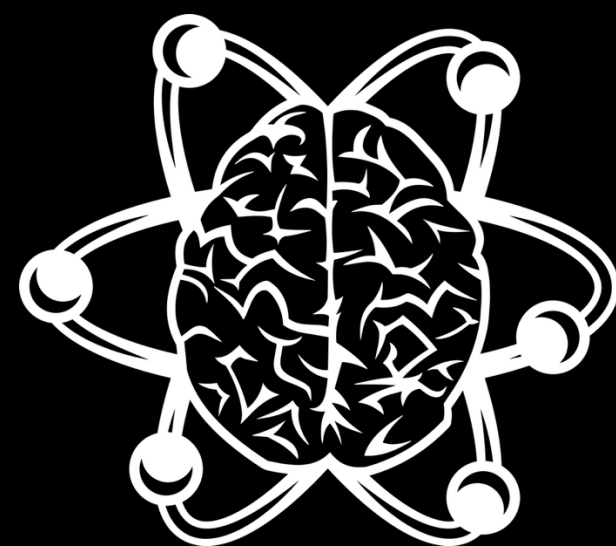
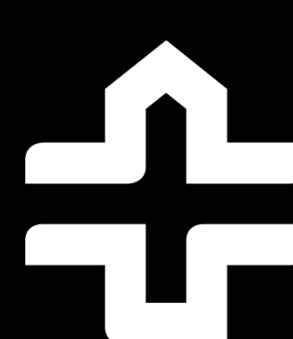


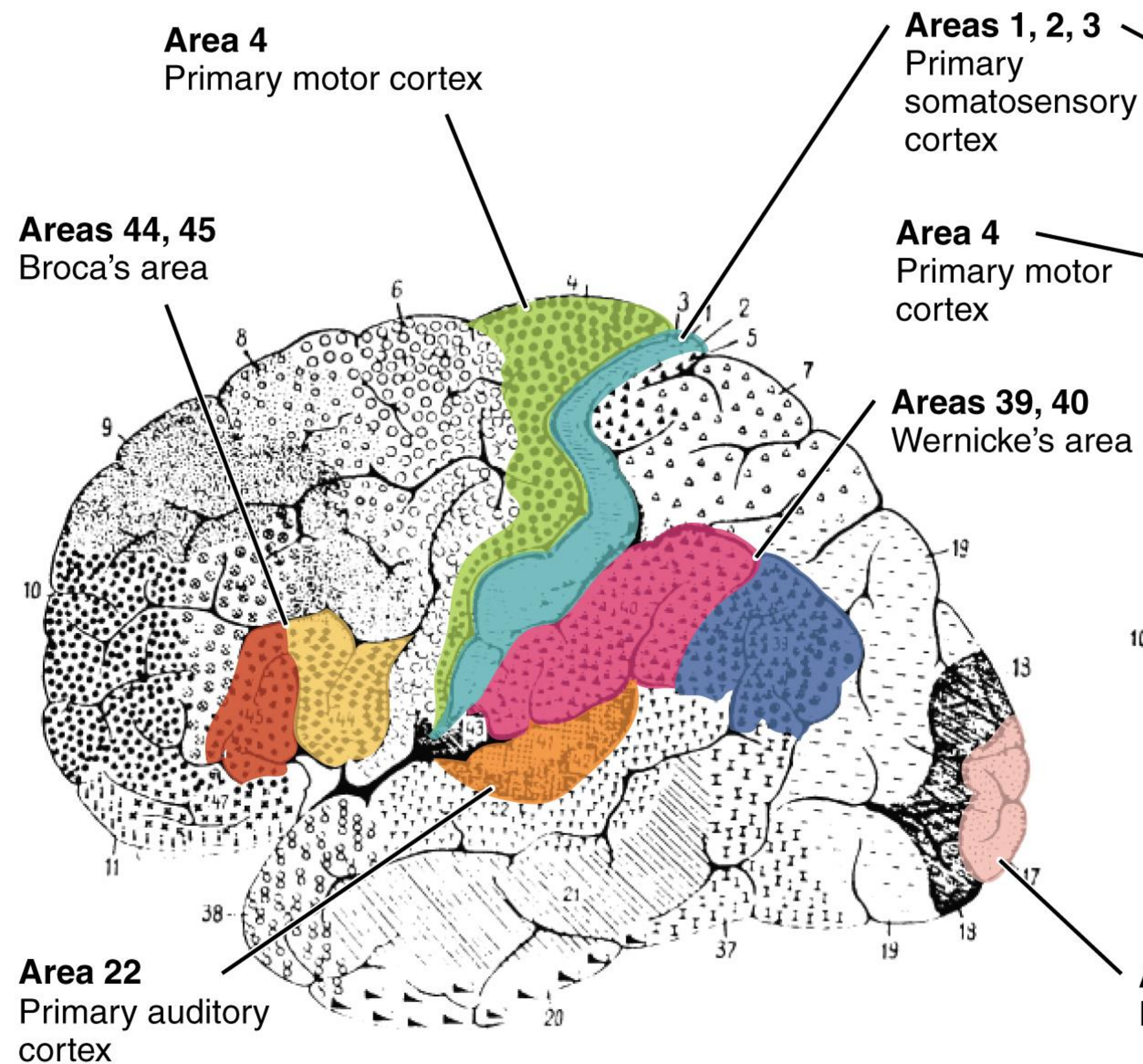


REGION OF INTEREST ANALYSIS

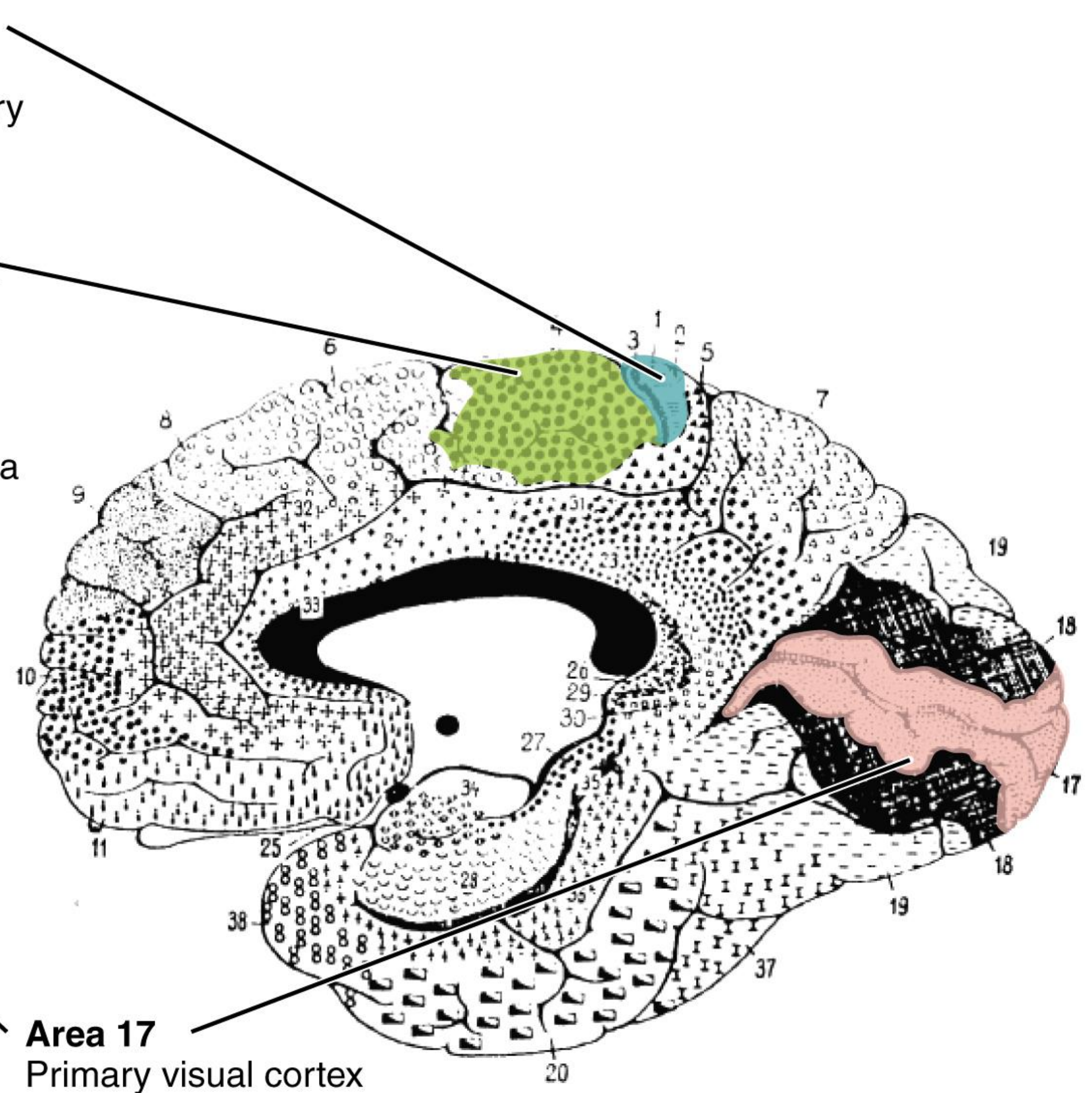
Turku PET Centre Brain Imaging Course 2025

Lauri Nummenmaa, Turku PET Centre





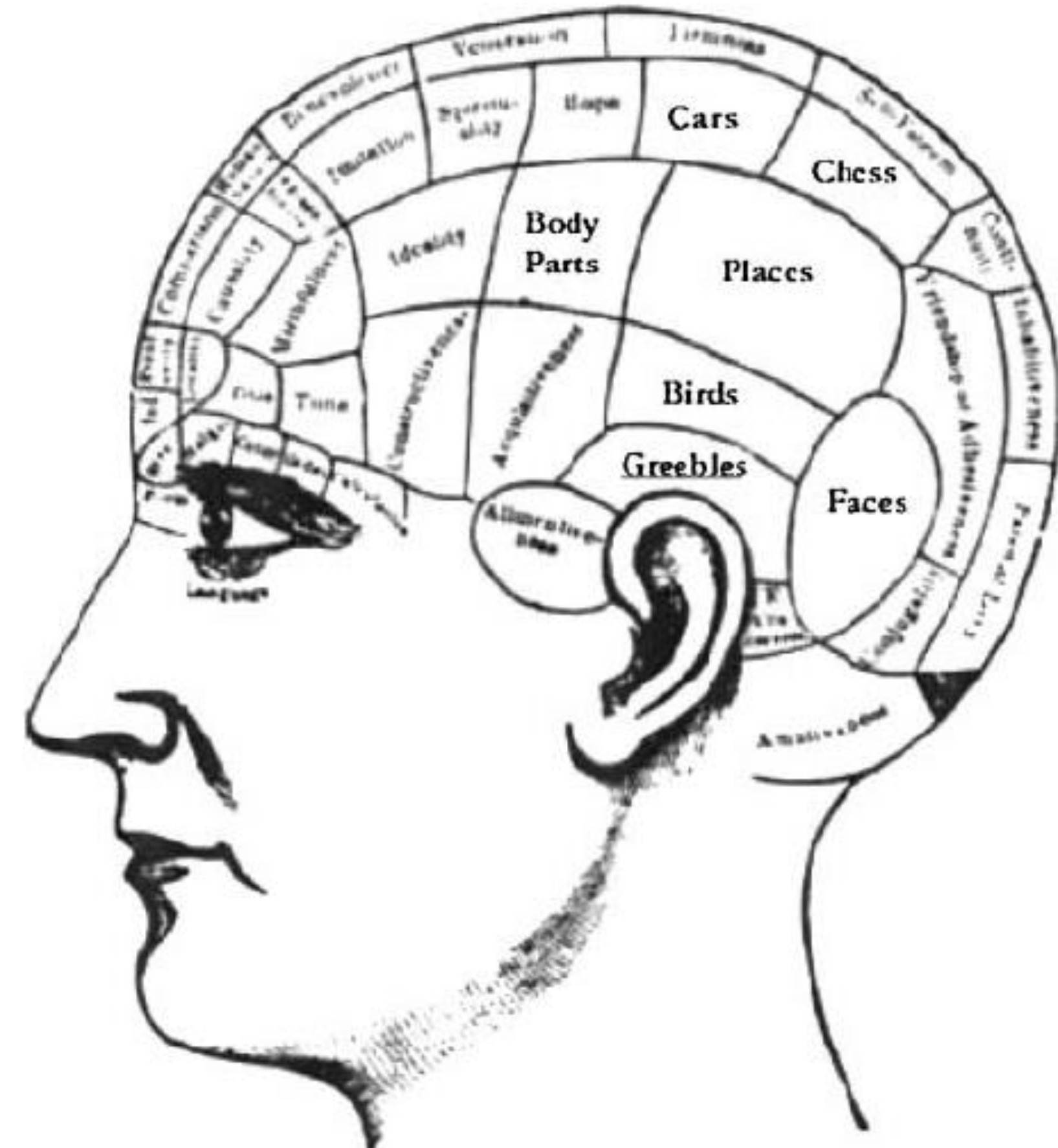
Brodman's cytoarchitectonic map (1909):
Lateral surface



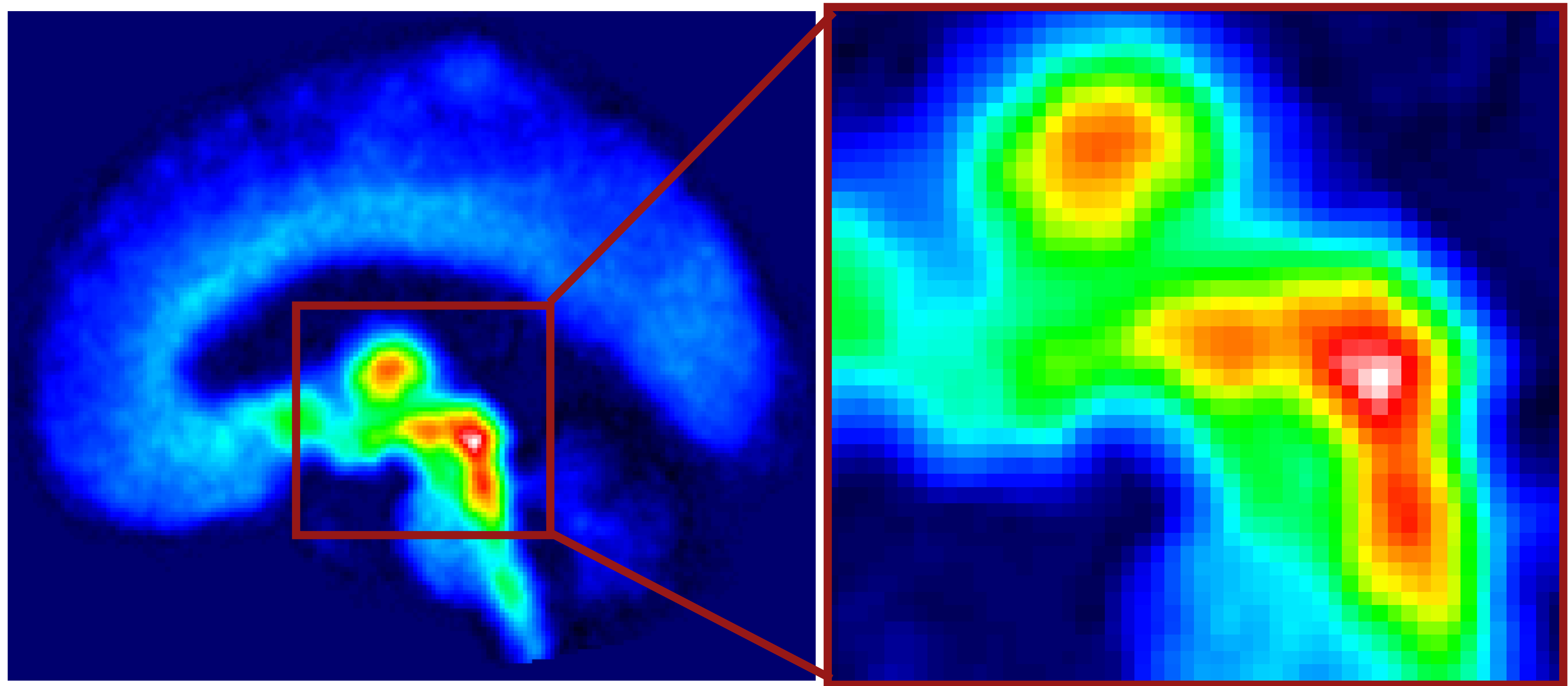
Brodman's cytoarchitectonic map (1909):
Medial surface

Brodmann areas

- Korbinian Brodmann (1909)
- Based on cytoarchitectural (cellular) organization of neurons observed in Nissl staining
- Initial idea of dividing brain into different regions based on their similarity — but similarity in what?



Why ROI analysis

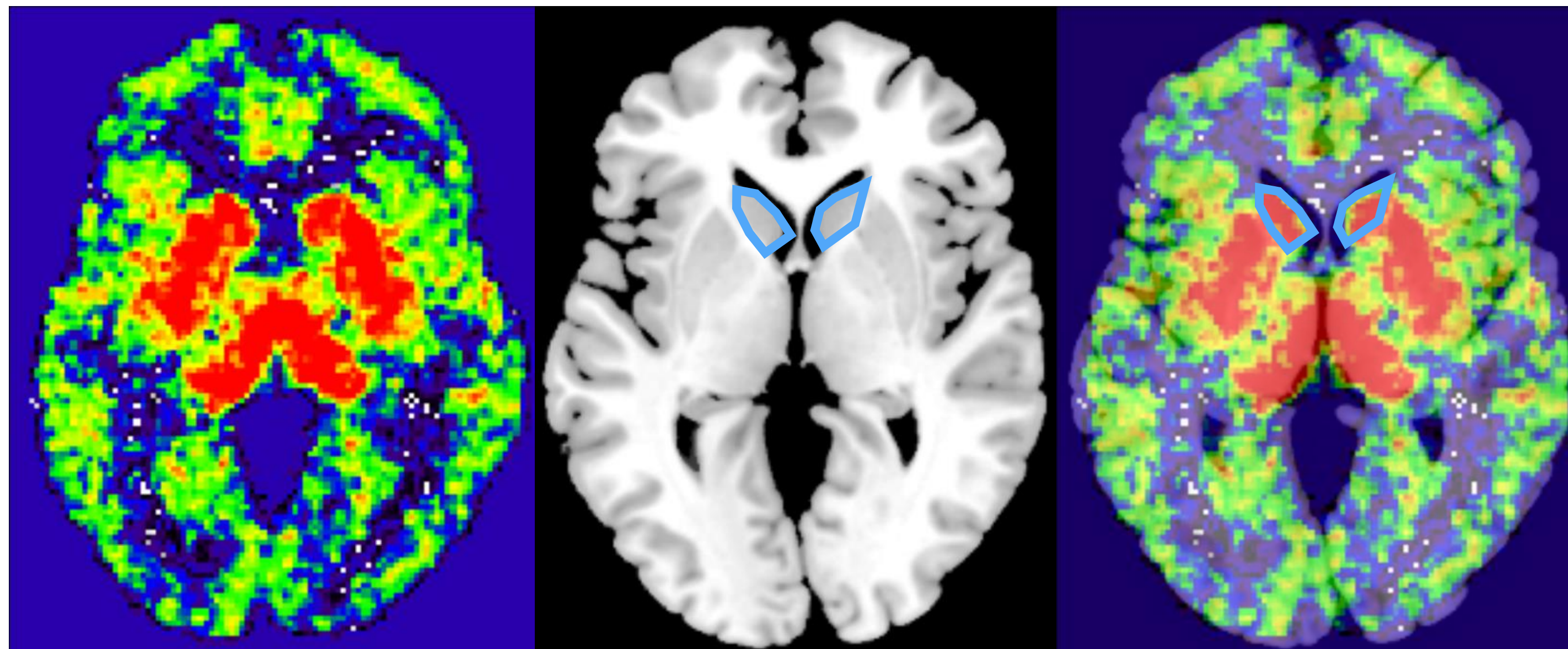


We still have good reasons!

- ROI data extraction = dimension reduction
- Complex statistical models that cannot be accommodated to voxel space (e.g. multivariate analysis, Bayesian analyses...)
- Difficulties in interpretation of factorial statistical models at voxel level
- Comparison across modalities
- Visualisation
- Need for high anatomical accuracy

Dimension reduction

Univariate data
regularly shaped
can use univariate stats

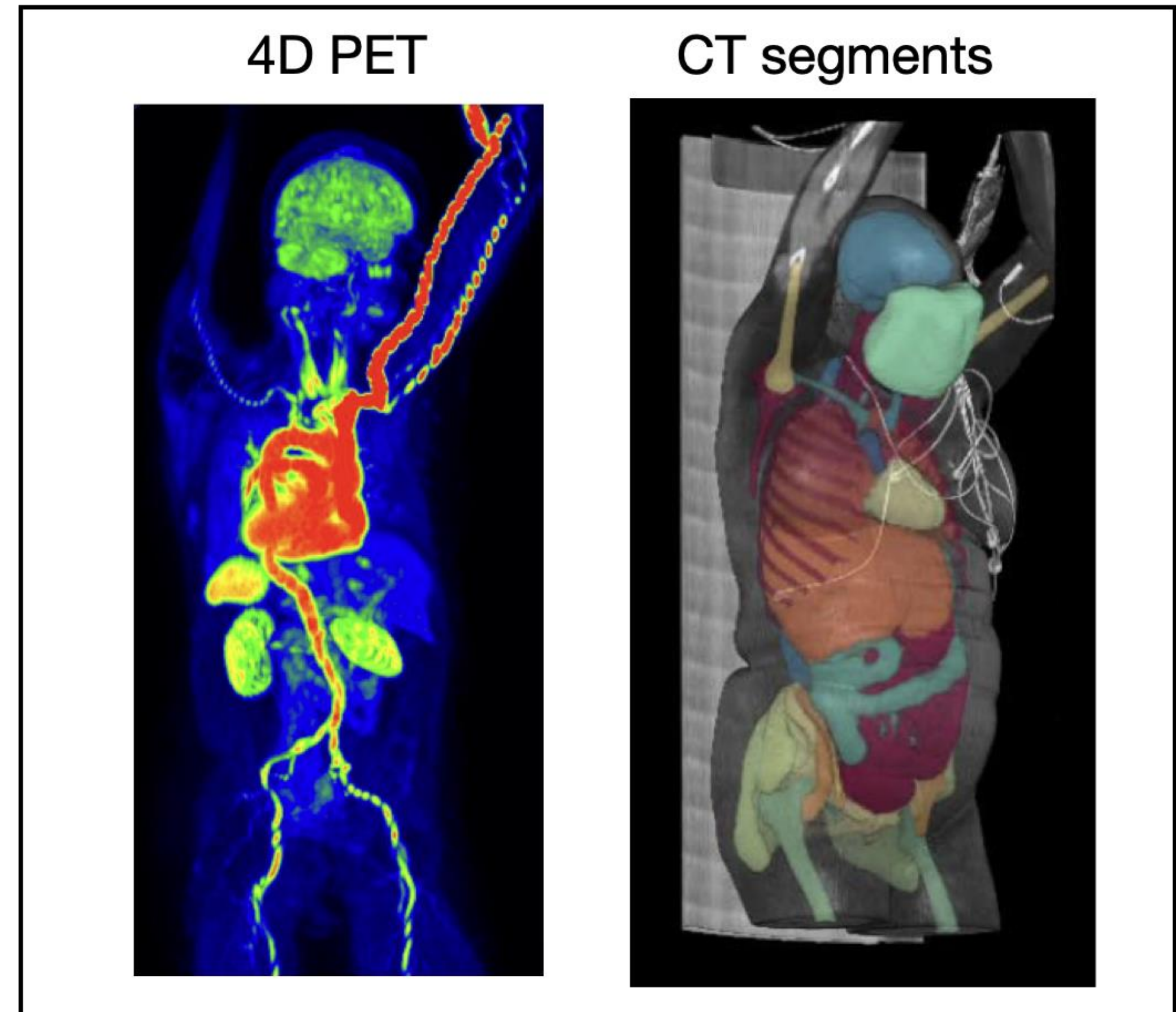
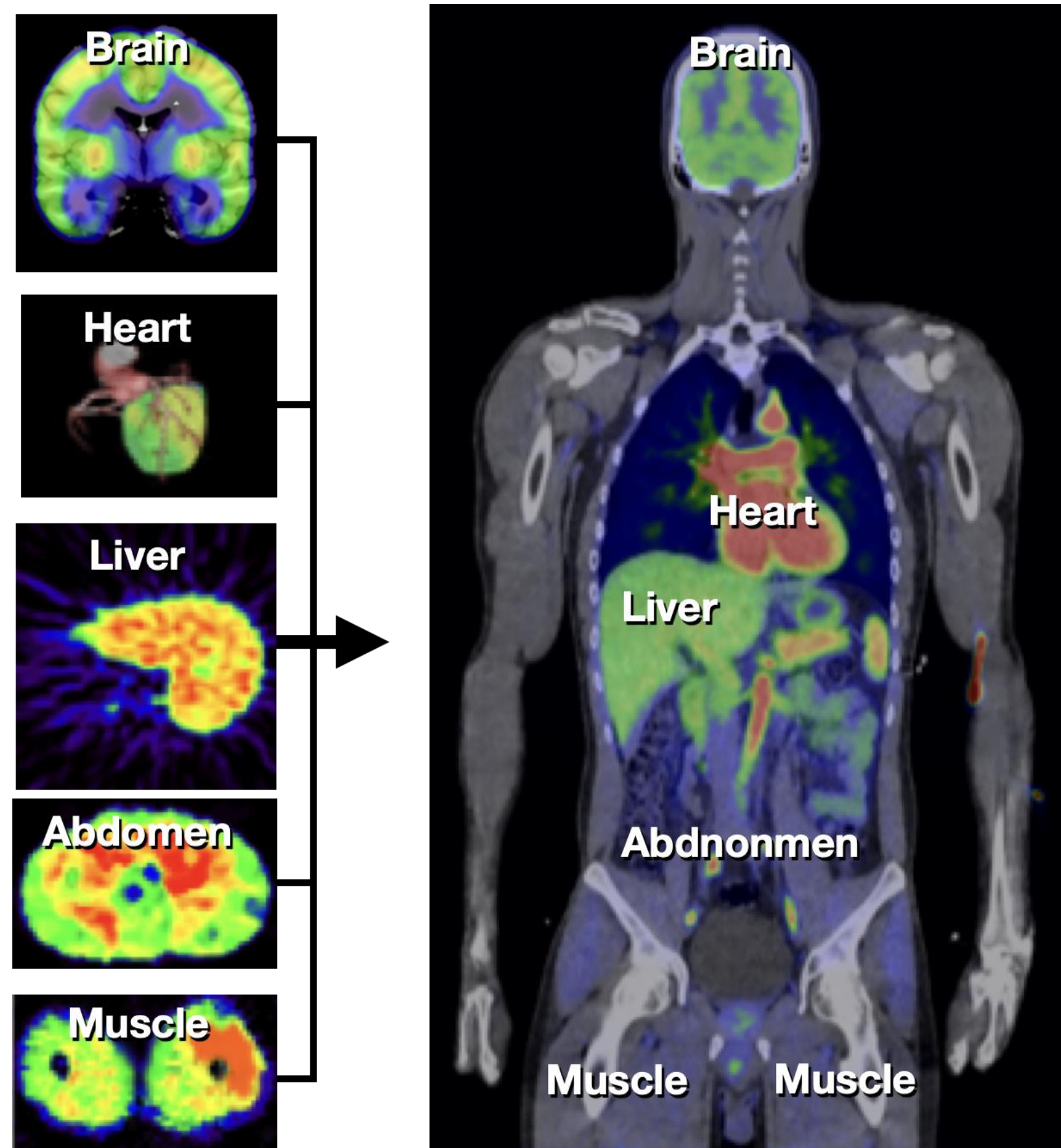


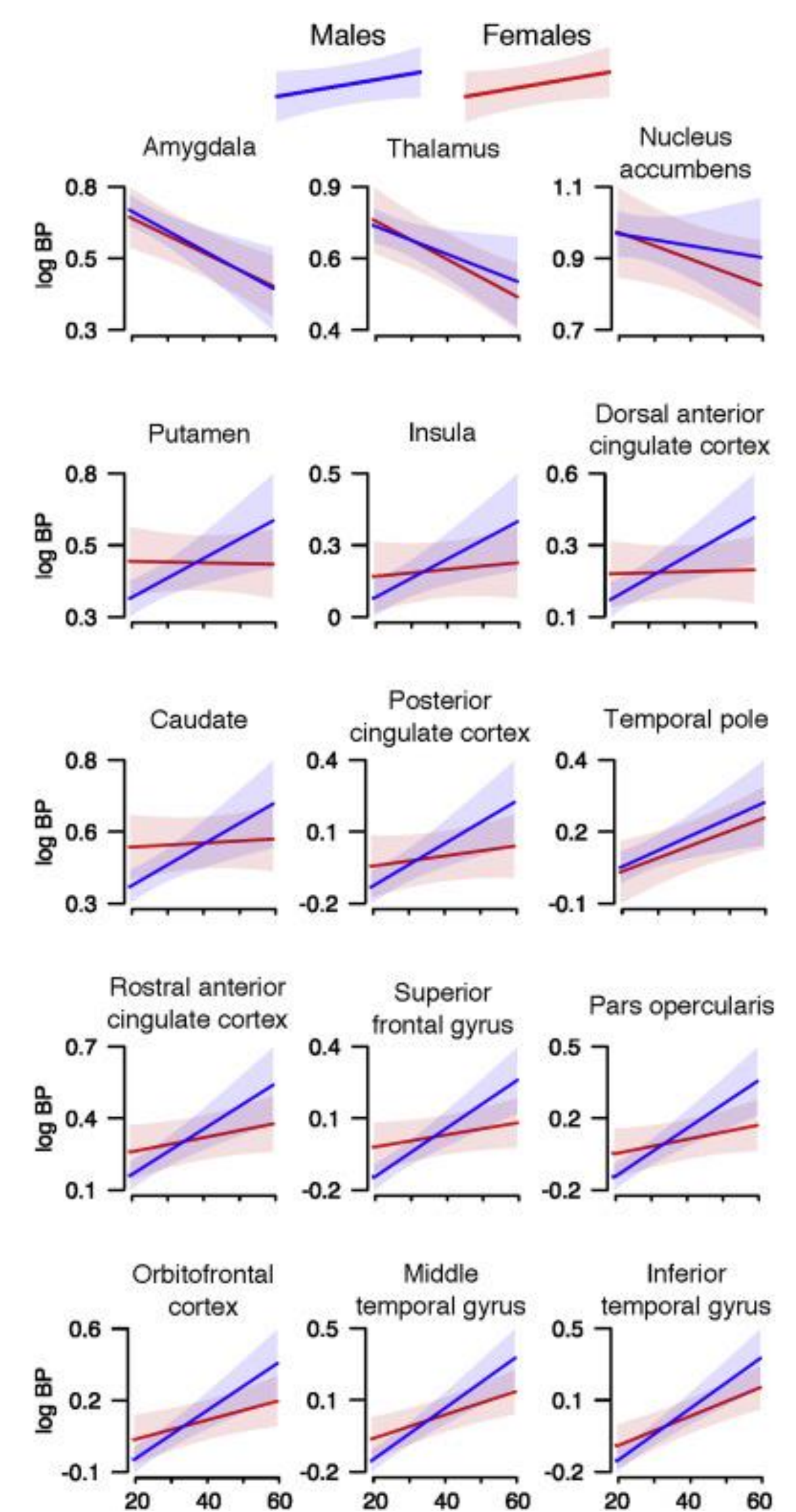
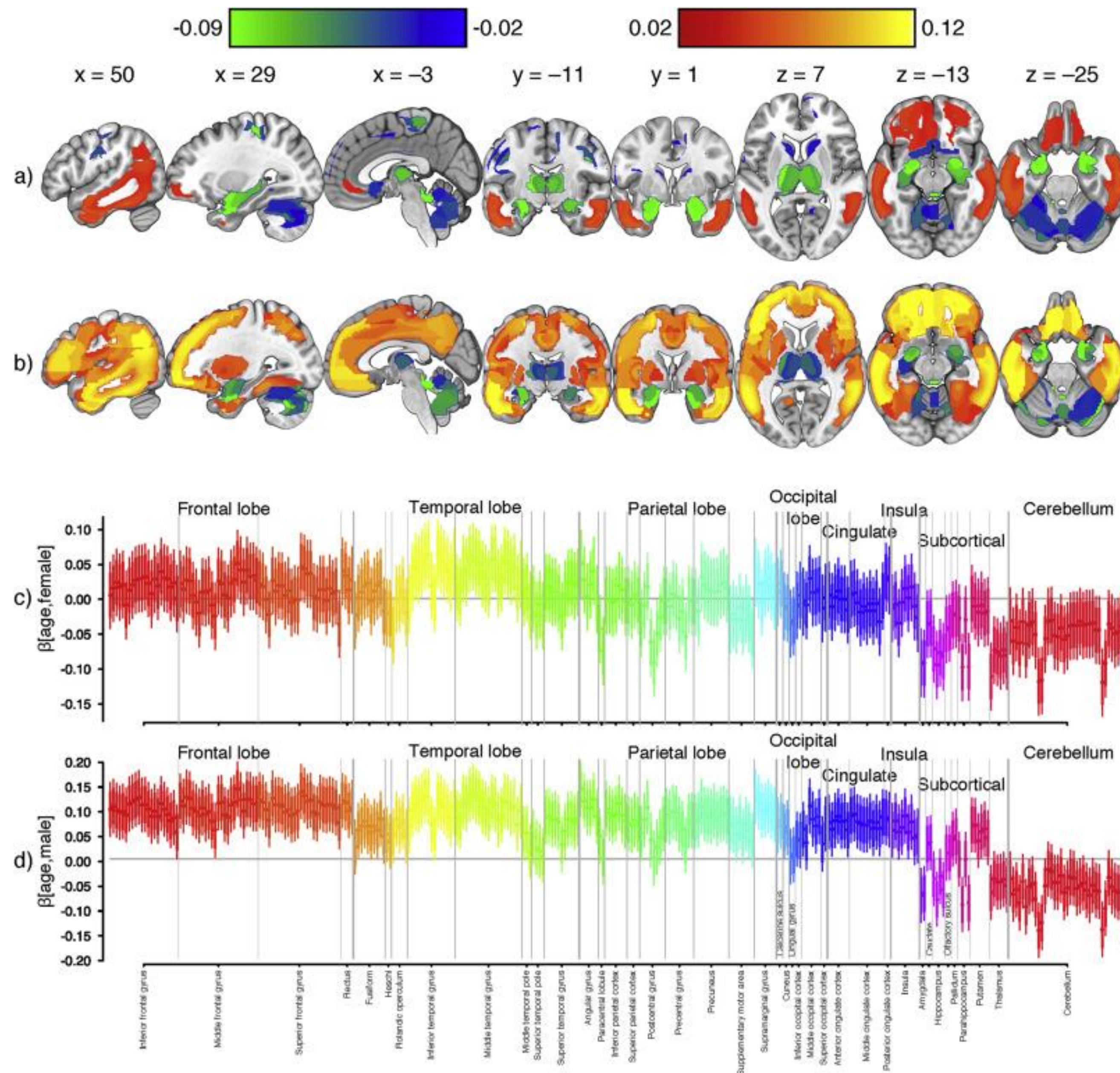
Extract
outcome
measure
in ROI

Controls	Patients
3	5
4	4
5	6
6	7
3	6
2	5
3	2
5	6
2	8

- **Pros:** Anatomically accurate if ROIs well defined, data can be analyzed with simple univariate statistical tests
- **Cons:** Laborious, using many ROIs not feasible, averaging within ROI not always appropriate

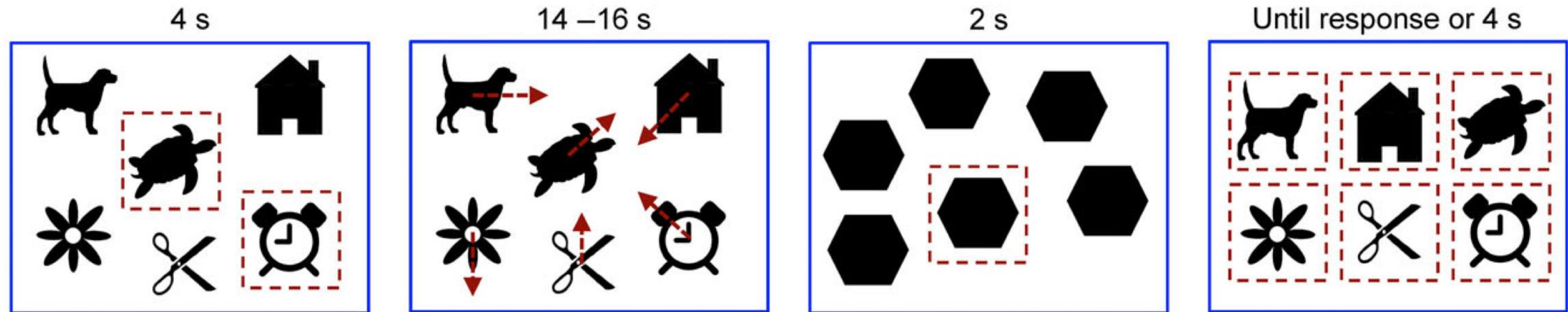
Major issue in total-body analysis



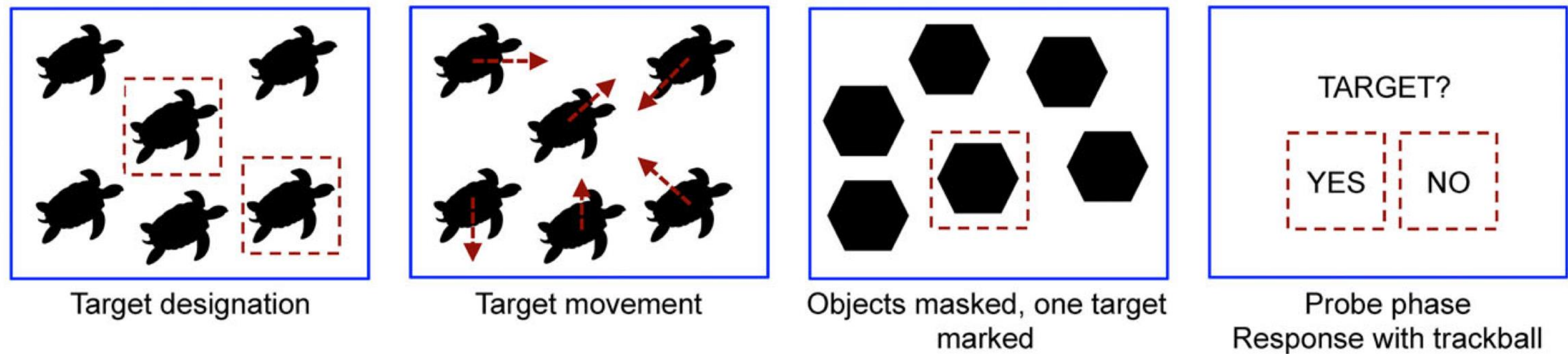


Kantonen et al (2020 NeuroImage)

A Multiple Identity Tracking (MIT)

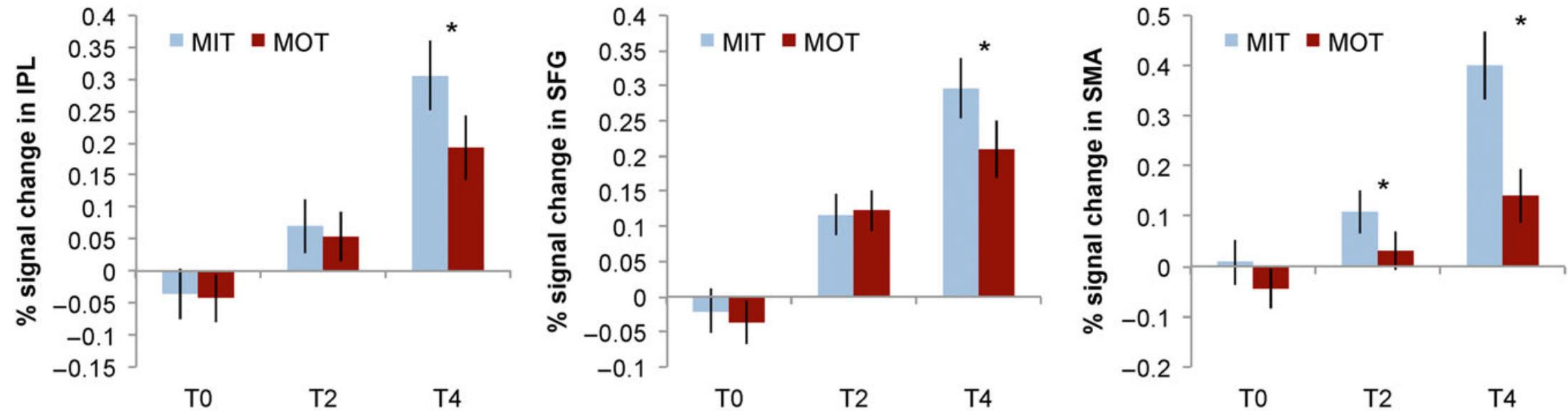


B Multiple Object Tracking (MOT)



what's
going on
MARVIN GAYE

ROI analysis helps in breaking down the interaction

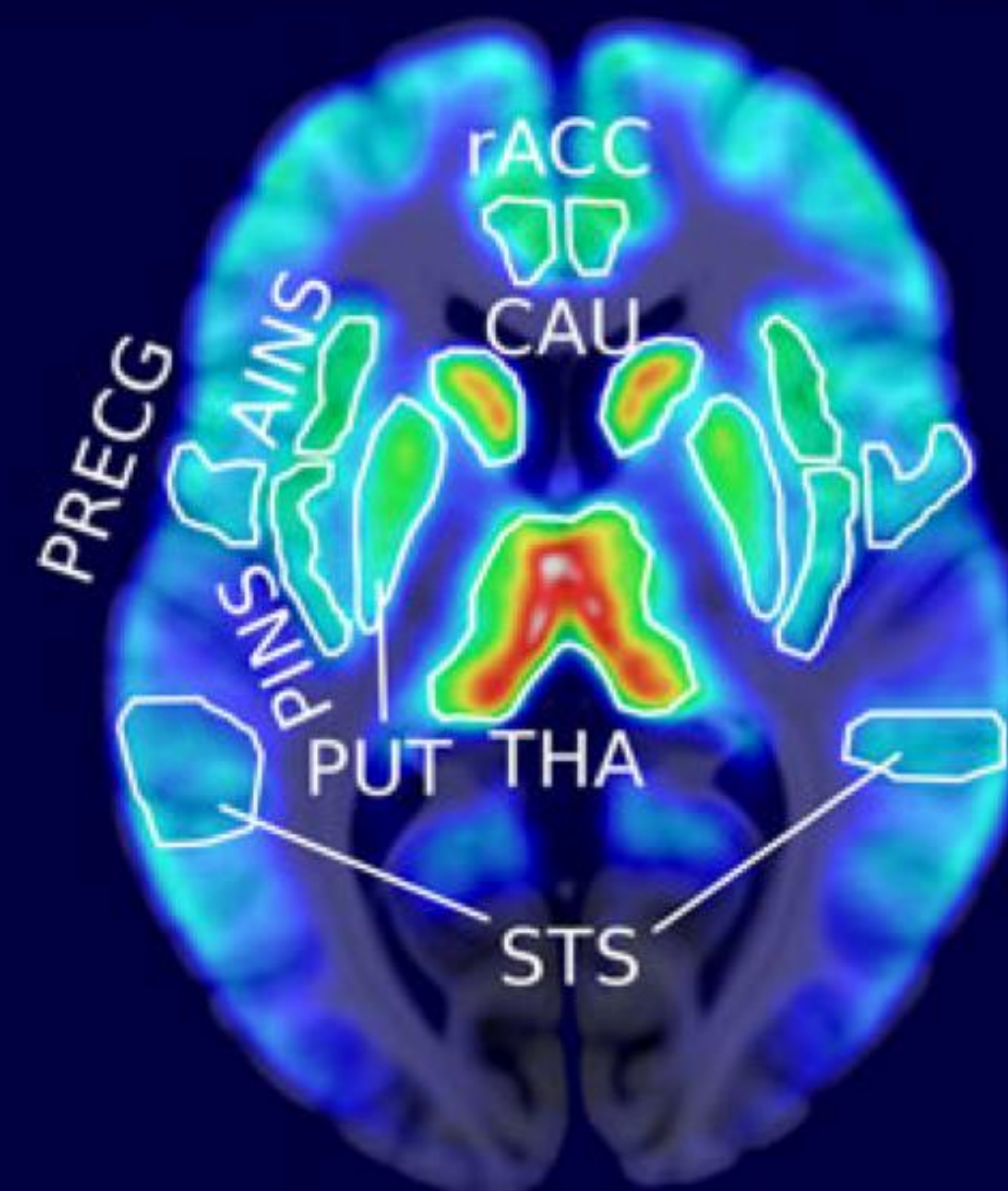
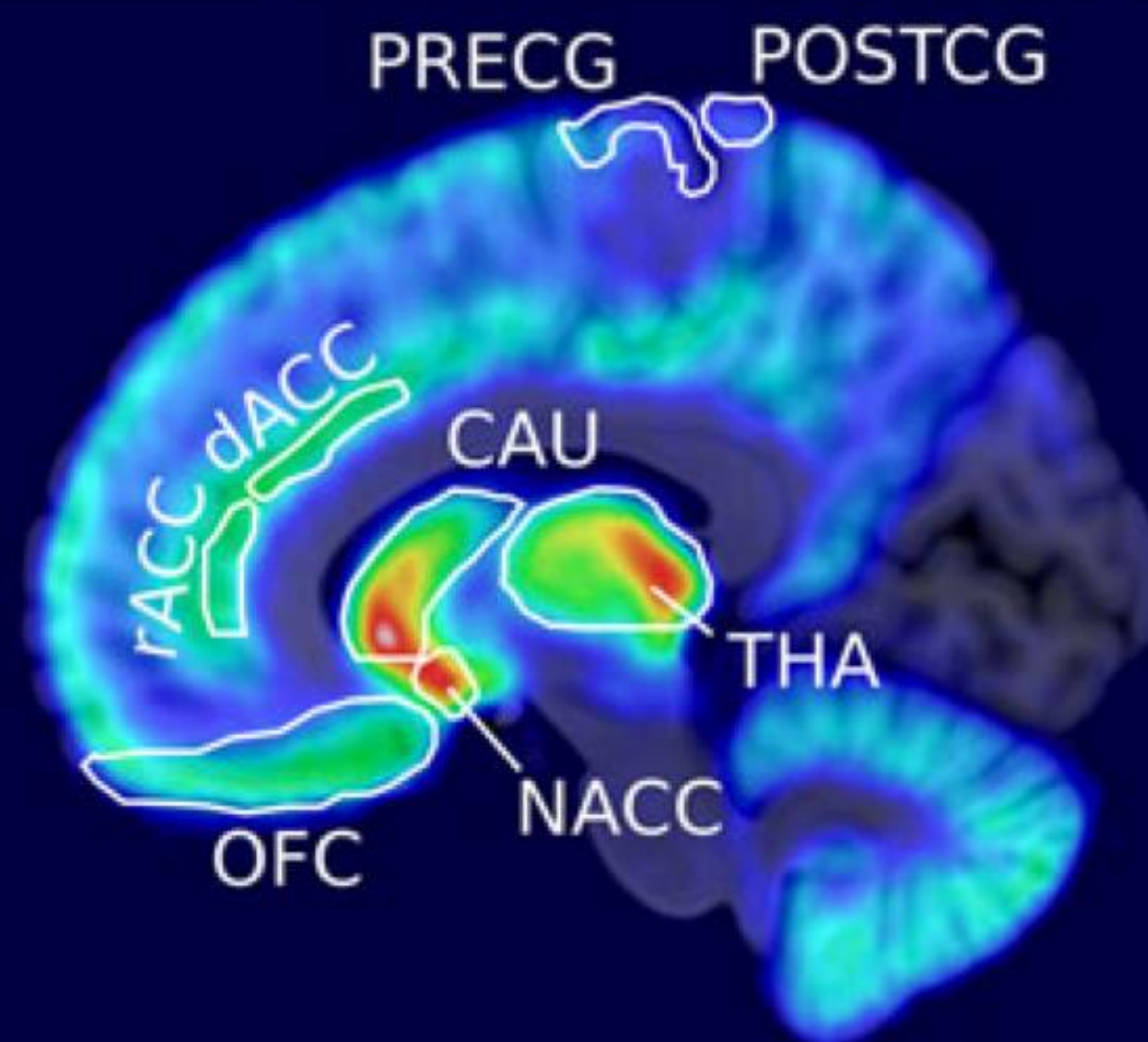
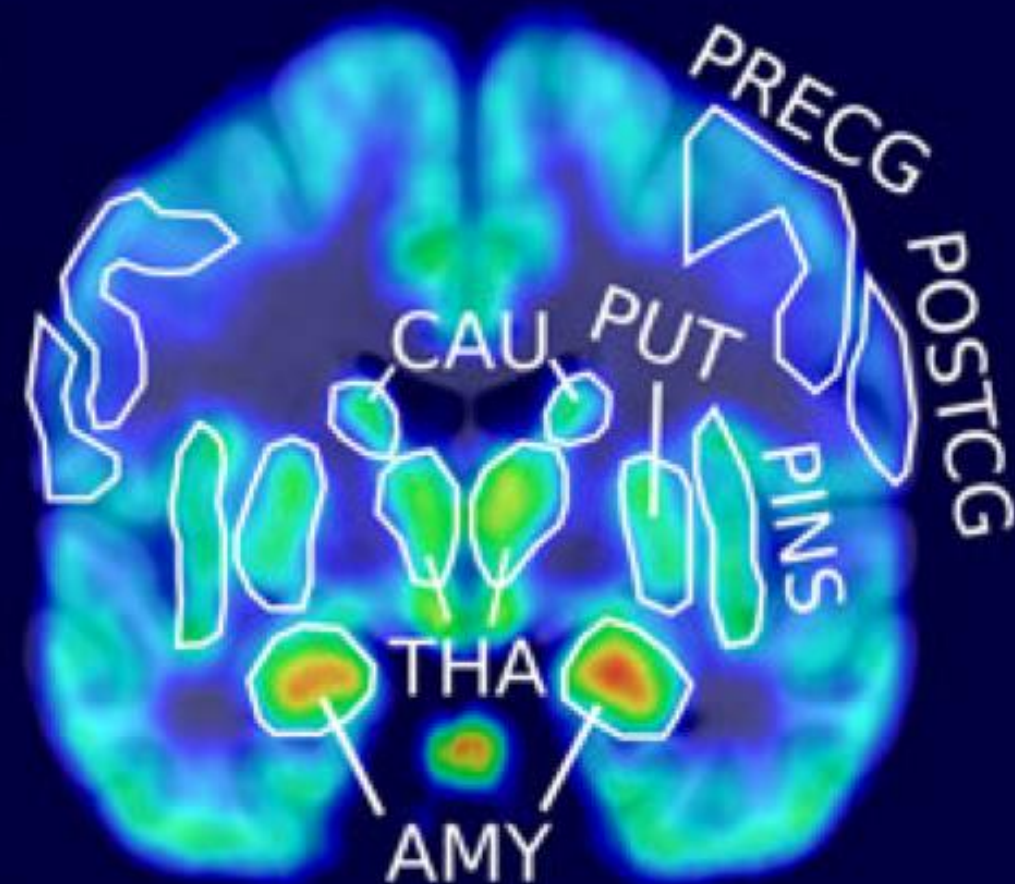


$y = -4$

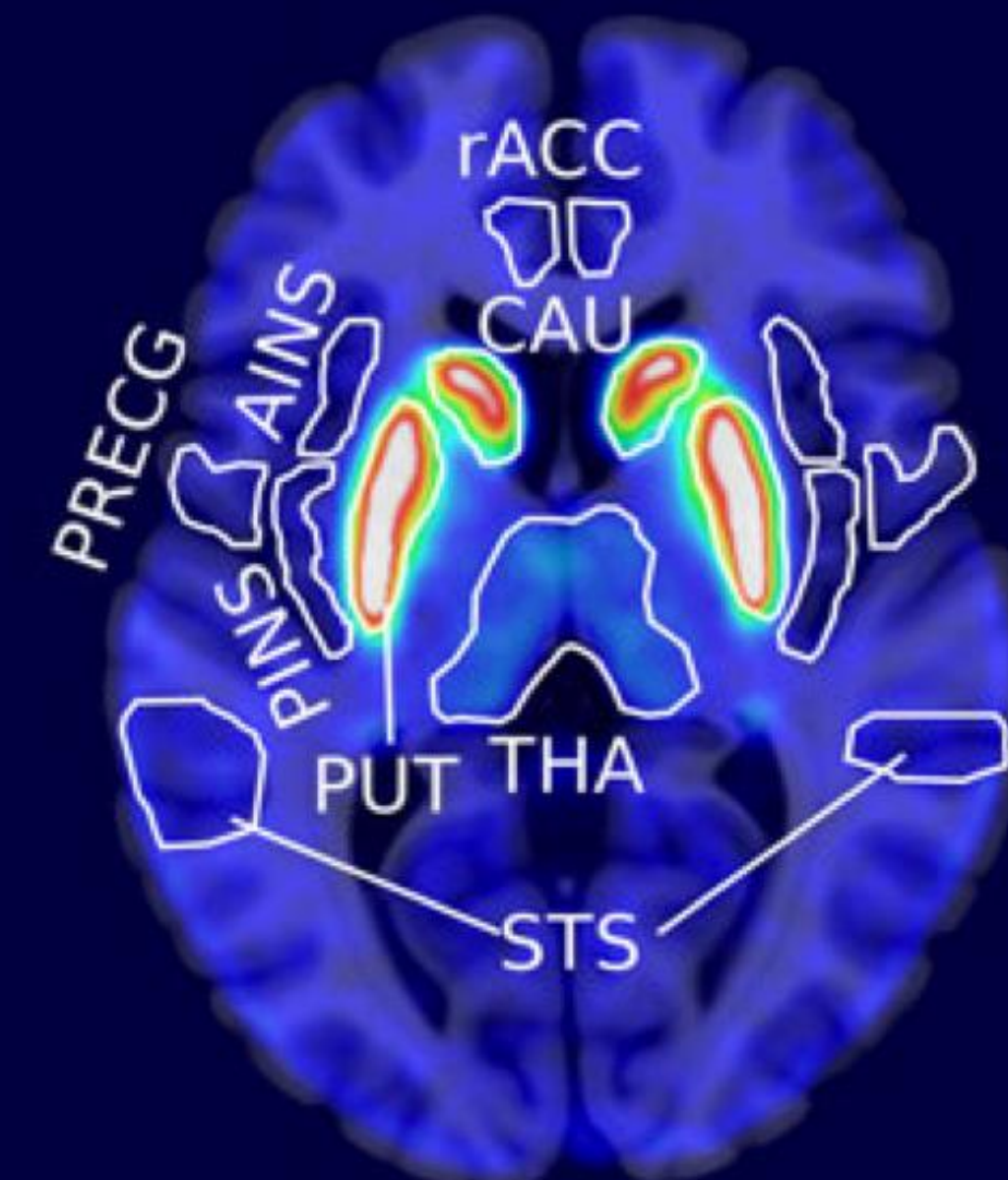
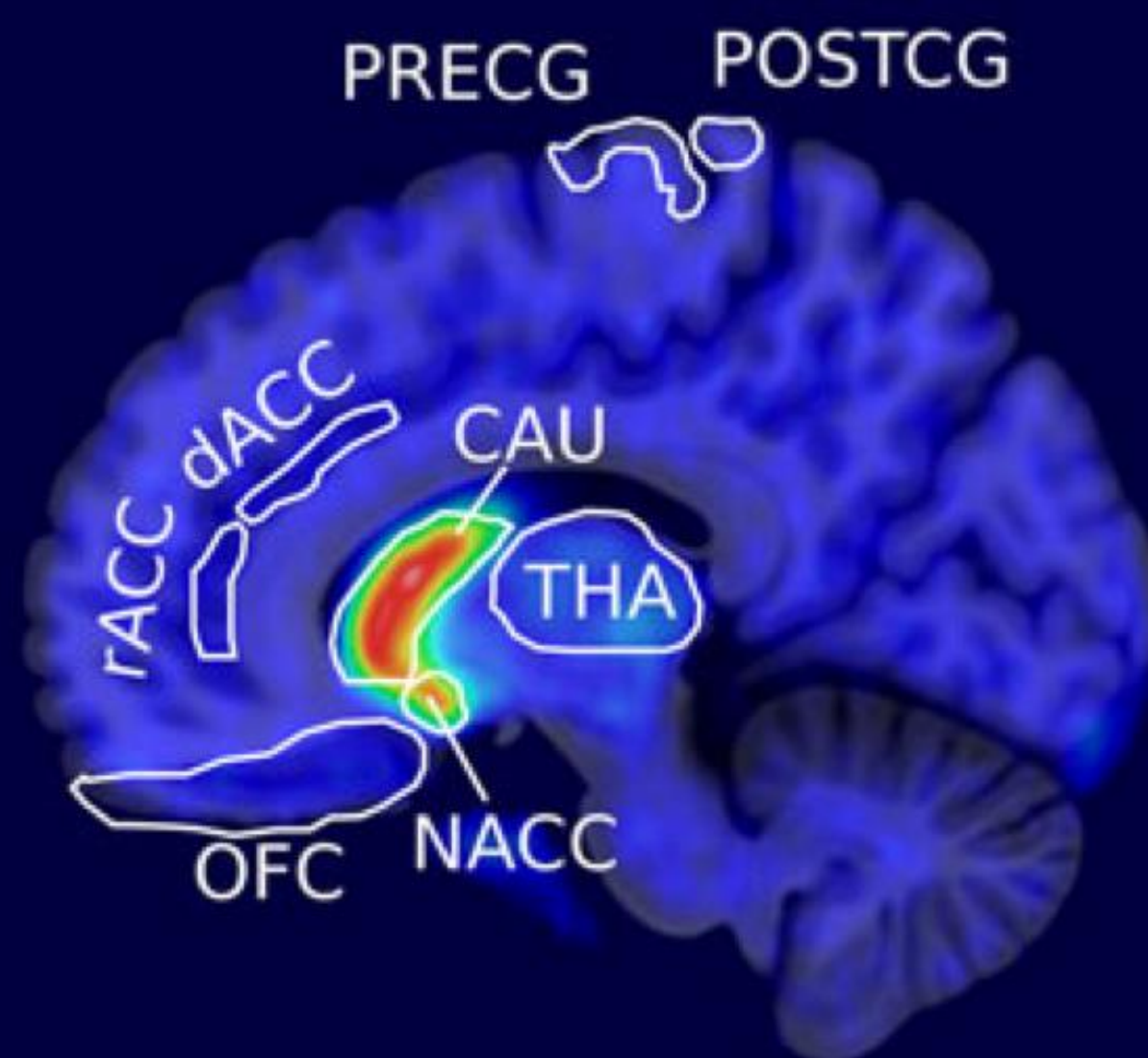
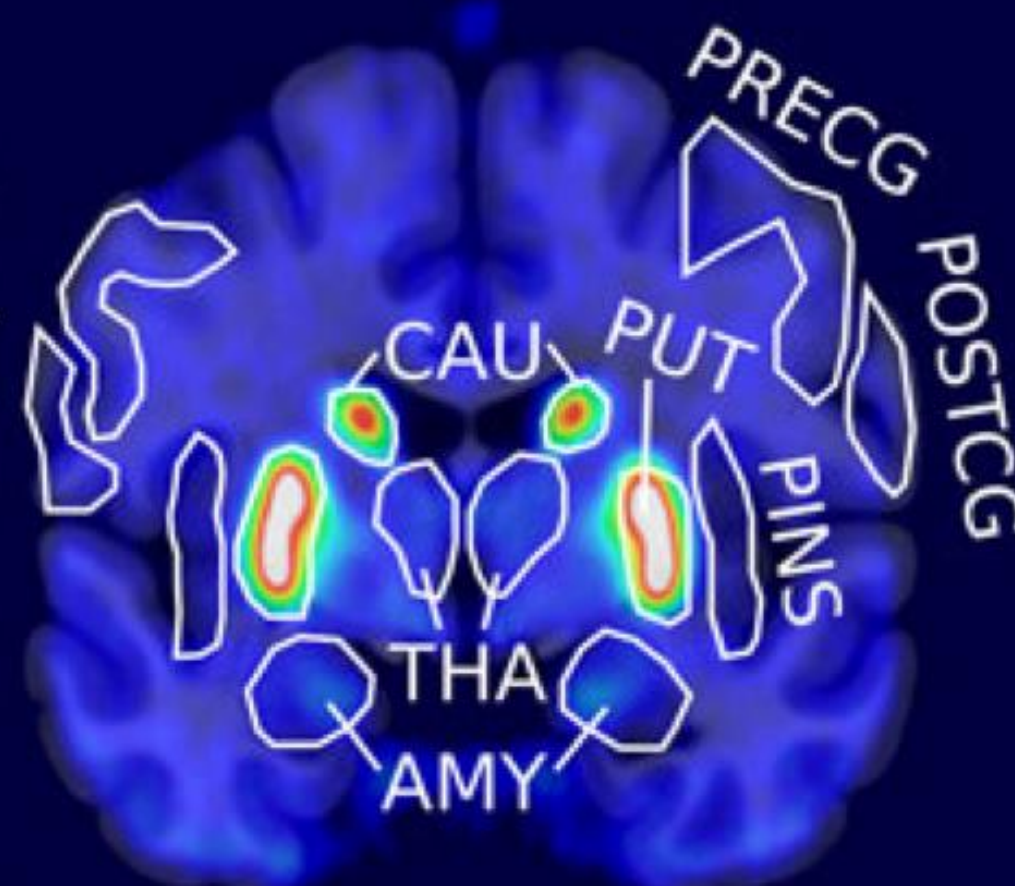
$x = 11$

$z = 5$

[¹¹C]carfentanil



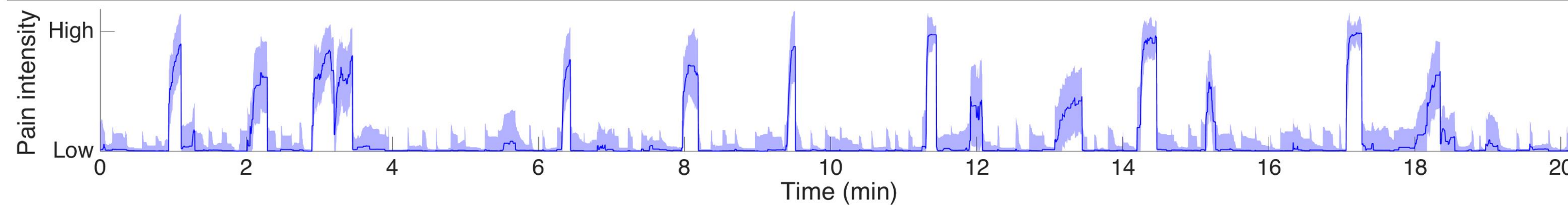
[¹¹C]raclopride



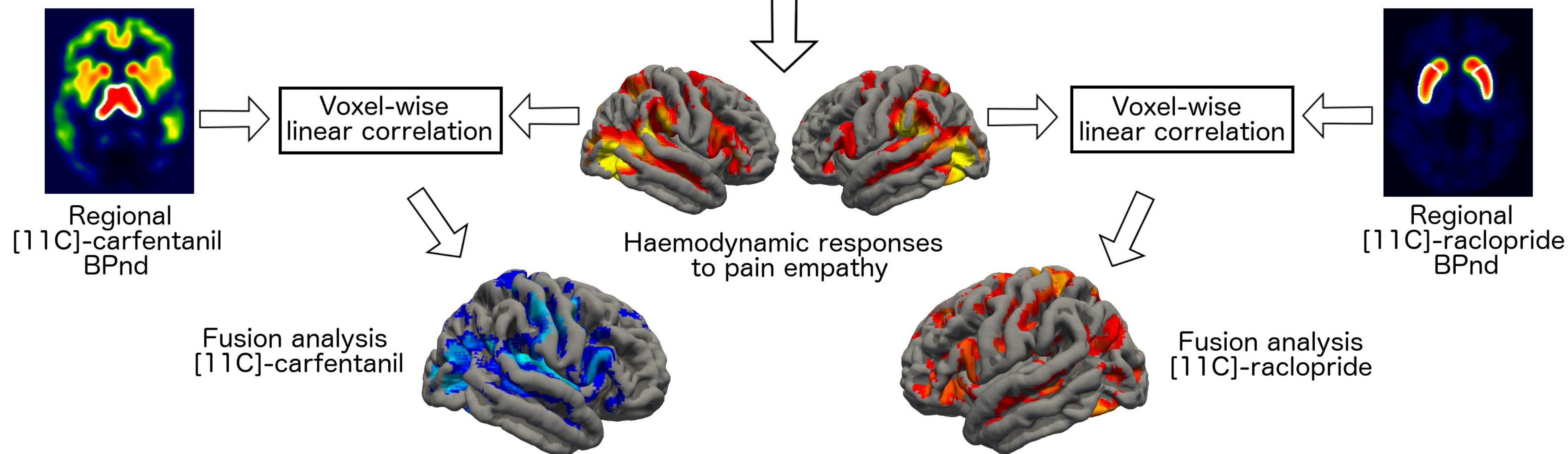
a)

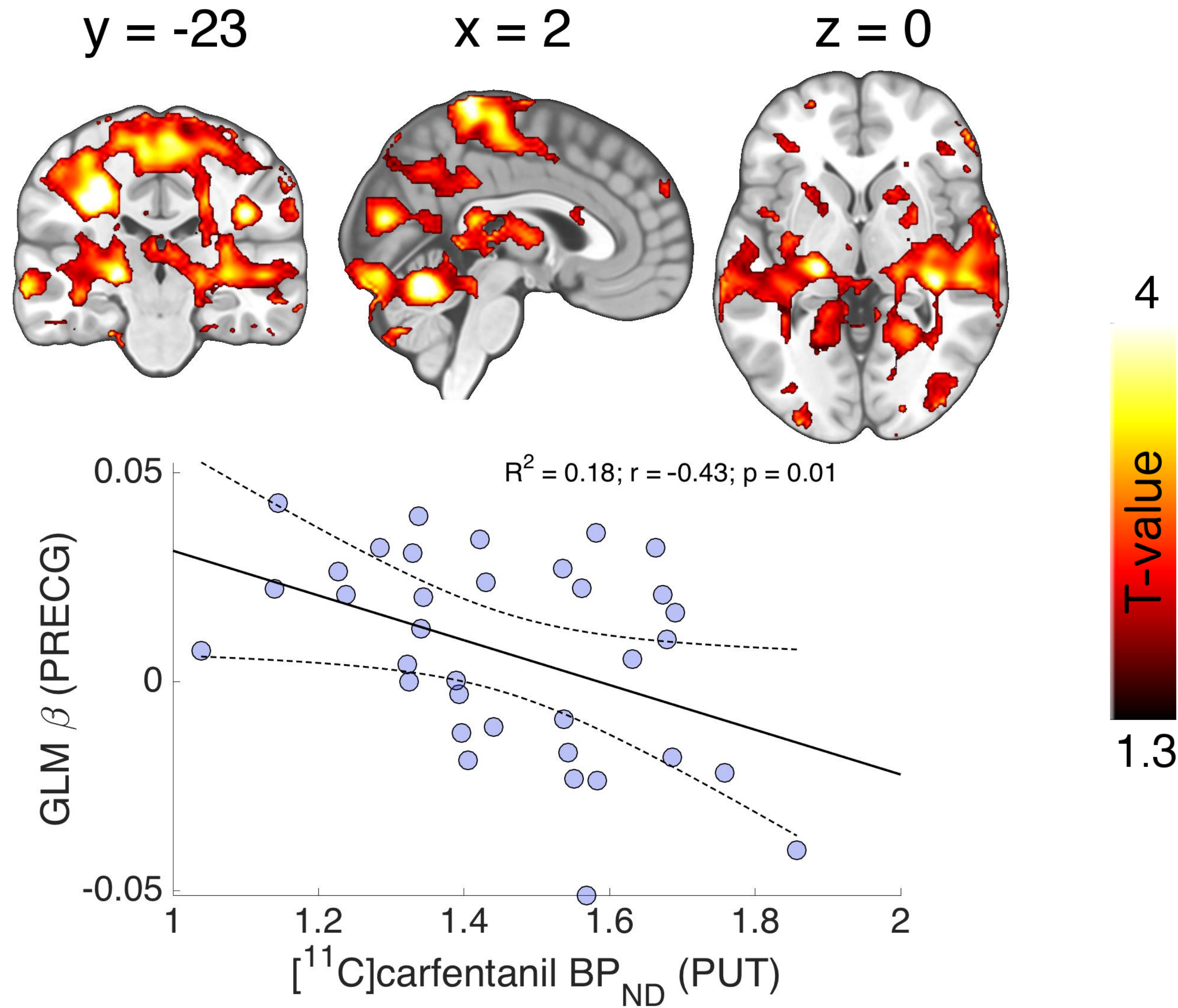


b)



c)

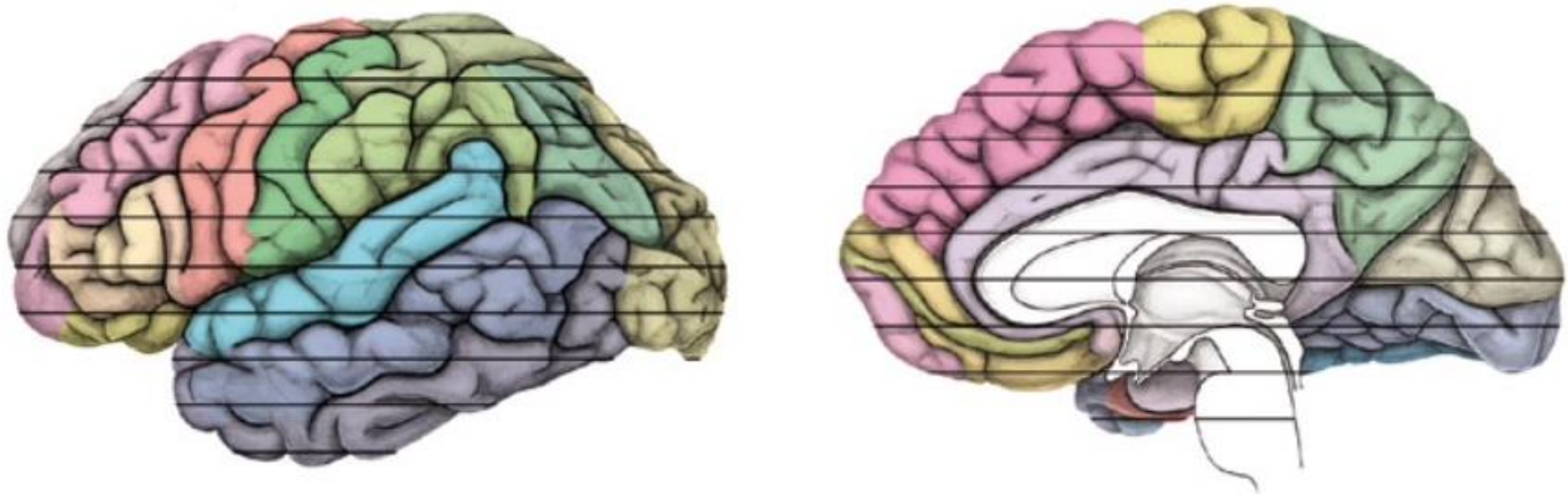




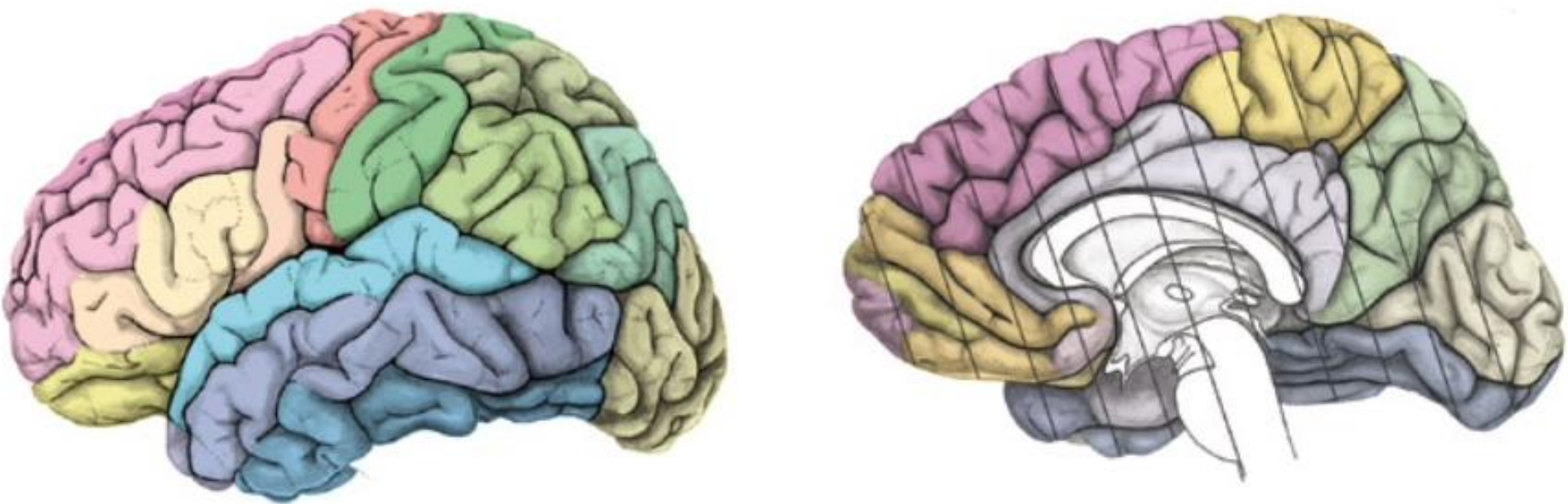
Karjalainen et al (2017; 2019 Cereb Cortex)

How to define ROIs?

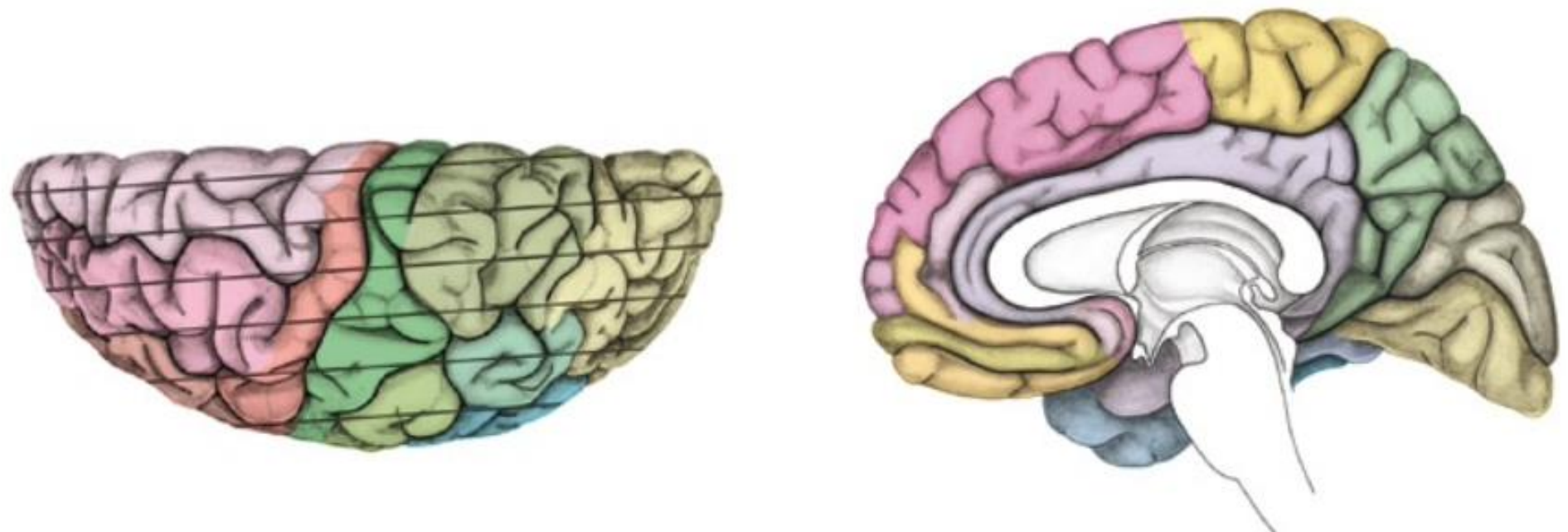
Horizontal Atlas:



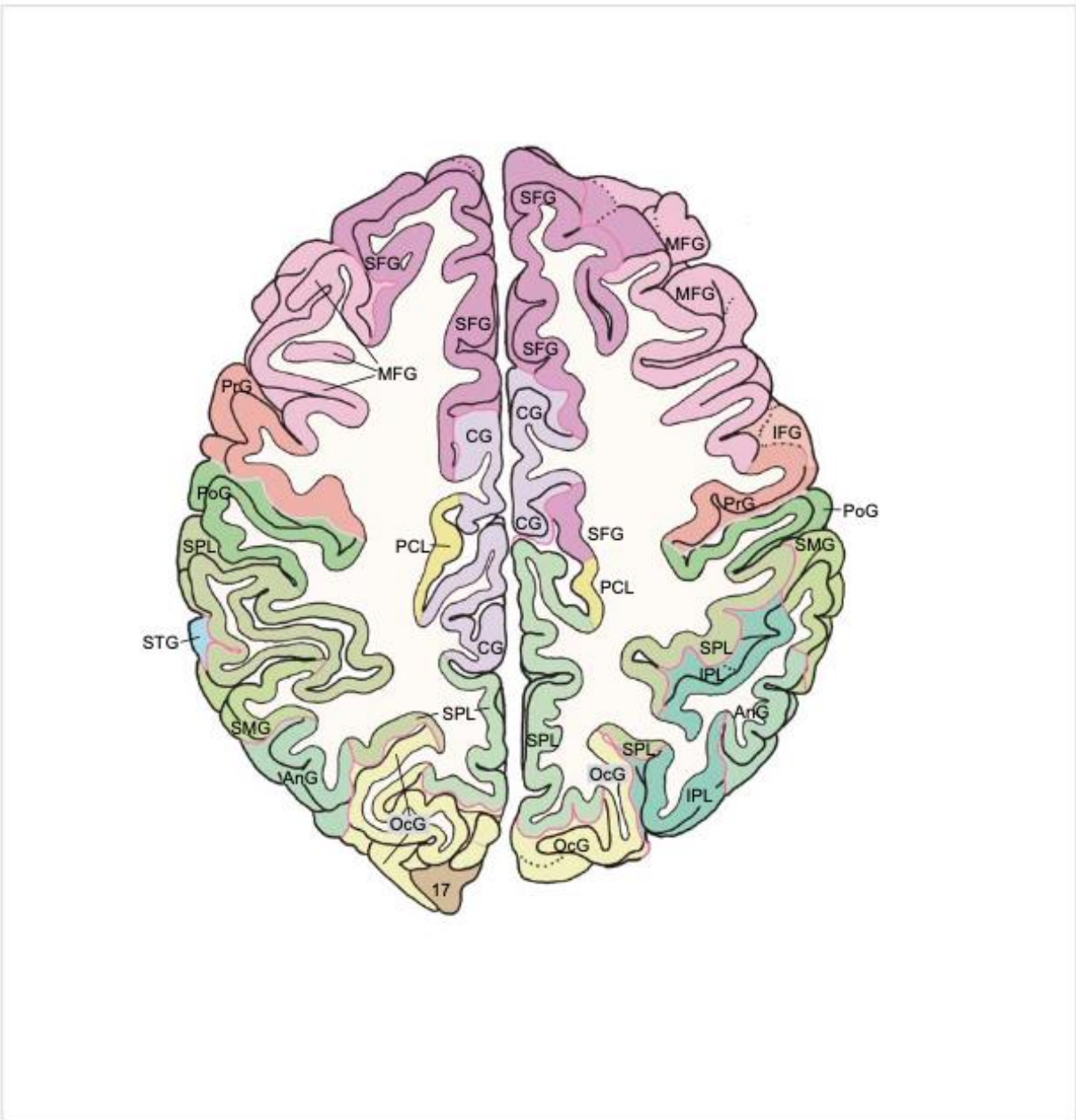
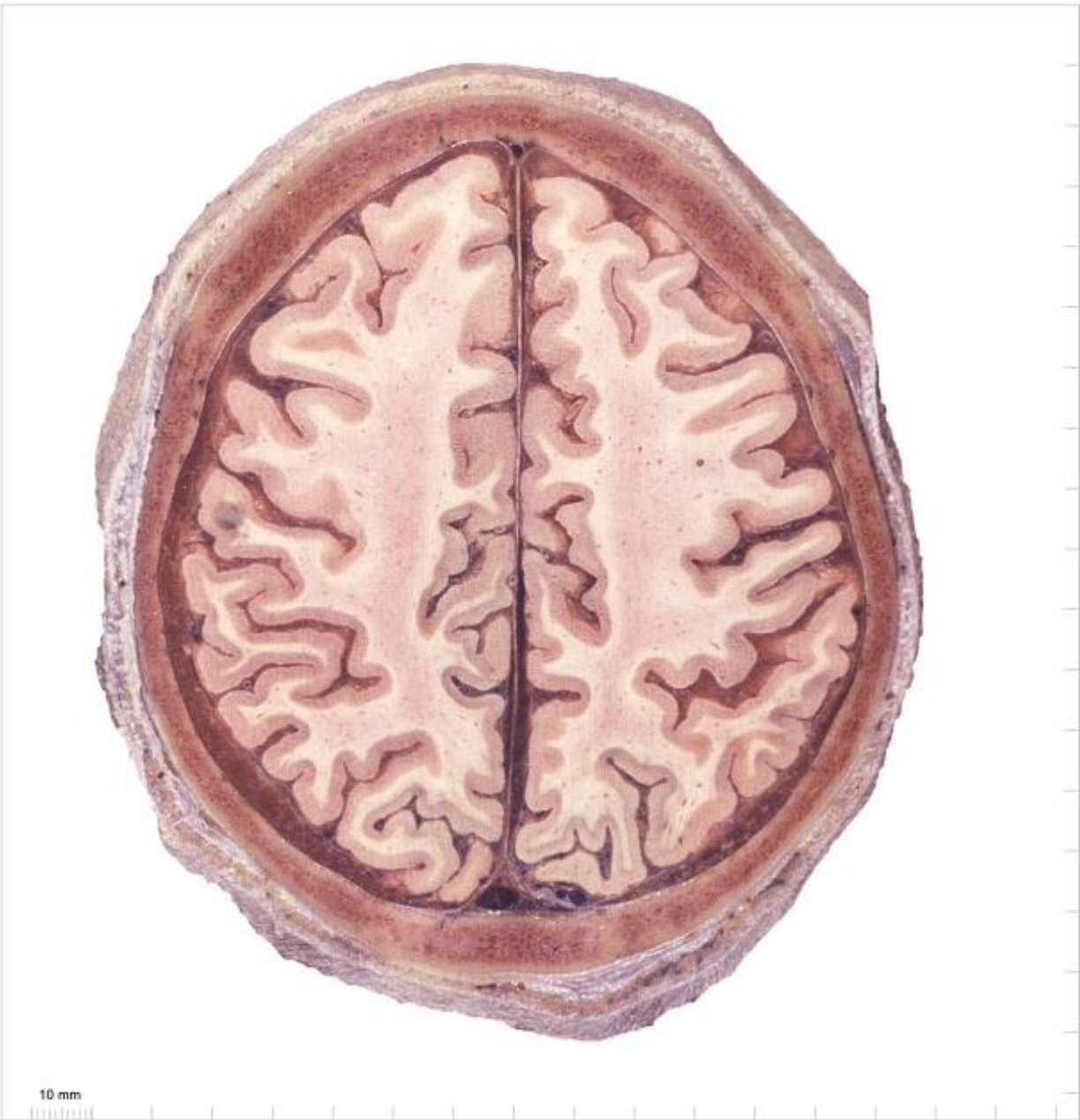
Coronal Atlas:



Sagittal Atlas:



Mai et al (2008)

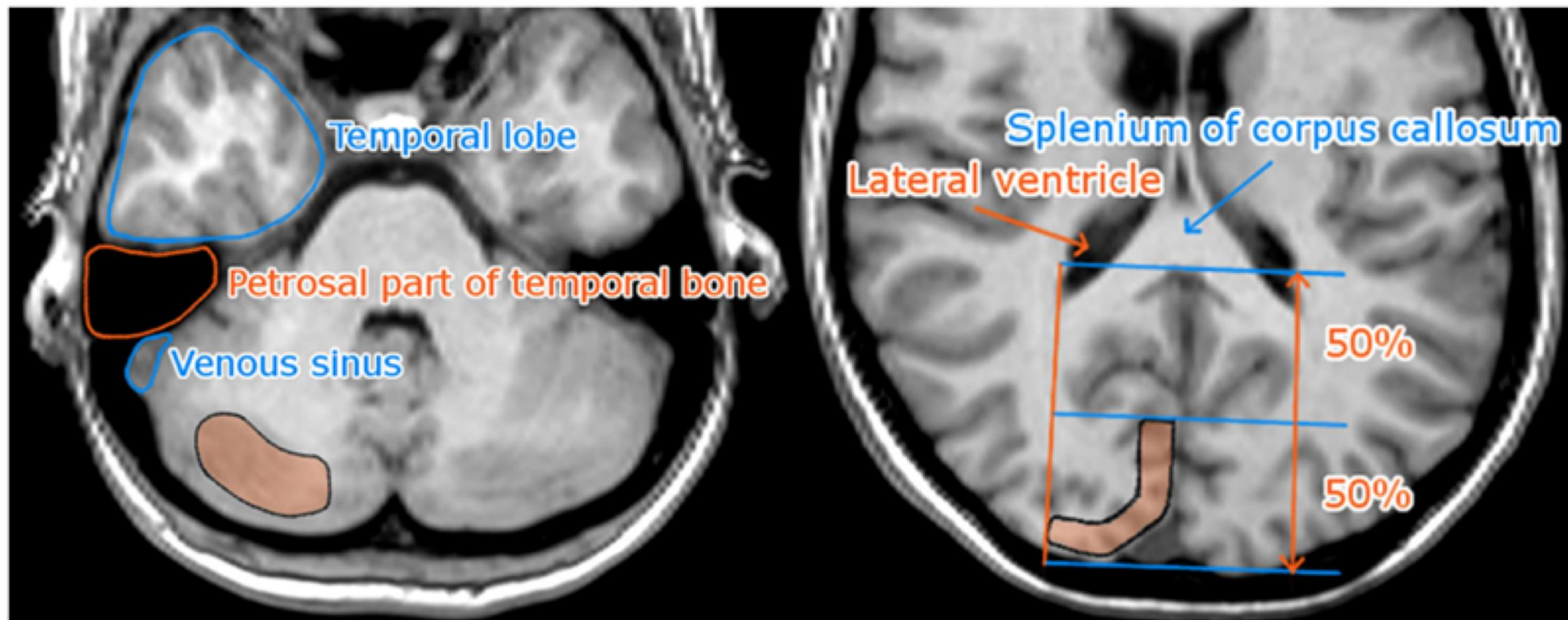


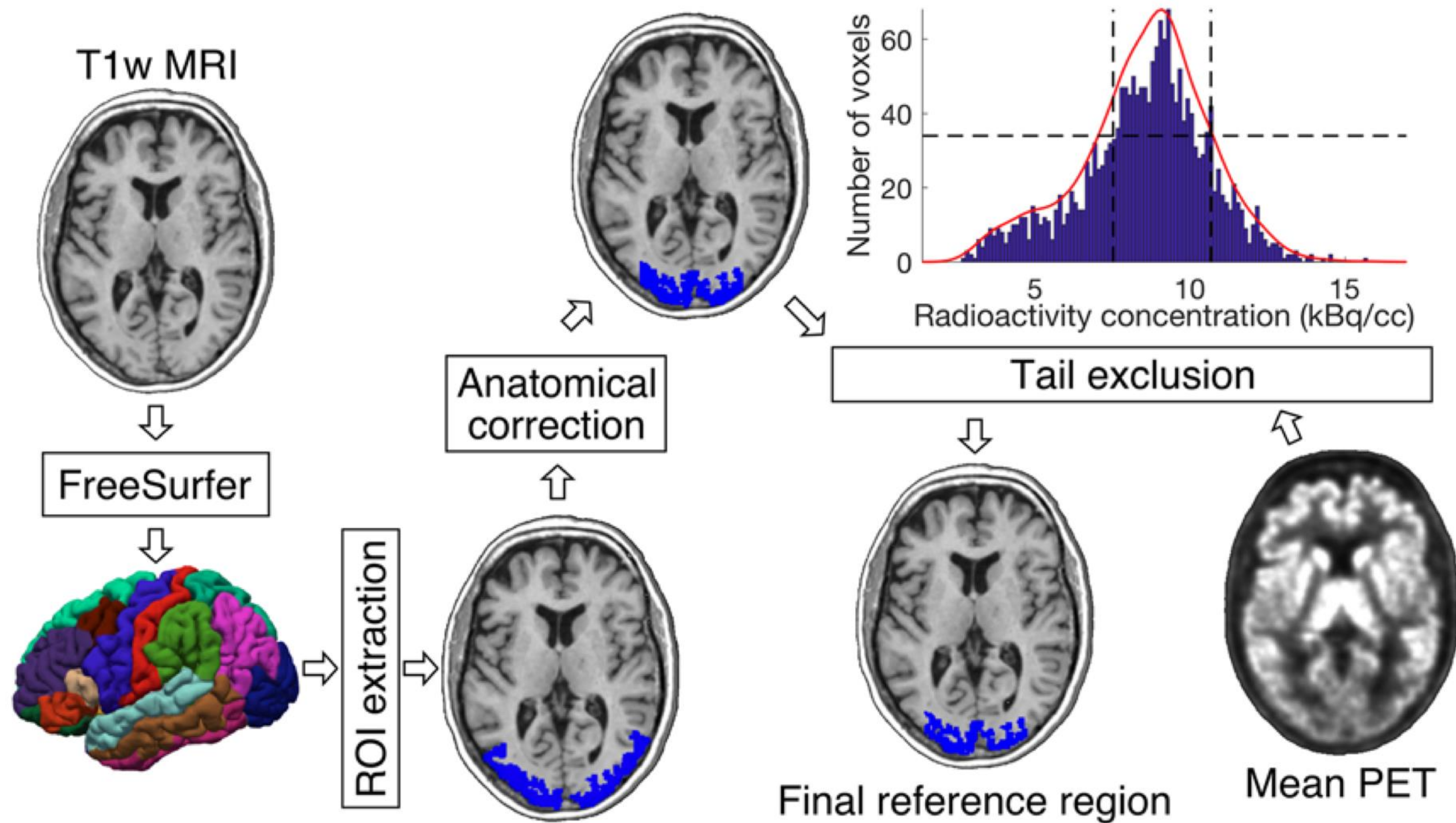


4
(dorsal view)



17	striate area
acer	anterior cerebral artery
AnG	angular gyrus
CG	cingulate gyrus
IFG	inferior frontal gyrus
IPL	inferior parietal lobule
mcer	middle cerebral artery
MFG	middle frontal gyrus
OcG	occipital gyri
PCL	paracentral lobule
PCun	precuneus
PoG	postcentral gyrus
PrG	precentral gyrus
SFG	superior frontal gyrus
SMG	supramarginal gyrus
SPL	superior parietal lobule
STG	superior temporal gyrus



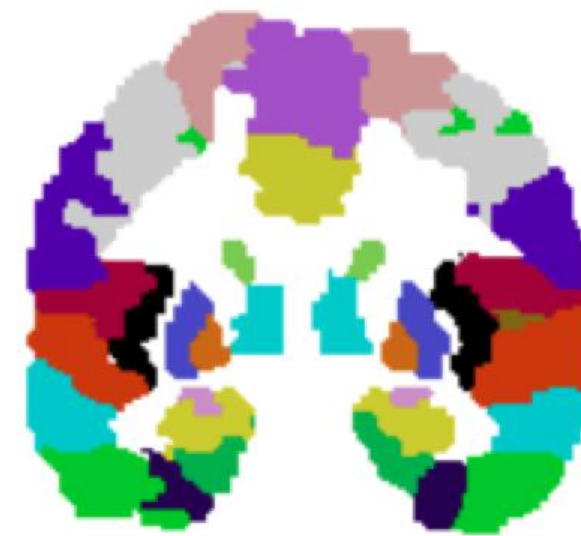


Anatomical and functional parcellations

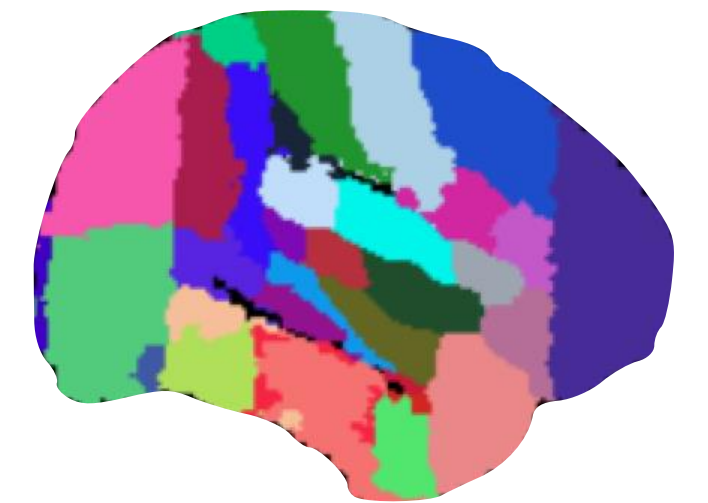
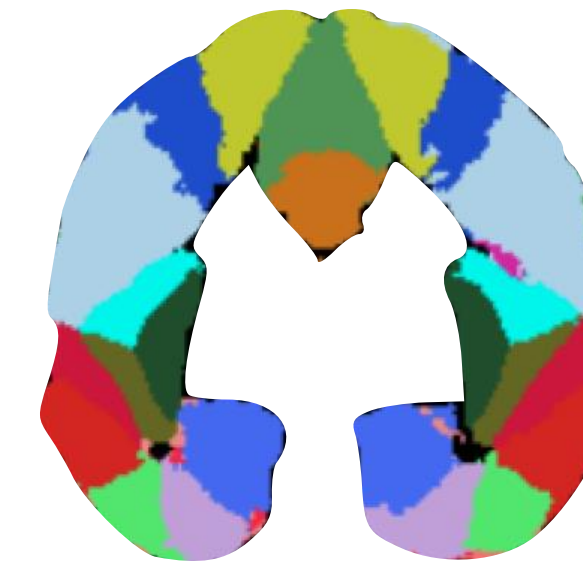
Brodmann atlas



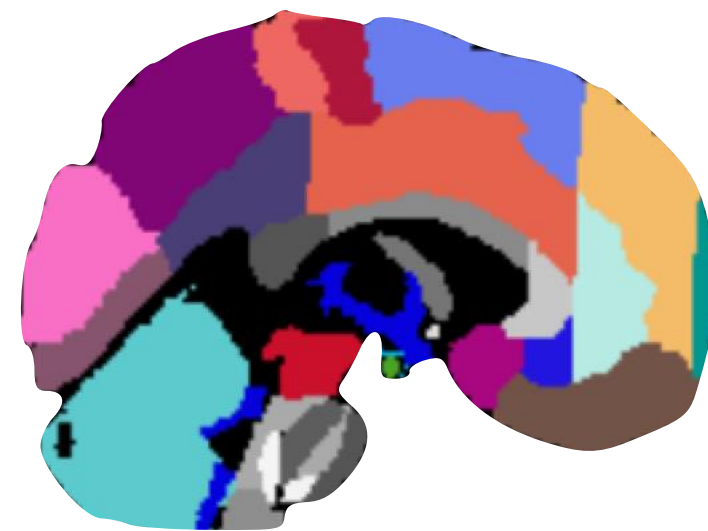
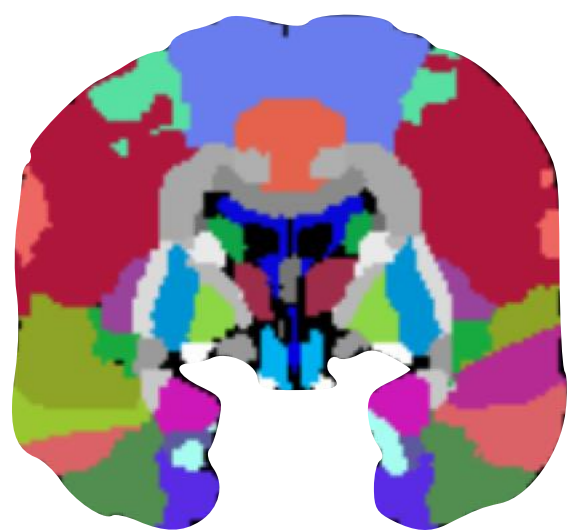
AAL atlas



Harvard-Oxford



JHU atlas



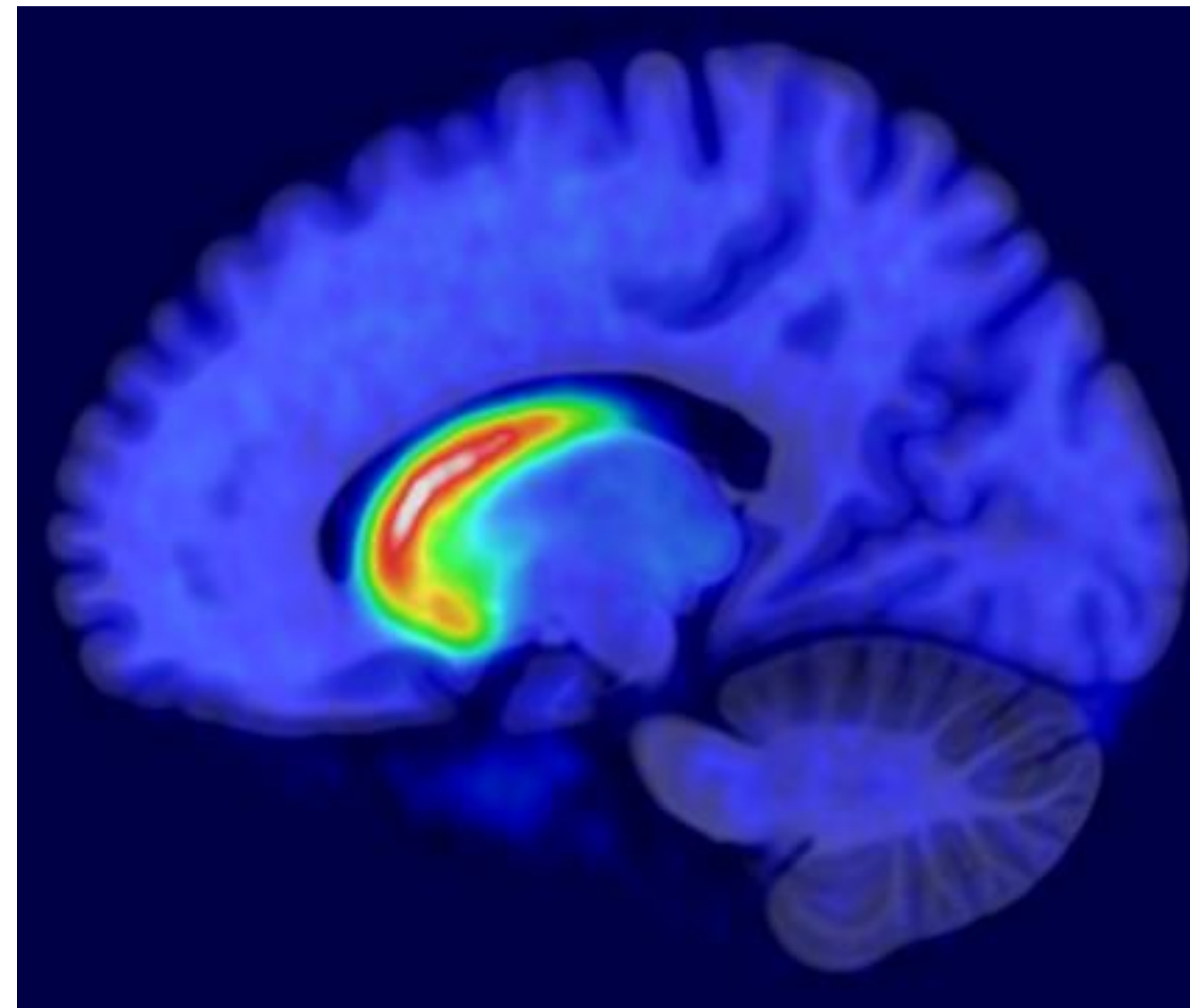
AICHA atlas



And many,
many more!

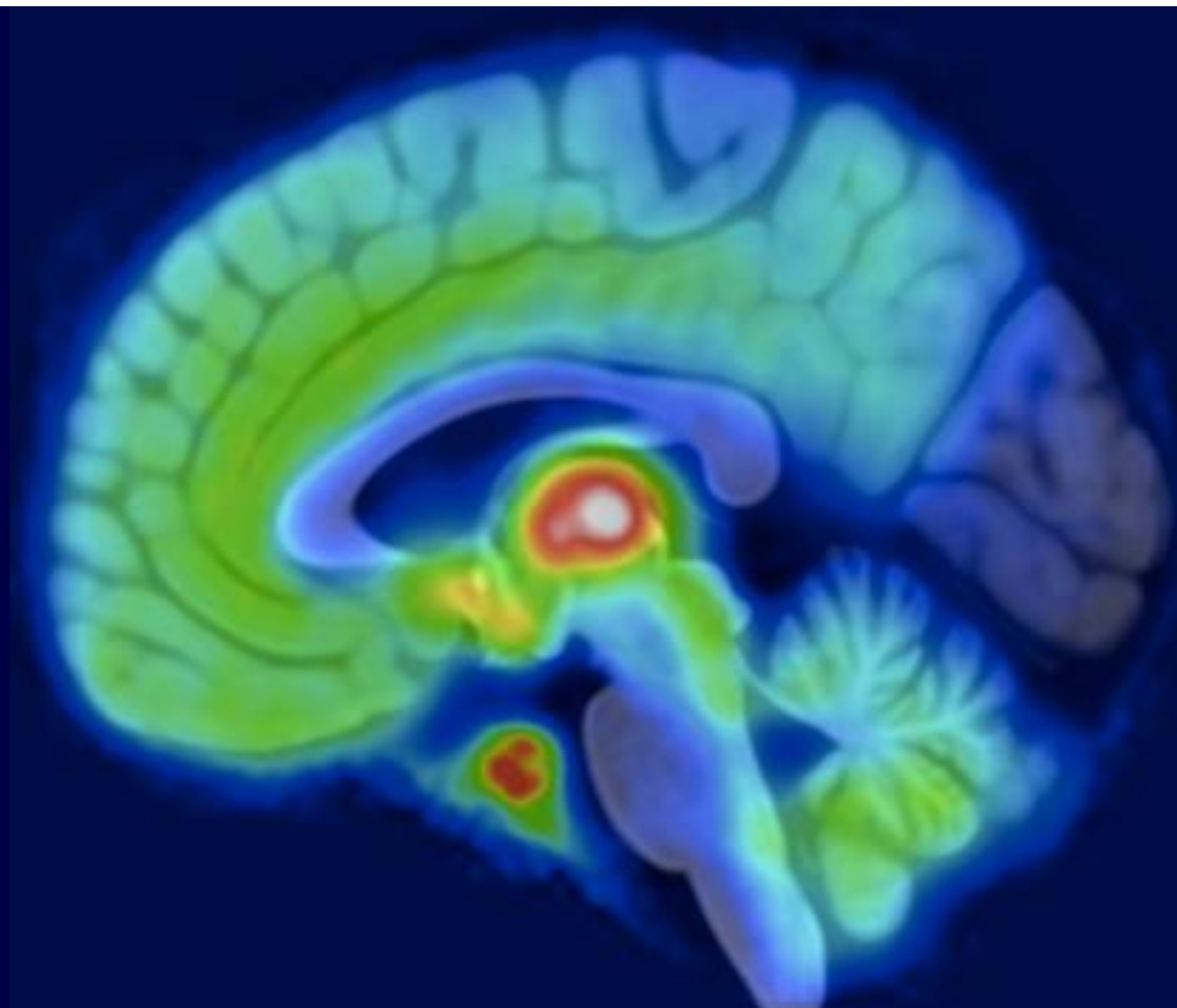
Turku PET Centre molecular atlases

Type 2 dopamine
receptors



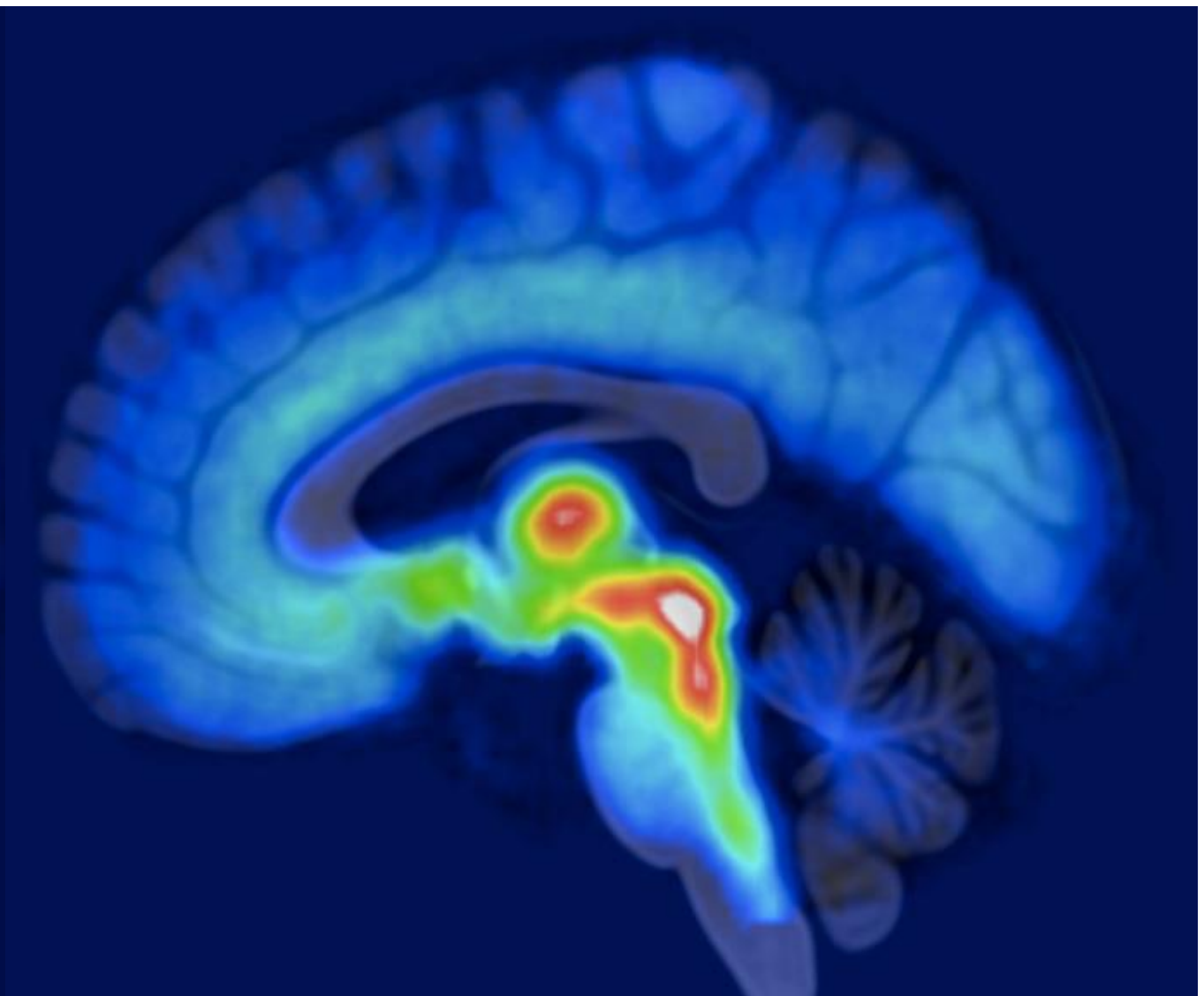
[11C]raclopride
Malen et al (2022)

μ -opioid
receptors



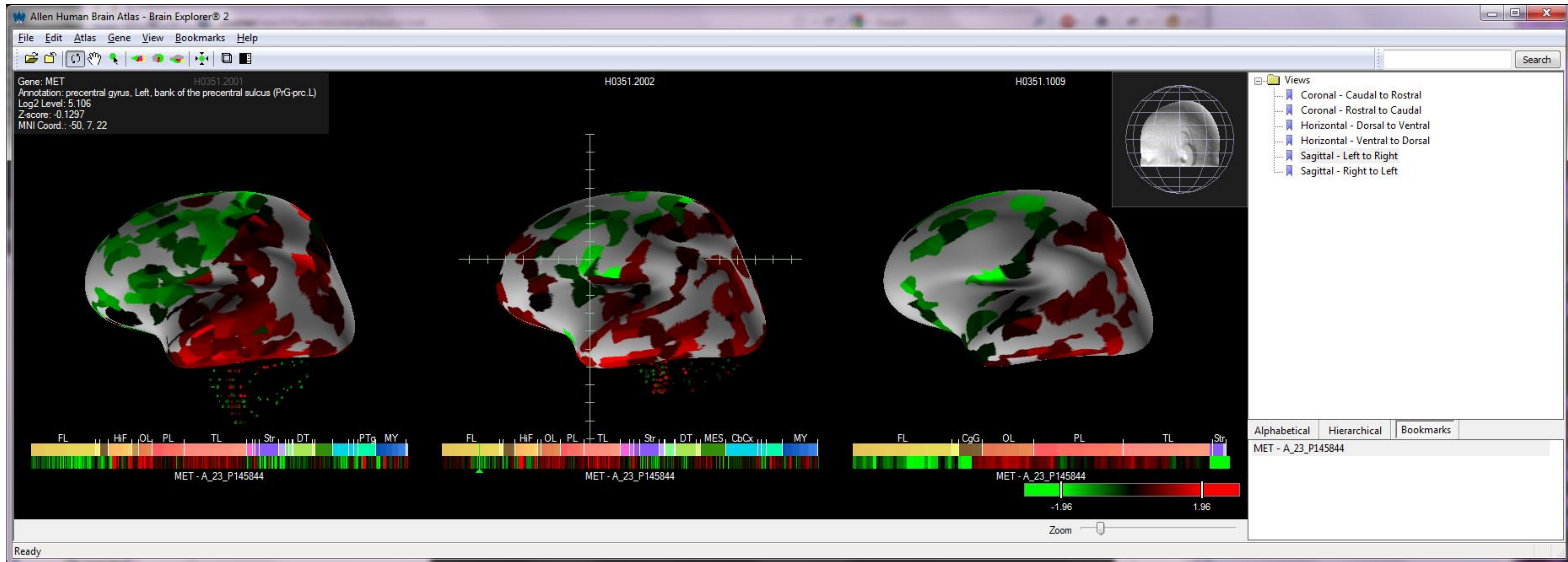
[11C]carfentanil
Kantonen et al (2020)

Serotonin
transporters



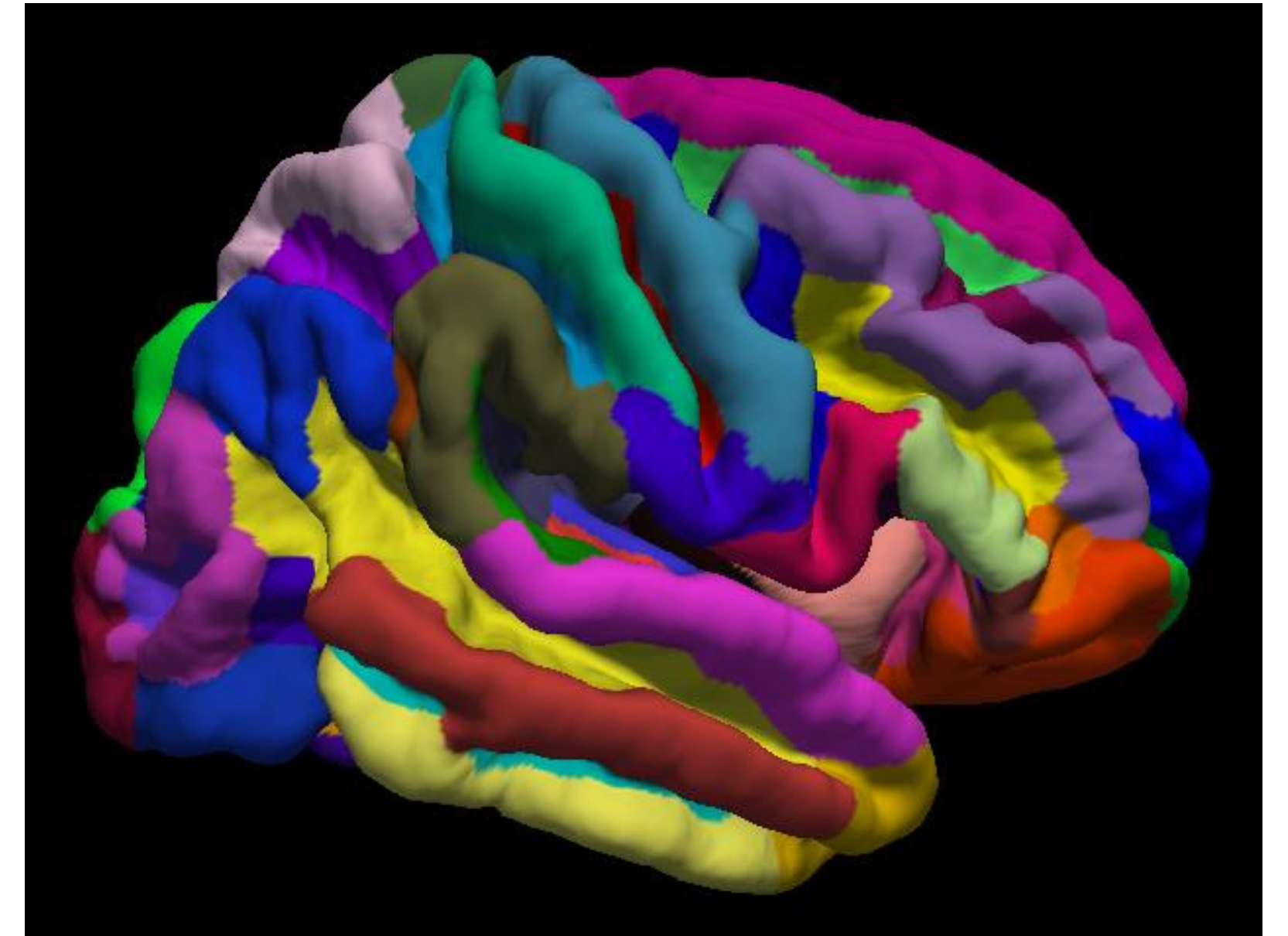
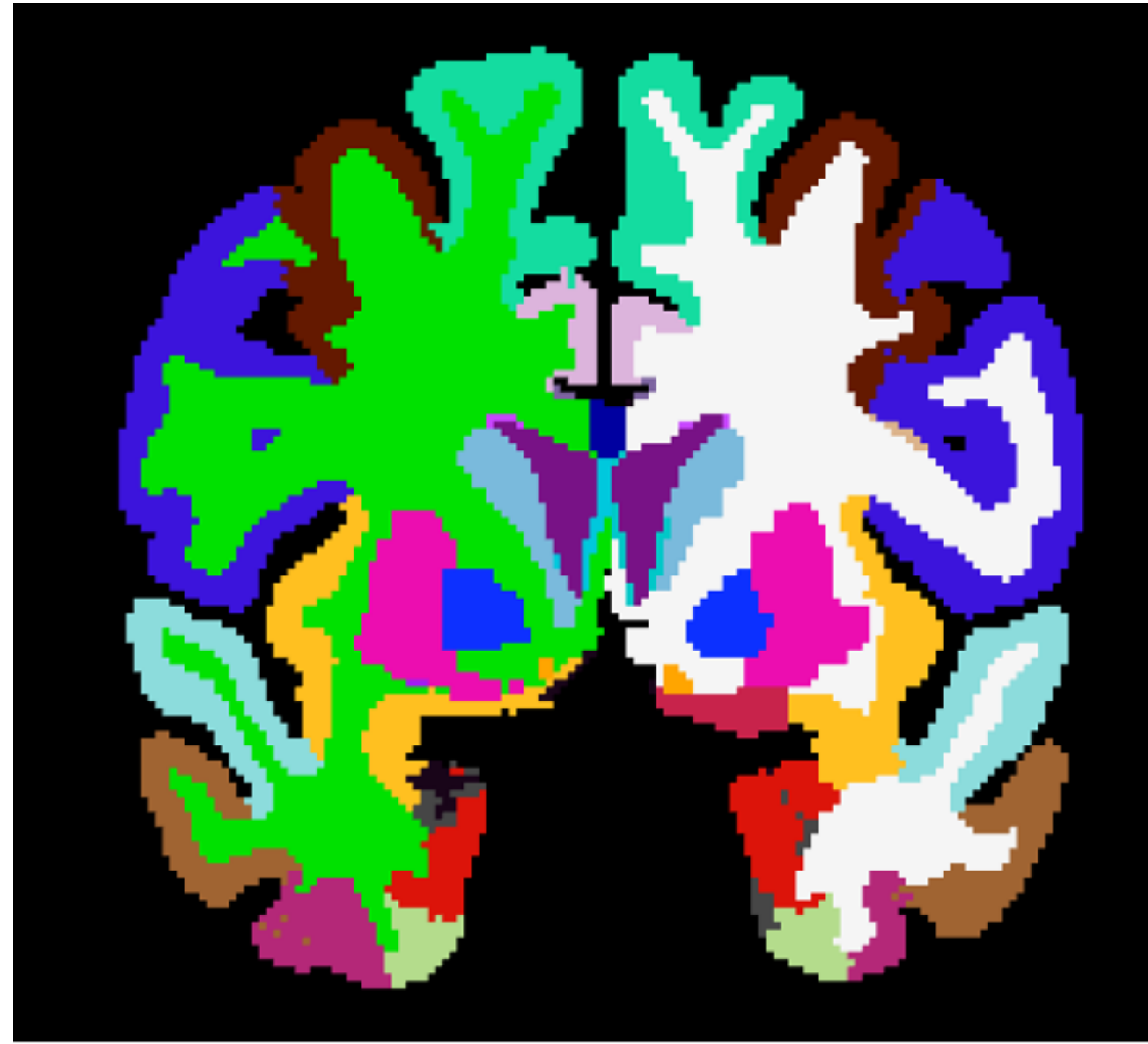
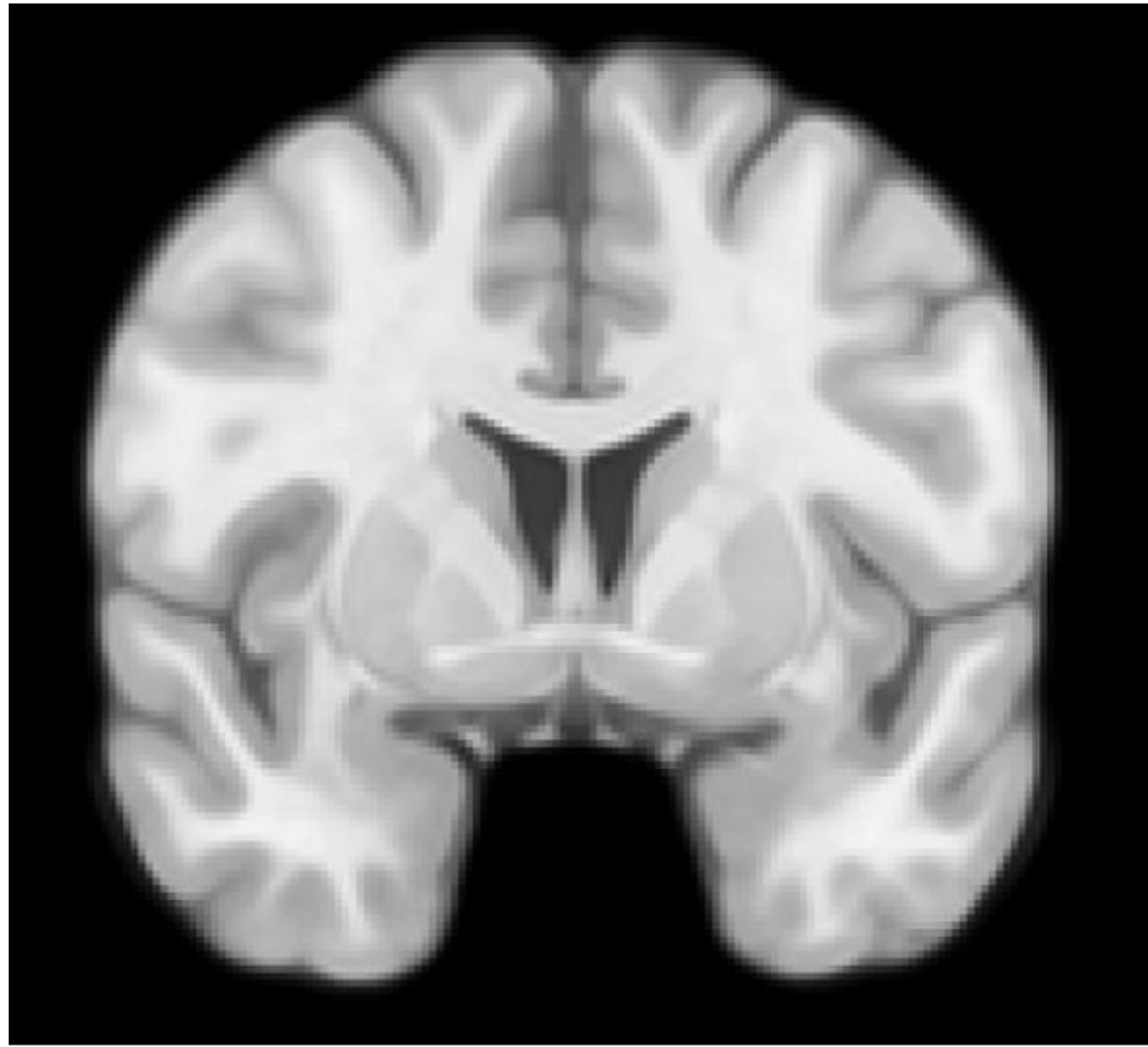
[11C]MADAM
Manninen et al (2021)

Transcriptomic atlases



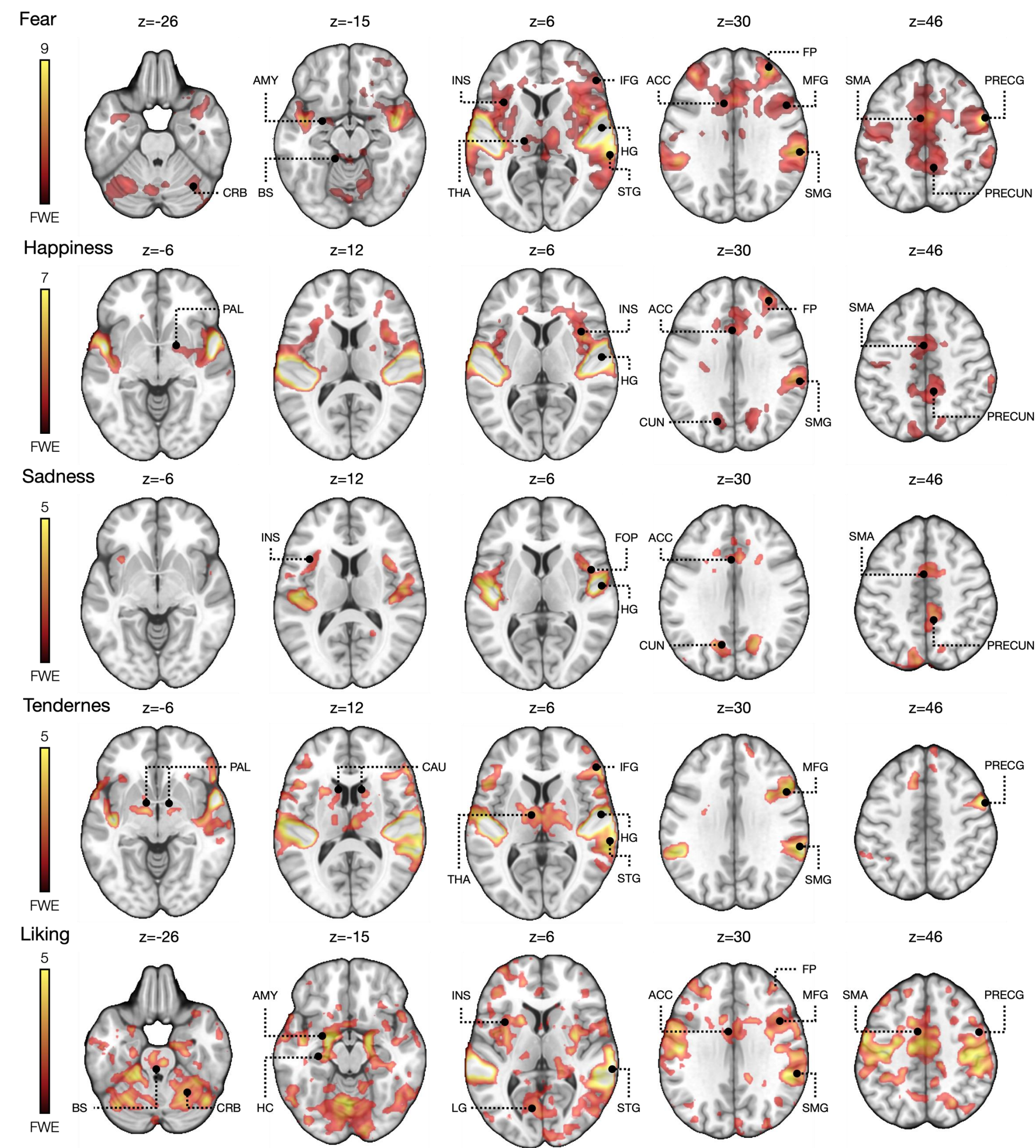
<http://human.brain-map.org>

Surfin' U.S.A.



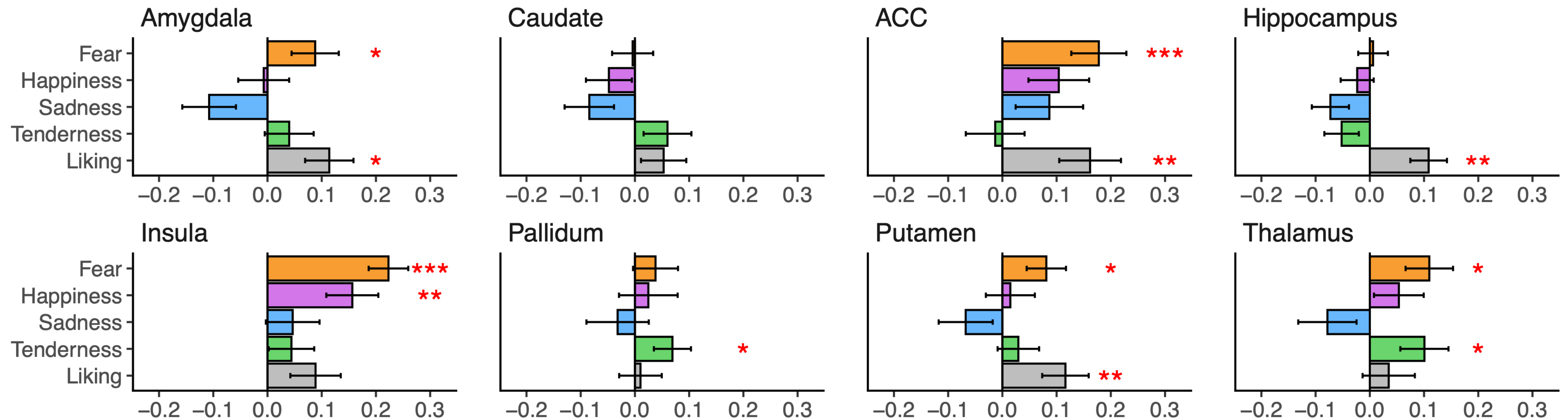
Freesurfer parcellations allow definition of subject-specific and anatomically specific ROIs - however response homogeneity across large ROIs remains an issue

What about functional ROIs?

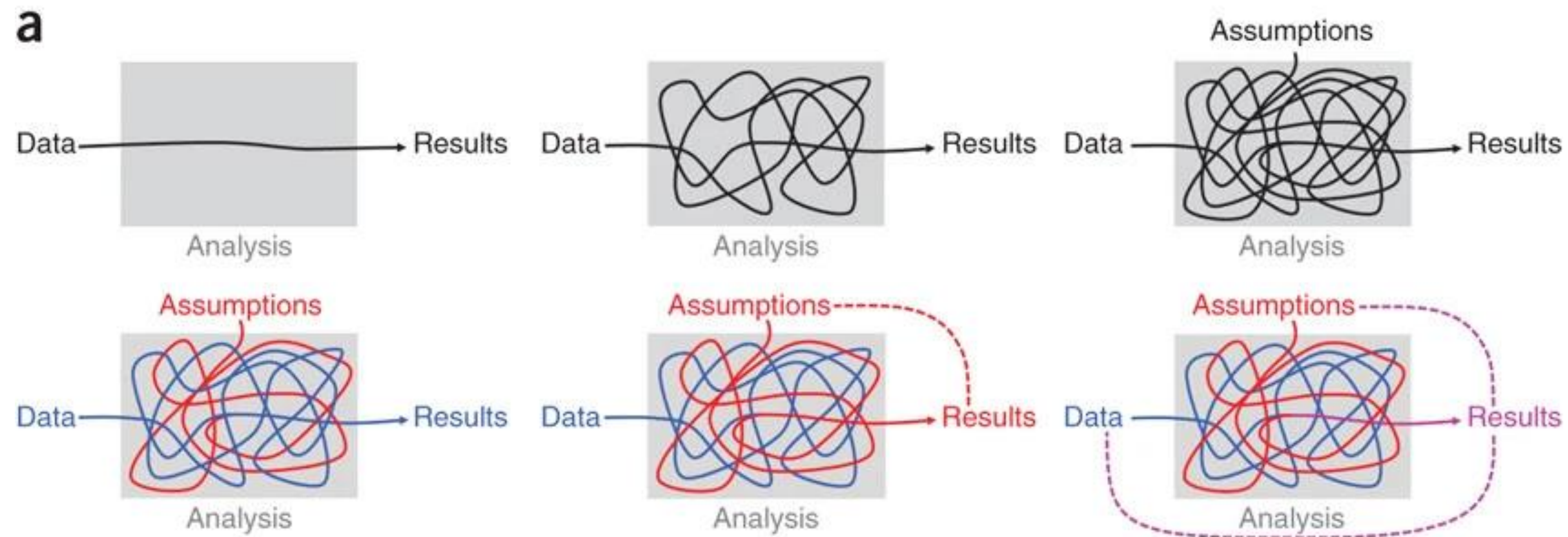


Putkinen et al (2020)

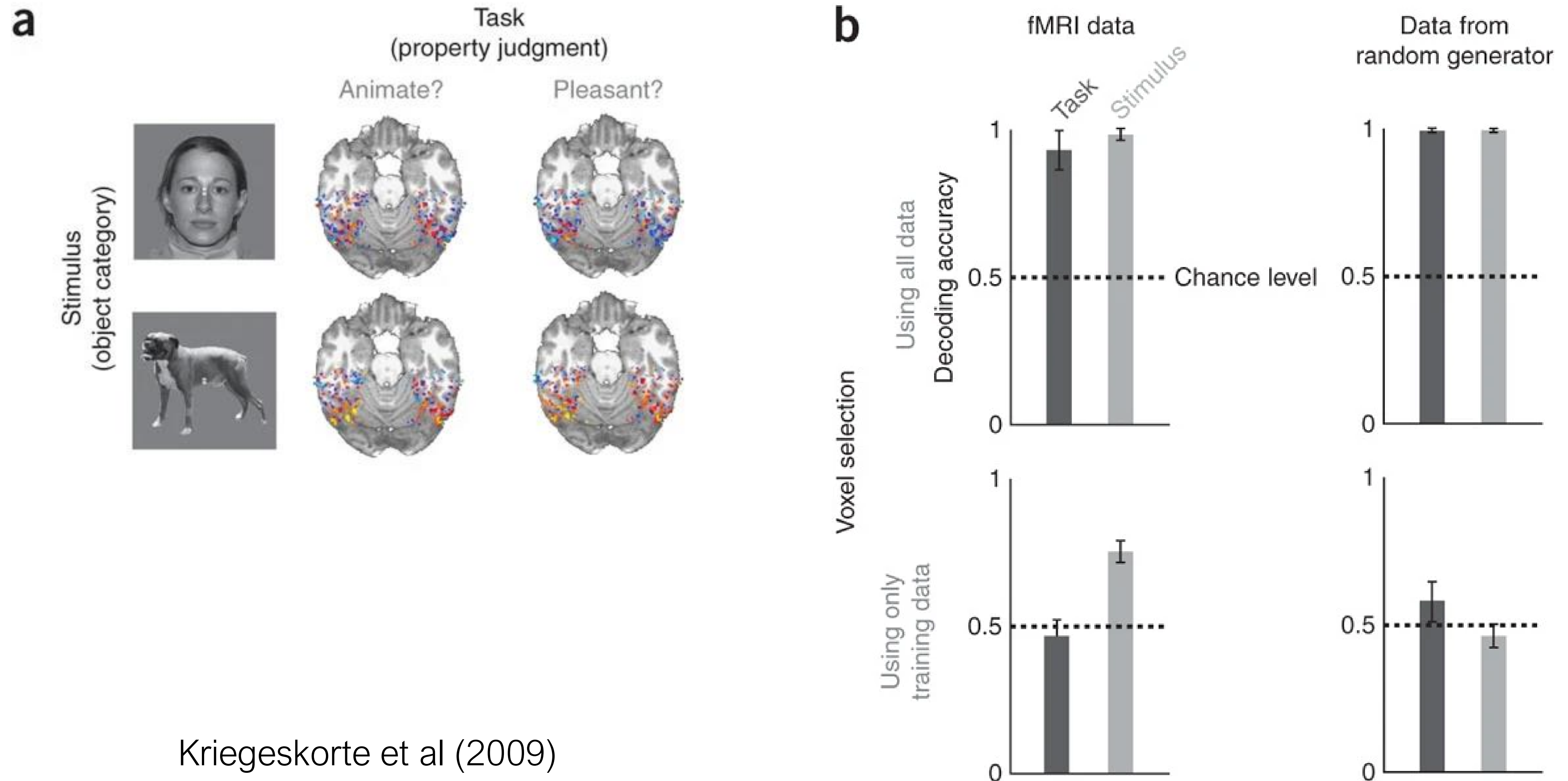
Why can't we analyze regional data for clusters?



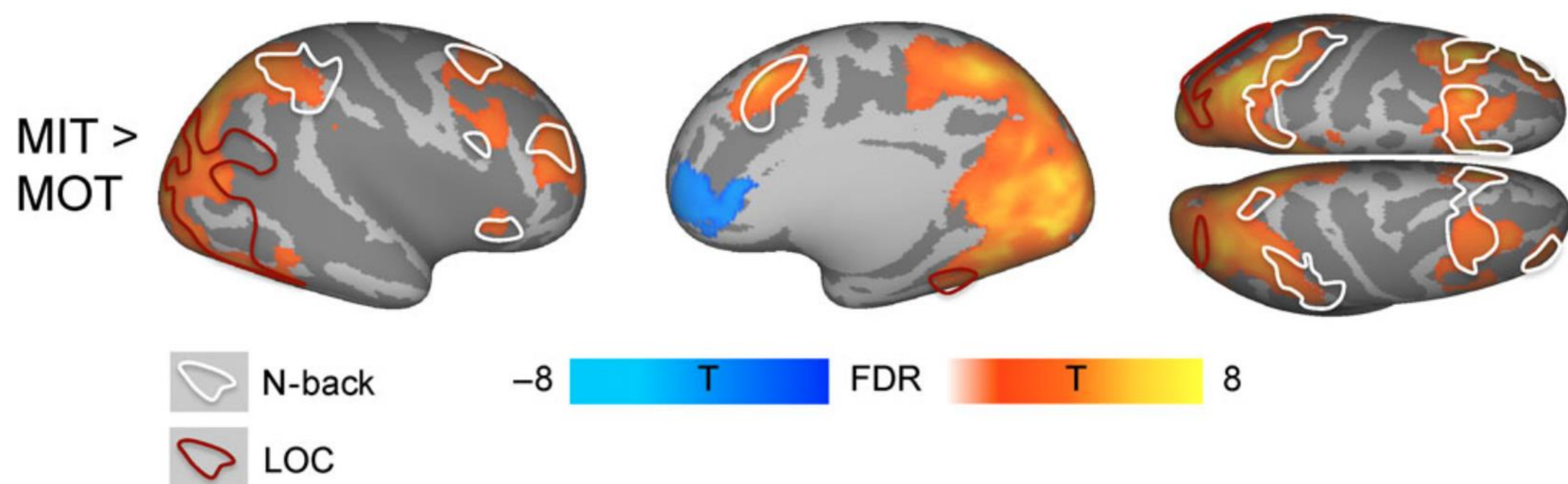
Dangers of double dipping



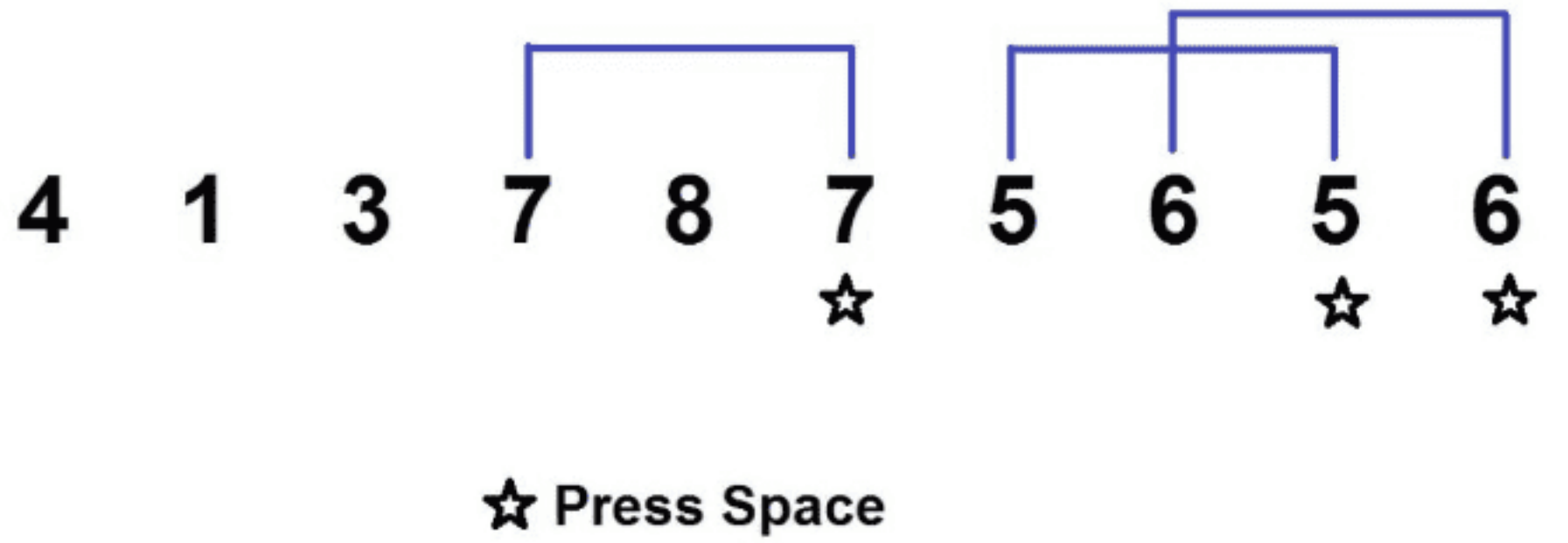
Double dipping in action



Solution Anatomical ROIs and functional localizers



N-back: Working memory localizer

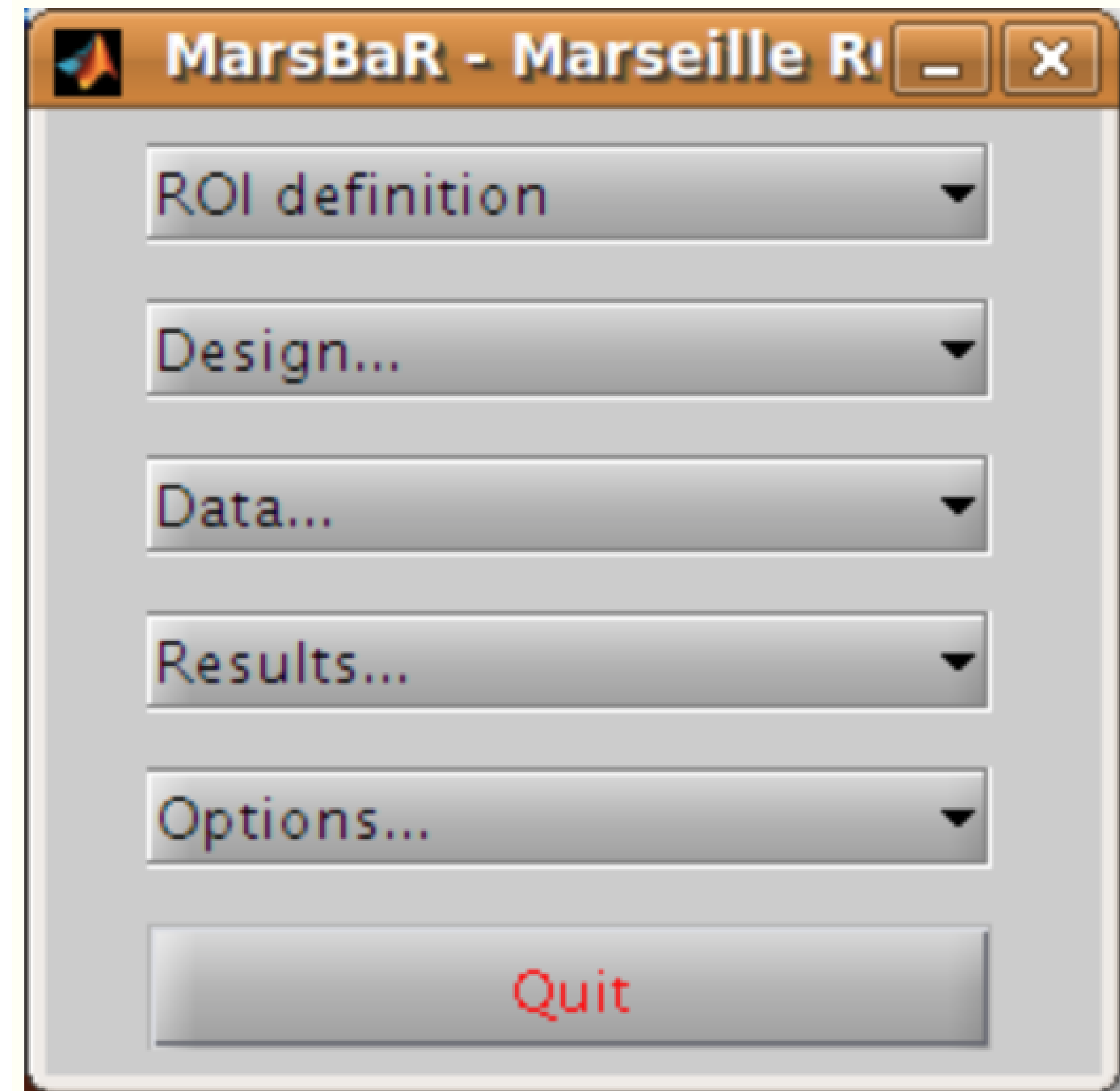


Picture task: LOC localizer



How to extract?

- MarsBaR toolbox allows extracting regional data from already estimated 1st and 2nd level SPM models
- ROI definition also supported
- Useful for extracting %signal changes or regional PET outcome measures (BPND, SUVR...)
- A model has to exist to extract data, you may need to set up e.g. dummy 2nd level model testing voxel values against zero
- Note - in the end really easy to use, although confusing to start with



How to extract?

- NIFTI is a well-standardised image format
- Numerous packages allow accessing and manipulating NIFTI structures
- Often the easiest way for ROI data extraction is simply to define your mask in the same space as the target image and just work on the data matrices

