

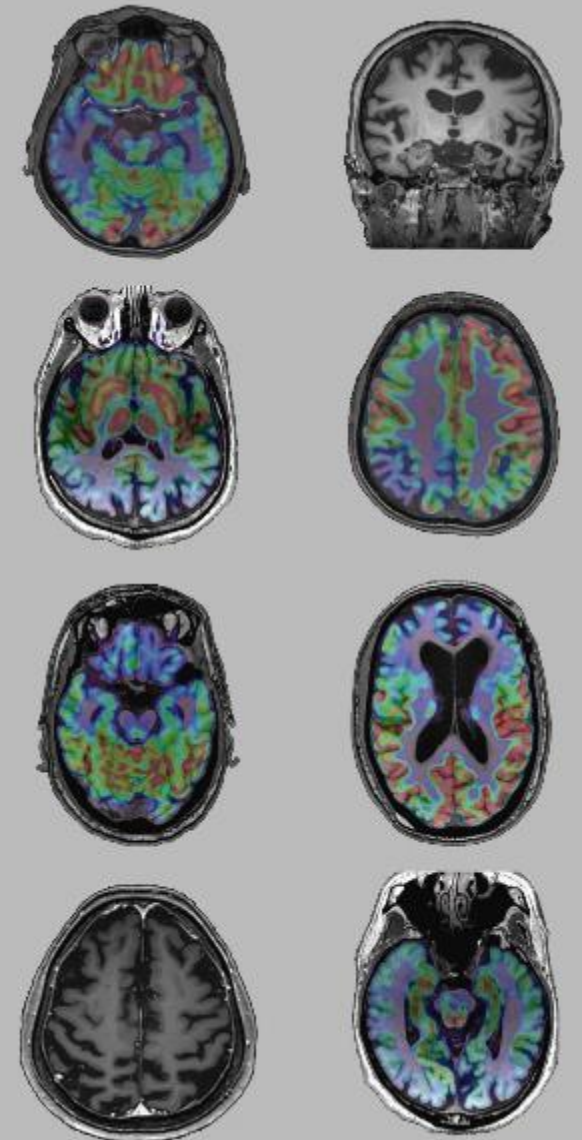
# Neuroradiological Workup in Neurodegeneration and Dementia

PD Dr. med. Maria Blatow, University Hospital Zürich

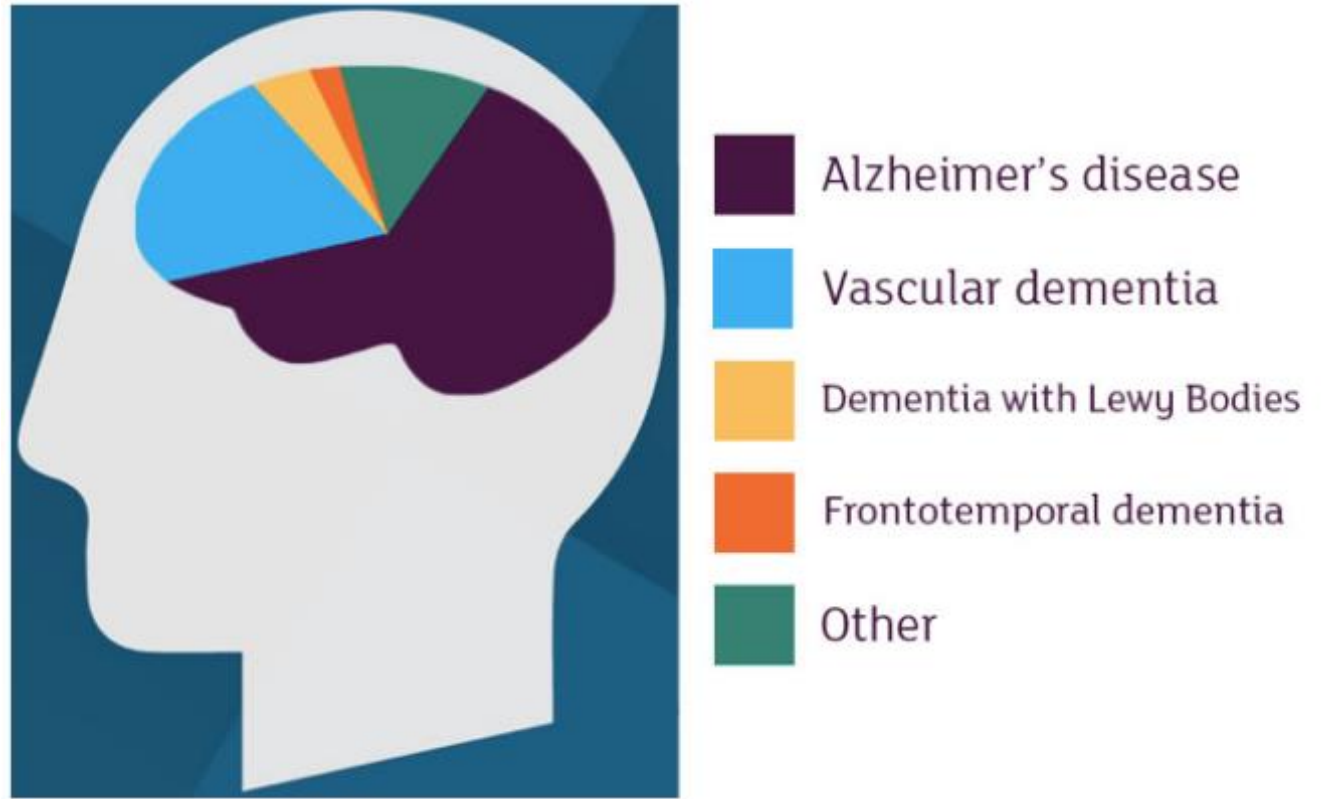
Dr. med. Johanna Lieb, University Hospital Basel

SFCNS Neuroimaging Course

1st Module: Imaging Neurodegeneration



# Overview



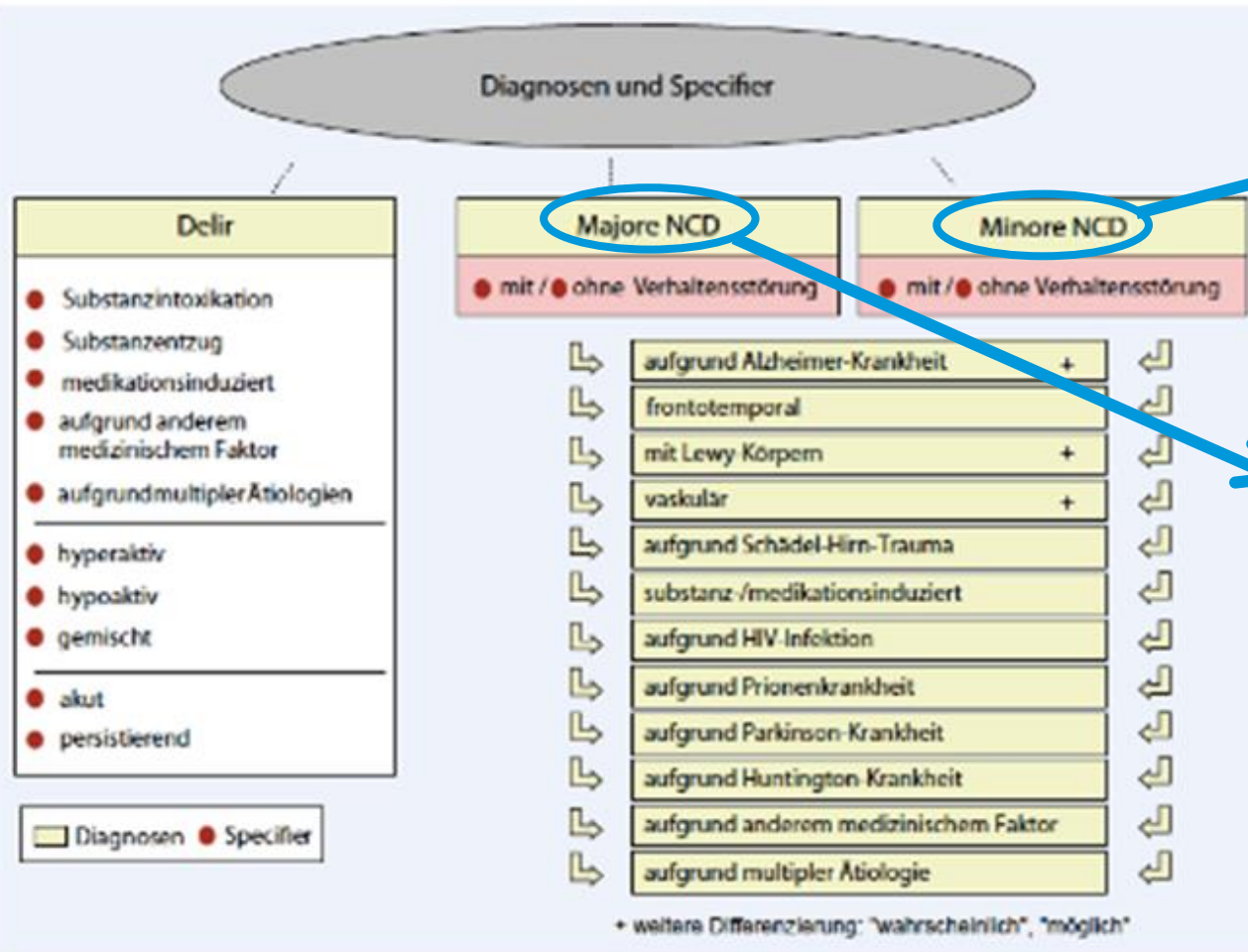
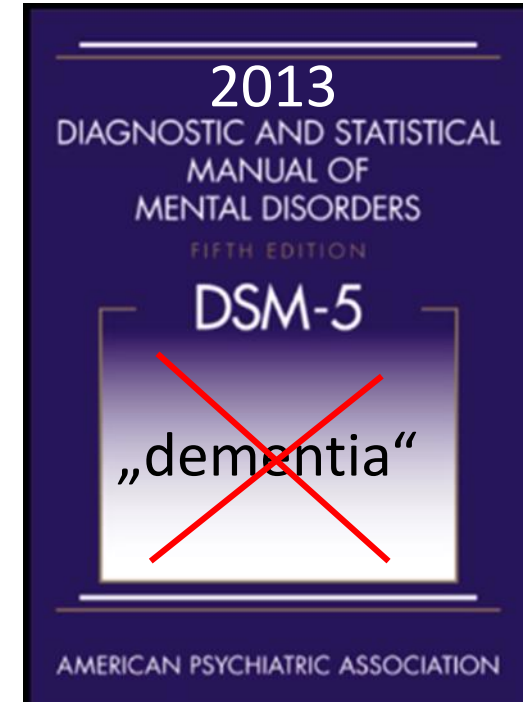
- Basic definitions
- Background information
- Pathological hallmarks of Alzheimer`s Disease
- Important anatomic structures for memory
- Neuroradiological Workup, Imaging correlation, Visual scores

# Basic definitions

- **Neurodegeneration:** progressive loss of function or structure of neurons
- **Dementia:** clinical syndrome: acquired cognitive decline, affects ADLs, > 6 months, delirium and psychiatric disorder excluded
- **Cognition:** „thinking“; „any form of information processing, mental operation, intellectual activity as thinking, reasoning, remembering, imagining or learning“
- **Cognitive decline:** subjective (not measurable), objective (measurable)
- **ADLs:** activities of daily living
  - basic ADLs: personal hygiene, self-feeding, functional mobility
  - instrumental ADLs: personal financial management, moving within a community, housekeeping, shopping, preparing meals, taking medication, using a telephone...

# Background

# Neurocognitive Disorders (NCD)

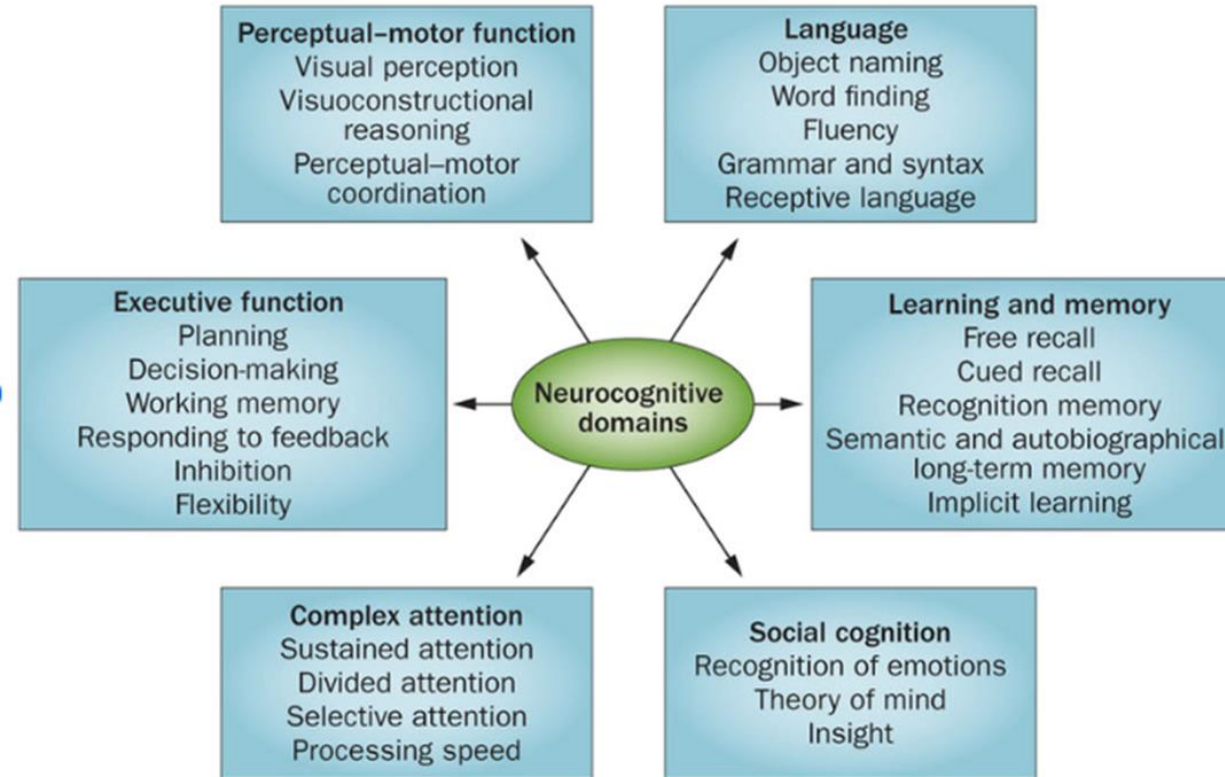


measurable cognitive decline, but no interfere with ADL`s (former MCI)

significant cognitive decline with interference of ADL`s

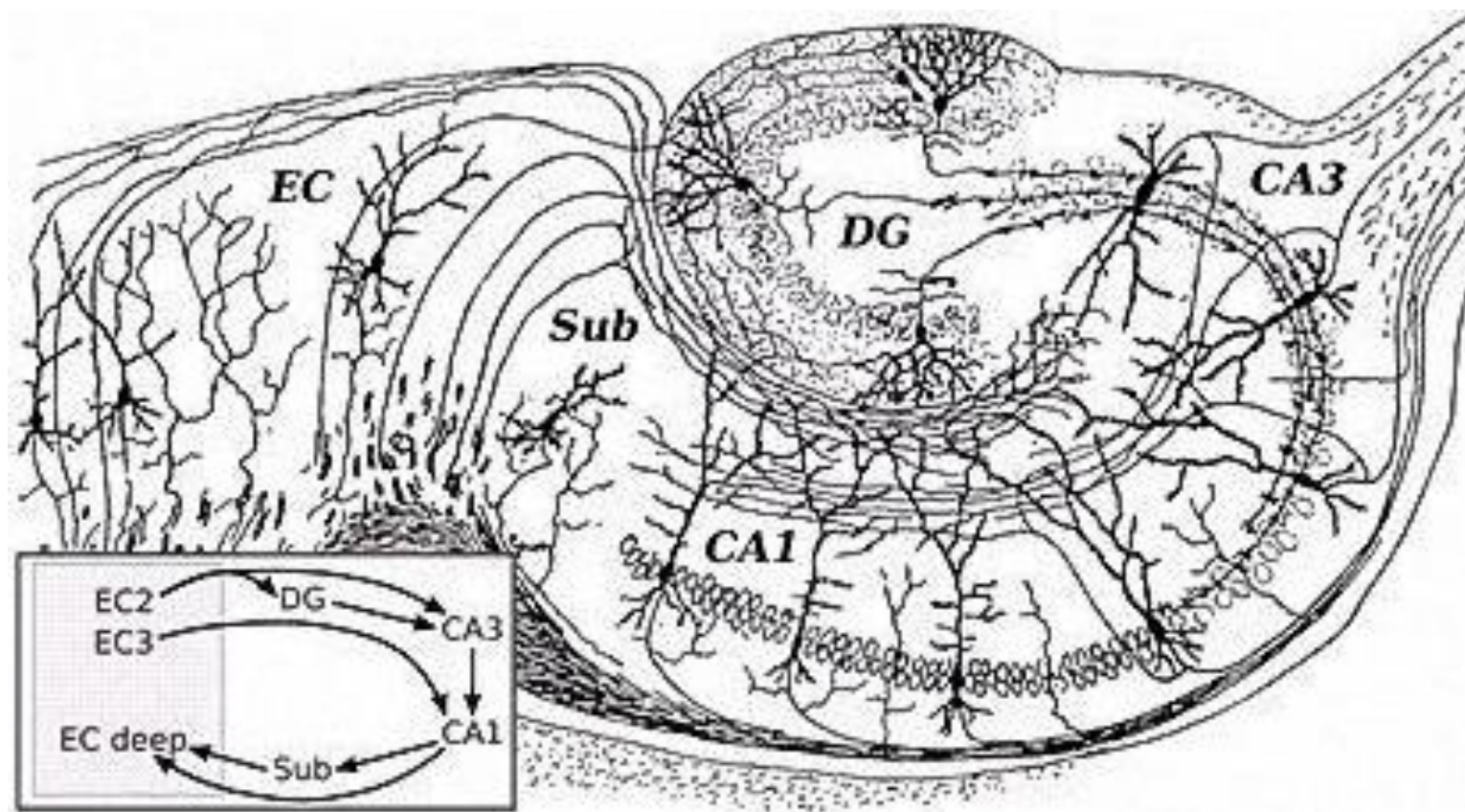
severity:  
 mild → iADLS affected  
 moderate → basic ADLs affected  
 severe → fully dependant patient

# Background

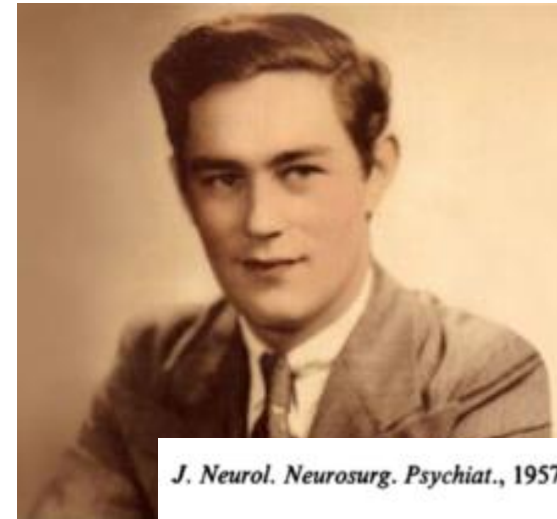
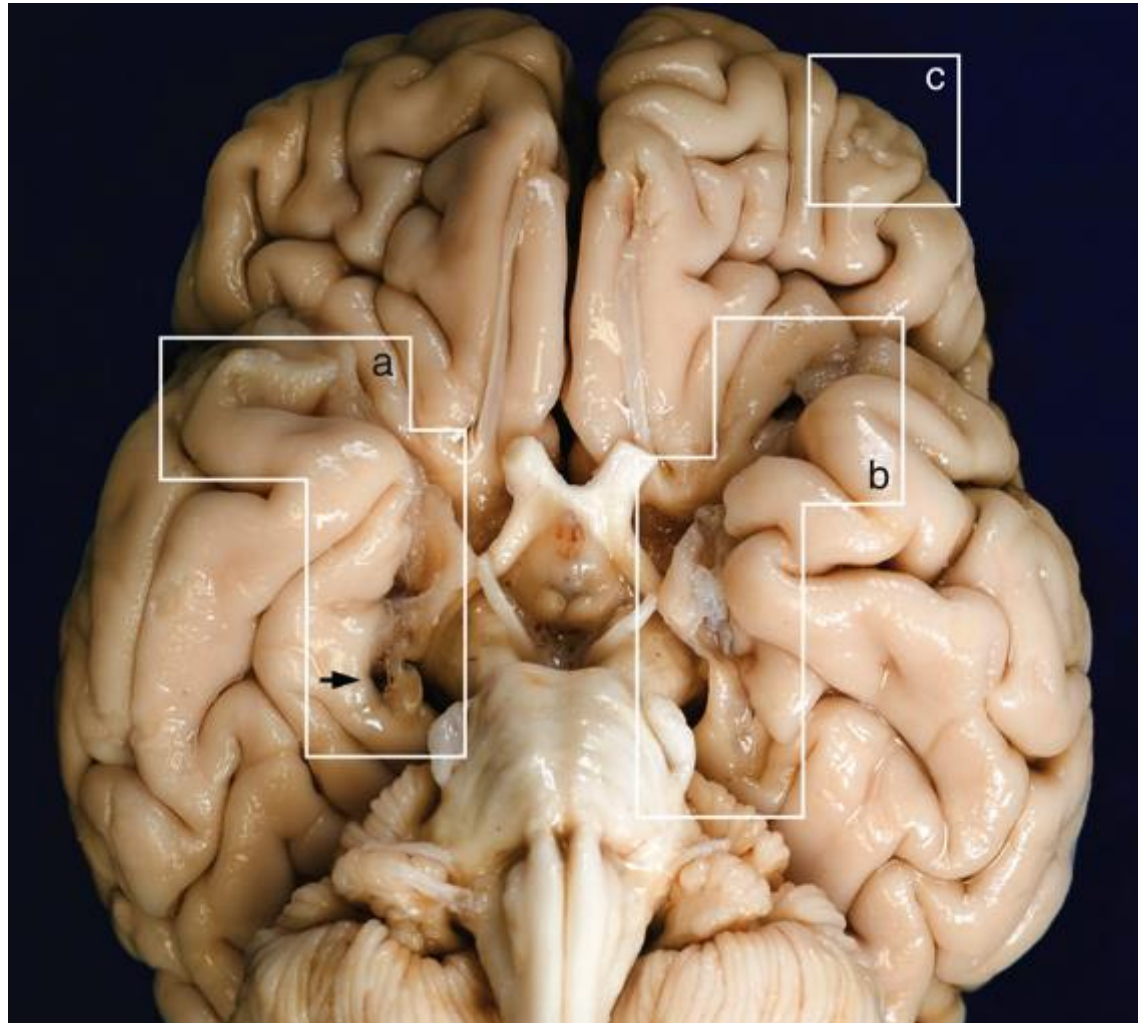


Neurocognitive domains. The DSM-5 defines six key domains of cognitive function, and each of these has subdomains. Identifying the domains and subdomains affected in a particular patient can help establish the aetiology and severity of the neurocognitive disorder. Objective assessments are essential, but the DSM-5 does not name any proprietary tests. Abbreviation: DSM-5, Diagnostic and Statistical Manual of Mental Disorders 5th edition.

# Ramon y Cajal 1911: Neuronal elements of the hippocampal formation



# Memory-loss and how our knowledge all began...



*J. Neurol. Neurosurg. Psychiat.*, 1957, 20, 11.

**1953**  
**Patient H. M.**  
**(male 28y)**

## **LOSS OF RECENT MEMORY AFTER BILATERAL HIPPOCAMPAL LESIONS**

BY

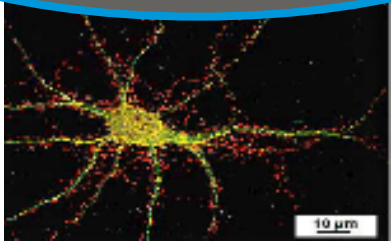
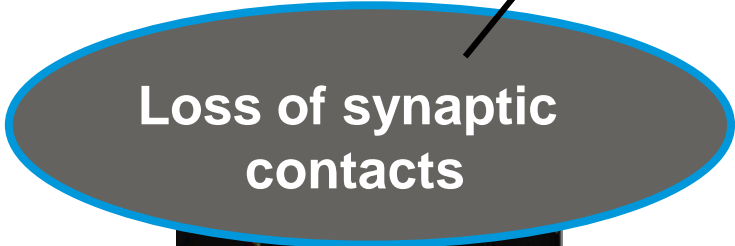
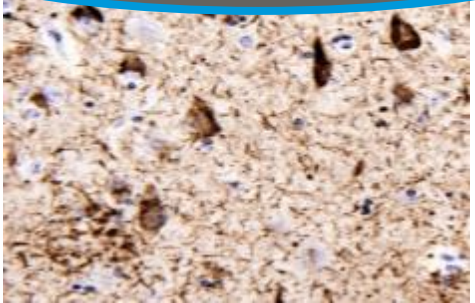
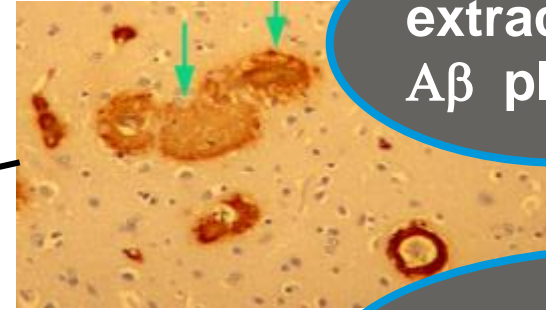
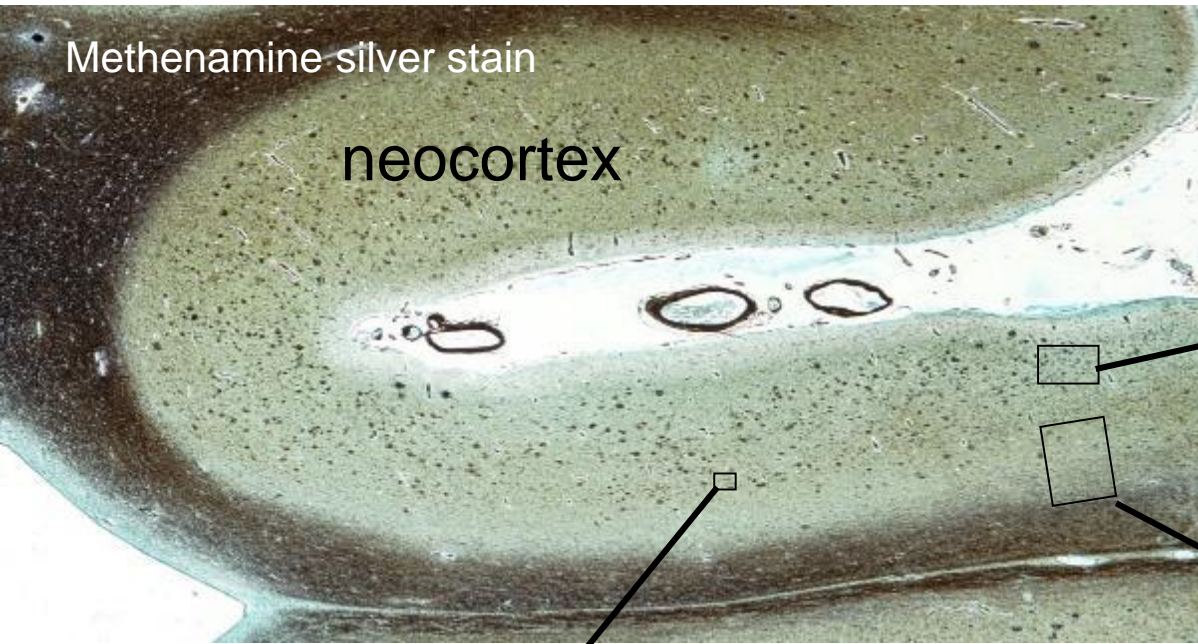
**WILLIAM BEECHER SCOVILLE and BRENDA MILNER**

*From the Department of Neurosurgery, Hartford Hospital, and the Department of Neurology and Neurosurgery, McGill University, and the Montreal Neurological Institute, Canada*

In 1954 Scoville described a grave loss of recent memory which he had observed as a sequel to bilateral medial temporal-lobe resection in one psychotic patient and one patient with intractable seizures. In both cases the operations had been radical ones, undertaken only when more conservative forms of treatment had failed. The removals extended posteriorly along the mesial surface of the temporal lobes for a distance of approximately 8 cm.

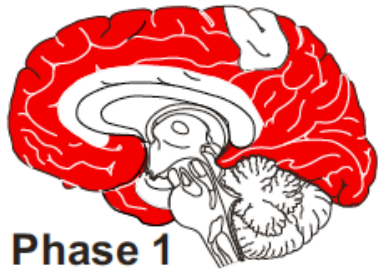
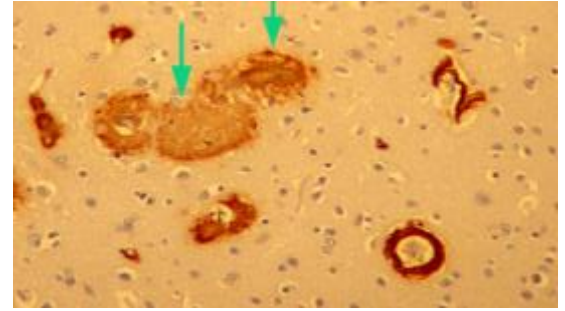
found that undercutting limited to the orbital surfaces of both frontal lobes has an appreciable therapeutic effect in psychosis and yet does not cause any new personality deficit to appear (Scoville, Wilk, and Pepe, 1951). In view of the known close relationship between the posterior orbital and mesial temporal cortices (MacLean, 1952; Pribram and Kruger, 1954), it was hoped that still greater psychiatric benefit might be obtained by extending

# Alzheimer's disease (AD) : histological hallmarks



# Distribution of amyloid pathology

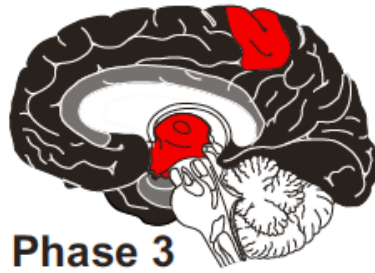
## The concept of Thal phases



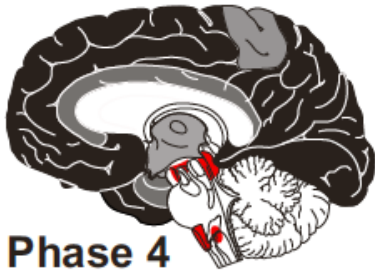
Phase 1



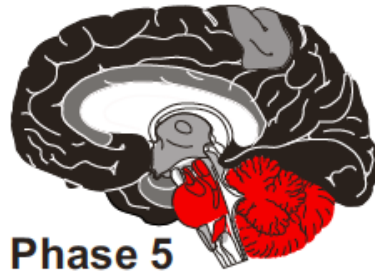
Phase 2



Phase 3

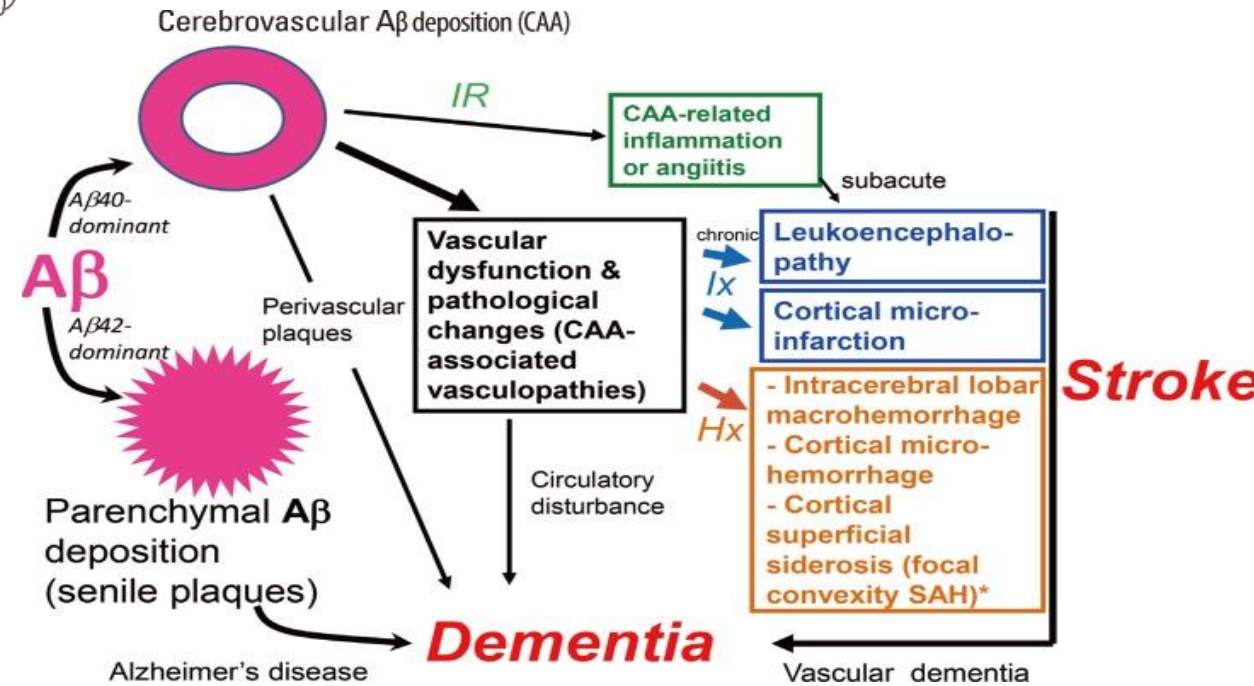


Phase 4



Phase 5

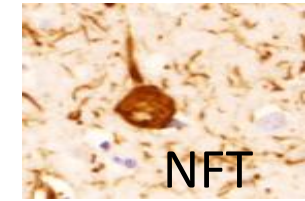
Amyloid Distribution, Thal phases (Thal et al Neurology 2002)



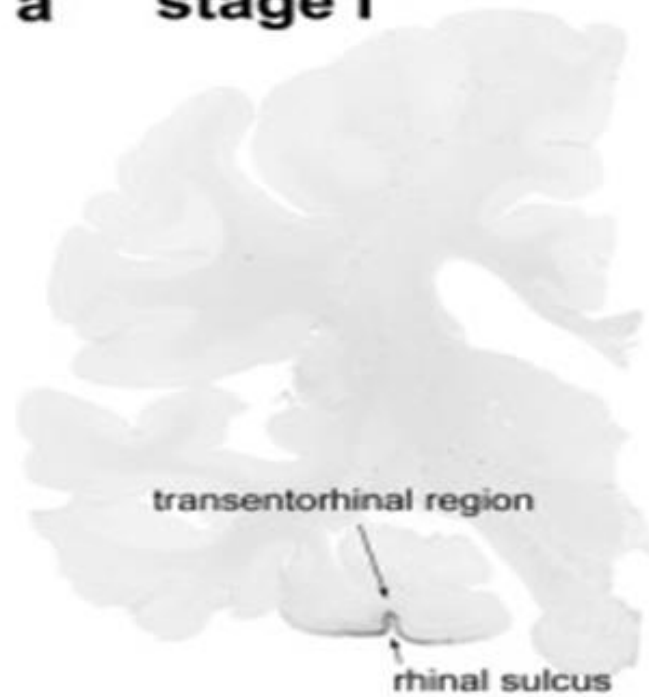
Yamada M: Cerebral Amyloid Angiopathy: Emerging Concepts  
Journal of Stroke 2015; 17(1): 17-30.

# Distribution of tau-pathology in typical AD

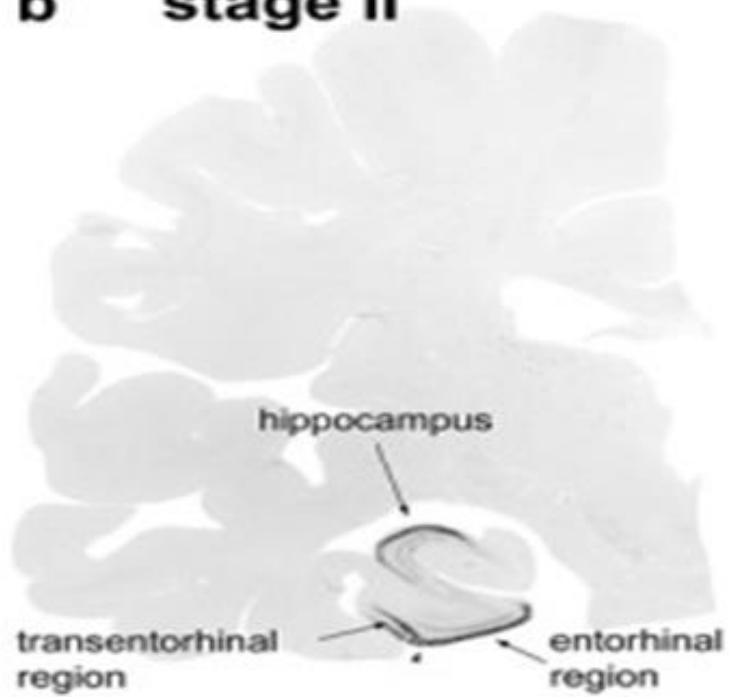
## *The concept of Braak stages*



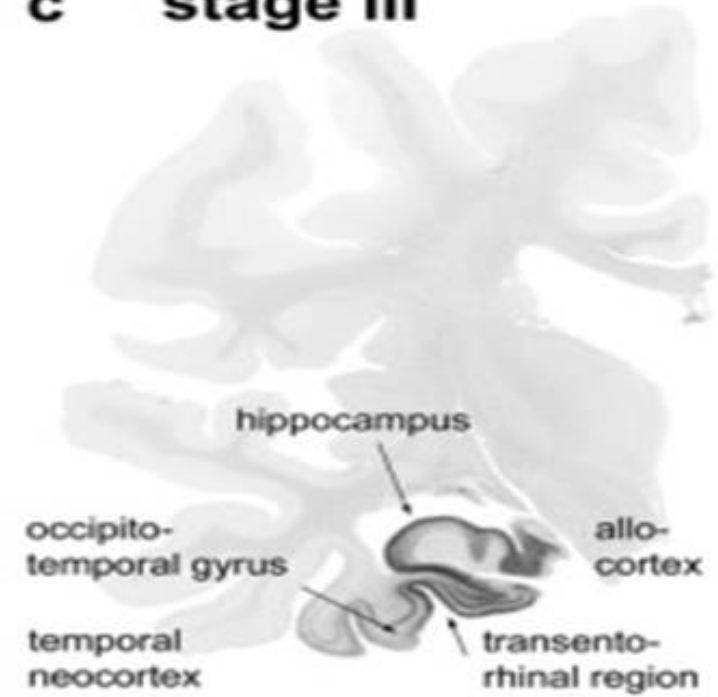
**a stage I**



**b stage II**

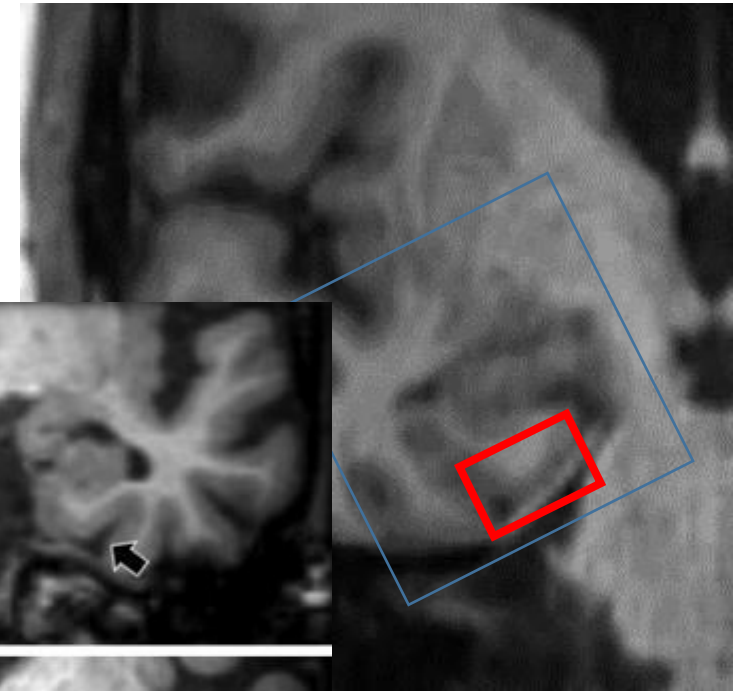
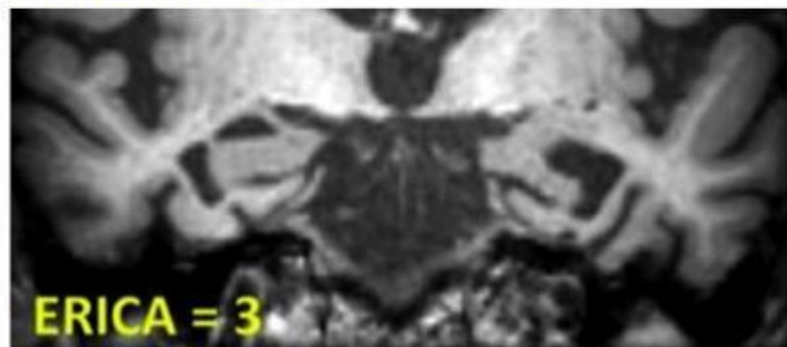
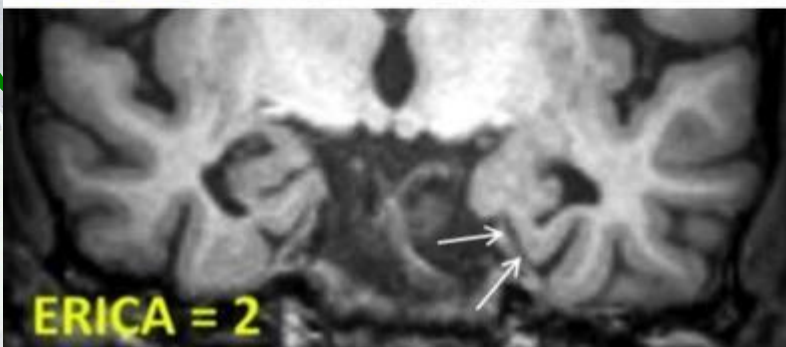
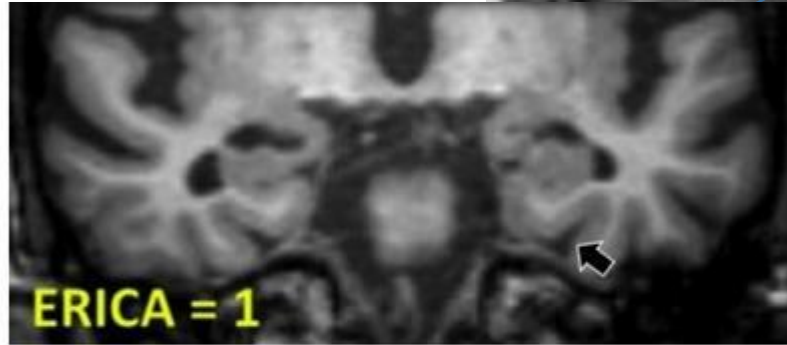
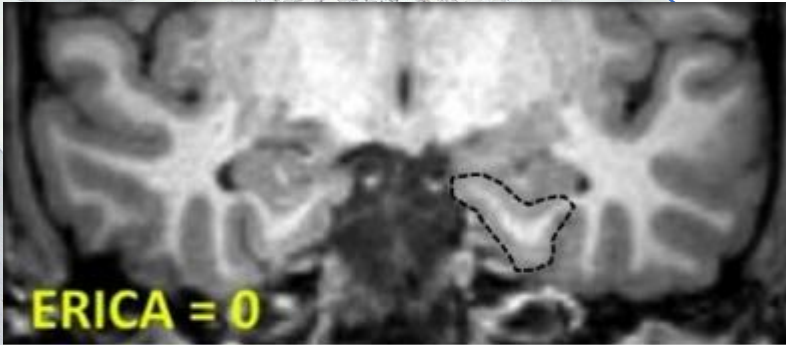
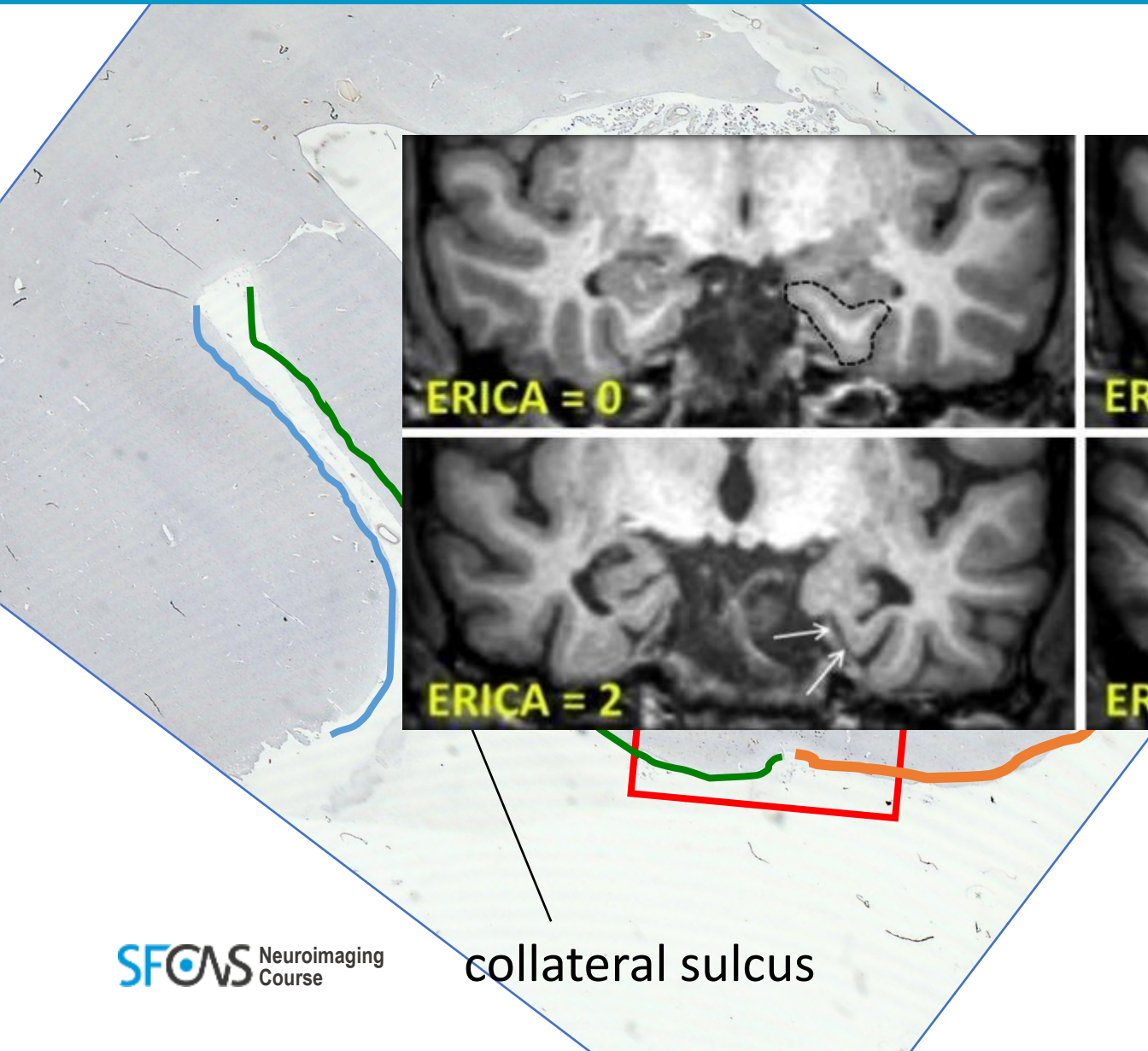


**c stage III**



the main clinical components of AD

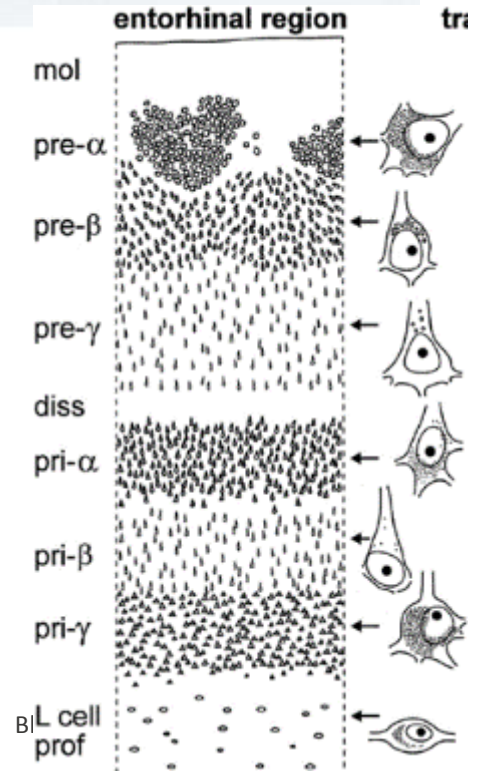
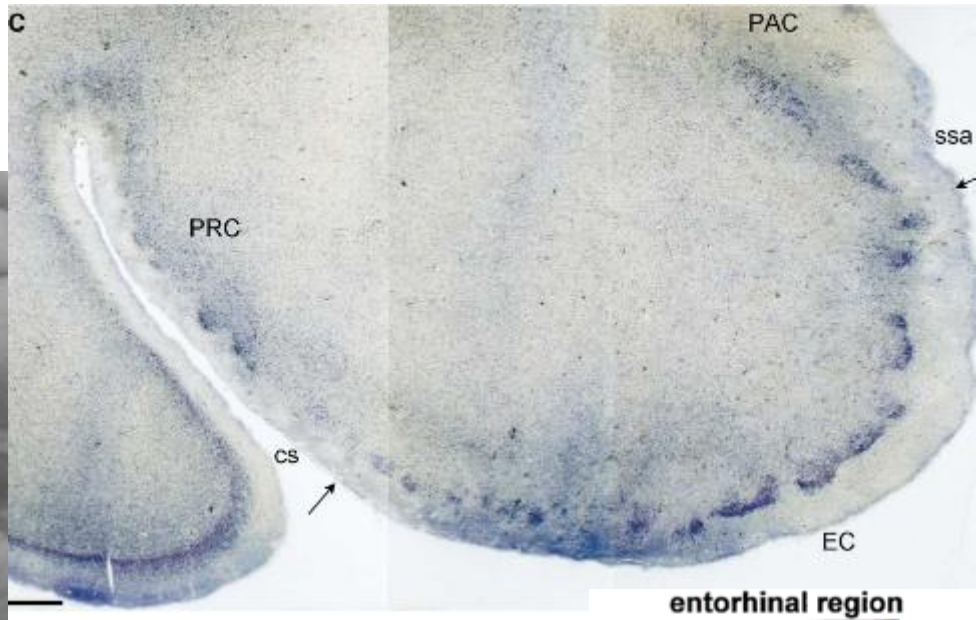
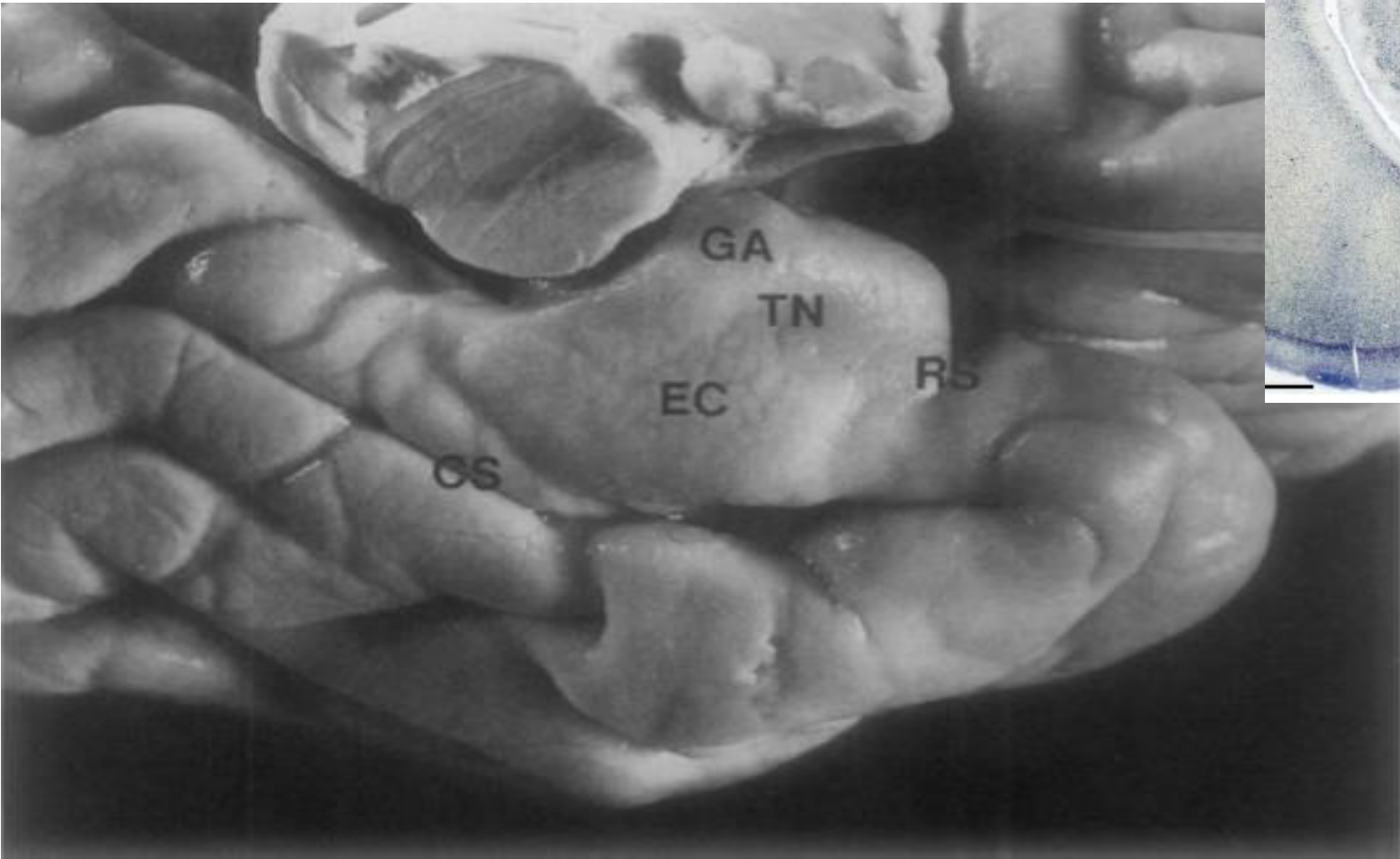
First tau/NFT pathology starts in the medial perirhinal cortex, near the junction with the entorhinal cortex



hippus  
entorhinal cortex  
medial perirhinal cortex  
lateral perirhinal cortex

# Entorhinal cortex with „verrucae gyri hippocampi“

(Retzius; Klingler 1948)

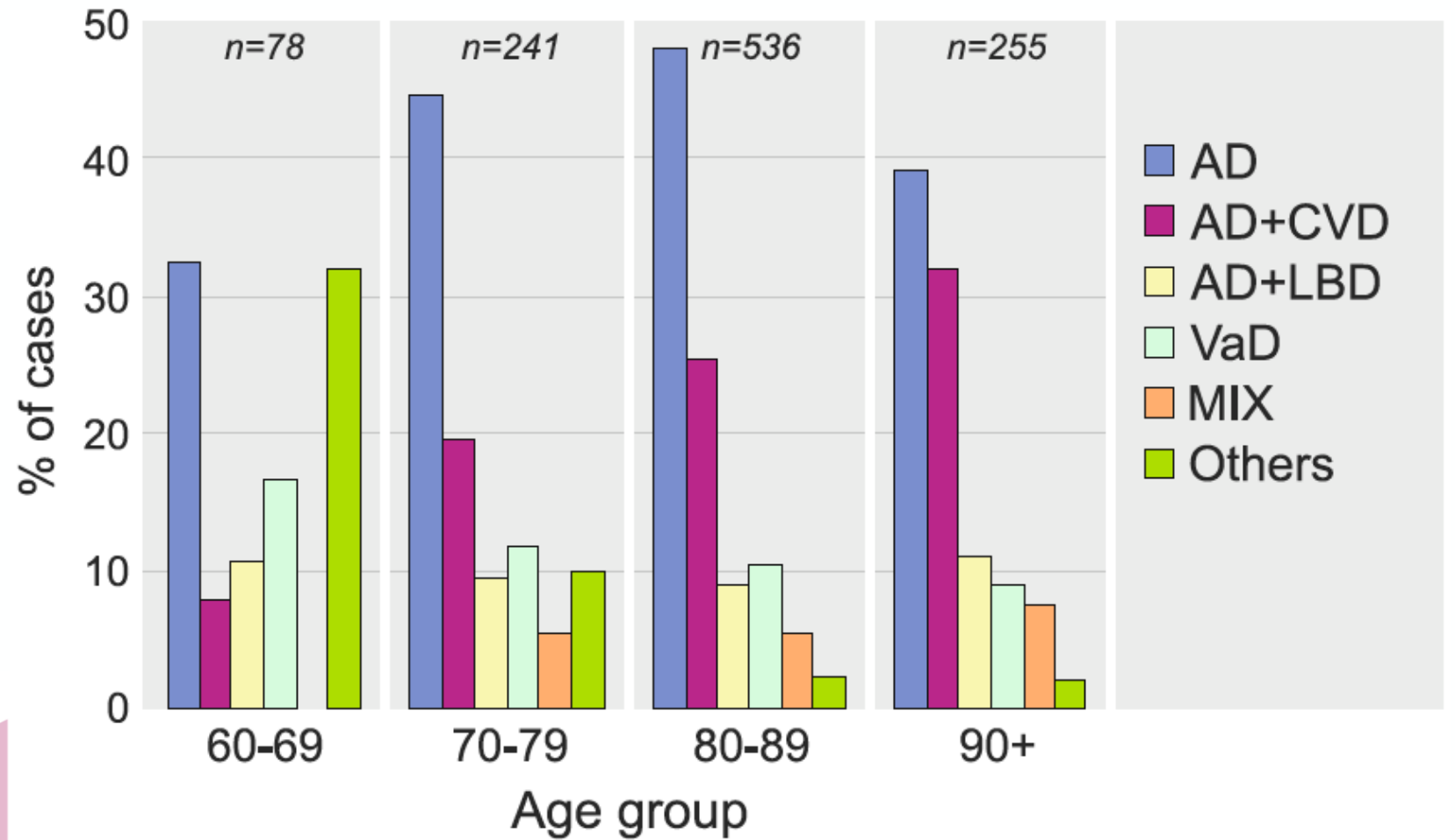
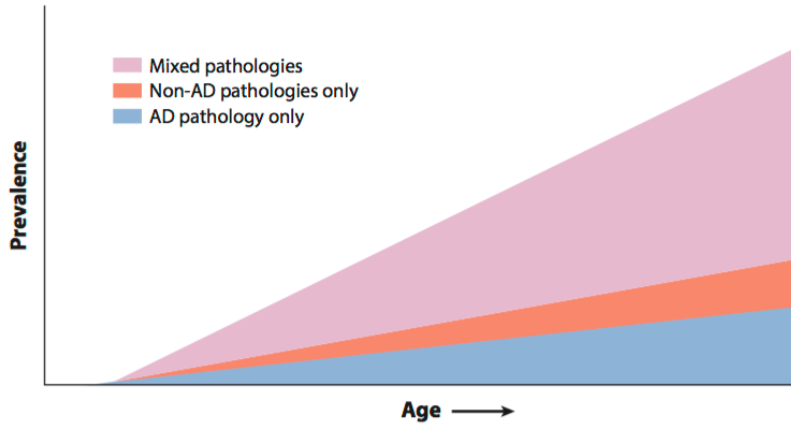


EC: entorhinal cortex (BA28); GA : gyrus ambiens (BA34) ; RS: rhinal sulcus, TN: temporal notch ; CS:collateral sulcus

# Background



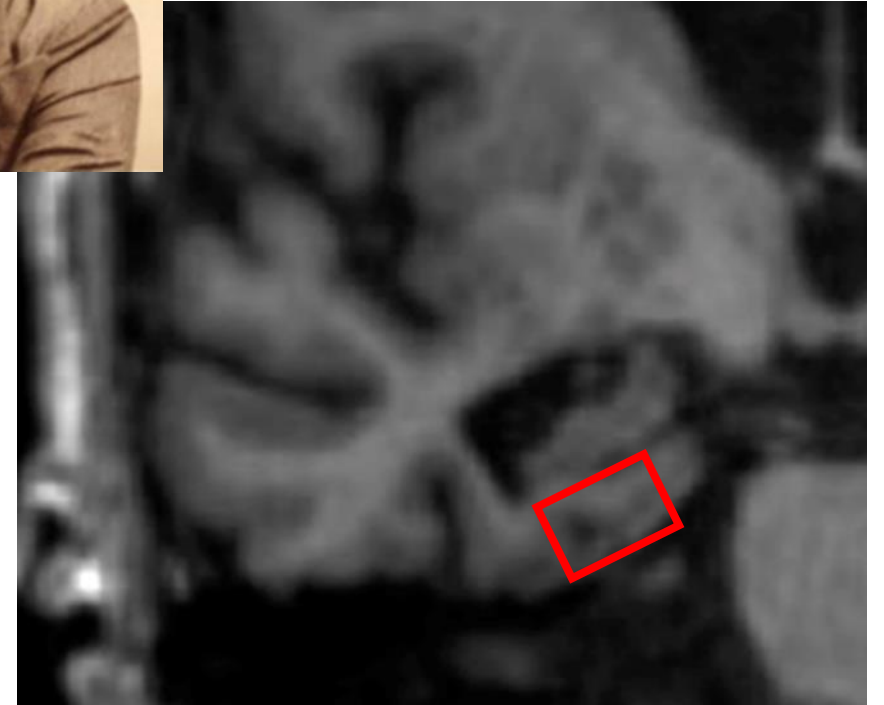
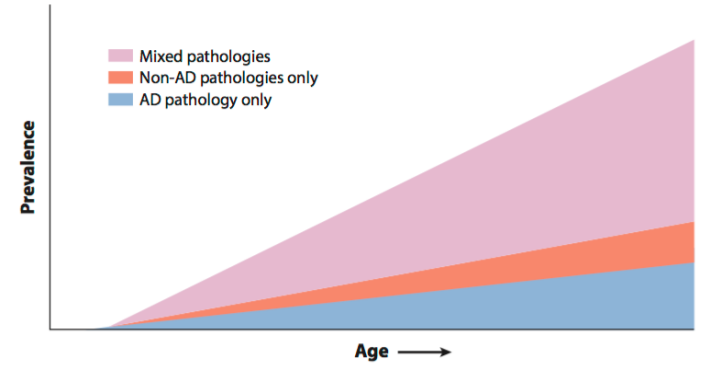
- Alzheimer's disease
- Vascular dementia
- Dementia with Lewy Bodies
- Frontotemporal dementia
- Other



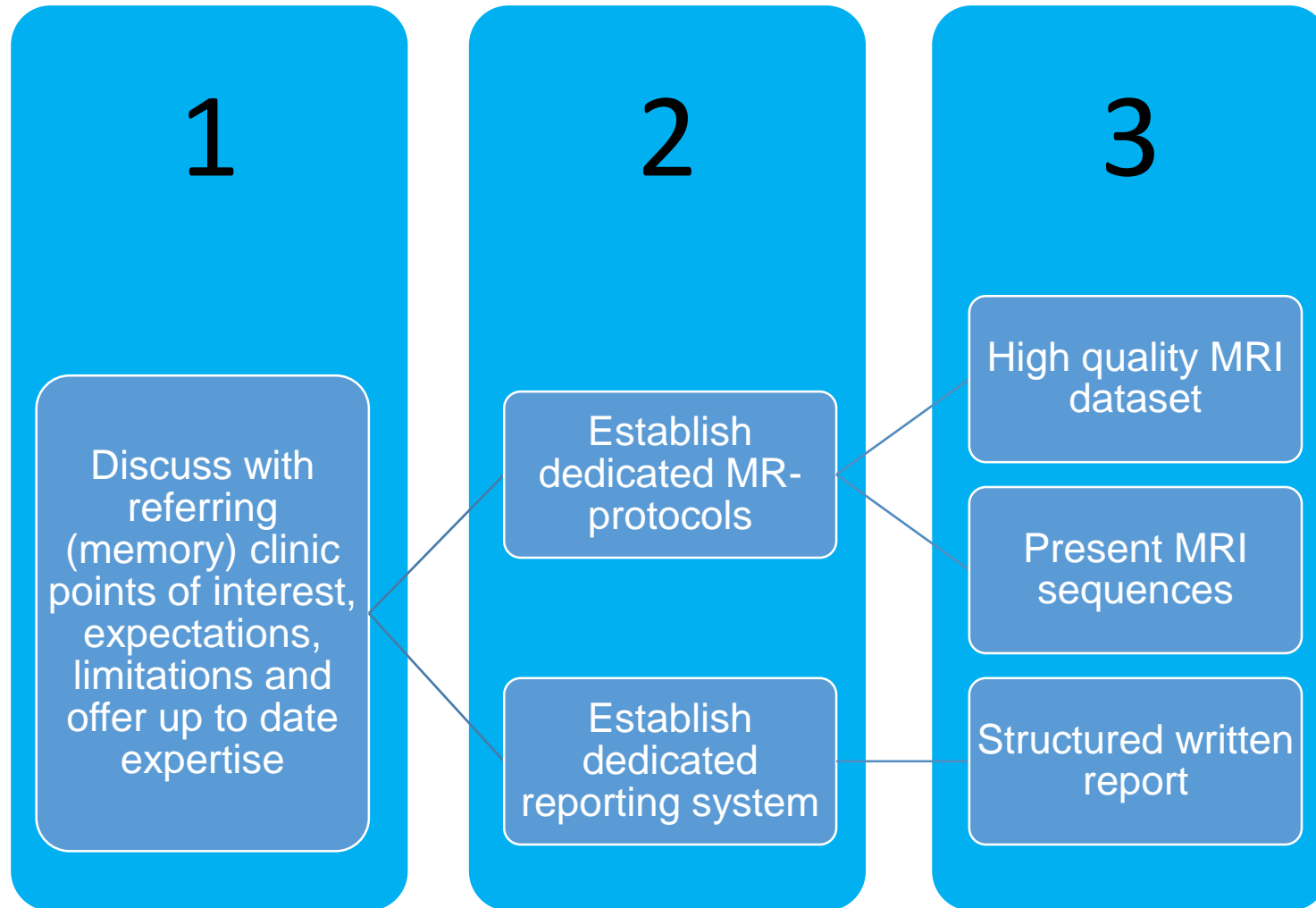
Jellinger K & Attems J, Acta Neuropathol, 2010



- Alzheimer's disease
- Vascular dementia
- Dementia with Lewy Bodies
- Frontotemporal dementia
- Other



# MRI reading in dementia - what's expected from the neuroradiologist?



# MRI protocol

## 3T MRI scanner



- T1 3D-MPRAGE
- T2-(3D)FLAIR
- SWI tra
- DWI tra

Post-processing: Volumetry  
(automated, T1 3D-MRPAGE)

Scanning time < 30 min

# Anatomical landmarks

Fissura longitudinalis cerebri

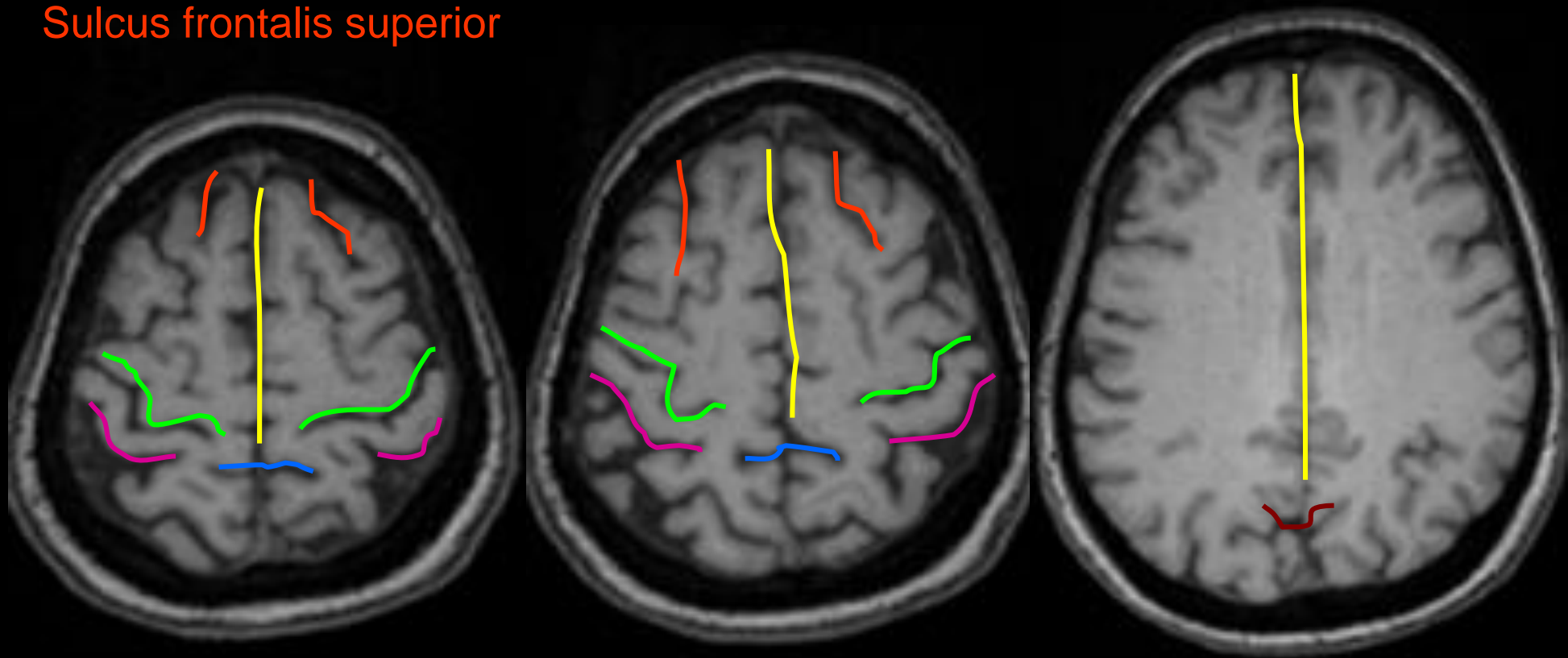
Sulcus centralis

Sulcus postcentralis

Sulcus cinguli posterior

Sulcus parietooccipitalis

Sulcus frontalis superior



# Anatomical landmarks

Sulcus circularis insulae

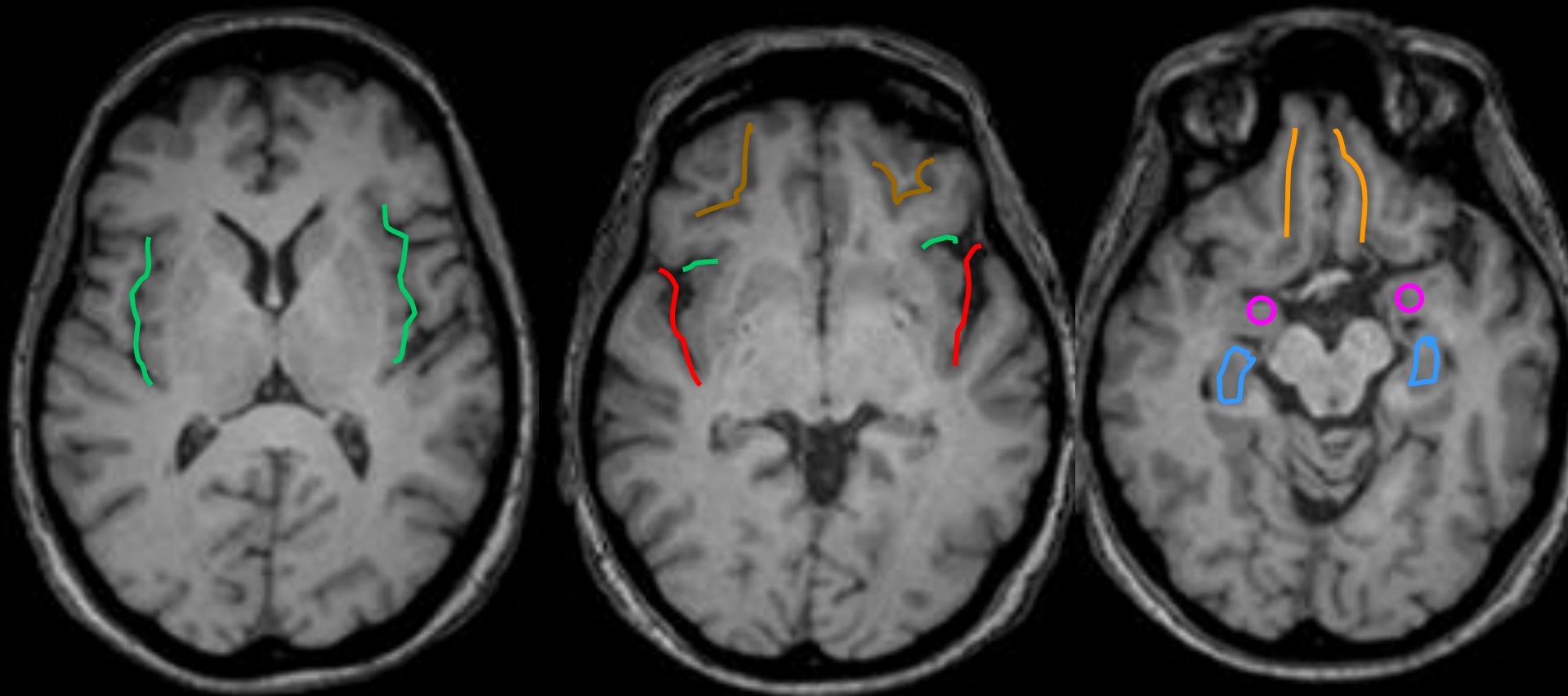
Fissura lateralis (Sylvii)

Sulci orbitales

Sulcus olfactorius

Amygdala

Hippocampus



# Anatomical landmarks

Fissura longitudinalis cerebri

Sulcus frontalis superior

Sulcus olfactorius

Sulci orbitales

Sulcus circularis insulae

Fissura lateralis (Sylvii)

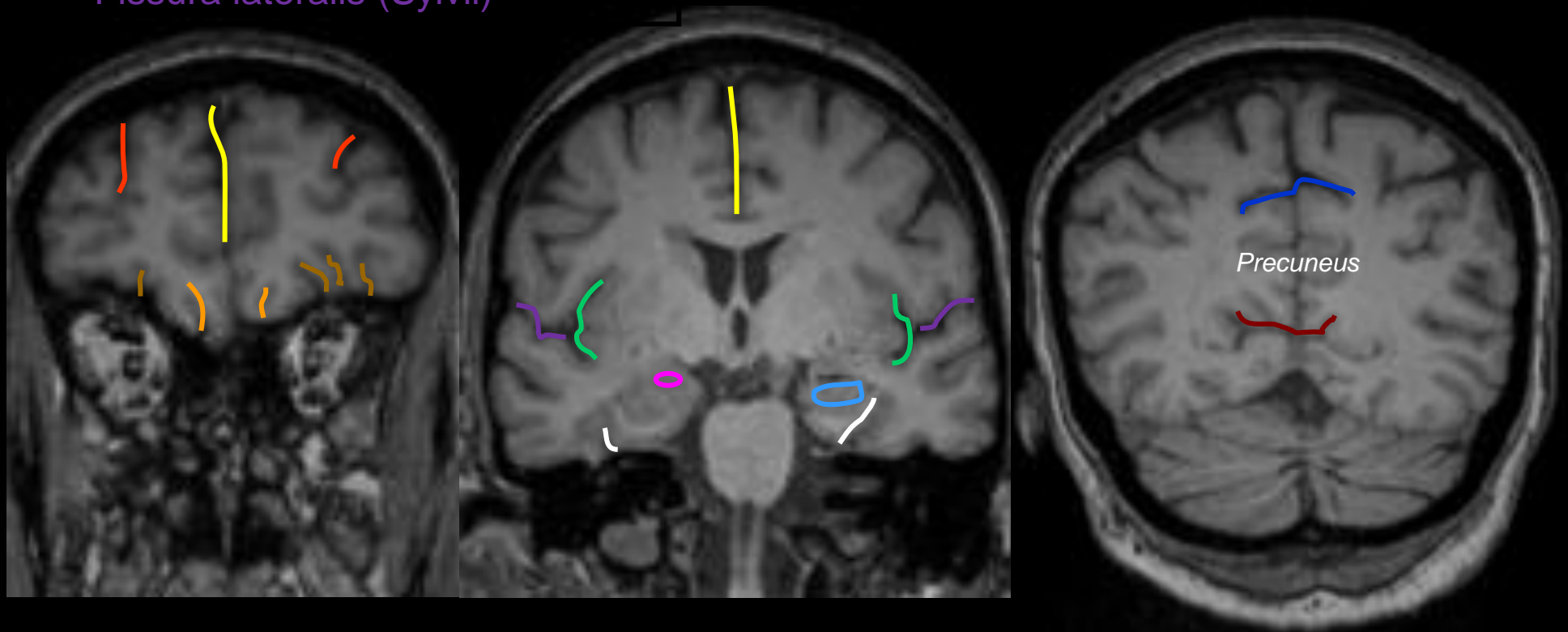
Amygdala

Hippocampus

Sulcus collateralis

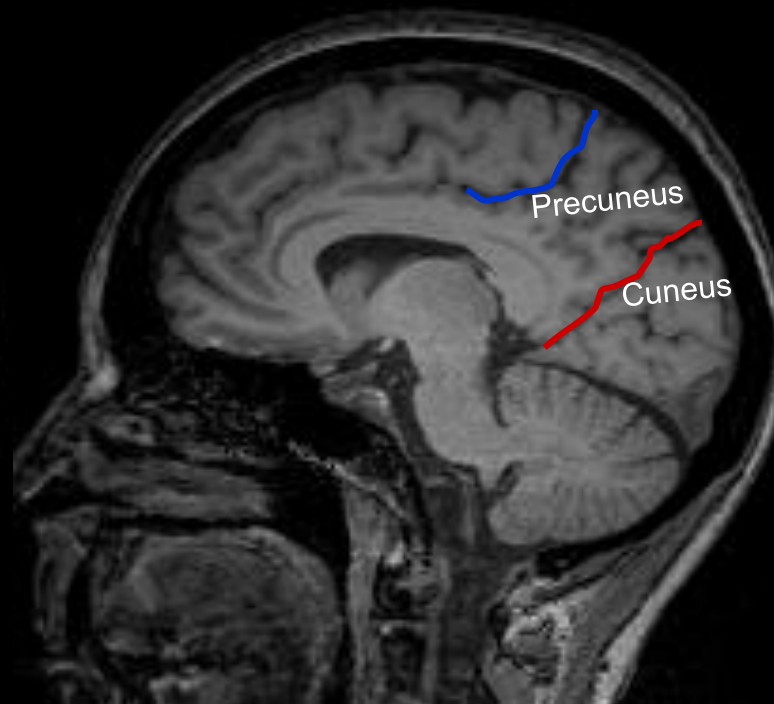
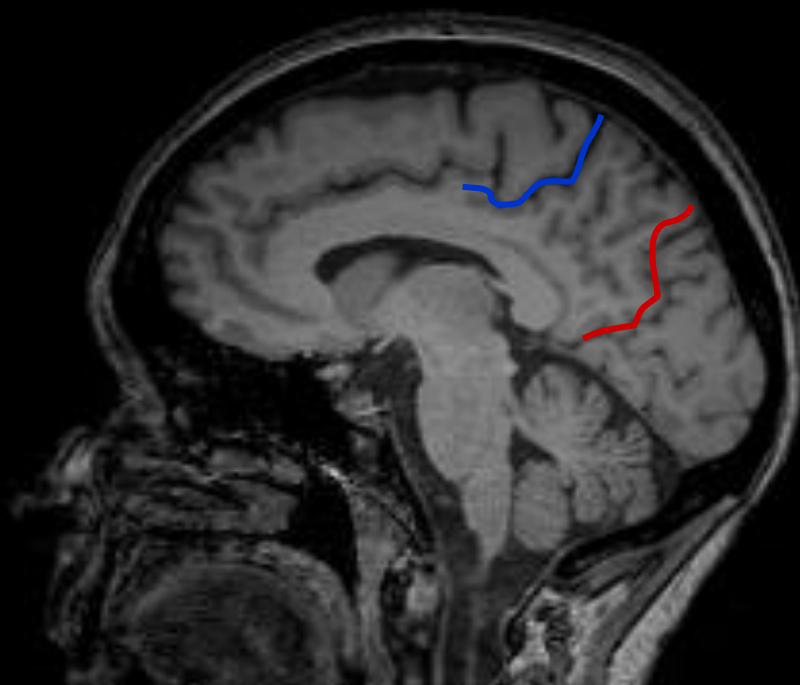
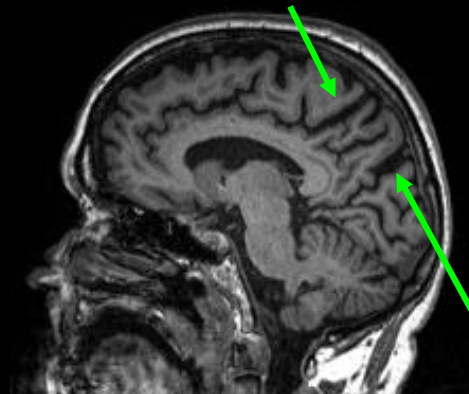
Sulcus cinguli posterior

Sulcus parietooccipitalis

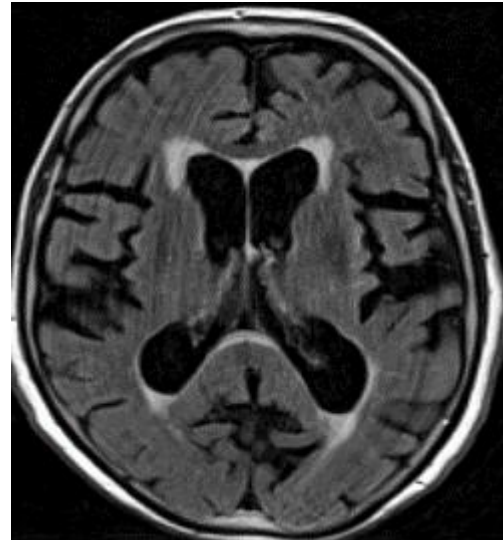
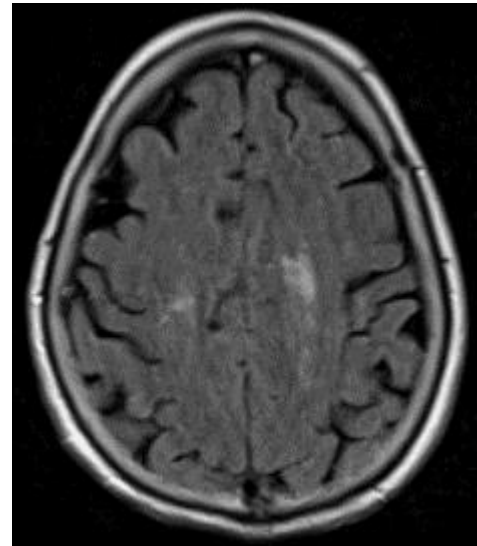
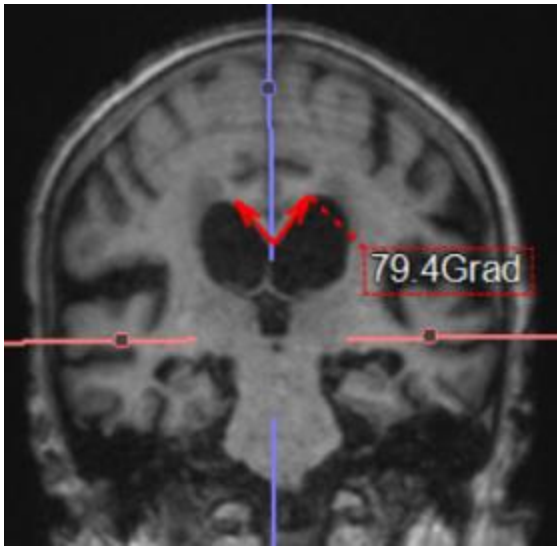


# Anatomical landmarks

Sulcus cinguli posterior  
Sulcus parietooccipitalis



# Ventricles



## Interhemispheric fissure

in midline

not in midline

## Widening of ventricles

no

mild

moderate

severe

## Acute Hydrocephalus

yes

no

## NPH -Aspect

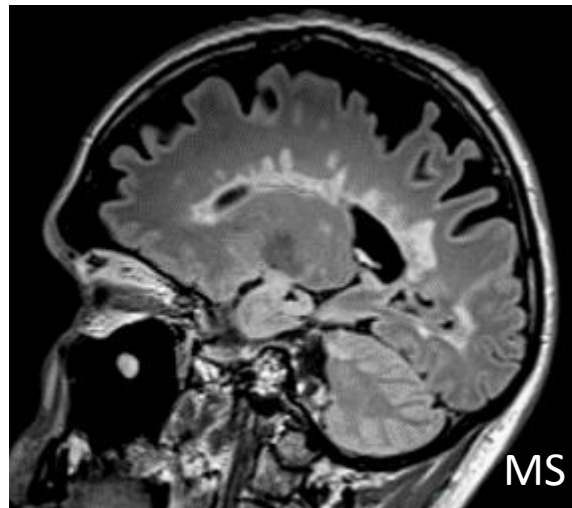
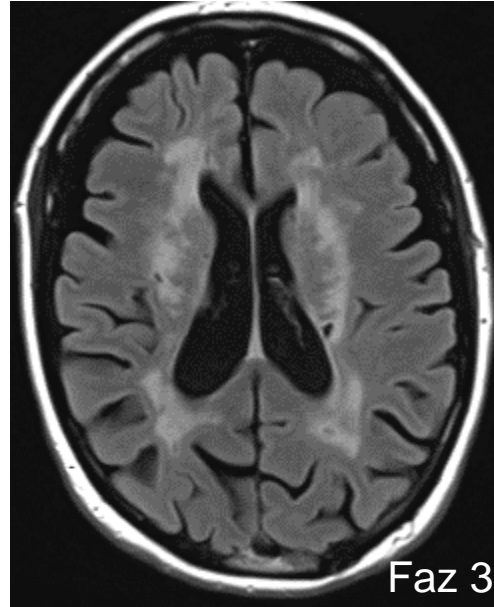
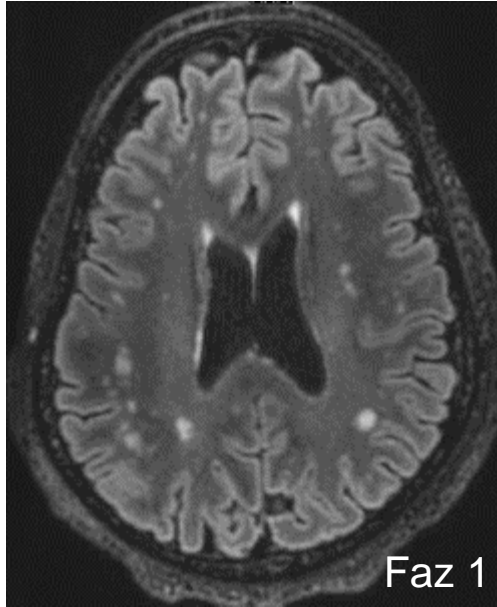
yes

no

## Callosal Angle:

79°

# White matter lesions (FLAIR), Fazekas score



WM lesions
none
one (FAZEKAS 0)
few (FAZEKAS 1)
multiple patchy (FAZEKAS 1)
early confluence (FAZEKAS 2)
mostly confluent (FAZEKAS 3)

WM lesions location
periventricular
paraventricular
subcortical
subcortical and periventricular
periventricular > subcortical
subcortical > periventricular

# Infarcts (FLAIR, DWI)

Old infarcts
Yes
no

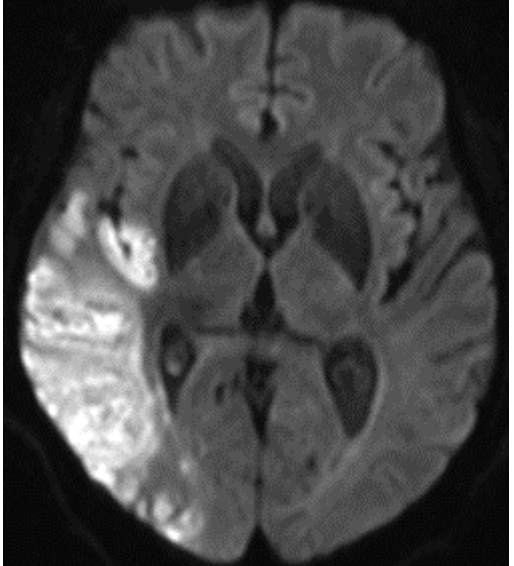
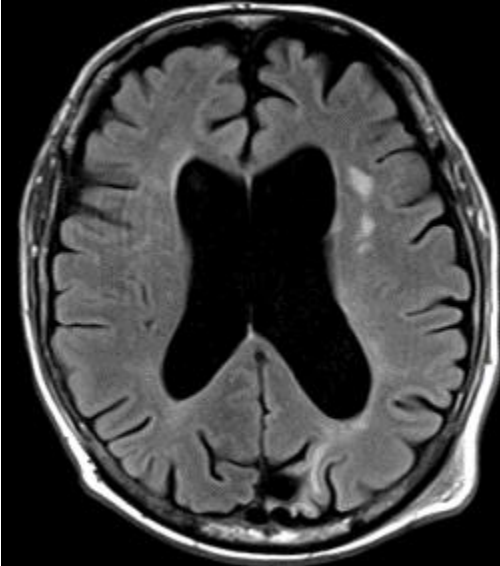
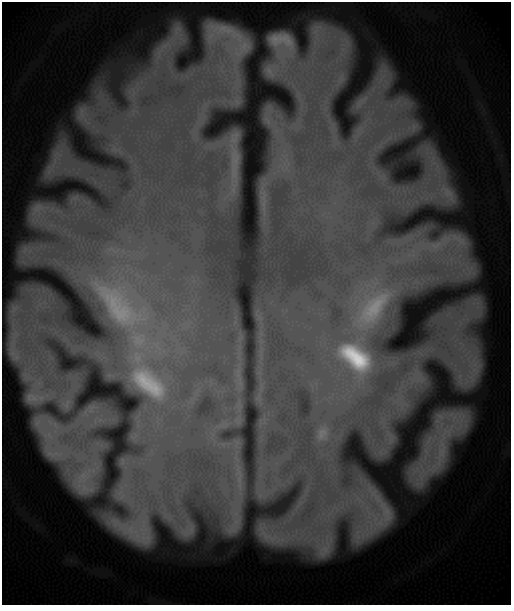
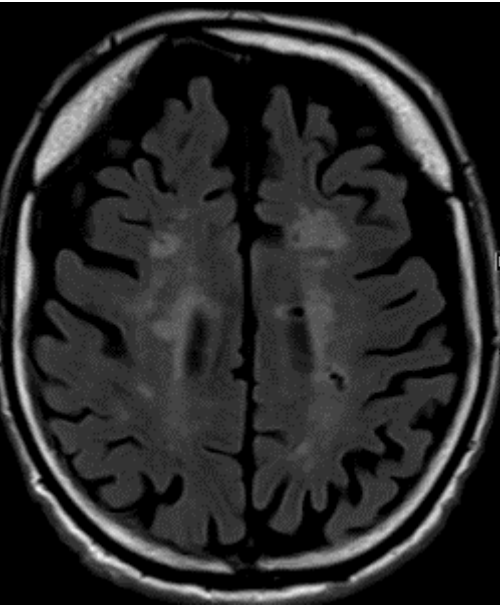
↓

<b>FREETEXT «location»</b>
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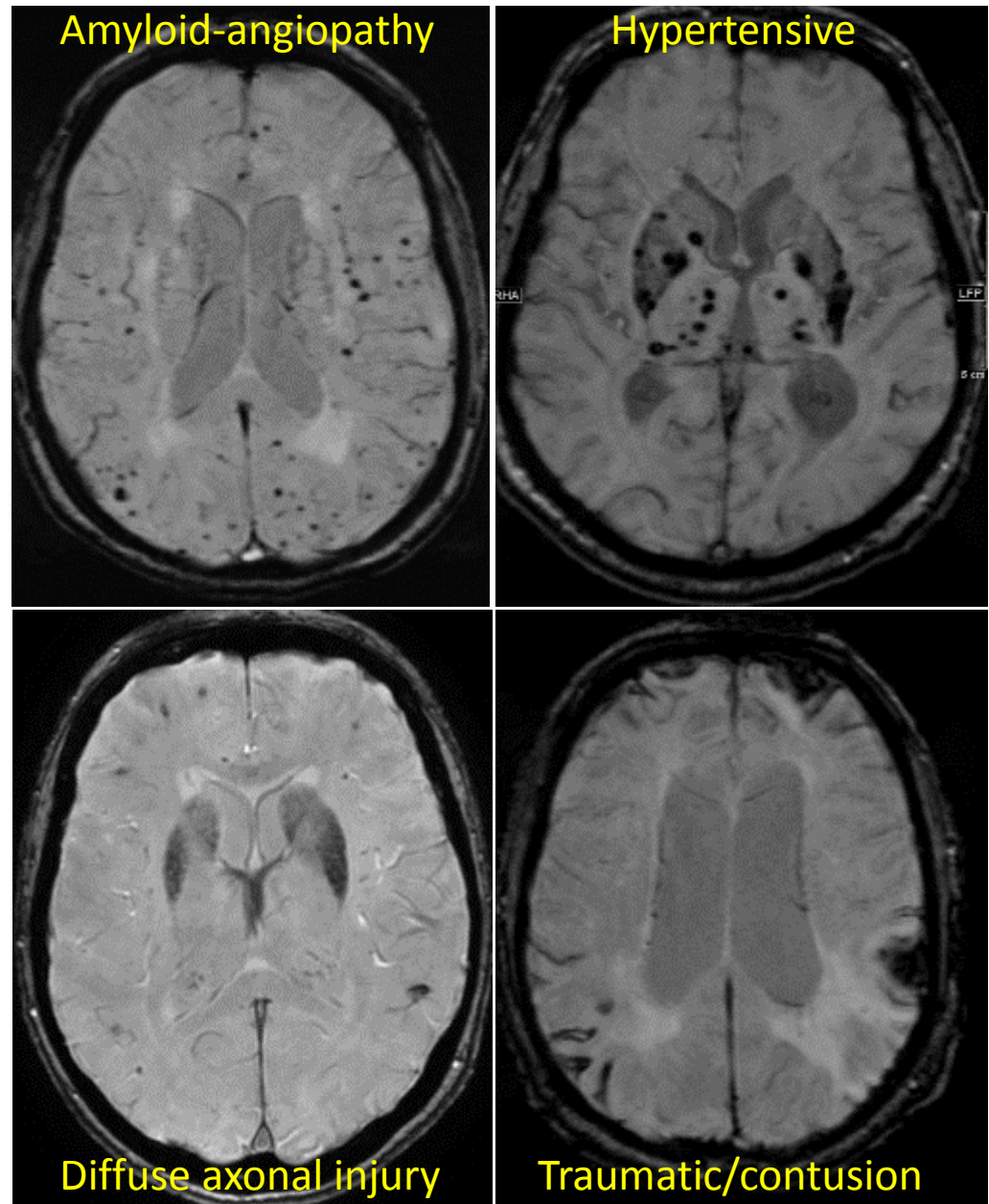
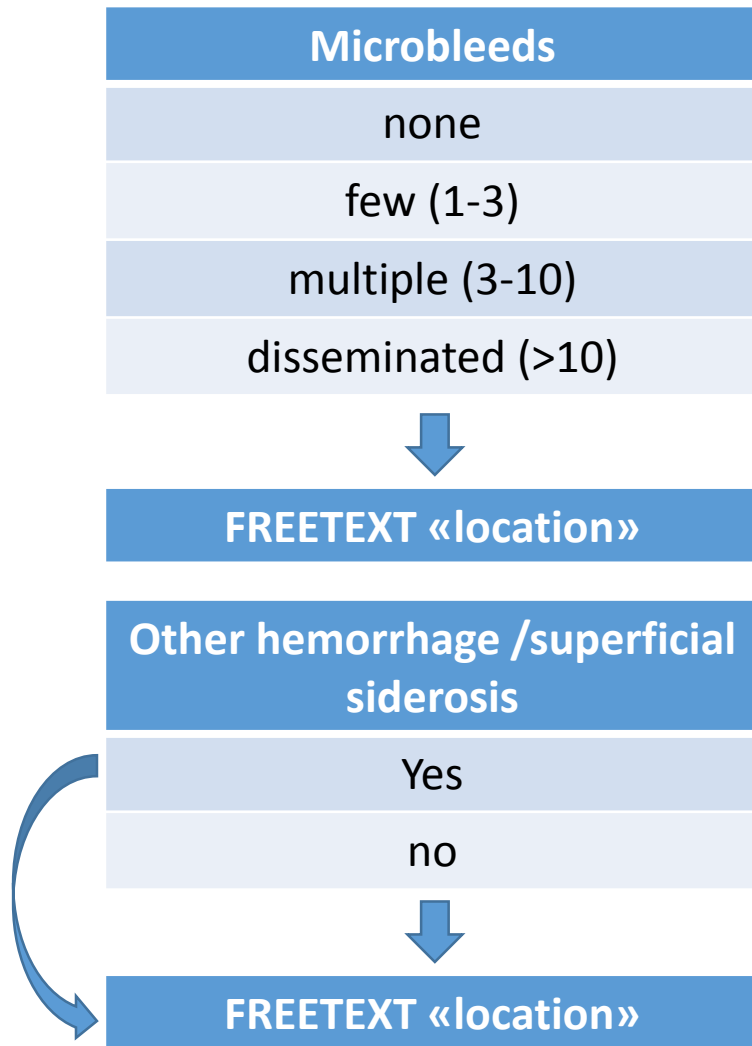
Acute infarcts
yes
no

↓

<b>FREETEXT «location»</b>
----------------------------



# (Micro)-Hemorrhage (SWI)

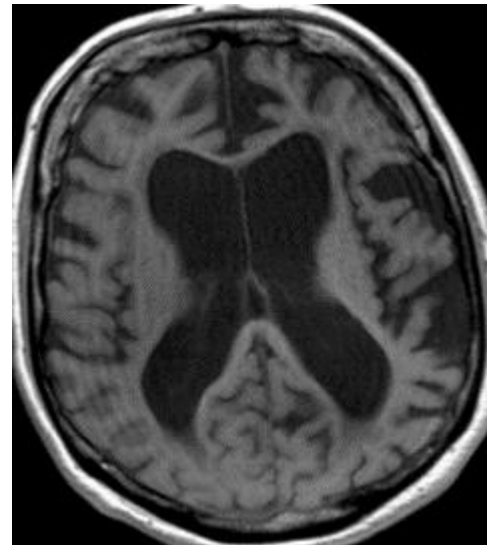


# Global cortical atrophy (GCA score)

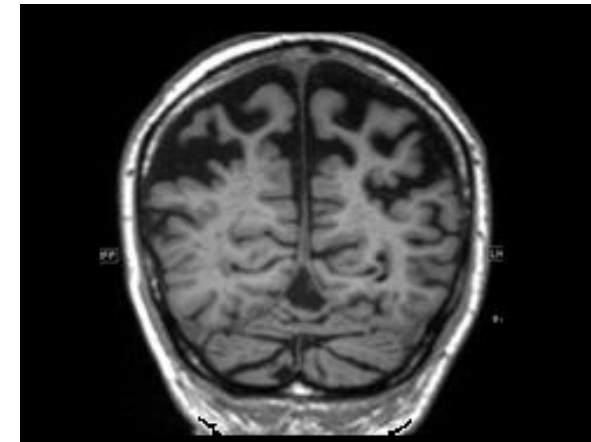
GCA
no (GCA 0)
mild (GCA 1)
mild-moderate (GCA 1-2)
moderate (GCA 2)
moderate – severe (GCA 2-3)
severe (GCA 3)



Side predilection
no
right
left

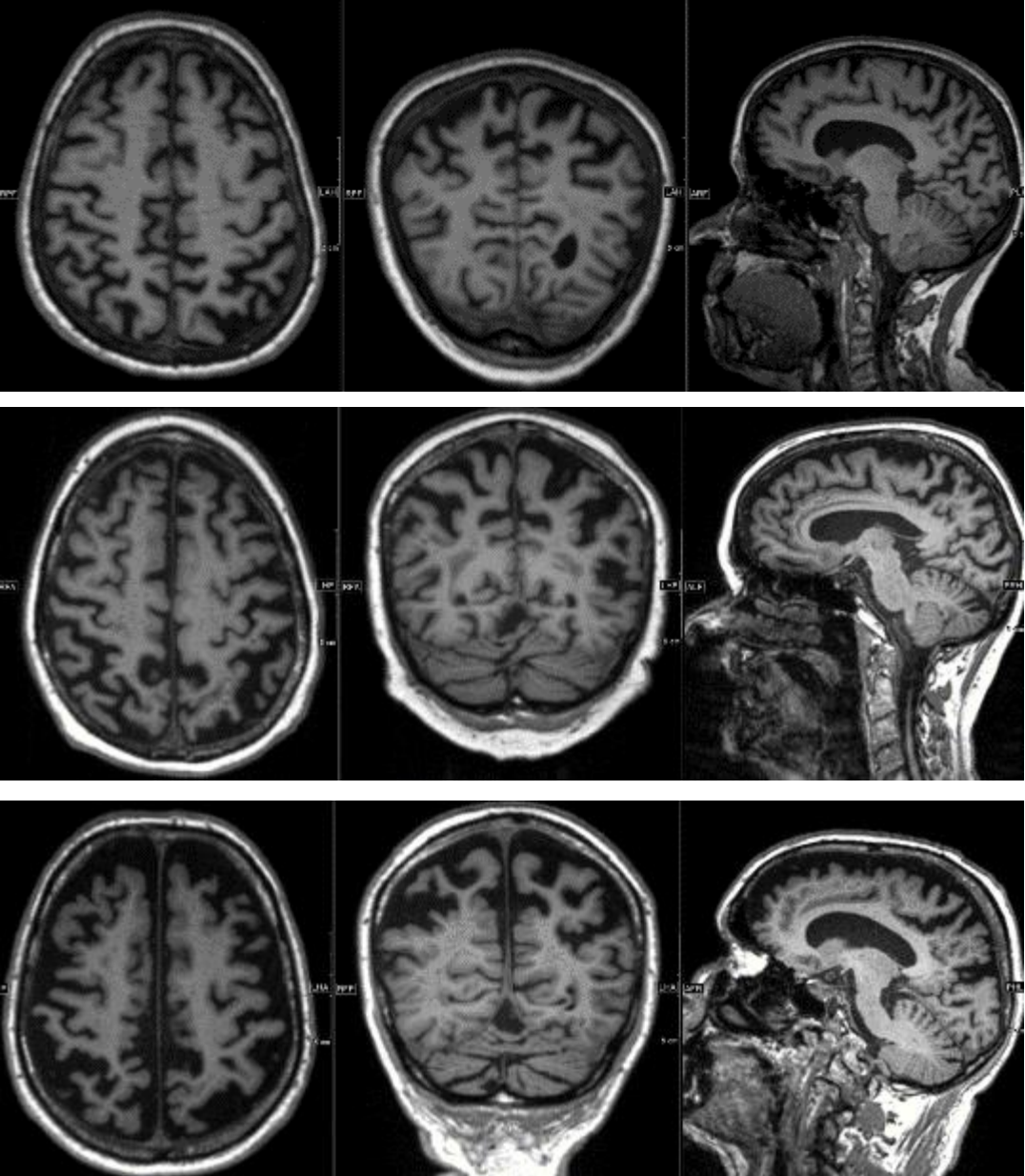


Focal predilection
no
frontal
parietal
temporal
occipital
infratentorial



# Posterior parietal atrophy, PA (Koedam score)

PA
none (Koedam 0)
mild (Koedam 1)
moderate (Koedam 2)
severe (Koedam 3)



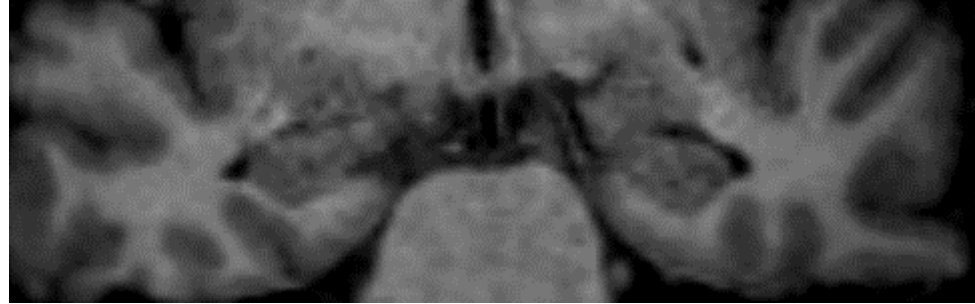
# Mesiotemporal (MTA) & entorhinal (ERICA) atrophy

MTA [left]; MTA [right]	Entorhinal atrophy (ERICA [left]; ERICA [right])	Amygdala atrophy
none (MTA 0)		no
unspecific (MTA 1)	none (ERICA 0)	mild-moderate
mild (MTA 2)	mild (ERICA 1)	moderate-severe
moderate (MTA 3)	moderate (ERICA 2)	↓
severe (MTA 4)	severe (ERICA 3)	Side predilection
		left
		right
		bilateral

# Mesiotemporal atrophy (MTA score)

Right: **MTA 0**

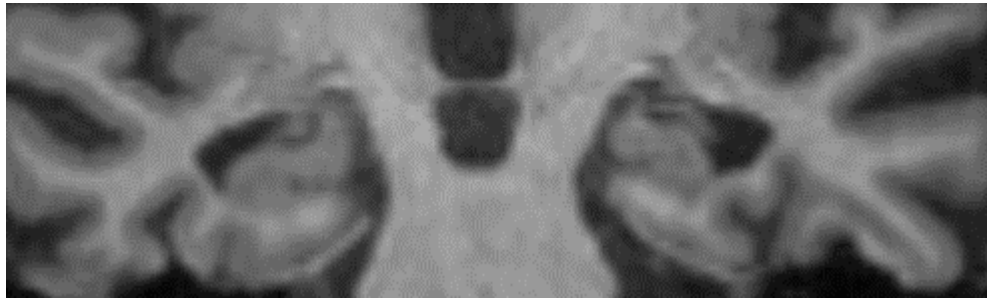
*(normal)*



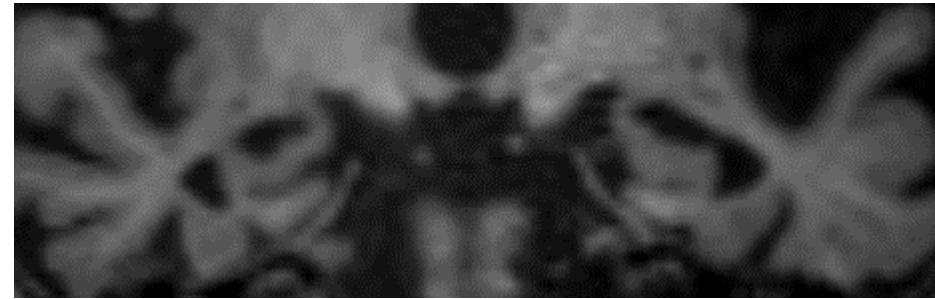
Left: **MTA 1**

*(widening of choroidal fissure)*

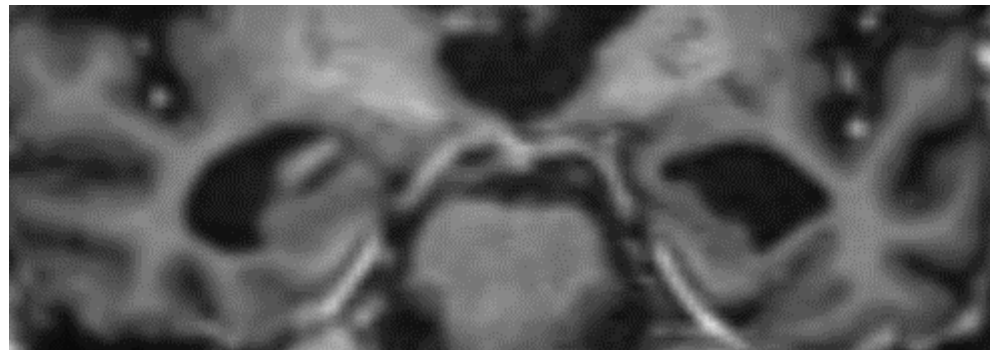
**MTA 2** *(widening temporal horn)*



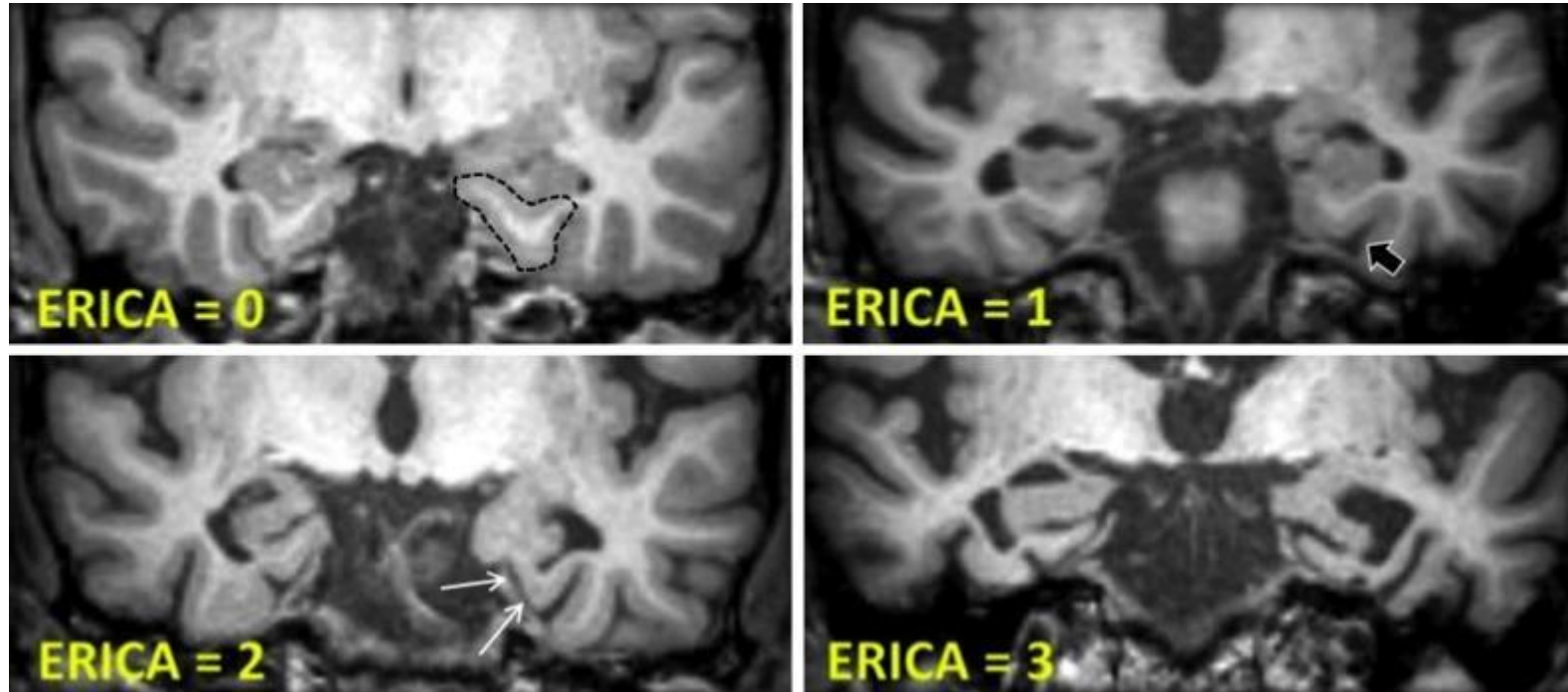
**MTA 3** *(decreasing hippocampal volume)*



**MTA 4** *(severe hippocampal volume loss)*

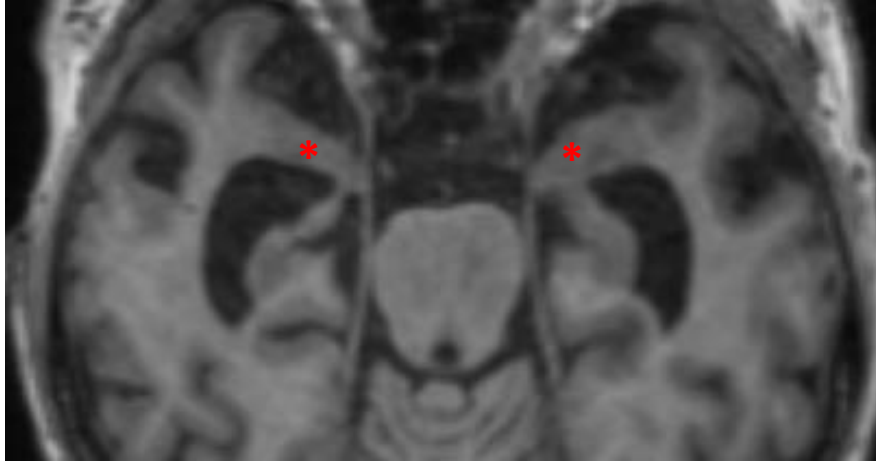


# Entorhinal atrophy (ERICA score)

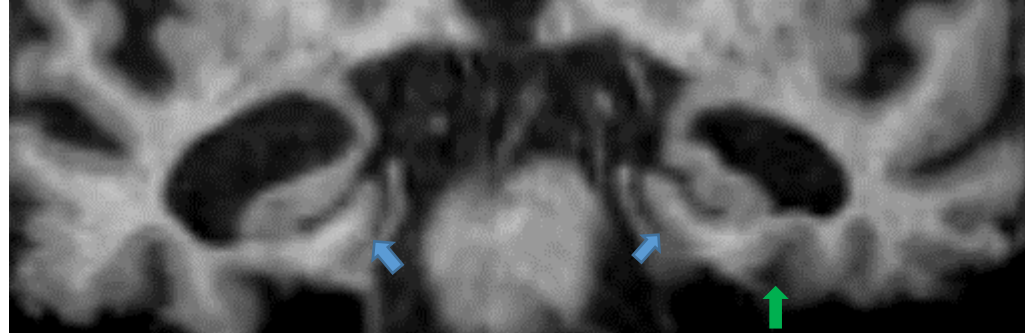
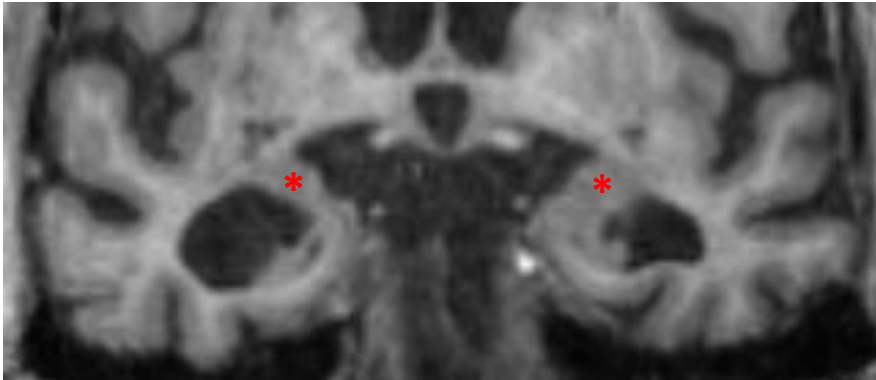


- Erica 0 = normal volume of the entorhinal cortex and parahippocampal gyrus
- Erica 1 = mild atrophy with widening of the collateral sulcus
- Erica 2 = moderate atrophy with detachment of the entorhinal cortex from the cerebellar tentorium (the “tentorial cleft sign”)
- Erica 3 = pronounced atrophy of the parahippocampal gyrus and a wide cleft between entorhinal cortex and the cerebellar tentorium.

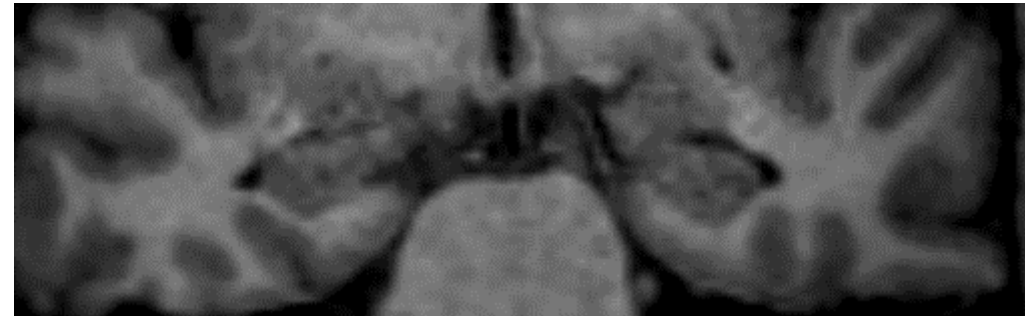
# Amygdala & entorhinal cortex



Atrophy of amygdala; MTA 4 ; entorhinal atrophy; widening of collateral sulcus



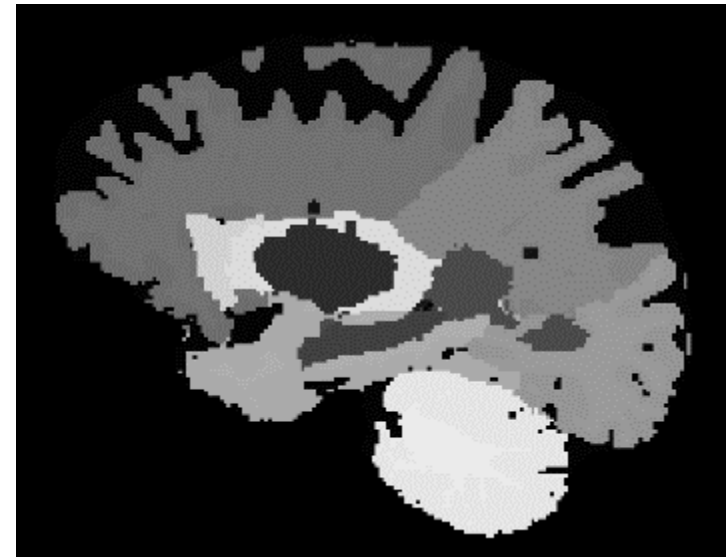
MTA 4 ; entorhinal atrophy; widening of collateral sulcus



MTA 0; no entorhinal atrophy; no widening of collateral sulcus

# Brain morphometry report – parameters (n=54)

Total intracranial volume	White matter (total)	CSF
Brain	Wmab	Total and Ventricles
Grey matter	White matter (left; right)	Lateral (left; right)
Cortical and Total	Parietal lobe	3rd
Grey matter (left; right)	Occipital lobe	4th
Parietal lobe	Temporal lobe	
Occipital lobe	Frontal lobe	
Temporal lobe	Corpus callosum (total bilateral)	
Frontal lobe	Deep WM	
Insula	Hippocampus (total; left; right)	
Cingulate gyrus	Cerebellum (total GM + WM)	
Putamen	Mesencephalon	
Caudate nucleus	Pons	
Pallidum	Medulla oblongata	



Siemens Morphobox

# Thank you for your attention!

**SFCNS Neuroimaging Course**

1st Module: Imaging Neurodegeneration

