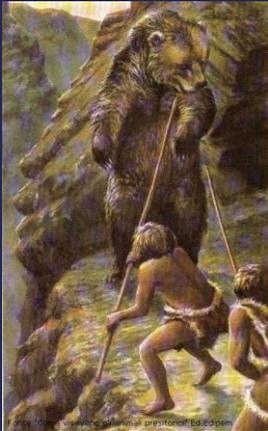
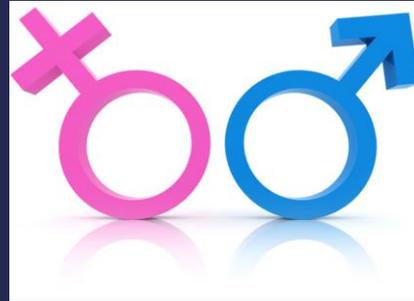


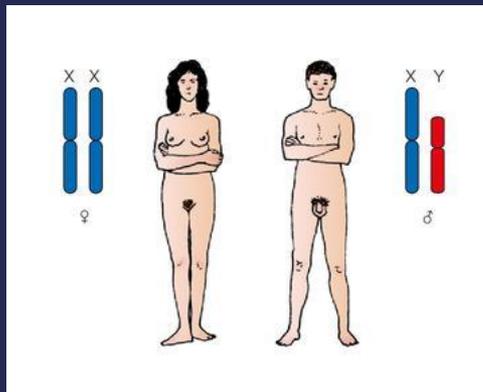
# **Cervello maschile e femminile: quali differenze?**

**Rosa Maria Moresco**

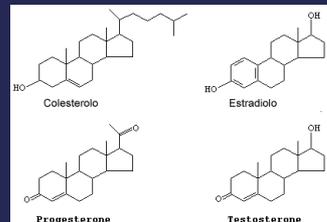
Università degli Studi Milano Bicocca,  
Ospedale San Raffaele, IBFM-CNR,  
Milano



SESSO



Biologia





# Ambiente

# GENERE



Ambiente

evoluzione

State socio  
econ

anza  
re

ambiente



genere

Sesso

biologia

genetic

epigenetic

immunità

microbioma

Neurobiologia

# Abilità cognitive: orientamento spaziale e fluenza verbale



Halpern DF 2002 : i maschi tendono ad essere migliori in varie abilità spaziali. rotazione astratta di un oggetto documentata anche in bambini di appena 3 mesi. Allo stesso i maschi di tutte le culture e specie sono più bravi identificare l'orientamento di un angolo.

Le femmine, d'altra parte, tendono ad avere una maggiore fluidità verbale e una maggiore memoria per gli oggetti, cioè "sono più bravi a ricordare dove sono le cose".

# Gender Similarities and Differences

Janet Shibley Hyde

Department of Psychology, University of Wisconsin, Madison, Wisconsin 53706;  
email: jshyde@wisc.edu

Annu. Rev. Psychol. 2014. 65:373–98

## GENERE

Overall, based on the numerous meta-analyses reported here, there is much evidence in support of the gender similarities hypothesis. Domains in which gender differences are small (around  $d = 0.20$ ) or trivial ( $d \leq 0.10$ ) include mathematics performance, verbal skills, some personality

UGUALI: matematica, capacità verbali, etc..

Nonetheless, the gender similarities hypothesis acknowledges exceptions to the general rule. Exceptions to gender similarities, where differences are moderate ( $d = 0.50$ ) or large ( $d = 0.80$ ), include 3D mental rotation, the personality dimension of agreeableness/tender-mindedness, sensation seeking, interests in things versus people, physical aggression, some sexual behaviors

DIVERSI: immaginazione rotazione oggetti, tenerezza, interesse verso le persone, aggressività fisica etc..

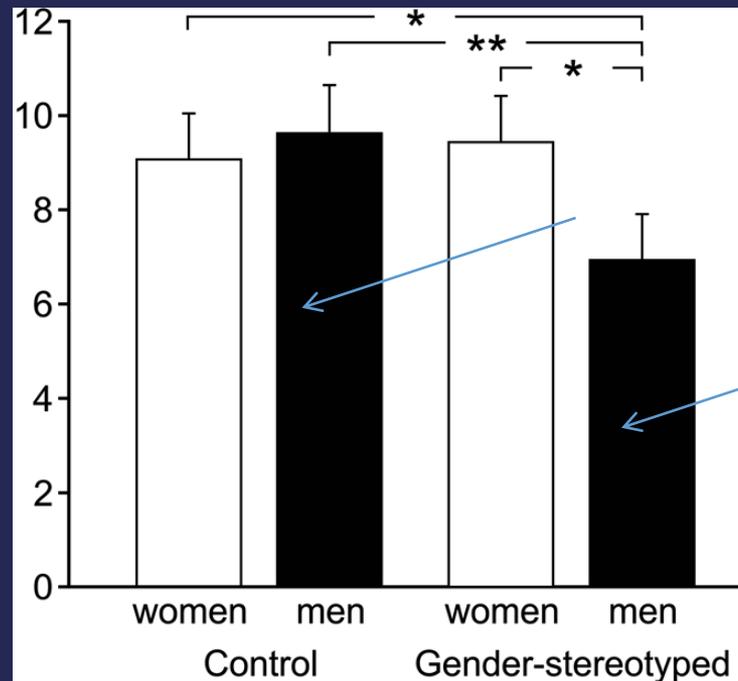
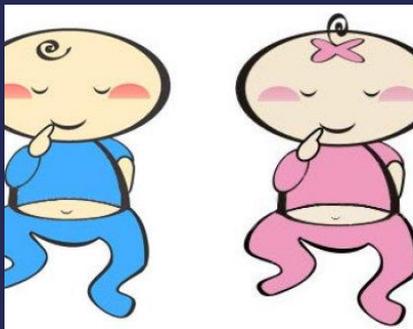
This review also reveals much evidence of the importance of context in creating or erasing gender differences. For example, deindividuation, which removes the influence of gender roles, erases the gender difference in aggression. Nations with greater gender equality have much smaller gender gaps in mathematics performance and in mate preferences.

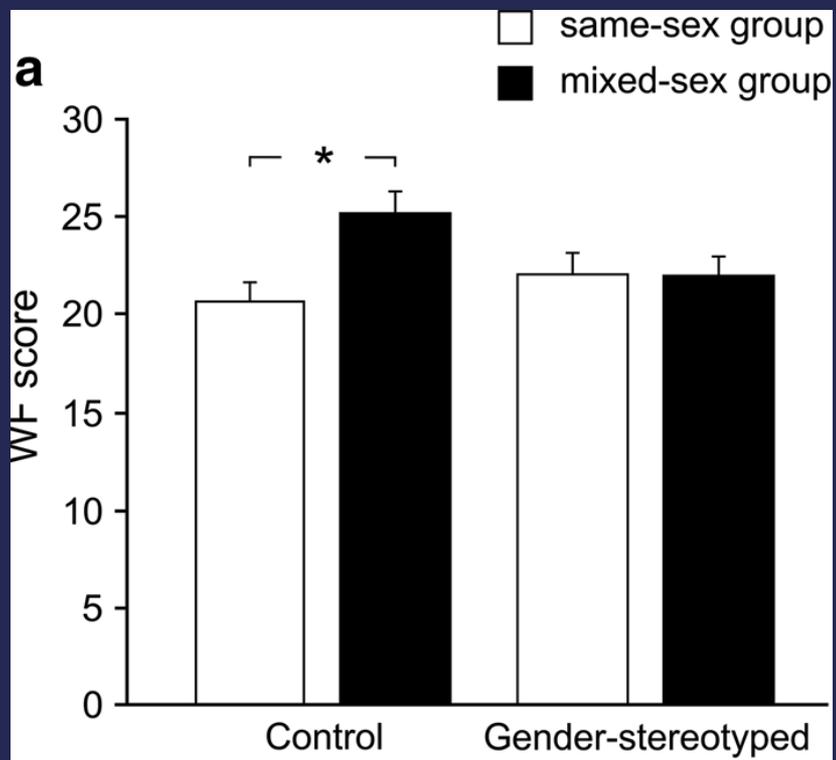
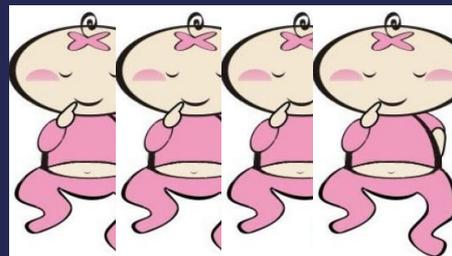
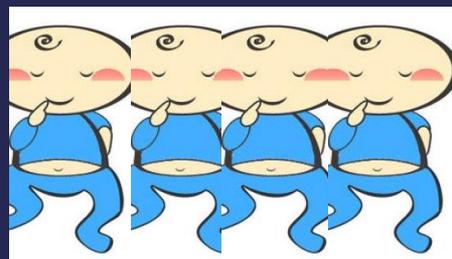
DIFFERENZE ALTAMENTE INFLUENZATE DAL CONTESTO

BIOLOGIA O AMBIENTE?

# Influenza dei «credo» sui risultati dei test

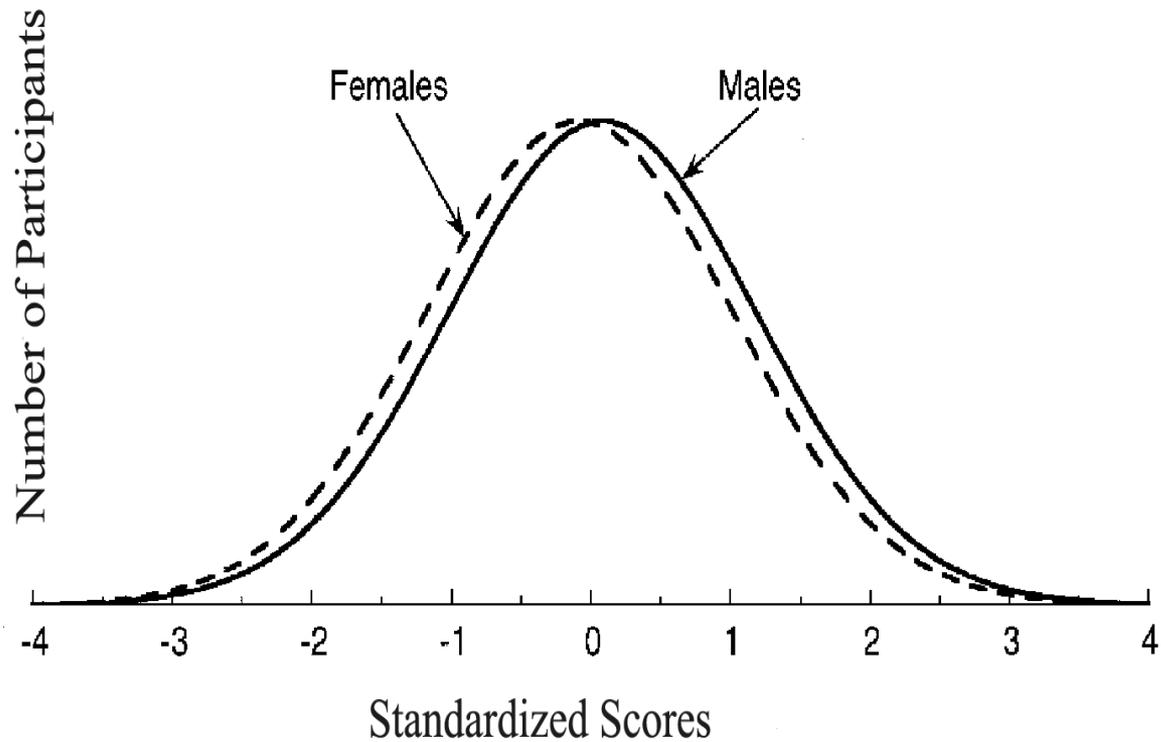
“Es: Ai partecipanti è chiesto di immaginare che stavano per incontrare una persona che non avevano mai incontrato prima di indicare la percentuale di probabilità che questa persona fosse **maschio o femmina (stereotipo)** o **europea o asiatica (controllo)** in base al fatto che questa persona, per esempio, "parla tre lingue straniere in modo fluente o parla molto ".





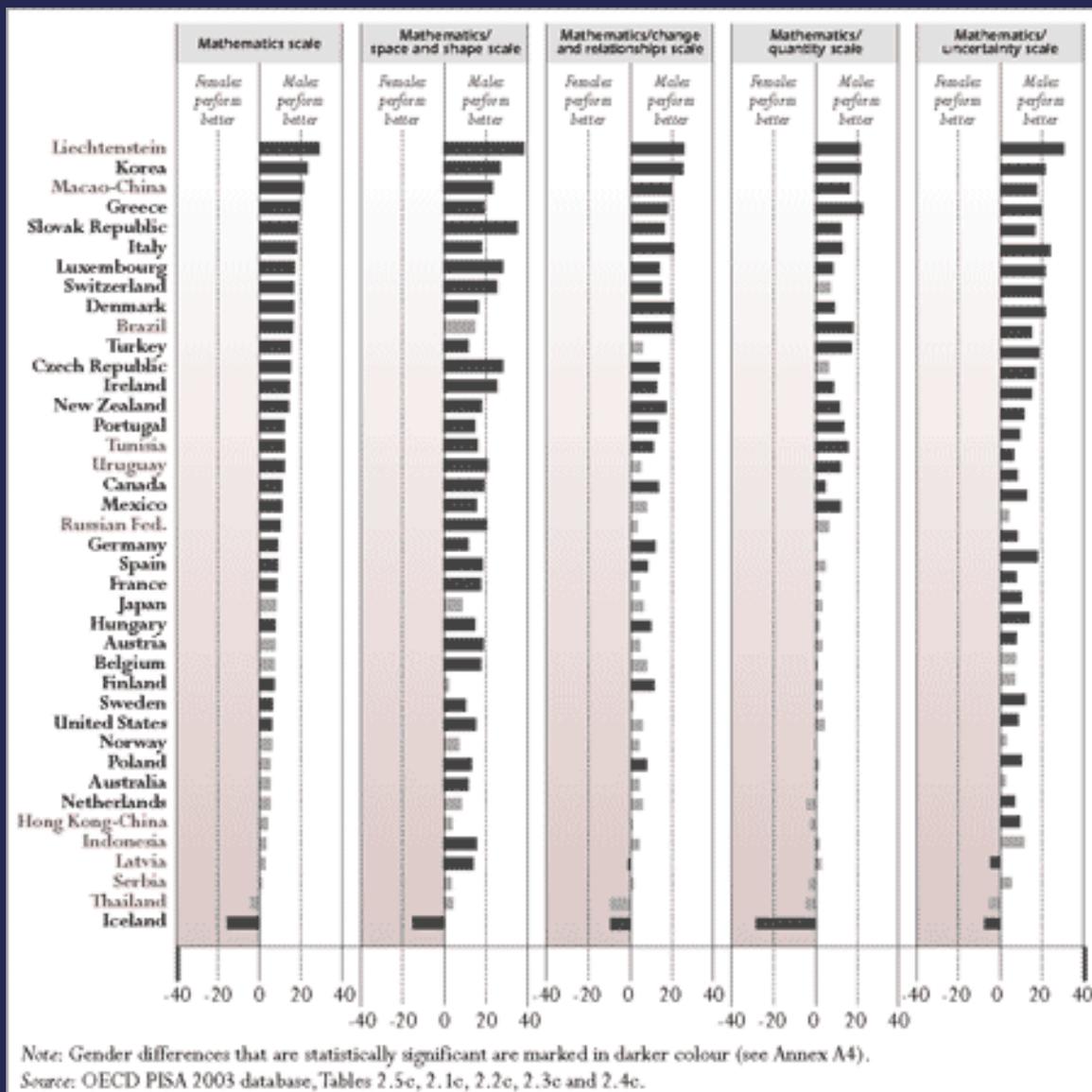
NESSUNA ASSOCIAZIONI CON  
LIVELLI TESTOSTERONE

## GENDER DIFFERENCES IN MATHEMATICS PERFORMANCE



*From "Gender Differences in Mathematics Performance: A Meta-Analysis" by J. S. Hyde, 1990, Psychological Bulletin, 107, p.149.*

# ABILITA' MATEMATICHE e contesto socioculturale



Risultati migliori

# Gender Differences in Sustained Attentional Control Relate to Gender Inequality across Countries

PLOS ONE | DOI:10.1371/journal.pone.0165100 November 1, 2016

21781 partecipanti da 41 paesi suddivisi per uguaglianza di genere valutati mediante test attenzione attraverso domande su paesaggi o scene di vita urbane presentate con risposta si/no a domande associate.

**Table 2. Sociocultural country indices examined in the current study.**

| Index                            | Description  |
|----------------------------------|--|
| SIGI: discriminatory family code | "This sub-index captures social institutions that limit women's decision-making power and undervalue their status in the household and the family."  |
| Human Development Index (HDI)    | "The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living." |
| Poverty                          | "Percentage of population living below the poverty line"   |
| Women in the labor force         | "Female/male ratio of labor force participation"   |

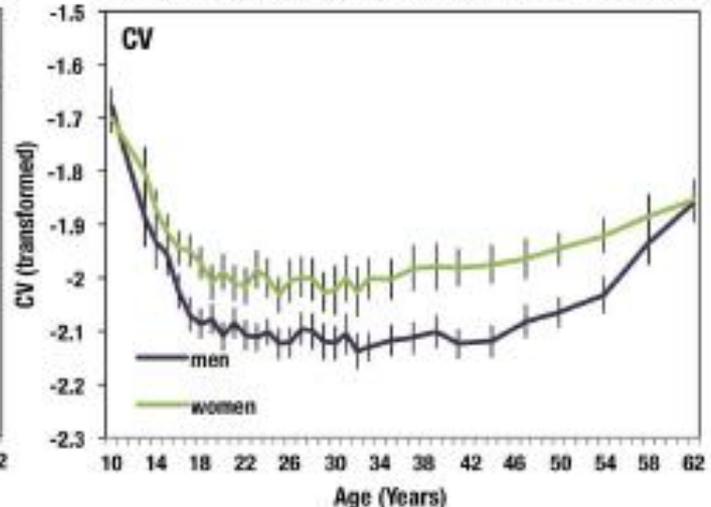
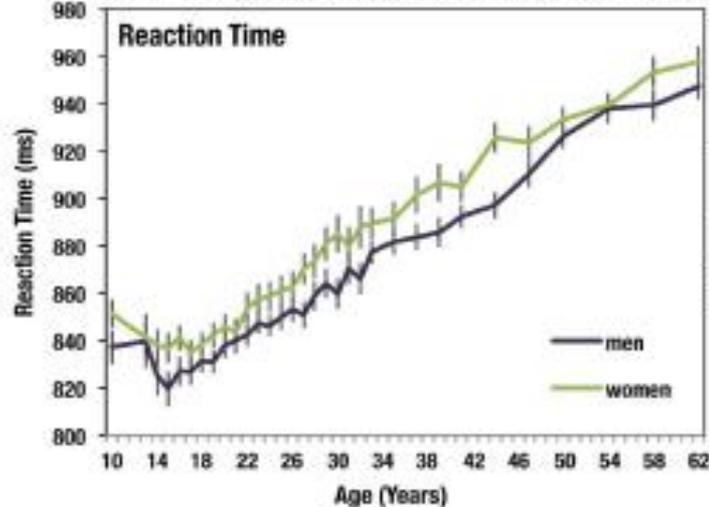
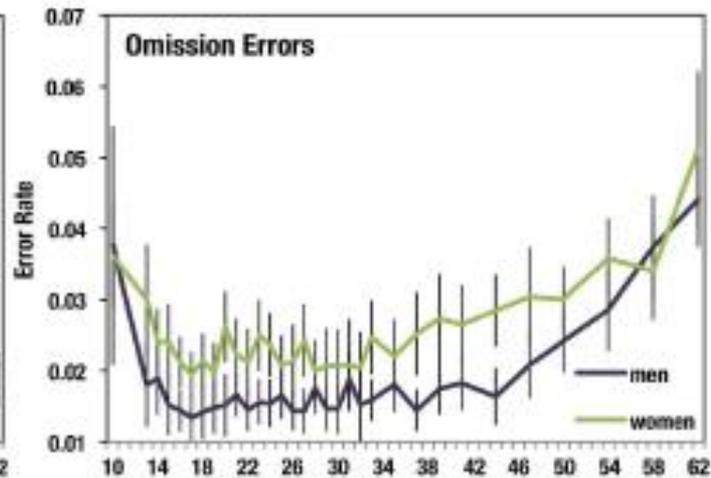
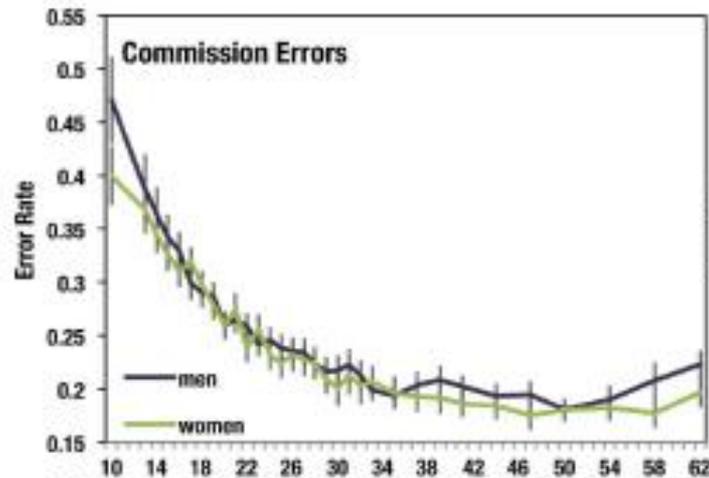
doi:10.1371/journal.pone.0165100.t002

CE: errori relativi a domande su riconoscimento paesaggio

OE: errori relativi a riconoscimento scene/situazioni

CV: variabilità risposte

RT: tempo di risposta



Le performance attentive sono influenzate da fattori socioculturali ma non dal grado di povertà

**Table 3. Effects of sociocultural conditions on average (men and women together) gradCPT performance.**

| Dependent Variable | Sociocultural Index | T              | P Value |
|--------------------|---------------------|----------------|---------|
| OE                 | Labor force         | T(43) = -7.22  | <0.001* |
|                    | SIGI                | T(51) = 7.26   | <0.001* |
|                    | HDI                 | T(42) = -6.79  | <0.001* |
|                    | Poverty             | T(39) = 1.41   | 0.17    |
| CE                 | Labor force         | T(59) = 3.09   | 0.003*  |
|                    | SIGI                | T(84) = -3.47  | <0.001* |
|                    | HDI                 | T(62) = 2.97   | 0.004   |
|                    | Poverty             | T(127) = -1.63 | 0.11    |
| RT                 | Labor force         | T(42) = -3.19  | 0.003*  |
|                    | SIGI                | T(51) = 3.23   | <0.001* |
|                    | HDI                 | T(47) = -3.25  | <0.001* |
|                    | Poverty             | T(44) = 1.16   | 0.250   |
| CV                 | Labor force         | T(47) = -4.46  | <0.001* |
|                    | SIGI                | T(66) = 4.17   | <0.001* |
|                    | HDI                 | T(59) = -6.46  | <0.001* |
|                    | Poverty             | T(47) = 0.875  | 0.386   |

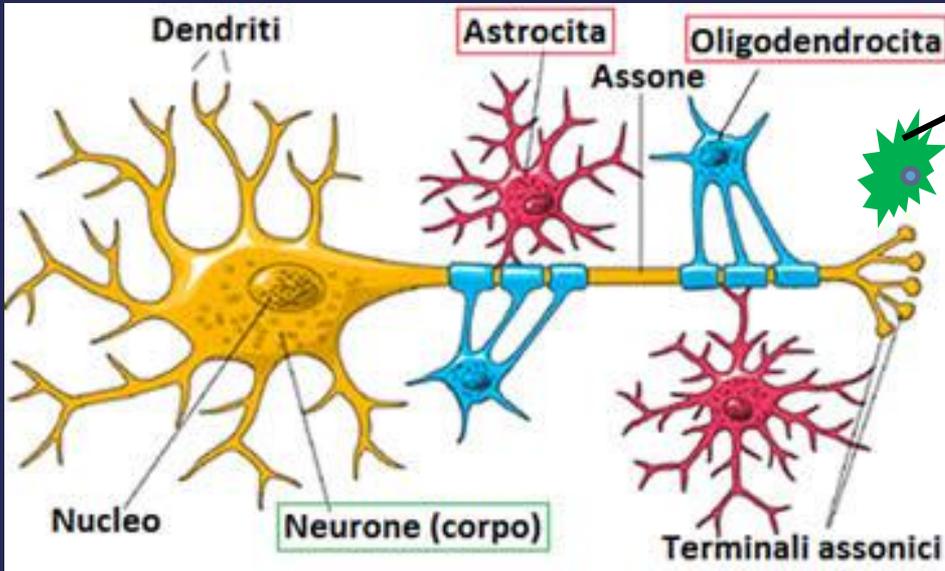
Note.

\* indicates significance after Bonferroni correction (cutoff = 0.003125).

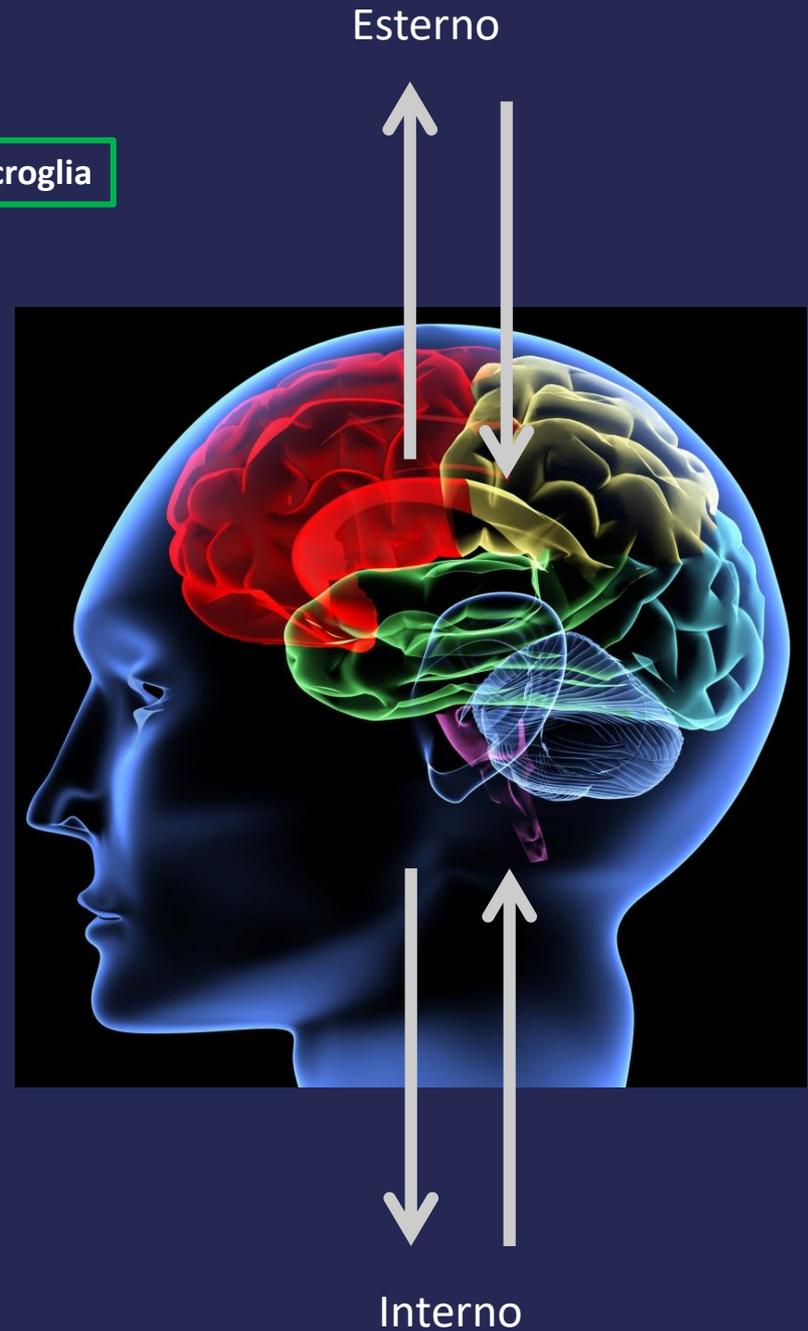
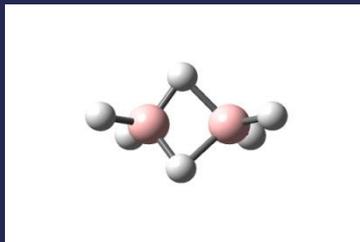
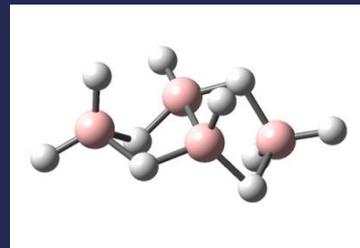
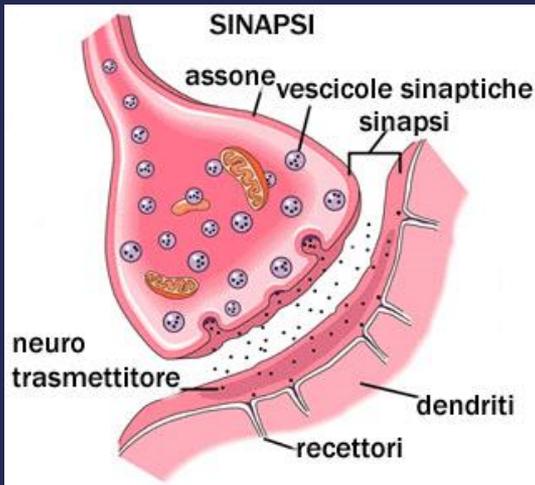
OE = omission error, CE = commission error, Labor force = female/male ratio of labor force participation

doi:10.1371/journal.pone.0165100.t003

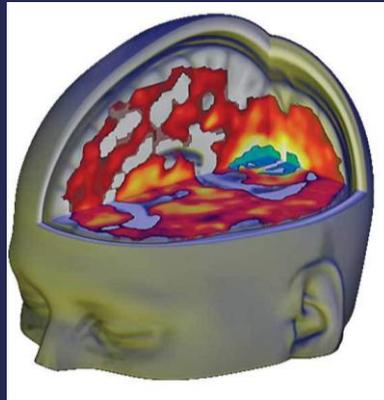
POSSIAMO CAPIRE DI PIU' GUARDANDO LA  
BIOLOGIA DEL CERVELLO?



100 miliardi di neuroni  
 100.000 neuroni per mm<sup>3</sup>



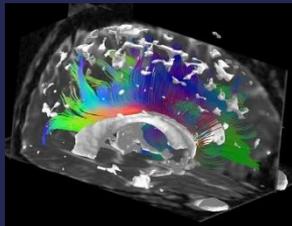
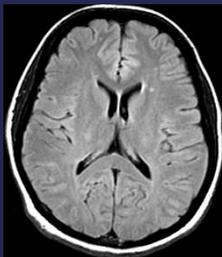
# Imaging in vivo (diagnostica per immagini)



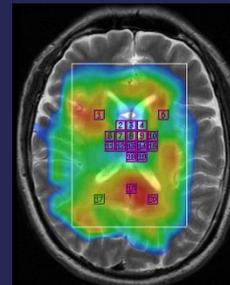
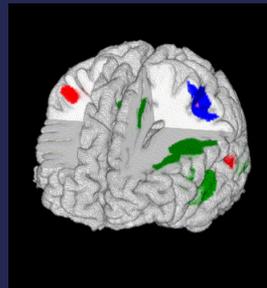
Struttura/forma  
connessioni

Funzione

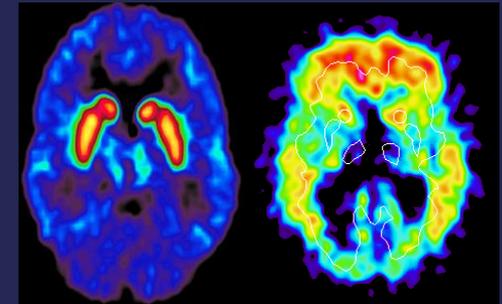
Biologia e Chimica



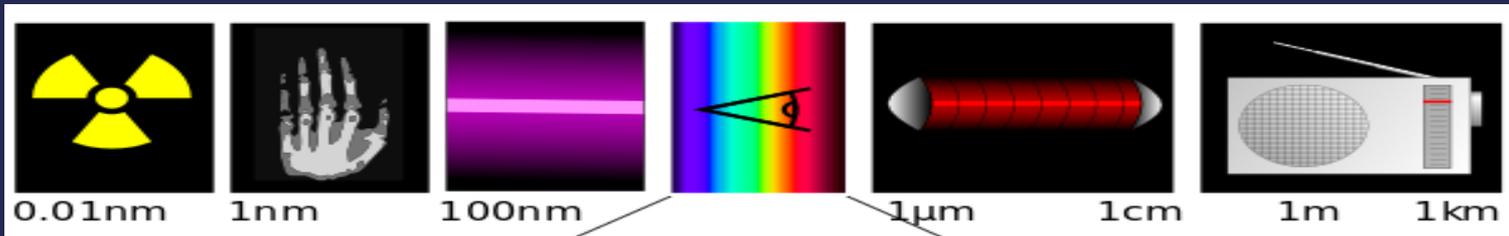
TAC, MRI



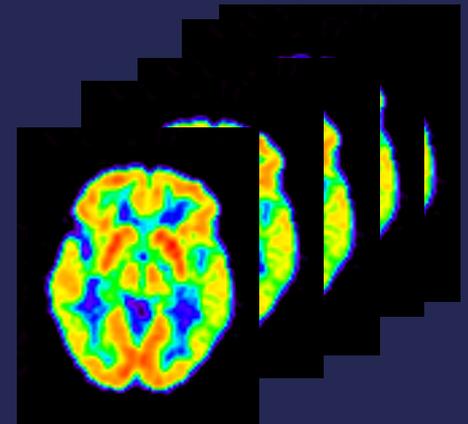
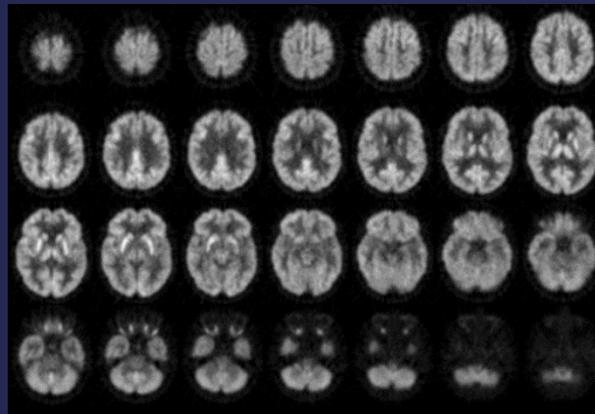
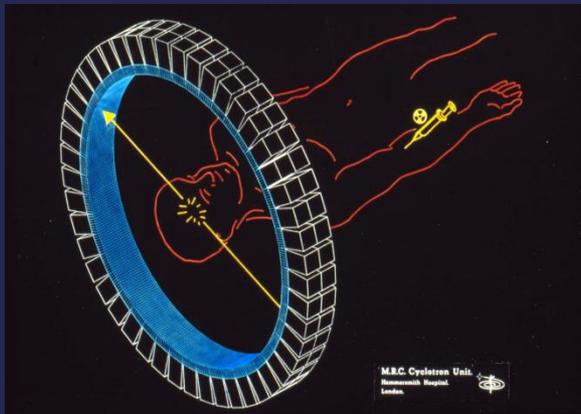
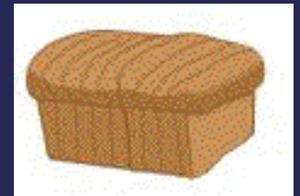
PET, fMRI, TAC perf.



PET/SPET



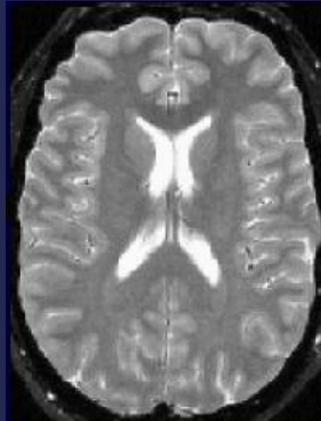
# Tomografia



# FORMA-STRUTTURA (MRI)



T1



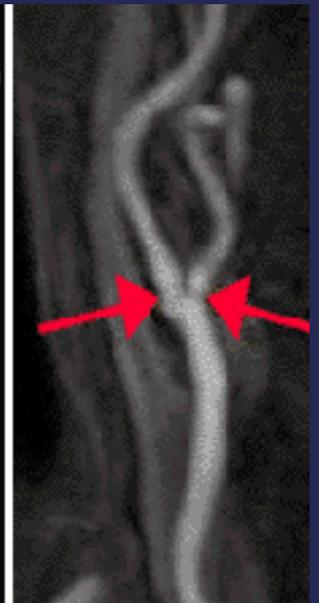
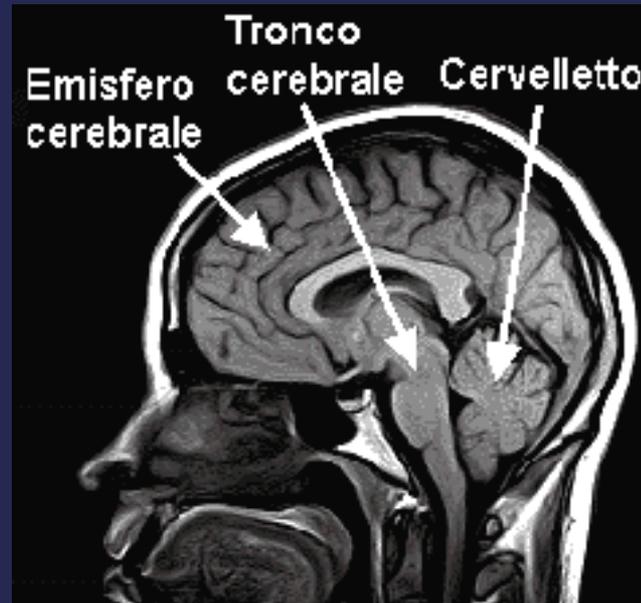
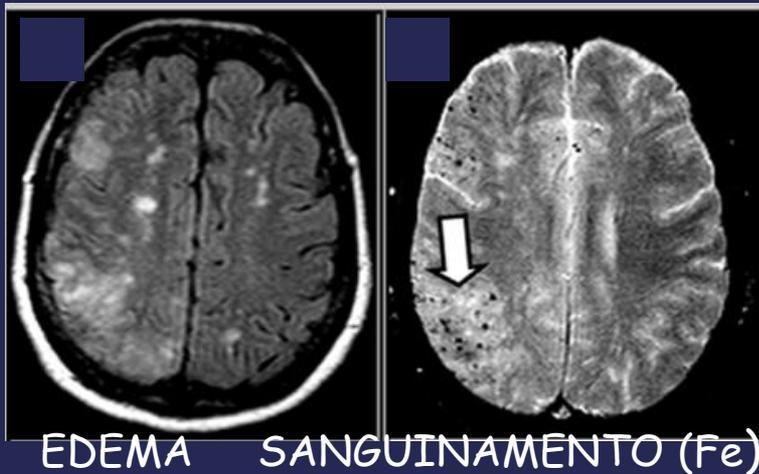
T2



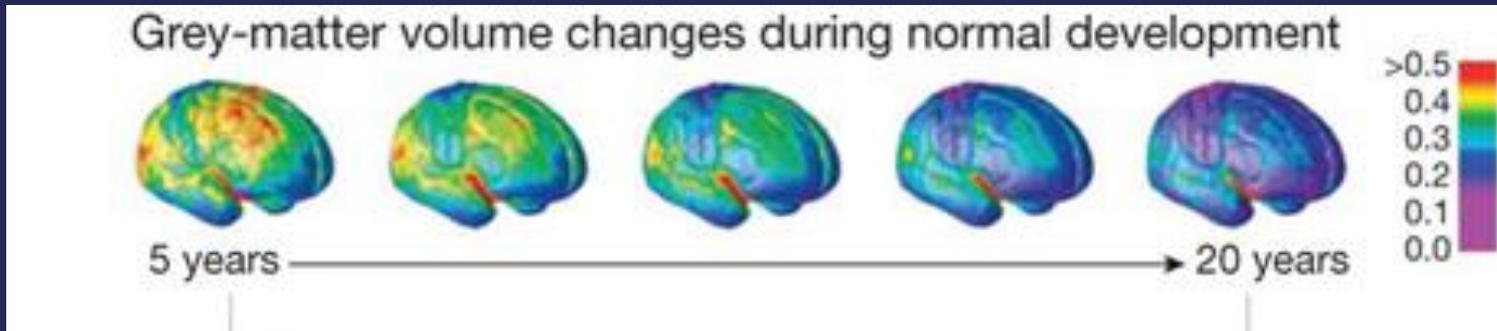
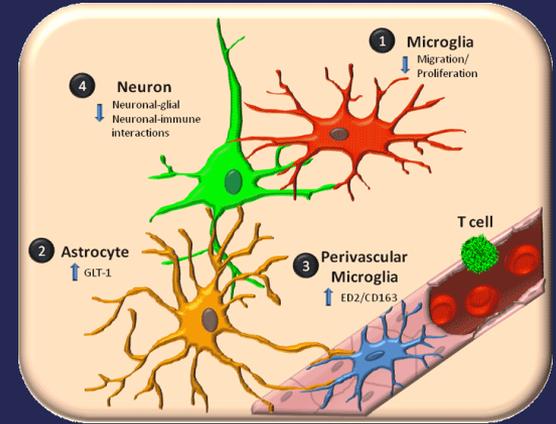
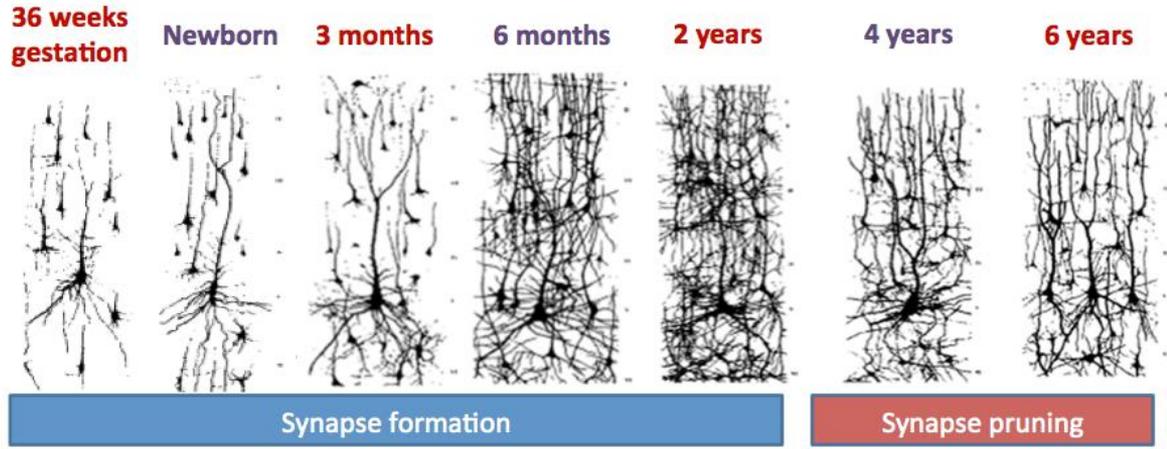
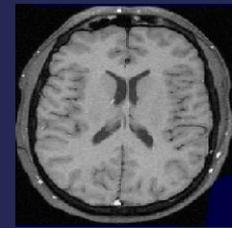
PD

$H_1$

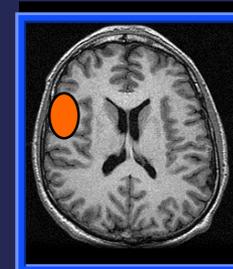
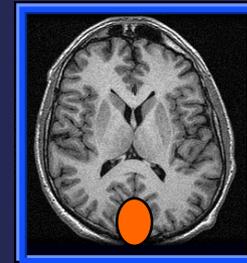
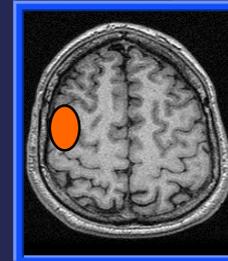
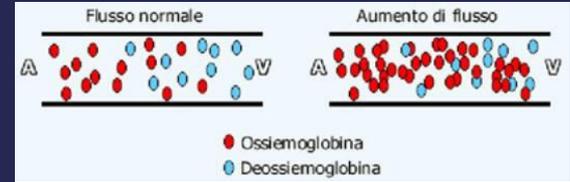
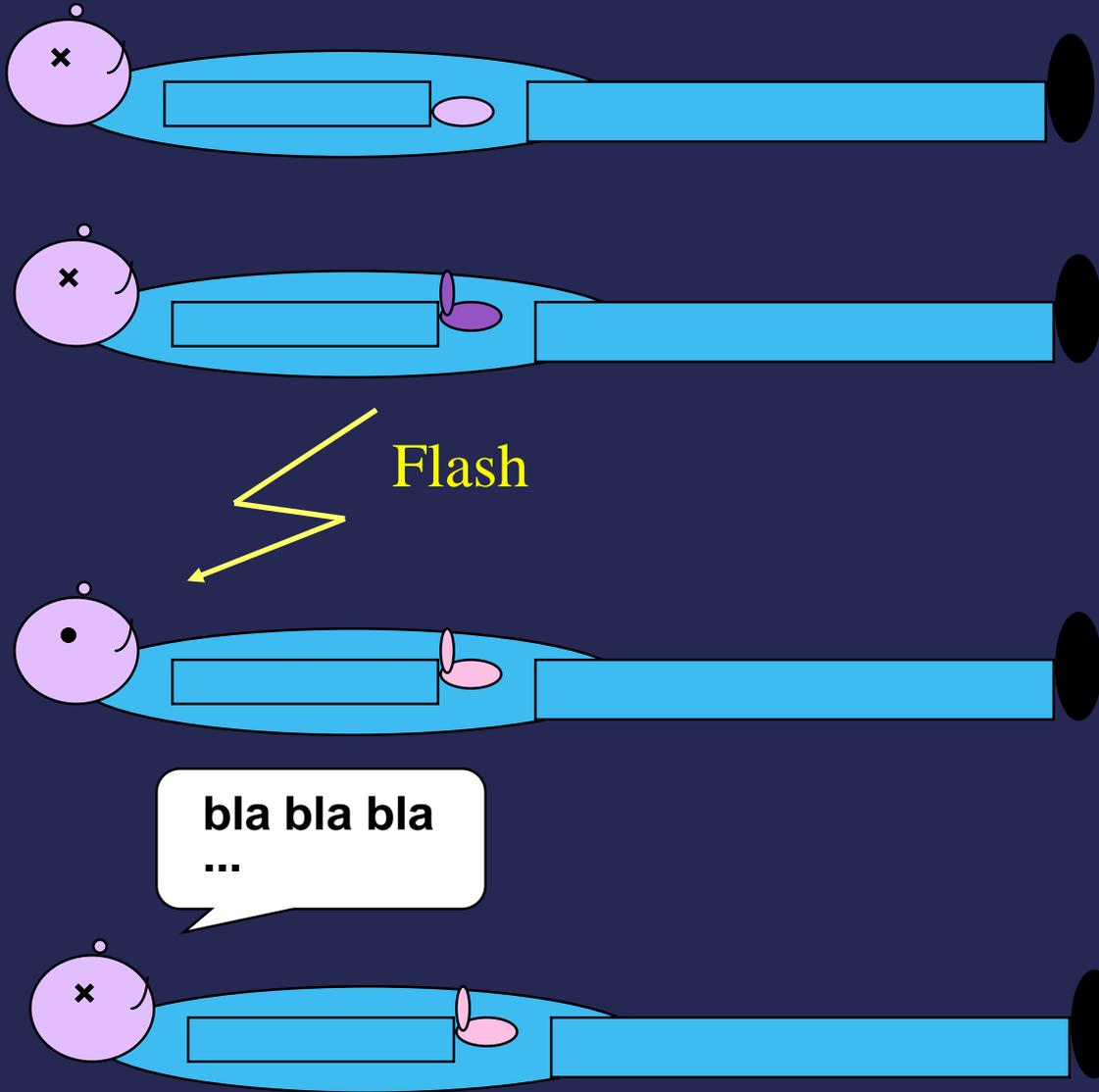
## Diagnostica clinica



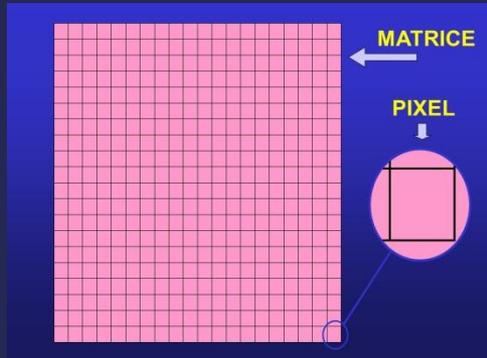
# Volume materia grigia



# Risonanza funzionale: variazione ossigenazione emoglobina sotto stimolo o a riposo

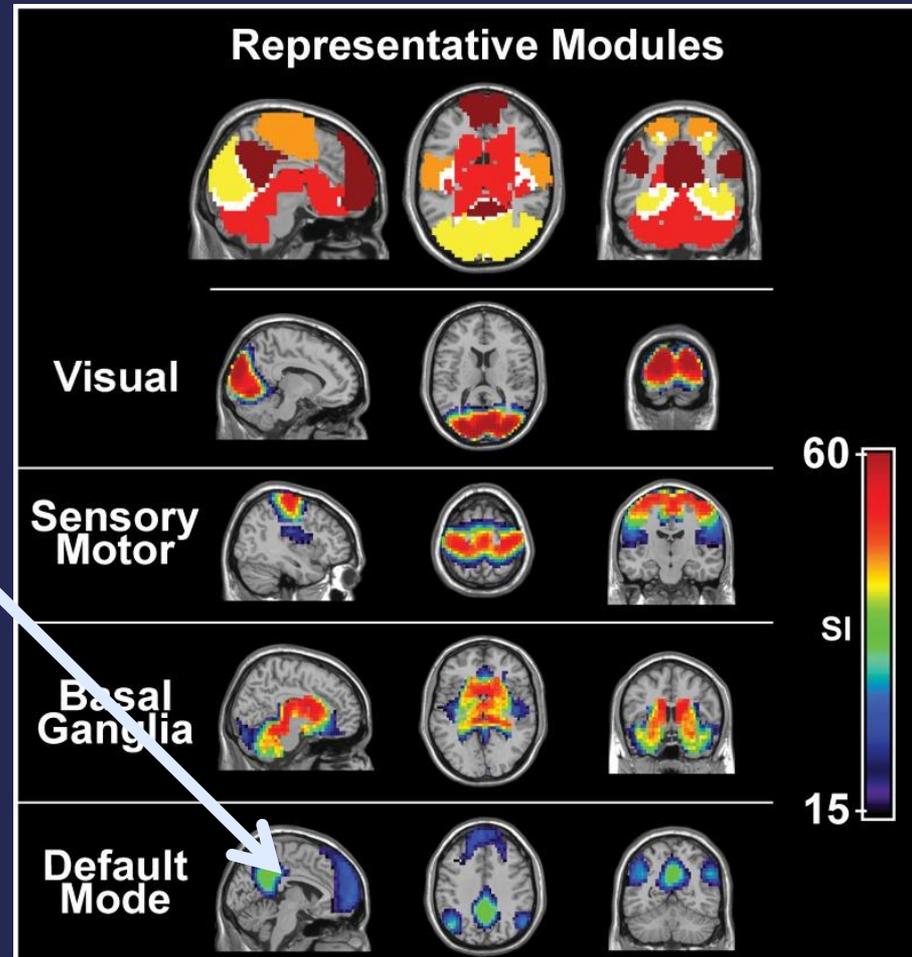
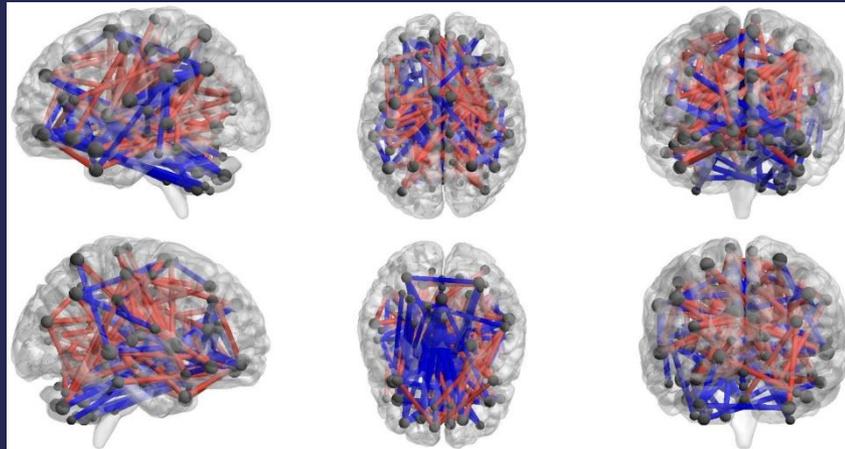


# Connessione funzionale

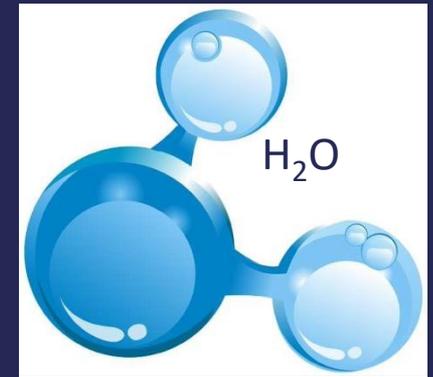
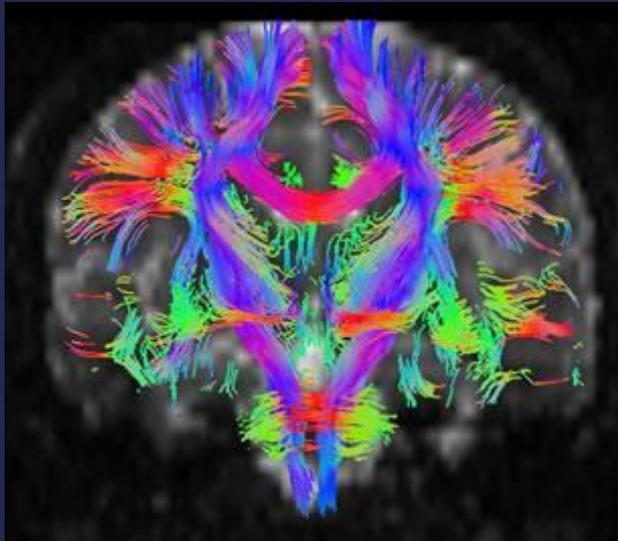


$$A = \begin{pmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{pmatrix}$$

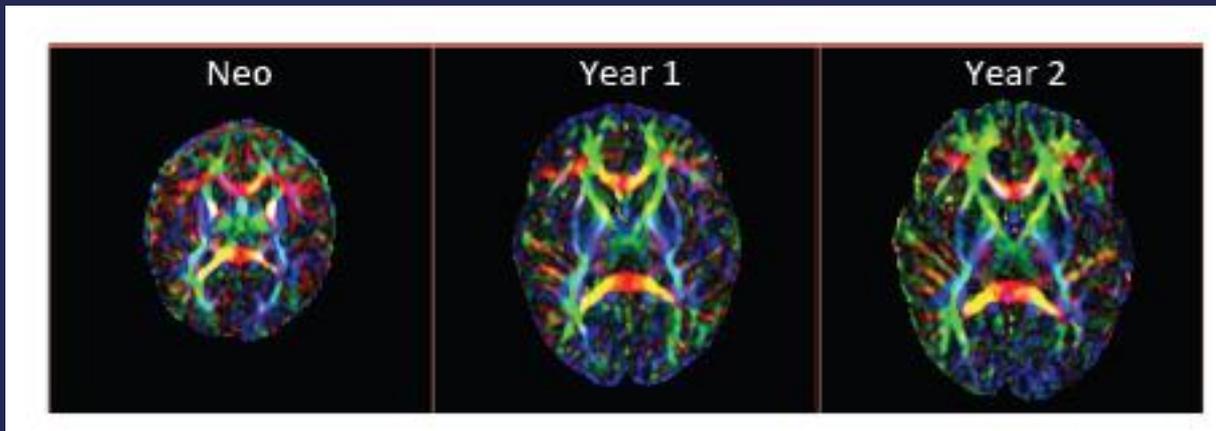
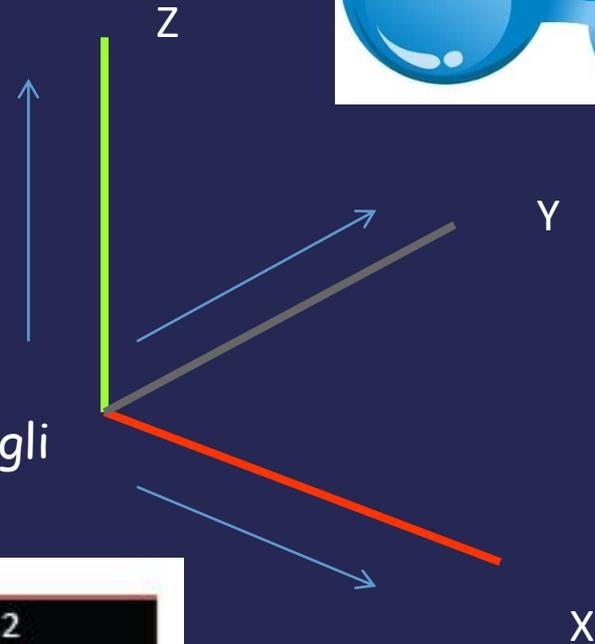
## Modelli matematici, statistica

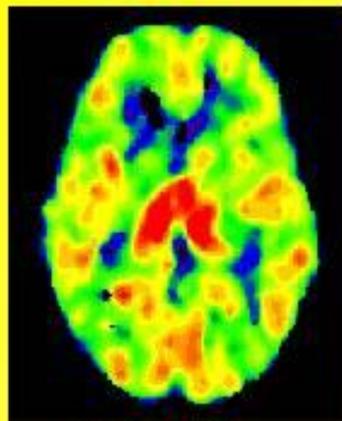


# I fasci neuronali di collegamento

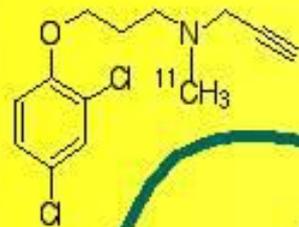


Fiber tracking o tensore di diffusione :  
Movimento unidirezionale molecole d'acqua negli  
assoni





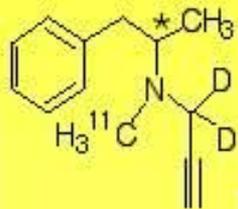
MAO A



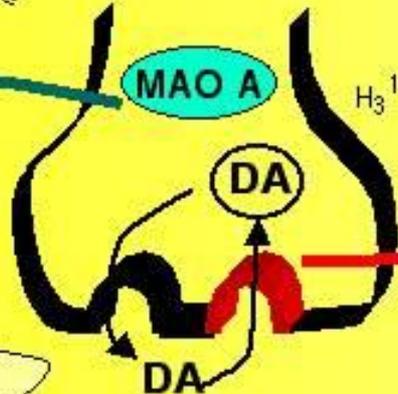
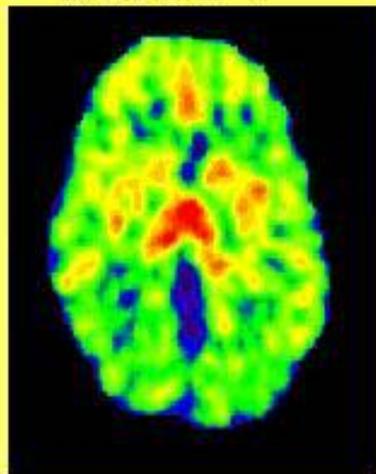
MAO A



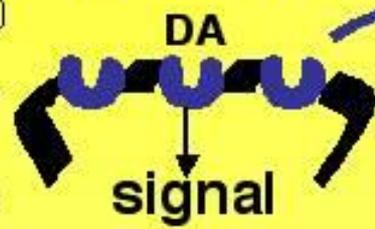
MAO B



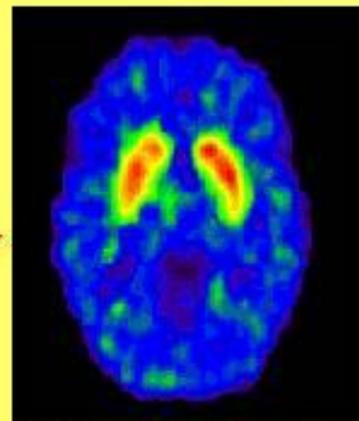
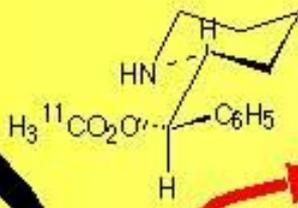
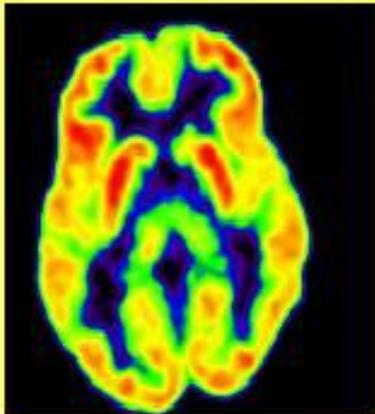
MAO B



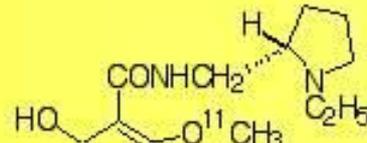
DA DA



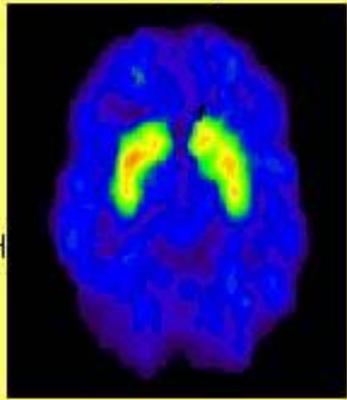
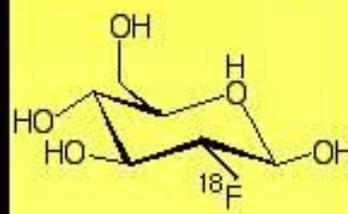
signal



DA transporters



DA receptors



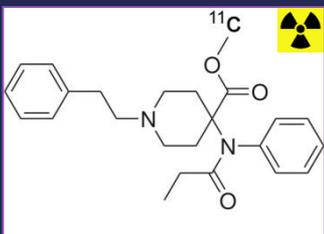
# Imaging molecolare tomografia a emissione di positroni (PET)



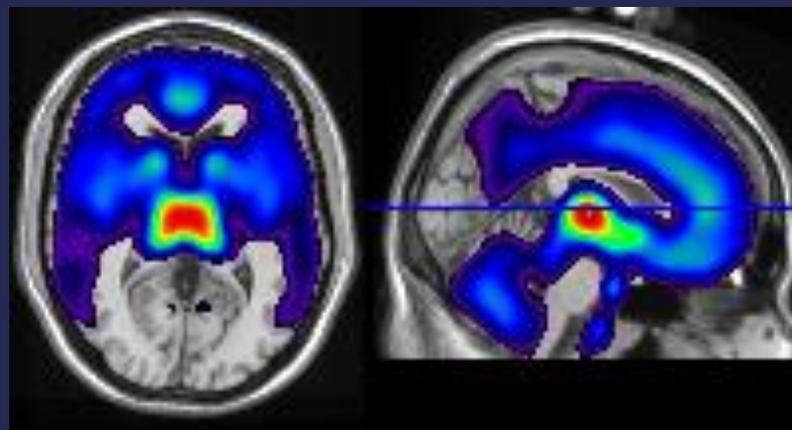
ciclotrone

c) Quantificazione (fisici)

- a) Radionuclidi (chimici)
- b) Marcatura eQC

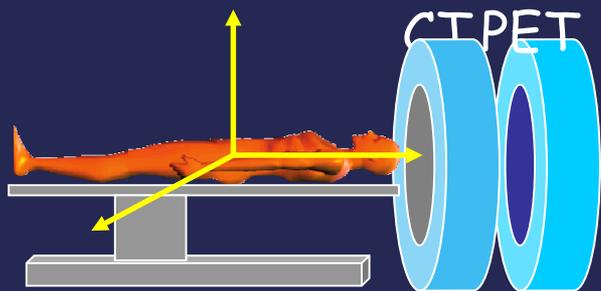


radiochimica

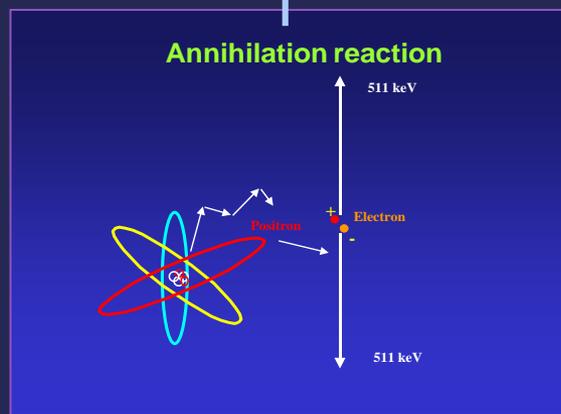


Tomoscintigrafia

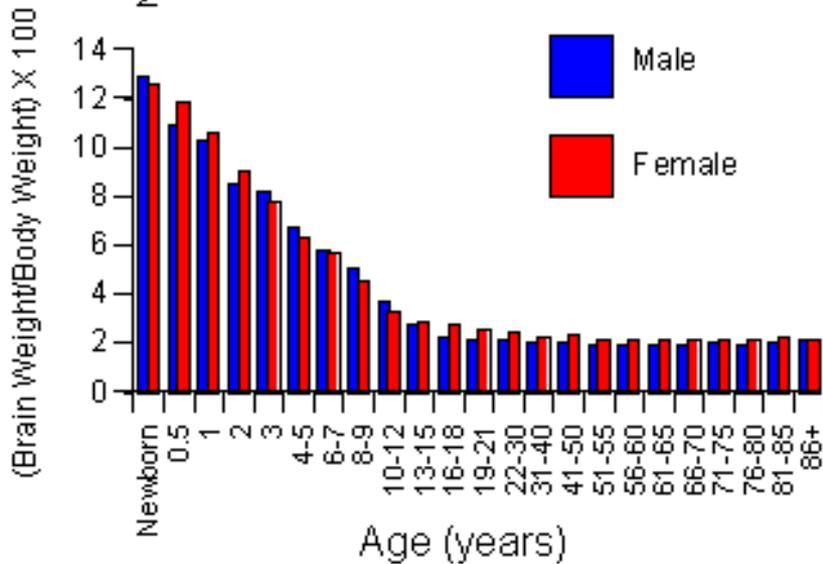
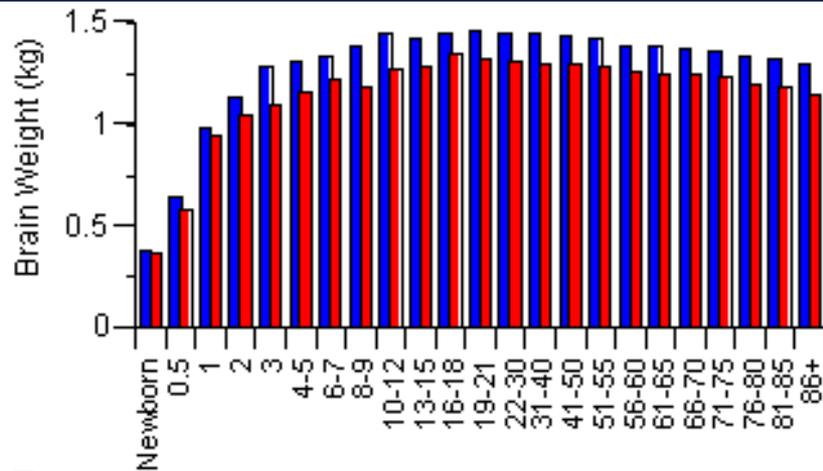
- b) iniezione, acquisizione (medici)



clinica



STRUTTURA/DIMENSIONE



Peso diverso ma non se normalizzato al peso corporeo



## A meta-analysis of sex differences in human brain structure



Amber N.V. Ruigrok<sup>a,\*</sup>, Gholamreza Salimi-Khorshidi<sup>b</sup>, Meng-Chuan Lai<sup>a,c</sup>,  
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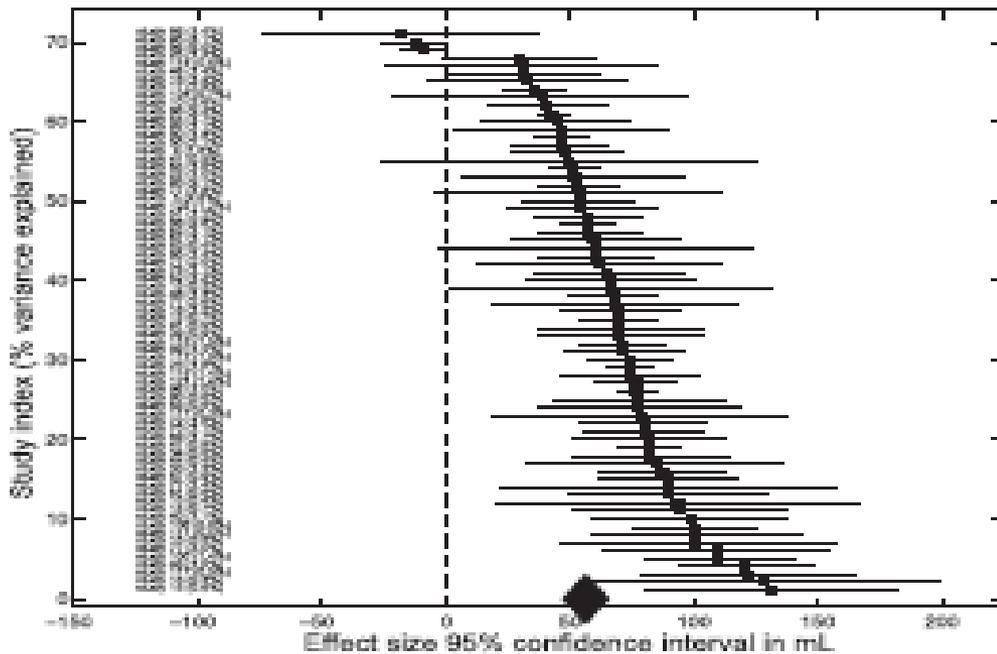
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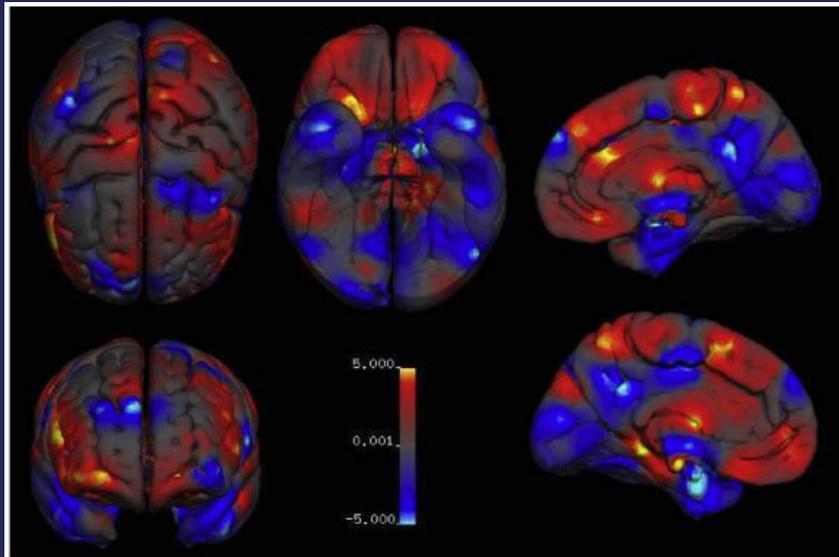
# Volume

Forest plot of brain volume effect size

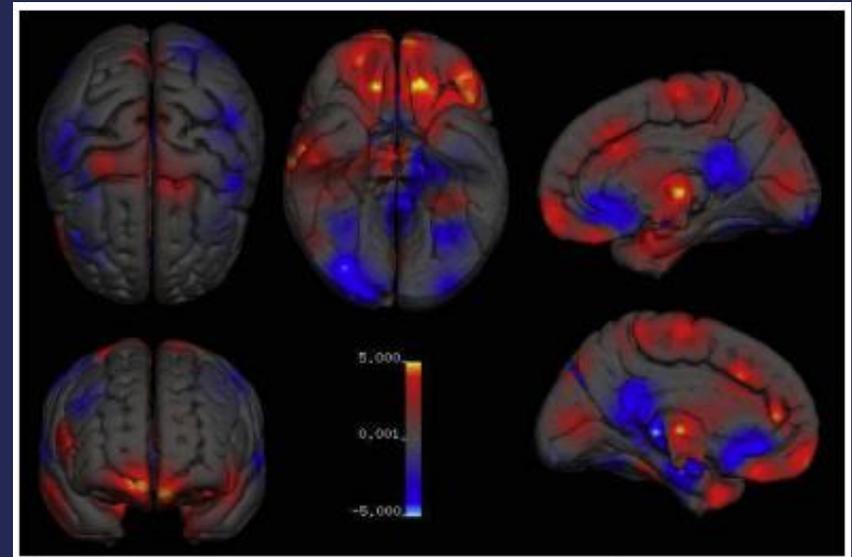
## Volume regionale

Maschi > femmine 8.13%: grigia ( 7,934 cervelli), bianca (13%; 7,515 cervelli)

### Volume regionale



### Densità di grigia



F: aree linguaggio, ascolto, emozioni

M: aree dedicate astrazione, analisi, aggressività

**Femmine > maschi  
(rosso)**

**Maschi >  
femmine (blu)**

**Il volume** cerebrale nelle donne é mediamente il 10% in meno che negli uomini, esistono differenze d'area ma il numero dei neuroni invariato. Negli uomini maggior ruolo materia grigia, nelle donne la materia bianca

il **cervello maschile** possiede **un'asimmetria** più pronunciata e riduzione del corpo calloso (associazioni tra emisferi). Maggiori volume **nella parte sinistra**. Collegano più facilmente percezione e azioni coordinate; nelle donne è facilitato il collegamento tra processi analitici e intuitivi caratteristici, rispettivamente, dell'emisfero sinistro e dell'emisfero destro (associazioni interemisferiche).

i centri del linguaggio si trovano nell'emisfero sinistro, mentre la percezione spaziale nell'emisfero destro. Questa **lateralizzazione** è molto spiccata **nel maschio** e meno nella femmina

Ma la femmina e il maschio doc  
esistono?

# Sex beyond the genitalia: The human brain mosaic

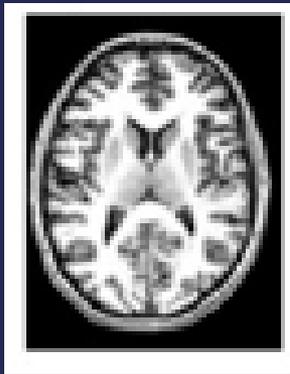
Daphna Joel<sup>a,b,1</sup>, Zohar Berman<sup>b</sup>, Ido Tavor<sup>c</sup>, Nadav Wexler<sup>d</sup>, Olga Gaber<sup>b</sup>, Yaniv Stein<sup>d</sup>, Nisan Shefi<sup>a,b</sup>, Jared Pool<sup>e</sup>, Sebastian Urchs<sup>e</sup>, Daniel S. Margulies<sup>e</sup>, Franziskus Liem<sup>e,f</sup>, Jürgen Hänggi<sup>f</sup>, Lutz Jäncke<sup>f</sup>, and Yaniv Assaf<sup>b,c</sup>

1400 cervelli

Maschi maggiore volume con elevata sovrapposizione tra F and M

MRI

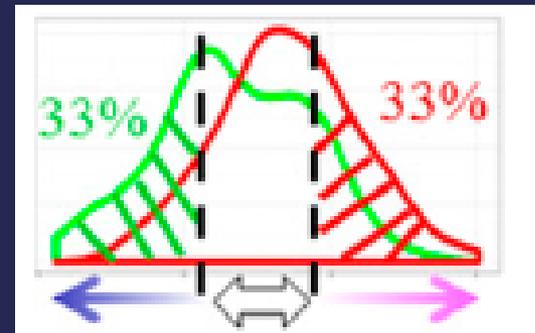
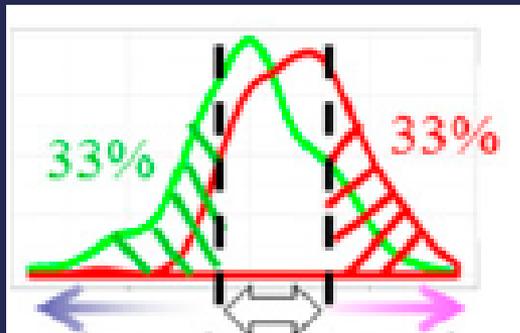
ROI



Dimorfismo sessuale è un tratto continuo quando si analizza il volume regionale cerebrale

L ippo (memoria)

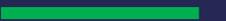
L caud (emozioni)



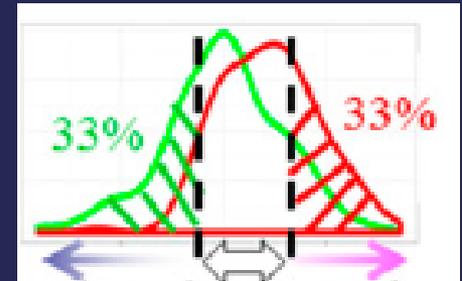
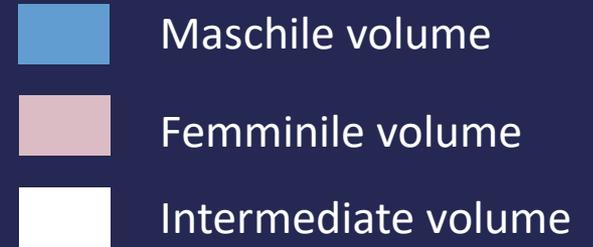
femmine



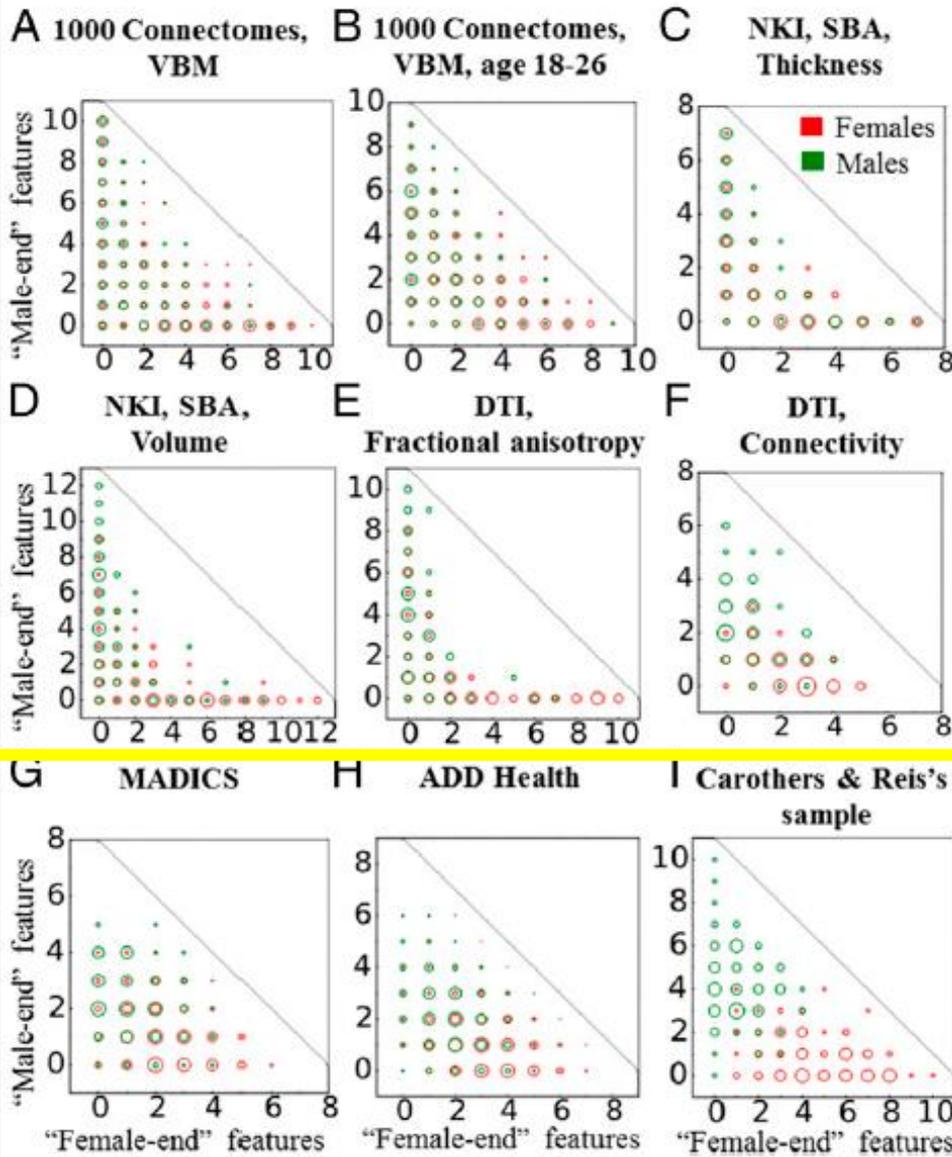
maschi



Volume



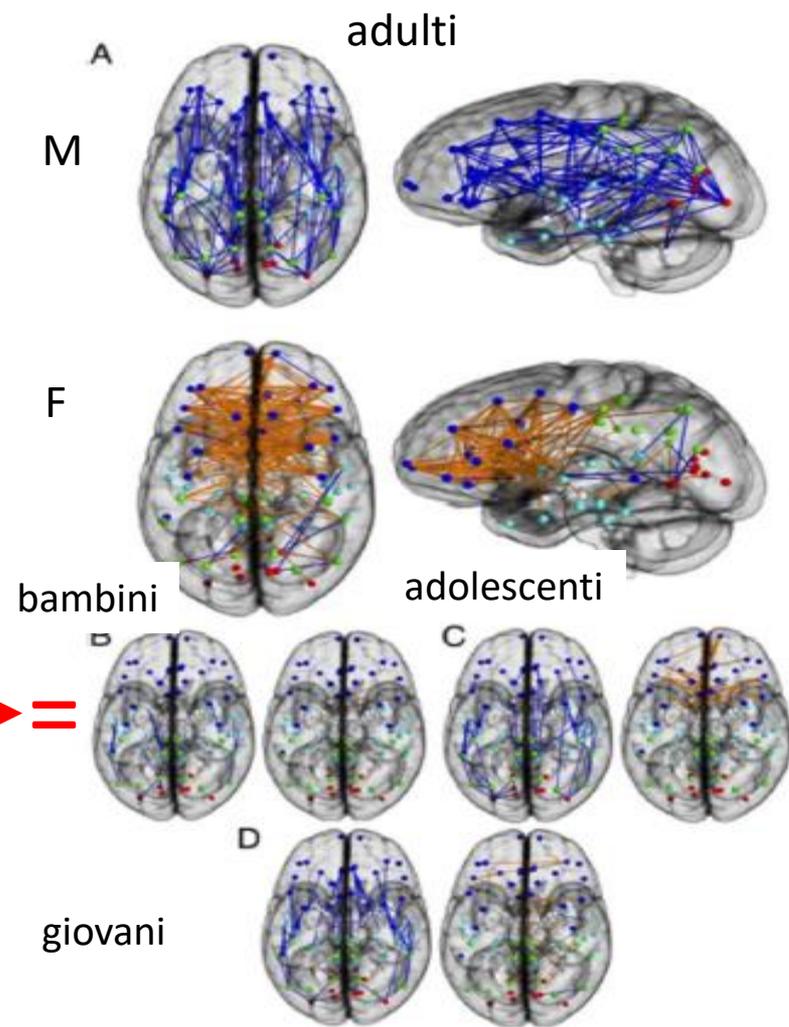
co-presenza di regioni con volumi maschili, femminili o intermedi anche all'interno di uno stesso encefalo



data base Imaging

data base  
comportamento di  
genere

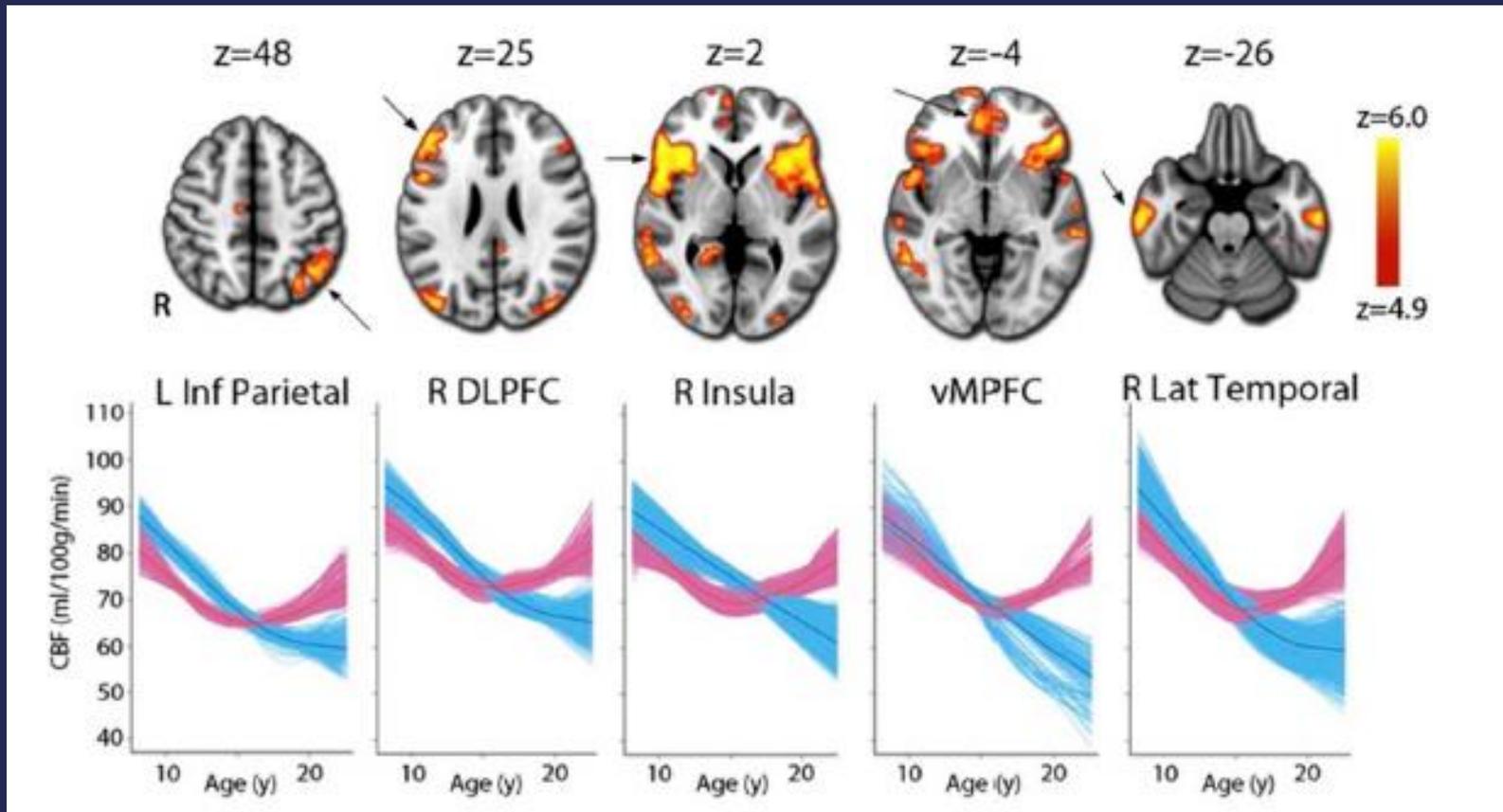
# INTERAZIONE TRA EMISFERI



Maschi > connessioni intraemisferiche a livello della corteccia mentre nelle femmine predominano le connessioni interemisferiche. Queste differenze sono già presenti nell'adolescente e giovane adulto

In generale il cervello maschile sembra essere strutturato per facilitare la connessione tra attività percettive e azione mentre le femmine per facilitare la comunicazione tra modelli di processazione analitica e intuitiva

# Funzionalità regionale nello sviluppo



il **cervello maschile** possiede **un'asimmetria** più pronunciata e riduzione del corpo calloso (associazioni tra emisferi). Maggiori volume **nella parte sinistra**.

i centri del linguaggio si trovano nell'emisfero sinistro, mentre la percezione spaziale nell'emisfero destro. Questa come altre **lateralizzazione** sono più evidenti **nel maschio** e meno nella femmina

# Funzioni

# SCIENTIFIC REPORTS



**OPEN**

**Sex differences in number processing: Differential systems for subtraction and multiplication were confirmed in men, but not in women**

Received: 05 July 2016

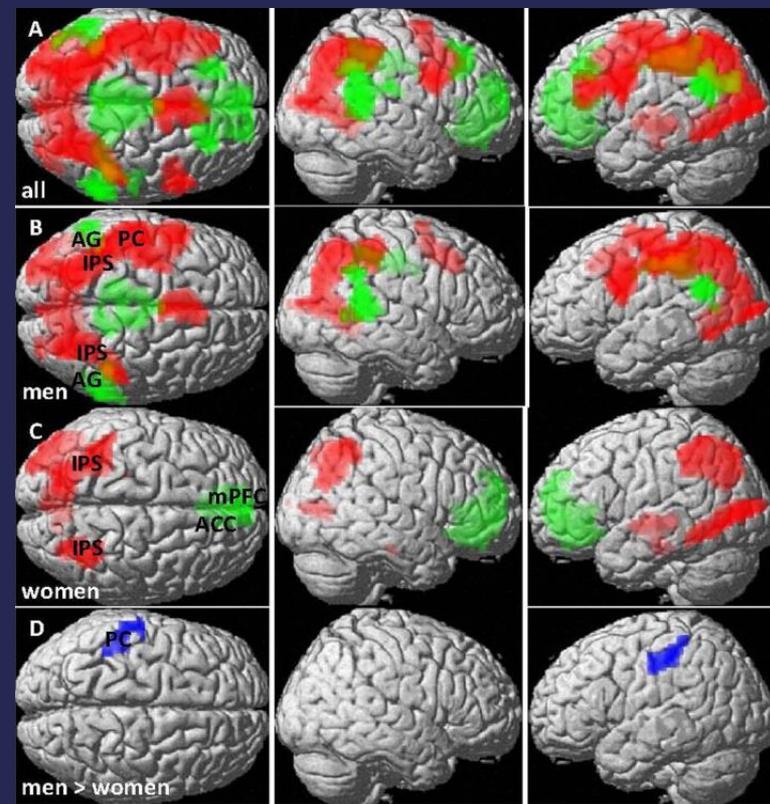
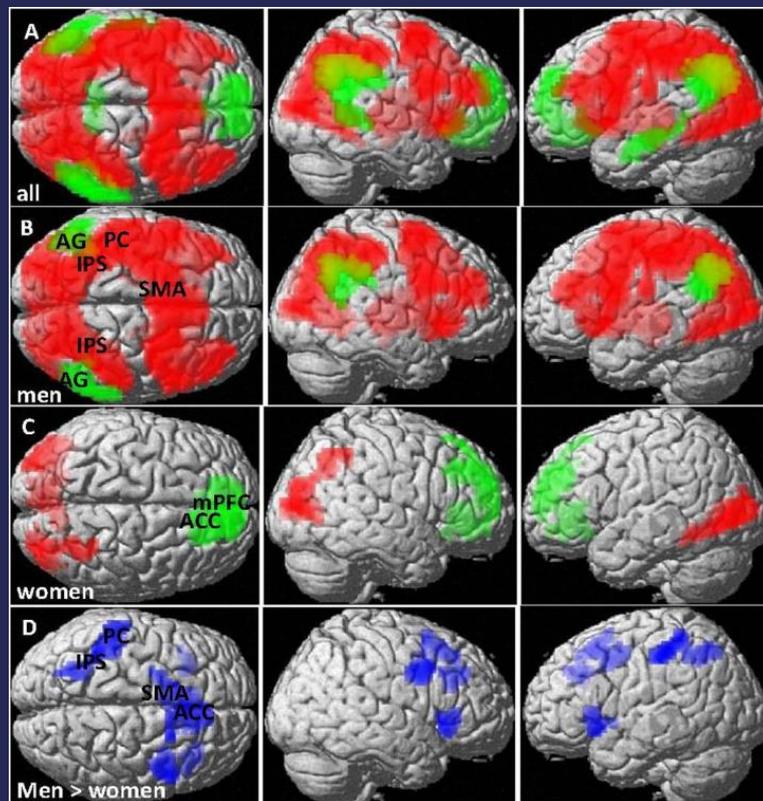
Accepted: 17 November 2016

Published: 14 December 2016

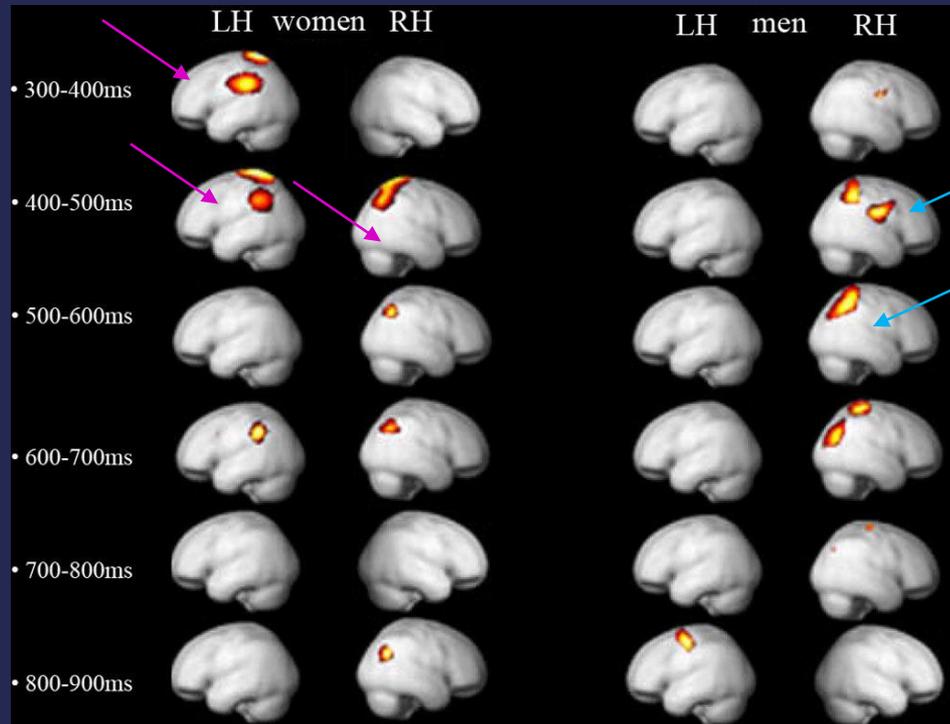
# SEGREGAZIONE DEI SISTEMI NEURALI CORRELATI A SOTTRAZIONE O MOLTIPLICAZIONE SOPRATUTTO NEL MASCHIO

sottrazione

moltiplicazione



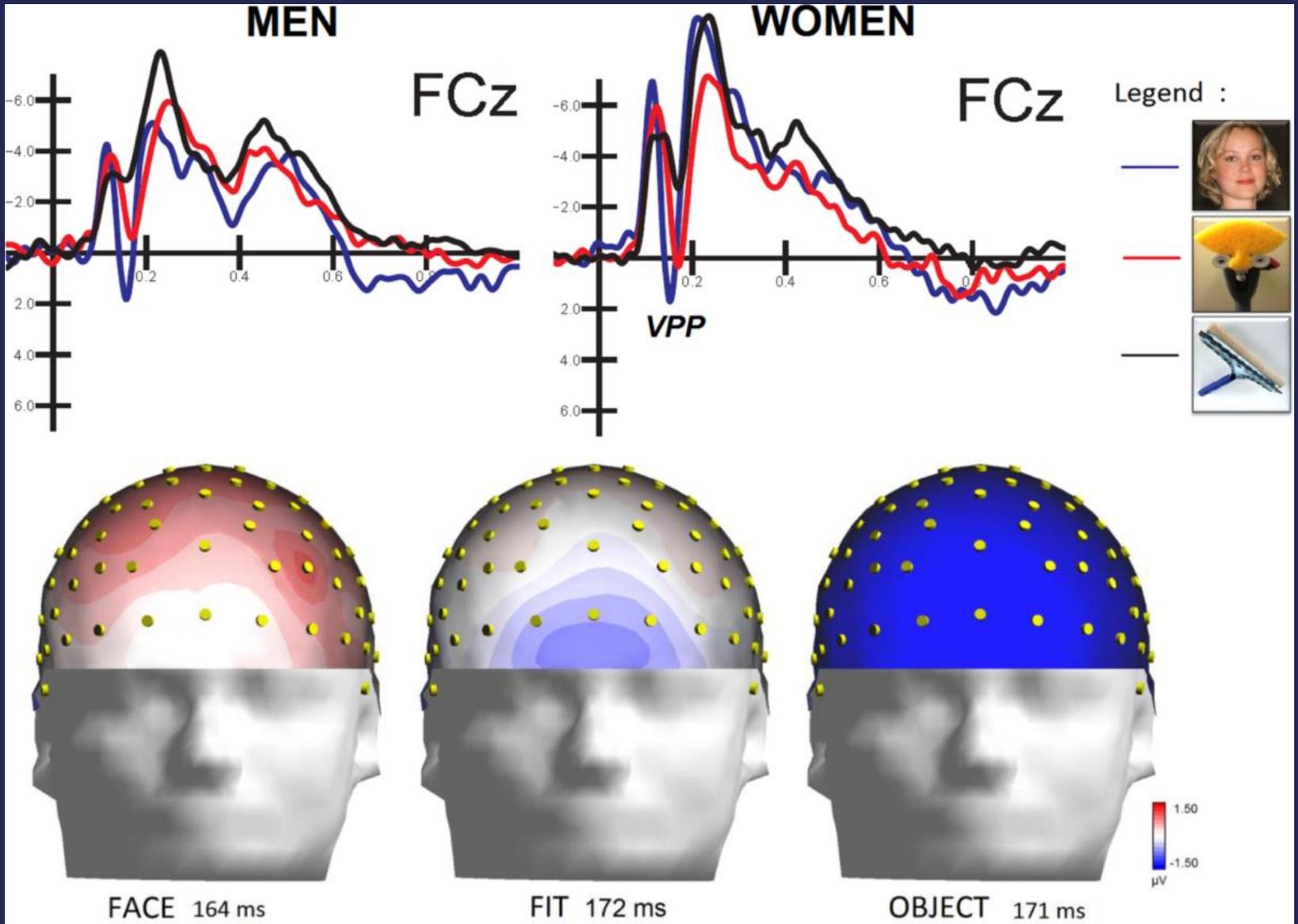
# Correlati neuronali nella identificazione del “bello”

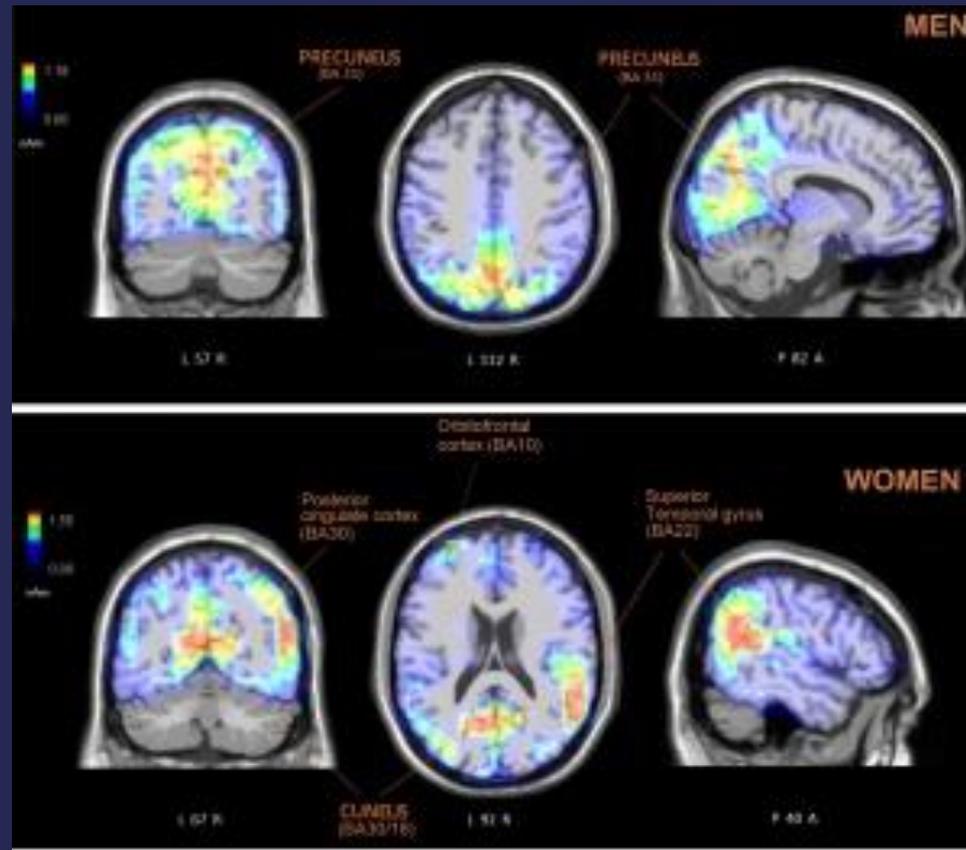


La processazione di immagini a diverso contenuto estetico riflette secondo gli autori le differenze ancestrali esistenti tra maschio e femmina nelle funzioni sociali (Hunter-gatherer hypothesis of human spatial gender differences)

· Camilo J. Cela-Conde et al. PNAS 2009

# Donne indicano presenza di immagini di volti umani più facilmente anche all'interno di oggetti





Riconoscimento dello schema facciale che coinvolge aree posteriori identico tra M e F  
 F>M aree interazione sociale giro temporale superiore, la corteccia orbito-frontale e cingolata destra in modo più marcato

Proverbio AM, Galli J. Soc Cogn Affect Neurosci. 2016 Sep;11(9):1501-12.

# SCIENTIFIC REPORTS

OPEN

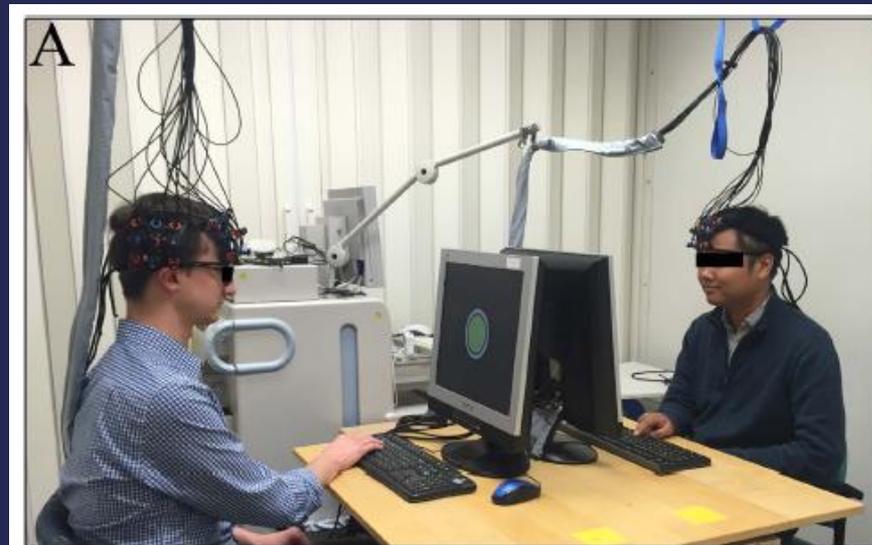
## Sex differences in neural and behavioral signatures of cooperation revealed by fNIRS hyperscanning

Received: 16 March 2016

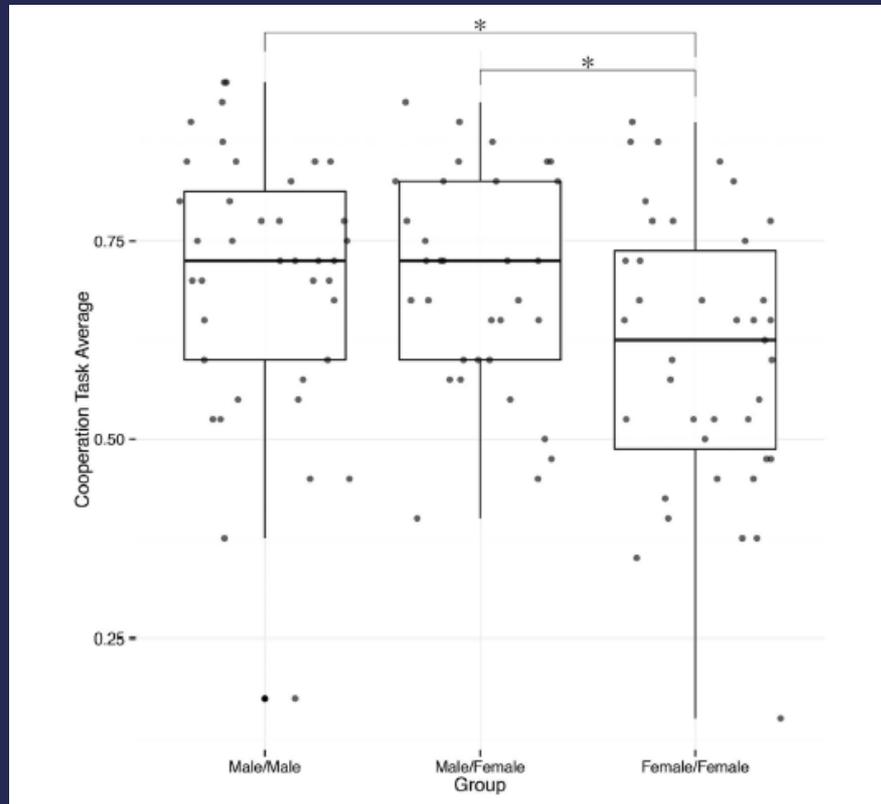
Accepted: 04 May 2016

Published: 08 June 2016

Joseph M. Baker<sup>1,2</sup>, Ning Liu<sup>1,2</sup>, Xu Cui<sup>2</sup>, Pascal Vrticka<sup>3</sup>, Manish Sogger<sup>4</sup>, S. M. Hadi Hossaini<sup>2</sup> & Allen L. Reiss<sup>1,3</sup>



# Performance al test di cooperativita

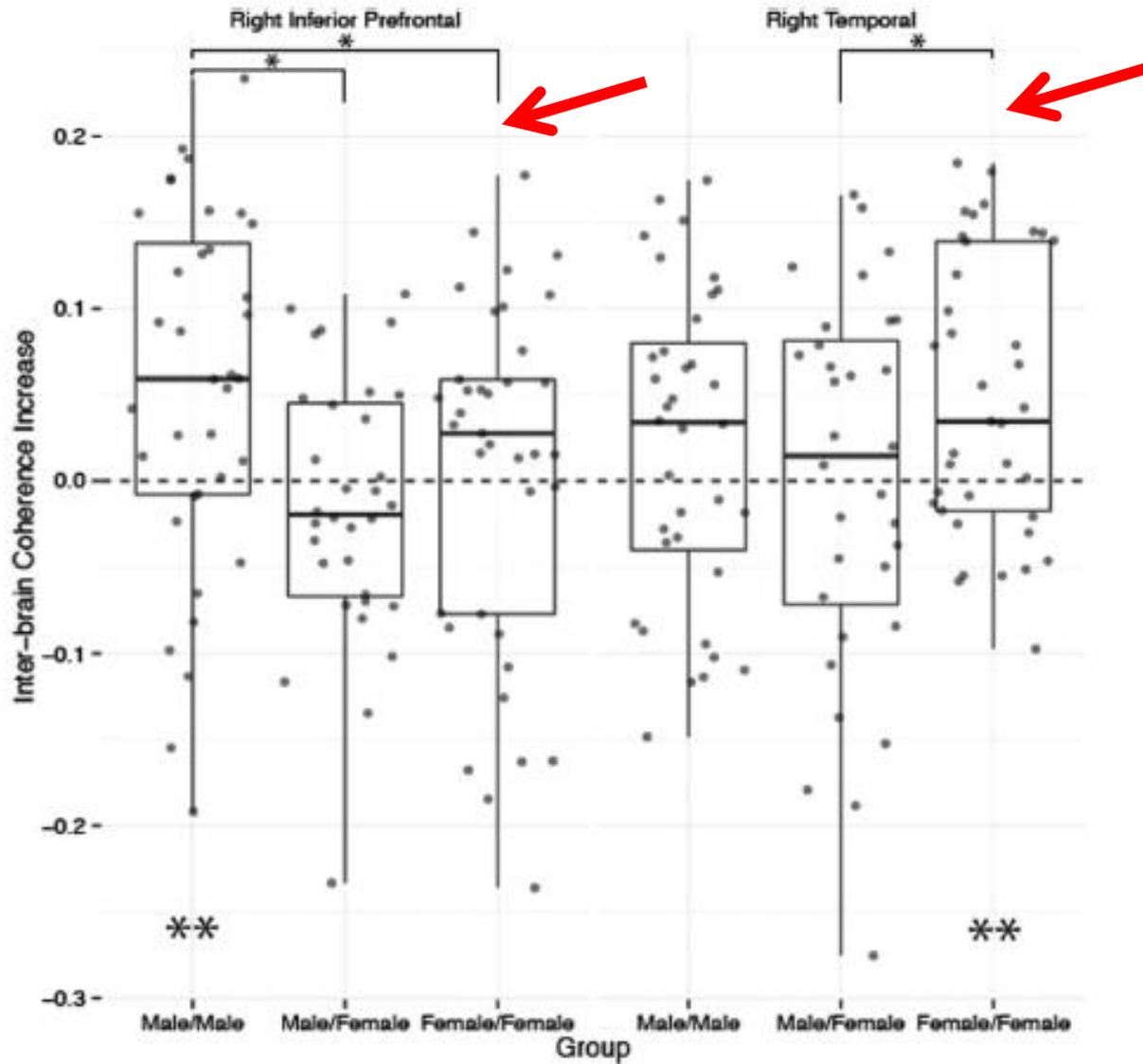


M/M

M/F

F/F

# Uso di regioni differenti

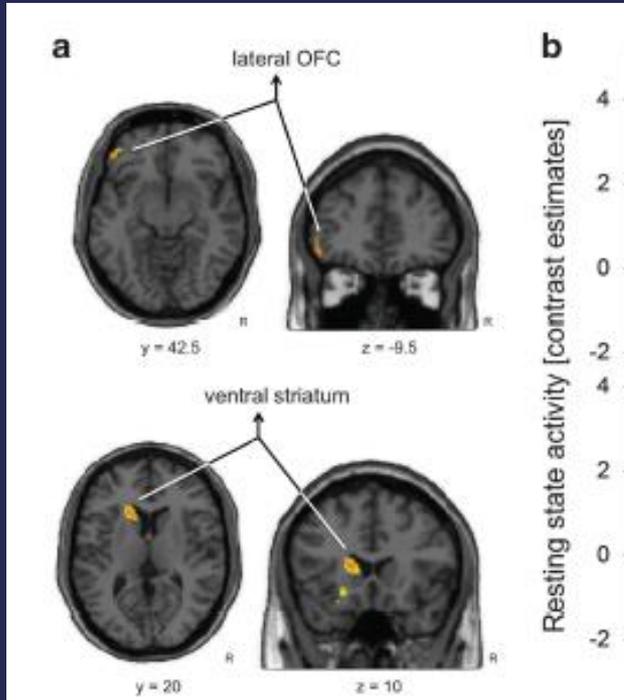


MOLECOLARE

ORIGINAL ARTICLE

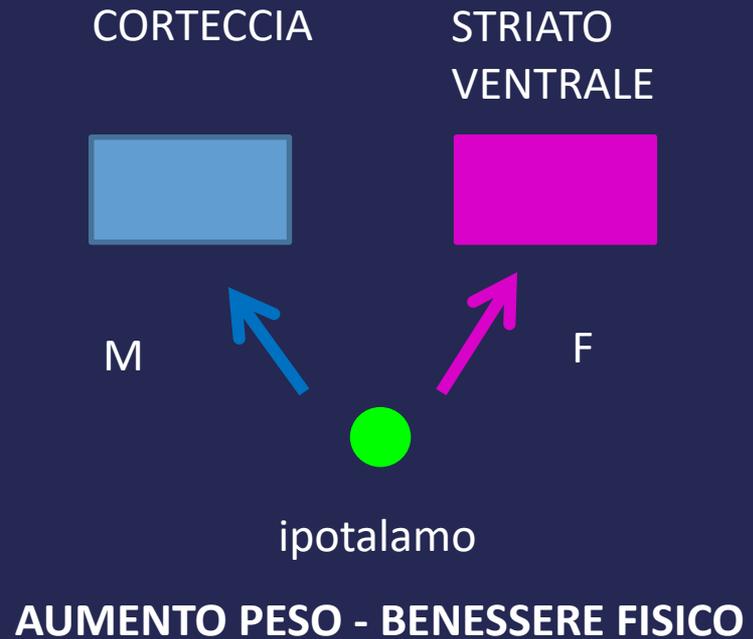
Sex differences in serotonin–hypothalamic connections underpin a diminished sense of emotional well-being with increasing body weight

J Melasch<sup>1,2</sup>, M Rullmann<sup>1,2</sup>, A Hilbert<sup>1</sup>, J Luthardt<sup>2</sup>, GA Becker<sup>2</sup>, M Patt<sup>2</sup>, M Stumvoll<sup>1,3</sup>, M Blüher<sup>1,3</sup>, A Villringer<sup>1,4,5</sup>, K Arelin<sup>1,4,5</sup>, PM Meyer<sup>2</sup>, A Bresch<sup>2</sup>, O Sabri<sup>1,2</sup>, S Hesse<sup>1,2</sup> and B Pflieger<sup>1,4,5,6</sup>



maschi

femmine



Aumento forza connessioni vie serotoninergiche ipotalamiche correlano BMI e scala qualità della vita.

Nelle femmine la connessione ipotalamo-striato è MAGGIORMENTE LEGATA A SENSO DI MALESSERE PSICOAFFETTIVO (scala BDI PER DEPRESSIONE)

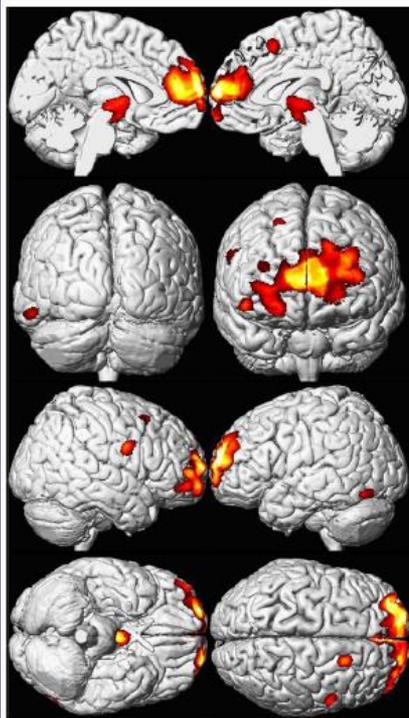
Le donne e uomini usano strutture cerebrali differenti nell'esecuzione di compiti cognitivi legati al calcolo, riconoscimento dei volti, colori (>donne) o oggetti in movimento (>uomini) anche quando ottengono risultati simili. Alcune differenze sono associate a distribuzione cerebrale recettori per ormoni



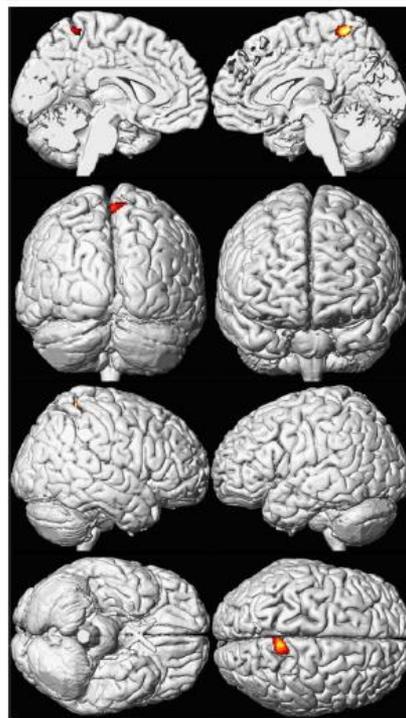
# Decreased Brain Volume in Adults with Childhood Lead Exposure

Kim M. Cecil<sup>1,2,3\*</sup>, Christopher J. Brubaker<sup>2</sup>, Caleb M. Adler<sup>4</sup>, Kim N. Dietrich<sup>1,5</sup>, Mekibib Altaye<sup>3</sup>, John C. Egelhoff<sup>2</sup>, Stephanie Wessel<sup>1,5</sup>, Ilayaraja Elangovan<sup>2</sup>, Richard Hornung<sup>1,5</sup>, Kelly Jarvis<sup>4</sup>, Bruce P. Lanphear<sup>1,3,5</sup>

**1** Cincinnati Children's Environmental Health Center, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, United States of America, **2** Department of Radiology, University of Cincinnati College of Medicine, Cincinnati, Ohio, United States of America, **3** Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio, United States of America, **4** Department of Psychiatry, University of Cincinnati College of Medicine, Cincinnati, Ohio, United States of America, **5** Department of Environmental Health, University of Cincinnati College of Medicine, Cincinnati, Ohio, United States of America



**Figure 4.** Sex Influences Brain Volume Loss Associated with Lead Exposure (Males)



**Figure 5.** Sex Influences Brain Volume Loss Associated with Lead Exposure (Females)

## Effetto neurotossico del piombo:

Maggior effetto a lungo termine nel maschio (riduzione volume grigia) a livello di regioni come corteccia prefrontale e cingolo anteriore coinvolte in funzioni esecutive, regolazione dell'umore e decision making.

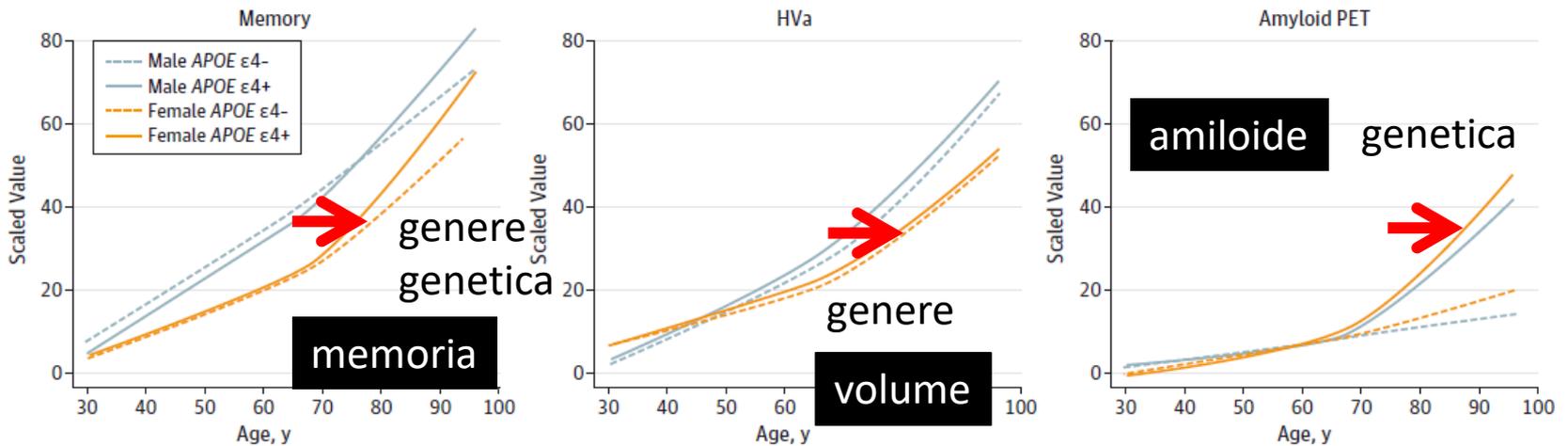
Original Investigation

# Age, Sex, and APOE $\epsilon$ 4 Effects on Memory, Brain Structure, and $\beta$ -Amyloid Across the Adult Life Span

Clifford R. Jack Jr, MD; Heather J. Wiste, BA; Stephen D. Weigand, MS; David S. Knopman, MD; Prashanthi Vemuri, PhD; Michelle M. Mielke, PhD; Val Lowe, MD; Matthew L. Senjem, MS; Jeffrey L. Gunter, PhD; Mary M. Machulda, PhD; Brian E. Gregg, BS; V. Shane Pankratz, PhD; Walter A. Rocca, MD, MPH; Ronald C. Petersen, MD, PhD

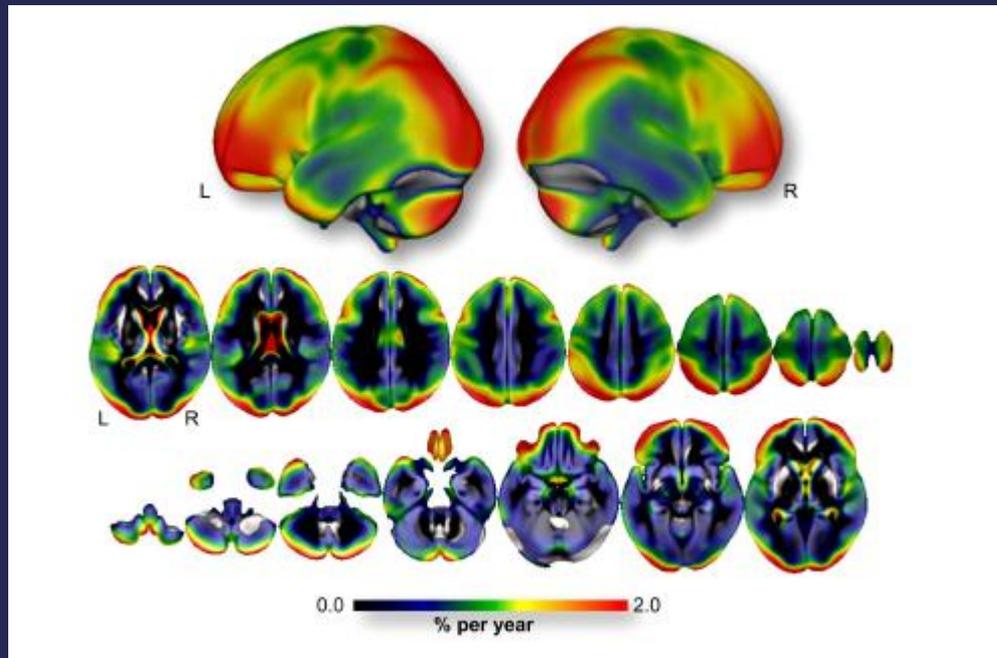
JAMA Neurol. 2015;72(5):511-519.

Figure 2. Estimated Median Regression Lines in Scaled Units vs Age for All 4 Demographic Groups, With Separate Panels for Memory, Adjusted Hippocampal Volume (HVa), and Amyloid Positron Emission Tomography (PET)

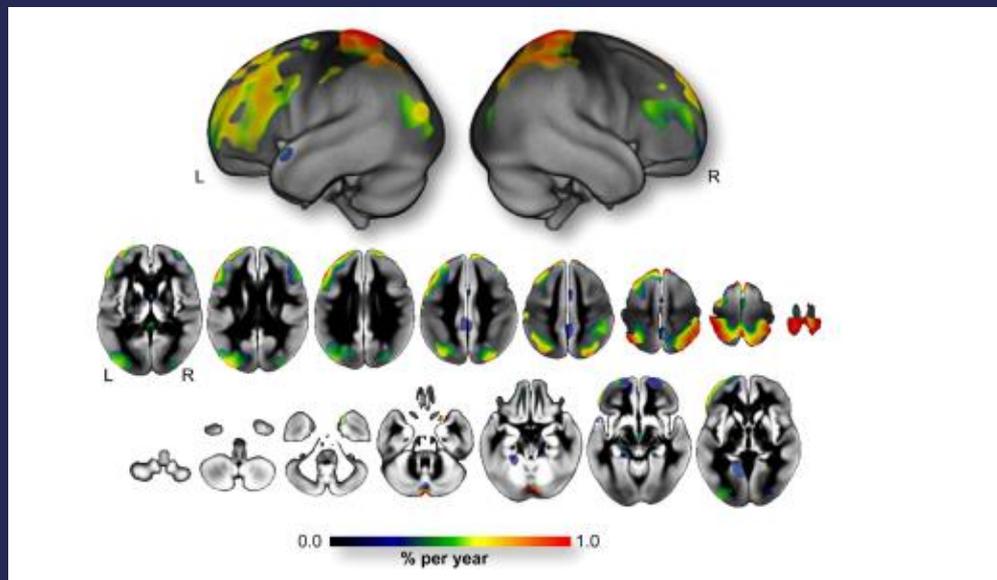


Knots were placed at ages 50, 75, and 80 years. Blue lines represent relationships in men, and orange lines represent relationships in women. Solid lines represent APOE  $\epsilon$ 4 carriers, and dashed lines represent APOE  $\epsilon$ 4 noncarriers.

## Perdita di grigia: effetto età



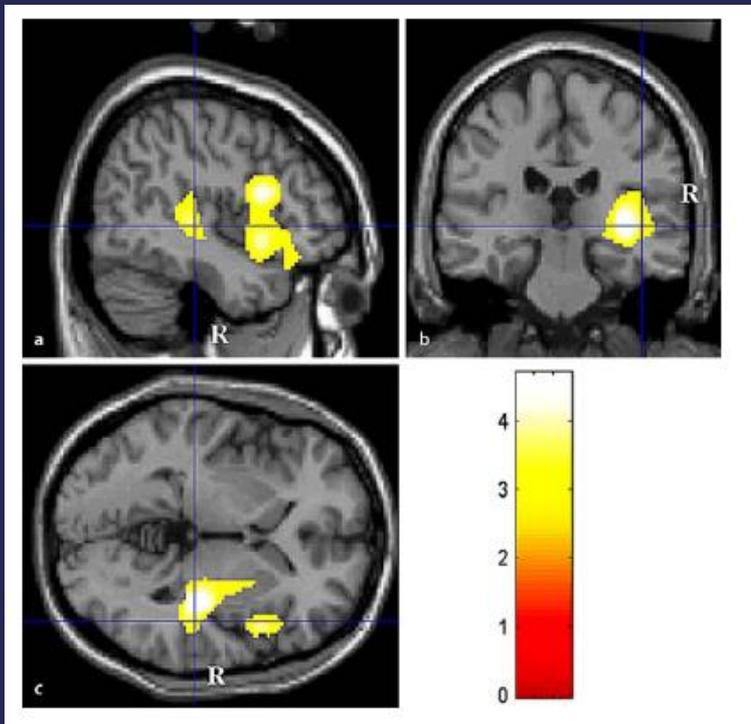
Effetto genere: (dopo 65 anni ): perdita grigia: F>M



Robert Perneczky  
Alexander Drzezga  
Janine Diehl-Schmid  
Yi Li  
Alexander Kurz

## Gender differences in brain reserve An $^{18}\text{F}$ -FDG PET study in Alzheimer's disease

Riserva cognitiva cerebrale: circa il 25% degli individui con criteri anatomico patologici per AD non hanno mai manifestato alcun deterioramento cognitive. Riserva cognitive maggiore nei maschi



Differenze nel metabolismo cerebrale di glucosio

**Femmine > maschi**

## DIFFERENZE

### **Uomo:**

- Maggiore asimmetria strutturale e funzionale
- Maggiore quantità di fibre intra-emisferiche
- Migliore analisi dello spazio
- Minore quantità di informazioni percepite
- Maggiore analisi e maggiore memoria spaziale

### **Donna:**

- Minore organizzazione asimmetrica
- Maggiore quantità di fibre inter-emisferiche
- Maggiore percezione dello spazio nel suo insieme
- Maggiore quantità di informazioni percepite nell'unità di tempo, maggiore sintesi
- Maggiore percezione dell'aspetto emozionale
- Maggiore fluidità verbale

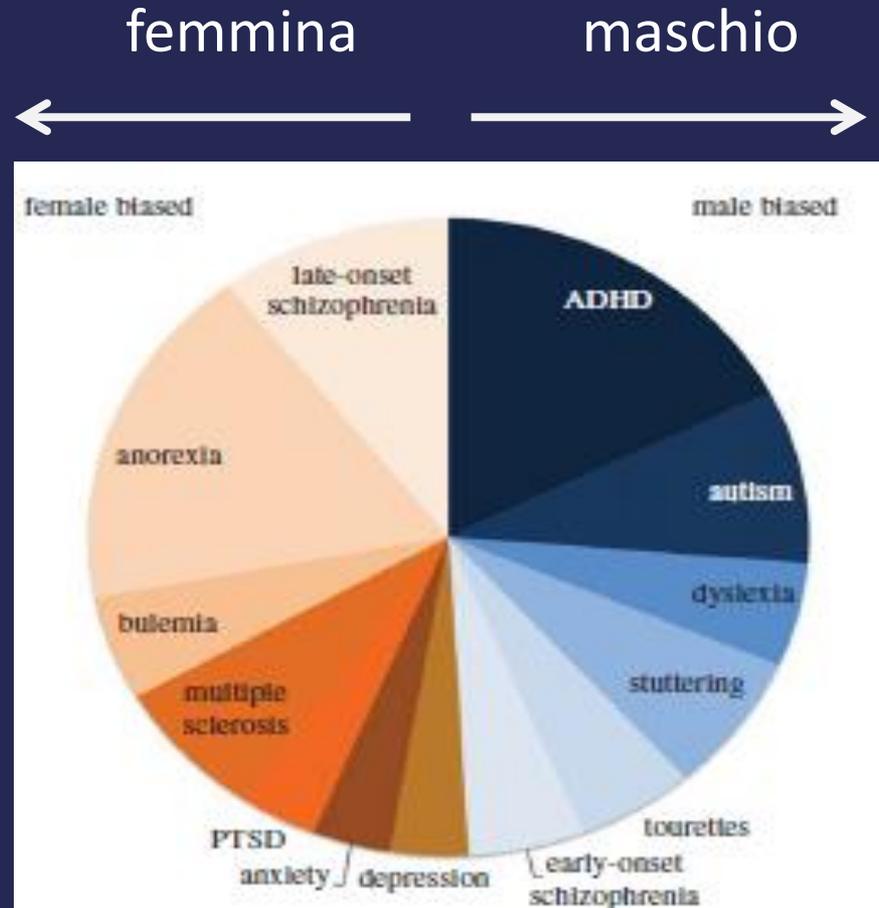
Spesso risultati simili con percorsi cerebrali differenti (matematica e riconoscimento)  
Importante influenza biologica anche legata ad evoluzione ma sicura influenza ambientale

# trattamenti

F & M sono diversi anche se non esiste il cervello super maschio o super femmina. Tuttavia anche in presenza di risposte simili possiamo osservare strategie diverse

In patologia:  
esistono differenze di:  
Struttura  
Funzione  
Neurochimica

Che spiegano:  
Suscettibilità  
Decorso  
Fenotipo



Ruolo dell'ambiente nell'età post moderna sulle differenze di Genere?



E grazie per l'attenzione