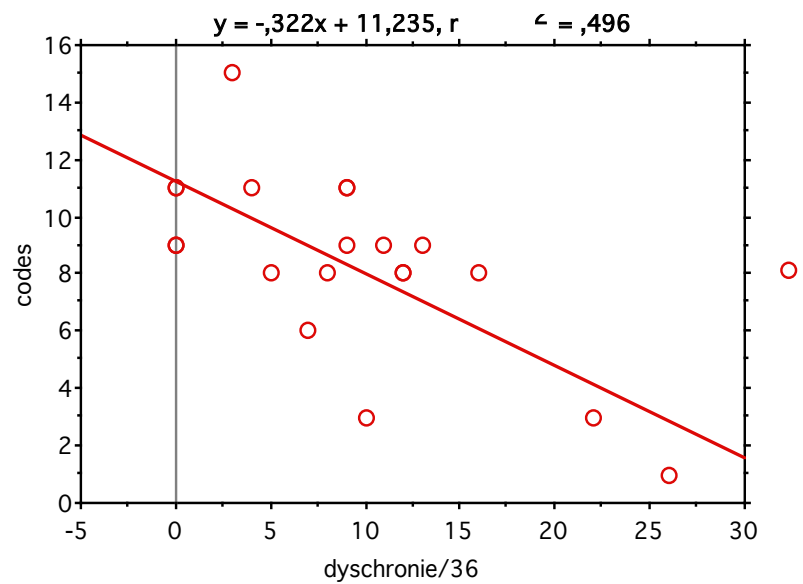
**Corrélation entre reproduction
de rythmes et questionnaire de
« temps social »**



corr lation dyschronie / IVT

$r=0.647$

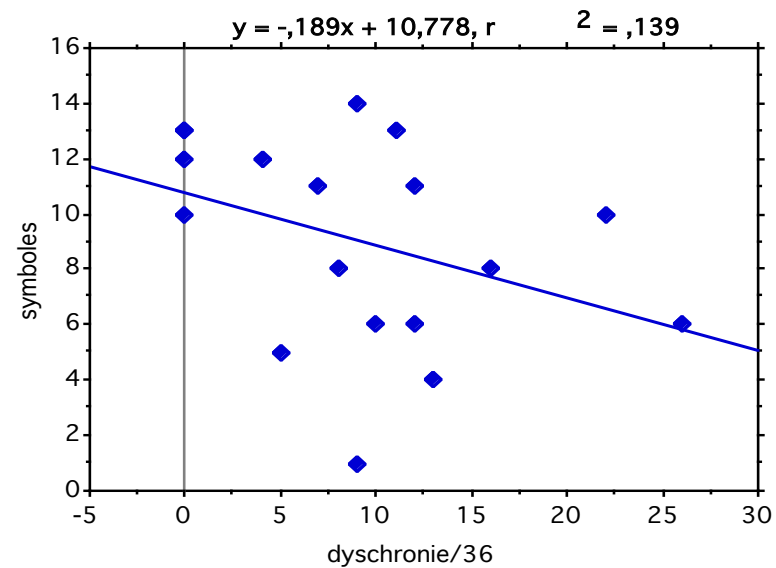
$p=0.002$



corr lation dyschronie / codes

$r=0.713$

$p=0.0005$

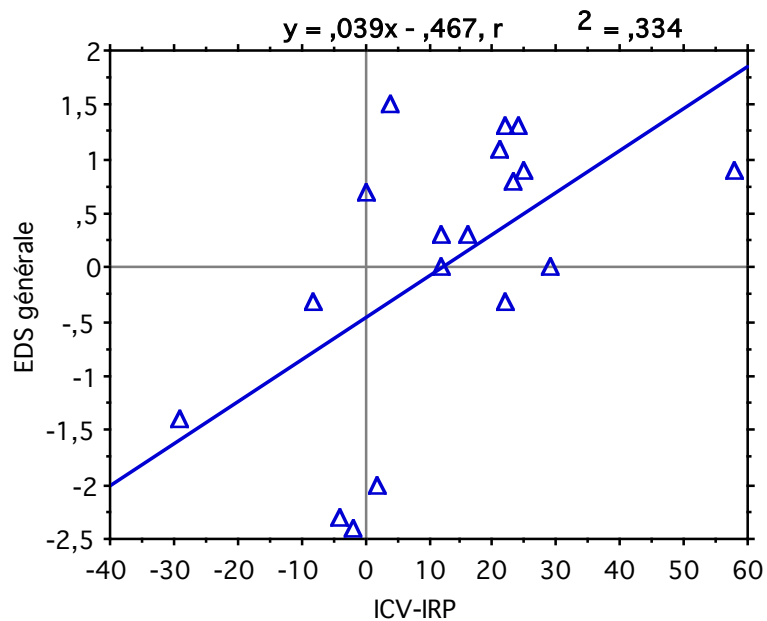


corr lation dyschronie / symboles

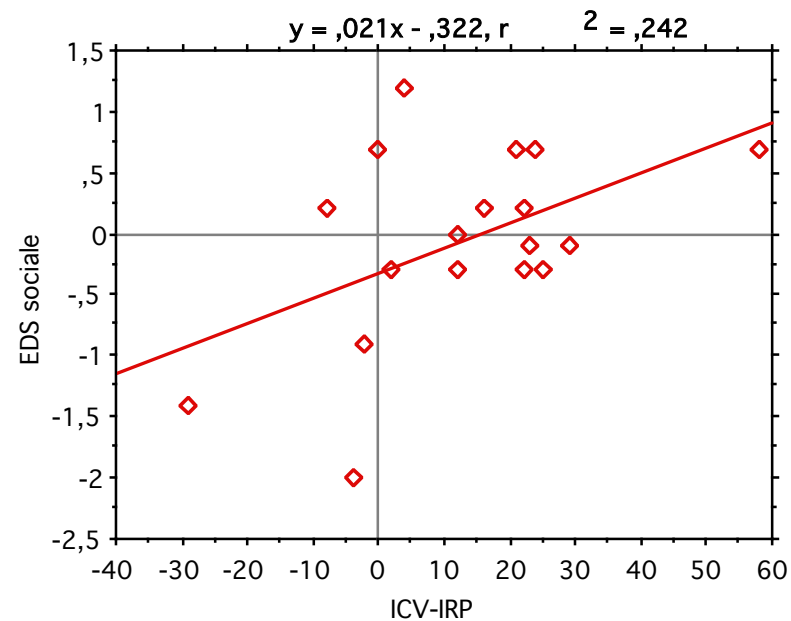
$r=0.373$

$p=0.1272$

Corrélation écart verb/non-verb avec estime de soi (questionnaire de Coopersmith)



Estime de soi : score global. **$r=0.578$, $p=0.012$**



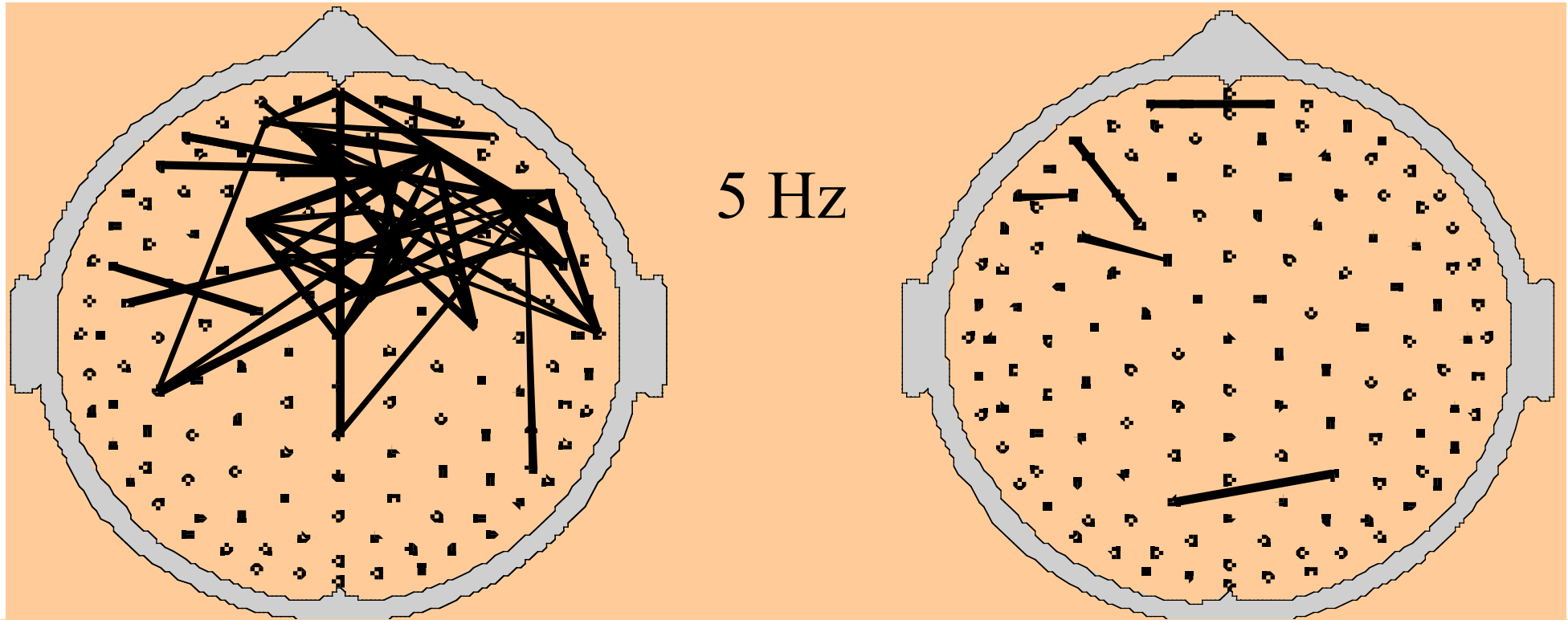
Estime de soi : score social **$r=0.492$, $p=0.0383$**

Conclusion (2)

- Les enfants intellectuellement précoces et en difficultés d'apprentissage ont un profil étonnamment stéréotypé
- Outre des compétences verbales supérieures, et les caractéristiques classiques de raisonnement, de curiosité et de créativité...
- ...leurs difficultés sont également similaires, relevant d'un déficit relatif dans les fonctions non verbales (praxies, graphisme, temporalité, attention)
- Sans doute en lien avec un profil émotionnel spécifique, fait d'empathie et de sensibilité exacerbées, et de difficultés relatives dans l'établissement de relations avec les pairs, ils souffrent systématiquement d'une faiblesse paradoxale de l'estime de soi, strictement proportionnelle à l'écart entre leur intelligence et leur réussite.

Fonctionnement du cerveau chez les EIP

I/ Données d'imagerie fonctionnelle



Electrode pairs with 100% consistent coherence increases (left) or reductions (right) during (1-min) periods of mental calculations. Comparison with resting periods; 11 state transitions.

PL Nunez, BM Wingeier & RB Silberstein, *Human Brain Mapping*, 2001

EEG and intelligence: Relations between EEG coherence, EEG phase delay and power

R.W. Thatcher^{a,b,*}, D. North^a, C. Biver^a

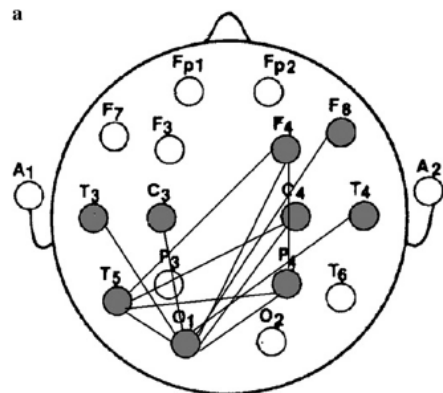
^aEEG and Neuroimaging Laboratory, Bay Pines VA Medical Center, Research and Development Service-151, 10000 Bay Pines Blvd.,
 Bldg 22 Room 117, Dade County, Bay Pines, FL 33744, USA

qEEG Measures:		TOTAL
Absolute Power_5 frequencies @ 19 channels		95
Relative Power_5 frequencies @ 19 channels		95
RP_Ratios_4 sets (T:B, T:A, A:B, D:T) @ 19 channels		76
Amplitude Asymmetry_5 frequencies @ 171 variable		855
Coherence_5 frequencies @ 171 variables		855
Absolute Phase_5 frequencies @ 171 variables		855
TOTAL VARIABLES		2831
Neuropsychological Tests:		
VERBAL IQ	FULL SCALE IQ	PERFORMANCE IQ
Information Mathematics Vocabulary Digit Span	SUBTESTS	Picture Completion Block Design Coding Mazes

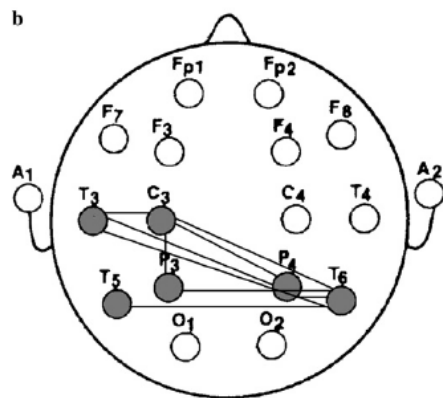
The strongest correlations to IQ were short EEG phase delays in the frontal lobes and long phase delays in the posterior cortical regions, reduced coherence and increased absolute power.

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

Seung-Hyun Jin ^a, Yong-Ju Kwon ^{b,*}, Jin-Su Jeong ^b, Suk-Won Kwon ^b, Dong-Hoon Shin ^b



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 *t*-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."

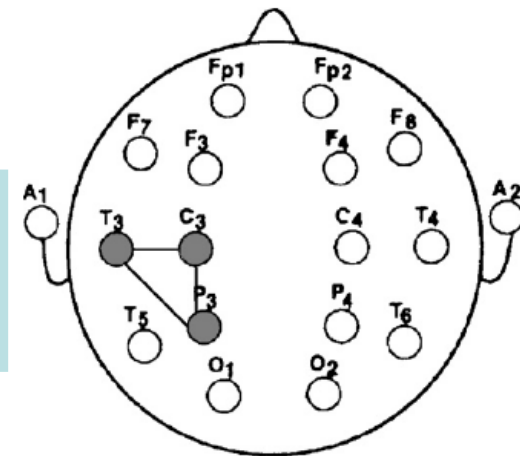
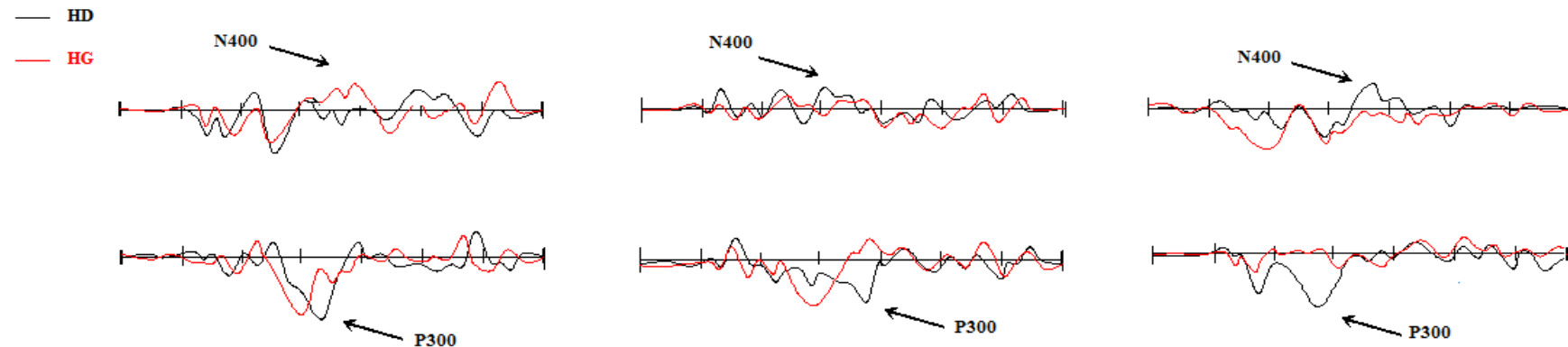


Fig. 2. *t*-map describing all the pairs where the gifted children have higher A-CMI values (unpaired *t*-test, $P < .05$) than the normal children. The straight line indicates the bi-directionally increased A-CMI values.

Exemples de PE enregistrés lors des tâches de décision lexicale et de complètement 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 10th – 15th, 2003

Short Communication

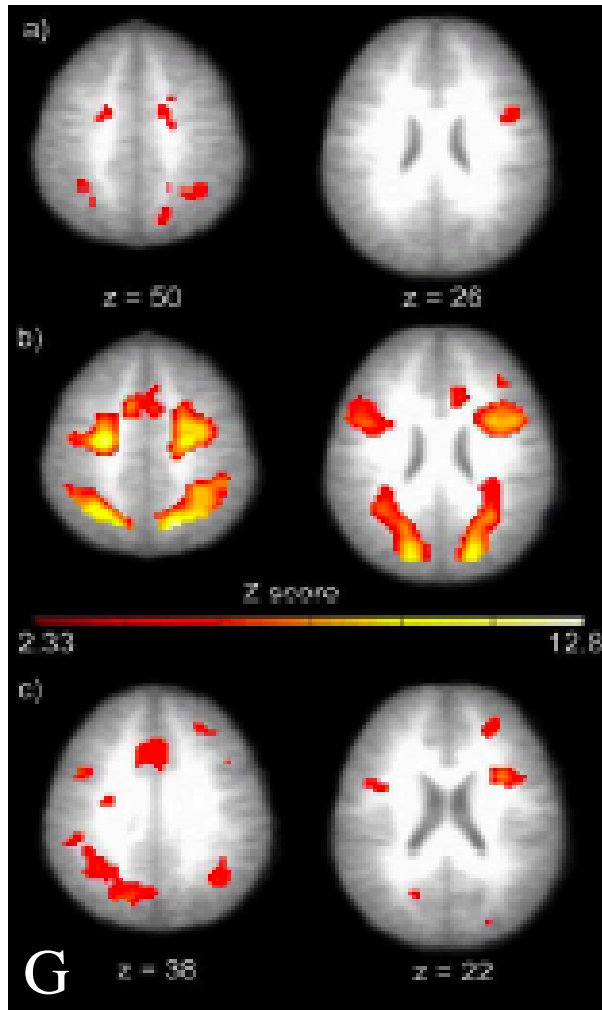
Mathematically gifted male adolescents activate a unique brain network during mental rotation

Michael W. O'Boyle^{a,*}, Ross Cunnington^{b,c}, Timothy I. Silk^b, David Vaughan^b, Graeme Jackson^c, Ari Syngeniotis^c, Gary F. Egan^b

^aDepartment of Human Development and Family Studies, Texas Tech University, Lubbock, TX 79409-1162, USA

^bHoward Florey Institute of Experimental Physiology and Medicine, University of Melbourne, Parkville, Victoria 3010, Australia

^cBrain Research Institute, Austin Health, West Heidelberg, Victoria 3081, Australia

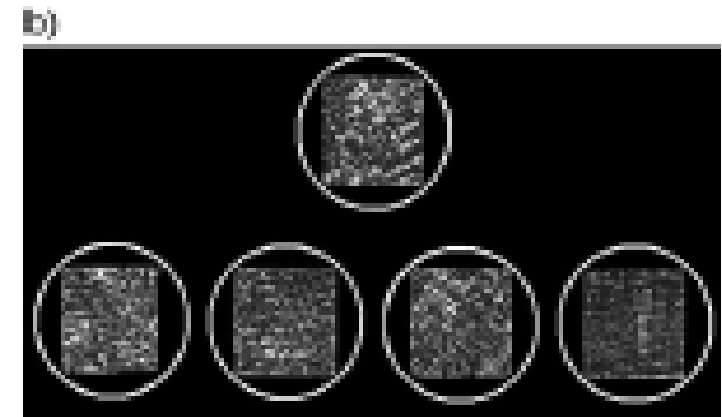
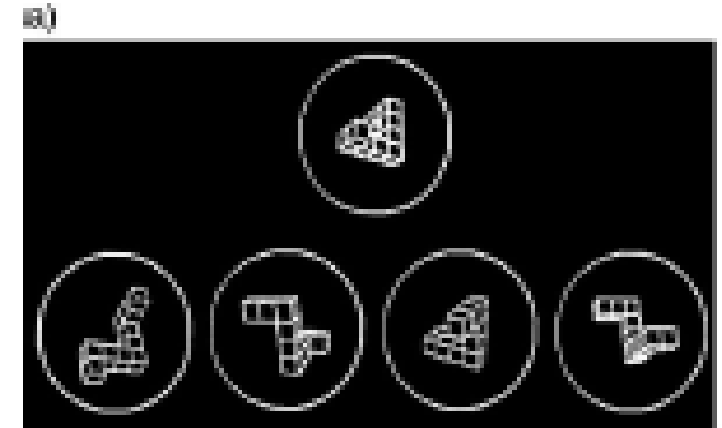


Pas de précocité

Activation durant une
épreuve de rotation
mentale

Doués en mathématiques

soustraction

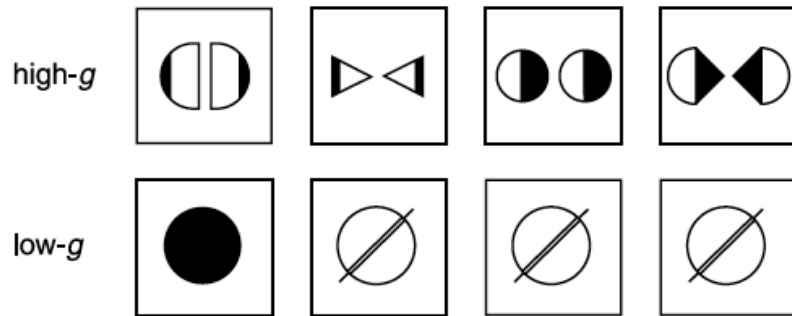


Activation pariétale plus forte,
et plus bilatérale (seult droite
chez les non-doués) :
meilleure représentation
spatiale + meilleur transfert

A Neural Basis for General Intelligence

John Duncan,^{1*} Rüdiger J. Seitz,² Jonathan Kolodny,¹
 Daniel Bor,¹ Hans Herzog,³ Ayesha Ahmed,¹ Fiona N. Newell,¹
 Hazel Emslie¹

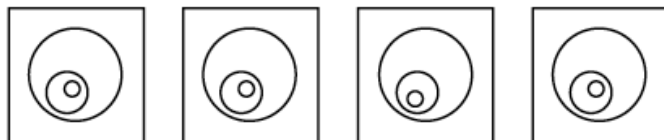
A Spatial



B Verbal

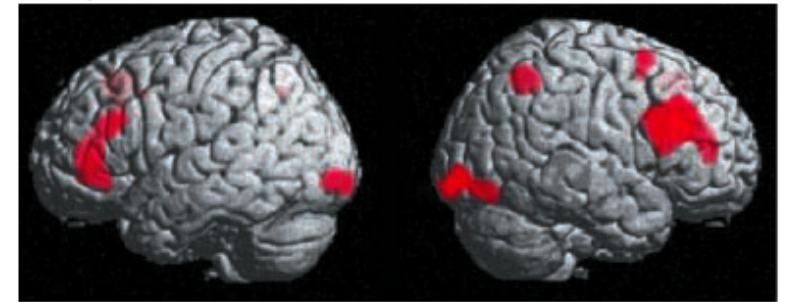
high- <i>g</i>	L H E C	D F I M	T Q N K	H J M Q
low- <i>g</i>	O P Q S	G H I J	L M N O	I J K L

C Circles

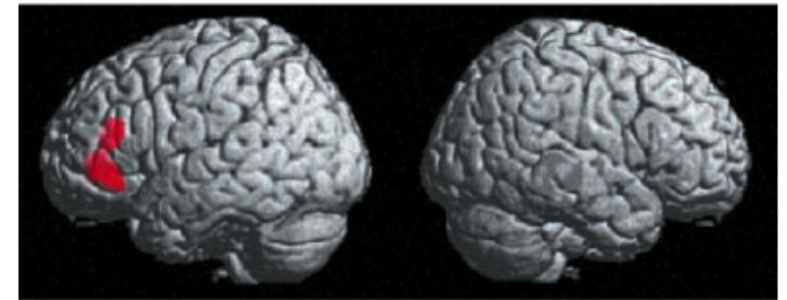


Regions of significantly higher activation in high-*g* vs low-*g* tasks

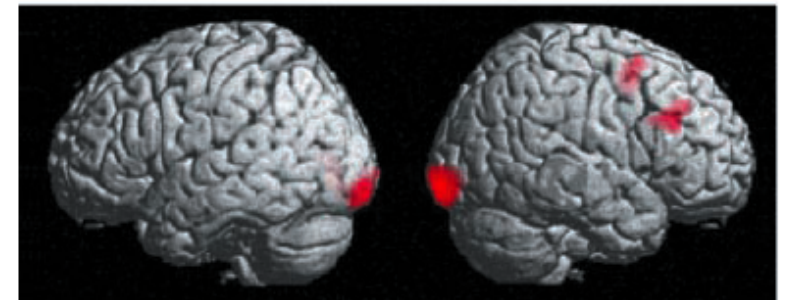
A Spatial



B Verbal



C Circles



Duncan et al. :

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

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

Kun Ho Lee,^{a,*} Yu Yong Choi,^{a,e} Jeremy R. Gray,^b Sun Hee Cho,^c Jeong-Ho Chae,^d Seunghyun Lee,^e and Kyungjin Kim^a

g-related neural substrates were revealed by the contrasting of complex *g*-task versus simple *g*-task

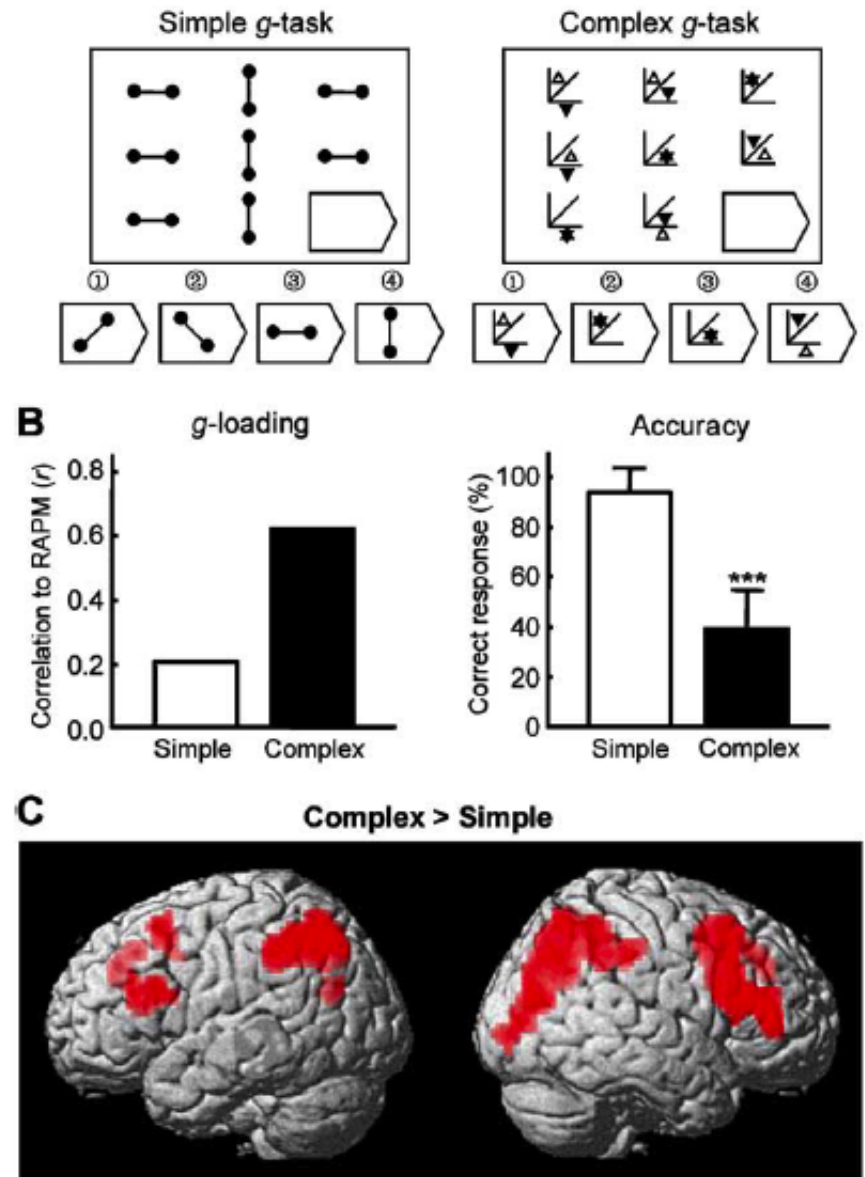
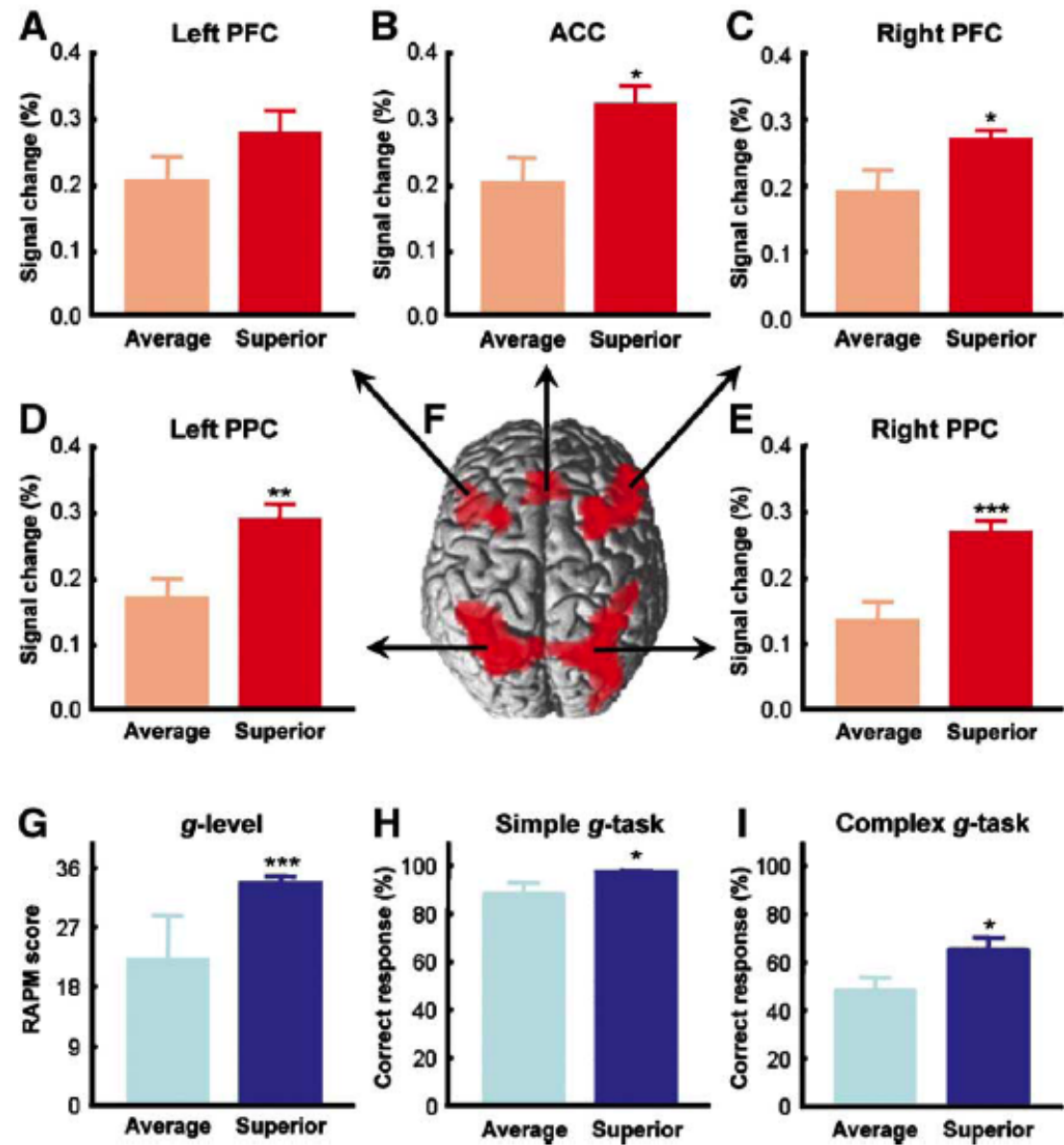


Fig. 1. Behavioral tasks and *g*-related neural network. (A) Example task

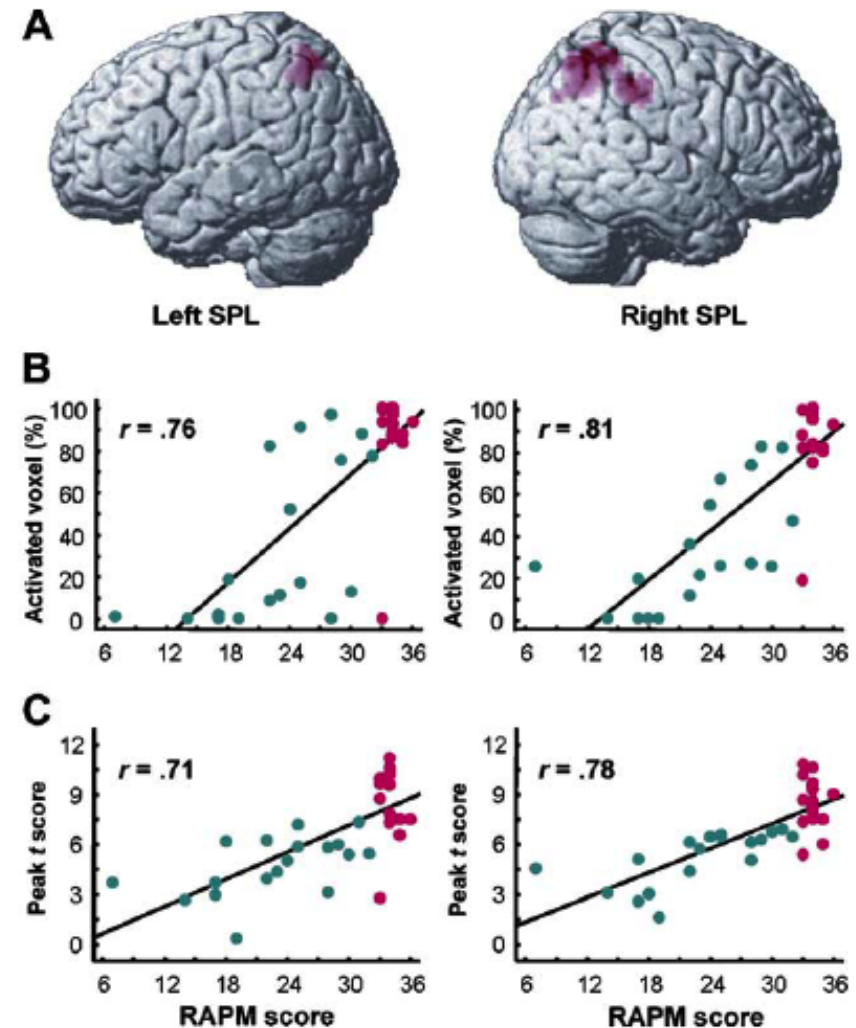
Differences in regional activation and behavioral performance between the superior- and average-g groups.



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

Lee et al. :

"our results demonstrated
that the posterior parietal
regions including bilateral
SPL and right IPS could
be the neural correlates
for superior general
intelligence."



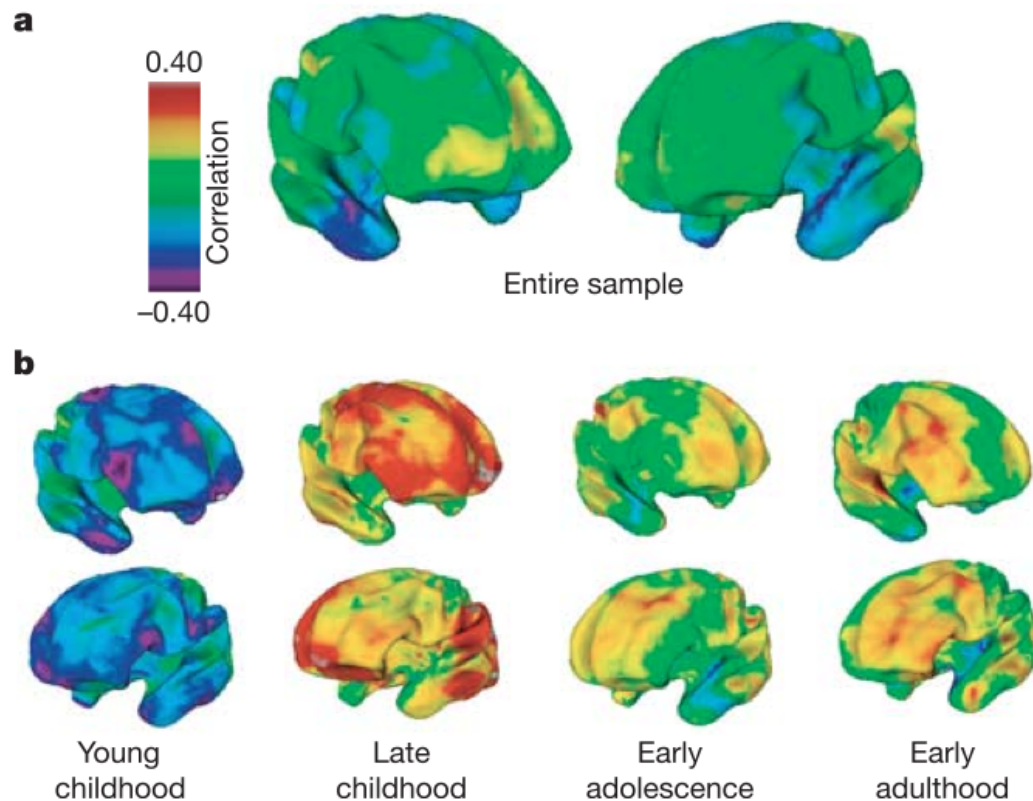
Précocité : un cerveau différent?

II/ Données d'imagerie morphologique

LETTERS

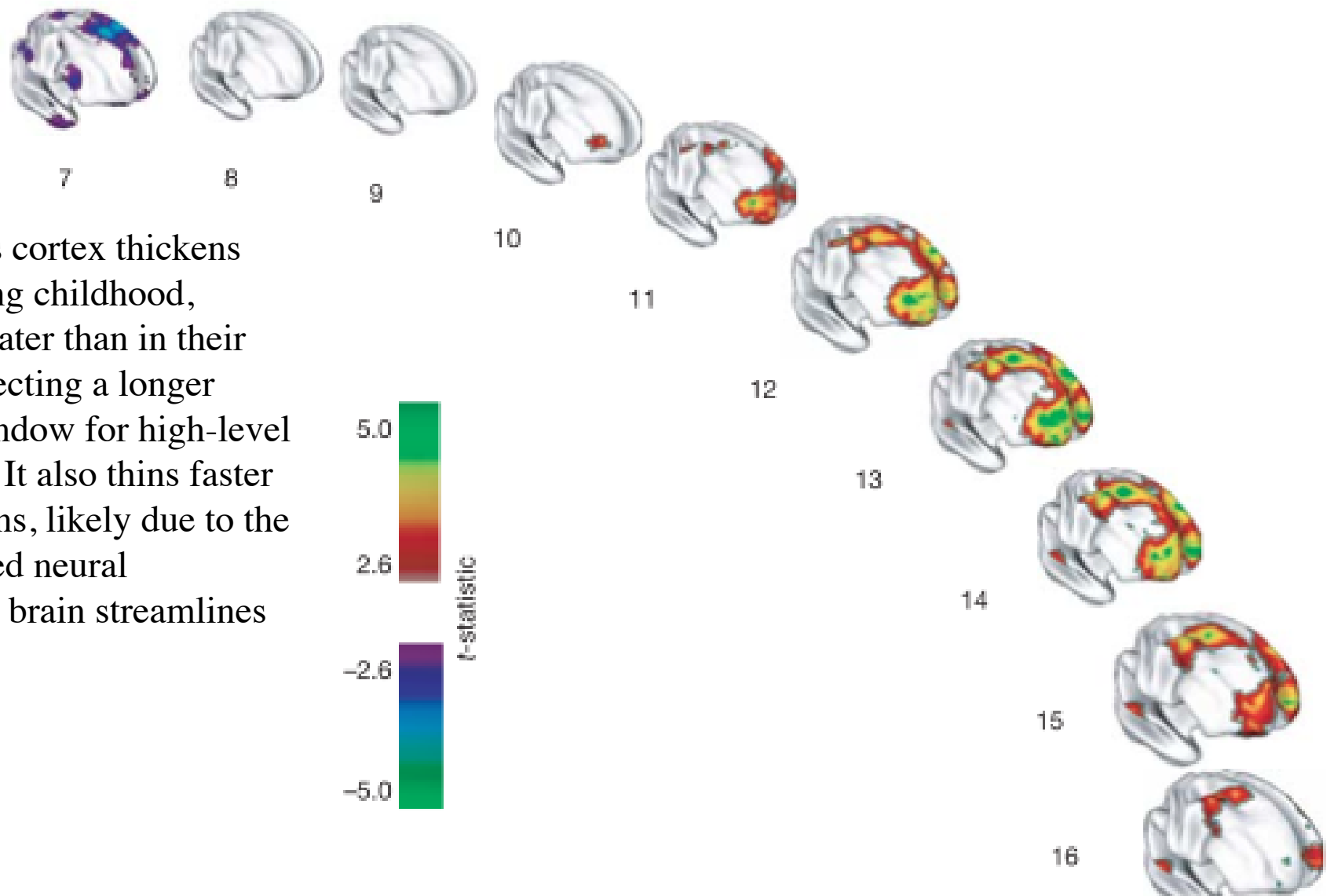
Intellectual ability and cortical development in children and adolescents

P. Shaw¹, D. Greenstein¹, J. Lerch², L. Clasen¹, R. Lenroot¹, N. Gogtay¹, A. Evans², J. Rapoport¹ & J. Giedd¹



A main finding was that individuals having an estimated IQ in the superior range (ie >121) had a generally thicker cortex (primarily in frontal areas) during their late childhood to early adulthood (ie between 8.6 to 29 years of age) than subjects with a lower IQ. However, the pattern was reversed for early childhood (ie between 3.8 and 8.4 years of age) as high IQ was associated with a thinner cortex in the same areas.

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



Gifted individual's cortex thickens more rapidly during childhood, reaching its peak later than in their peers perhaps reflecting a longer developmental window for high-level thinking circuitry. It also thins faster during the late teens, likely due to the withering of unused neural connections as the brain streamlines its operations.

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.



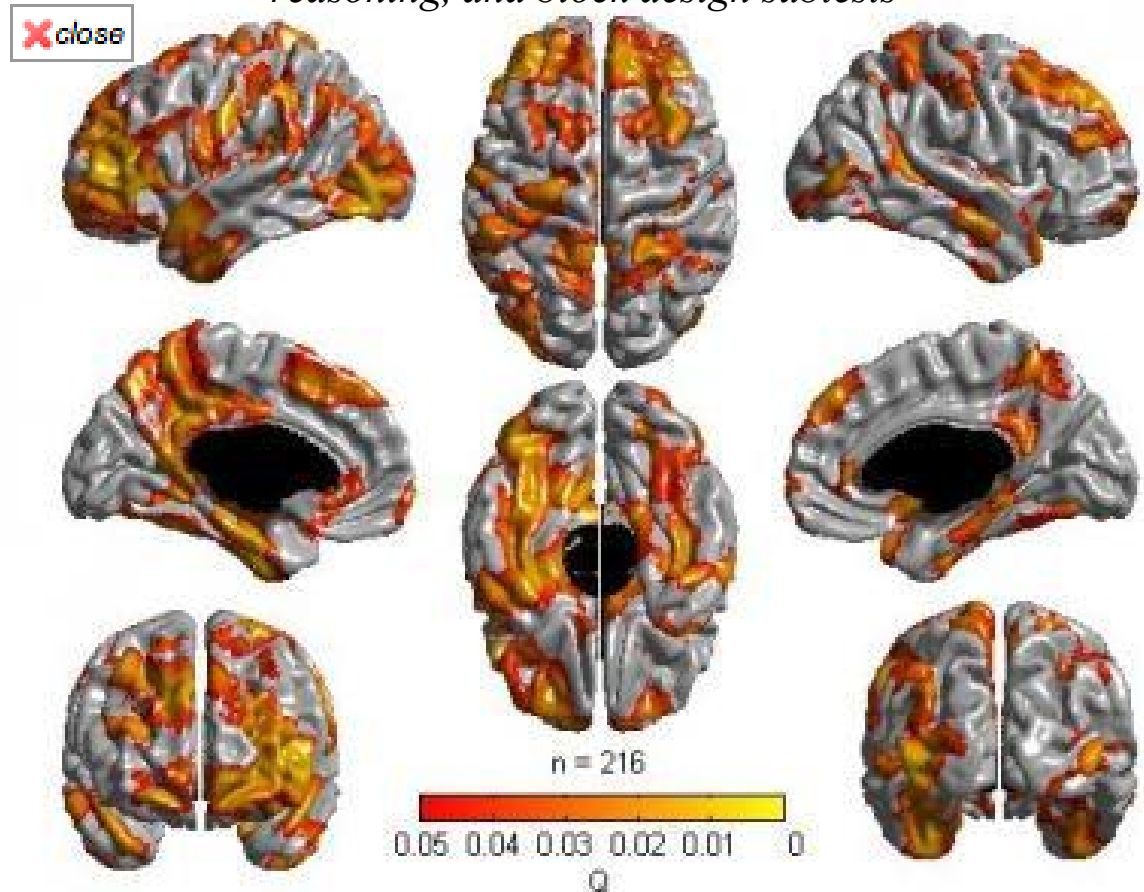
Positive association between cognitive ability and cortical thickness in a representative US sample of healthy 6 to 18 year-olds

Karama S^{1,*}, Ad-Dab'bagh Y¹, Haier RJ², Deary IJ³, Lyttelton OC¹, Lepage C¹, Evans AC¹, and Brain Development Cooperative Group⁴

¹McConnell Brain Imaging Centre, Montreal Neurological Institute, McGill University, Montreal,

A large sample of healthy children and adolescents (ages 6-18, N=216) representative of the US population were scanned with MRI and received Wechsler Abbreviated Scale of Intelligence (WASI) (Wechsler, 1999) administered to children ages 6 and older. Thus, the same test was used to measure intelligence across the age range analyzed in this paper. The WASI includes vocabulary, similarities, matrix reasoning, and block design subtests

Significant positive associations were evidenced between the cognitive ability factor and cortical thickness in most multimodal association areas. Results are consistent with a distributed model of intelligence





GENETICS OF BRAIN FIBER ARCHITECTURE AND INTELLECTUAL PERFORMANCE

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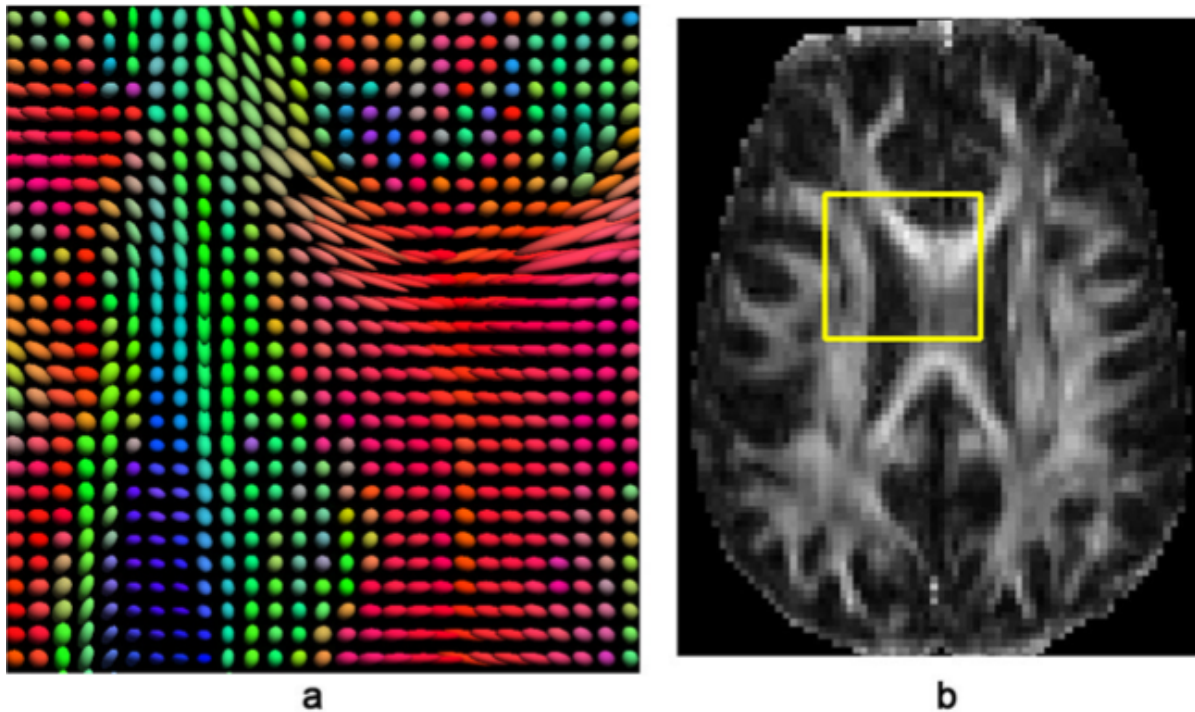


Fig. 2.

The image of diffusion tensors (a) selected from the brain region at the junction of the corpus callosum and the *corona radiata*, shown as the yellow box in the corresponding FA image

Thompson and his colleagues took DTI scans of 92 pairs of fraternal and identical twins. They found a strong correlation between the integrity of the white matter and performance on a standard IQ test.

White matter integrity (FA) was under strong genetic control and was highly heritable in bilateral frontal bilateral parietal and left occipital lobes, and was correlated with FIQ and PIQ in the cingulum, optic radiations, superior fronto-occipital fasciculus, internal capsule, callosal isthmus, and the *corona radiata*

Positive correlations between corpus callosum thickness and intelligence

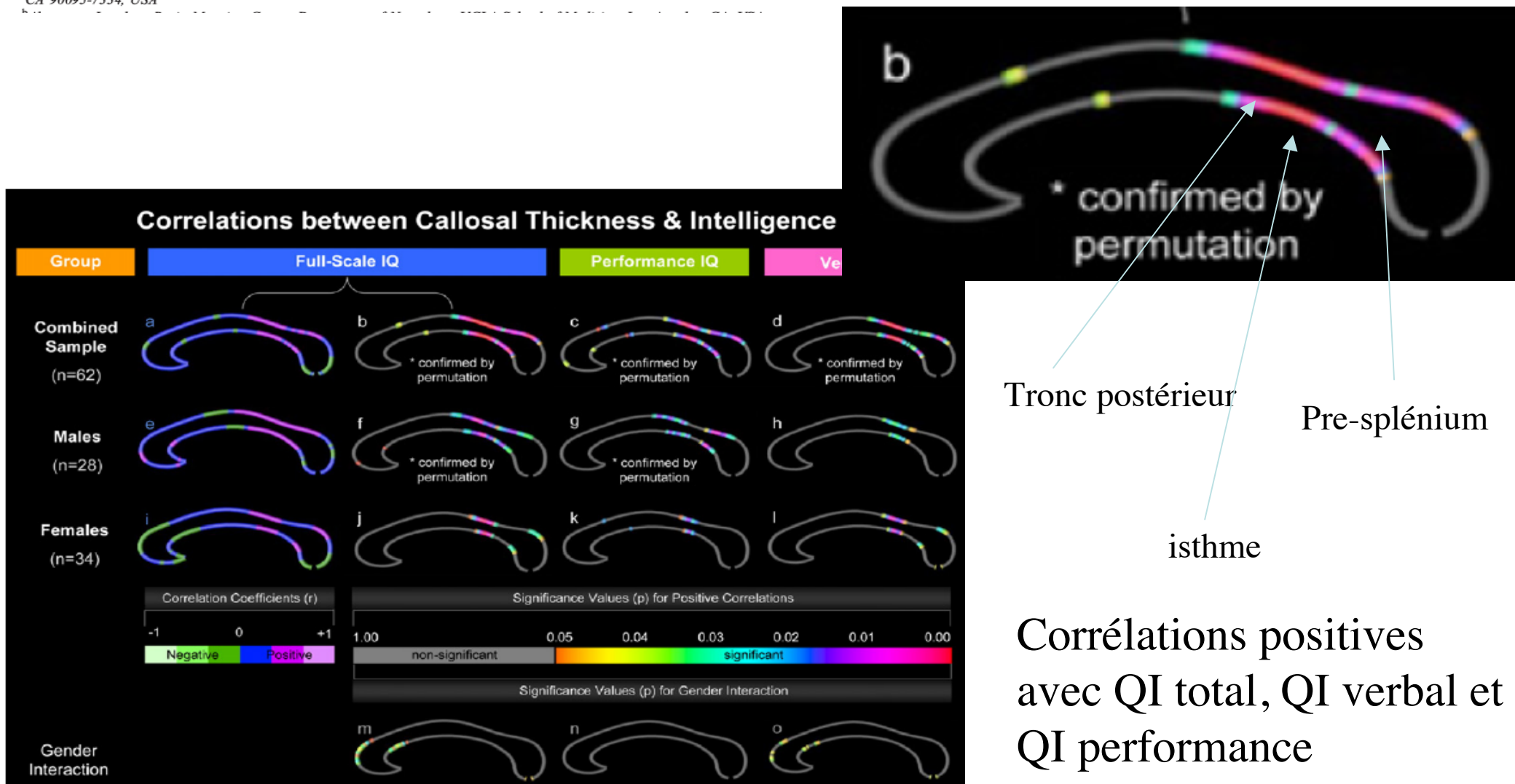
Eileen Luders,^a Katherine L. Narr,^a Robert M. Bilder,^{b,c} Paul M. Thompson,^a
 Philip R. Szeszko,^d Liberty Hamilton,^a and Arthur W. Toga^{a,*}

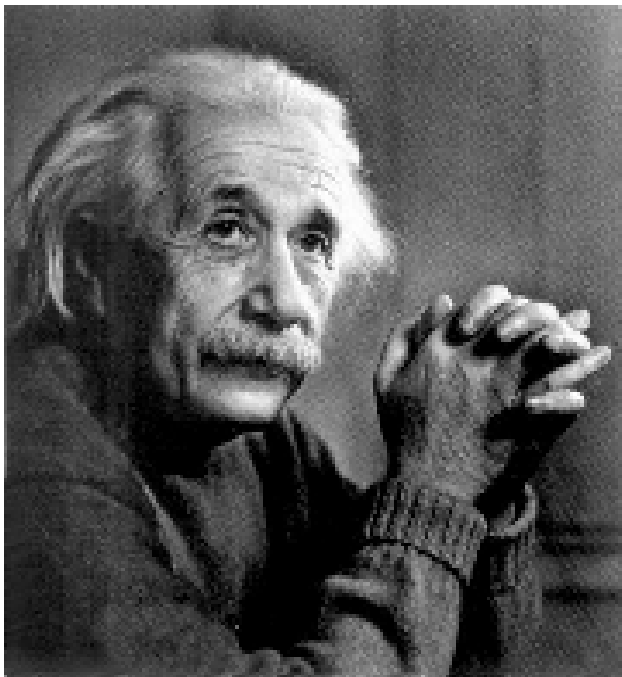
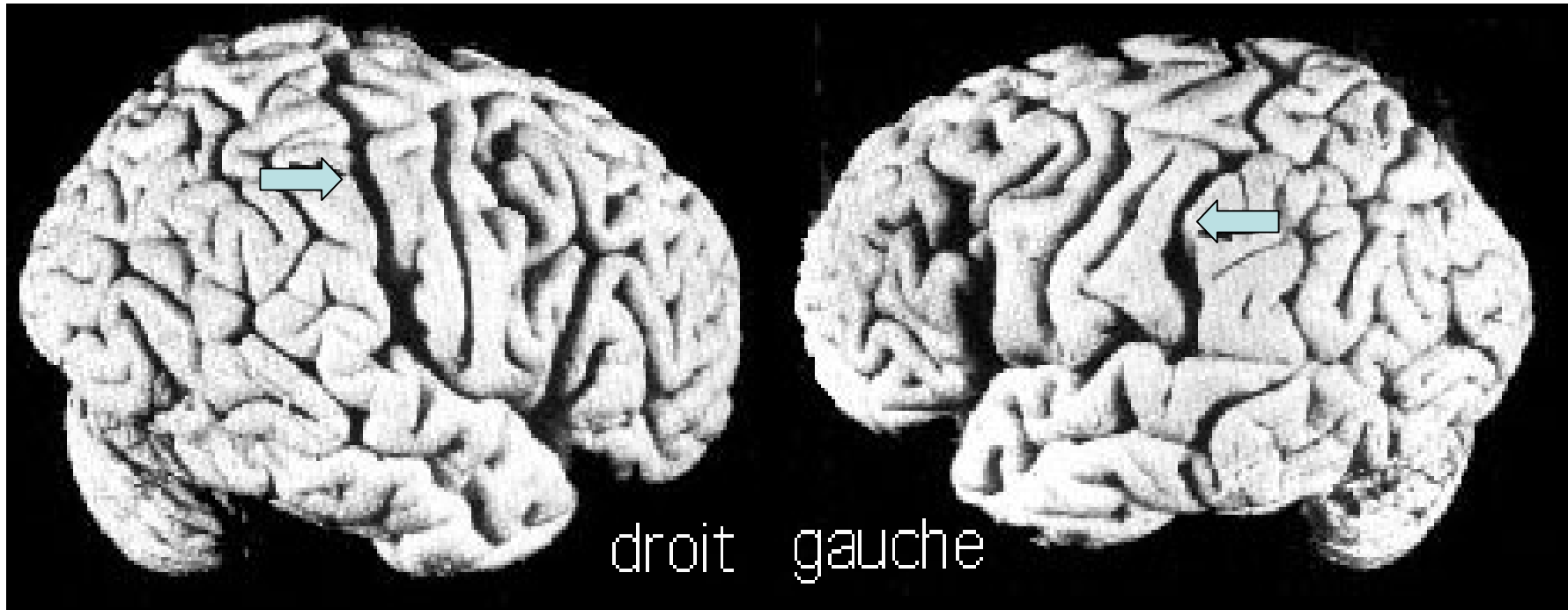
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Correlations between callosal thickness and intelligence measures (corrected p -values computed by permutation testing for $p < 0.05$)

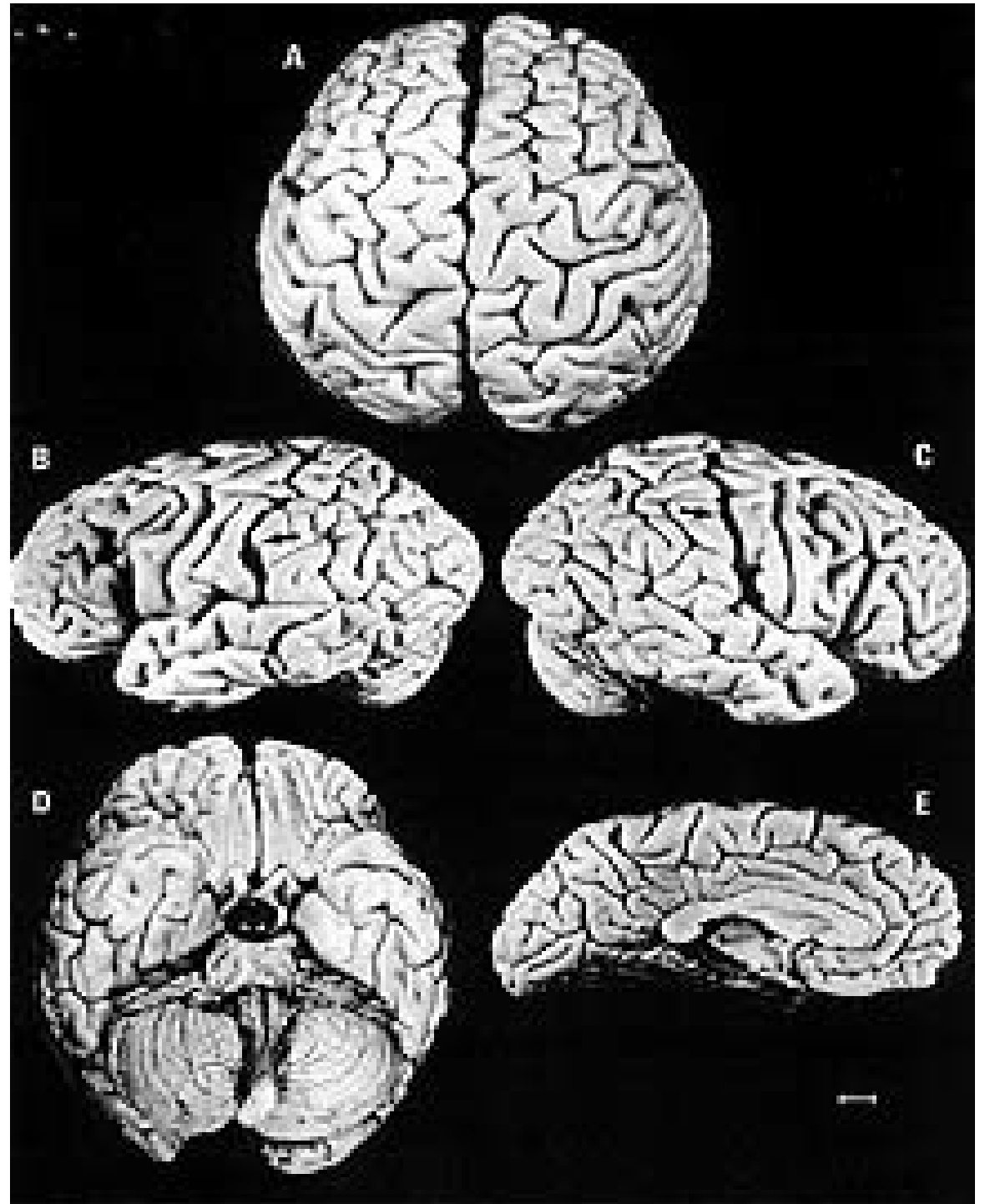
	Full-scale IQ	Performance IQ	Verbal IQ
Combined sample ($n=62$)	0.01*	0.01*	0.03*
Males ($n=28$)	0.03*	0.05*	0.17
Females ($n=34$)	0.09	0.28	0.11
Gender interaction	0.15	1.00	0.27

The asterisk (*) denotes significant findings.





Einstein's brain : no parietal opercula
(from Witelson et al., 1999)



"We held Einstein's brain in our hands and realized that this is the organ that was responsible for changing our perceptions of the universe, and we were in awe."

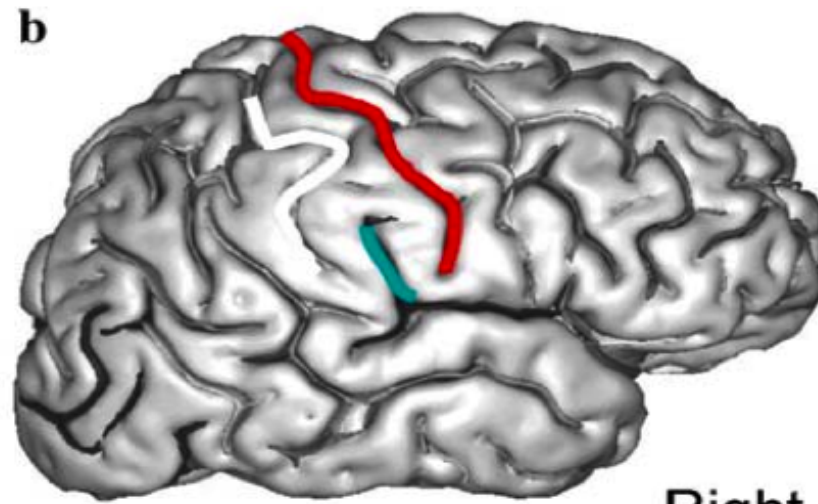
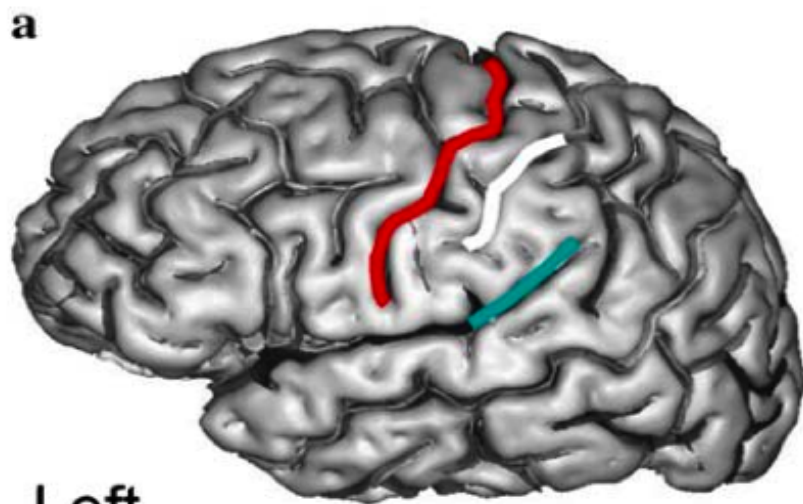
Neuroanatomical and behavioral asymmetry in an adult compensated dyslexic [☆]

Christine Chiarello ^{a,*}, Linda J. Lombardino ^b, Natalie A. Kacinik ^{a,c},
Ronald Otto ^d, Christiana M. Leonard ^b

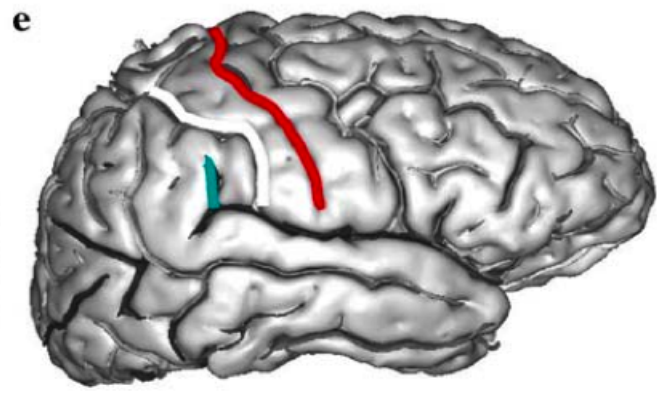
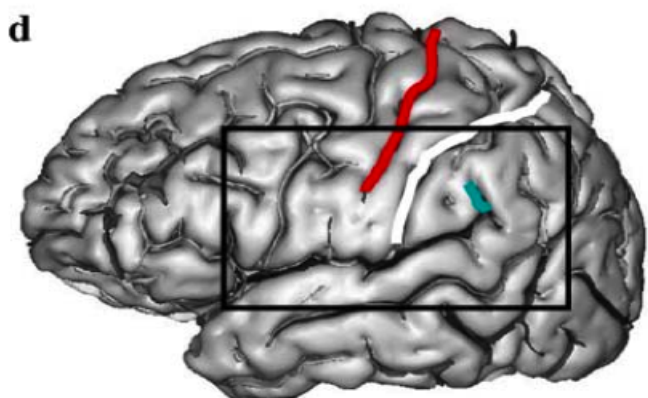
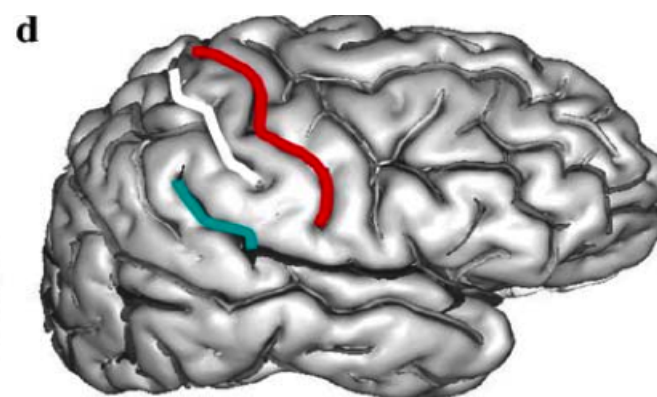
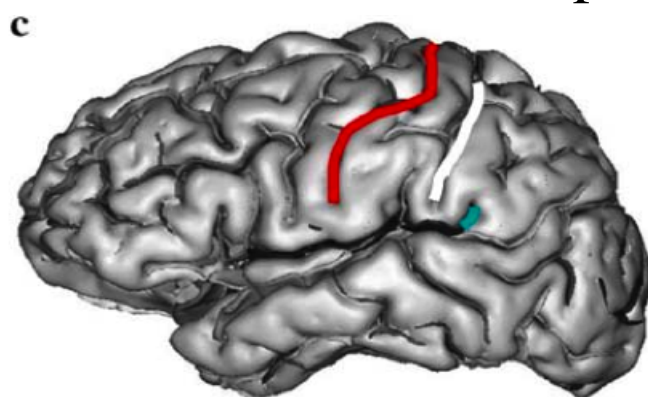
Table 1
Standardized test results for T.F.

Category	Skill (measure)	Score [*]	Percentile
Nonverbal IQ	(Ravens Advanced Progressive Matrices)	29	86
Reading	Untimed word reading aloud (WRMT-R Word Identification)	93	32
	Timed word reading aloud (TOWRE Sight Word Efficiency)	83	13
	Untimed nonword reading aloud (WRMT-R Word Attack)	92	29
	Timed nonword reading aloud (TOWRE Phonemic Decoding Efficiency)	94	35
	Word comprehension (WRMT-R Word Comprehension)	109	72
	Text comprehension (WRMT-R Passage Comprehension)	124	95
Spelling	Untimed written spelling of spoken words (WRAT3)	104	61
Grammar	Grammaticality judgment (CASL Grammaticality Judgment)	92	30
	Syntax Construction (CASL Syntax Construction)	100	50
Rapid naming	Letter naming (CTOPP Rapid Letter Naming)	10	50
	Digit naming (CTOPP Rapid Digit Naming)	10	50
Span memory	(WAIS-R Digits Forward)	11	52
	(WAIS-R Digits Backward)	6	14
Math	Timed arithmetic computations (WJ COG III Math Fluency)	96	39
	Untimed computations and solving equations (WJ COG III Calculation)	112	78

^{*} Note: Scores listed are standard scores for all tests except WAIS digit spans, and Raven's Matrices.



patient

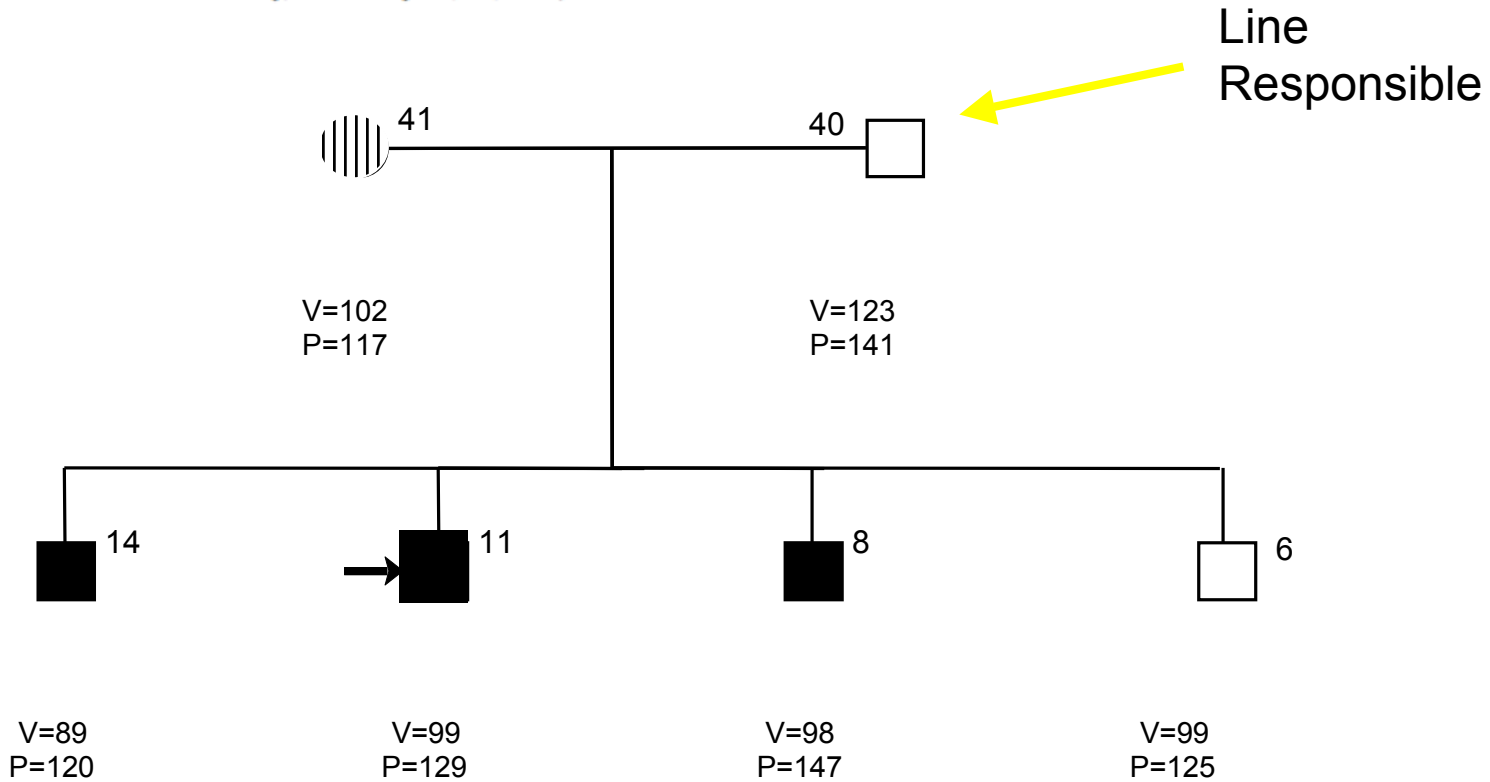


témoins

BRAIN MORPHOLOGY AND NEUROPSYCHOLOGICAL PROFILES
IN A FAMILY DISPLAYING DYSLEXIA
AND SUPERIOR NONVERBAL INTELLIGENCE

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²Washington State University, Pullman, WA, USA; ³California State University, Los Angeles, CA, USA;
⁴Purdue University, West Lafayette, IN, USA)



V = Verbal IQ

P = Performance IQ



Unaffected – No linguistic deficit



RD status unclear



RD

En résumé, le cerveau du surdoué

- Semble fonctionner de façon plus cohérente, mieux connectée
- Avec un recrutement plus important surtout des régions pariétales, et peut-être surtout à droite lors de tâches spatiales et mathématiques, en particulier
- Il semble exister une distinction nette entre mode de fonctionnement des surdoués 'homogènes' et 'hétérogènes', en termes d'engagement respectif des deux hémisphères lors d'une tâche cognitive
- Les données d'imagerie fonctionnelle plaident en faveur d'une particularité spécifique à certains modules fonctionnels et non pour une particularité générale du fonctionnement cérébral (fonctionnement en 'arborescence')
- Des liens complexes ont été retrouvés entre l'épaisseur de certaines régions du cortex et l'intelligence et l'organisation fibres blanches et l'héritabilité
- Les données les plus prometteuses, mais encore éparses, concernent la disposition anatomique des sillons corticaux, avec des patrons singuliers de la région temporo-pariétale du cerveau, seule marque obtenue jusqu'ici d'une particularité constitutionnelle