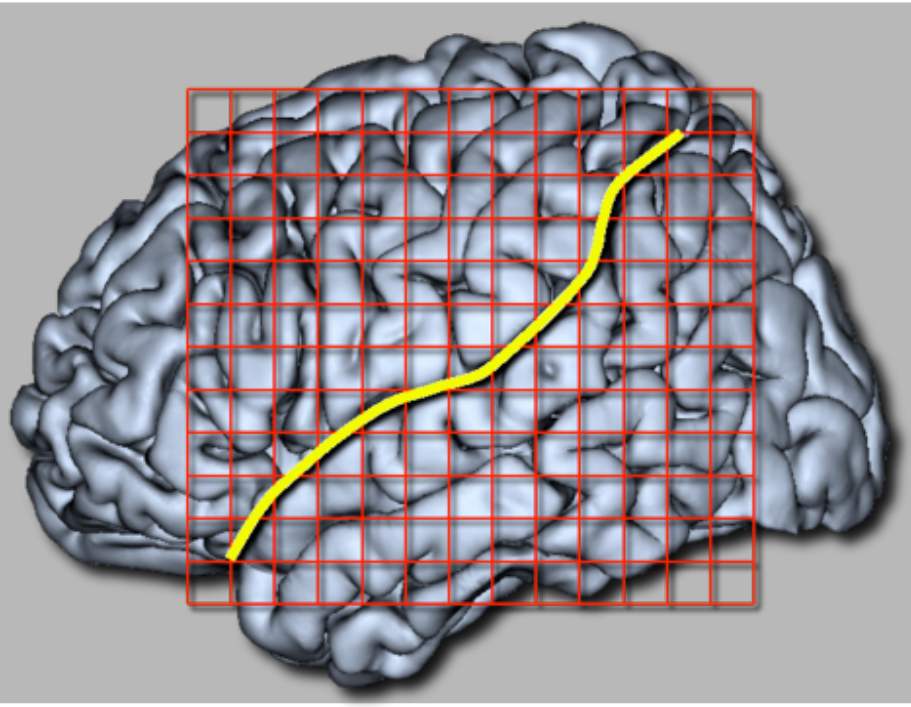
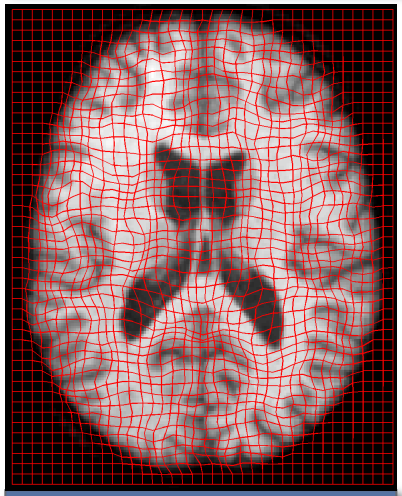
Anatomical Conditions and MR-Morphometry



Christian Gaser
Structural Brain Mapping Group
Depart. of Psychiatry and Neurology, Jena University Hospital

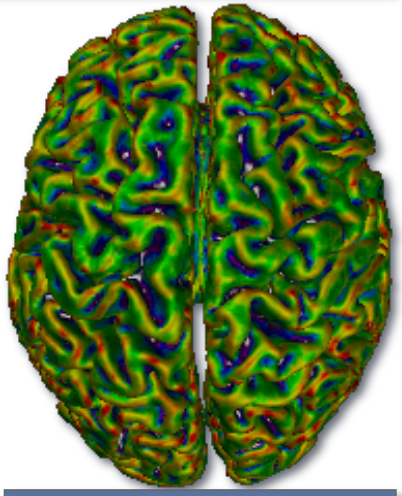
Overview

Morphometric methods



Deformation-based

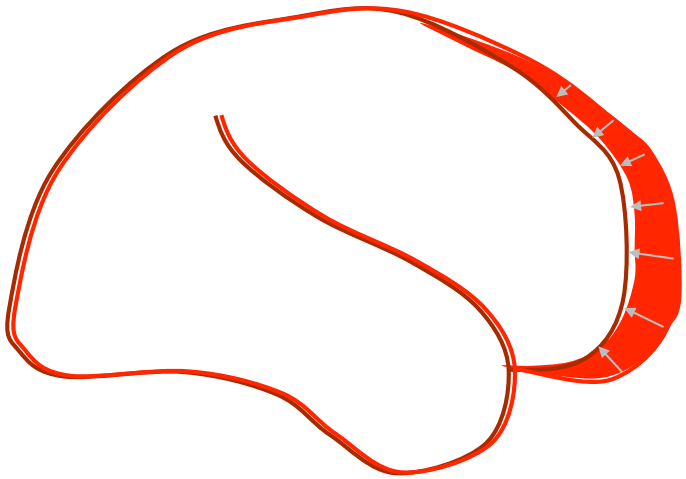
Voxel-based



Surface-based

Deformation-based morphometry (DBM)

Deformations can minimize local differences between images

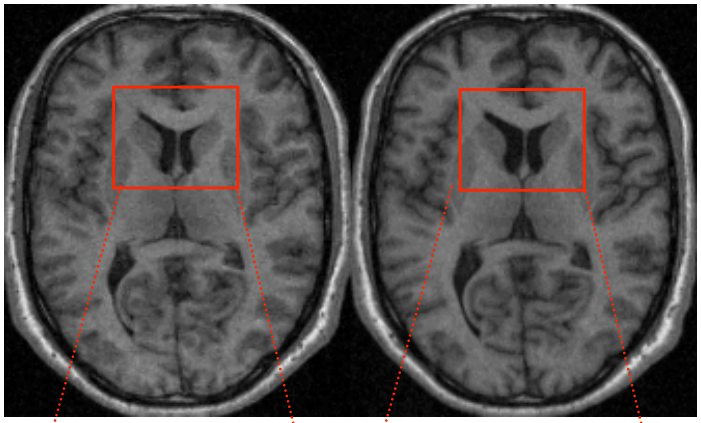


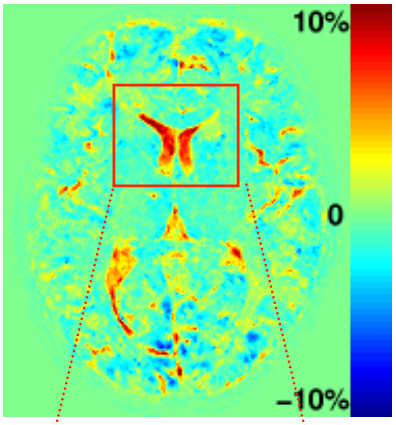
Deformations reveal information about kind and localization of these structural differences between brains and can be analyzed

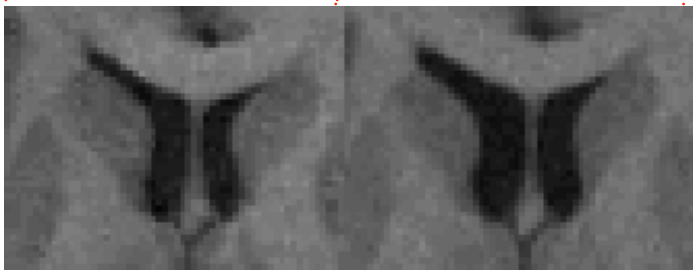
Longitudinal analysis using DBM

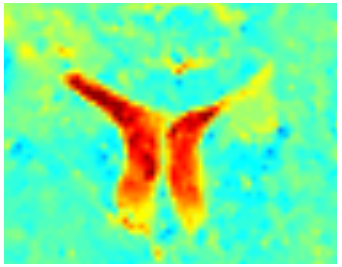
DBM: Deformation-based morphometry

t=0 (first episode) Δt=7 months Jacobian determinant (DBM)









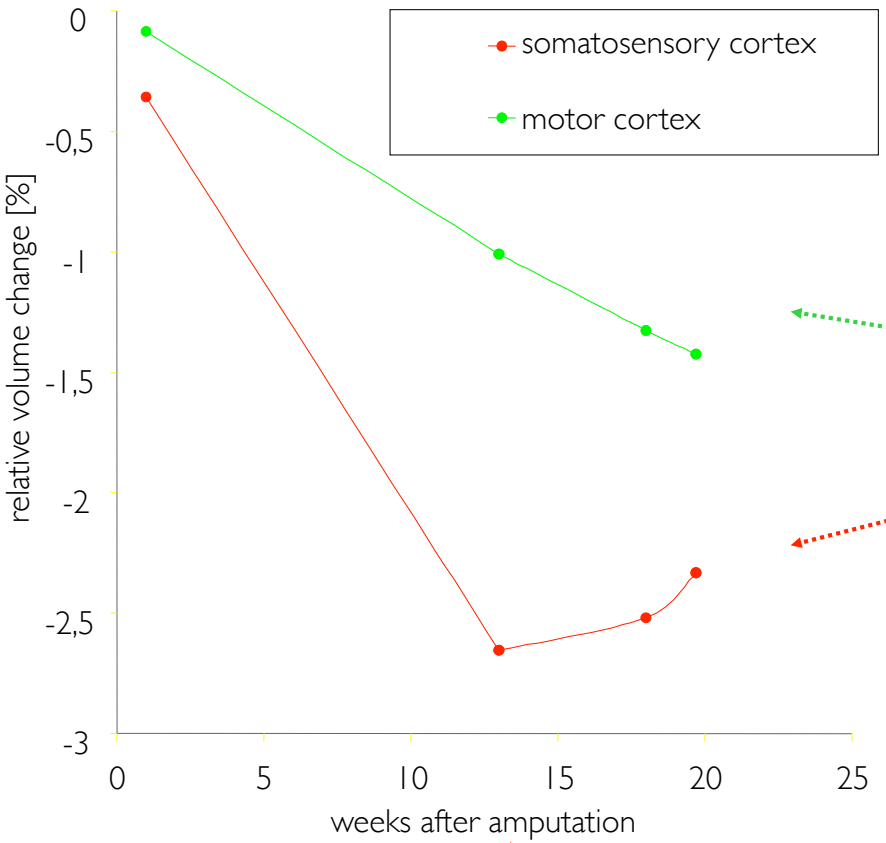
Zoom

Schizophrenic patient

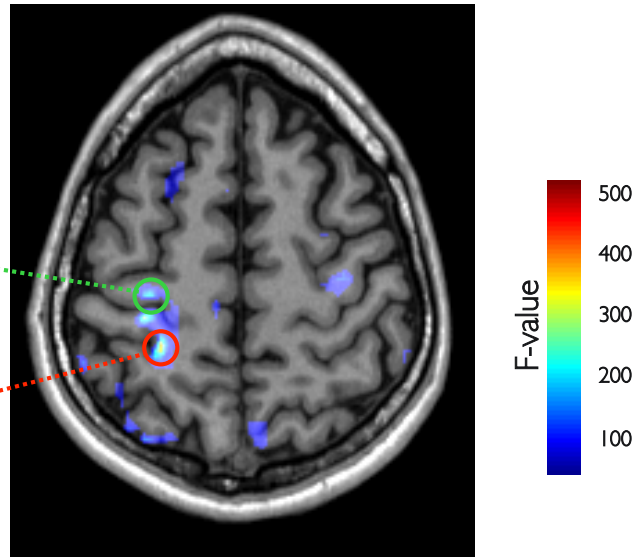
first episode

(25 years, male)

Plasticity after limb amputation



myoelectrical prosthesis (week 13)



Patient: 32 years, male

Amputation right forearm (50%)

1st MRI: 3 weeks after amputation

subsequent after 4,16, 21 weeks

Voxel-based Morphometry

Idea

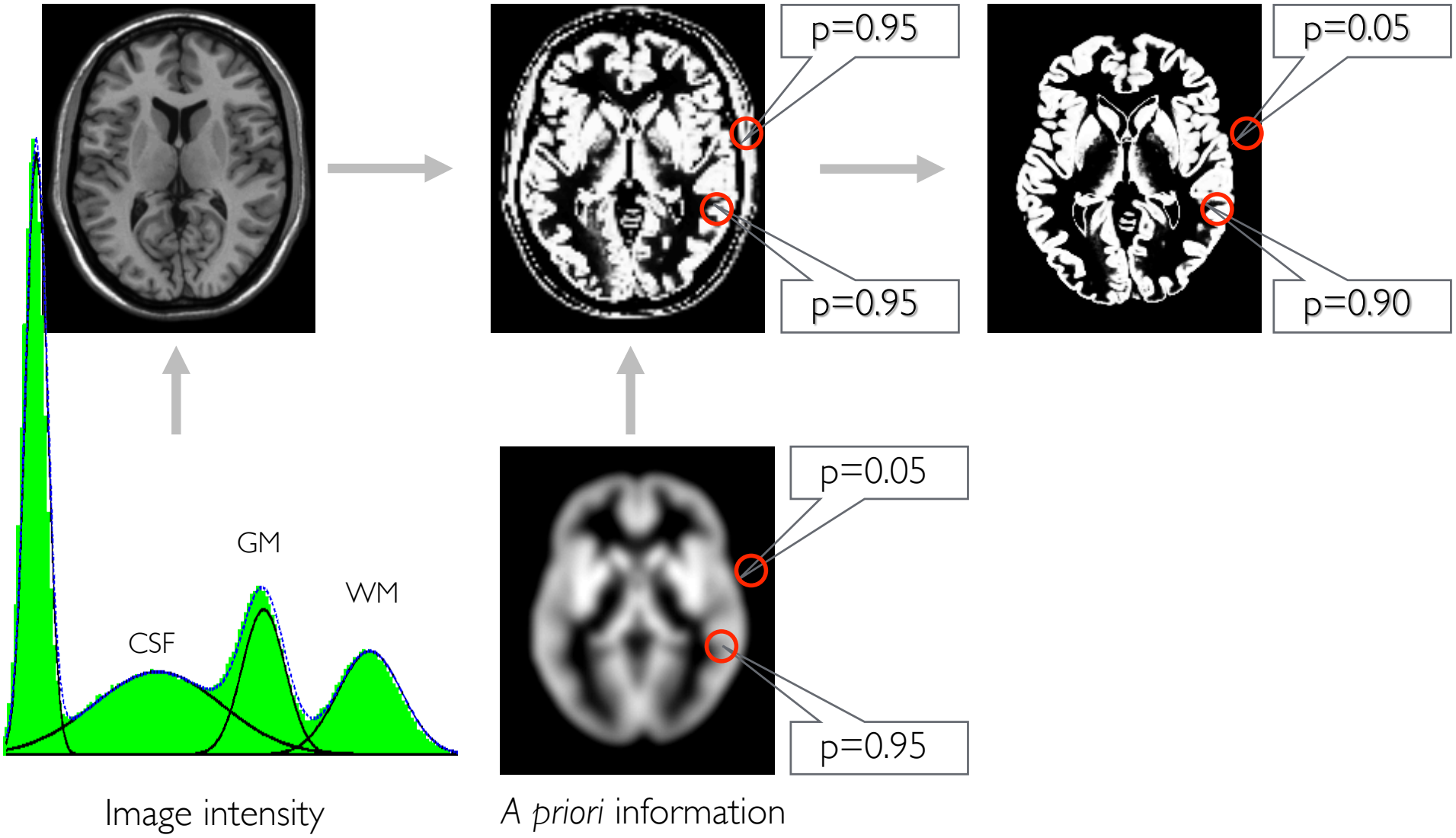
- Partitioning of image into gray and white matter and CSF
- Voxel-wise analysis

T_1 GM WM CSF

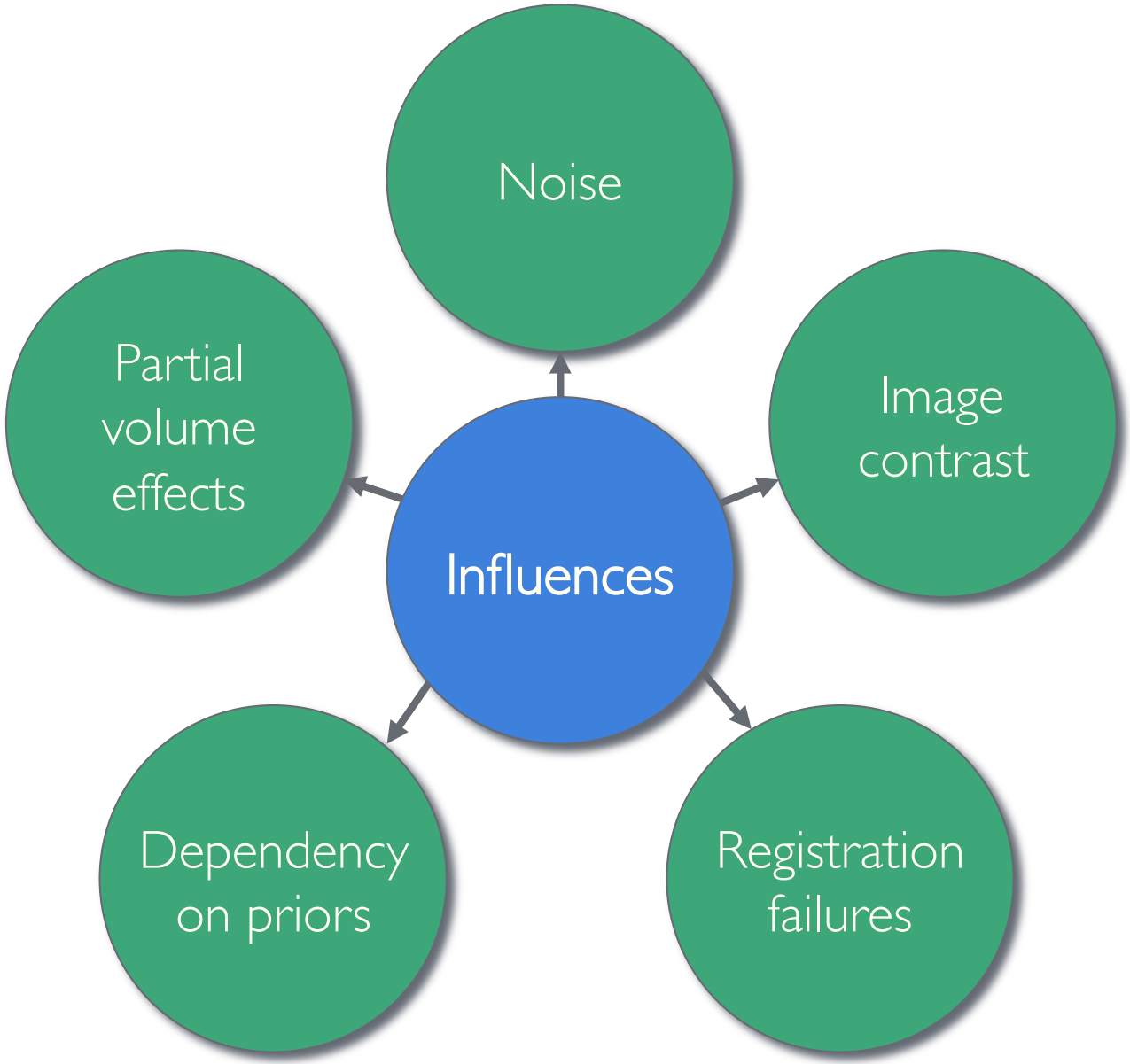
What is used?

- Image intensity
- *A priori* information (probability maps)

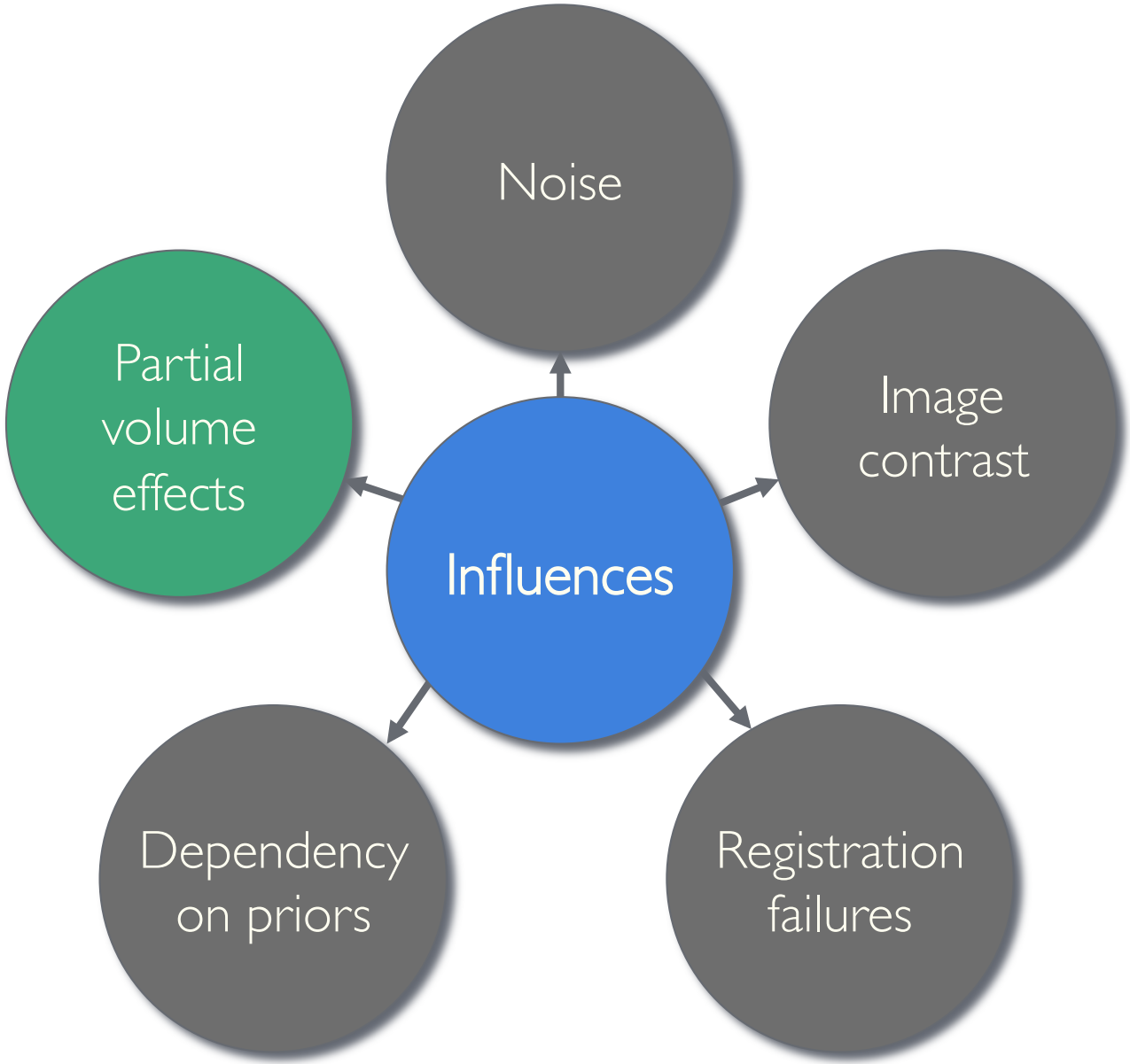
Segmentation



Voxel-based Morphometry

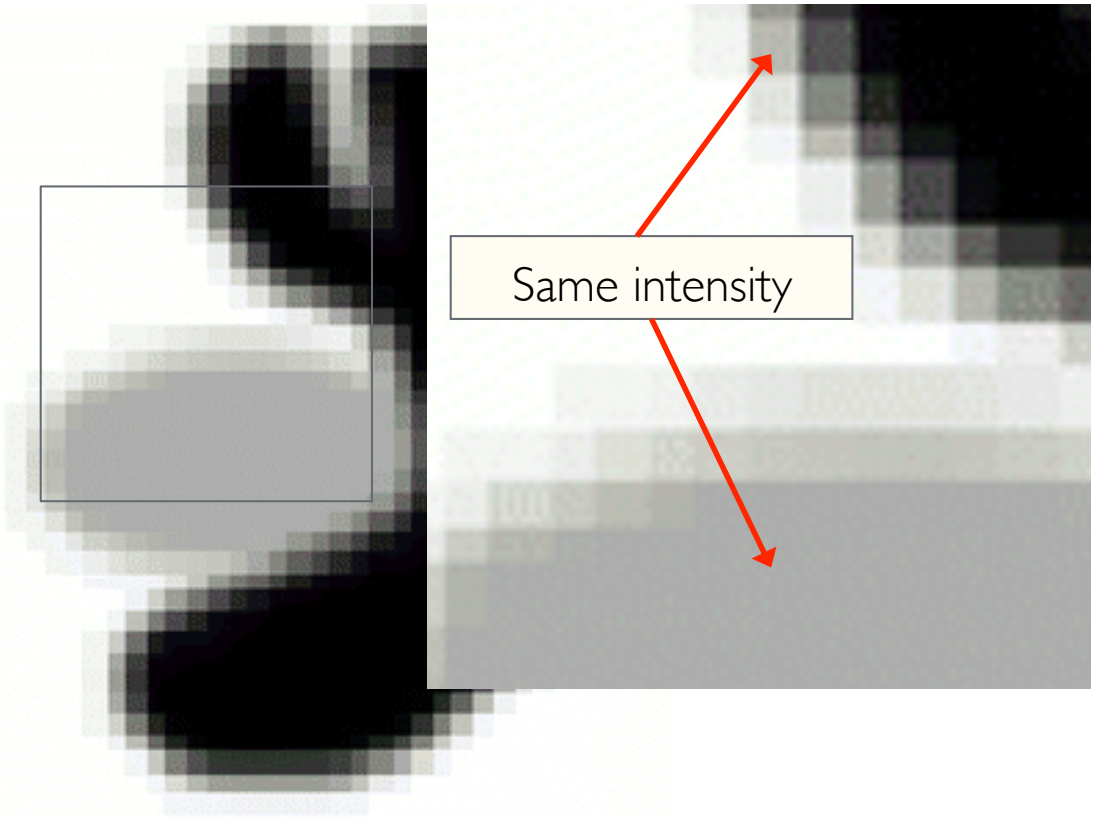


Voxel-based Morphometry



Partial Volume Effect

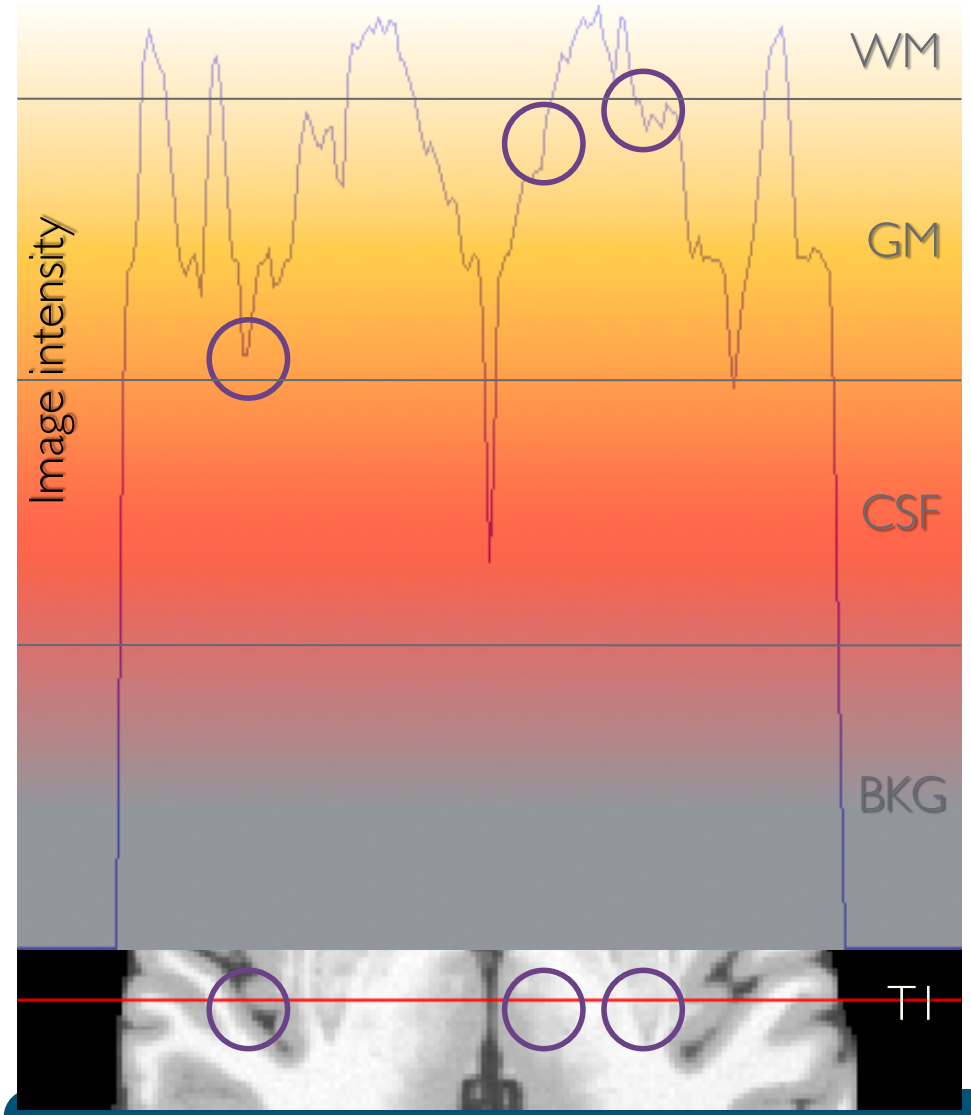
Real object

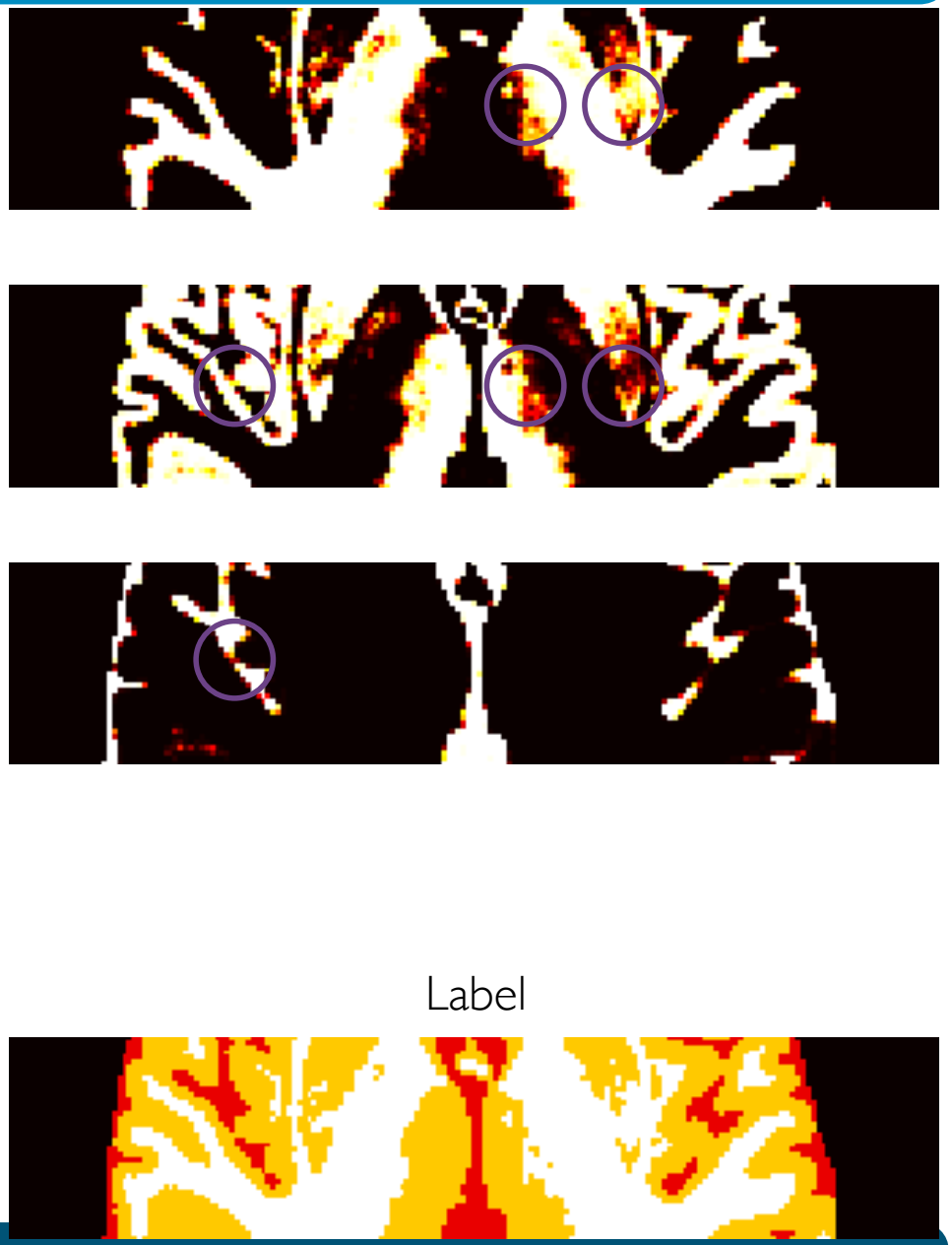


Object scanned with lower resolution

Pham et al., Ann Rev Biomed Eng 2000

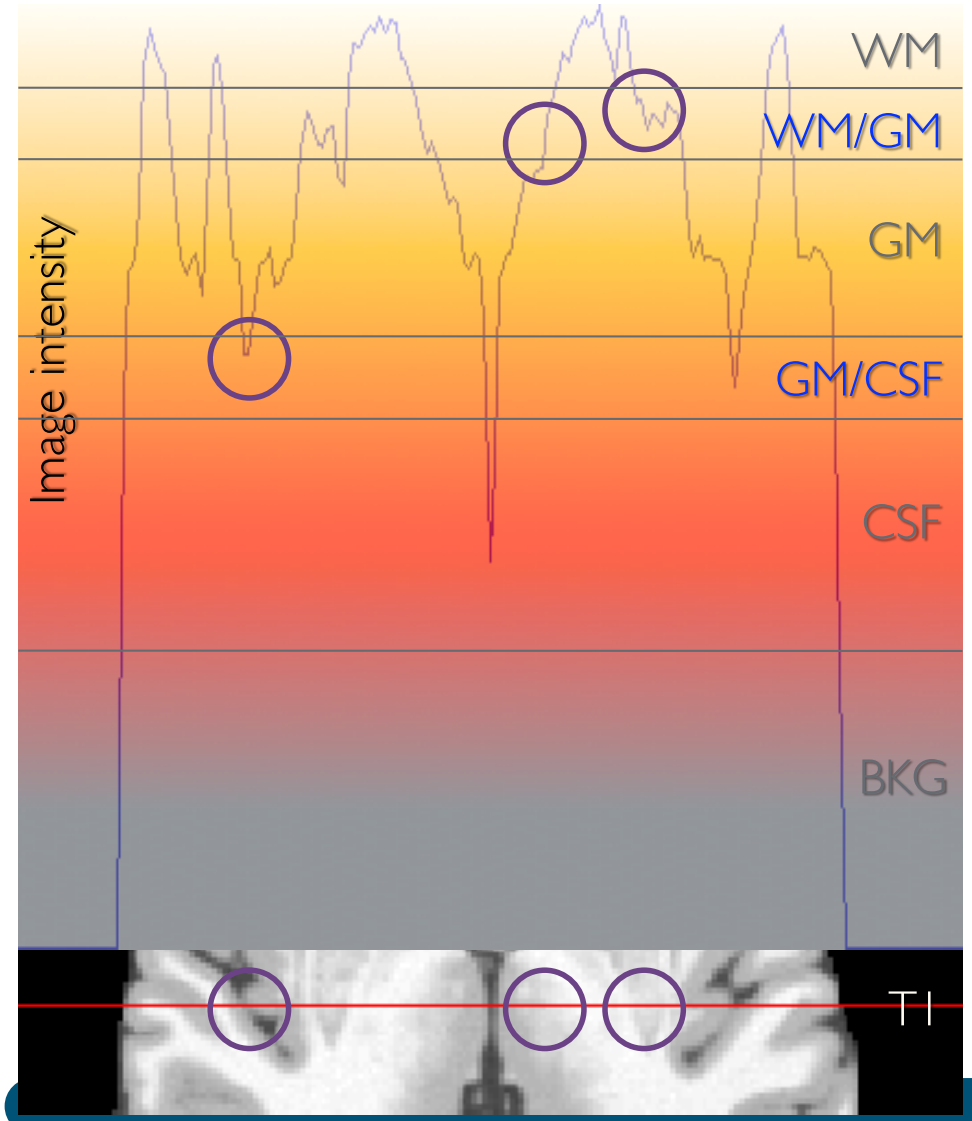
From T_1-image to segmentation

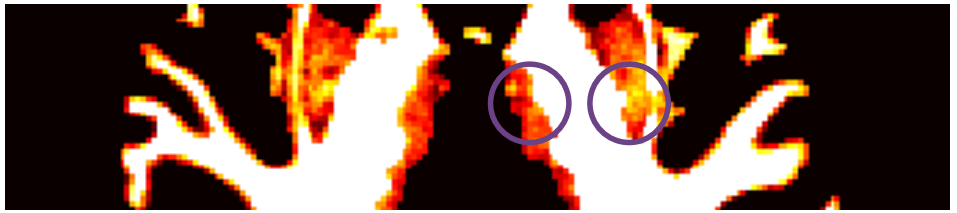


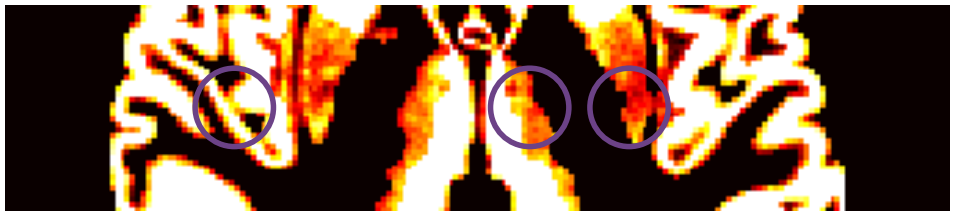


Partial Volume Estimation (PVE)

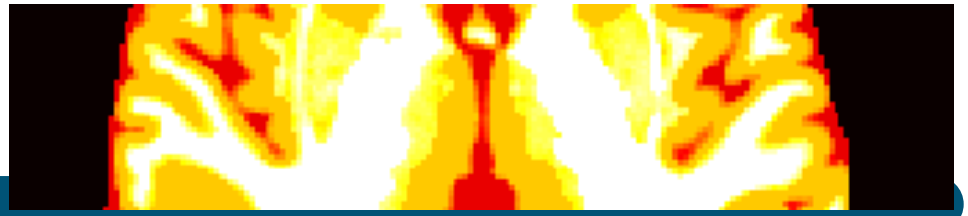
Two additional mixed-classes



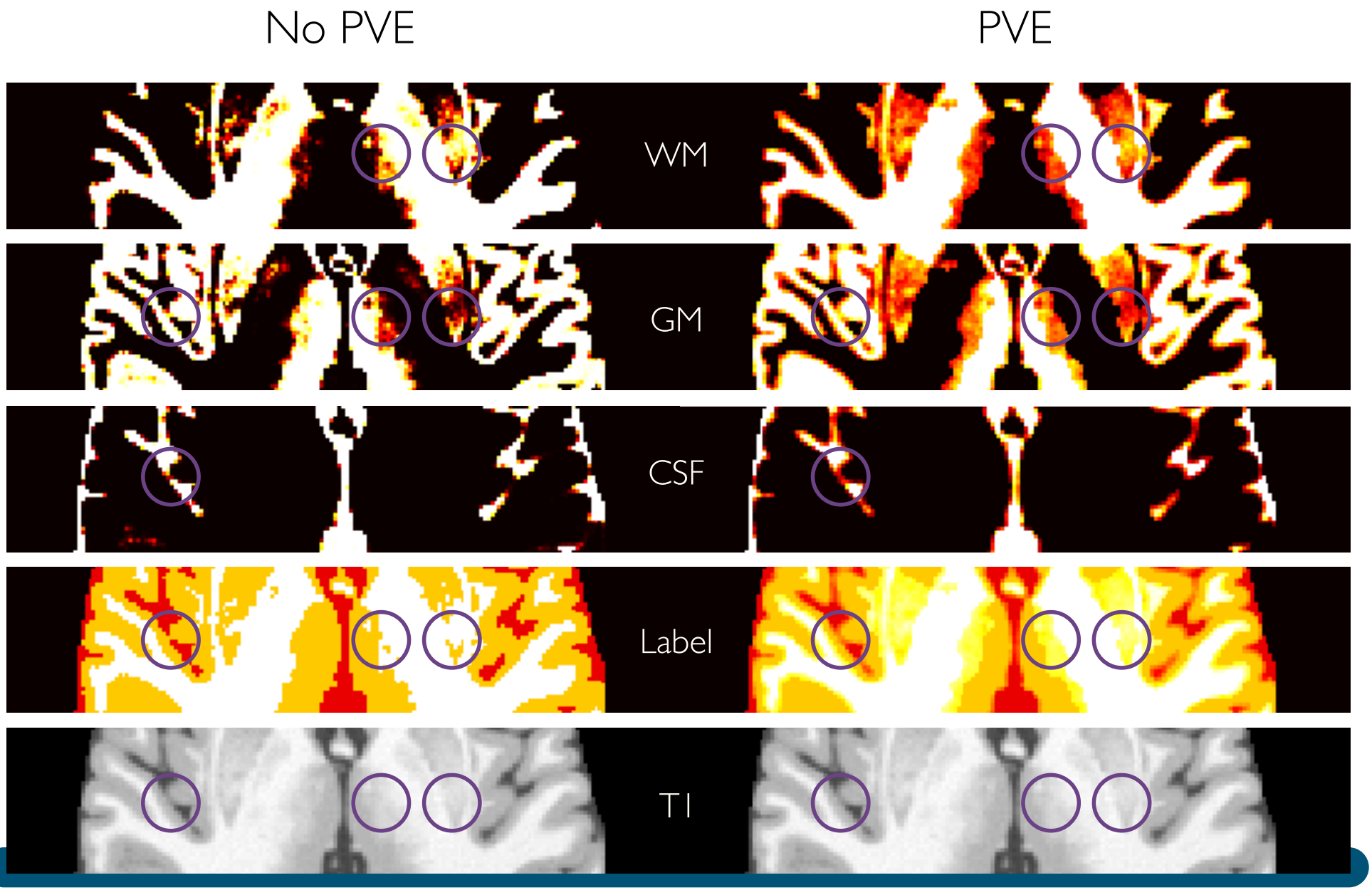




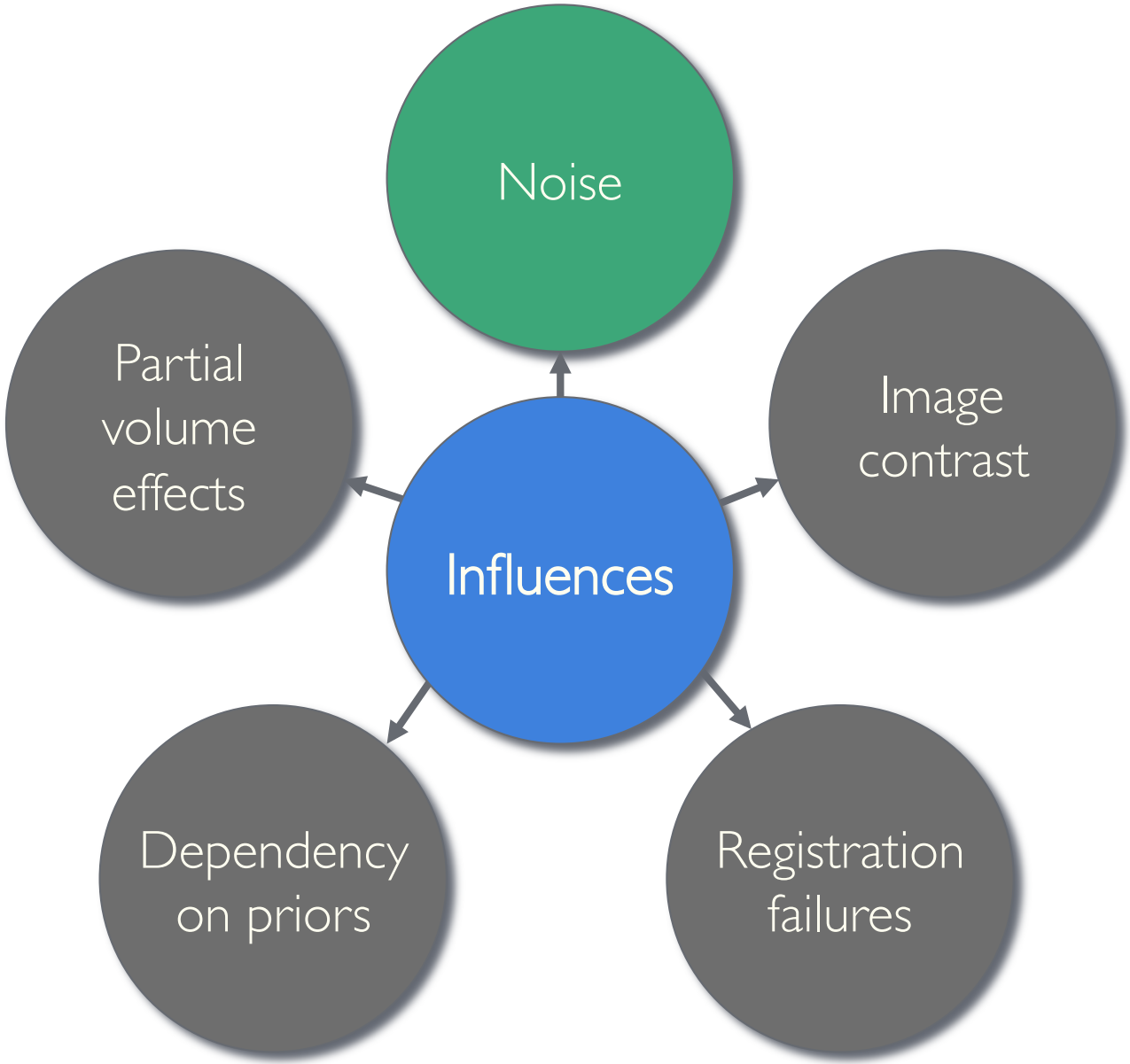
Label



Advantage of PVE



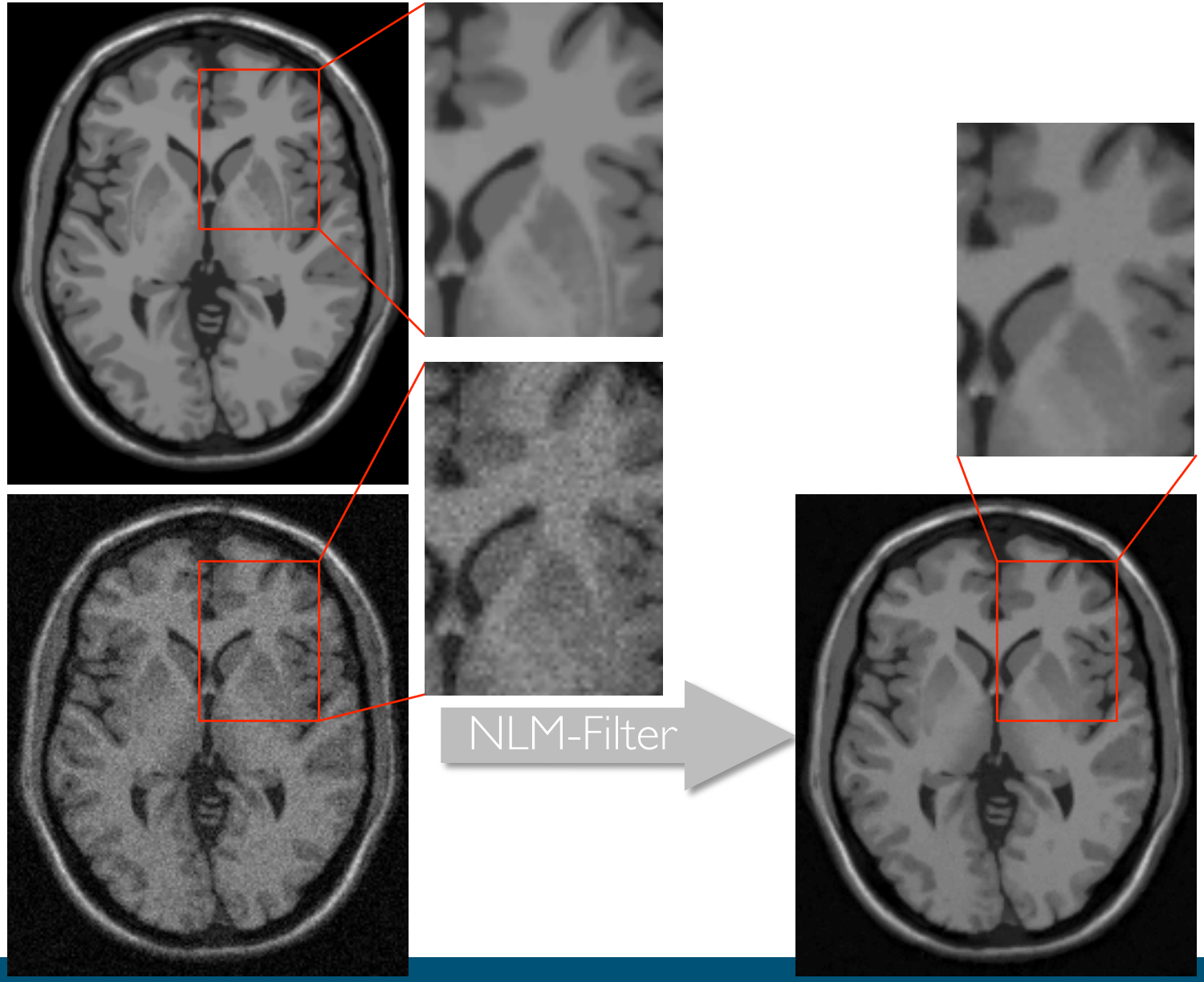
Voxel-based Morphometry



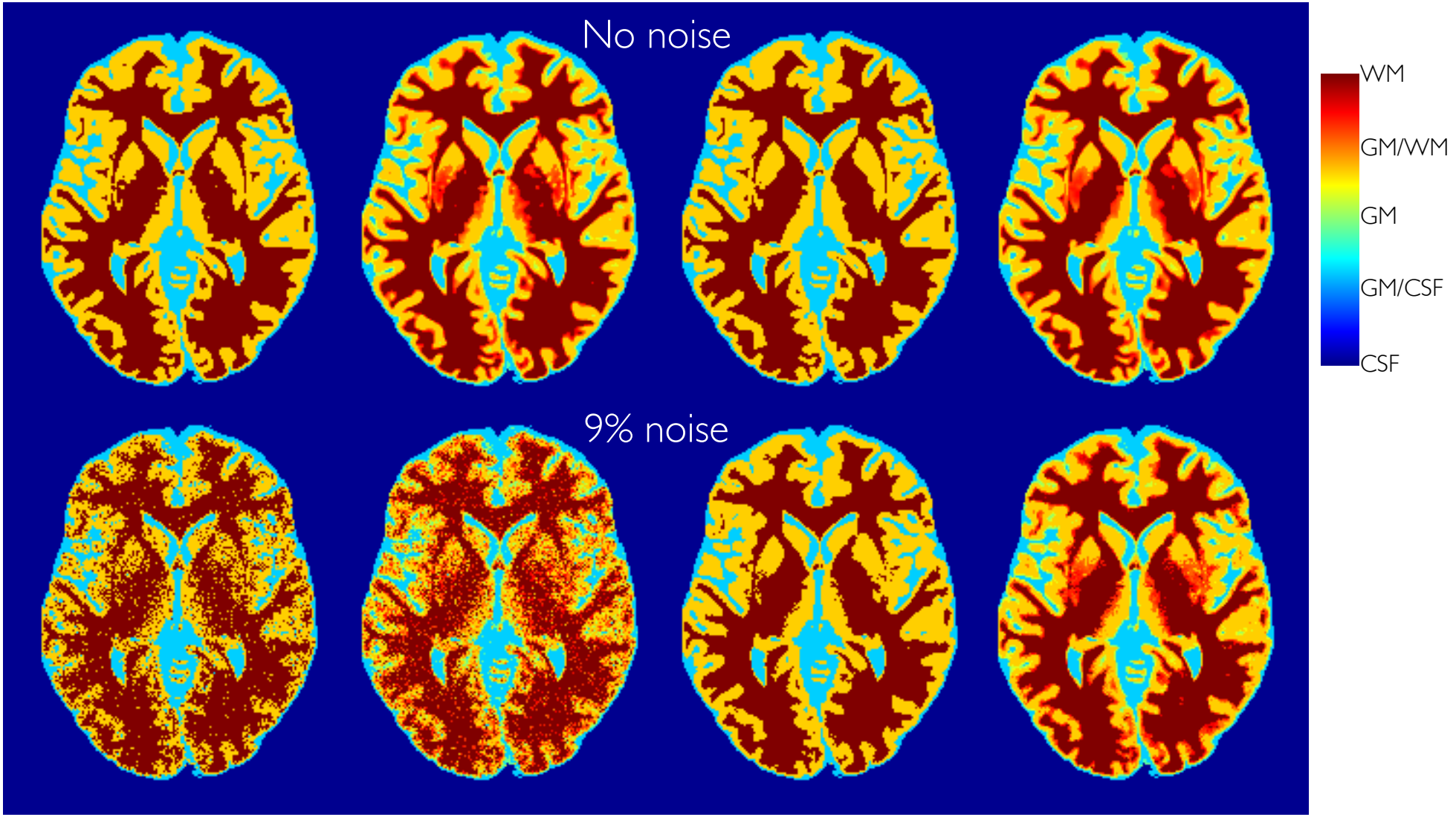
Non-Local Means Filter

No noise

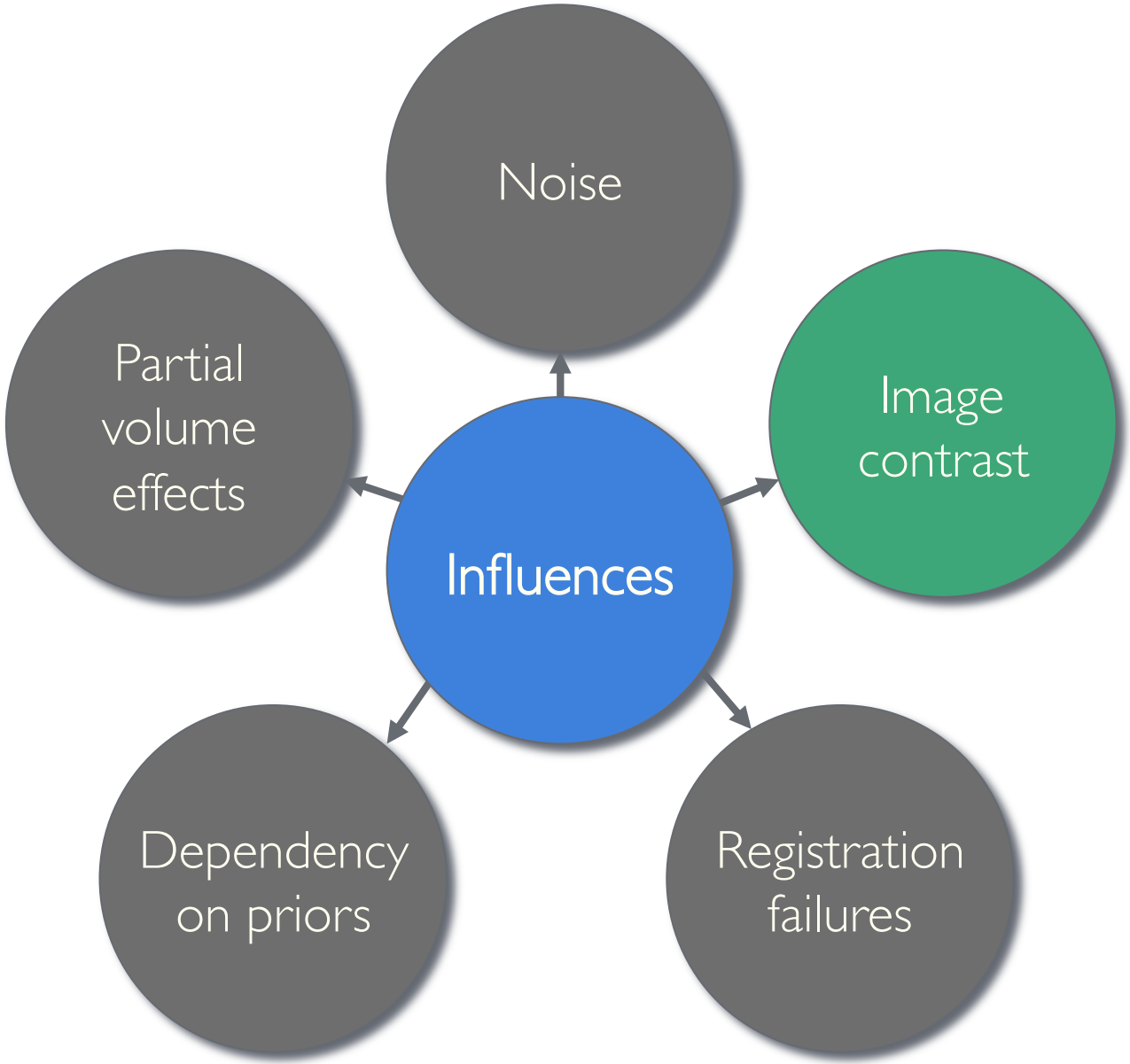
9% noise



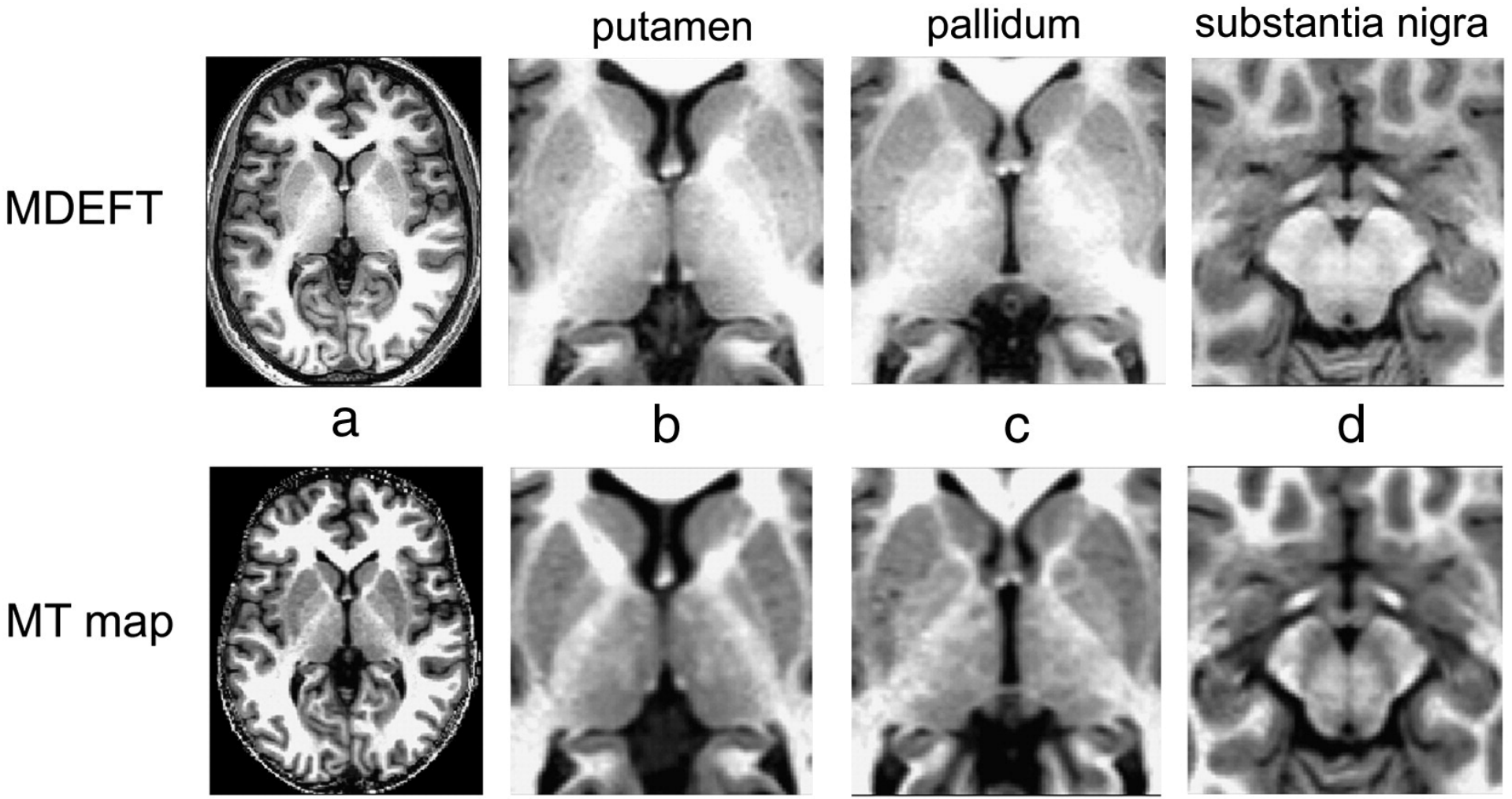
Non-Local Means Filter + Partial Volume Estimation



Voxel-based Morphometry

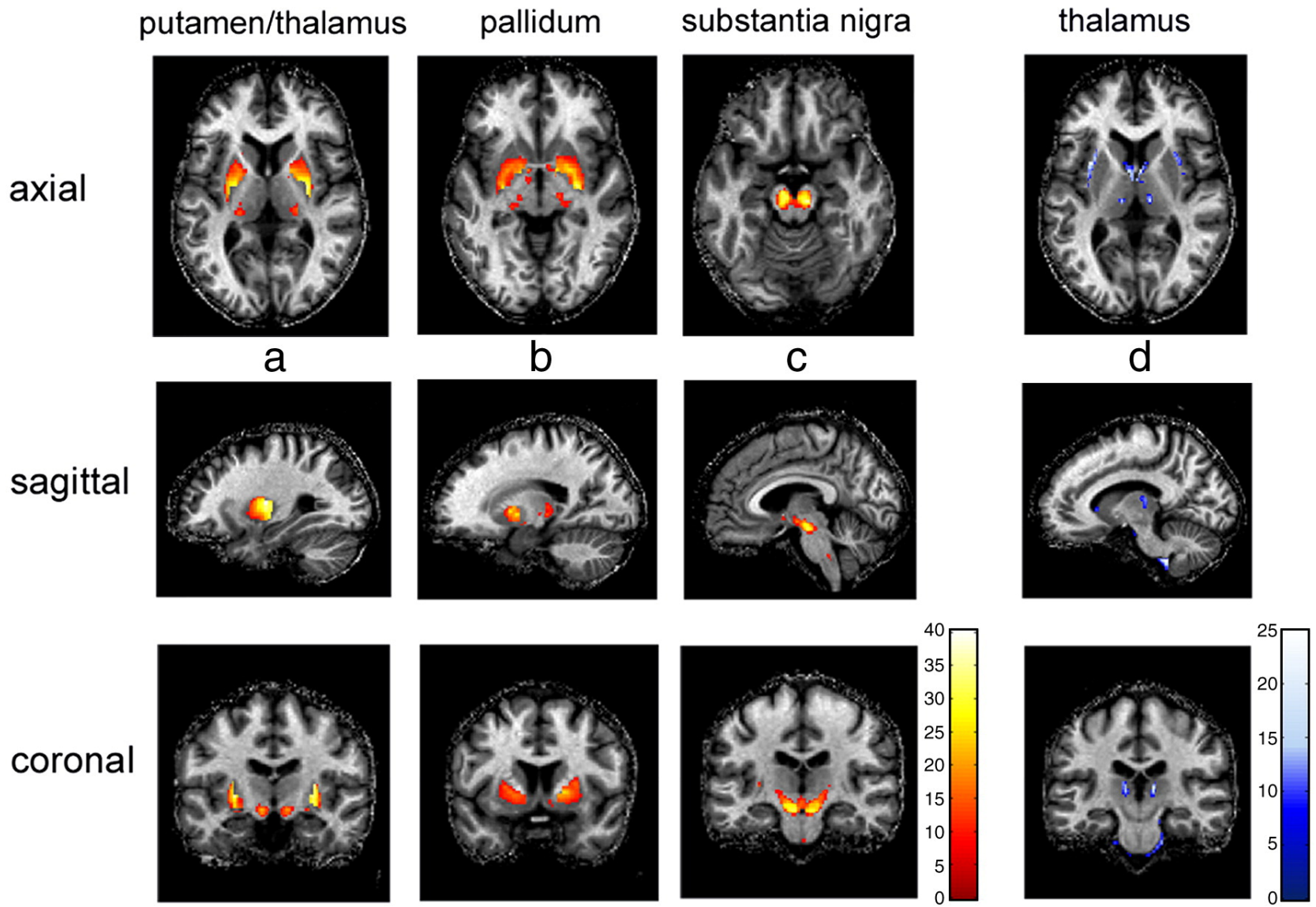


Use of Magnetisation Transfer (MT) Maps



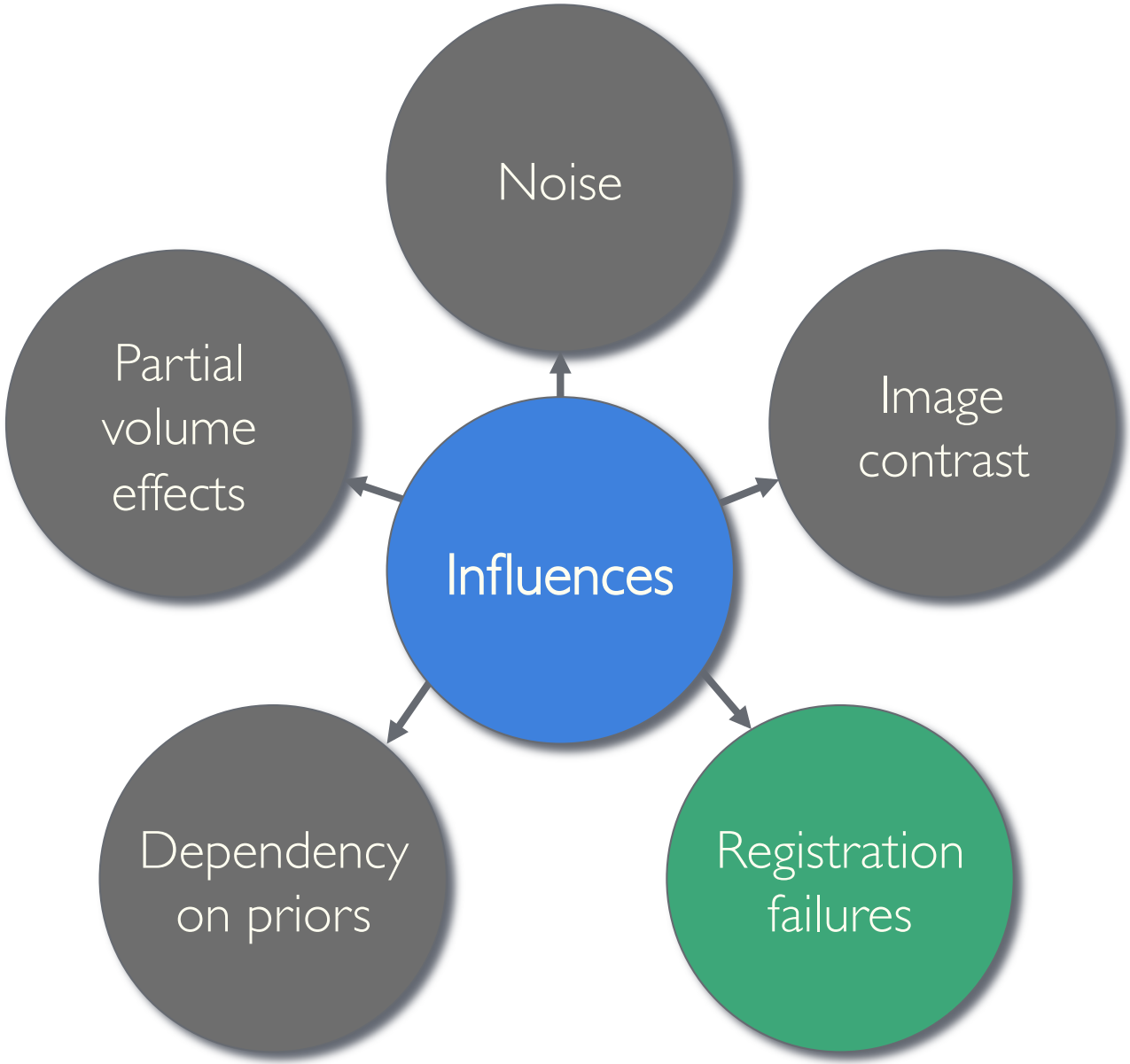
Helms et al., NeuroImage 2009

Image Contrast

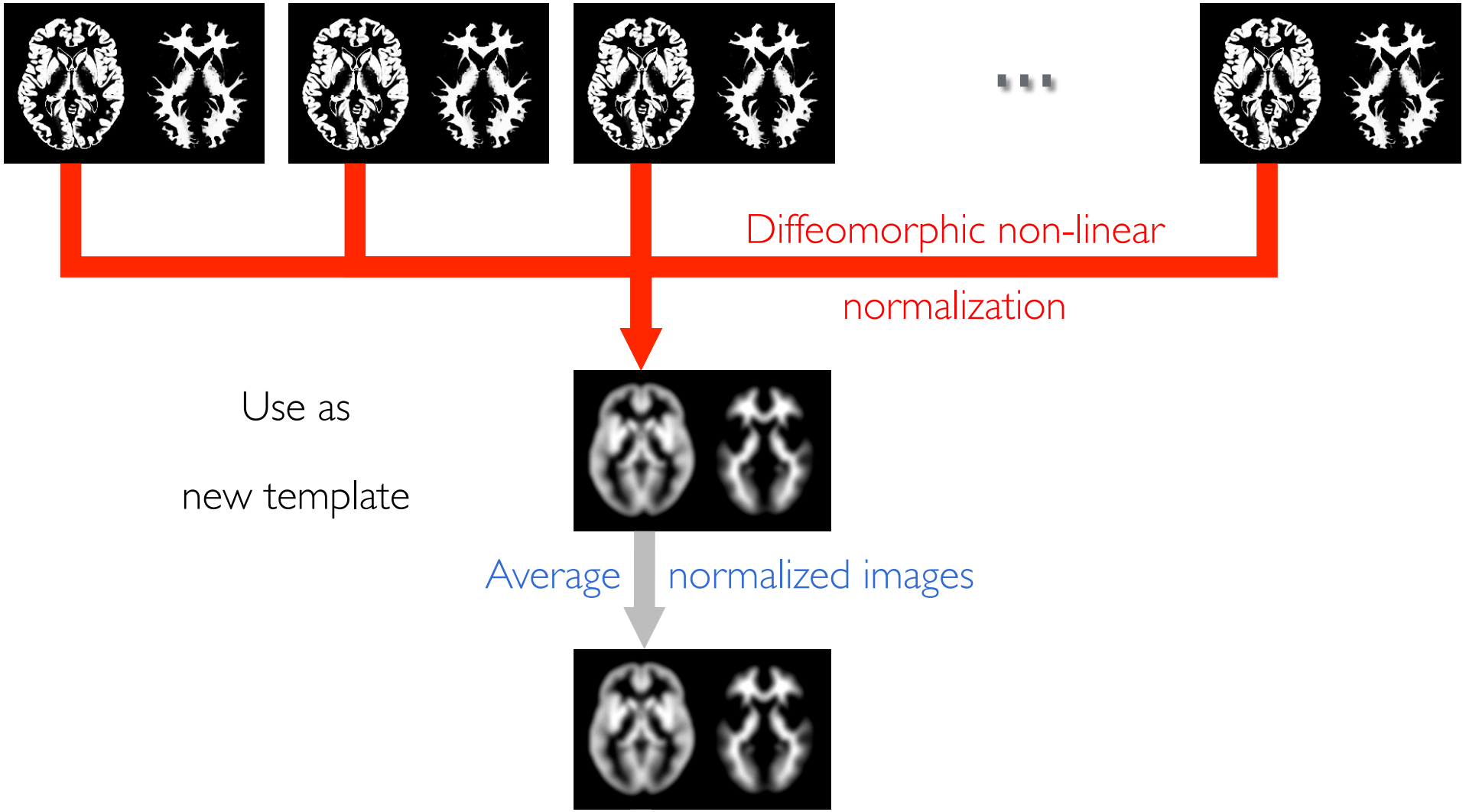


Helms et al., NeuroImage 2009

Voxel-based Morphometry

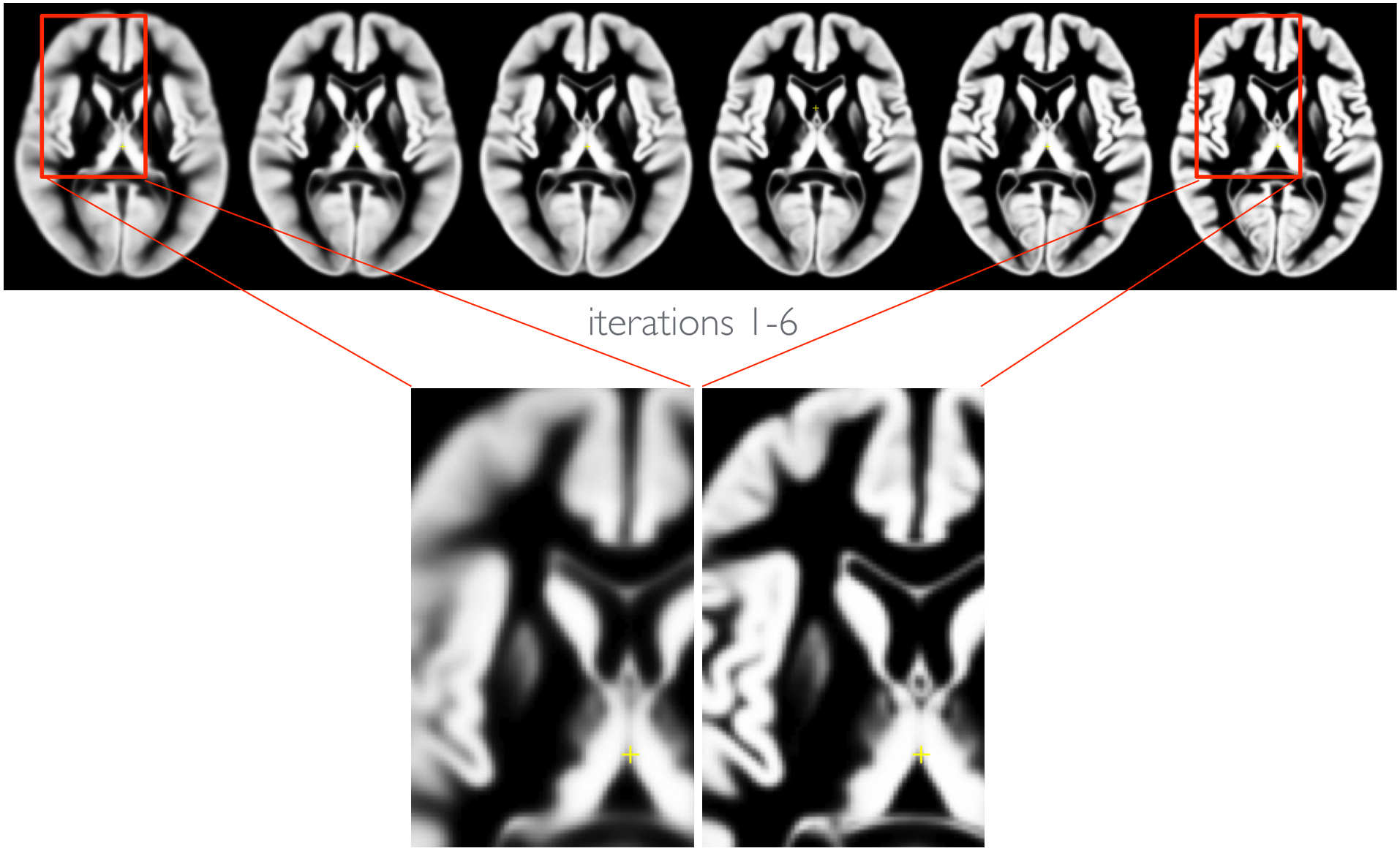


DARTEL Approach



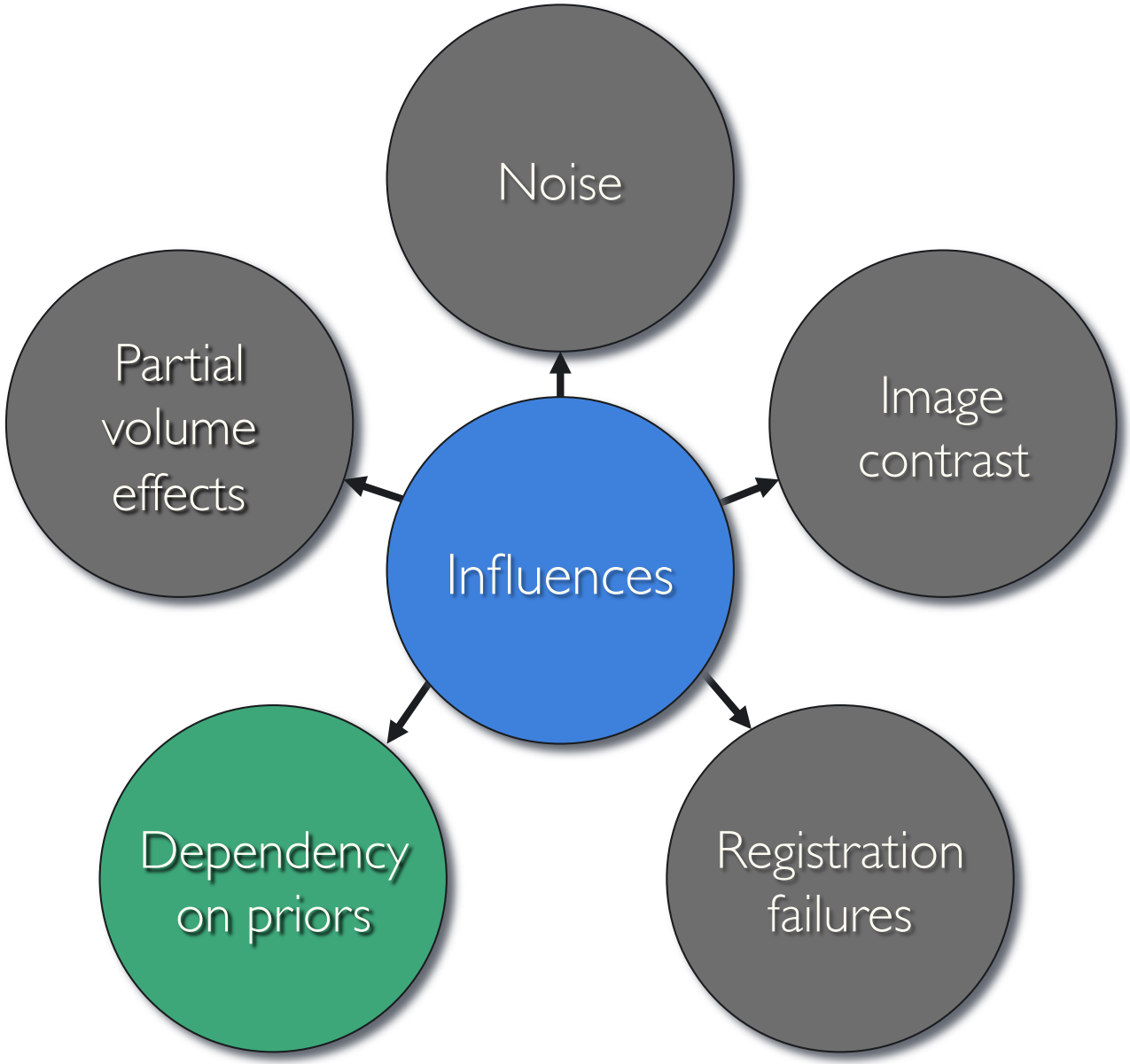
Ashburner et al., NeuroImage 2007

DARTEL Approach

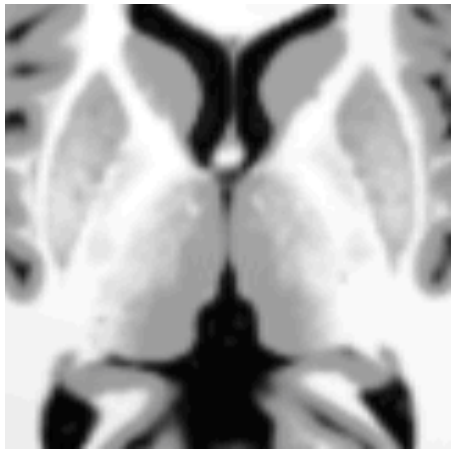


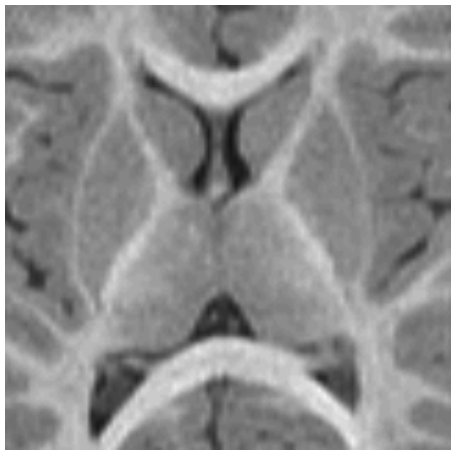
iterations 1-6

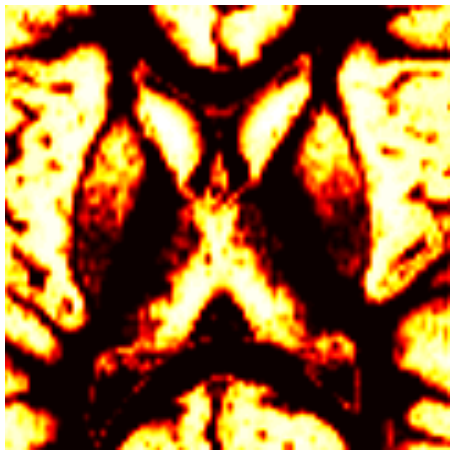
Voxel-based Morphometry

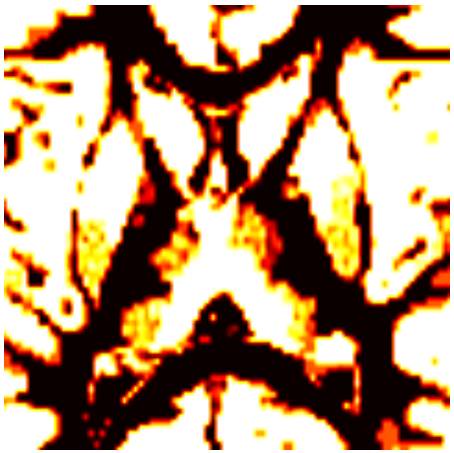


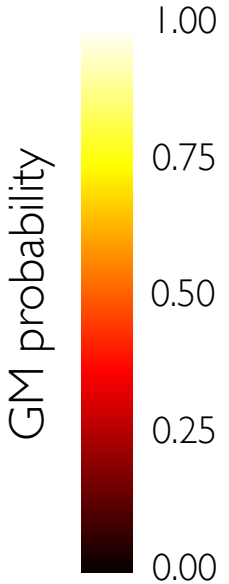
Segmentation Methods without Use of Priors









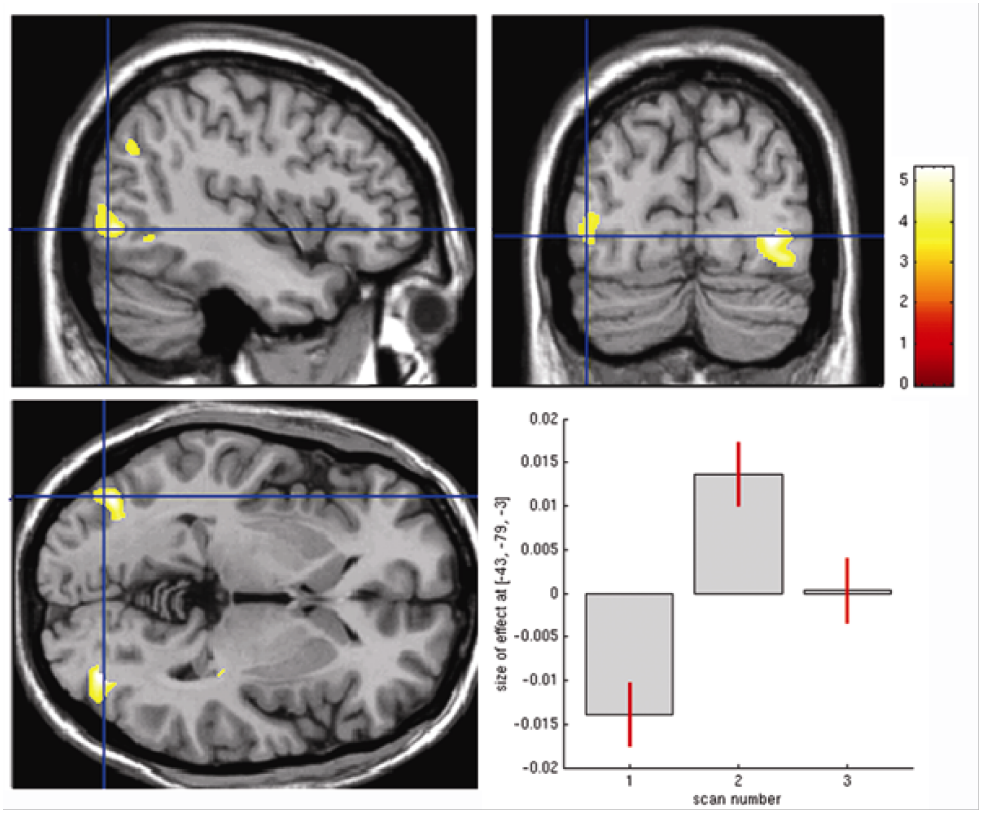


T_1

SPM8

VBM8 without priors

Learning and Structural Plasticity



12 healthy controls

3 months learning 3-ball cascade

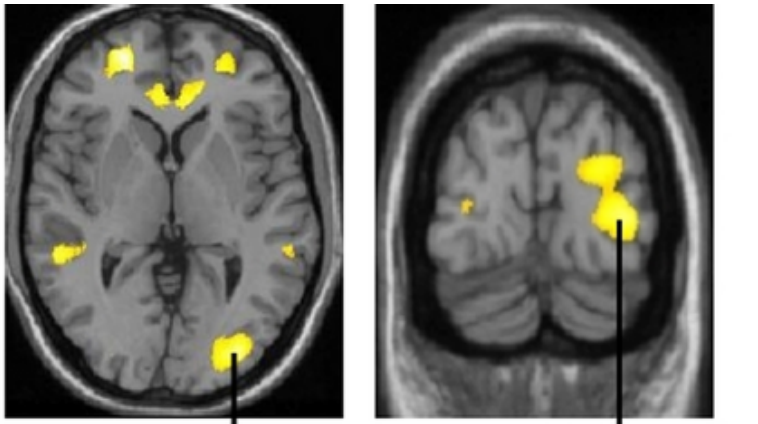
3 months no learning

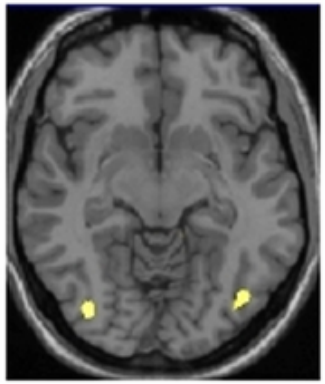
12 healthy controls

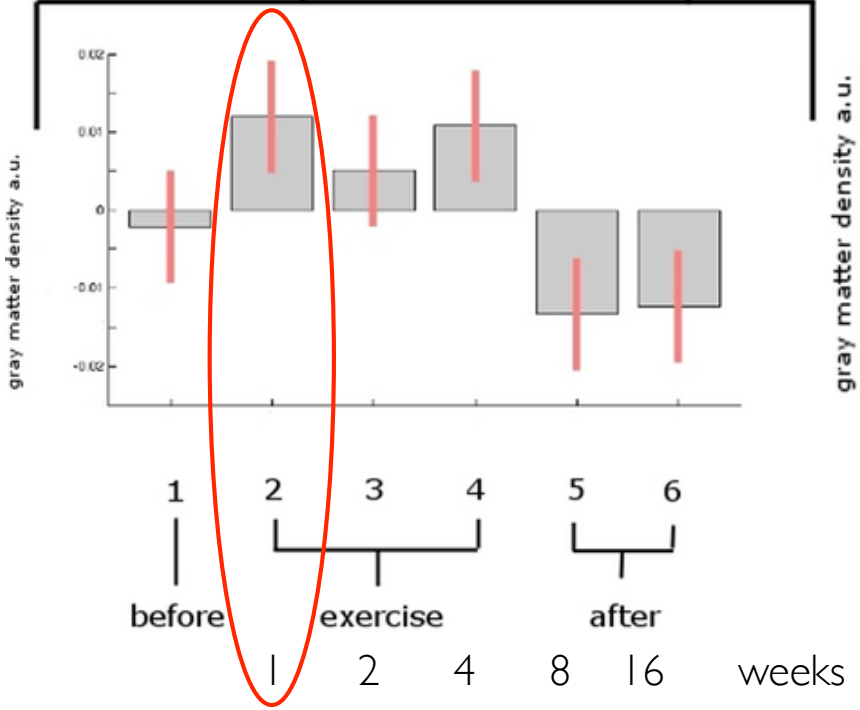
No learning

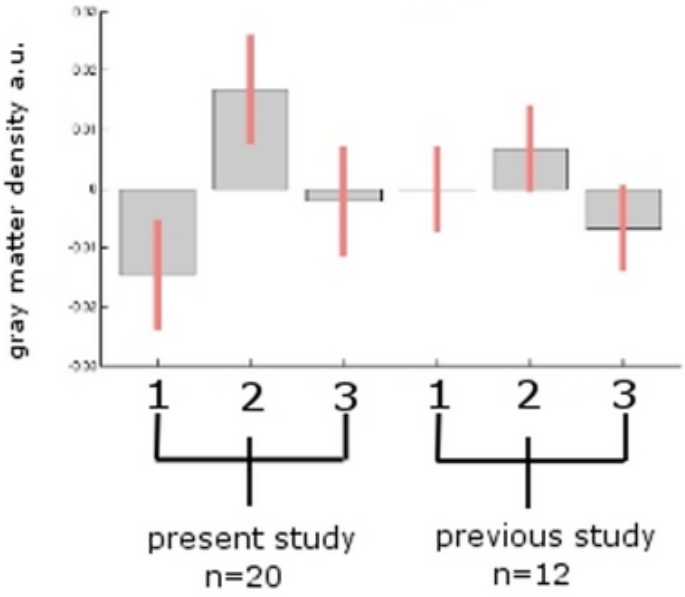
Draganski et al., Nature 2004

Follow-up Study about Dynamic of Changes









Driemeyer et al., Plos ONE 2008

Training | No Training

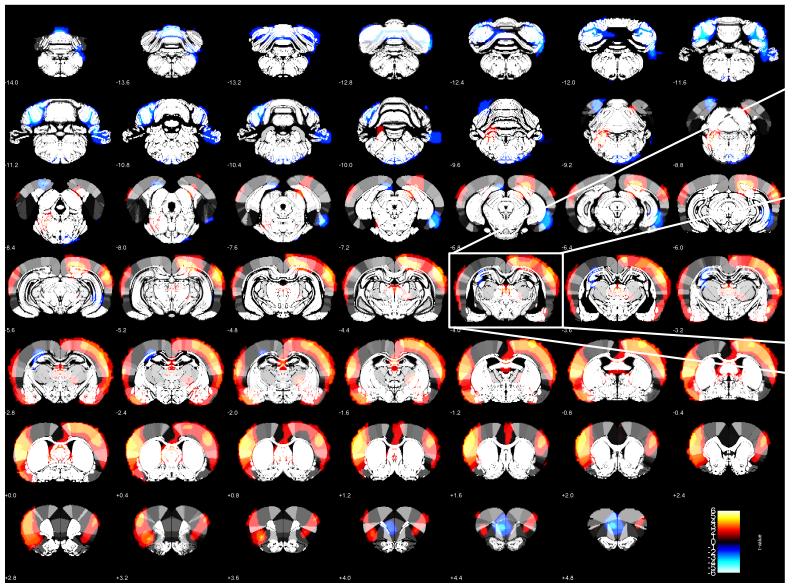
Environment and Plasticity

Physical exercise (motor activity) → Angiogenesis (greater density of blood vessels)

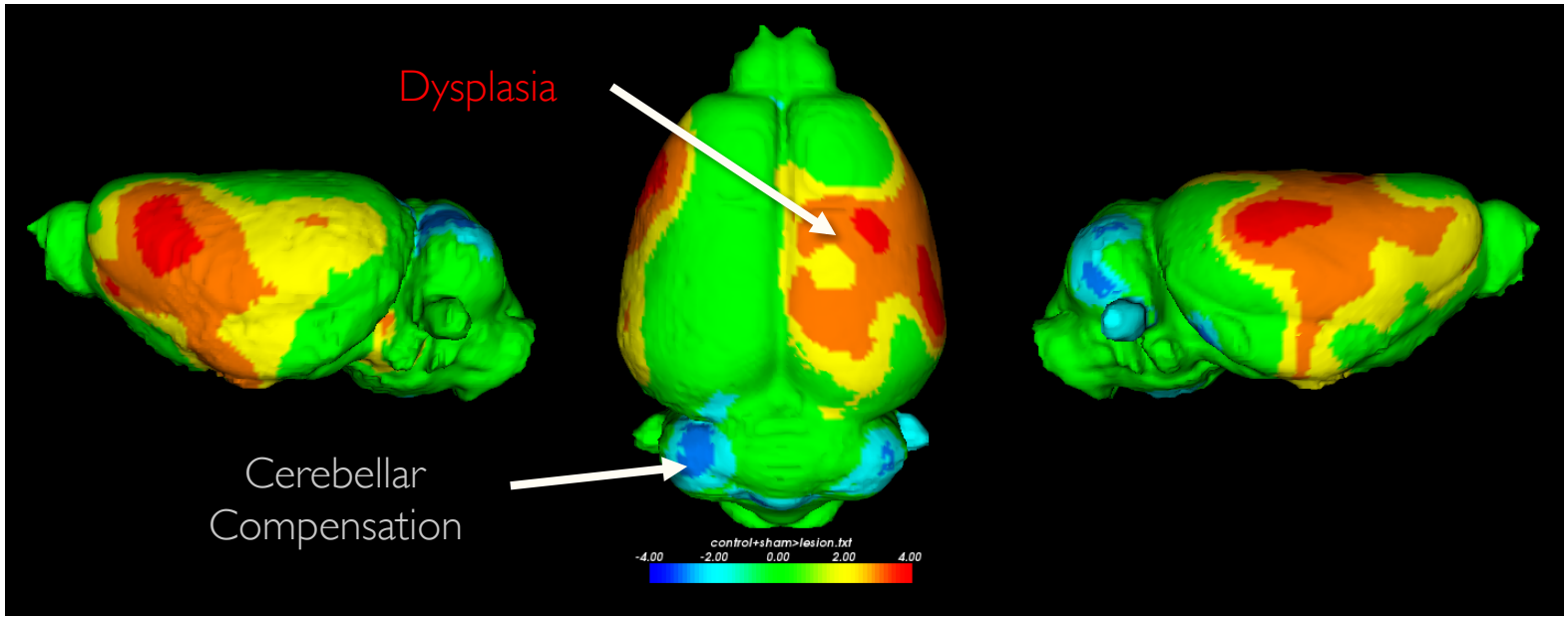
Acrobatic training (enriched environment) → Synaptogenesis (new synapses)

Black et al. PNAS 1990

Morphometry of Rats



Dysplasia and cerebellar compensation in aged rats after freeze lesion



Conclusions

Potential

- Fully automatic analysis
- Application to almost any disease, where brain alterations are expected
- Analysis of changes over time in longitudinal designs (e.g. learning/plasticity)

Future prospects

- Method improvements
- New MR sequences
- Comparison with histological analysis