Università degli Studi "G. d'Annunzio"
Chieti-Pescara

Vitality Day

**WP2: Diagnostic Imaging
and Personalised Medicine**

Chieti 13 Maggio 2024

WP2: Diagnostic Imaging and Personalised Medicine (Ud'A, Synergo)

Optimize new technologies to achieve **personalized medicine** from dentistry to neurology

Objective 1: Identification of novel non-invasive imaging biomarkers of human organ systems

Objective 2: Identification of new parameters to predict the onset, progression and response to treatment of dental-related or systemic pathologies.

Objective 3: Validation of novel multimodal biomarkers: towards personalised medicine in diagnostic and prognostic procedures
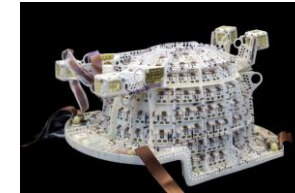
WP2: Diagnostic Imaging and Personalised Medicine

Optimize new technologies to achieve **personalized medicine** from dentistry to neurology

Task 2.1: Identification of novel imaging biomarkers

anatomical images; hemodynamic, metabolic and physiological MRI properties; ECG, EEG/MEG activity; structural and functional connectivity

3 T magnetom prisma

227 channels MEG system

Task 2.2: Dental imaging diagnostics

digital imaging dentistry from clinical trials and big data analysis; comparison with gold standards; prototypes of dental extended reality

Task 2.3: Validation of novel multimodal biomarkers: personalised diagnostics

validation on selected patient cohorts; integration with WP1 parameters; patient classification
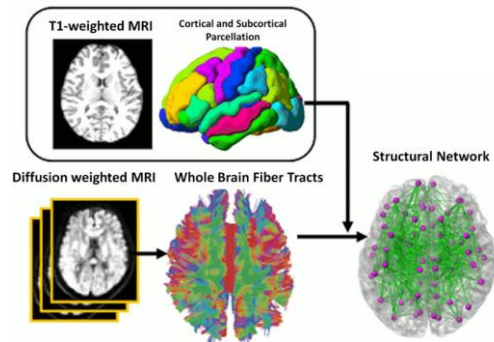
Task 2.1: Identification of novel imaging biomarkers

Novel features from MRI

MRI:REST 8min 8min | TASK 12min | REST

- **Structural MRI**

  - Quantitative T1 maps

    - *Neuroanatomical differences*

  - Structural Connectivity

    - *Brain microstructural informations*

- **Functional MRI**

  - Hypercapnic metabolic modulation

    - *Oxygen metabolism (CMRO$_2$)*

  - Calibrated fMRI

    - *Brain metabolism and function*

    - *Quantitative Cerebral Blood Flow CBF*

    - *BOLD activation*

  - Functional connectivity

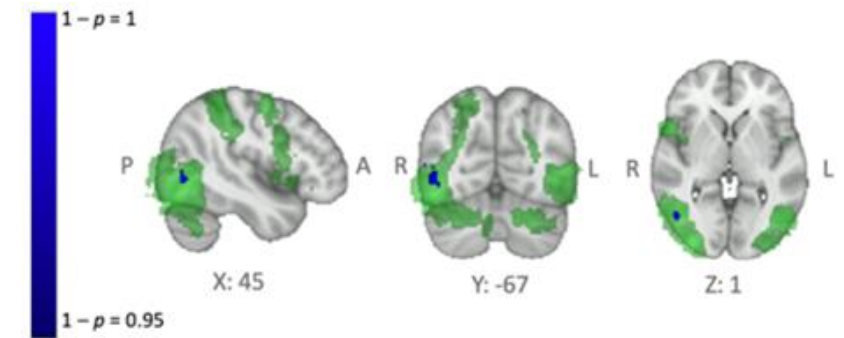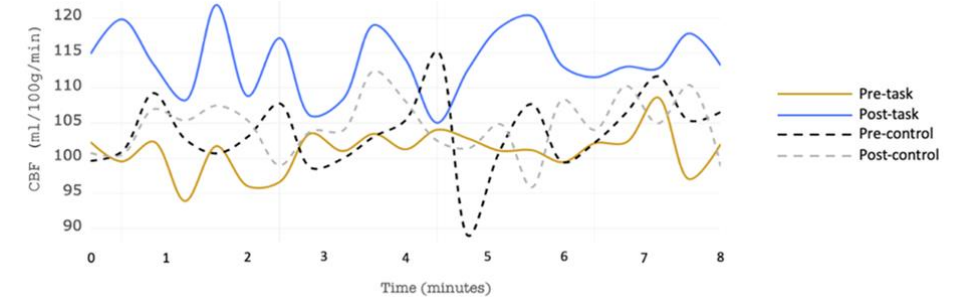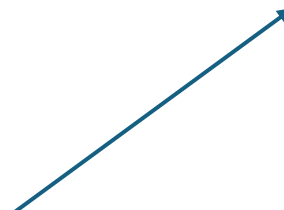   Biondetti E et al., , Neuroimage. 2024 doi: 10.1016/j.neuroimage.2023.120492.

CBF   BOLD

CMRO2
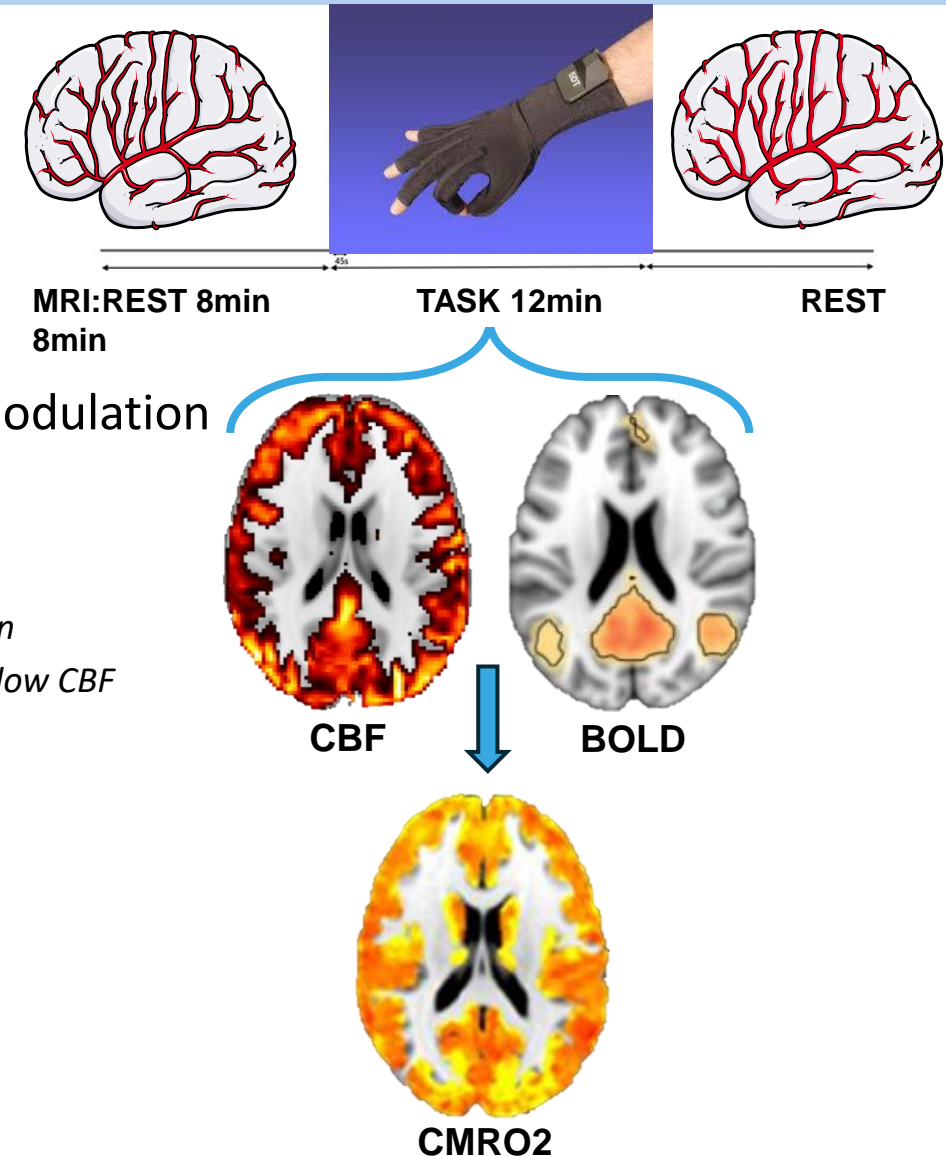
Task 2.1: Identification of novel imaging biomarkers

MRI – Pilot results:

- Increase in task performance
  - Sequence learning

- Sustained localised CBF increase
  - Post task metabolic increase in visuo-motor relevant area

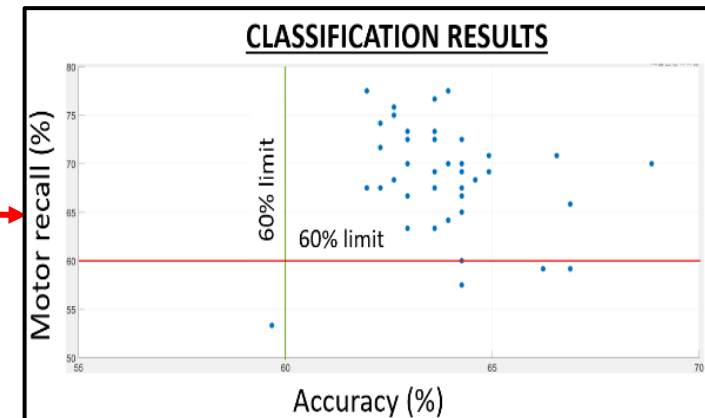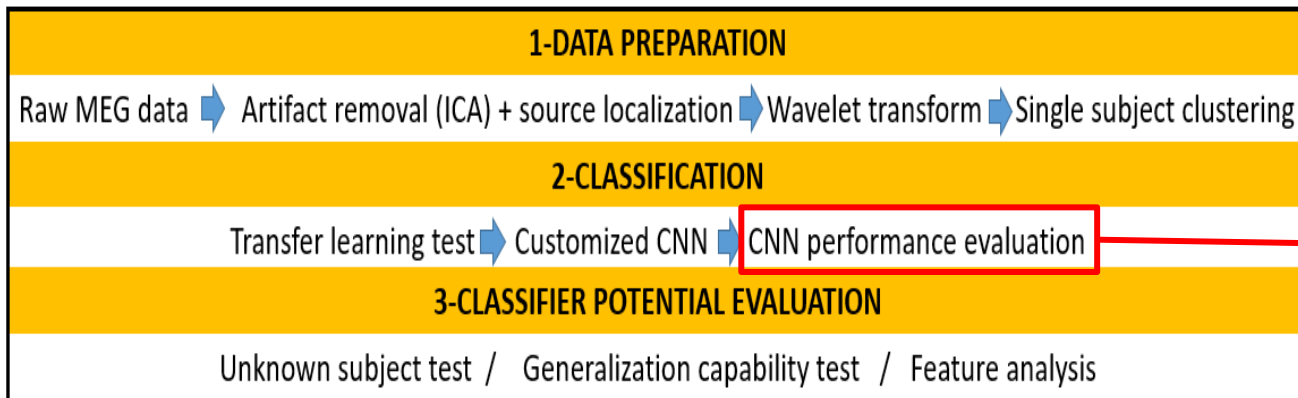- Increase in brain connectivity

Task-evoked BOLD response

CBF increase

Patitucci et al., submitted
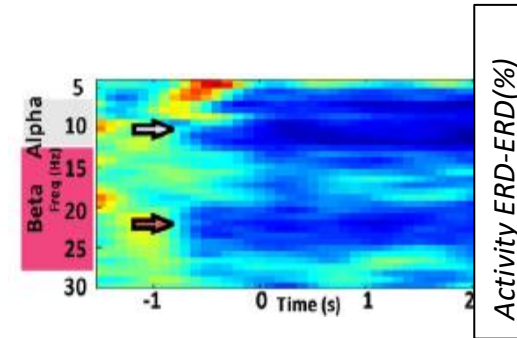
Università degli Studi «G. d'Annunzio» Chieti-Pescara
Missione 4 Componente 2 - M4C2 Investimento 1.5. Creazione e rafforzamento di "ecosistemi
dell'innovazione", costruzione di "leader territoriali di R&S" ECS00000041 **VITALITY**

Task 2.1: Identification of novel imaging biomarkers

Novel features from MEG data

Classification pipeline for small datasets – deep learning based (motor task)

Activity ERD-ERD(%)

1-DATA PREPARATION

Raw MEG data ➡ Artifact removal (ICA) + source localization ➡ Wavelet transform ➡ Single subject clustering

2-CLASSIFICATION

Transfer learning test ➡ Customized CNN ➡ CNN performance evaluation

3-CLASSIFIER POTENTIAL EVALUATION

Unknown subject test / Generalization capability test / Feature analysis

CLASSIFICATION RESULTS

Motor recall (%)

60% limit

60% limit

Accuracy (%)

Task 2.1: Identification of novel imaging biomarkers

Generalization
The classifier was successfully applied on a test dataset and
a dataset from a different paradigm

Generalization capability test

Random choice level

Promising for :
- **Classification of Activity/Connectivity/Topology maps**
- **Classification of multimodal biomarkers**

Functional connectivity

MEG hubs

DAN VAN SMN VIS LAN DMN FPN
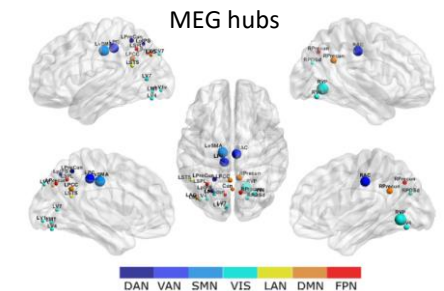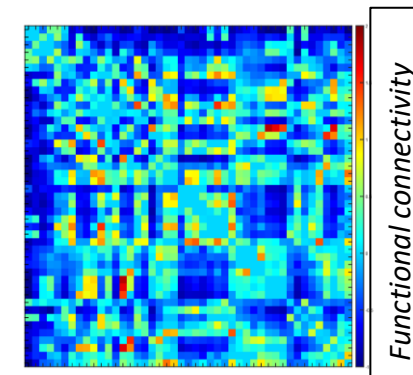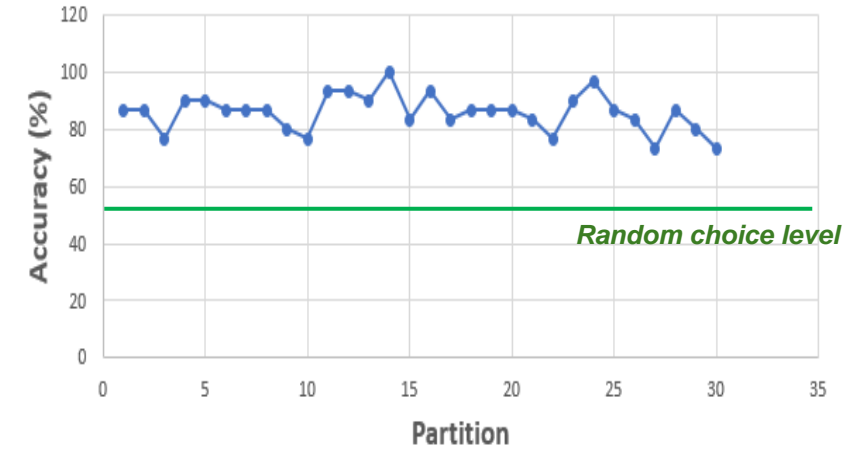
Topological parameters

Task 2.2: Dental imaging diagnostics

In the field of dentistry, AR primarily enhances reality by overlaying digital content onto real-world scenarios, facilitating enhanced communication between patients and collaborators through the sharing of images, videos, and 3D models
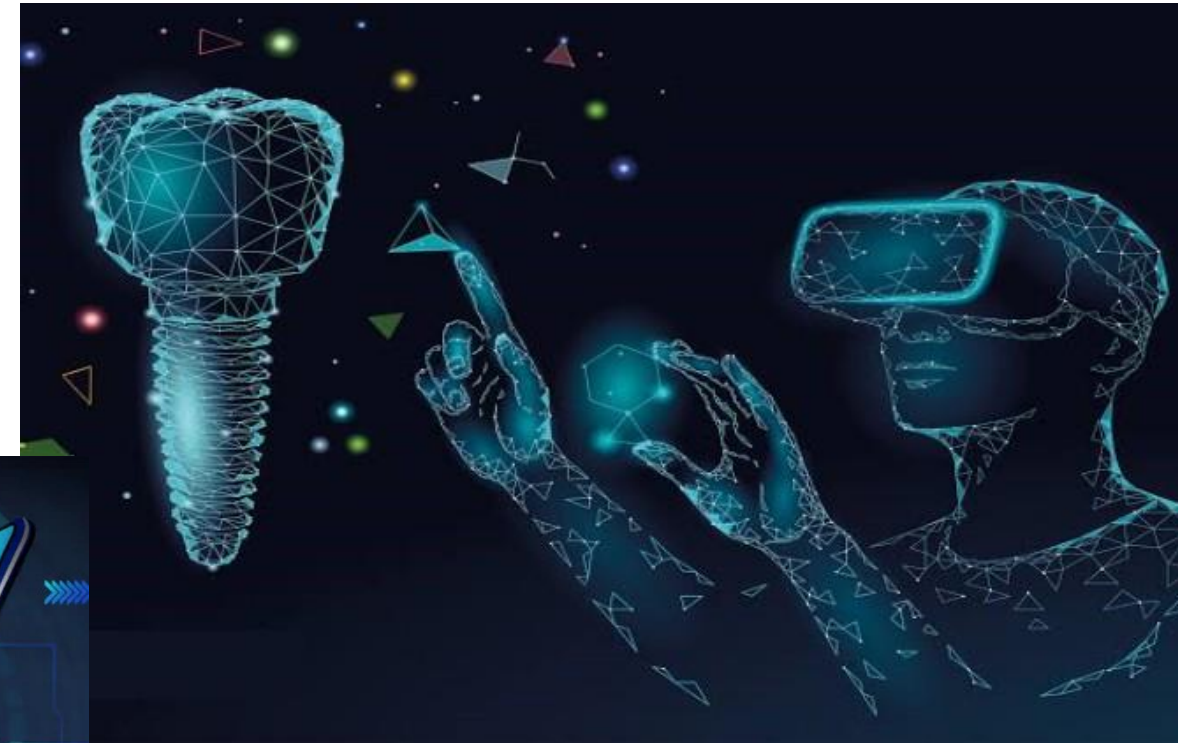
Task 2.2: Dental imaging diagnostics

Preliminary data collected for the following projects within the Diagnostic Imaging field supervised by Prof. Caputi, Prof. Traini and dr Rexhepi:

"Increased vertical dimension in digital and analog articulator: in vivo analysis with snap on mockup."

"Comparison of impressions detected with digital and traditional methods on the ISO 208 96-1 model."

Exploring the Interplay Between Air Pollution and Oral Health: A Comprehensive Systematic Review

Authors: Bruna Sinjari[1,2], Manlio Santilli[1,2], Maurizio Piattelli[1,2], Piero Di Carlo[3], Sergio Caputi[1,2]

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Characterize how chronic neuroinflammation affects brain function and neuronal plasticity

Experimental protocol:

- 3 experimental groups
  - Type II Diabetes
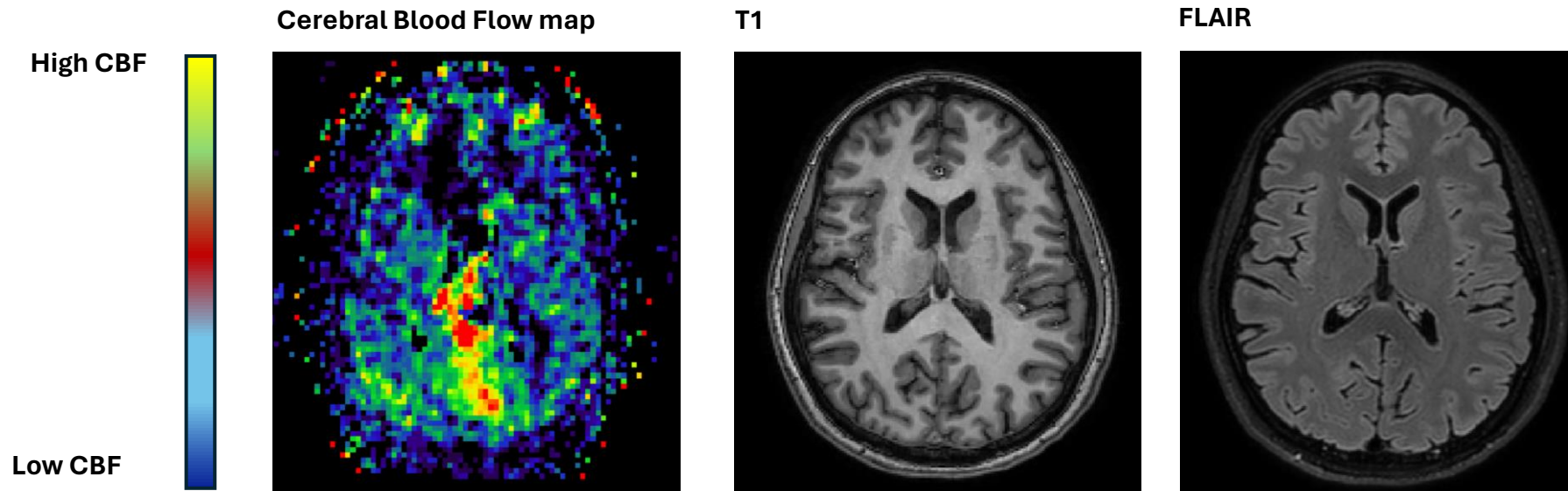 - Multiple Sclerosis
  - Controls

Novel behavioural paradigm

- MRI/MEG compatible data-glove
- Stimulate brain plasticity
- Measure behavioural indices:
  - Sequence learning
  - Accuracy

	REST	TASK	REST
MRI SESSION	8min	12min	8min
2 weeks time			
MEG SESSION	10min	30min	10min
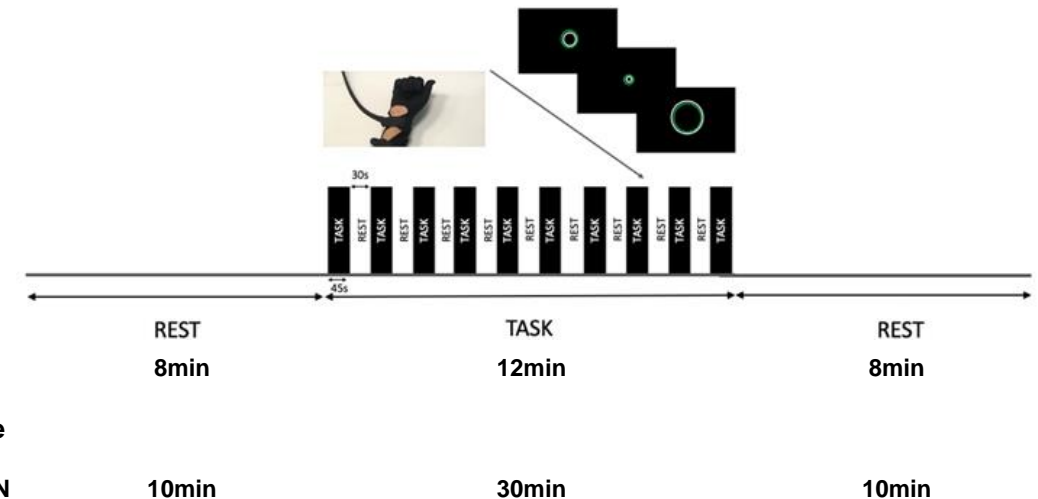
Quantification of resting perfusion in Multiple Sclerosis: Arterial Spin Labelling (ASL)

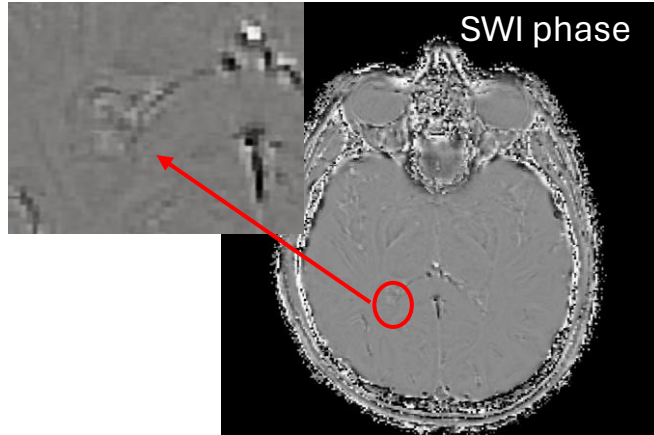**Cerebral Blood Flow map**   **T1**   **FLAIR**

High CBF — Low CBF

ASL sequences will be applied in the MR protocol to quantify the cerebral blood flow, a tissue physiology parameter that was shown to be abnormal in MS **(Chandler HL et al. J Cereb Blood Flow Metab. 2023)**
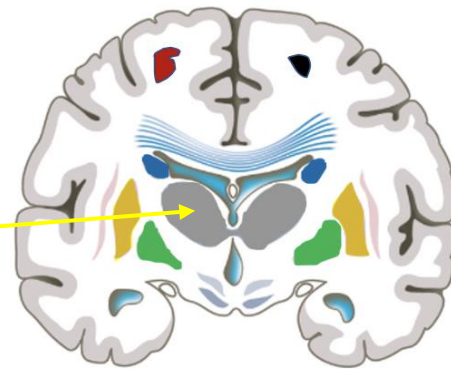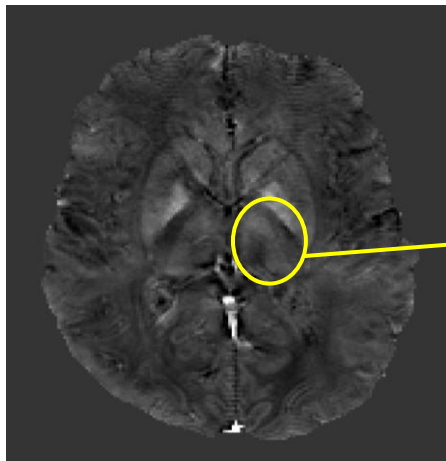
Quantification of the active chronic inflammation (smouldering inflammation) in Multiple Sclerosis: Susceptibility Weighted Imaging (SWI)

In the white matter: smouldering lesions

SWI phase

T1

FLAIR

In the grey matter: QSM maps

Thalamus

SWI sequences will be applied to quantify active chronic inflammation (smouldering inflammation) that in Multiple Sclerosis reflects compartmentalized inflammation, i.e., sustained by resident innate immunity.

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Grazie per l'attenzione