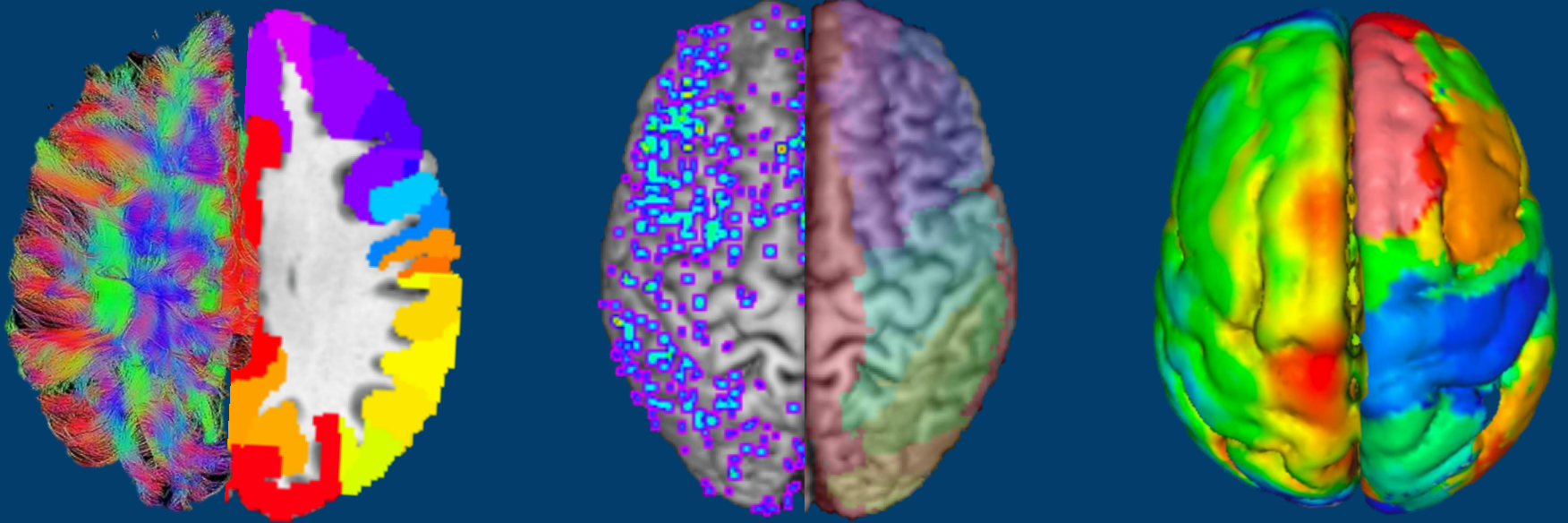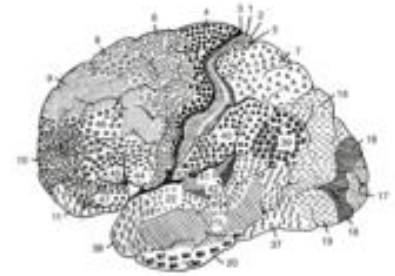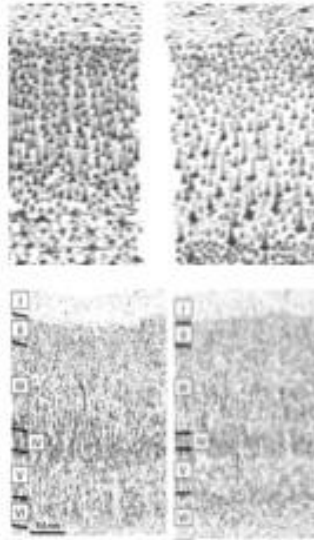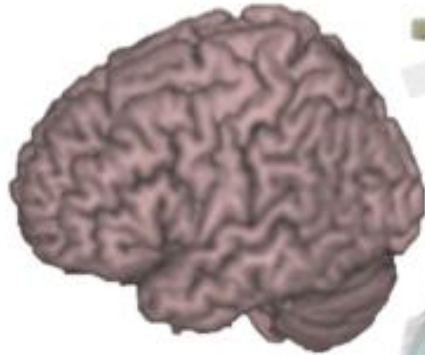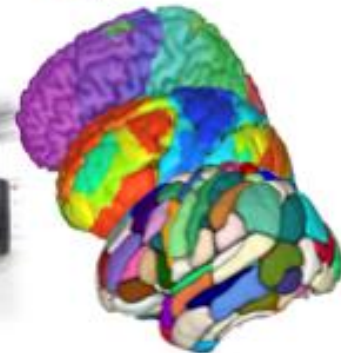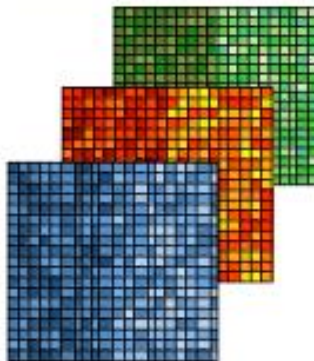# Introduction to brain parcellation

Sarah Genon
Cognitive Neuroinformatics Lab
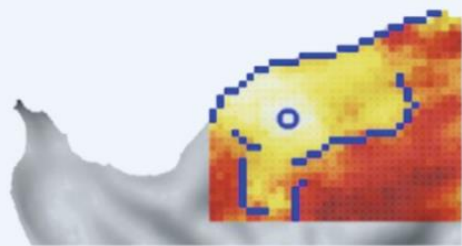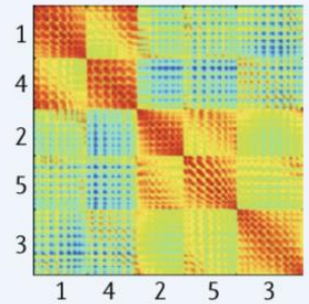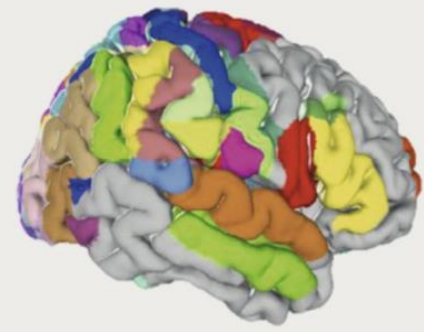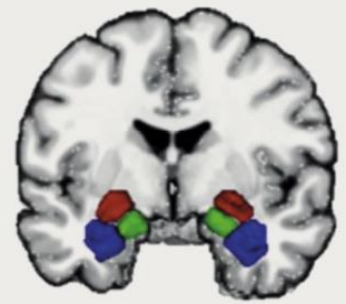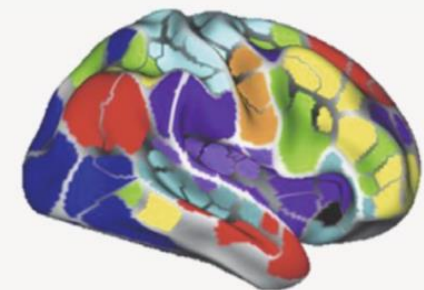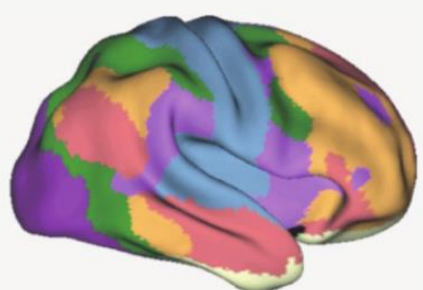
Brain parcellation

From histology

To multimodal MRI

	Algorithm	**Boundary mapping**	**Clustering or factorization**
Markers			
Local **Histology-based:** • Cytoarchitecture • Receptors • Myelin **MRI-based:** • Myelin • Meta-analytic activation modelling		Border detection in cortex based on cytoarchitecture 	Clustering of amygdala voxels based on their activation in behavioural paradigms
Global **MRI-based:** • Resting-state functional connectivity • Meta-analytic connectivity modelling • Diffusion tractography • Structural covariance		Boundary mapping of resting-state functional connectivity of cerebral cortex 	Clustering of cerebral cortex based on resting-state functional connectivity

Eickhoff, Yeo & Genon, 2018, Nat. Rev. Neurosci.
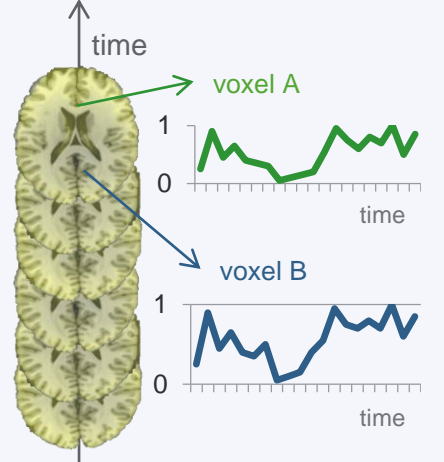
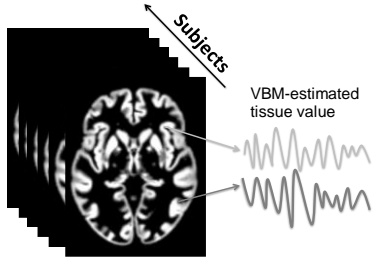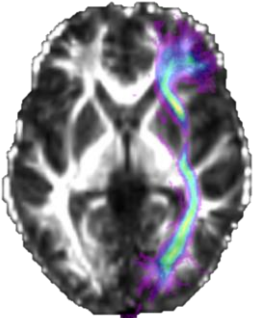# Connectivity-based parcellation (CBP)

Neuroimaging scanner

Connectivity
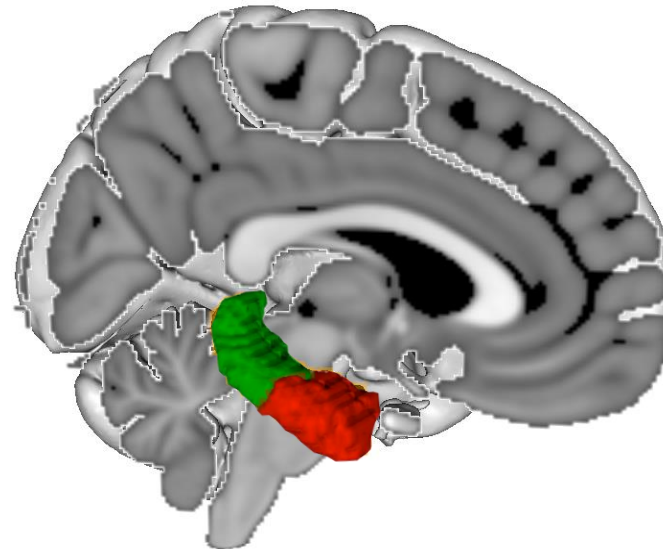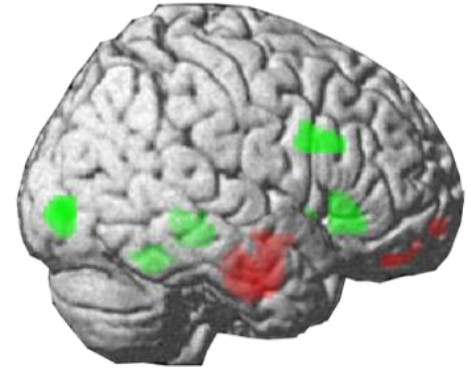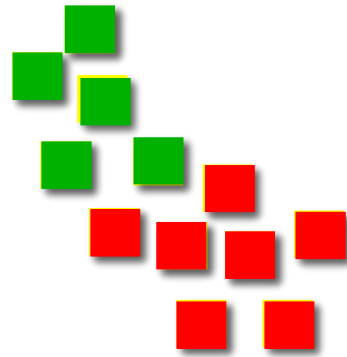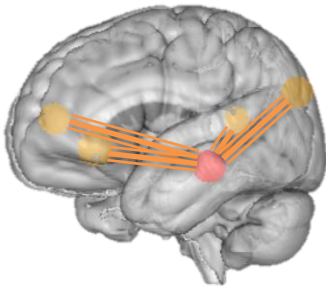
How to estimate connectivity ?

Type of connectivity	Functional		Co-plasticity	Structural (white matter)
Data	Task-based fMRI	Resting state fMRI	Anatomical MRI	Diffusion MRI
Approach	Task-based: Activation during task	Resting-state: Signal fluctuations at rest	Morphometry-based: Structural co-variation in the population	Diffusion-based: Estimation of fiber direction
Main method	Meta-Analytic Connectivity Modeling (**MACM**)	Cross-timepoint correlation in signal fluctuations (**RSFC**)	Correlation of local GM across subjects (**SC**)	Probabilistic diffusion tractography (**PDT**)

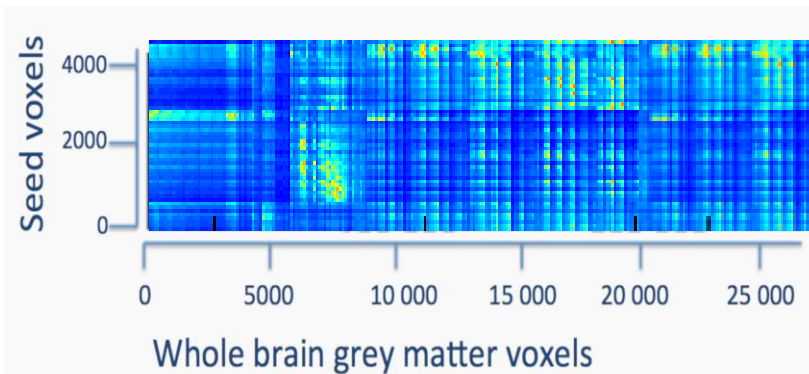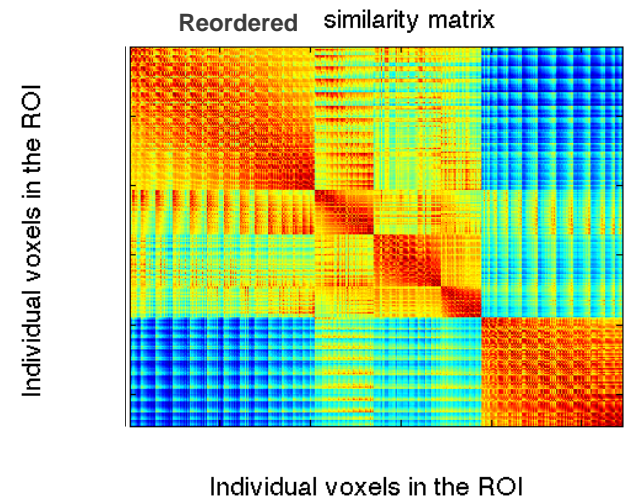*Eickhoff, Yeo & Genon, 2018, Nat. Rev. Neurosci.*

CBP: how ?
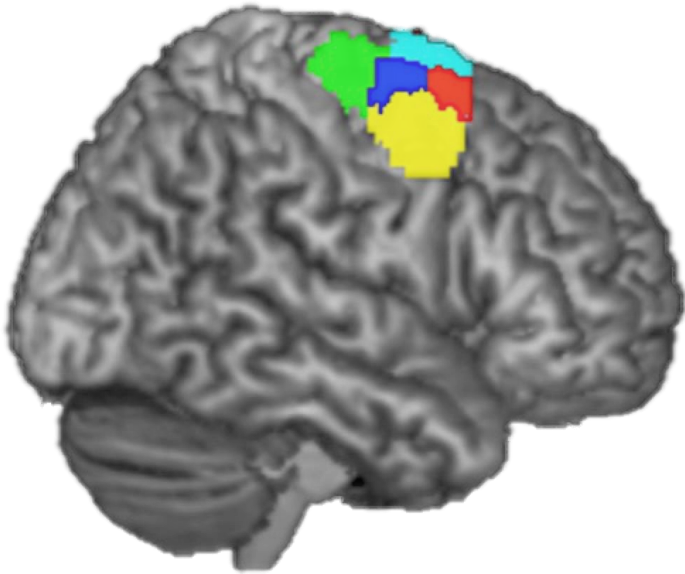
1) Region of Interest:

Dorsal Premotor Cortex:

Interface between prefrontal and primary motor

2) **Connectivity matrix**

3) **Clustering/factorization**
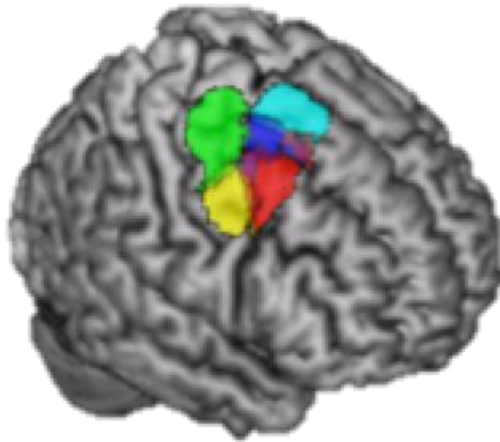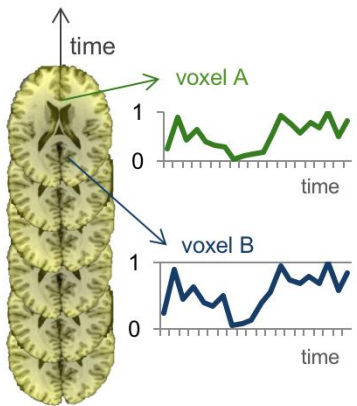
Reordered   similarity matrix

Genon et al., 2017, Cerebral Cortex

Convergence between connectivity modalities

Reordered similarity matrix

Seed voxels / Whole brain grey matter voxels / Individual voxels in the ROI

time / voxel A / voxel B

study a / study b / study c

Genon et al., 2017, Cerebral Cortex
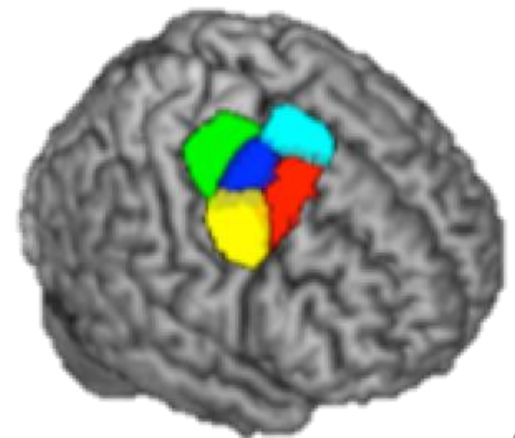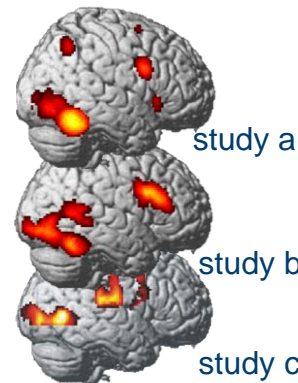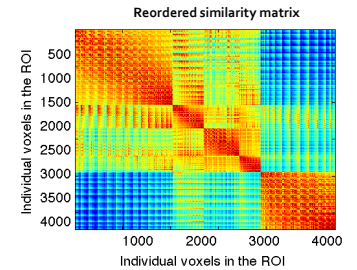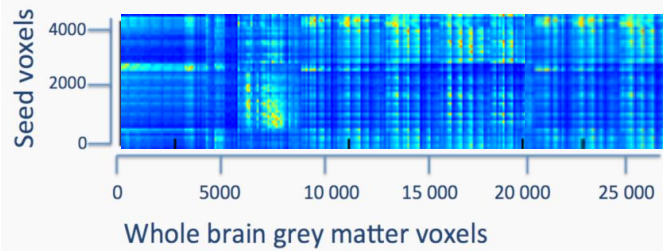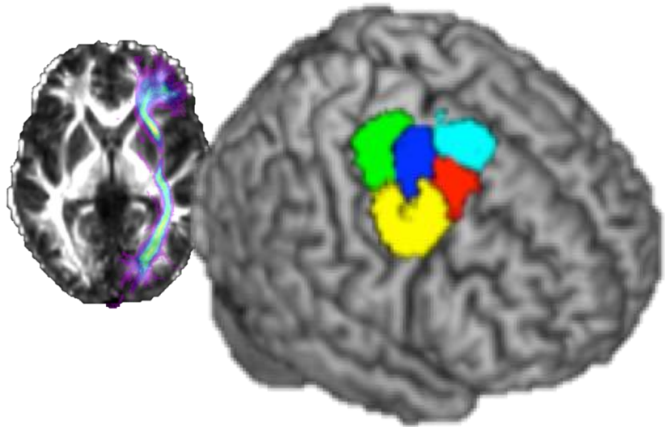
Local microstructure VS large-scale functional integration
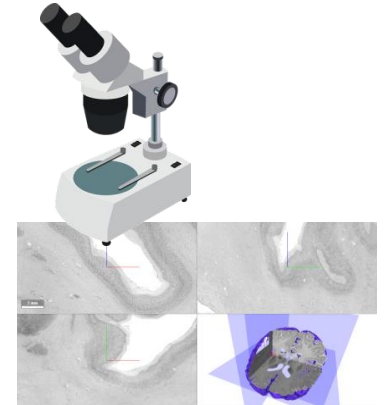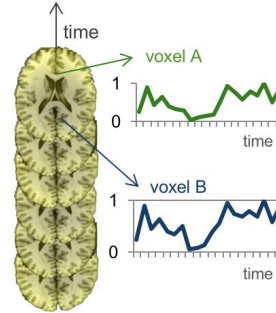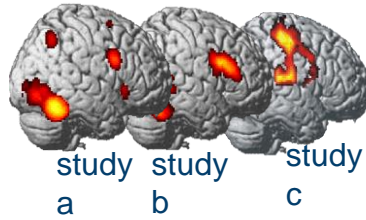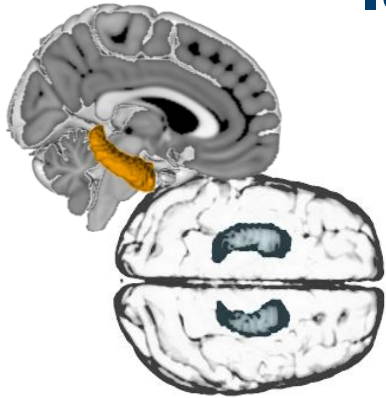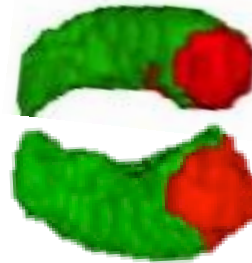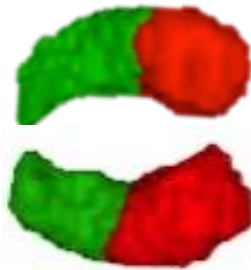
study a   study b   study c

voxel A
voxel B
time

2k

3k

Plachti et al., 2019, Cerebral Cortex; Plachti et al., 2020, Brain

Local microstructure and large-scale functional integration

study a   study b   study c

2k

3k

Plachti et al., 2019, Cerebral Cortex; Plachti et al., 2020, Brain

Local microstructure and
large-scale functional integration

Parcellations

Task co-activation — Robinson et al. (2015), Chase et al. (2015)

Resting-state functional connectivity — Zhong et al. (2019), Cheng et al. (2020)

Task co-activation ∩ resting-state FC — Plachti et al. (2019)

Structural covariance — Plachti et al. (2019), Ge et al. (2019)

MRI-based local microstructure — Patel et al. (2020)

Histology-based local structure — DeKraker et al. (2020)

Gradients

Task co-activation — Vos de Wael et al. (2018) 1st Gradient

Resting-state functional connectivity — Vos de Wael et al. (2018) 1st Gradient 2nd Gradient; Przeździk et al. (2019) 1st Gradient

Structural covariance — Kharabian et al. (2020) 1st Gradient 2nd Gradient

MRI-based local microstructure — Vos de Wael et al. (2018) 1st Gradient

Histology-based local structure — Paquola et al. (2020) 1st Gradient 2nd Gradient

Genon et al., 2022, Trends in Neuroscience
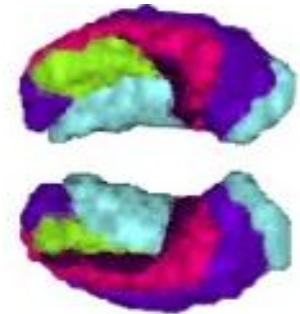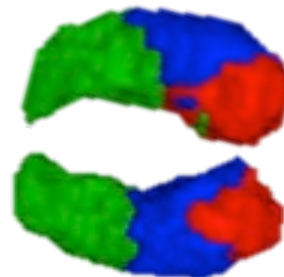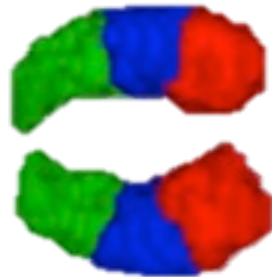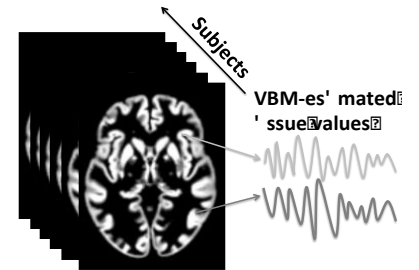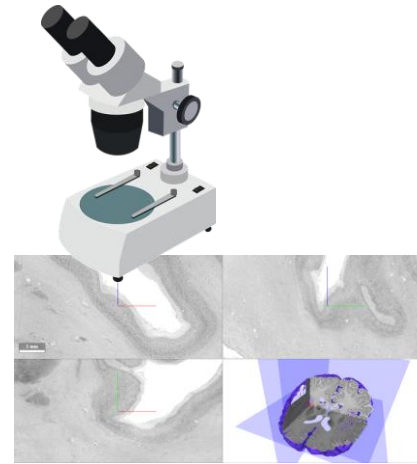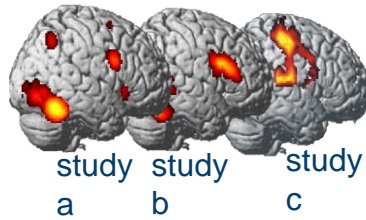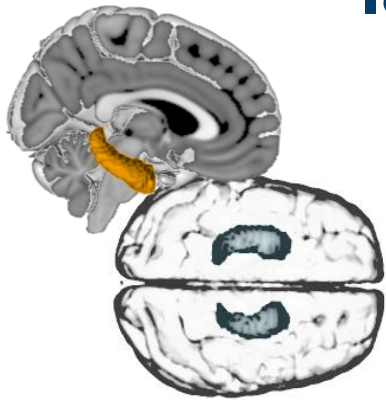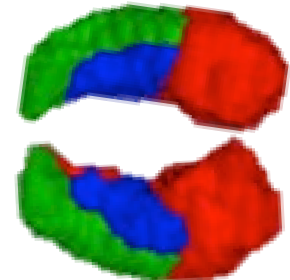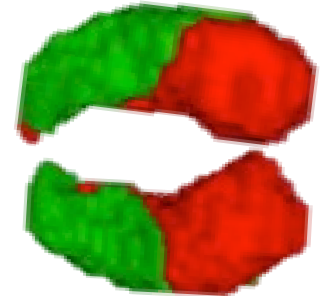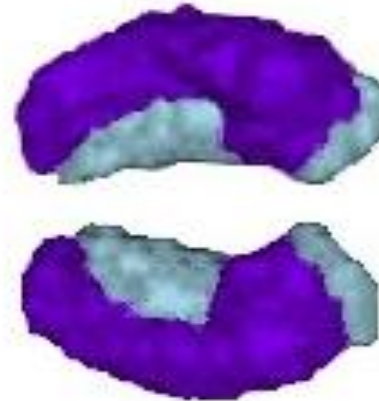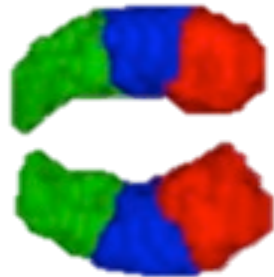
CBPtool for different connectivity modalities:

Reuter et al., BSF, 2020

CBPtool for different connectivity modalities:

Reuter et al., BSF, 2020

Take home messages

Brain parcellation

= a very wide **set of methods** to identify brain regions and/or networks

From histology to MRI-based connectivity

To **understand** and/or to **represent** brain organization and data

Convergence and divergence between mapping features

Resource for CBP:

CBPtool, user-friendly and flexible pipeline for connectivity-based parcellation https://github.com/inm7/cbptools

JÜLICH
Forschungszentrum

THANK YOU

Cognitive Neuroinformatics Lab

Simon Eickhoff

Düsseldorf university
Katrin Amunts

McGill University
Boris Bernhardt

Yale University
Todd Constable

NUS
Thomas Yeo