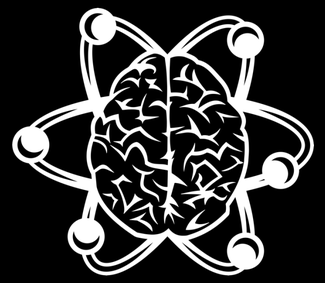
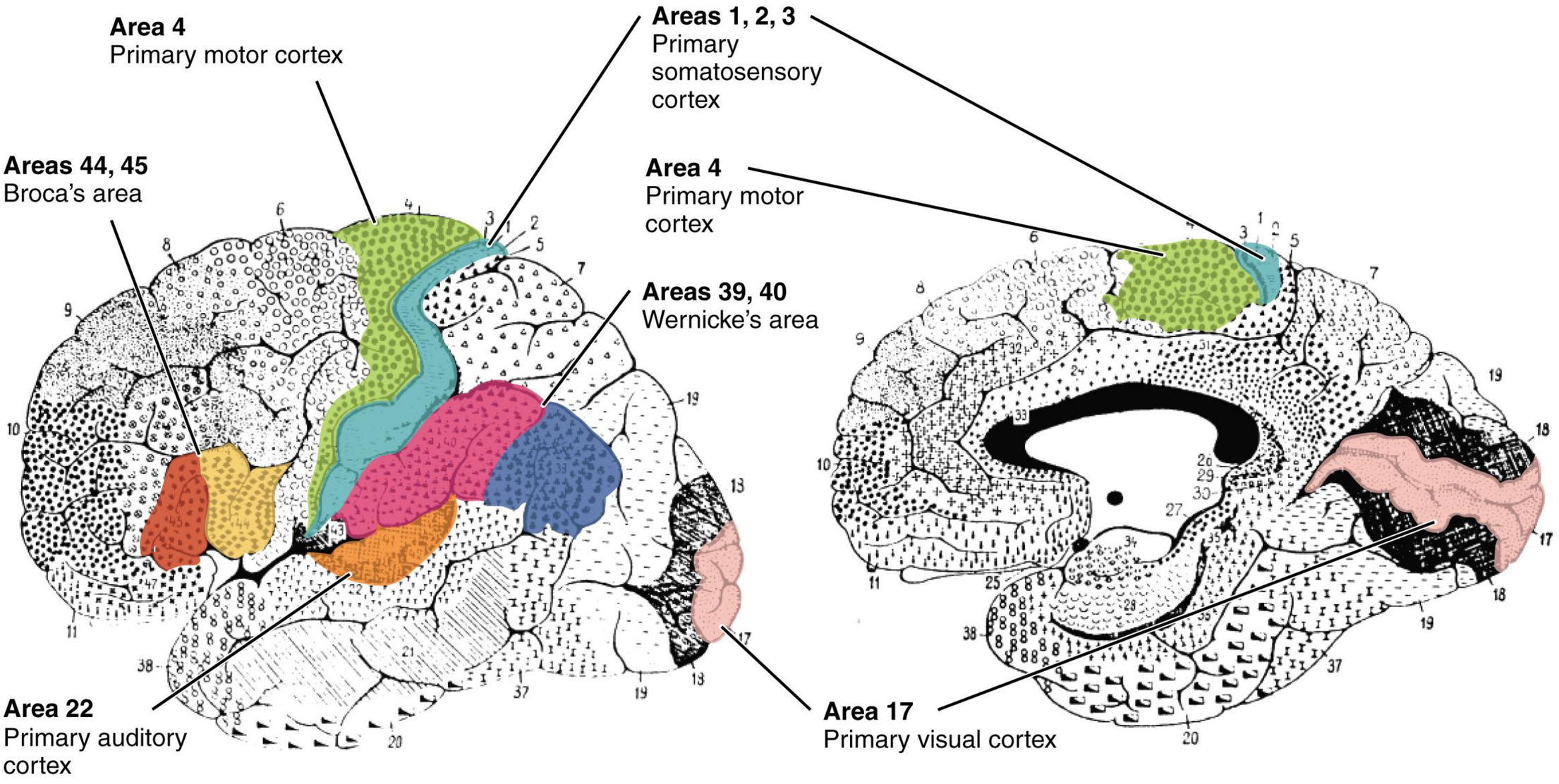


# REGION-OF INTEREST ANALYSIS

Turku PET Centre Brain Imaging Course 2024

Lauri Nummenmaa, Turku PET Centre



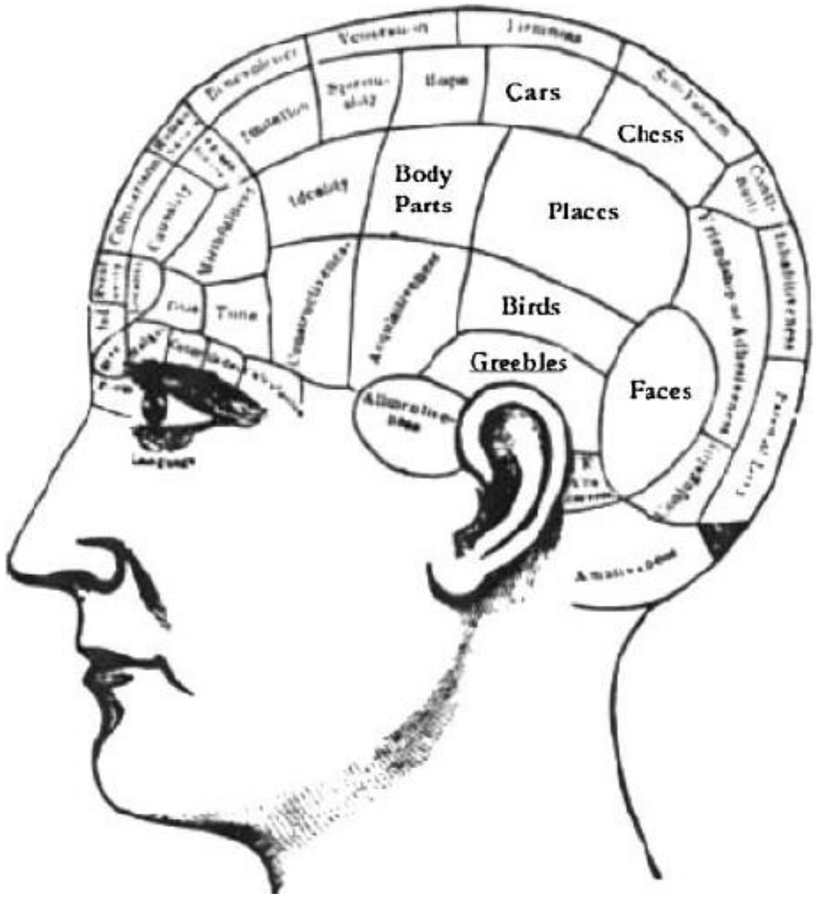



**Brodmann's cytotechtonic map (1909):**
Lateral surface

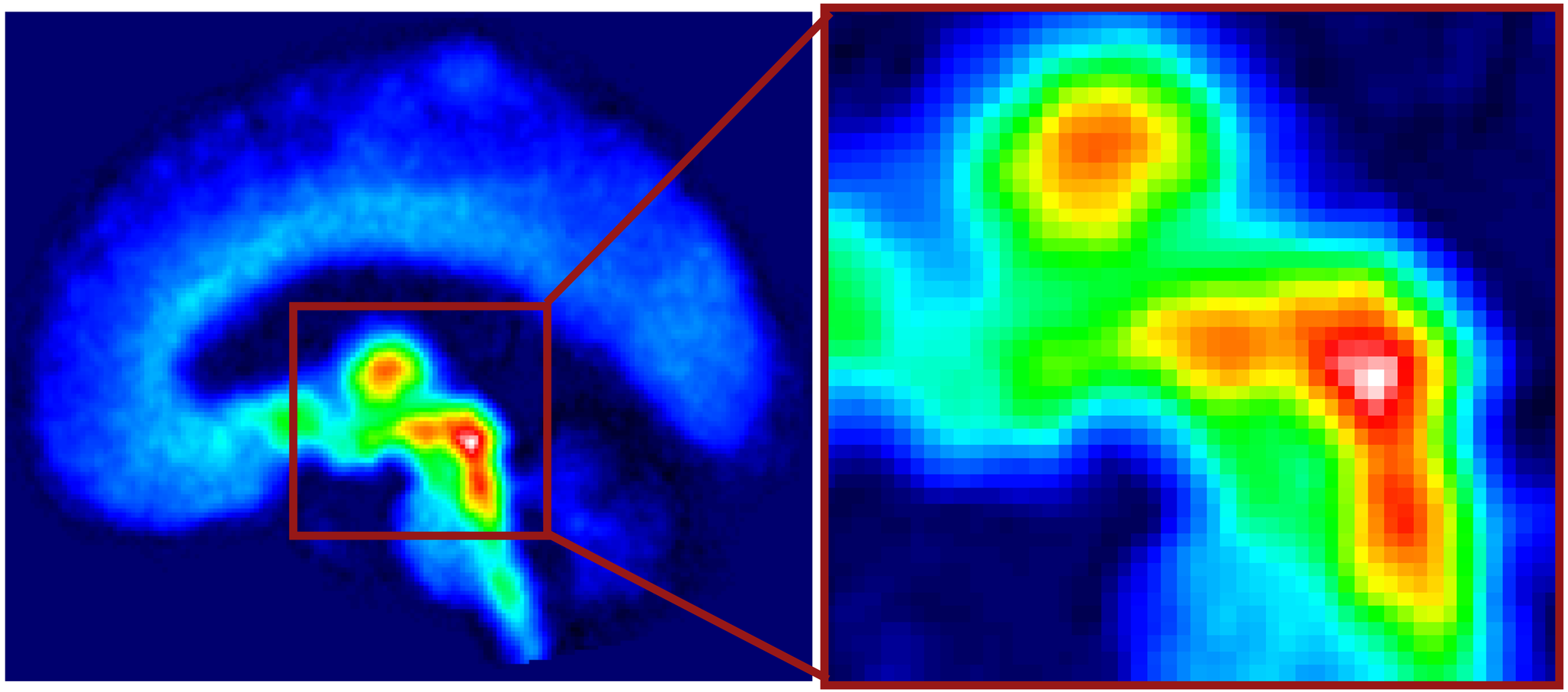
**Brodmann's cytotechtonic map (1909):**
Medial surface

# 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

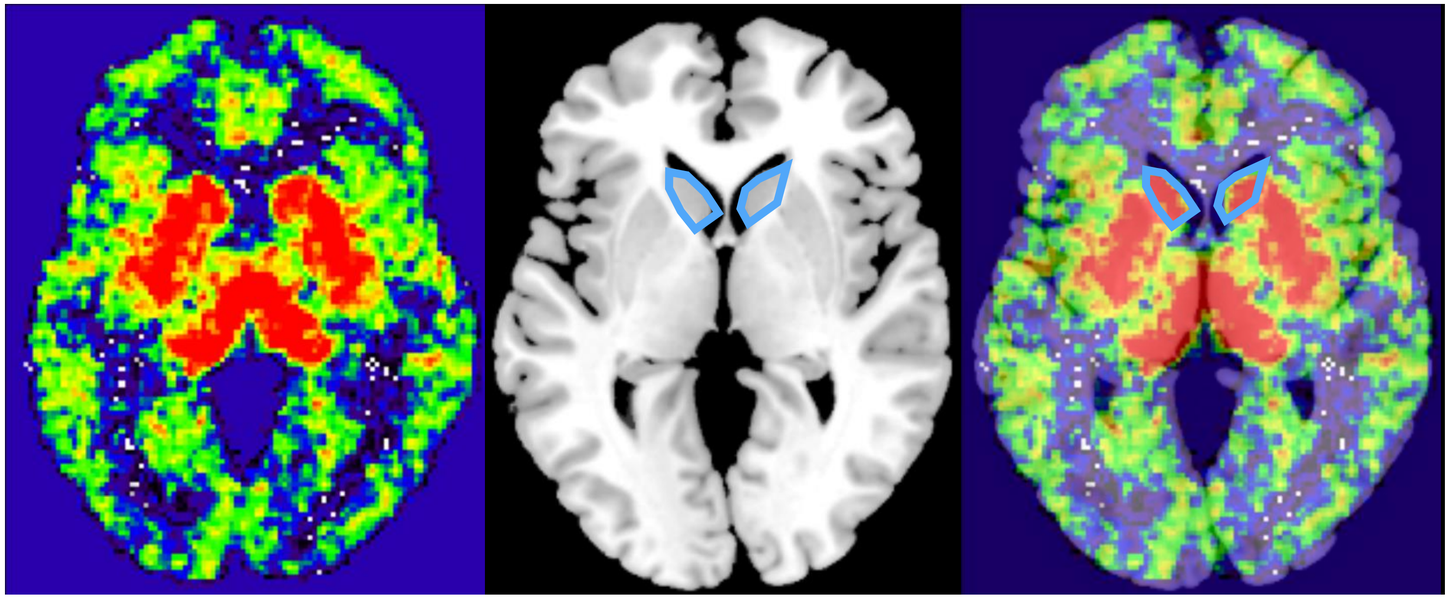


# We still have good reasons!

- 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

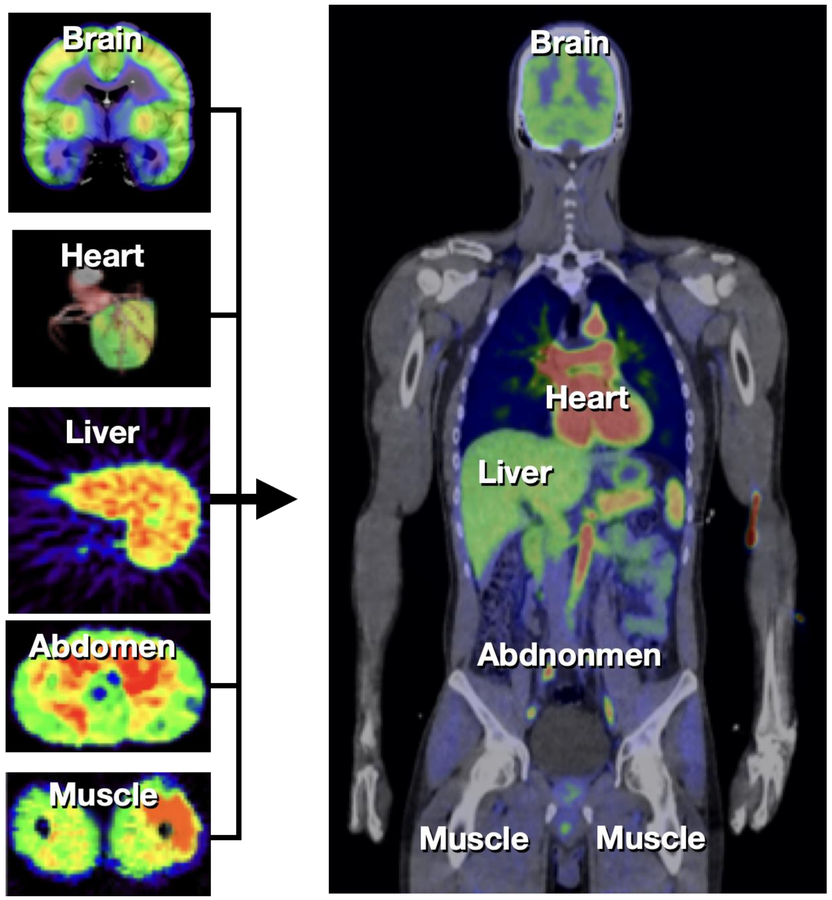


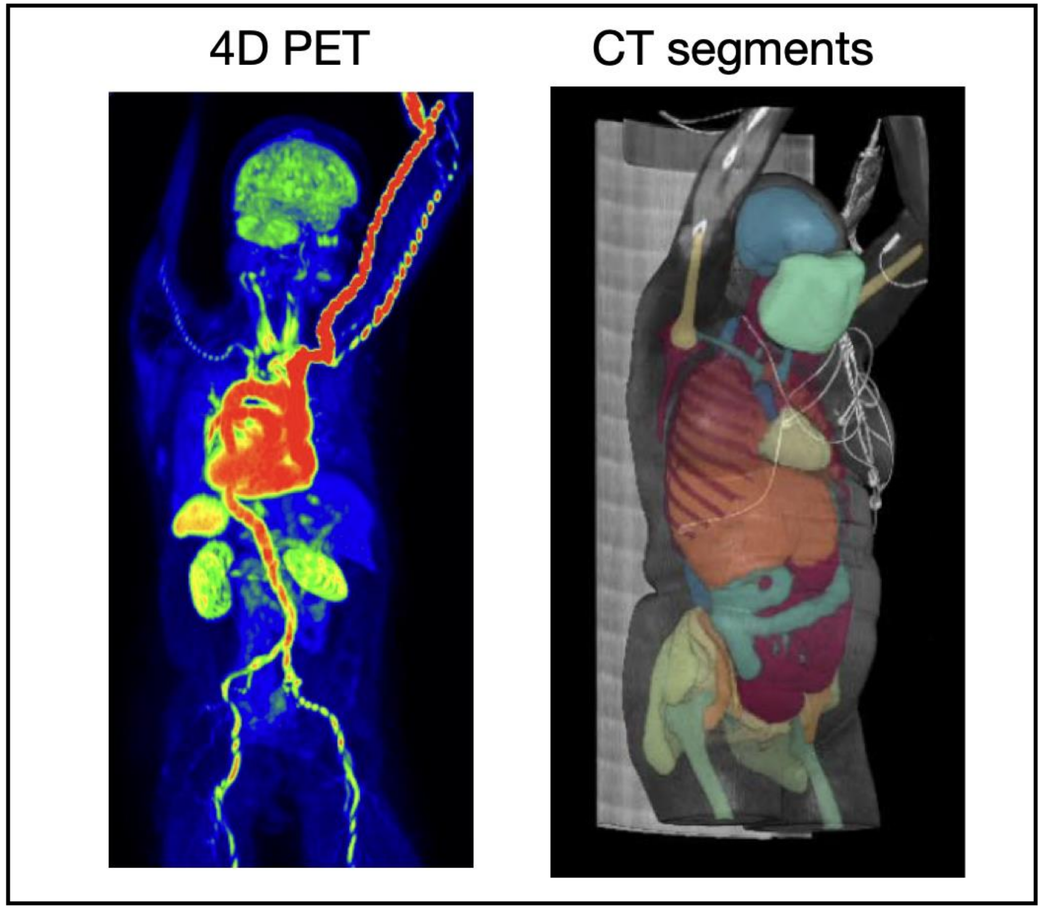
Extract outcome measure in ROI

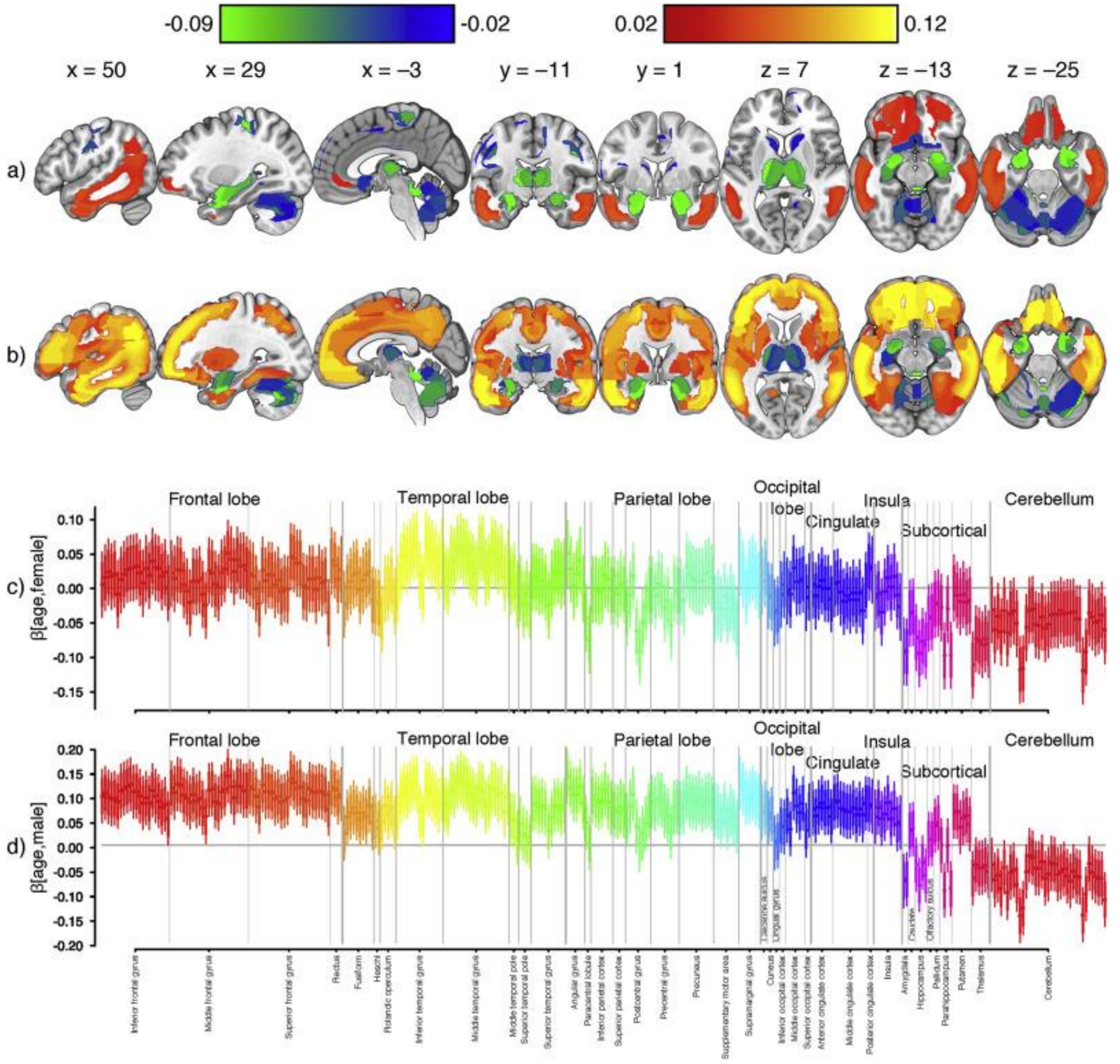
| Controls | Patients |
|---|---|
| 3 | 5 |
| 4 | 4 |
| 5 | 6 |
| 6 | 7 |
| 3 | 6 |
| 2 | 5 |
| 3 | 2 |
| 5 | 6 |
| 2 | 8 |

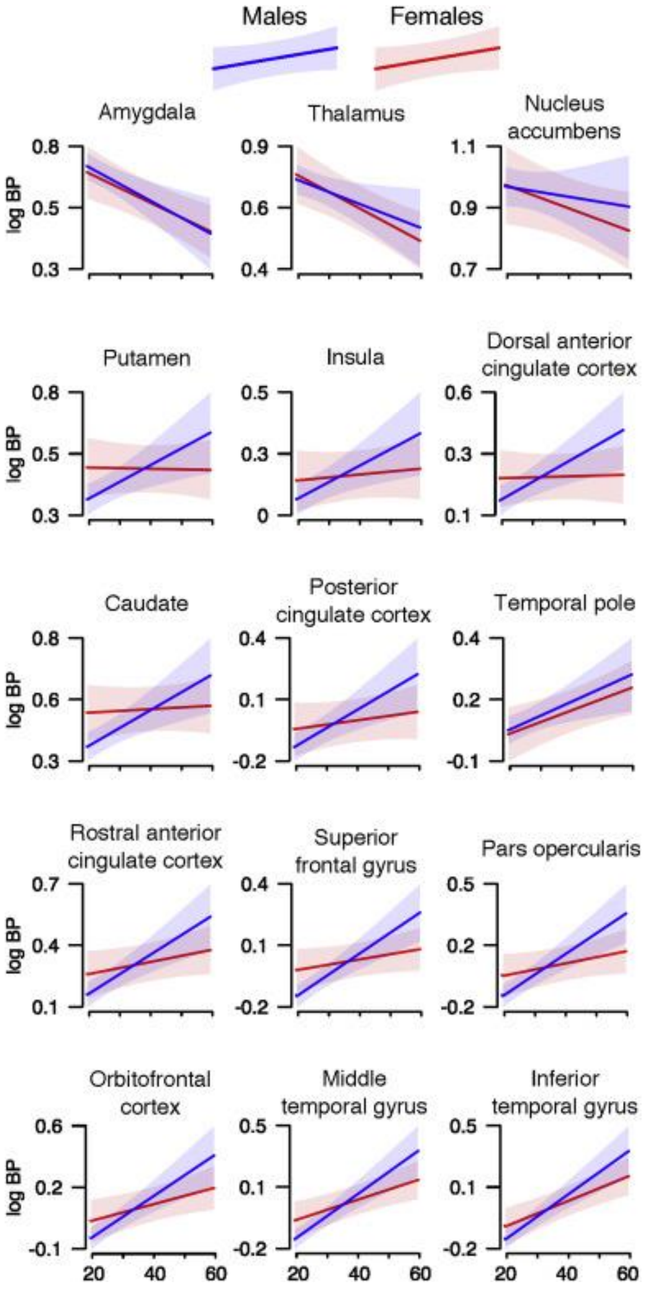
- Pros: Anatomically accurate if ROIs well definied, data can be analyzed with simple univariate statistical tests
- Cons: Laborious, using many ROIs not feasible, averaging within ROI not always appropriate

# Major issue in total-body analysis

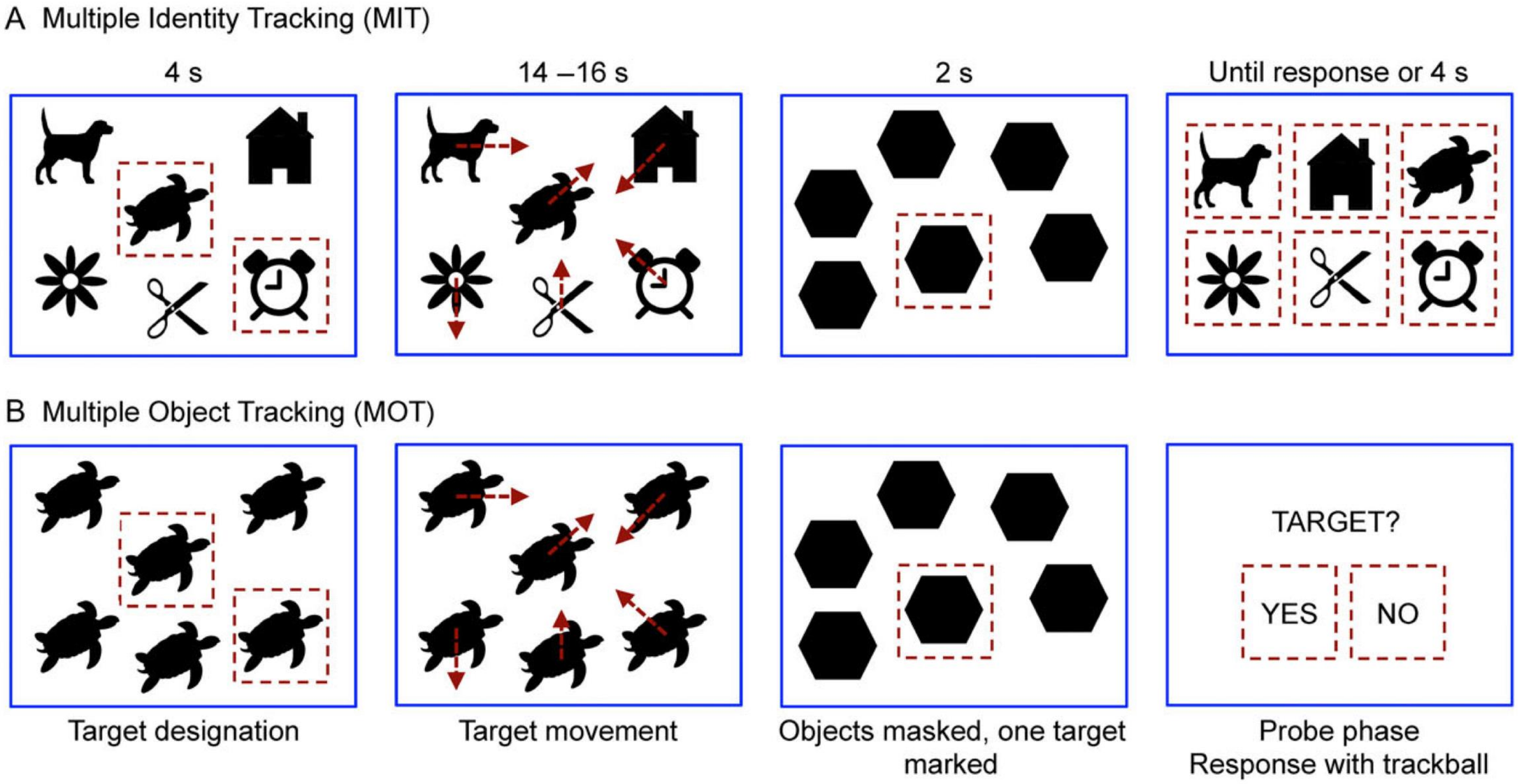


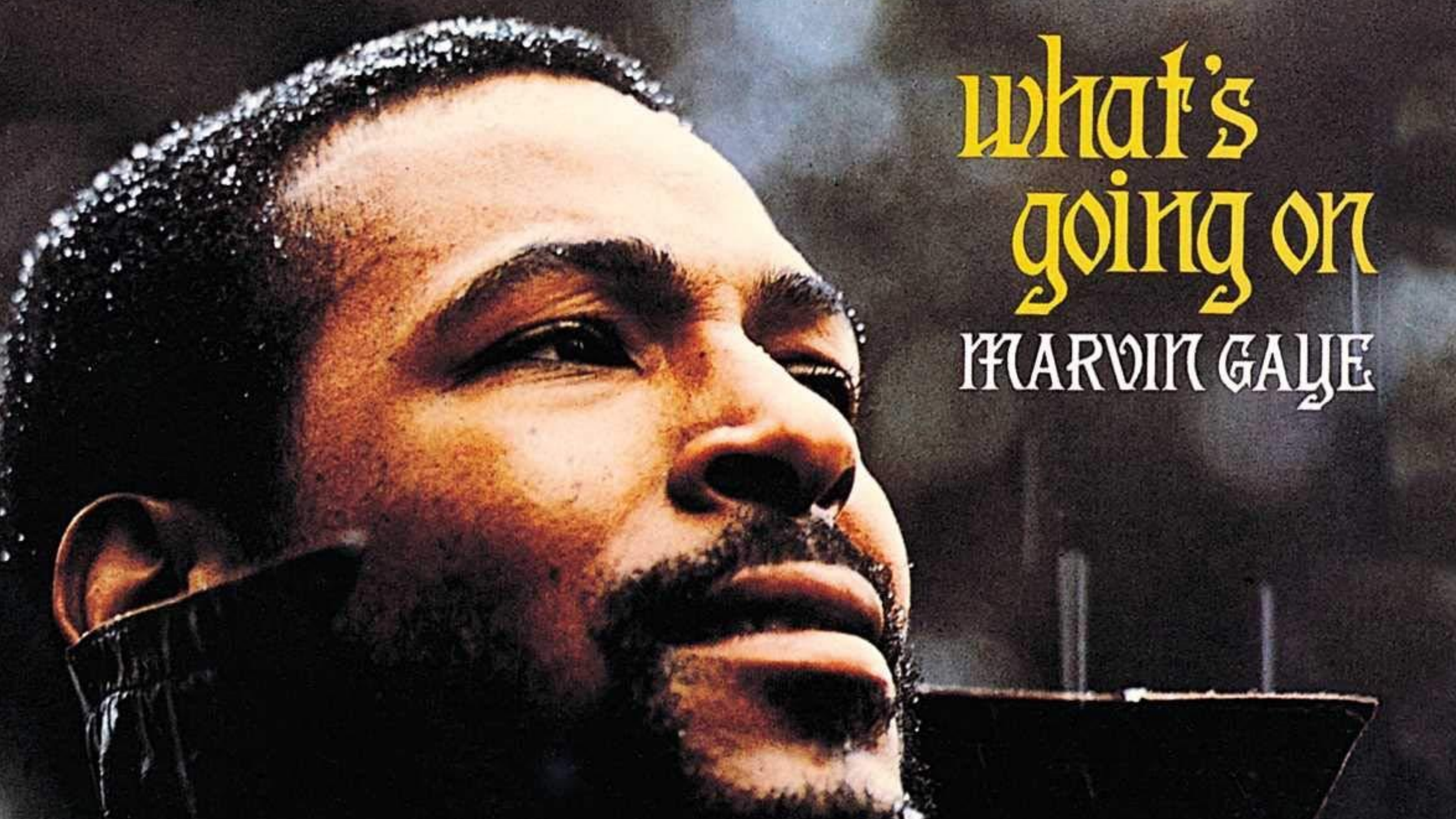


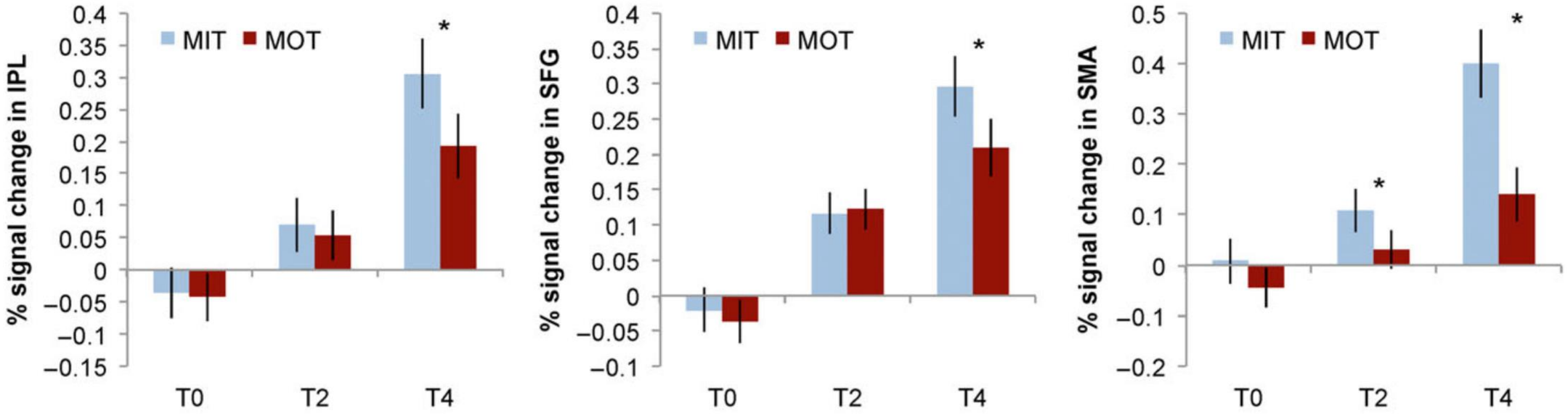

Kantonen et al (2020 NeuroImage)

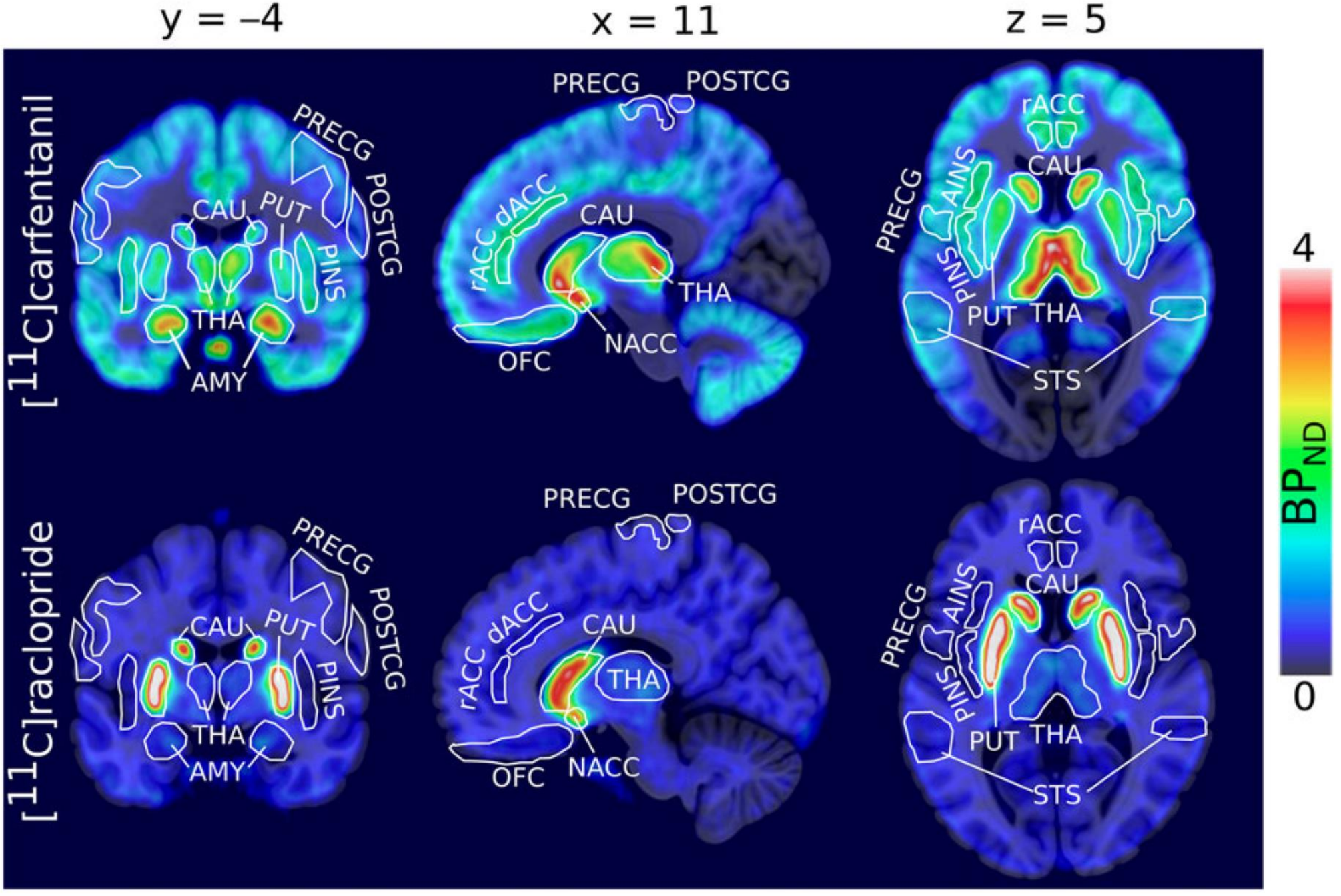


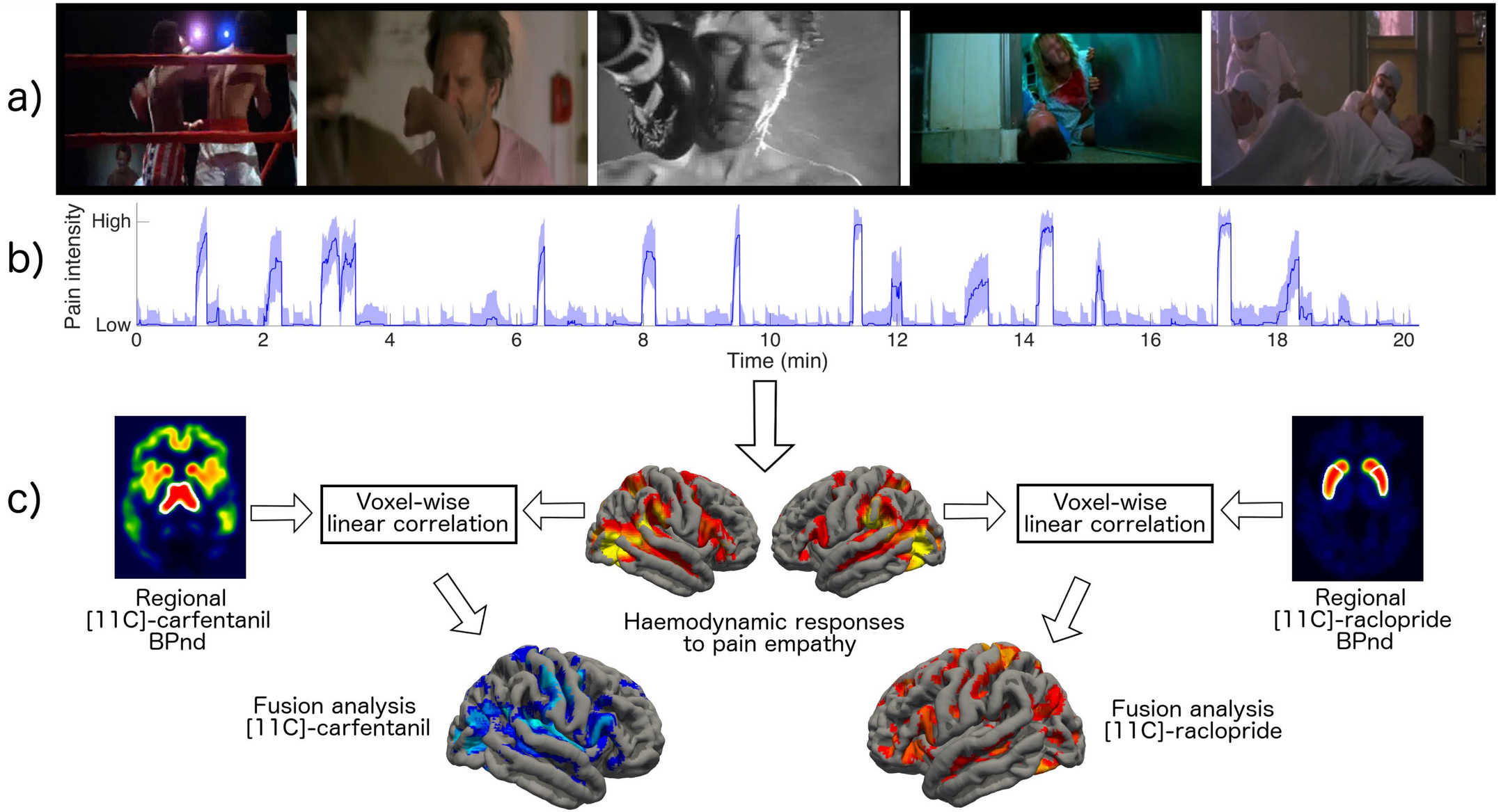

Nummenmaa et al (2017)


what's
going on
MARVIN GAYE

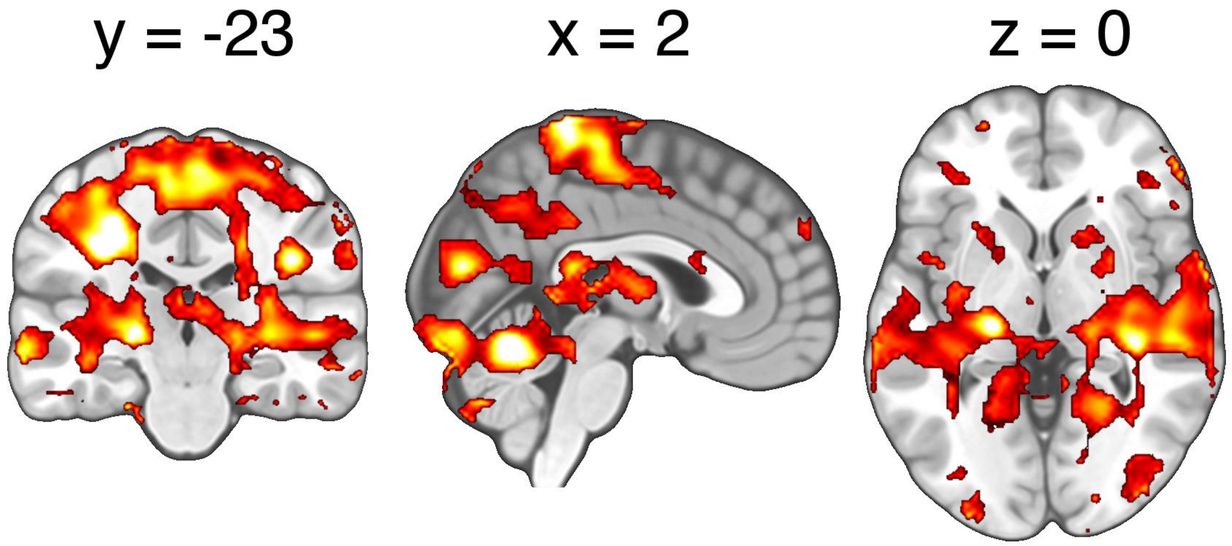
# ROI analysis helps in breaking down the interaction

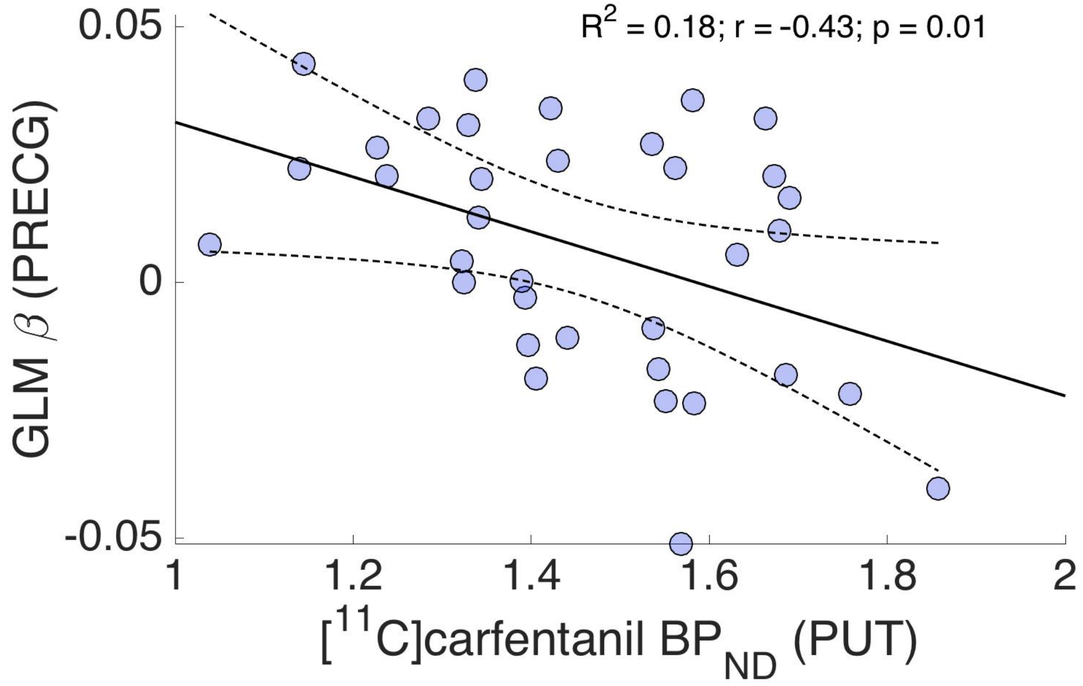



y = –4
x = 11
z = 5
[11C]carfentanil
[11C]raclopride
PRECG
POSTCG
CAU
PUT
PINS
THA
AMY
rACC
dACC
NACC
OFC
AINS
STS
4
BPND
0




Karjalainen et al (2017 Cereb Cortex)



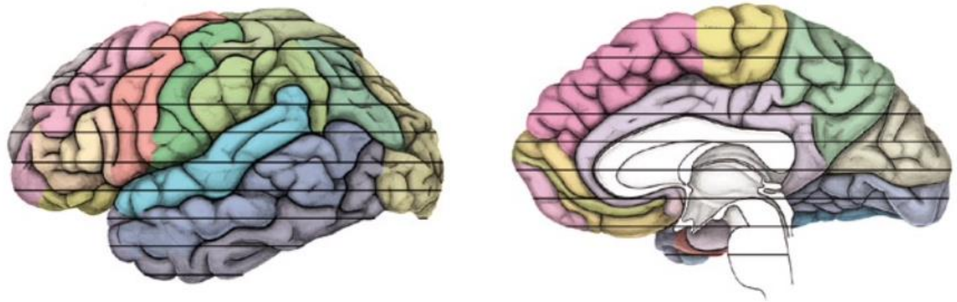





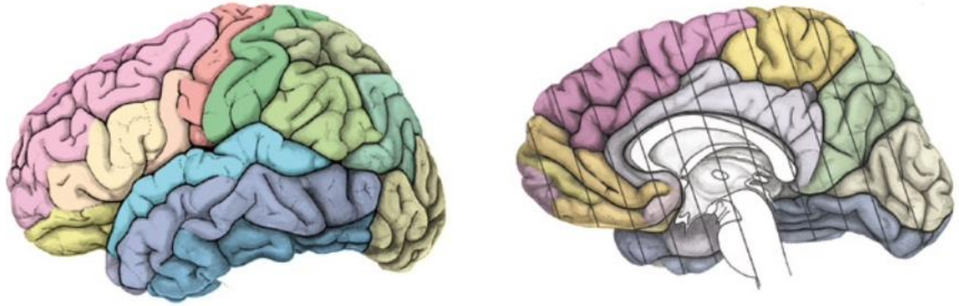
Karjalainen et al (2017; 2019 Cereb Cortex)

# How to define ROIs?

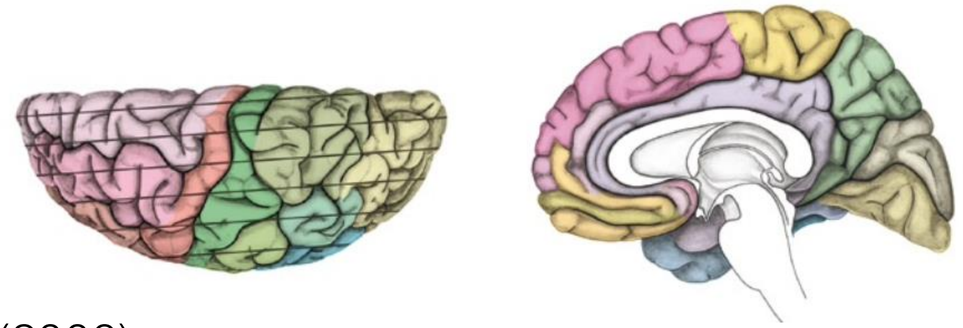
**Horizontal Atlas:**



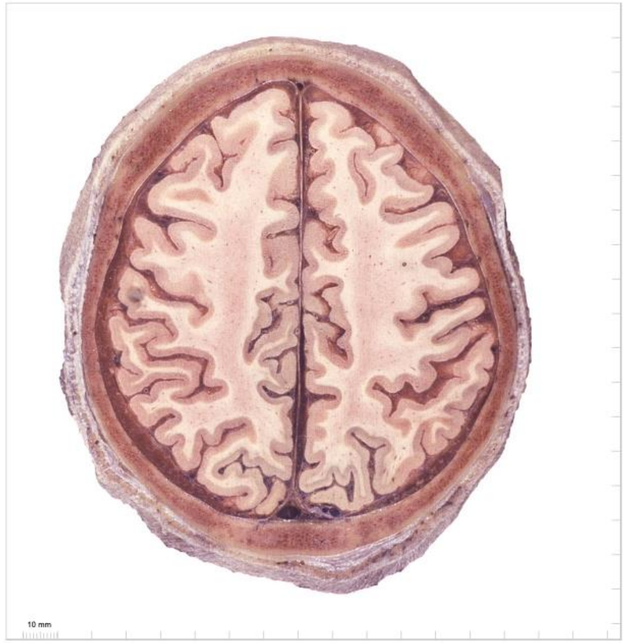
**Coronal Atlas:**

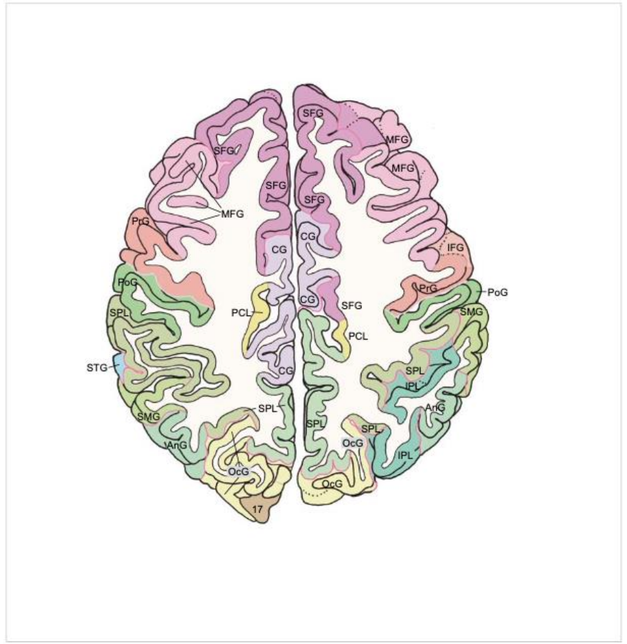


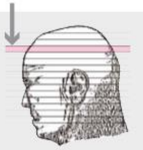
**Sagittal Atlas:**



Mai et al (2008)



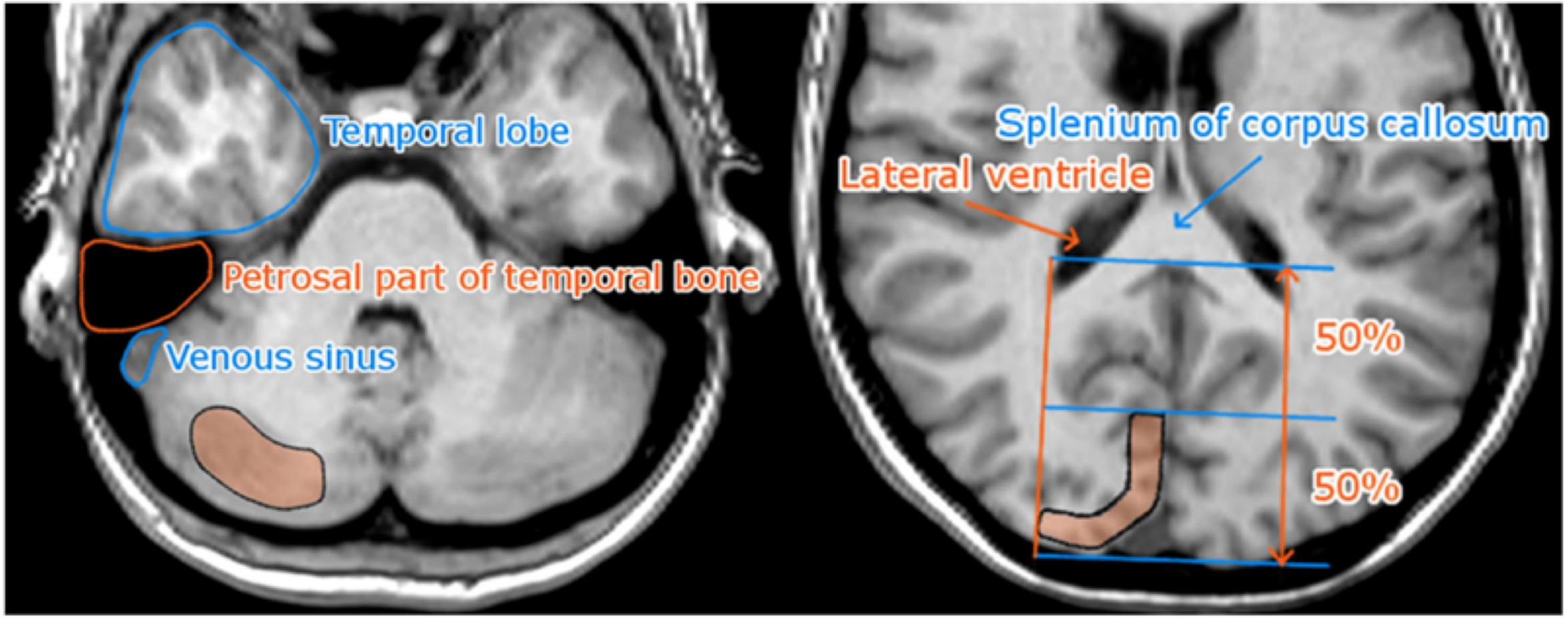



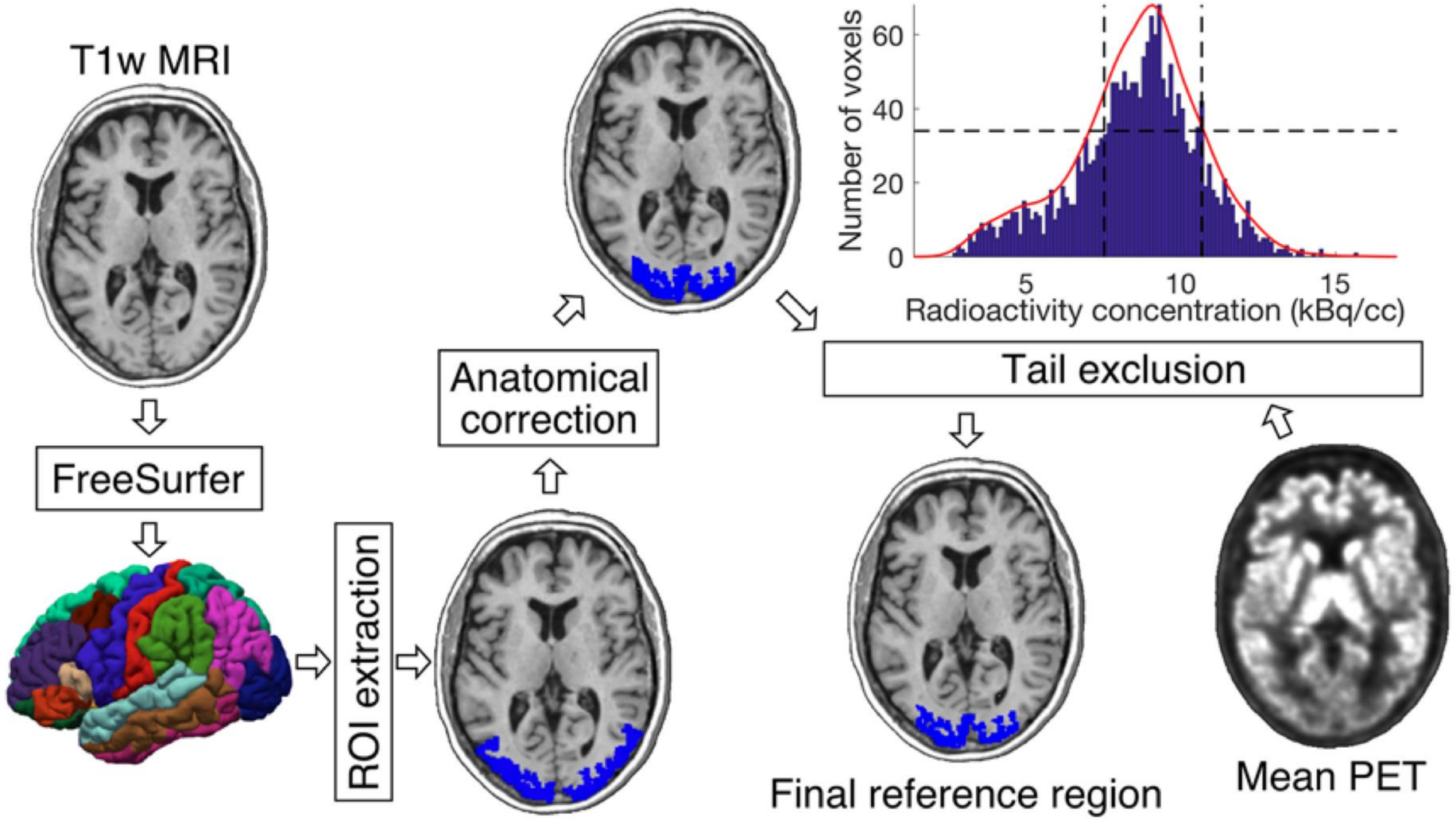
4

(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 |




Karjalainen et al (2017)

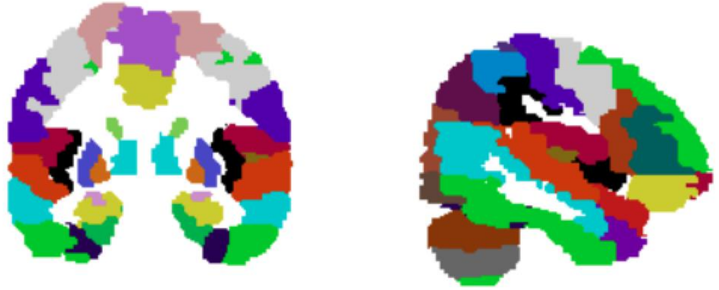



Karjalainen et al (2017)

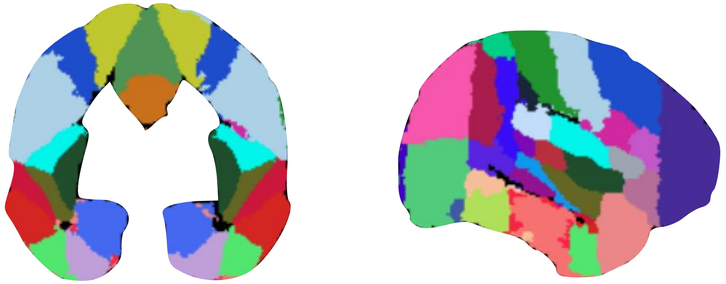
# Anatomical and functional parcellations

Brodmann atlas

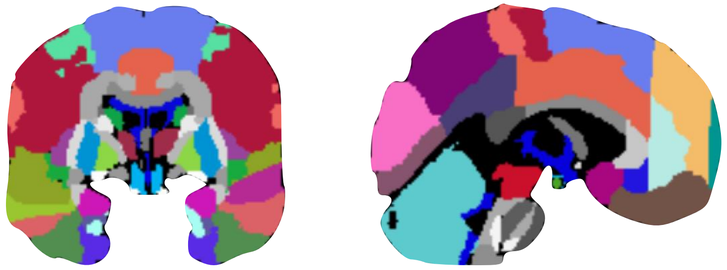
AAL atlas



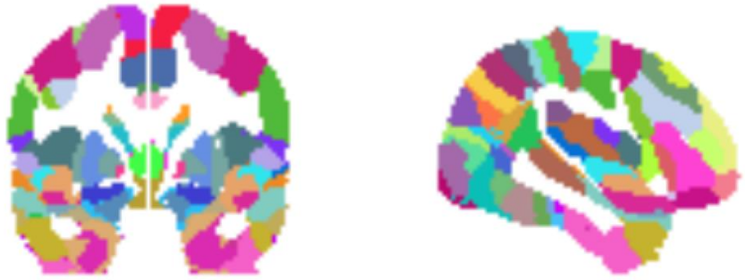
Harvard-Oxford



JHU atlas



AICHA atlas



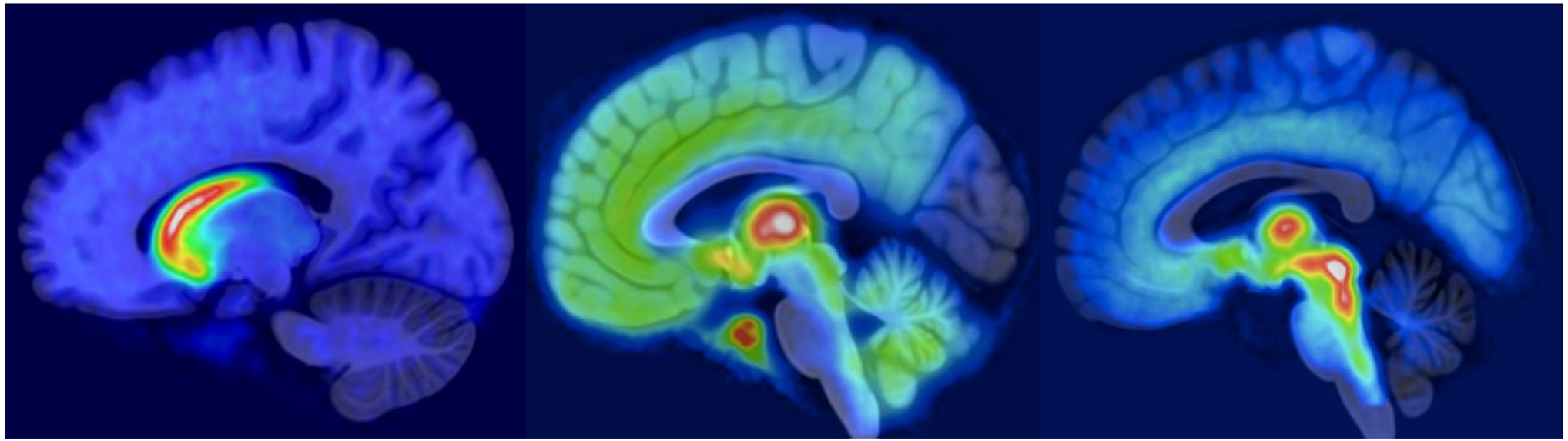
And many, many more!

# Turku PET Centre molecular atlases

Type 2 dopamine receptors

μ-opioid receptors

Serotonin transporters

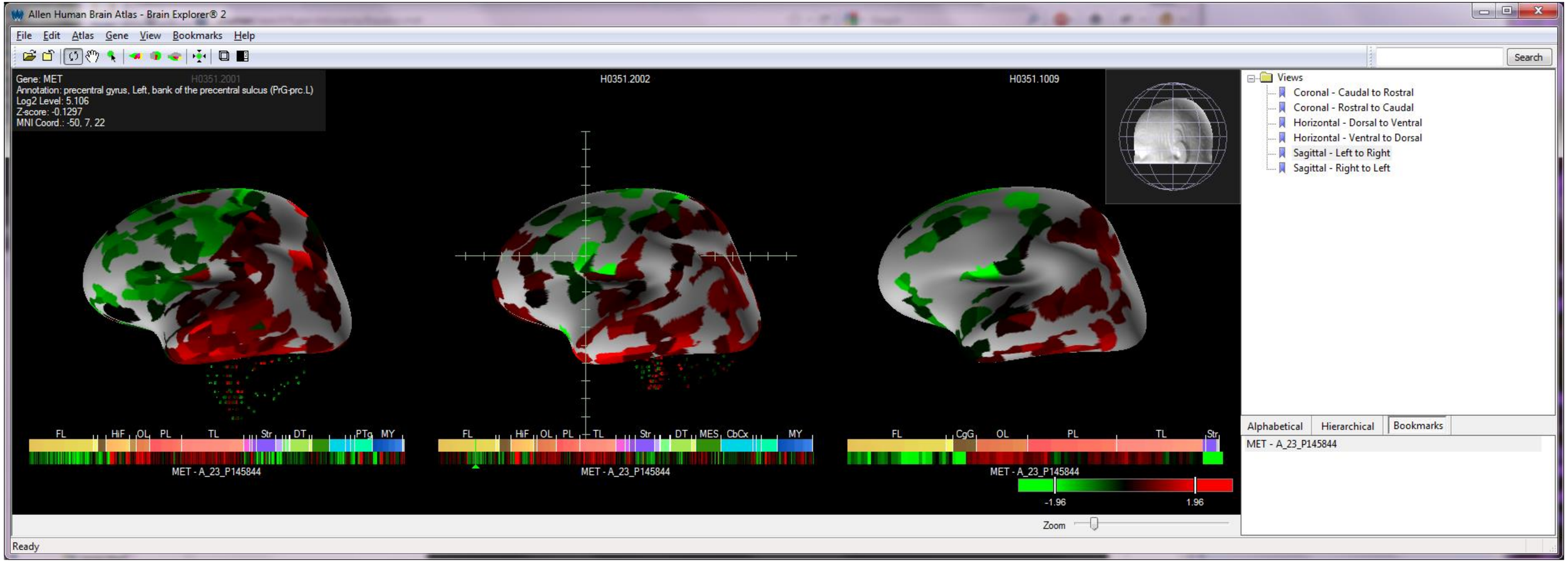


[11C]raclopride
Malen et al (2022)

[11C]carfentanil
Kantonen et al (2020)

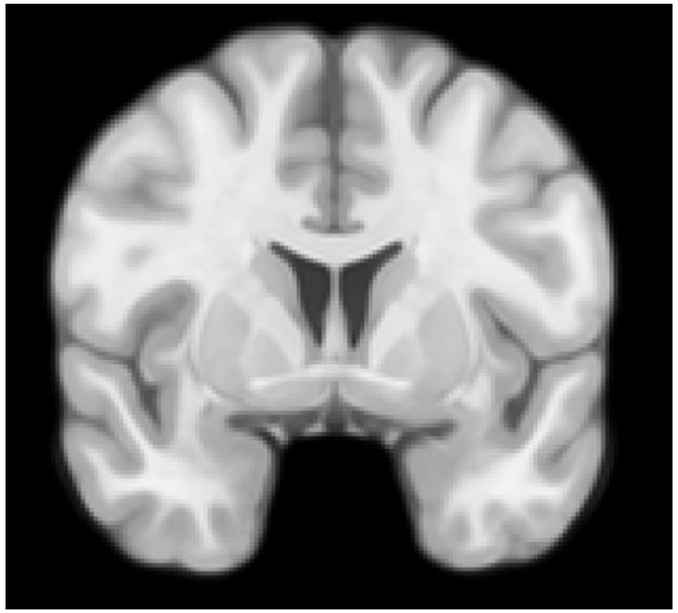
[11C]MADAM
Manninen et al (2021)

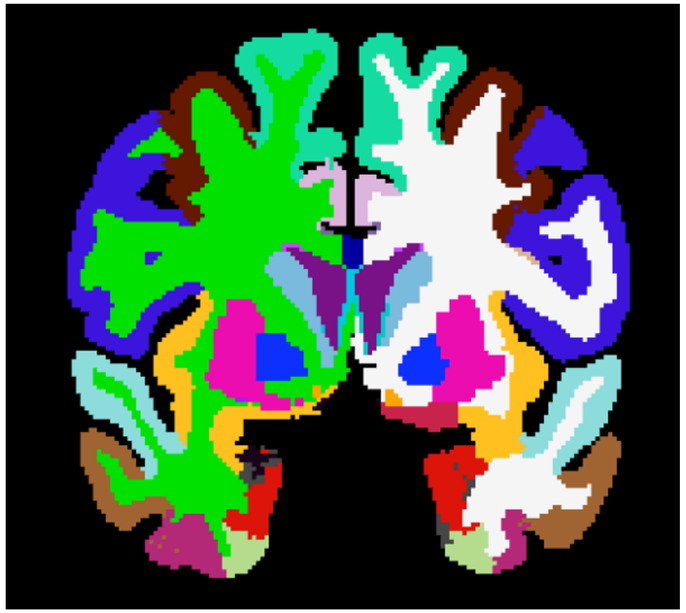
# Transcriptomic atlases

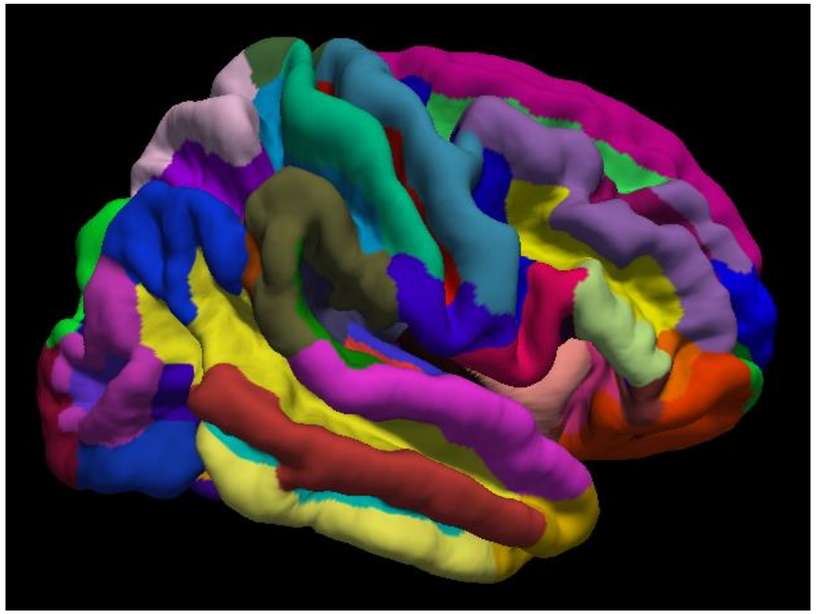



http://human.brain-map.org

# Surfin’ U.S.A.

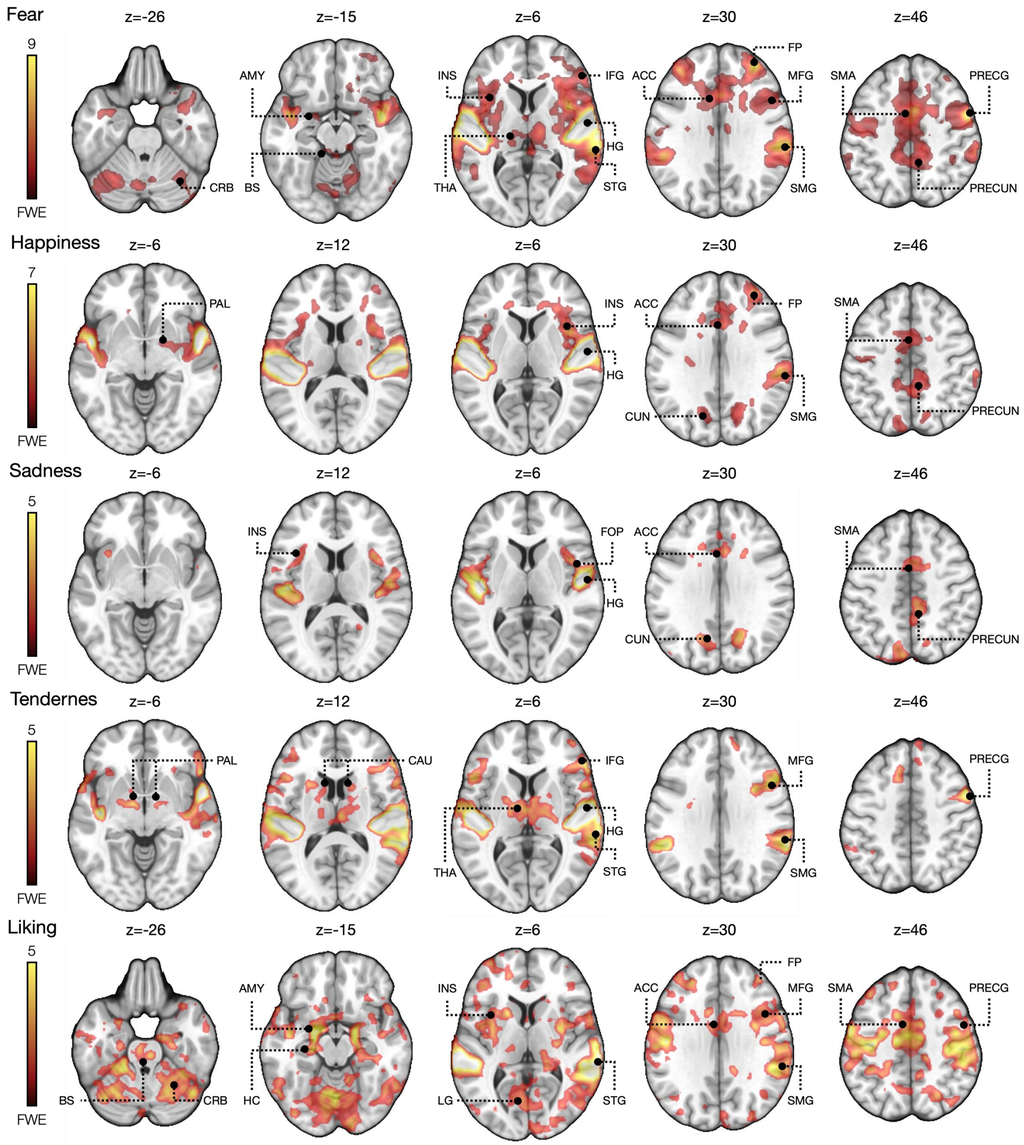






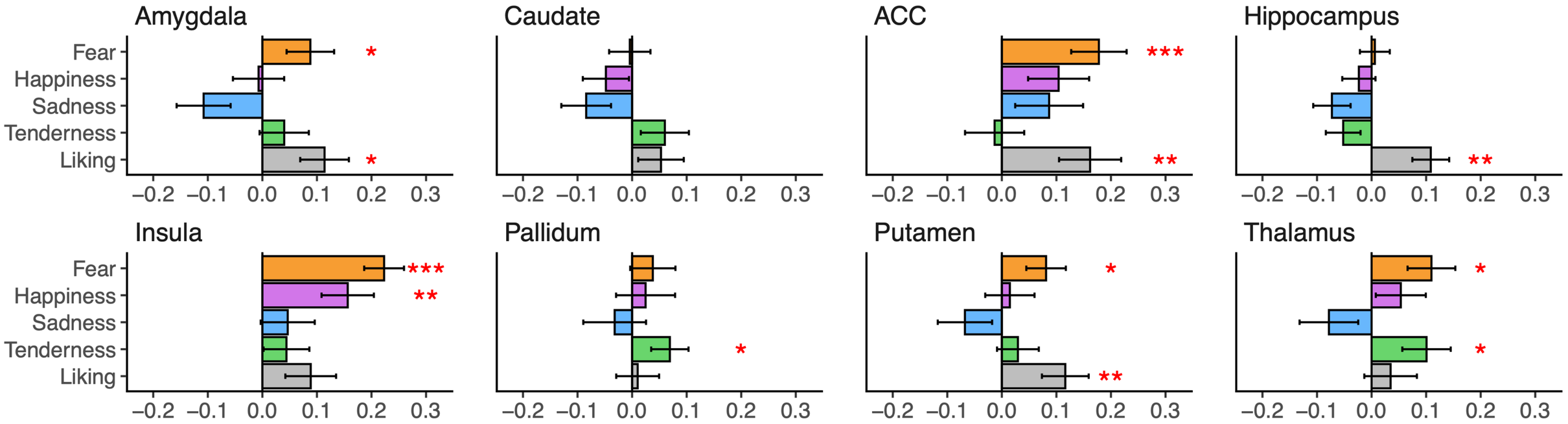
Fressurfer parcellations allow definition of subject-specific and anatomically specific ROIs - however response homogeneity across large ROIs remains an issue

# What about functional ROIs?



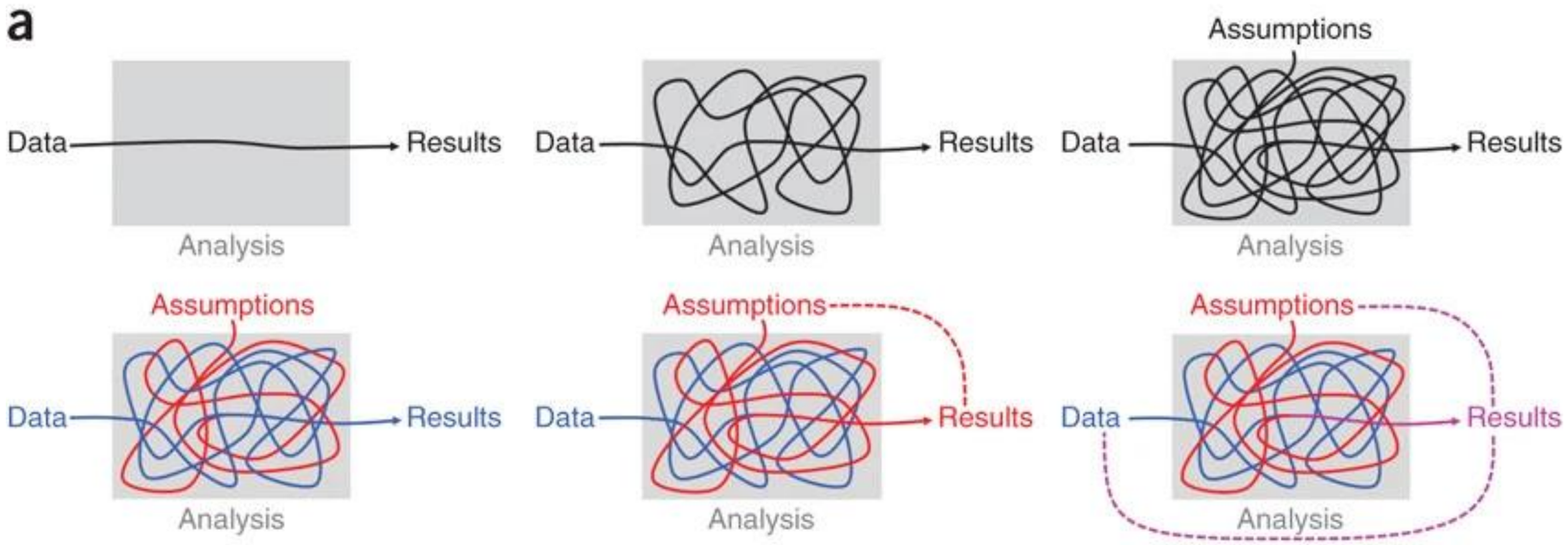

Putkinen et al (2020)

# Why can’t we analyze regional data for clusters?



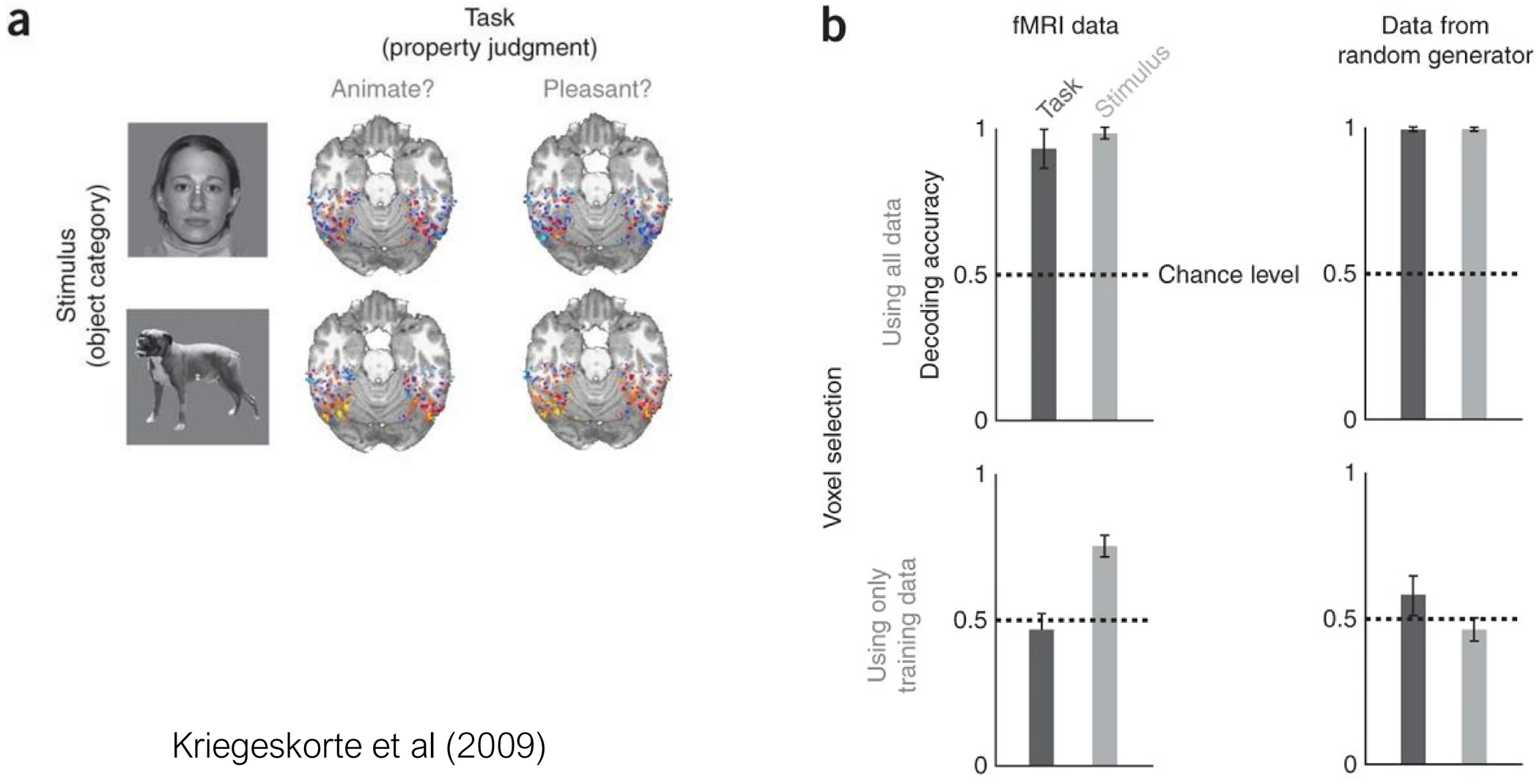

Putkinen et al (2020)

# Dangers of double dipping



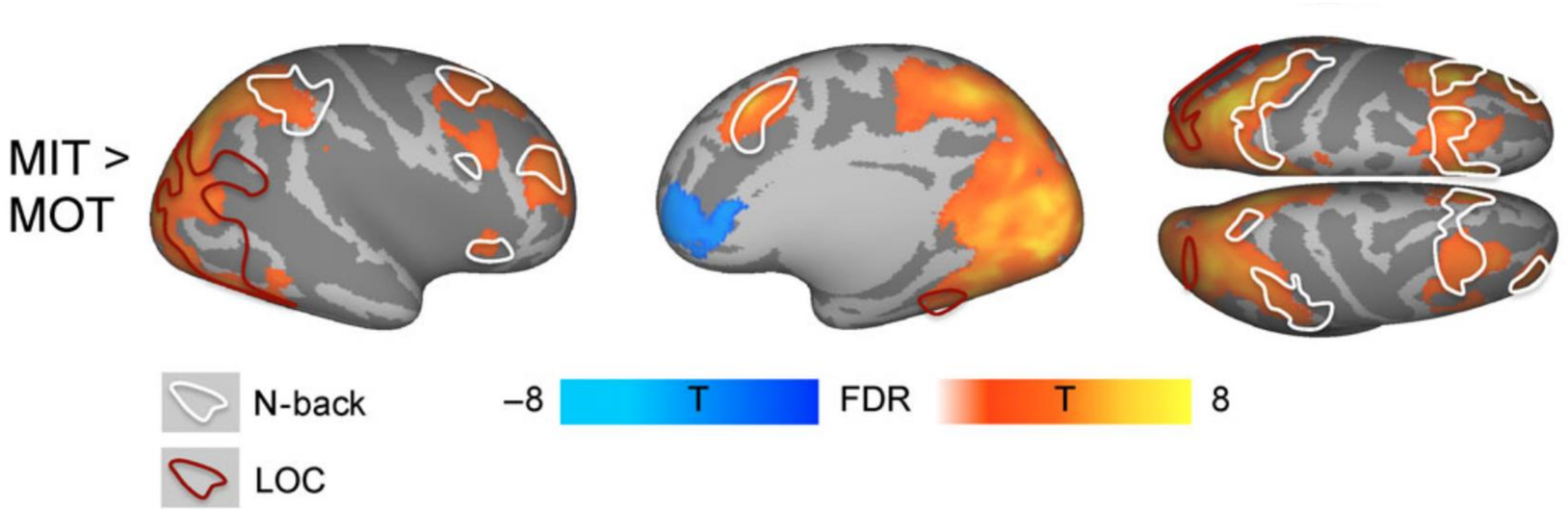

Kriegeskorte et al (2009)

# Double dipping in action

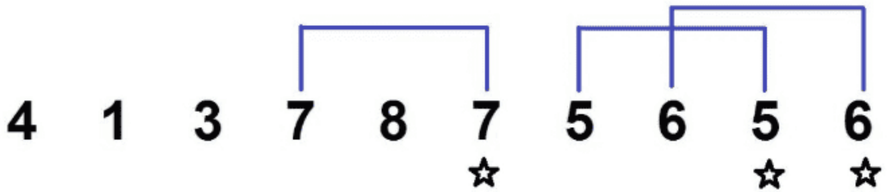



Kriegeskorte et al (2009)

# Solution Anatomical ROIs and functional localizers




## N-back: Working memory localizer

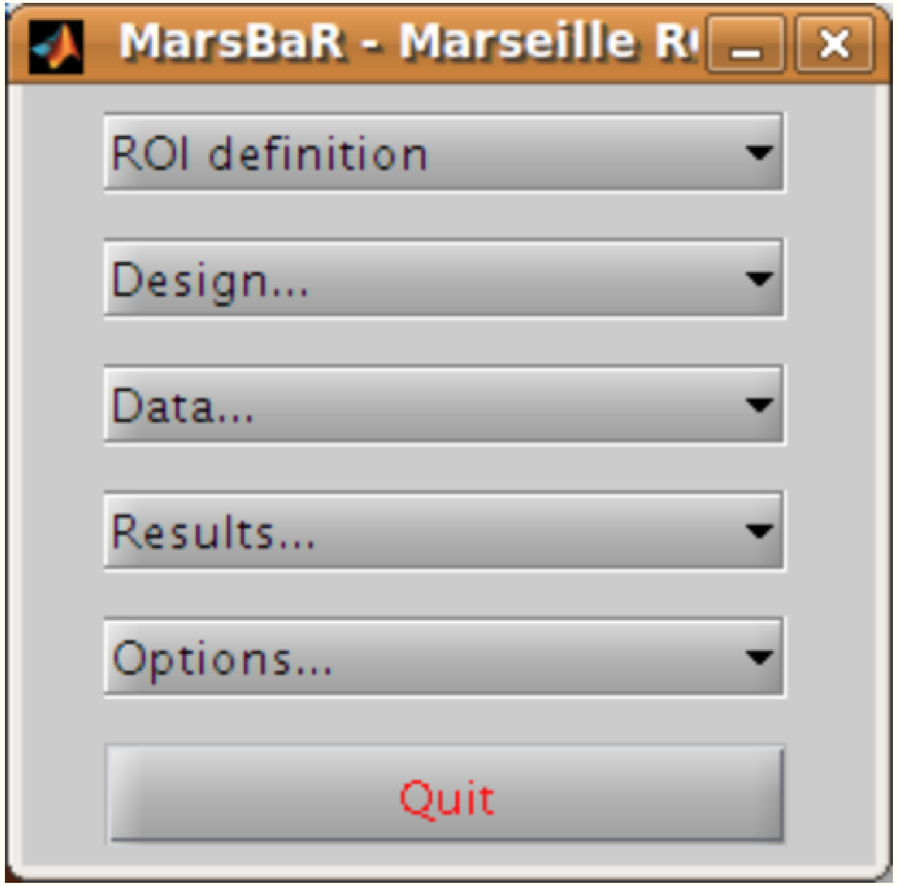



## Picture task: LOC localizer

Nummenmaa et al (2017)

# 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