



Recenti sviluppi e limiti delle Neuroimmagini



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ETGM.it



Acquisizioni Volumetriche RM variamente pesate: Valutazione Morfologica

- ❖ **Finalità:** Identificazione; Localizzazione; Caratterizzazione del segnale
- ❖ **Displasie Corticali Visibili**
32% alla TAC e 92% alla RM

La diagnosi è semplice quando le alterazioni sono grossolane
Le **tecniche moderne:** quelle più fini che possono sfuggire con metodiche *standard*





Valutazione morfologica

1,5T vs 3.0T

Mellerio C et Al. 3T MRI improves the detection of transmantle sign in type 2 focal cortical dysplasia. *Epilepsia*. 2014

Forse: riclassificazione di circa il 5%
delle FCD.

Il 29% di sclerosi mesiali sono meglio
visibili sul 3T vs 1,5T

FLAIR 3D vs 2D



Valutazione morfologica

1,5T vs 3.0T = NON sicuri vantaggi

Si ha la sensazione che l'utilizzo di alti campi magnetici **migliori la possibilità di identificare** le malformazioni corticali. Probabilmente si tratta solo di un miglioramento di tipo qualitativo delle immagini, mentre in realtà la possibilità di identificare le alterazioni rimane sostanzialmente invariata.

La qualità delle acquisizioni volumetriche è migliore con apparecchiature alto campo

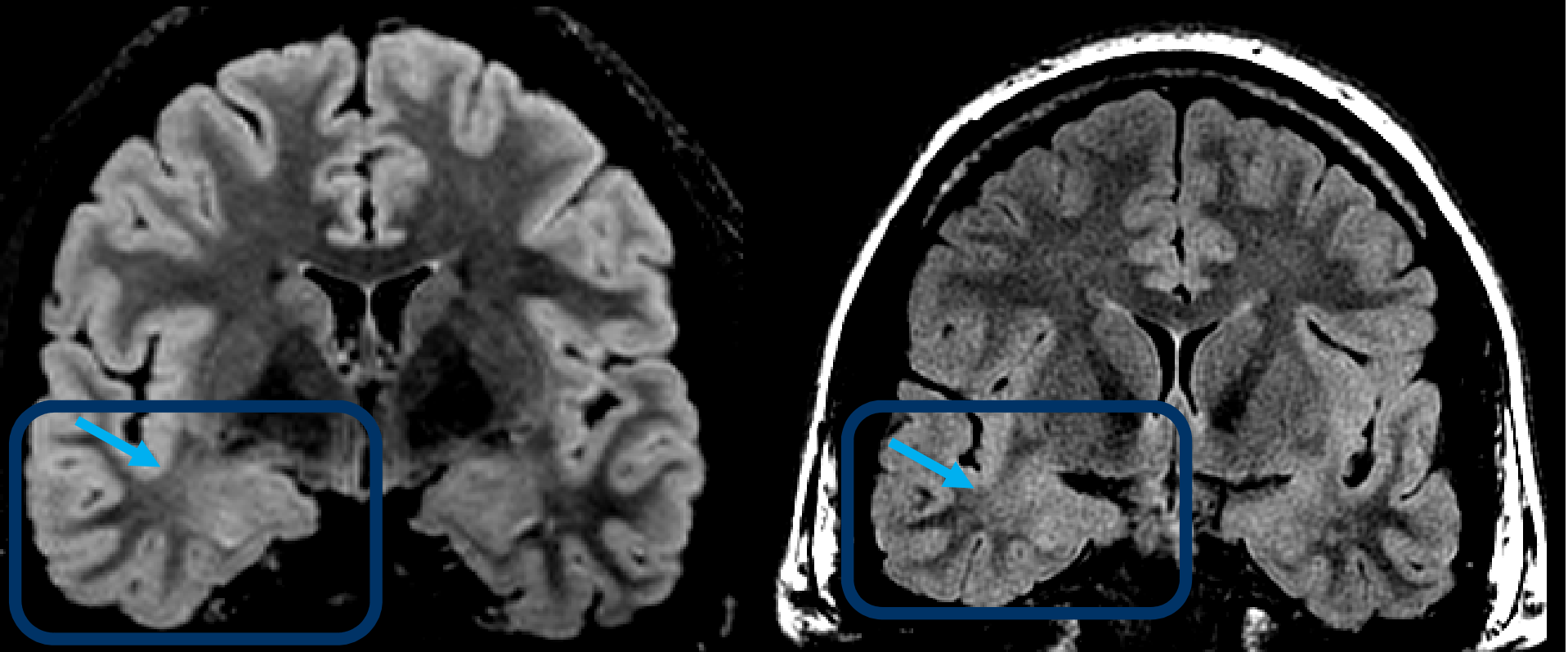
Contemporaneo incremento di effetti negativi (elevata suscettibilità da interferenze magnetiche, disomogeneità bobine multi-channel)

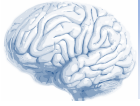
A. Bernasconi et Al. Nature-Reviews Neurology 2011

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Valutazione morfologica REALI VANTAGGI

- **T2-FLAIR** e altre sequenze 2D vs **3D**
Multiplanarità con spessori sottili (1mm vs 3-4mm)



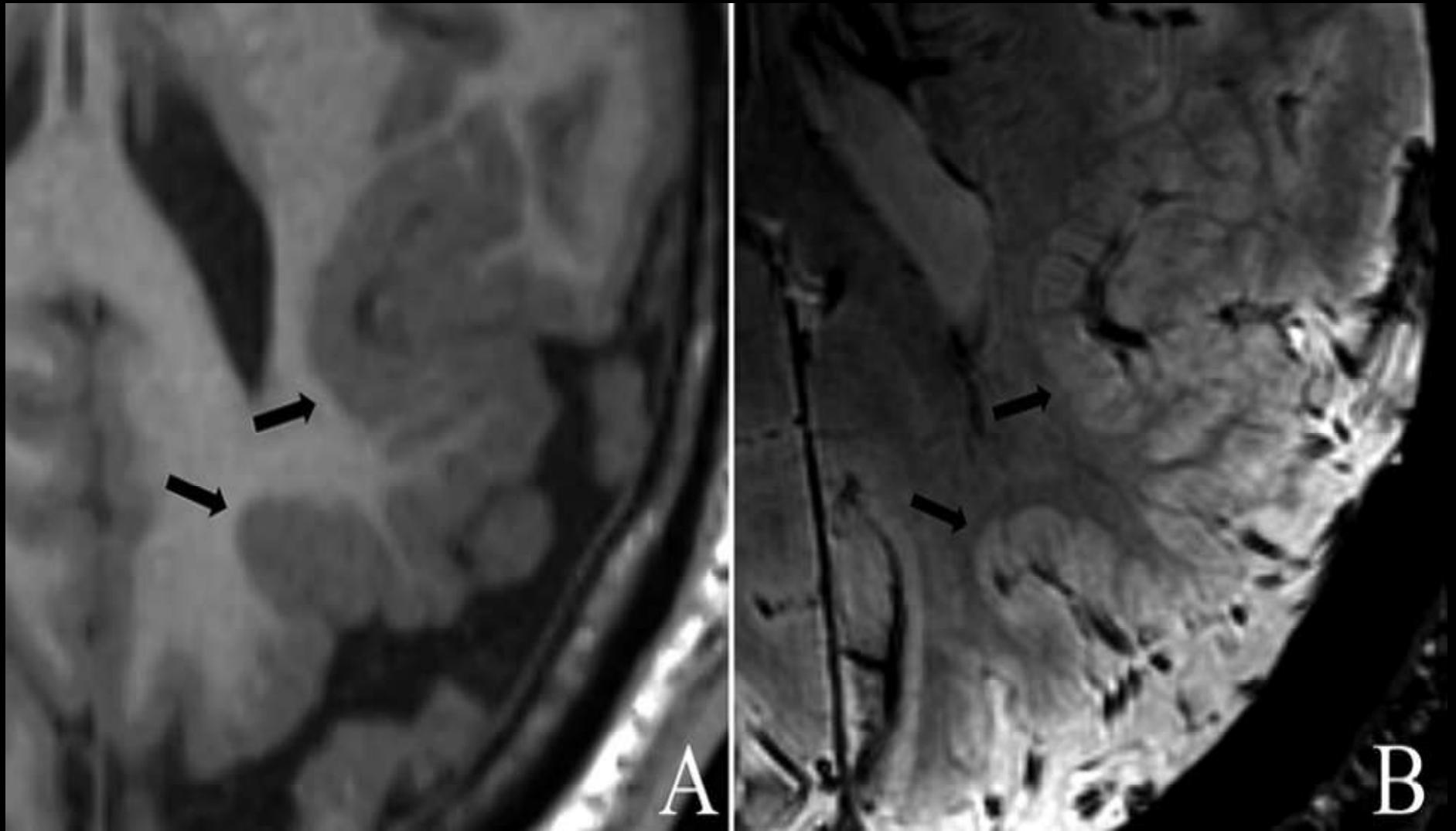


Valutazione morfologica

REALI VANTAGGI

➤ **FLAIR** e altre sequenze 2D vs **3D**
Multiplanarità con spessori sottili (1mm vs 3-4mm)

➤ **7.0T** e oltre
Alta RS e nuova Semeiotica



De Ciantis A, Barkovich AJ, Cosottini M, Barba C, Montanaro D, Costagli M, Tosetti M, Biagi M, Dobyns WB, Guerrini R. Ultra-High-Field MR Imaging in Polymicrogyria and Epilepsy. *Am J Neuroradiol* 2015



La sovrapponibilità anatomica è alla base di molti esami Neuro/Radiologici

**Controllo in malattie pluri-evolutive
(SM, Tumori, Metastasi ecc.)**

**Fondamentale la Sovrapponibilità di protocolli,
sezioni anatomiche, sequenze, ecc.:**

- **Apparecchiature di Diverse Marche**
 - **Sequenze non standardizzate**
 - **Artefatti da Movimento**



Acc: 3
21
Acq Tm: 09

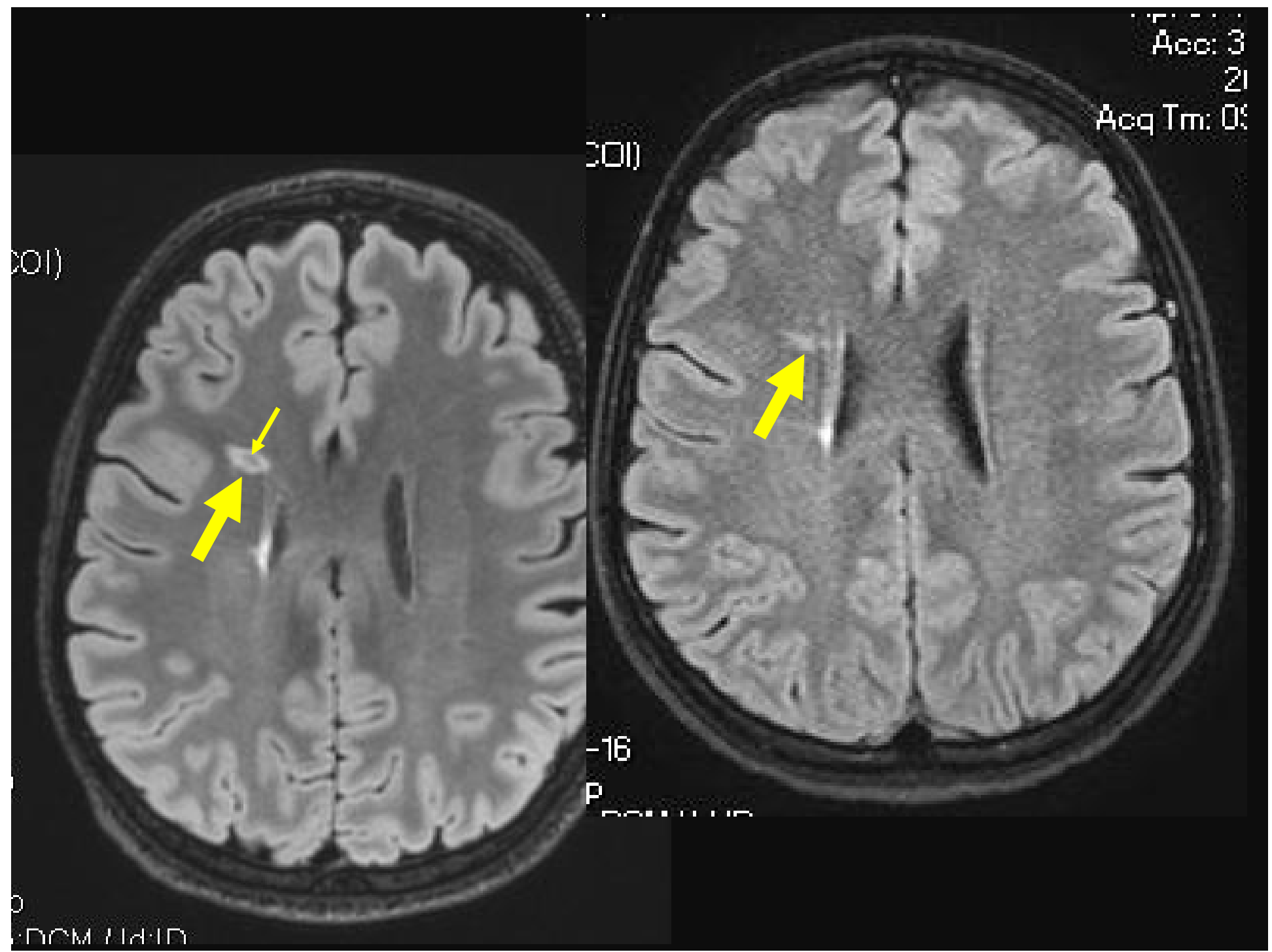
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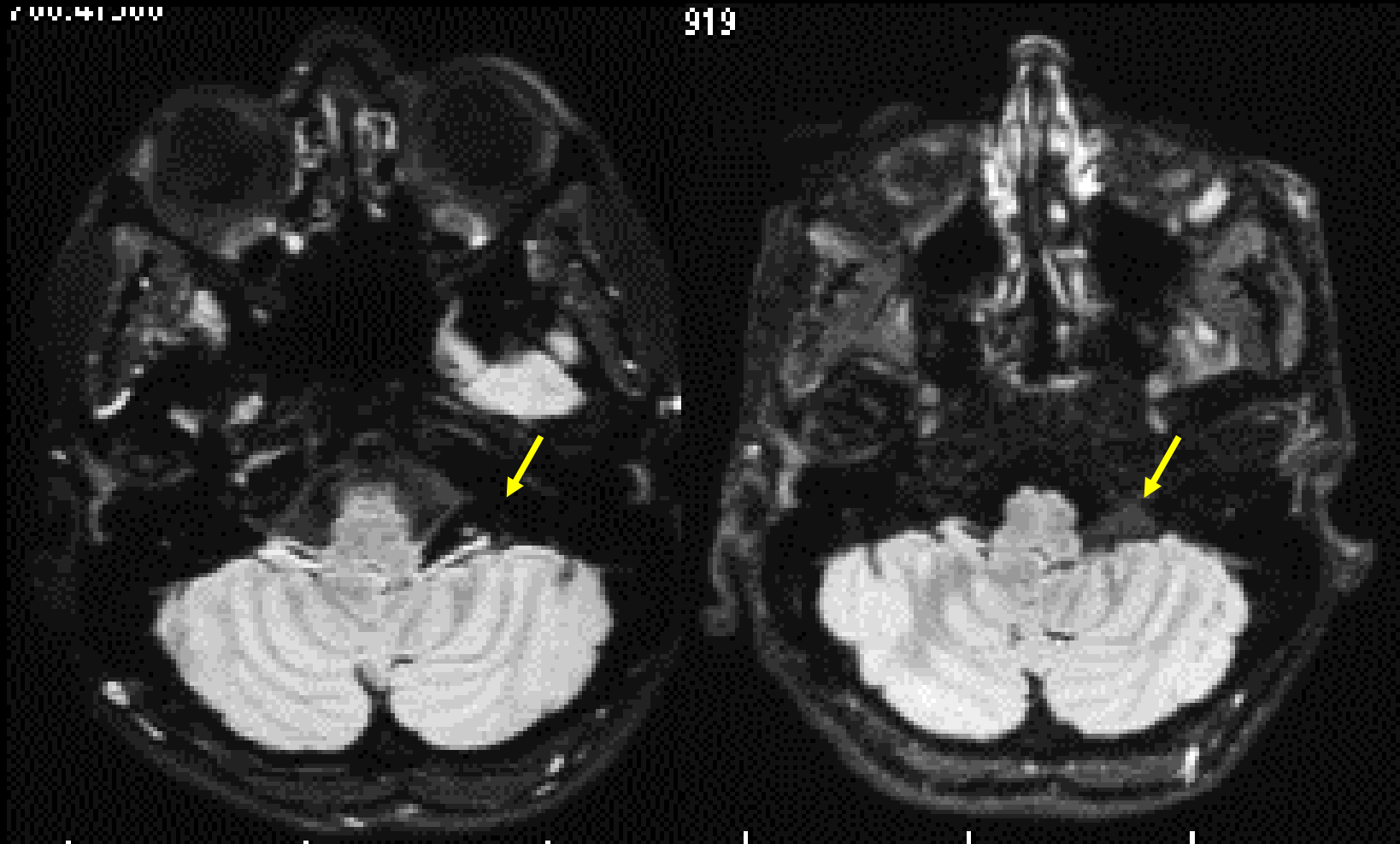
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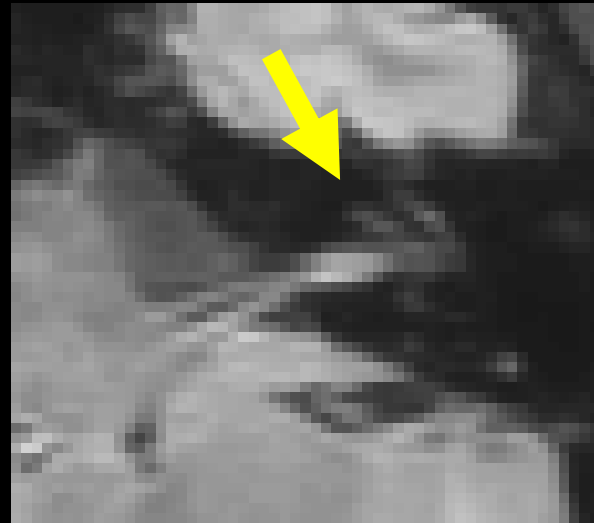
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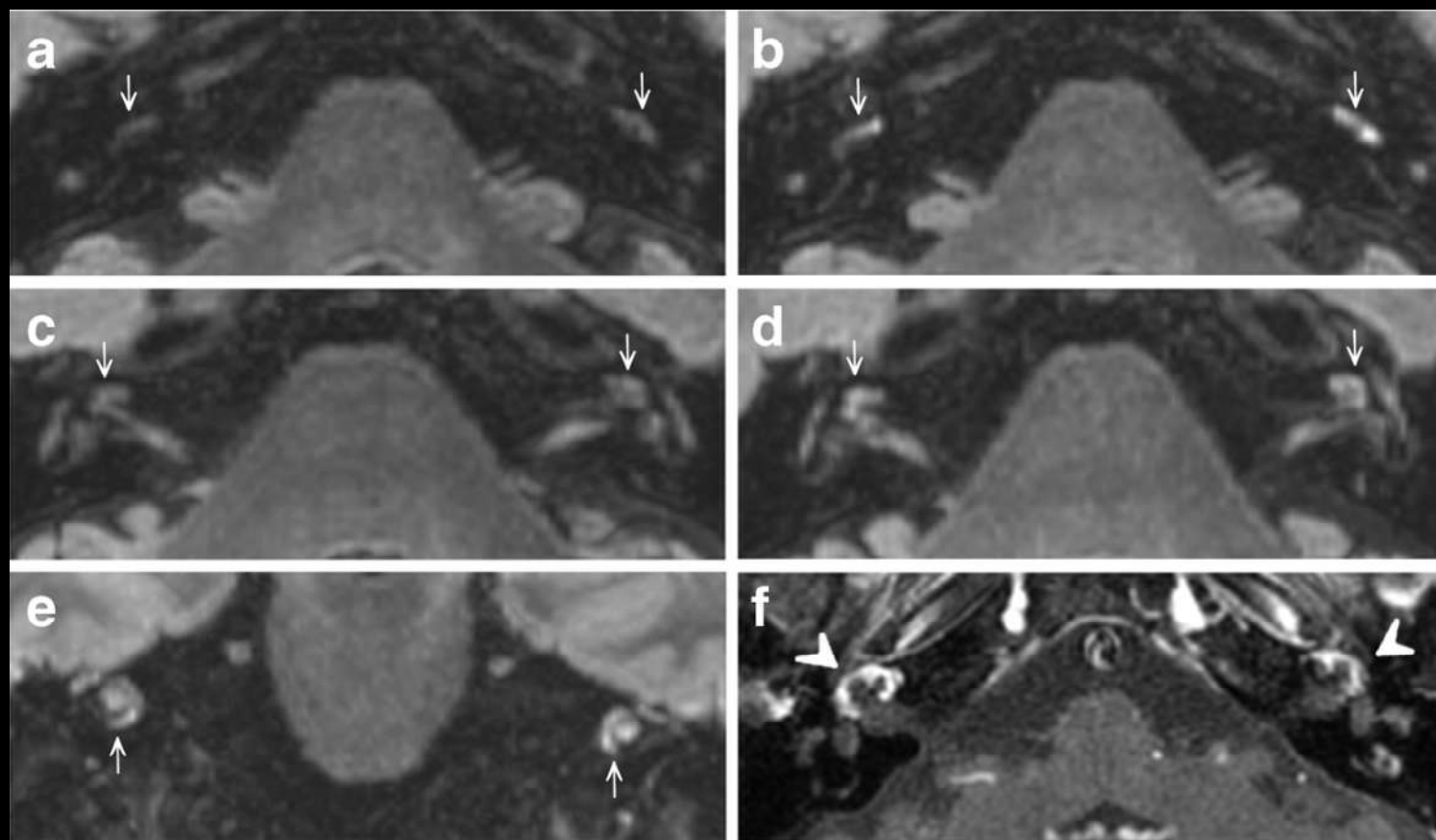


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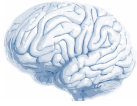
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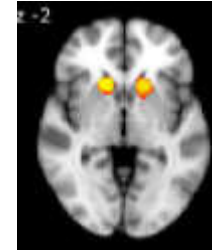


Lombardo F, De Cori S, Aghakhanyan G, Montanaro D, De Marchi D, Frijia F, Fortunato S, Forli F, Chiappino D, Berrettini S, Canapicchi R. 3D-Flair sequence at 3T in cochlear otosclerosis. *Eur Radiol* (2016) 26:3744–3751



Tecniche di quantificazione in Neuroimaging

Volumetria: misura la differenze locali nell'anatomia del cervello (specialmente nella sostanza grigia) usando un approccio statistico.





VOLUMETRIA CEREBRALE

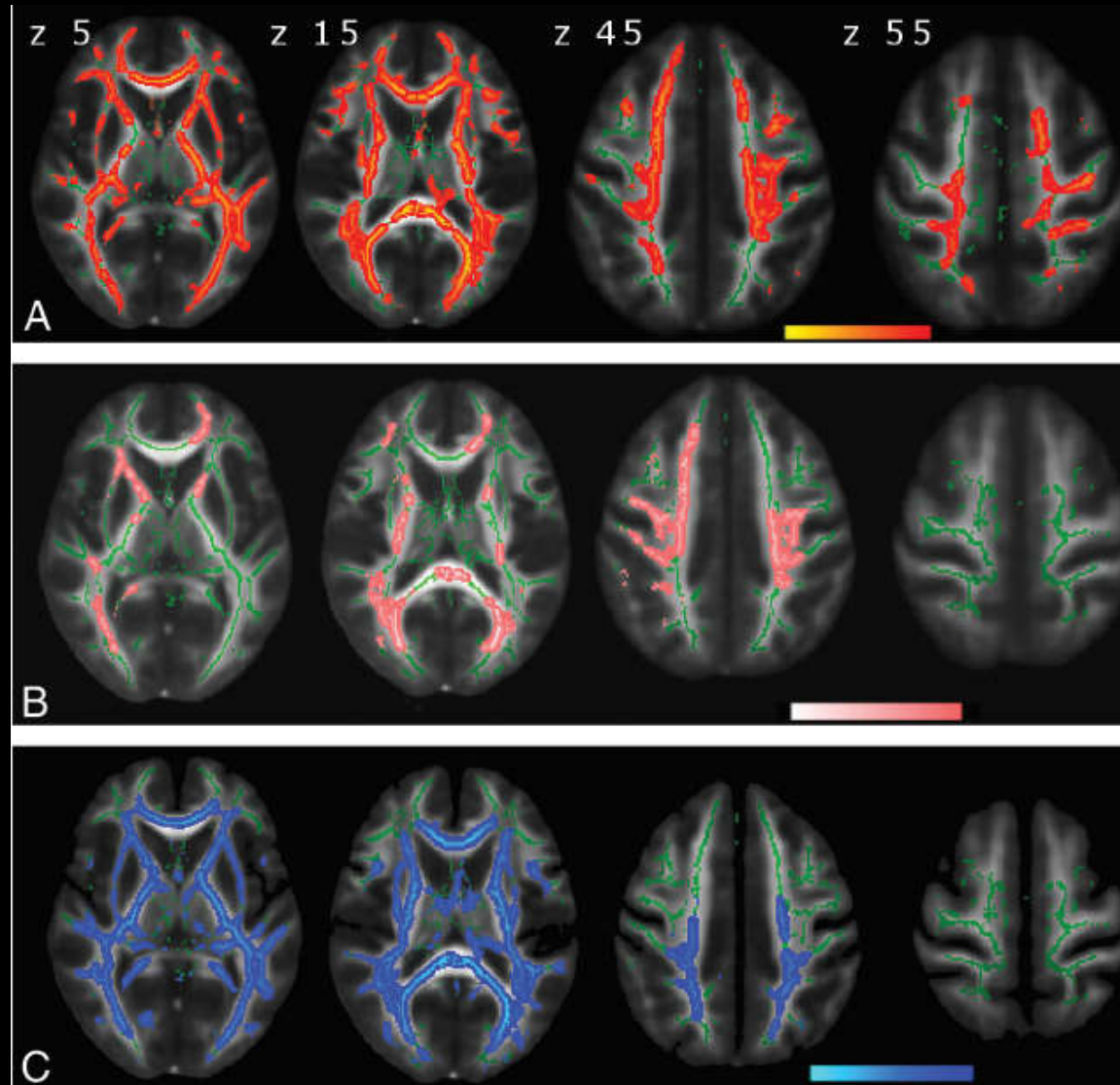
Ambito di ricerca

Ambito patologico

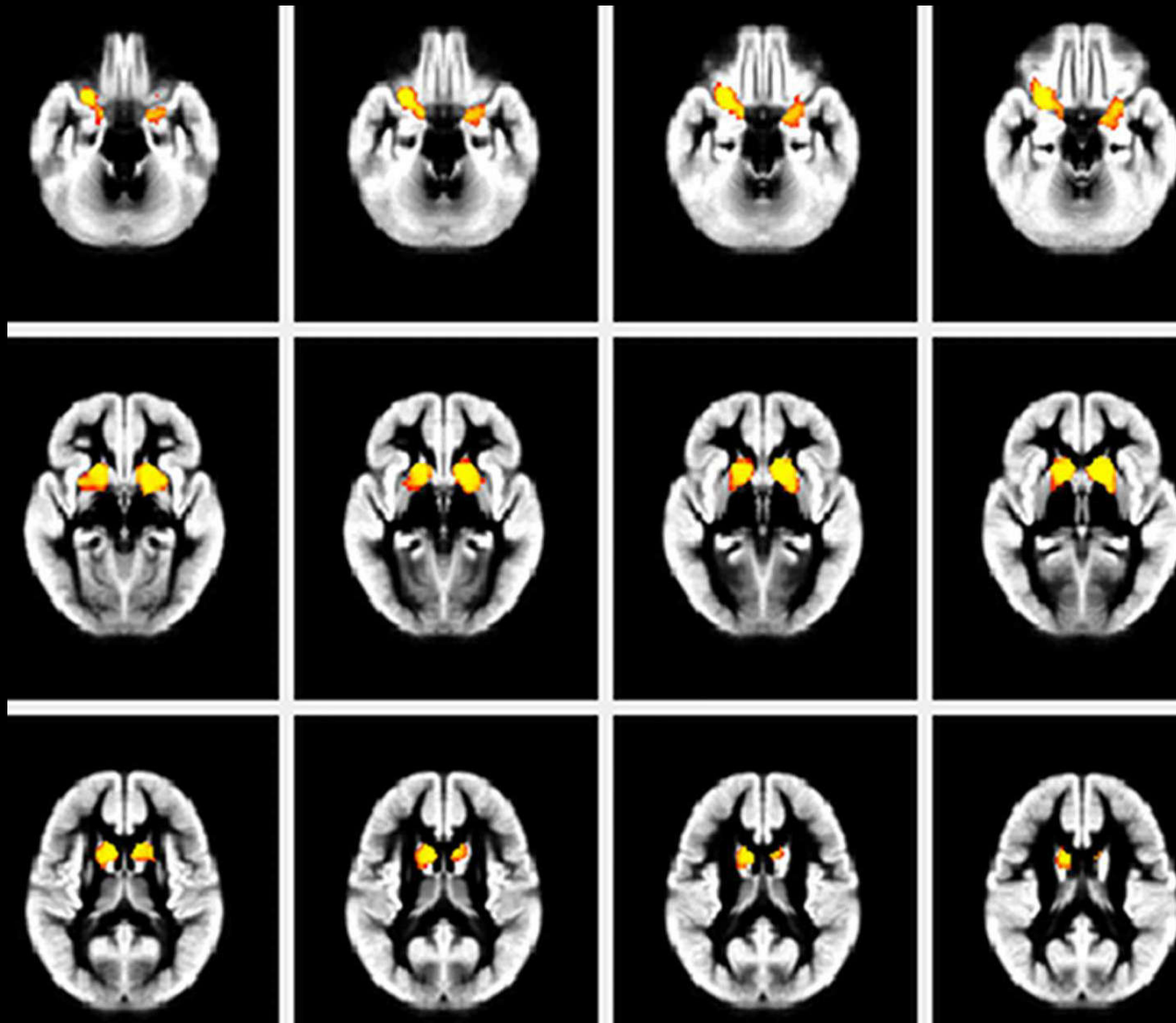
Quadri clinici estremamente complessi, in cui un semplice esame morfologico di RM non fornisce alcun elemento informativo

Analisi di Gruppo





Aghakhanyan G, Martinuzzi A, Frijia F, Vavla M, Hlavata H, Baratto A, Martino N, Paparella G, Montanaro D. Brain White Matter Involvement in **Hereditary Spastic Paraplegias**: Analysis with Multiple Diffusion Tensor Indices. AJNR 2014



Aghakhanyan G, Bonanni P, Randazzo G, Nappi S, Tessarotto F, De Martin L, Frijia F, De Marchi D, De Masi F, Koppers B, Lombardo F, Caramella D, Montanaro D. From Cortical and Subcortical Grey Matter Abnormalities to Neurobehavioral Phenotype of **Angelman Syndrome**: A Voxel-Based Morphometry Study. PLOS ONE |September 14, 2016.



VOLUMETRIA CEREBRALE

Ambito di ricerca

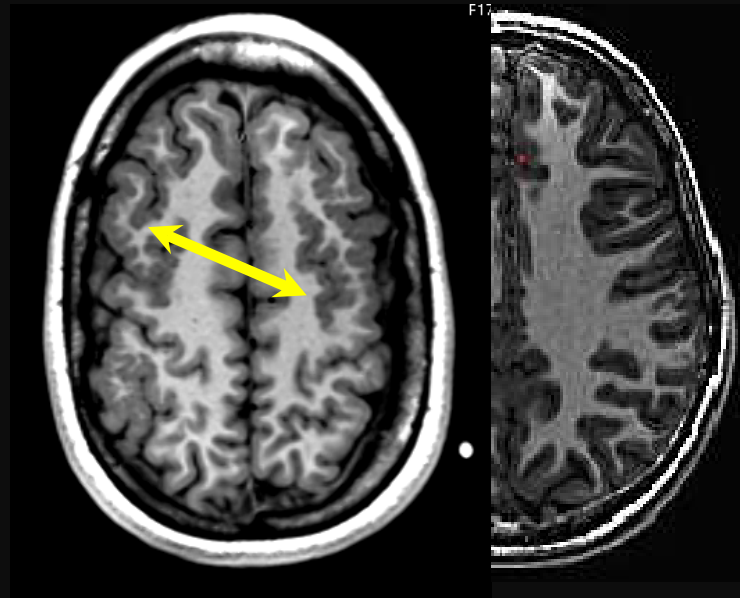
Ambito patologico

Quadri clinici estremamente complessi, in cui un semplice esame morfologico di RM non fornisce alcun elemento informativo.

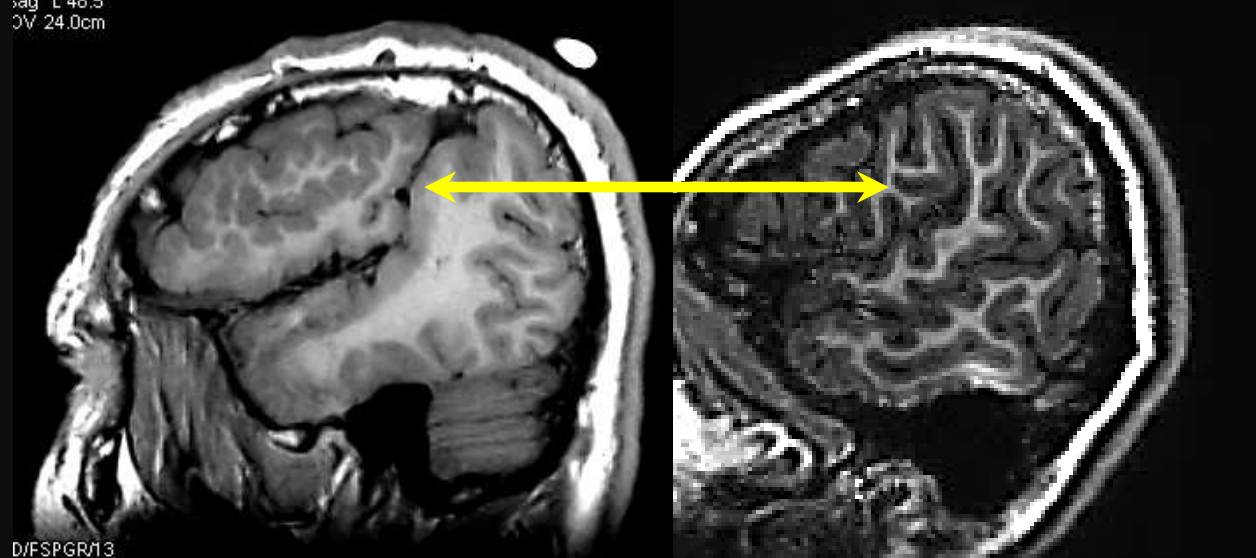
Analisi per singolo soggetto



**Anatomia
«normale» vs
Anatomia
Malformativa**

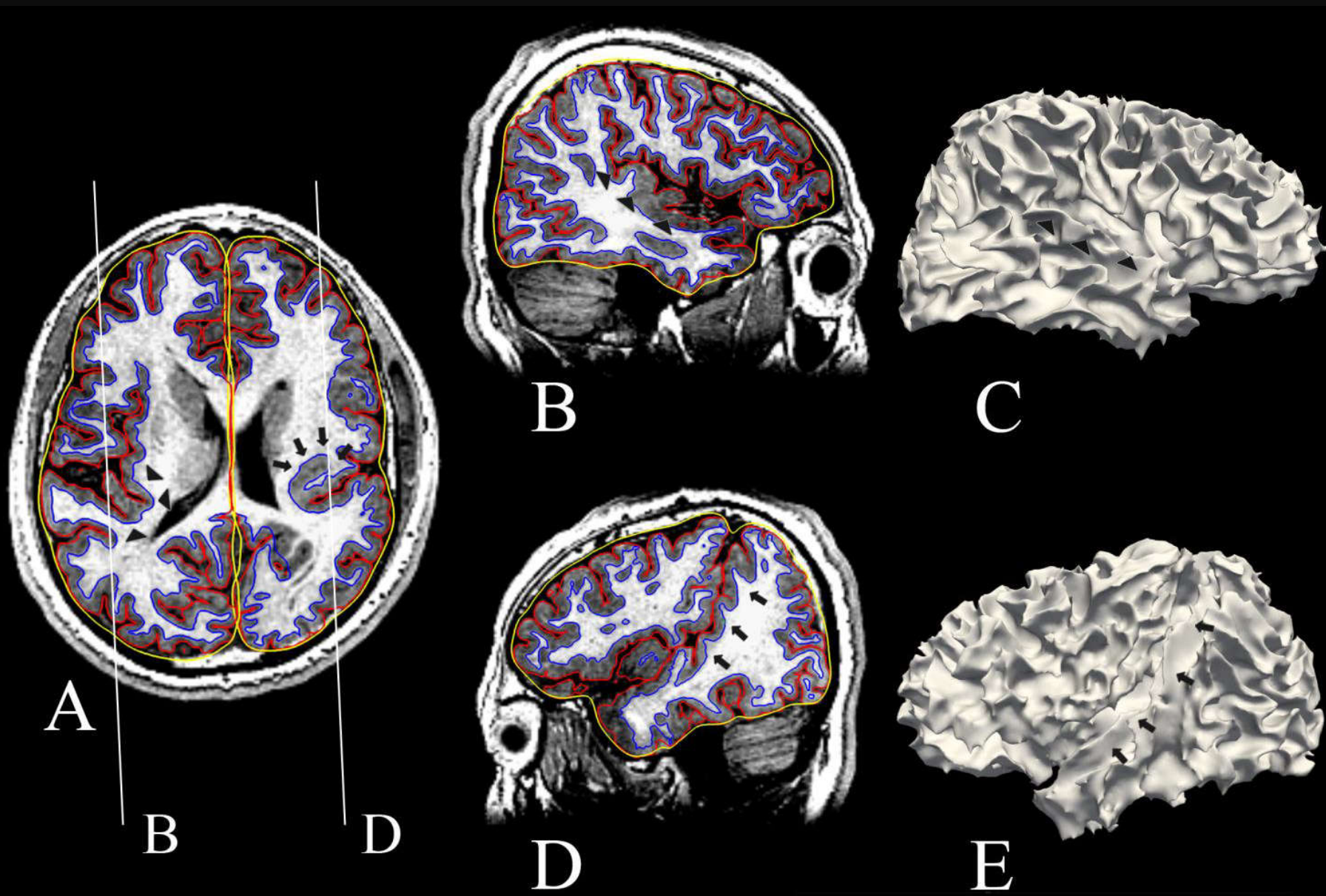


sag L 40.3
OV 24.0cm



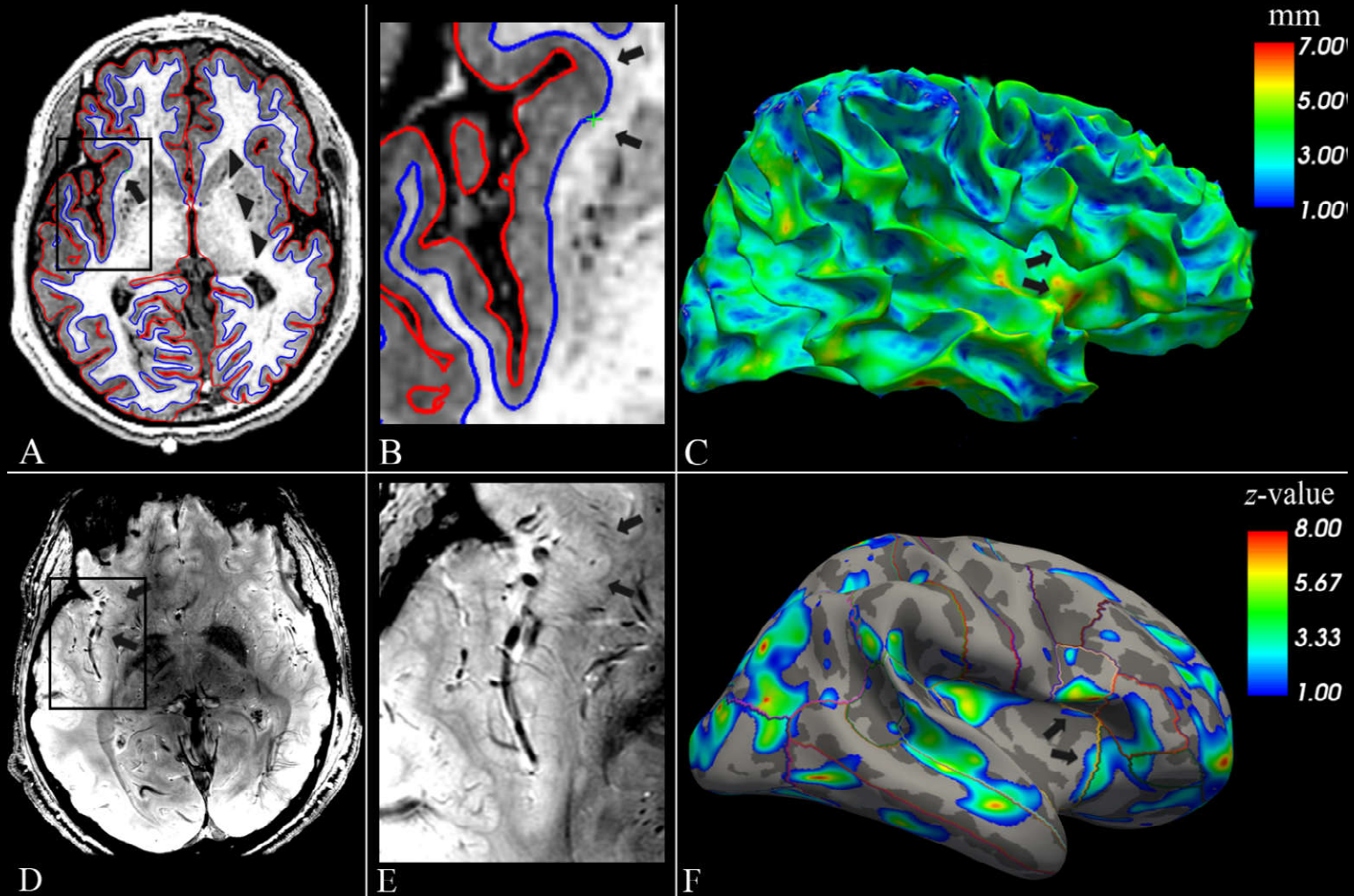
Anatomia «normale» vs Anatomia Malformativa

Valutazione Automatica/Semiautomatica



Anatomia «normale» vs Anatomia Malformativa

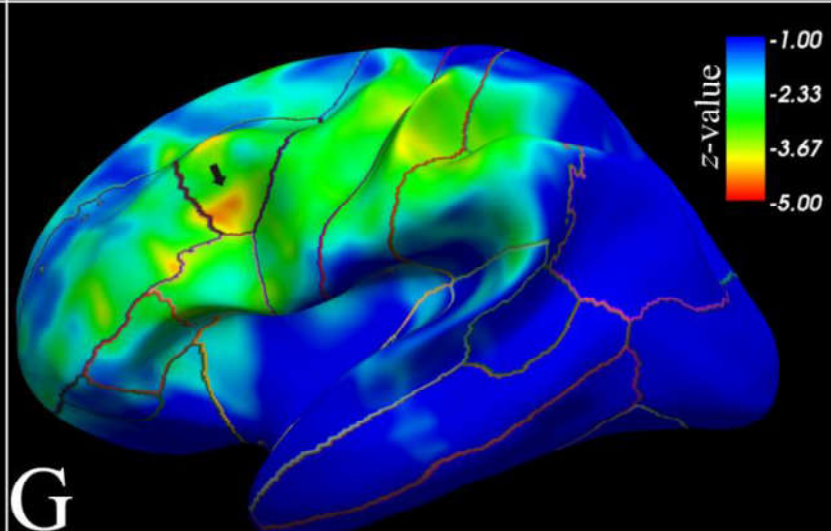
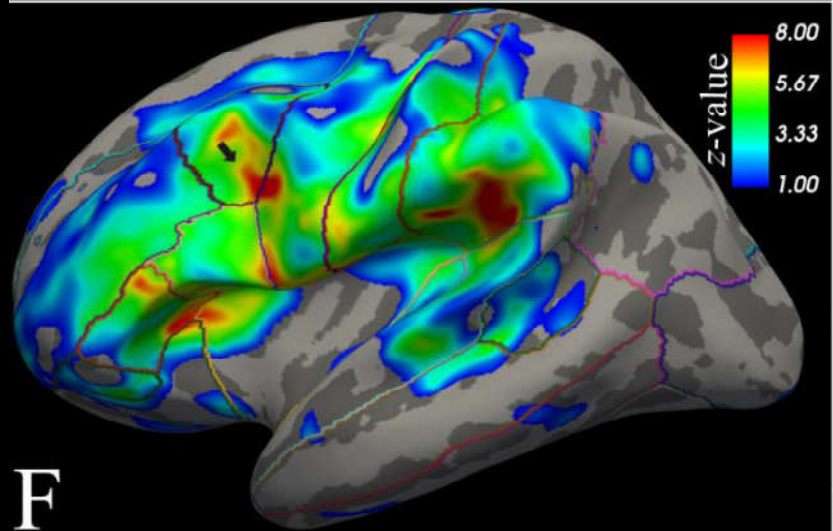
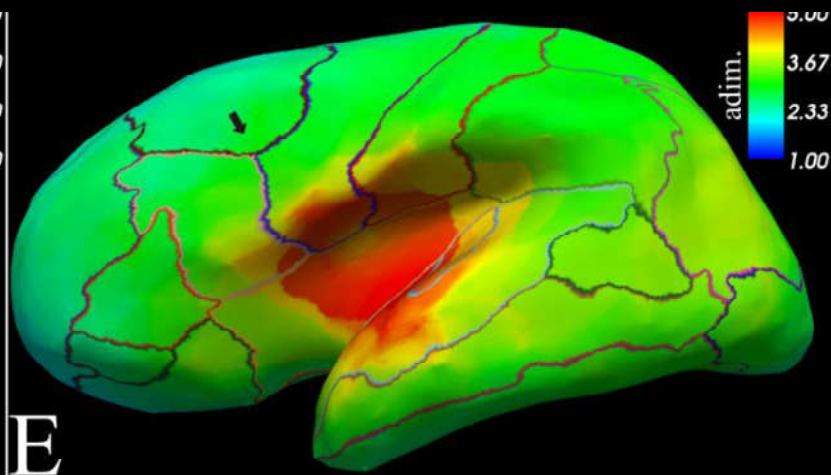
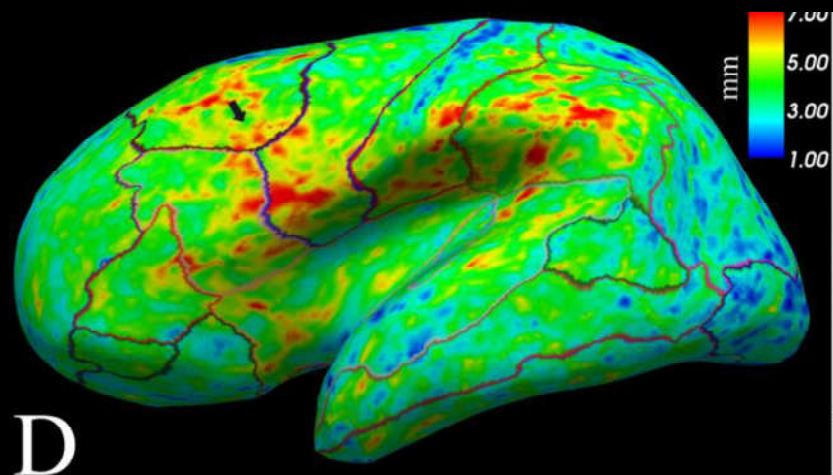
Valutazione Automatica/Semiautomatica



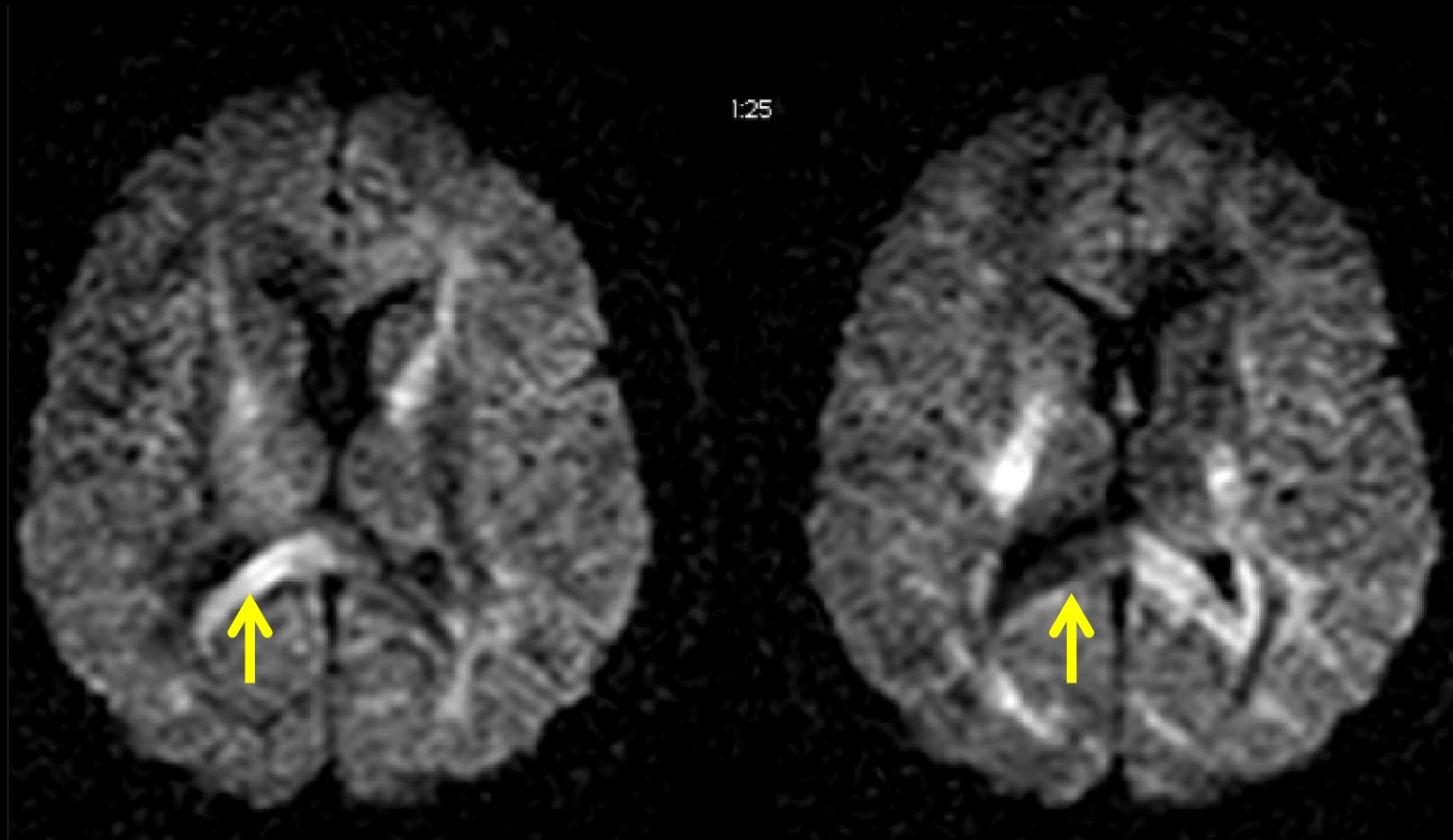
Lenge M, Barba C, Montanaro D, Aghakhanyan G, Frijia F, Guerrini R. Relationships Between Morphologic and Functional Patterns in the Polymicrogyric Cortex. *Cerebral Cortex*, 2017; 1–11

Anatomia «normale» vs Anatomia Malformativa

Valutazione Automatica/Semiautomatica

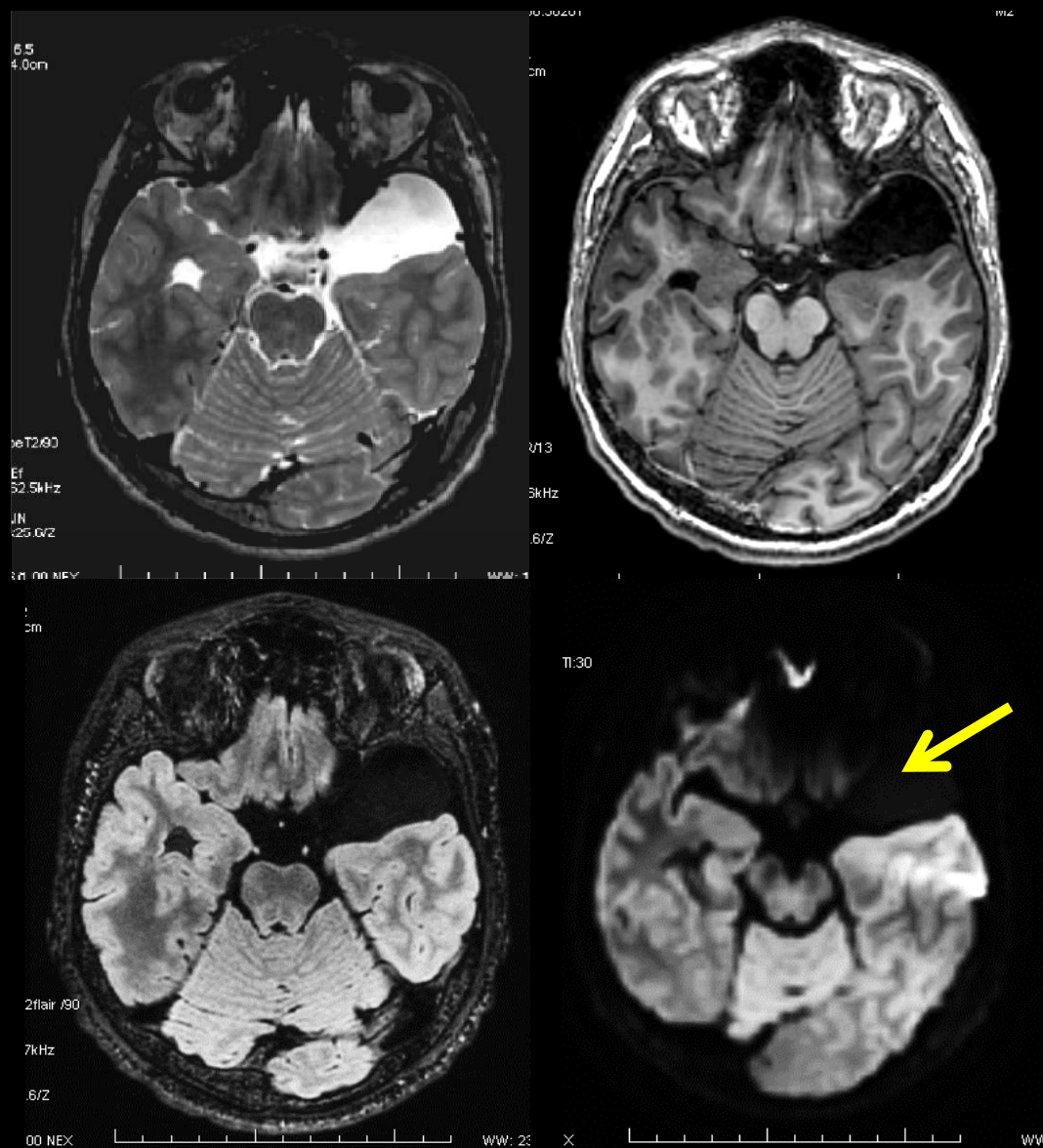


**Immagini pesate in DIFFUSIONE
QUESTA è L'ORIGINE**

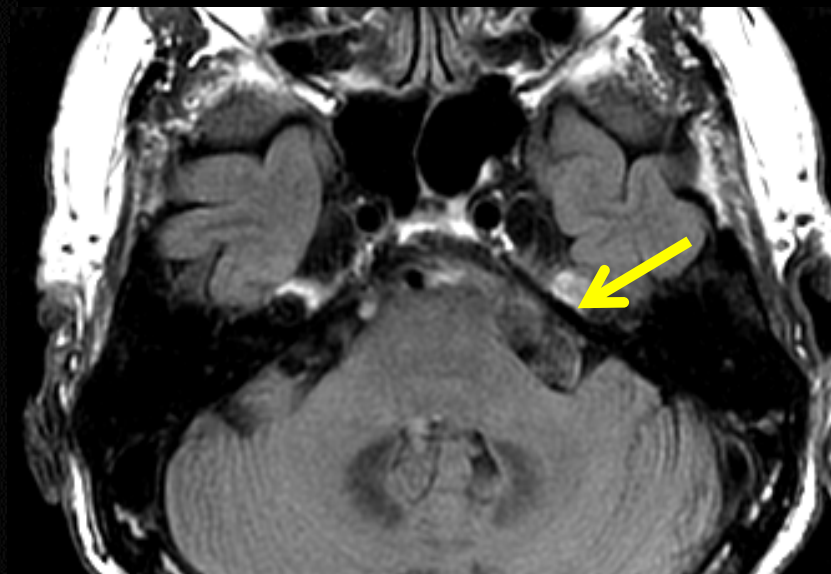
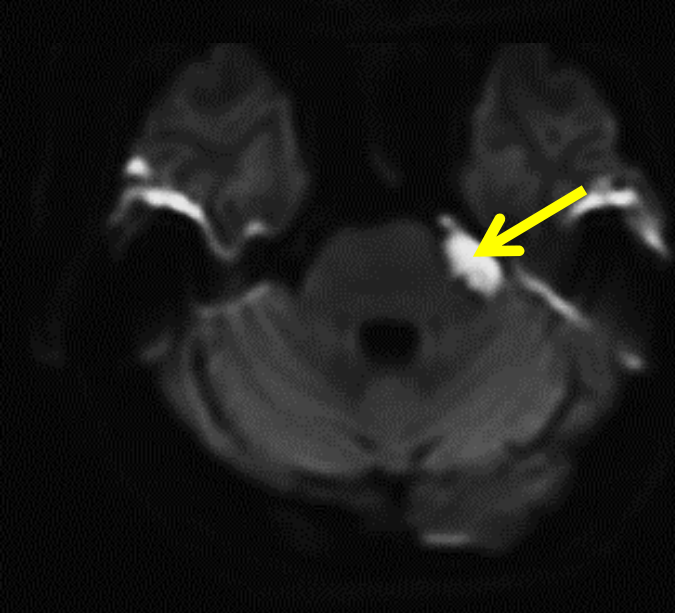
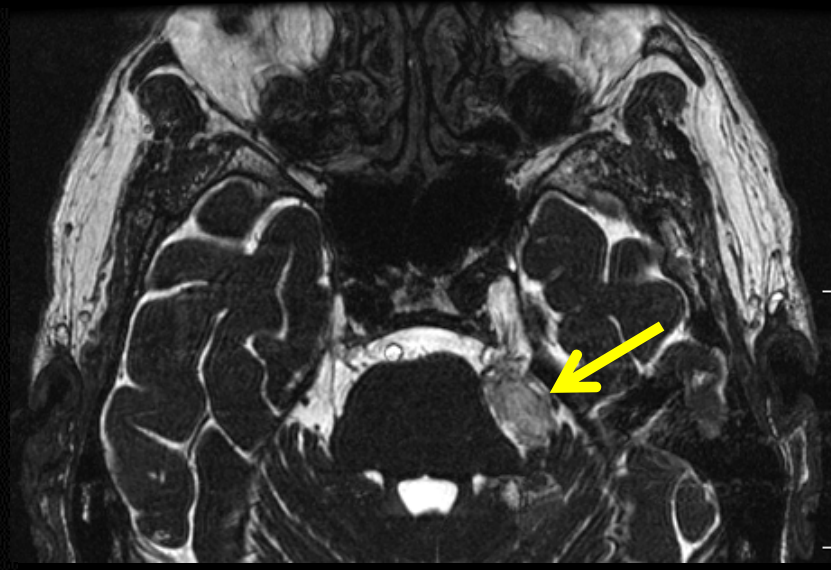
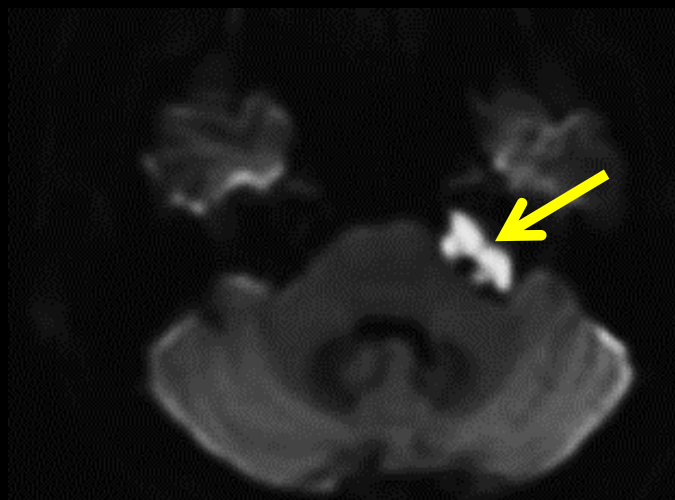


Montanaro D., Tosetti M. «Diffusione con RM» in: «Compendio di Risonanza Magnetica»,
Ed. G. Dal Pozzo, 2009. In stampa aggiornamento 2018 (?).

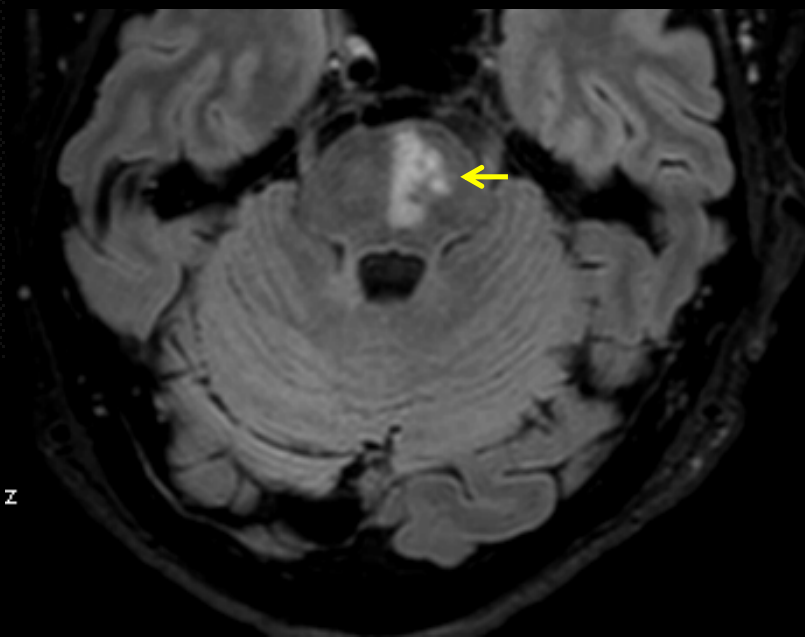
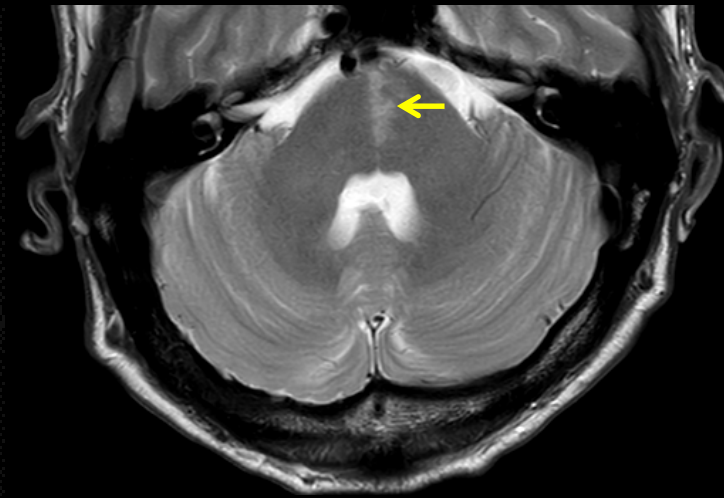
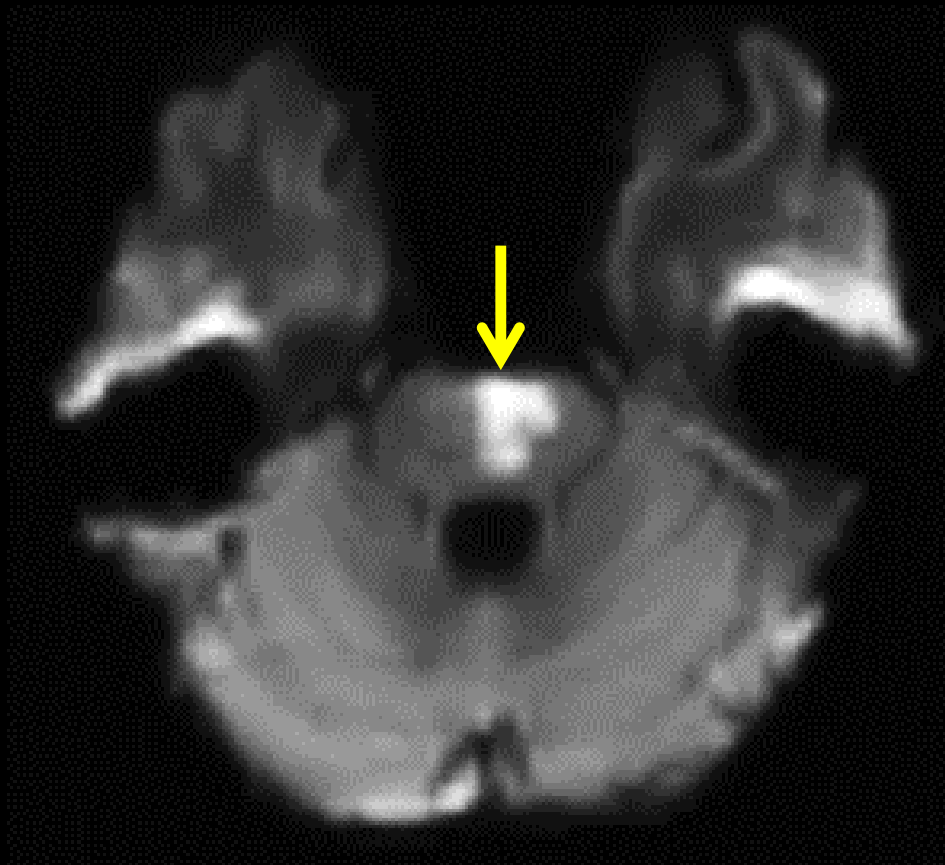
Abbiamo avuto Conferme dei Contenuti Liquidi Liberi



... e imparato a distinguerli da altre forme di accumuli apparentemente liquidi ma a contenuto cellulare particolare

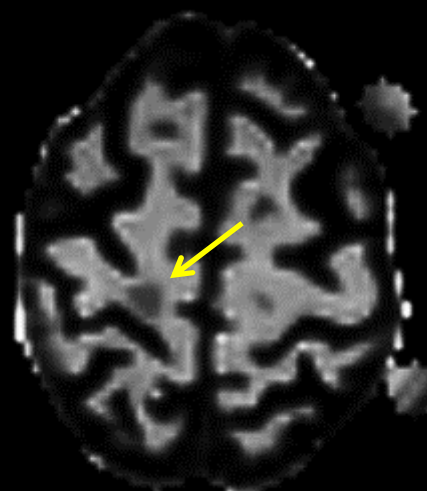
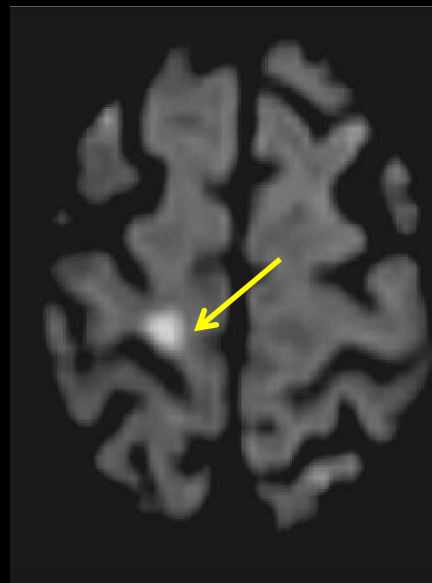
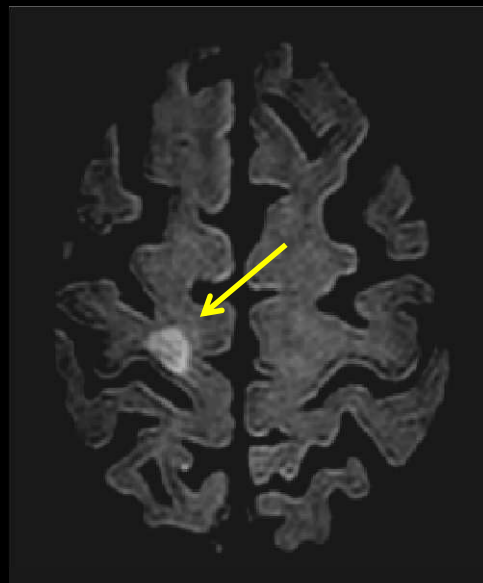


Espressioni simili ma natura **COMPLETAMENTE** differente



z

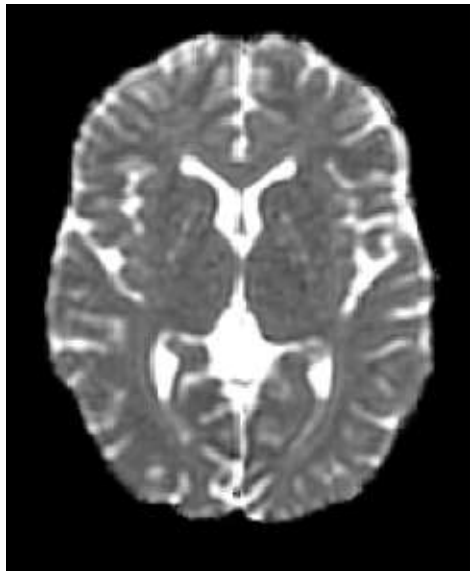
A parità di lesione, espressioni differenti... artefatti



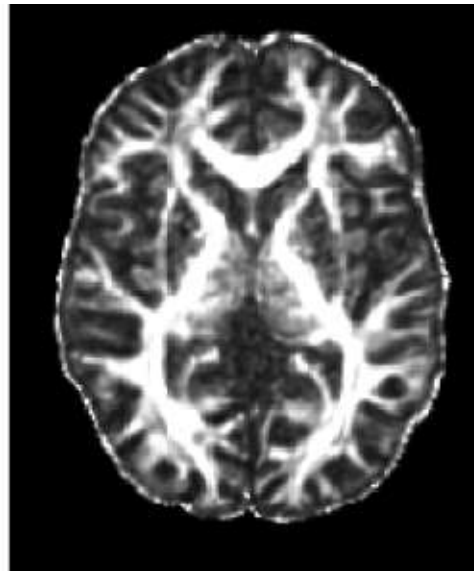


Rivalutazione dei parametri per Rappresentazioni più complesse: NUMERO ELEVATO DI GRADIENTI E APPLICAZIONE DEL TENSORE

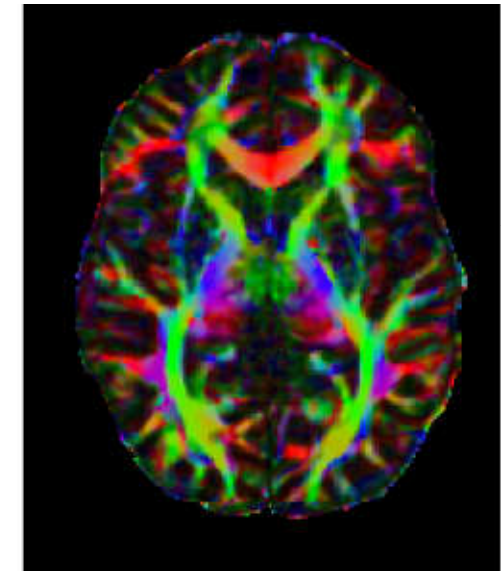
mADC



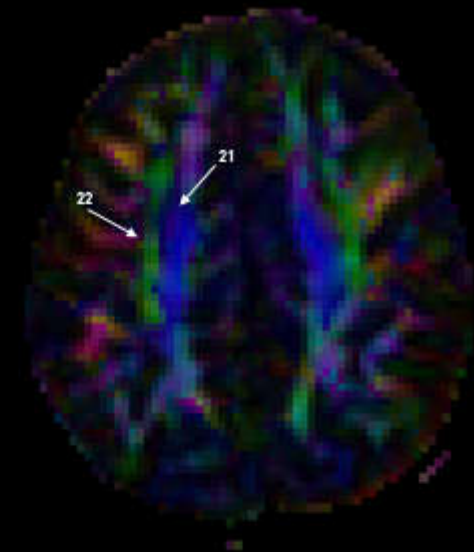
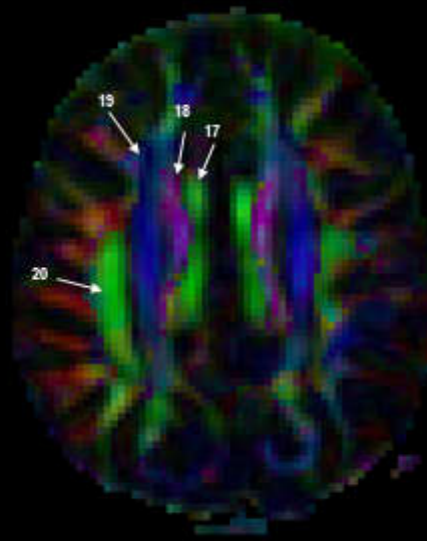
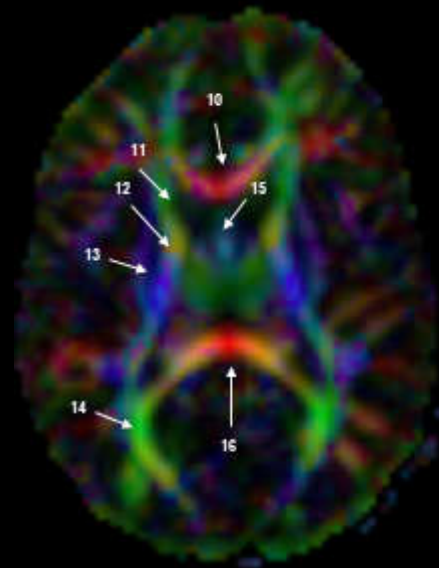
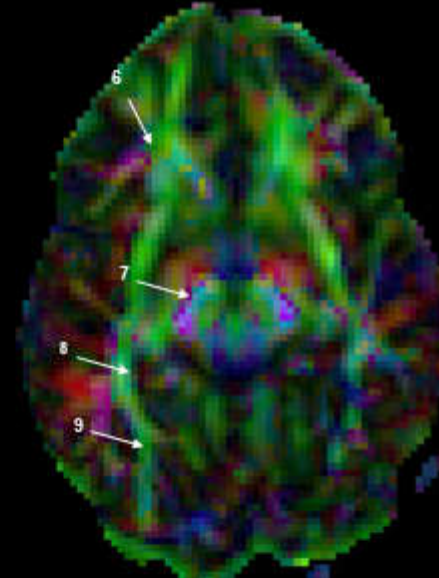
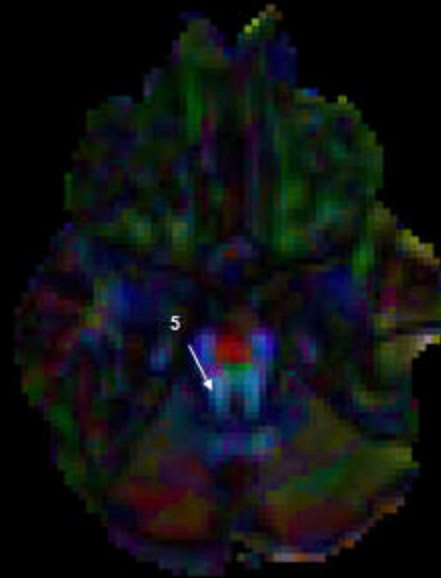
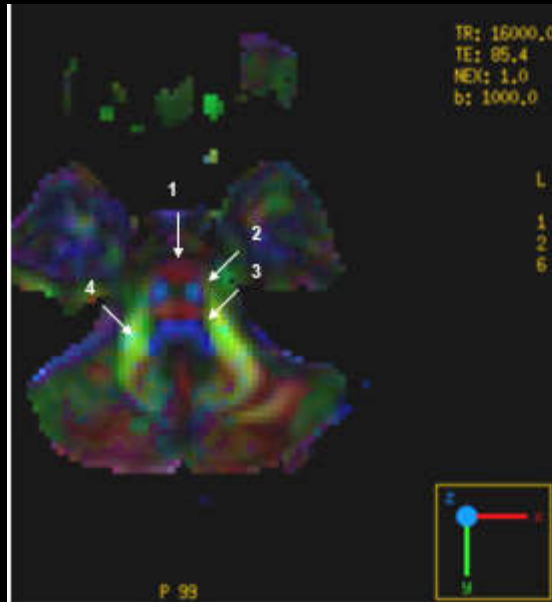
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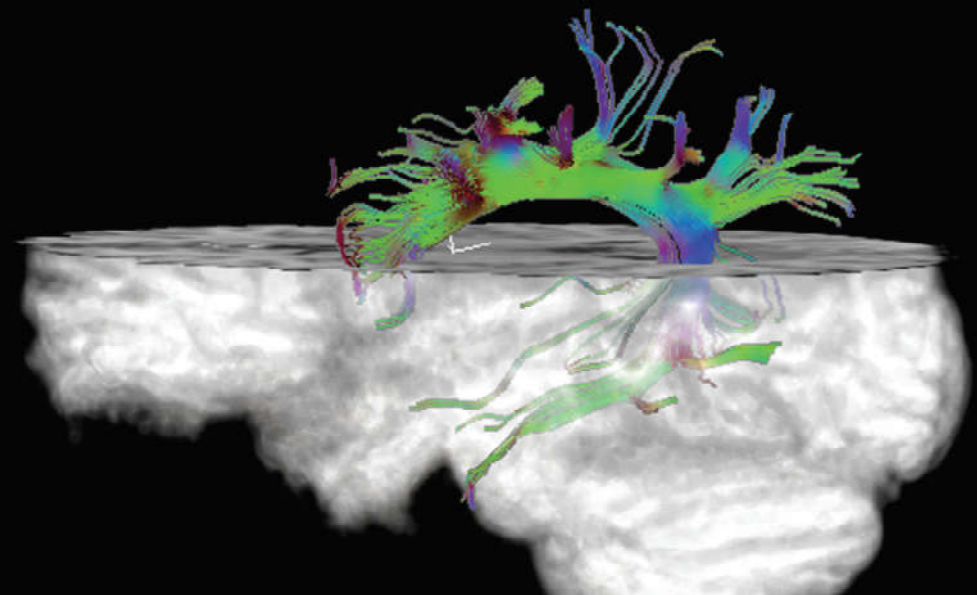
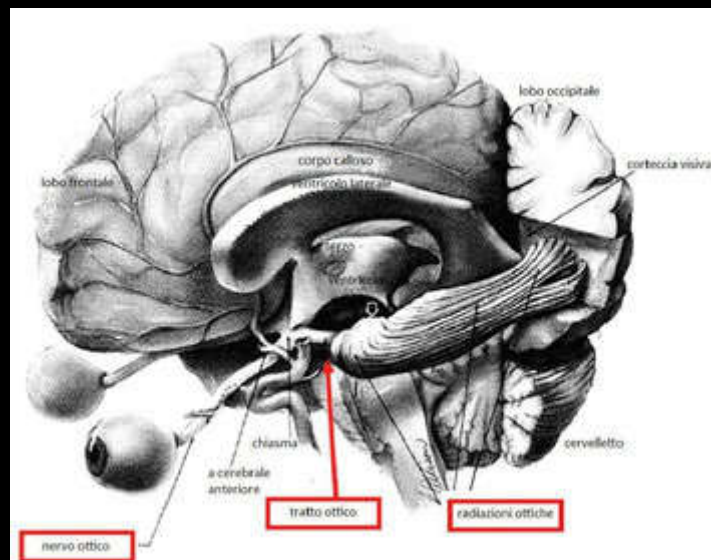
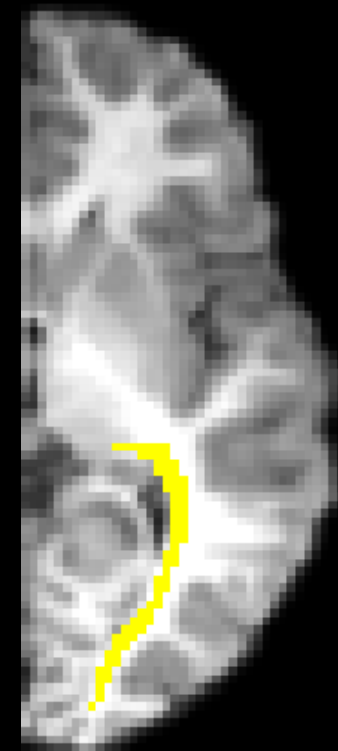
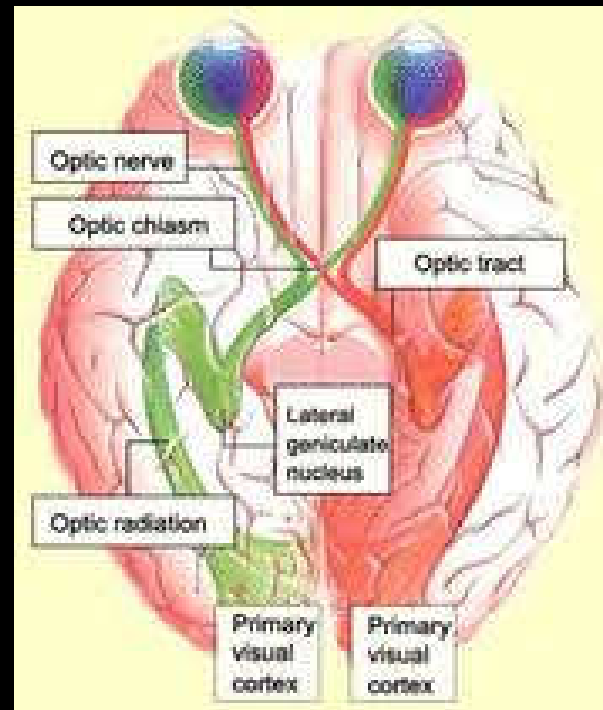
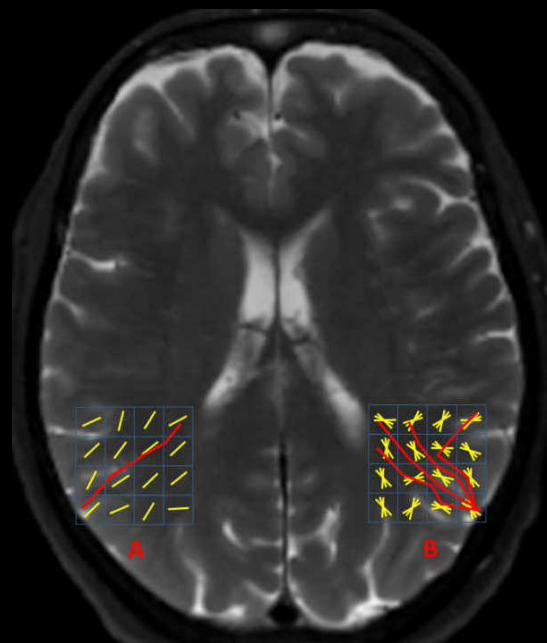
Color Map



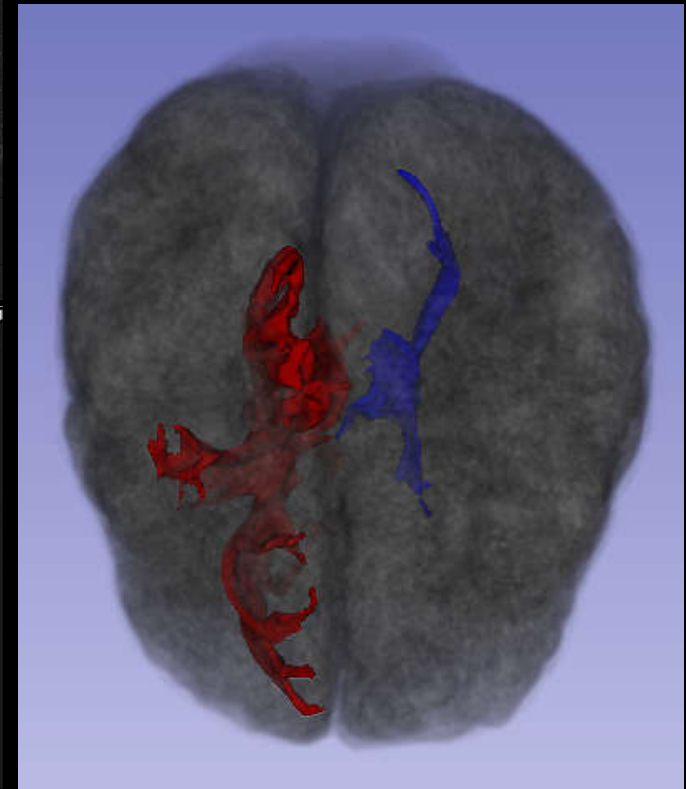
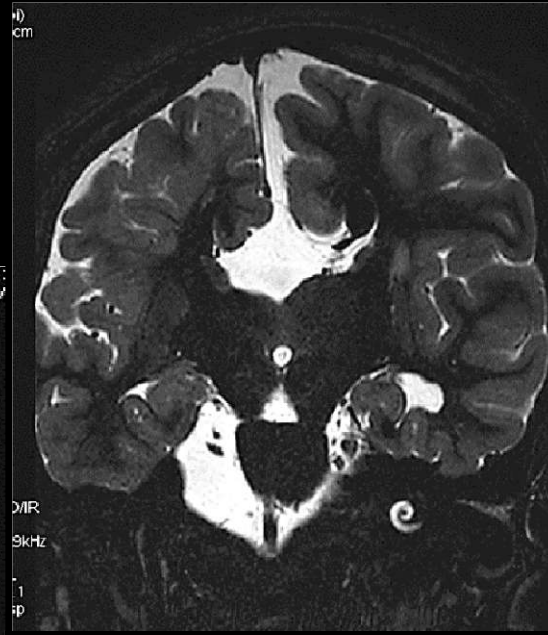
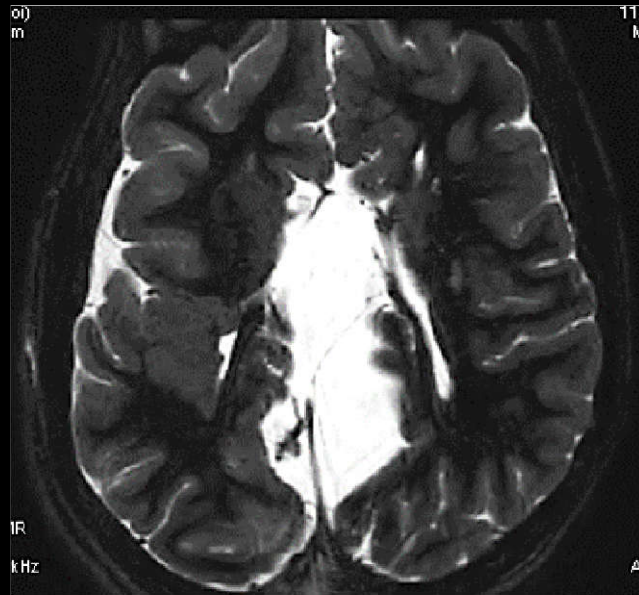
Trattografia: Anatomia Funzionale dei fasci di sostanza bianca



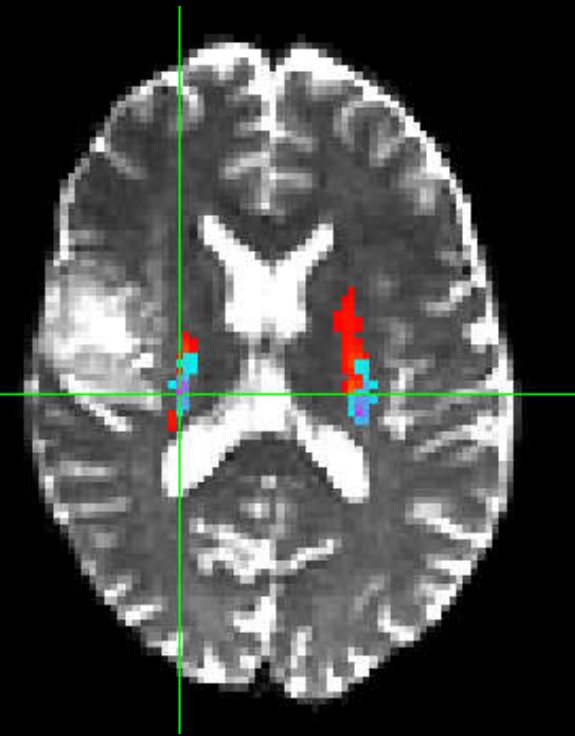
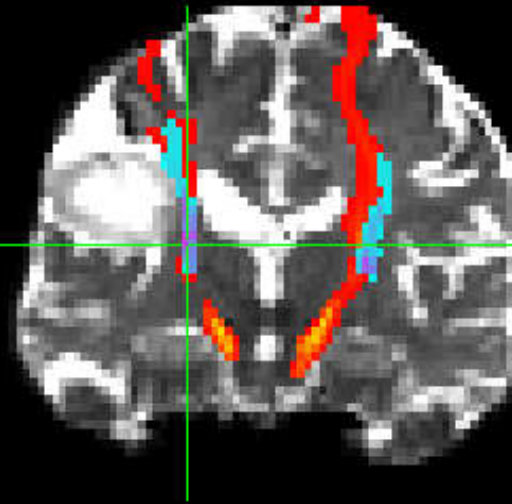
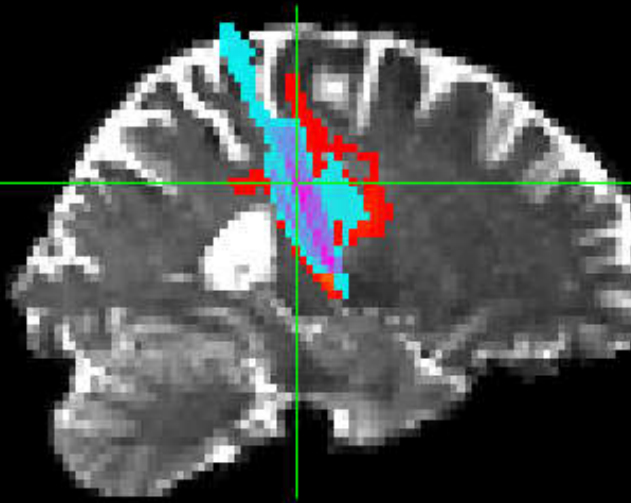
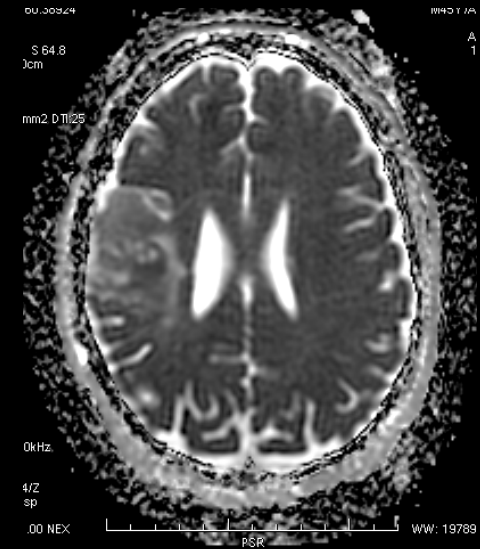
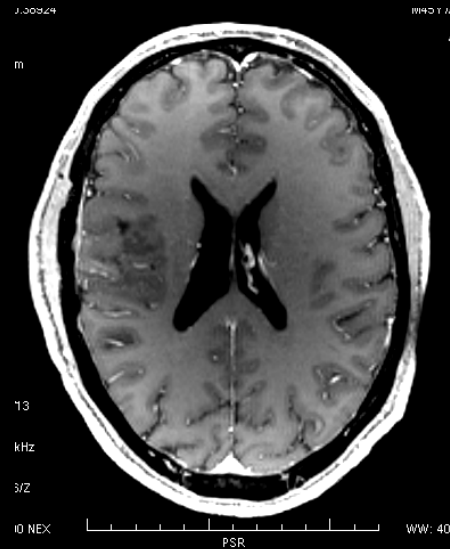
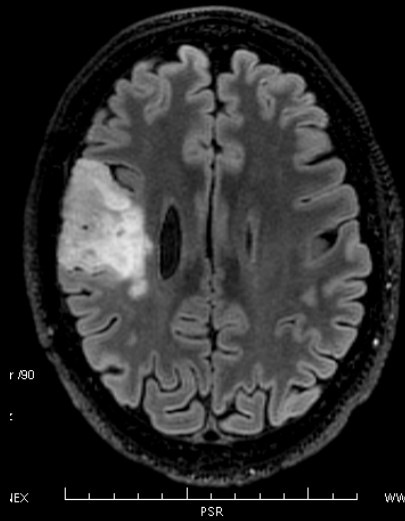
Trattografia



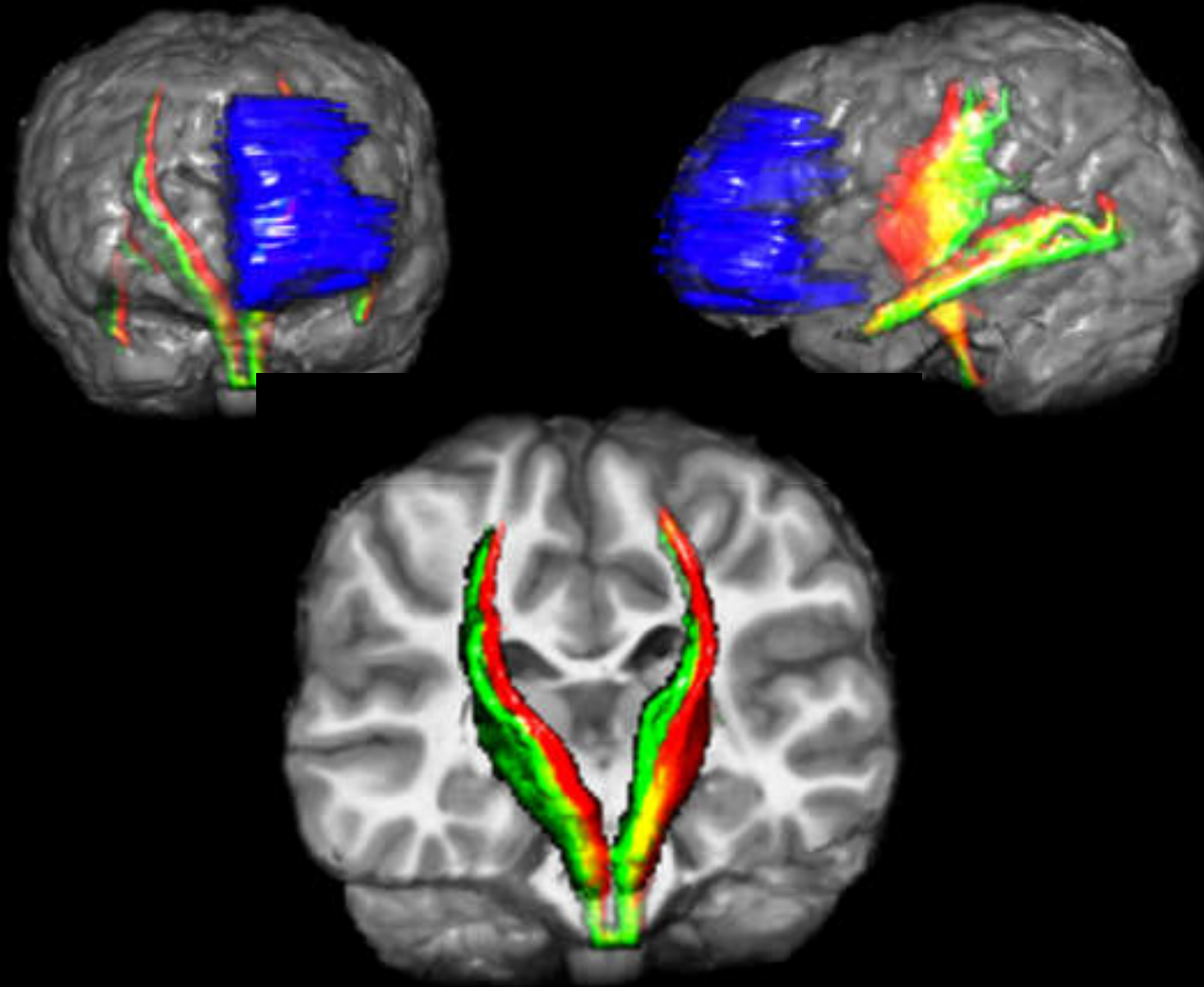
Trattografia: Malformazioni



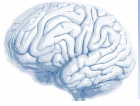
Trattografia: Lesione espansiva



Trattografia: pre- e post-Chirurgia. Plasticità Cerebrale



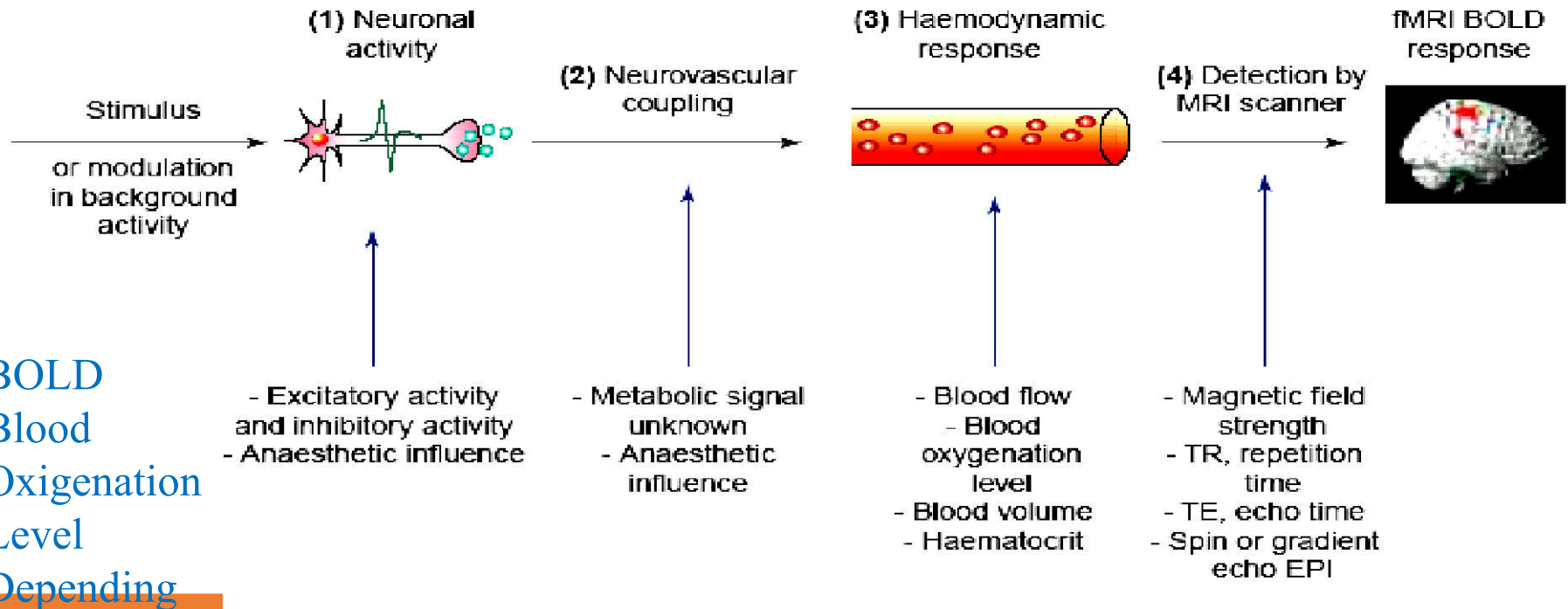
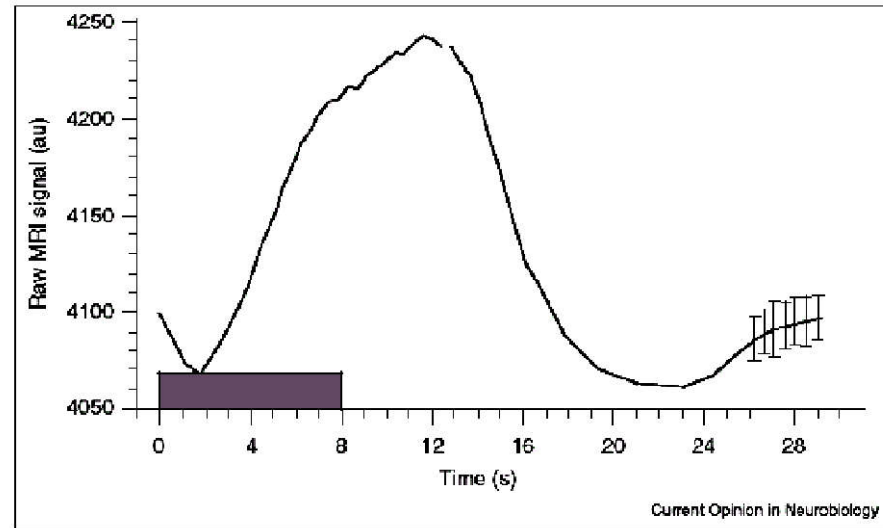
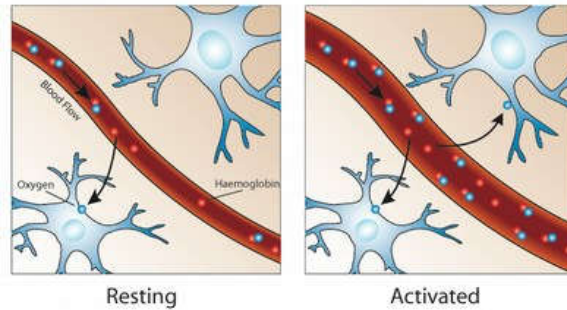
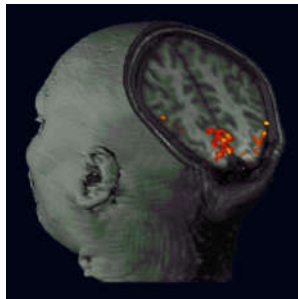
Grant agreement RF-2010-2309954, 2012-2016 "Reorganization of cortical function after surgery for lesional epilepsy in children". Ospedale Pediatrico "Meyer", Firenze- Fondazione G. Monasterio, Pisa.



BOLD - Functional Magnetic Resonance Imaging fMRI

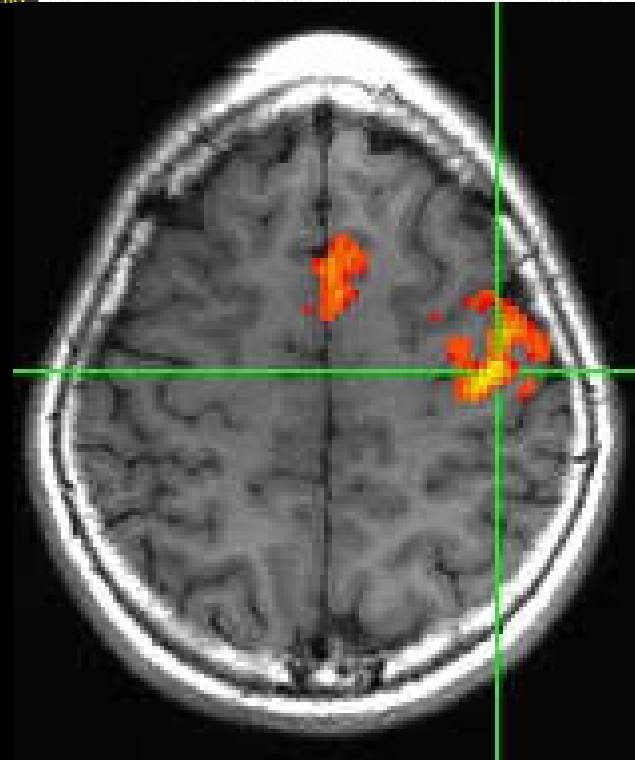
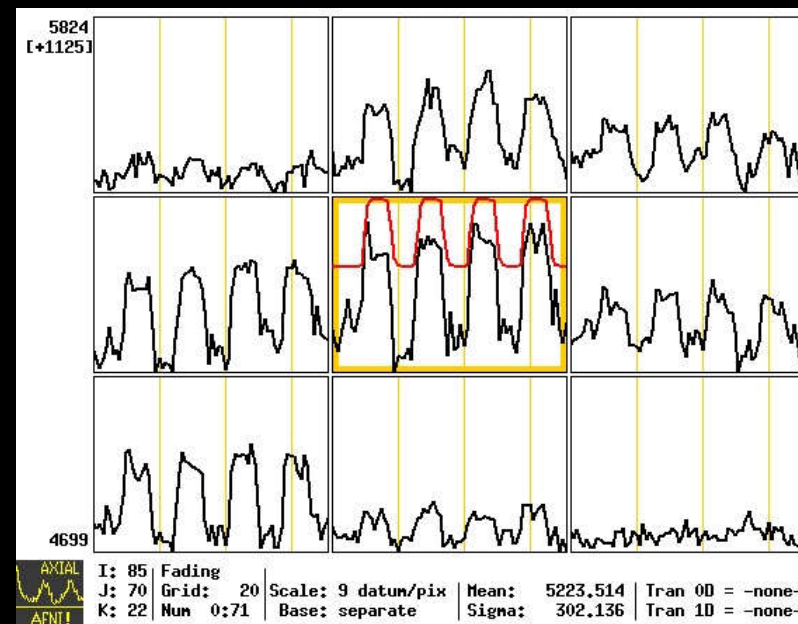


Belliveau et al., Science 1991



BOLD
Blood
Oxygenation
Level
Depending

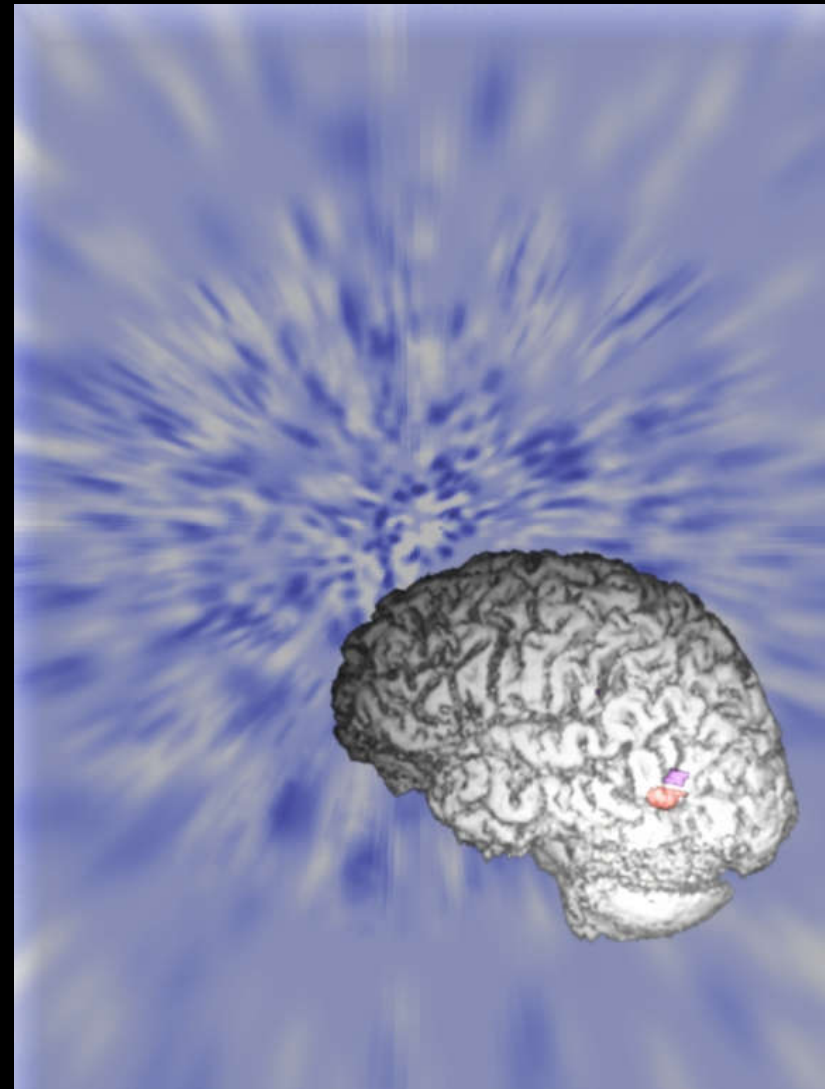
Stimolo Sensitivo



ROTATION / NOISE



TRANSLATION / NOISE

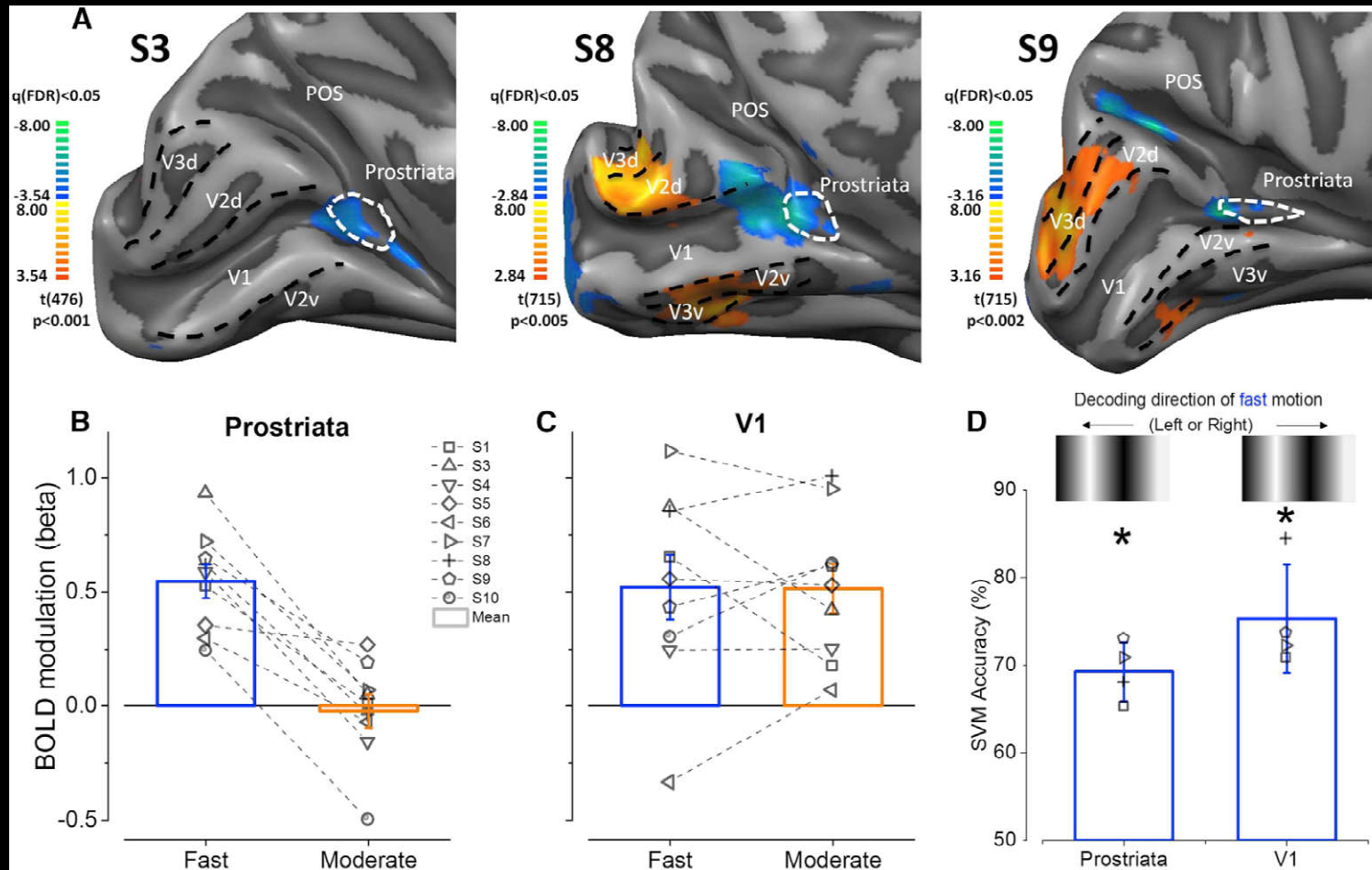


M. C. Morrone , M. Tosetti , D. Montanaro , A. Fiorentini , G. Cioni and D. C. Burr. A cortical area that responds specifically to optic flow, revealed by fMRI
Nature Neuroscience • volume 3 no 12 • December 2000

Utilizzo di strumentazione dedicata

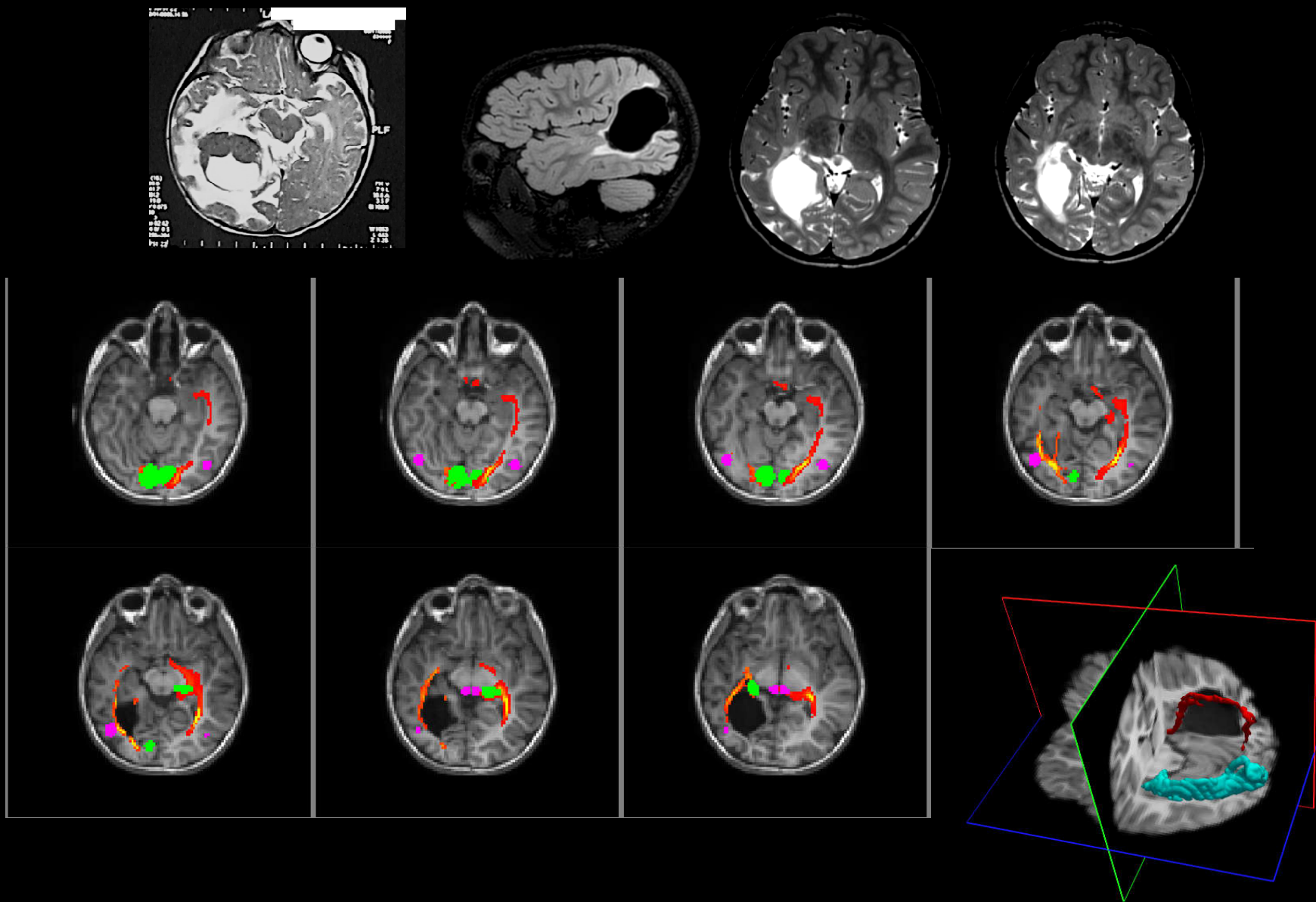


Greco V, Frijia F, Mikellidou K, Montanaro D, Farini A, D'Uva M, Poggi P, Pucci M, Sordini A, Morrone MC, Burr DC. A low-cost and versatile system for projecting wide-field visual stimuli within fMRI scanners. *Behav Res Methods*. 2016 Jun



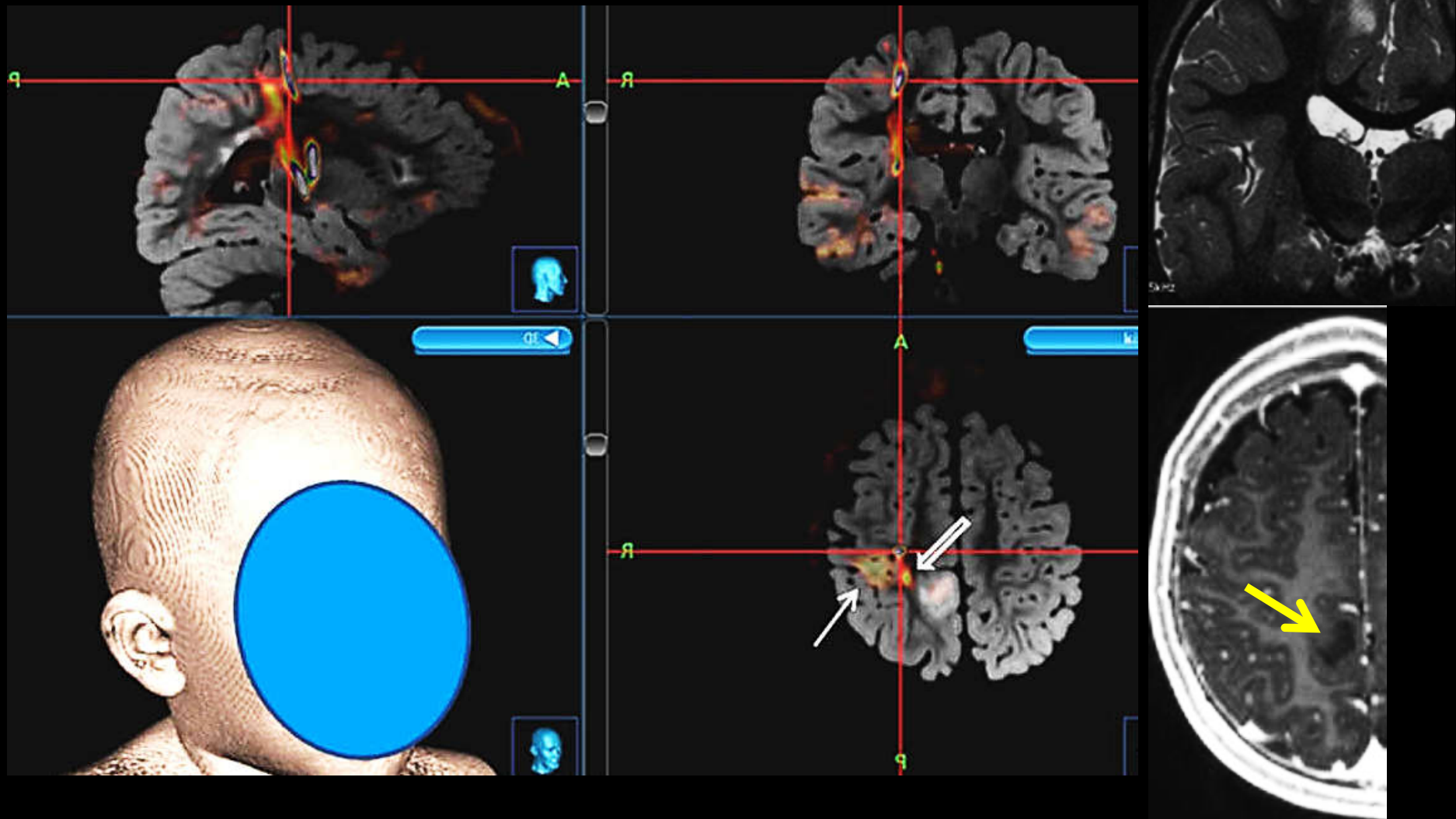
Mikellidou K, Kurzawski JW, Frijia F, Montanaro D, Greco V, Burr DC, Morrone MC. Area Prostriata in the Human Brain. 2017, Current Biology 27, 1–5

Integrazione fMRI === DTI-Tractography



Mikellidou K, Arrighi R, Aghakhanyan G, Tinelli F, Frijia F, Crespi S, De Masi F, Montanaro D, Morrone MC. Plasticity of the human visual brain after an early cortical lesion. *Neuropsychologia* 2017 Oct 31.

Integrazione fMRI === DTI-Tractography



Grant agreement RF-2010-2309954, 2012-2016 "Reorganization of cortical function after surgery for lesional epilepsy in children". Ospedale Pediatrico "Meyer", Firenze- Fondazione G. Monasterio, Pisa.

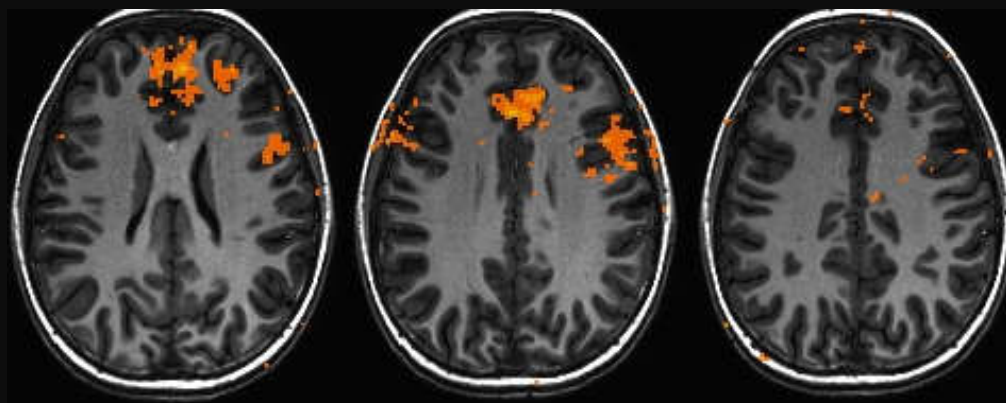
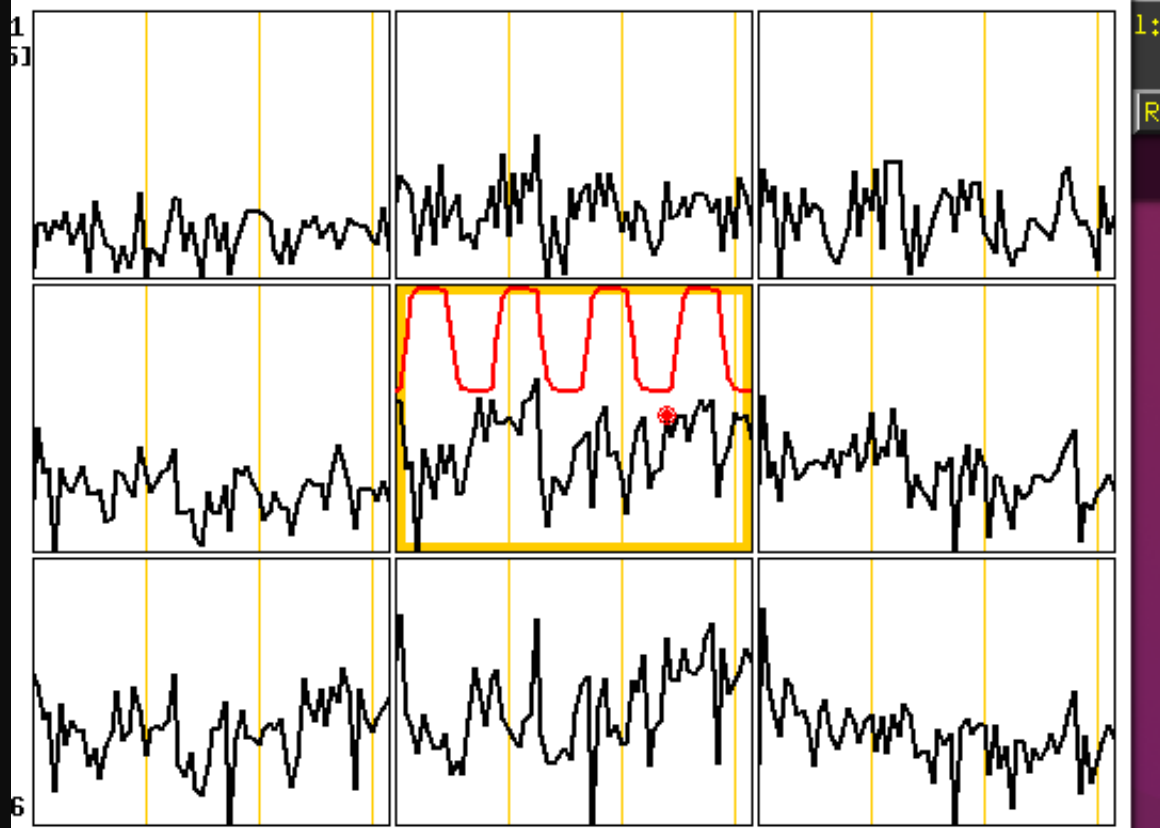
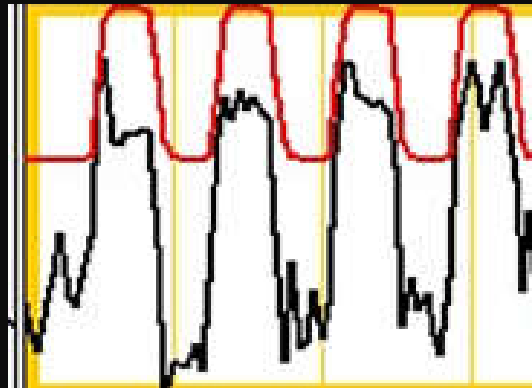


**Attivazioni vere e artefatti o pseudo-attivazioni.
In ambito clinico a volte non si può tralasciare
nessun esame**

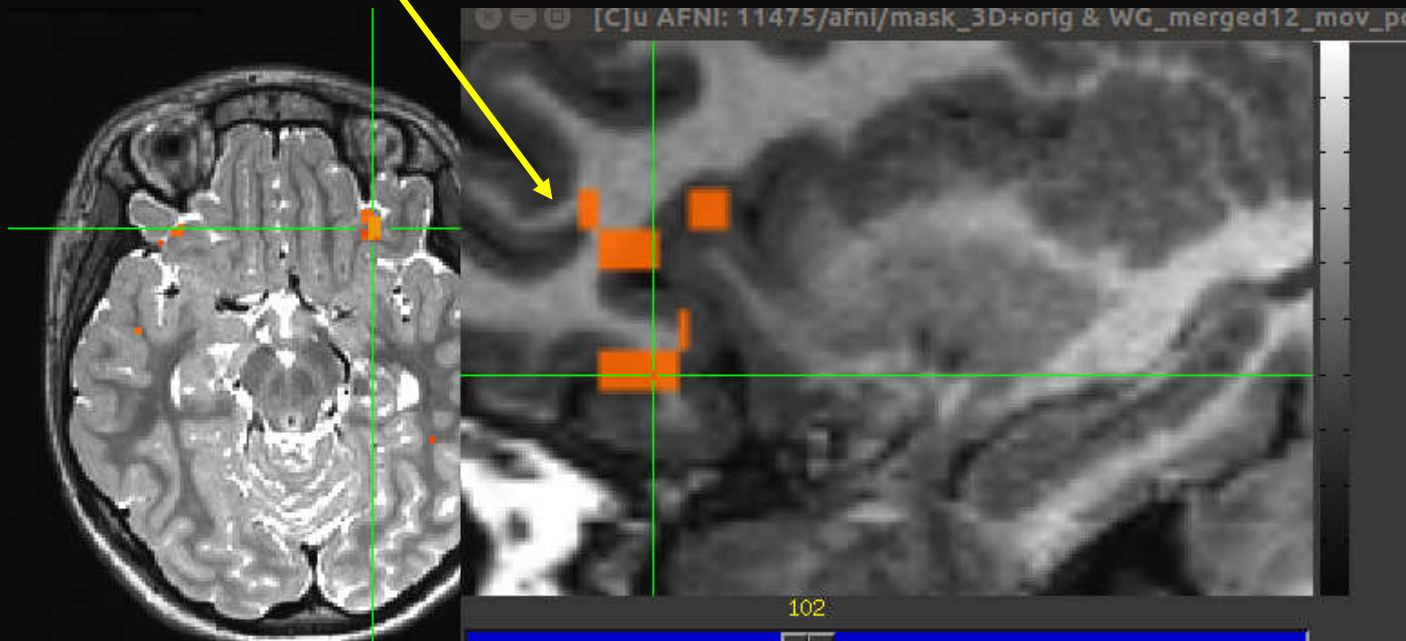
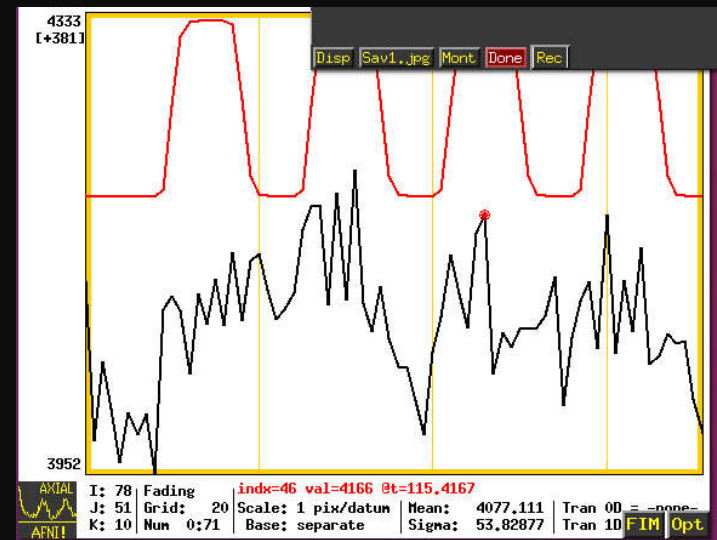
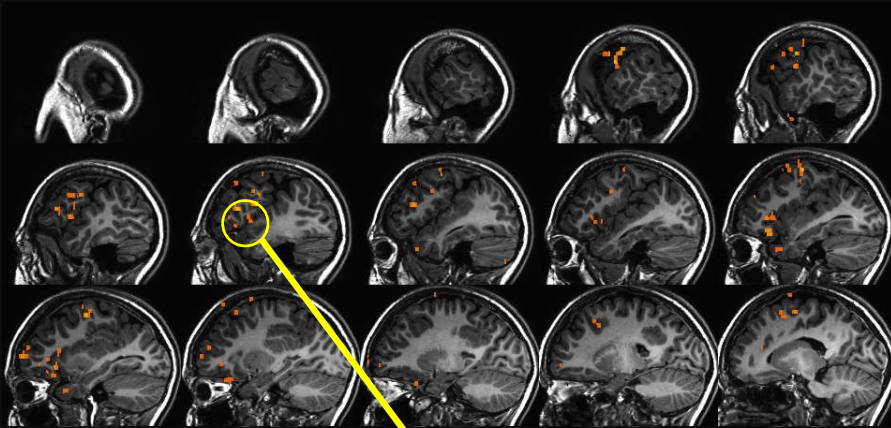
- **Statistiche più stringenti**
- **Analisi dei segnali che tengano conto di artefatti
(movimento ecc.)**
- **Verifica del compito funzionale effettivamente
eseguito**



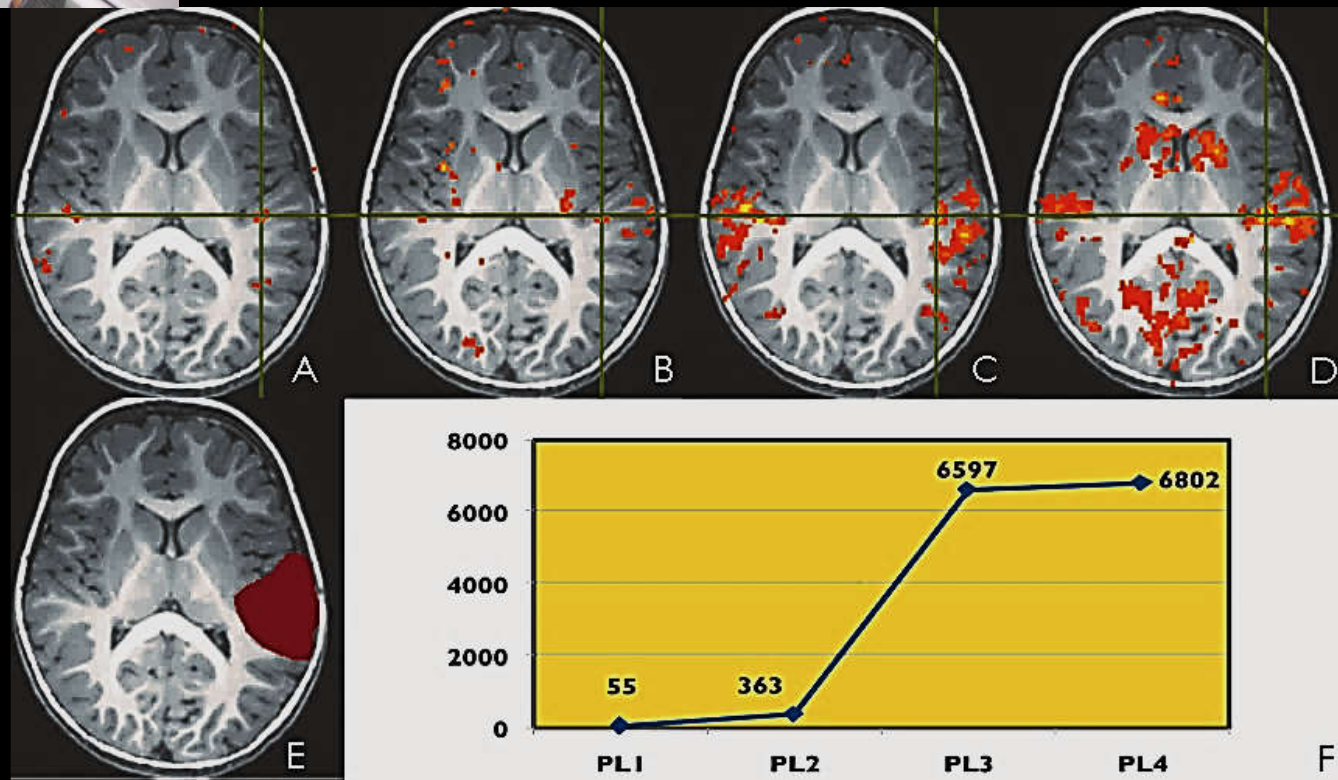
fMRI: Risposte non correttamente valutabili



fMRI: Risposte non correttamente valutabili. Necessità di ricercarle

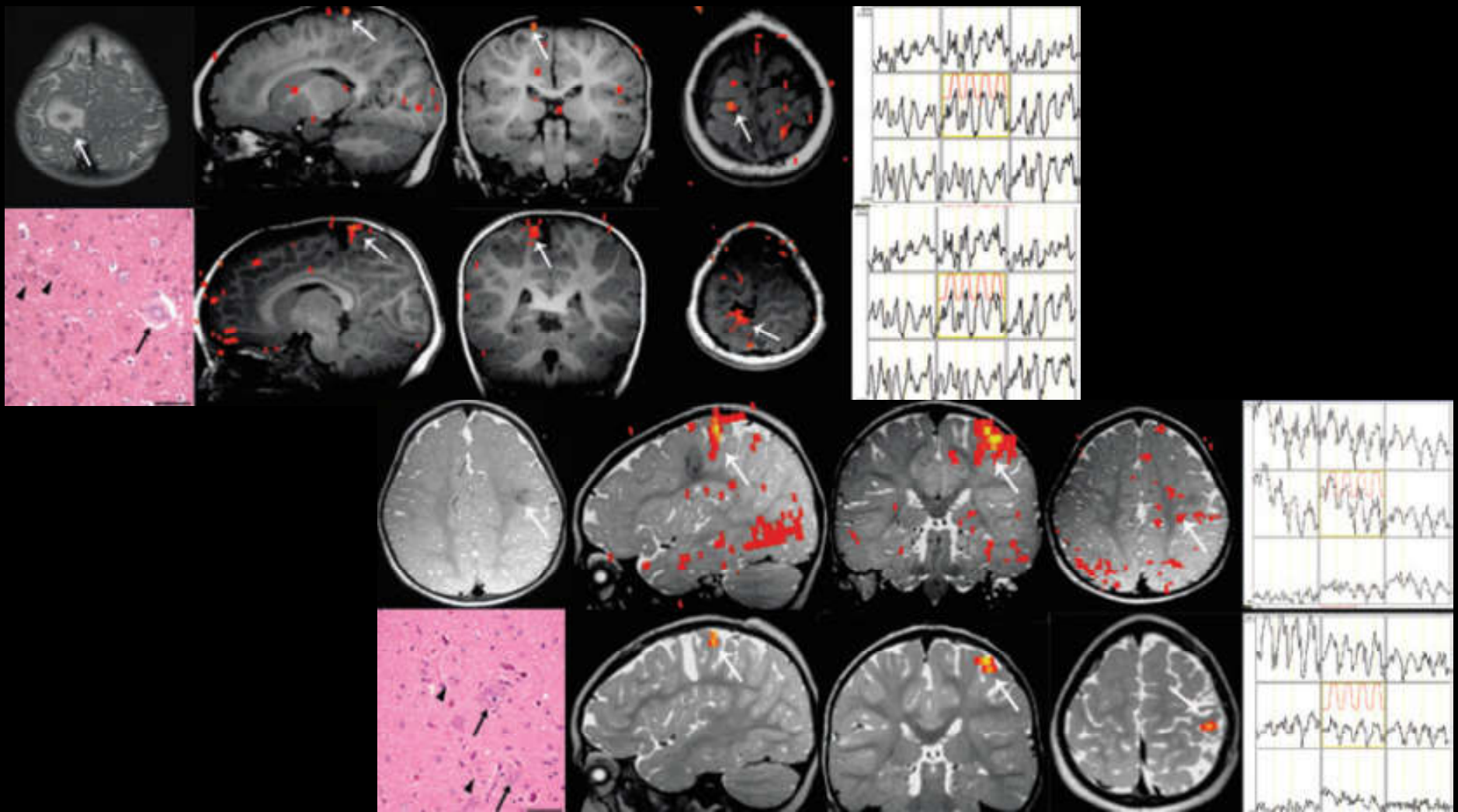


fMRI: nei Bambini e NON collaboranti ?



Barba C, Montanaro D, Cincotta M, Giovannelli F, Guerrini R. An integrated fMRI, SEPs and MEPs approach for assessing functional organization in the malformed sensorimotor cortex. *Epilepsy Res.* 2010 Mar;89(1):66-71.

**fMRI: Risposte non correttamente valutabili. Necessità di ricercarle.
Bambini e Non Collaboranti**



Barba C, Montanaro D, Frijia F, Giordano F, Blumcke I, Genitori L, De Masi F, Guerrini R. Focal cortical dysplasia type IIb in the rolandic cortex: Functional reorganization after early surgery documented by passive task functional MRI. *Epilepsia*, 53(8):e141–e145, 2012



Interpretazioni: apparente incongruenza tra anatomia funzionale Trattografica e fMRI.

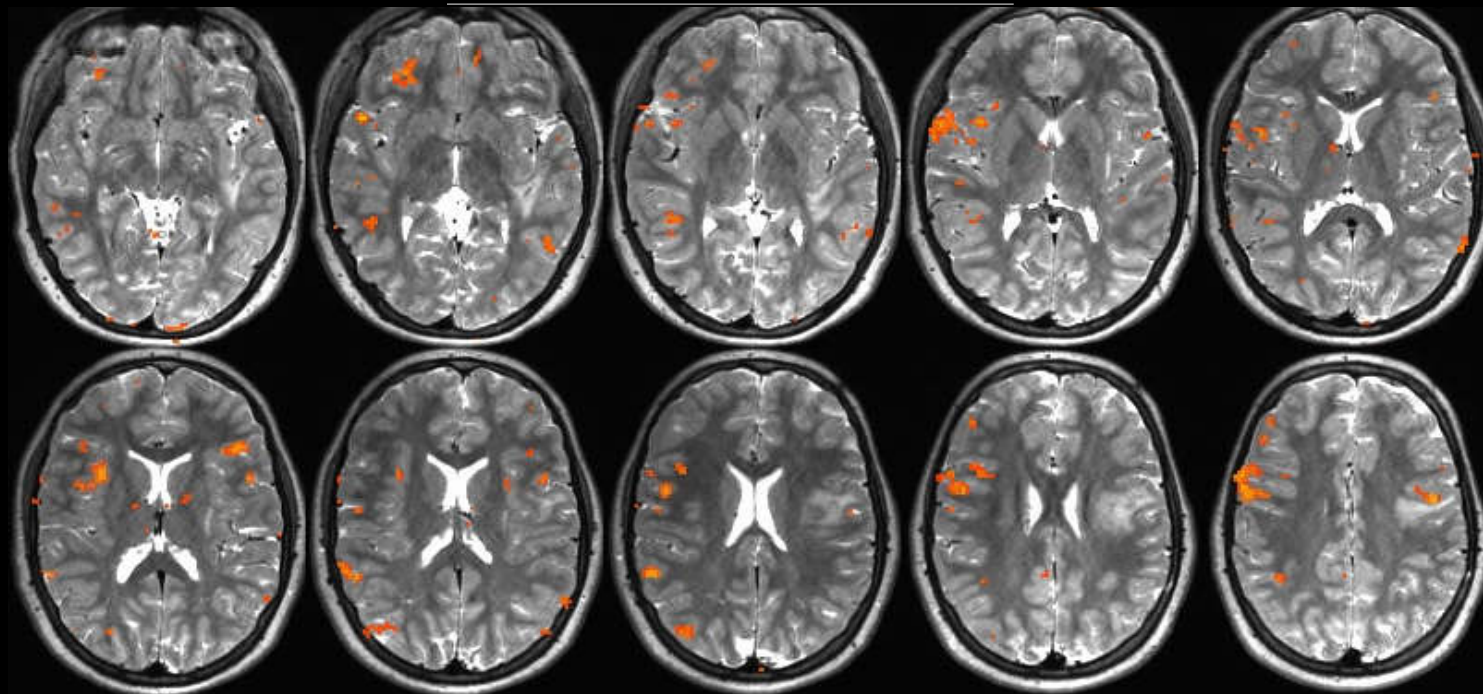
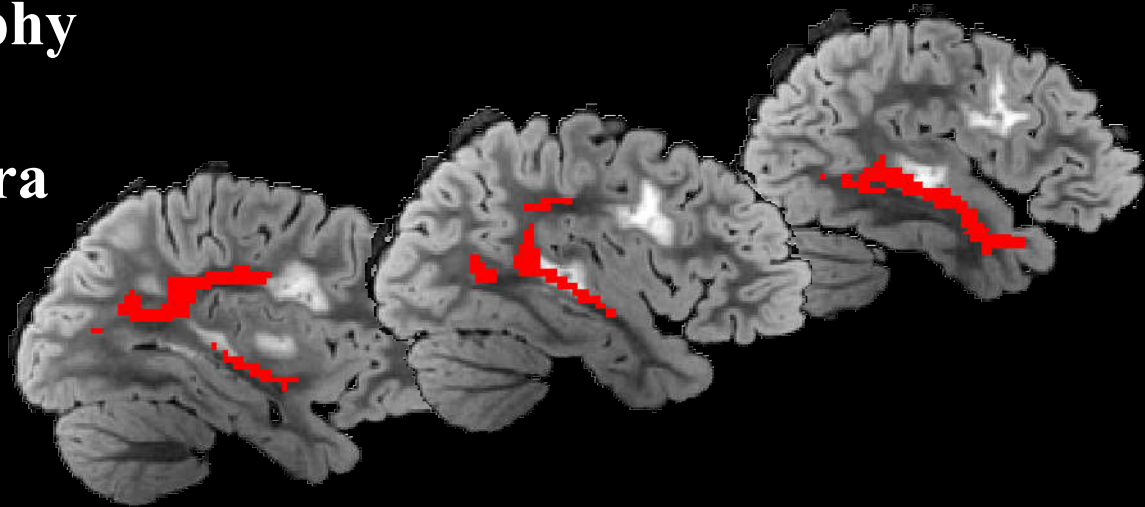
Valutazione Pre-Chirurgica



Diretto coinvolgimento dei fasci con DTI-tractography

fMRI attivazioni a destra

COSA STIAMO VEDENDO????





Attivazioni fMRI e Trattografia-DTI nel brain-mapping

**Bellissimi risultati funzionali ma estremo sforzo
tecnico e tecnologico:**

- **Eccessivi costi apparecchiature RM**
- **Tempi di acquisizione ed elaborazione lunghi**
 - **Eccessivi costi materiale di supporto**
 - **Personale aggiuntivo specialista**
(Ingegneri, Fisici, Informatici, Biologi)
- **Difficoltà in casi di anatomia «estrema»**



Discussione e Conclusioni



Enorme vantaggio dall'utilizzo della RM rispetto ad altre metodiche

*Nessun effetto collaterale.
Ripetibilità dell'esame: in ambito di ricerca e clinico*

Possibilità di eseguire esami morfologici, strutturali e funzionali nella stessa seduta





Limits and Working in Progress



Tempi di acquisizione lunghi

Alti campi magnetici

Sensibilità a movimenti

Programmi di correzione

Bambini e non collaboranti

**Esami in narcosi:
funzionale?**

Omogeneità tra vari centri

**Case costruttrici e
scambio tra i vari centri**





La diagnostica del futuro

- Veloce
- Poco costosa
- Usufruibile da tutti
- Confrontabile tra vari centri

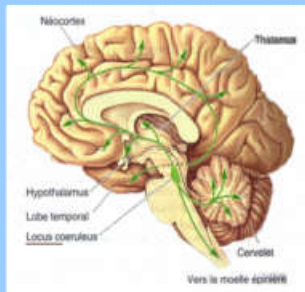
- Quantification MRI**
- Machine Learning**





#locus_coeruleus

R.F. Project Code: PE-2013-02359574. In vivo assessment of the role of Locus Coeruleus in the development of Alzheimer's Disease and other types of Dementia



Neuromelanin sensitive T1-weighted MRI

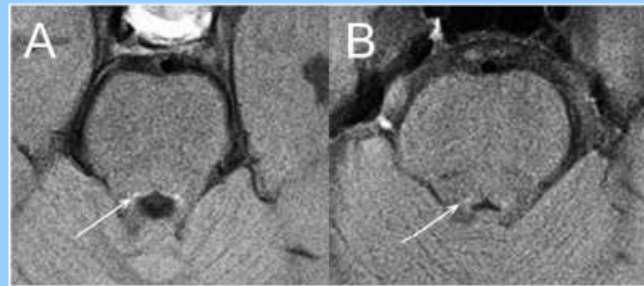
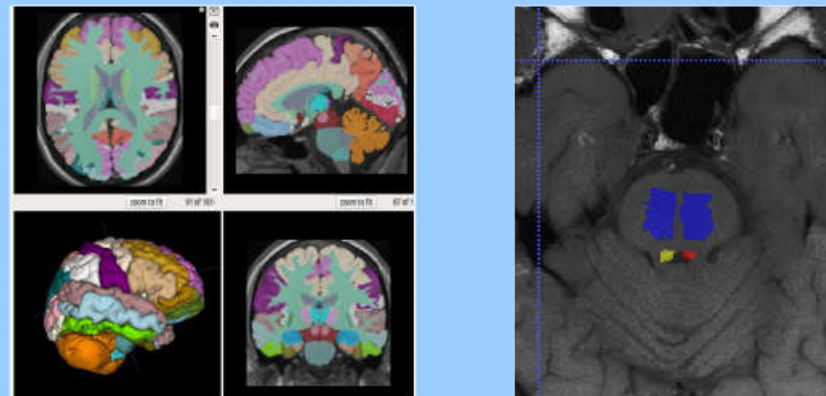


Image registration + region growing segmentation



Della Latta D, Martini N, Santini G
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