

Visualization of MR data

Tomáš Pšorn



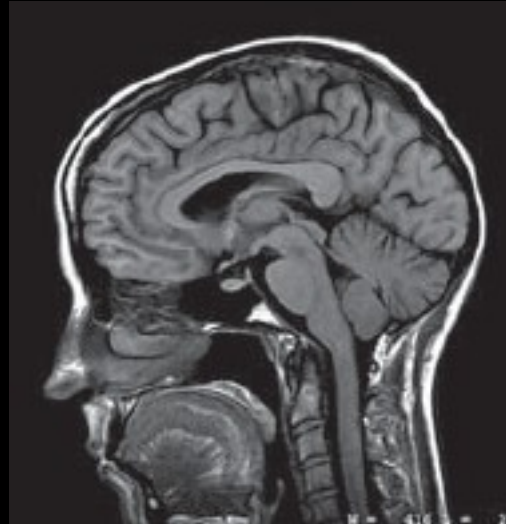
Takeaways

- Visualization of multidimensional data might be domain independent
- Visualization of multidimensional data should be domain specific, if needed
- We need to have an insight into every step of MR data processing

MR in medical imaging context



ultrasound



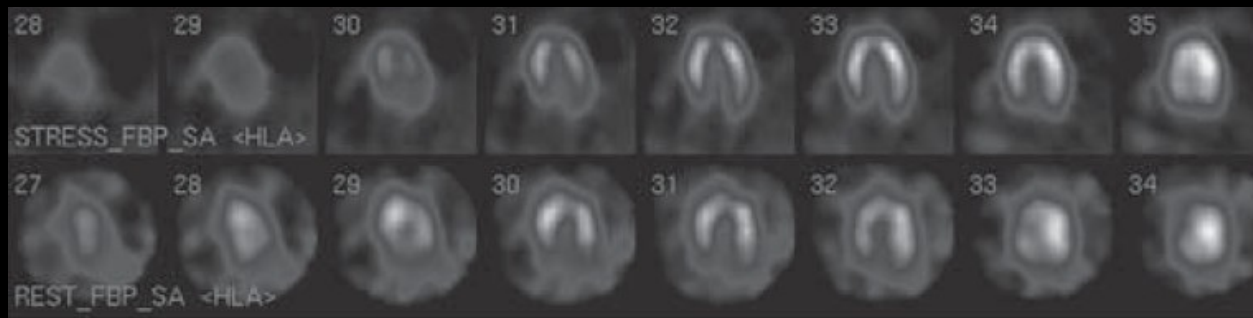
magnetic resonance imaging



scintigraphy



computed tomography

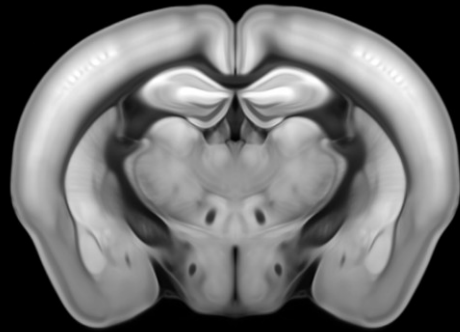


single-photon emission computed tomography

Prince, *Medical Imaging Signals and Systems*

MR in my context

preclinical imaging



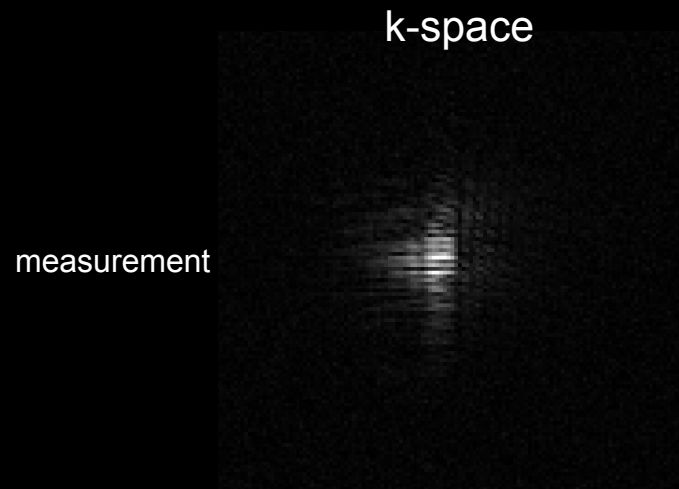
clinical imaging



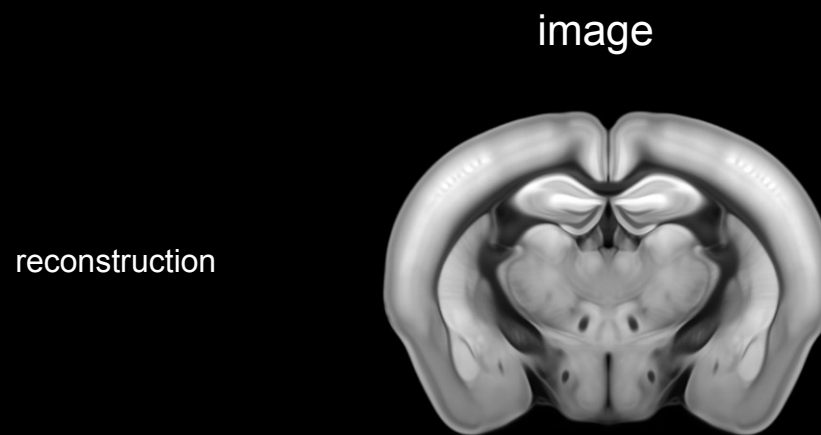
Prince, *Medical Imaging Signals and Systems*

Features of MR data

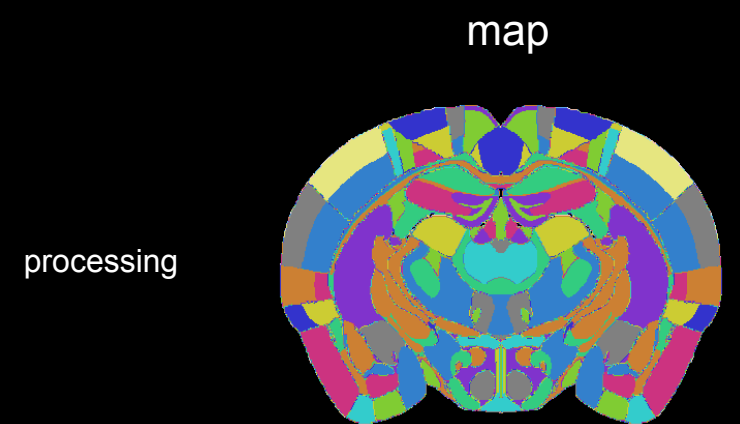
- Multiple processing stages
- Multidimensional matrices
- Complex entries
- Non-uniformly sampled
- Various contrasts encoded within
- Certain level of uncertainty



Try to somehow see something.



Visual analysis of specific anatomical features using generic software.

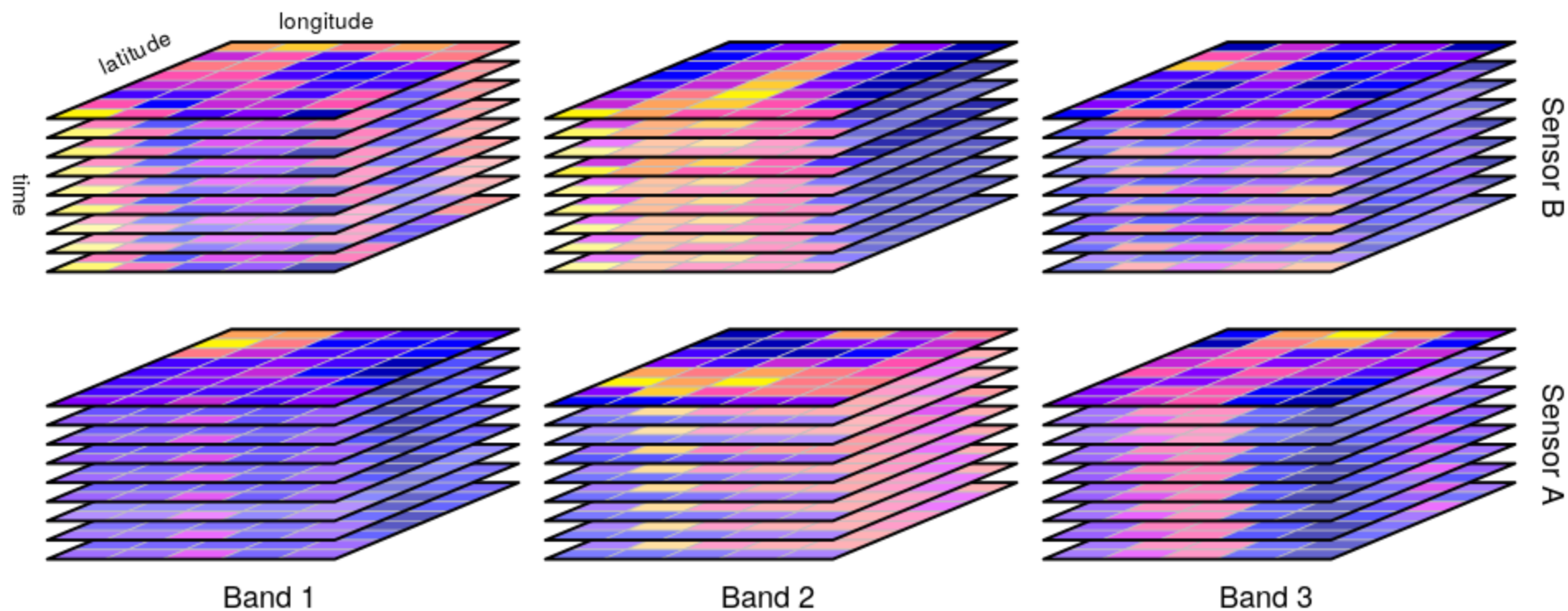


Decoding visually encoded information using method specific software.

Features of MR data

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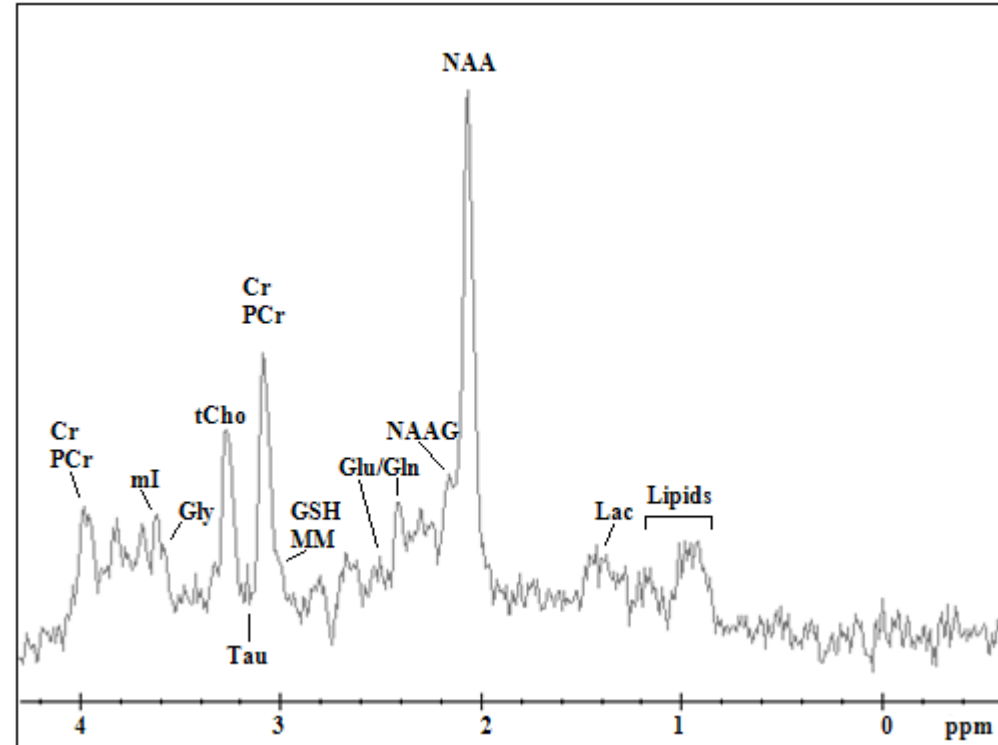
Multidimensional data



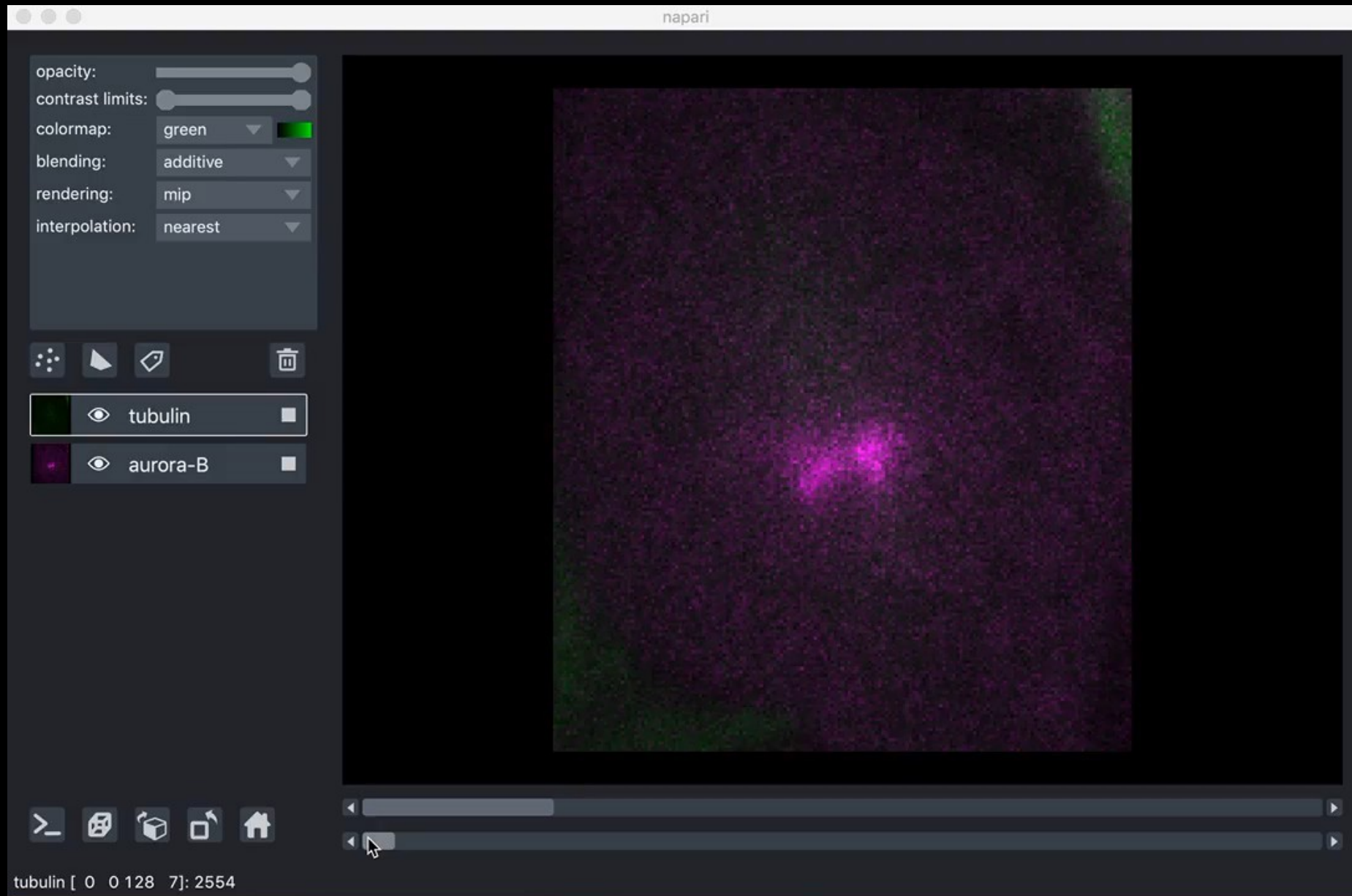
Meaning of MR dimensions

- Spatial frequency [1/rad]
- Space [mm]
- Spectrum [Hz, ppm]

- Coil
- Time – repetition, echo, inversion
- Diffusion
- Average
- Phase
- Contrast
- Segment



Kousi, E., et al. Novel Frontiers of Advanced Neuroimaging (2012)

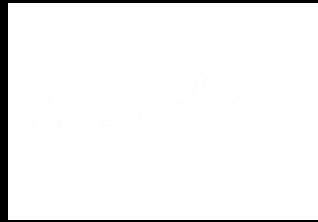


<https://ilovesymposia.com/2019/10/24/introducing-napari-a-fast-n-dimensional-image-viewer-in-python/>

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Complex entries



The key concept:

Information is encoded in the phase of signal. The encoding is done using spatially and temporarily varying magnetic field.

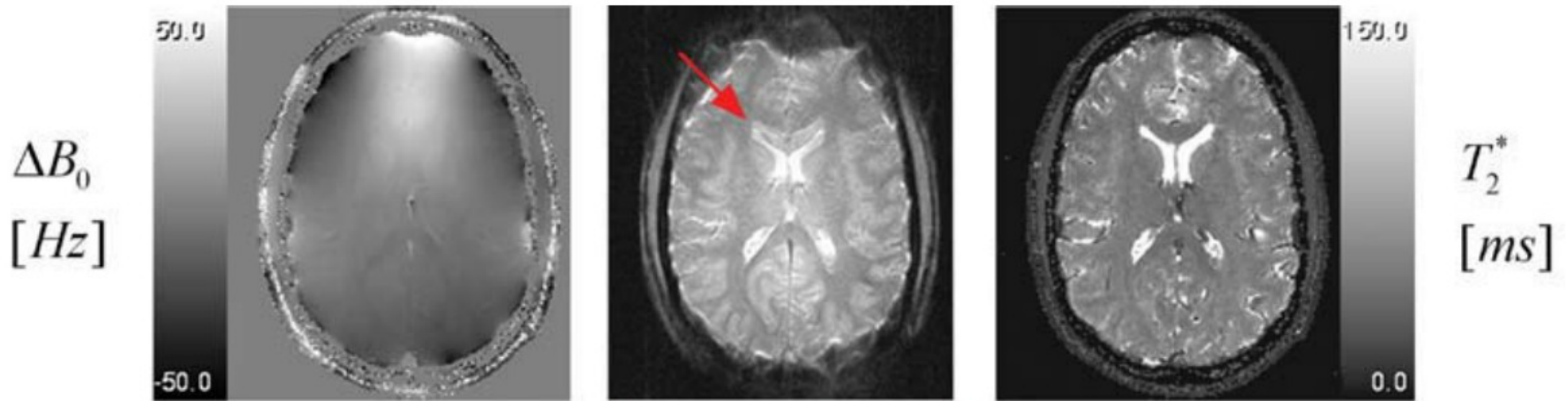


magnitude



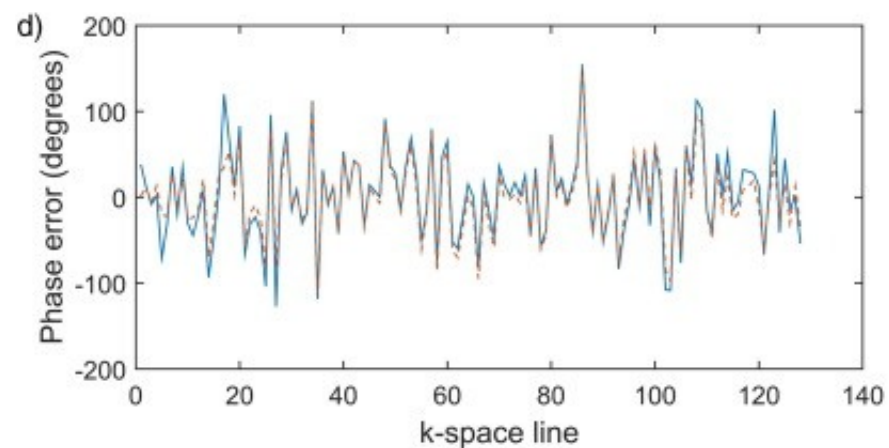
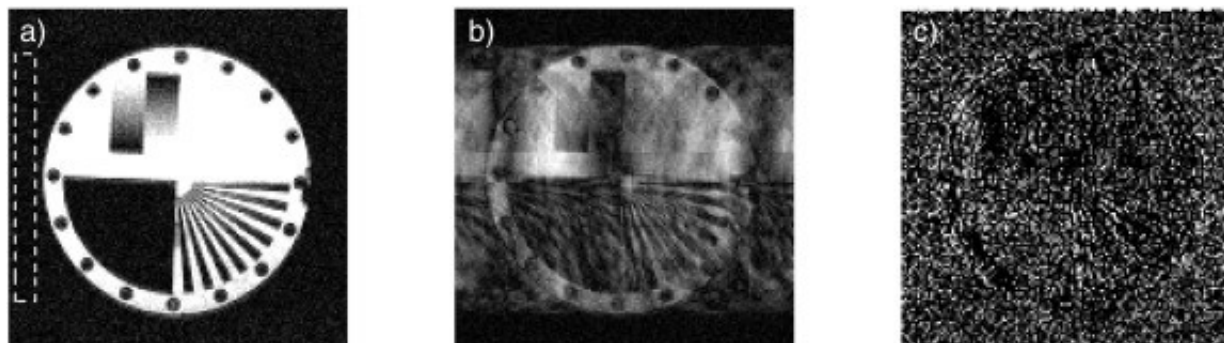
phase

Example of correction



Hetzer, S., et al. Magnetic Resonance in Medicine (2011)

Example of correction



Broche, L. M., et al. Magnetic Resonance Imaging (2017)

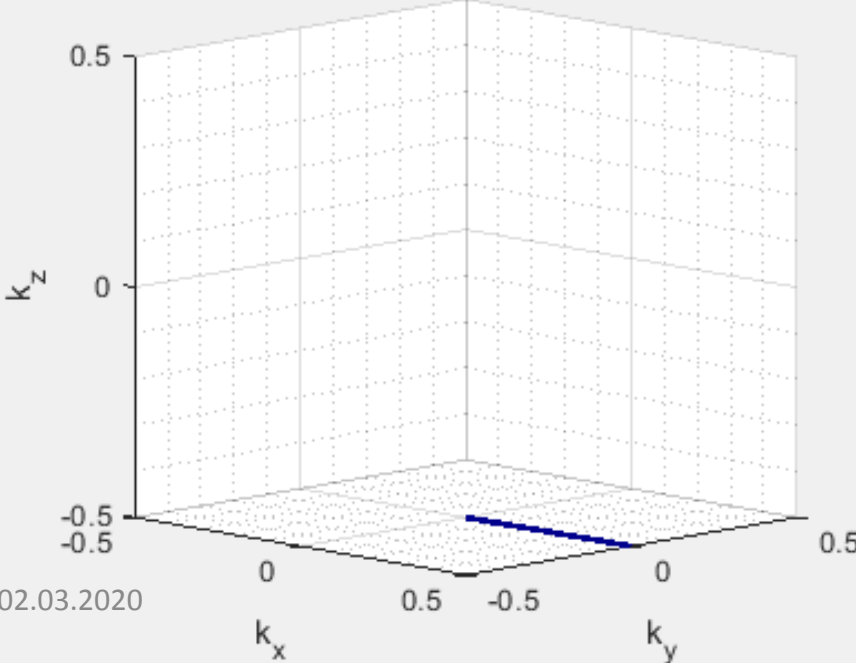
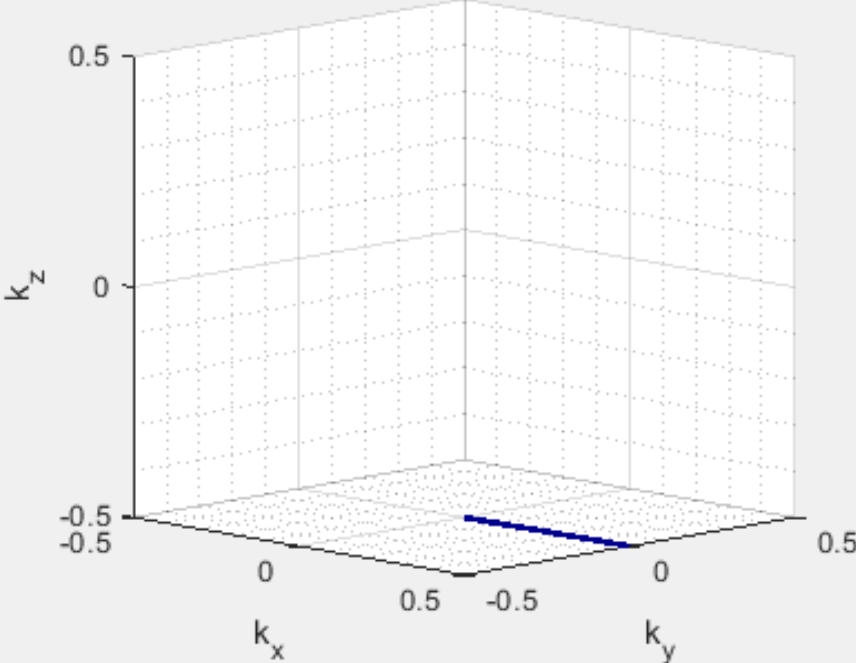
Can we spot the problem?



Features of MR data

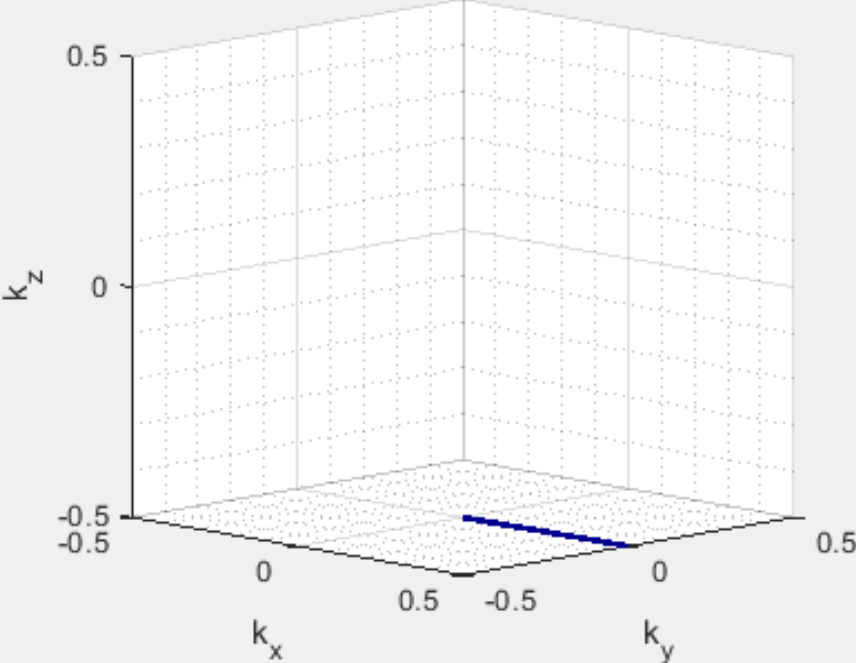
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k-space trajectory



02.03.2020

Visualization of MRI data



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Normally you see a nice looking image, which is not what you normally get.

“Standard“ methods are debugged, anything else is not.

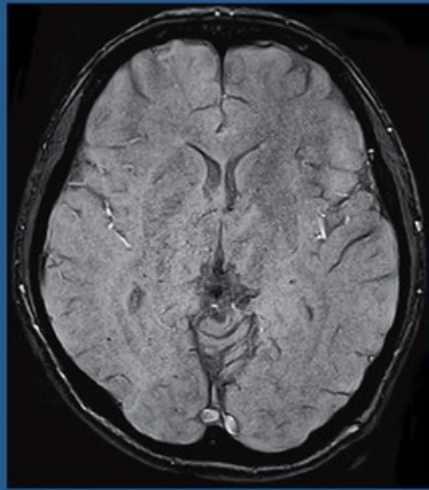
Data visualisazion infrastructure is the debugger.

Features of MR data

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SWI

Susceptibility weighted imaging



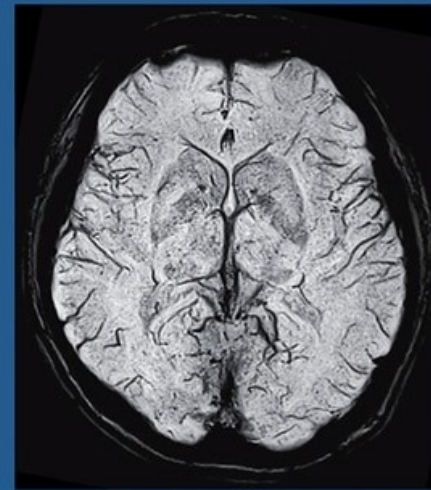
Magnitude Image

X



Phase Mask

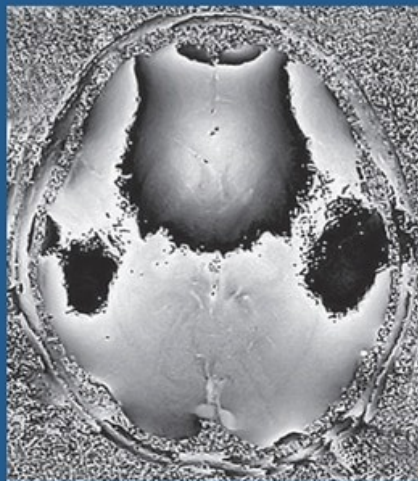
n



SW Image

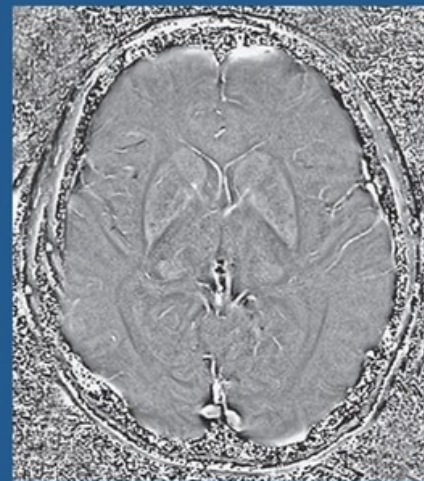


Scaling

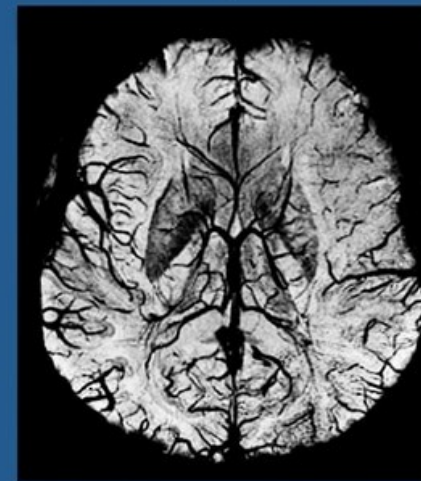


Raw Phase Image

High-pass filter



Filtered Phase Image



SW Image (mIP)

...A simple step to make sure that you always view the images, in the same way, is to look at venous structures and make sure they are of low signal (if bright you should invert the greyscale). Then window the image narrowly such that the image appears a little reminiscent of a dark CT of the brain...

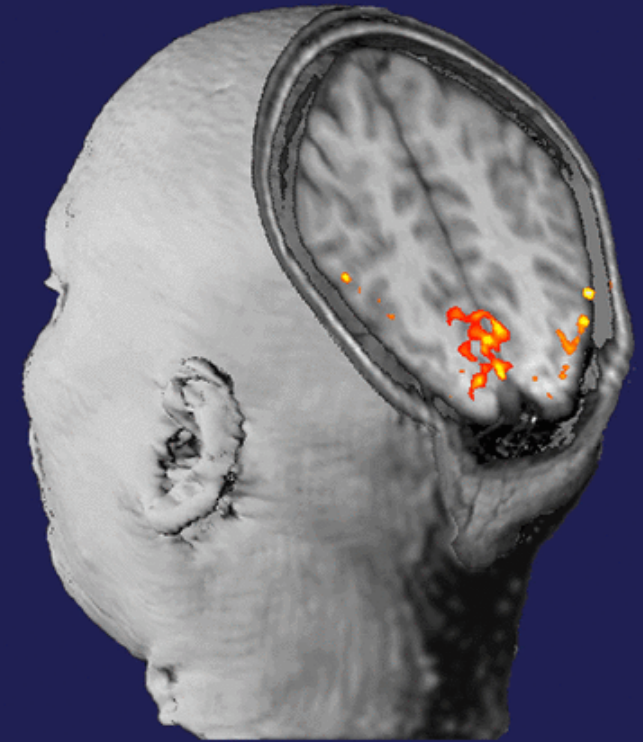
<https://radiopaedia.org/articles/susceptibility-weighted-imaging-1>

Does a common user know, what it means?

Is it possible to easily perform such a task?

fMRI

functional MRI

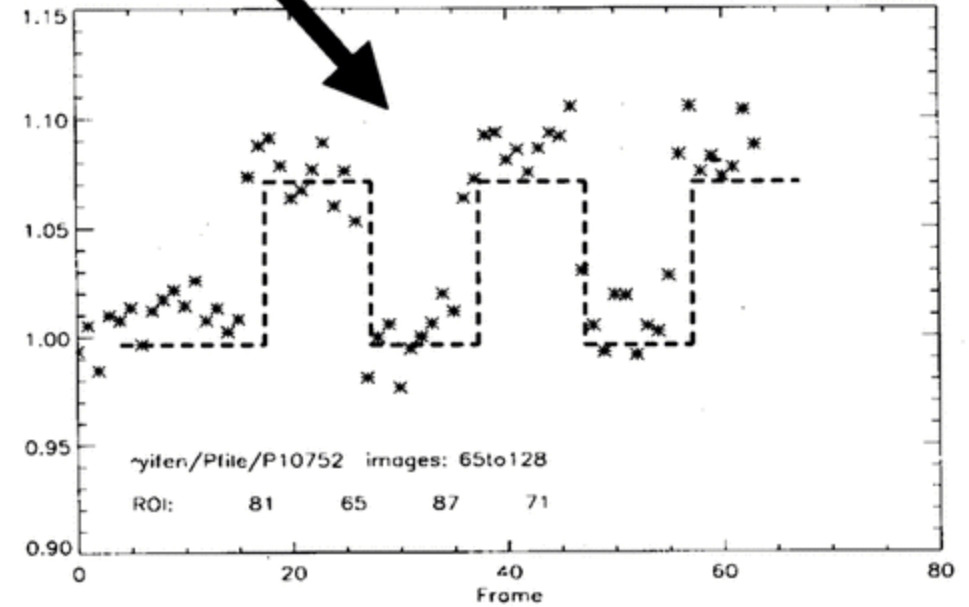
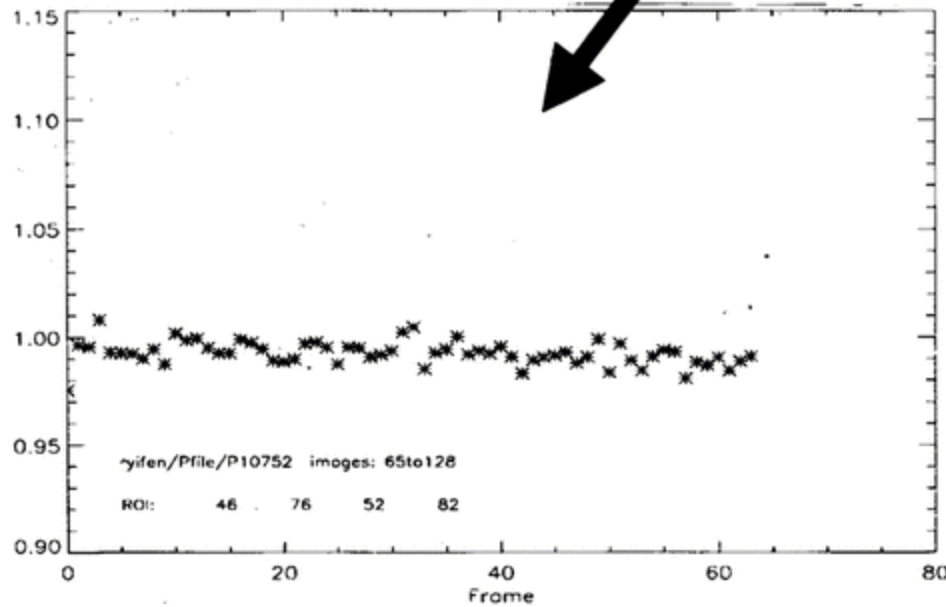




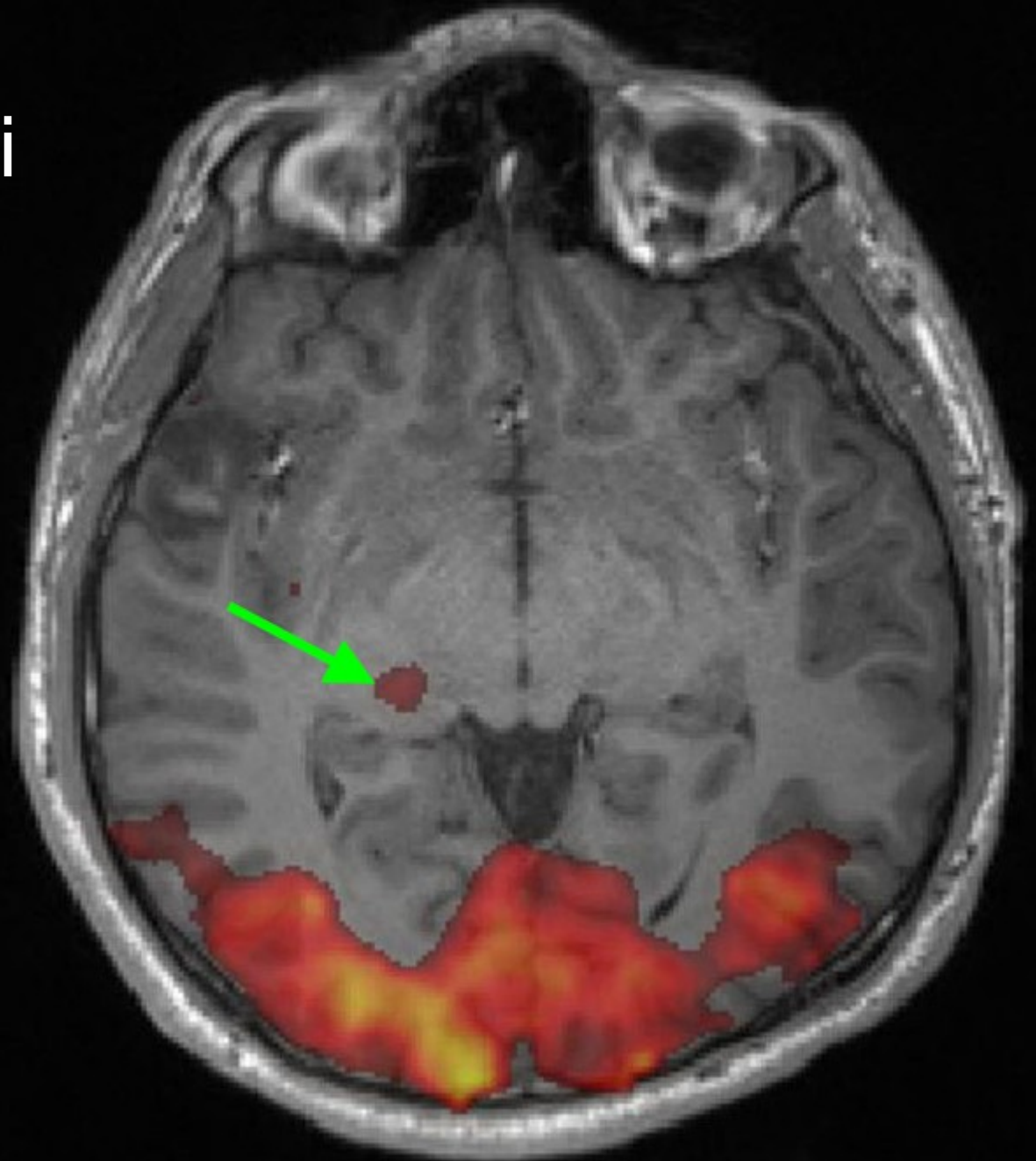
ROI of Noise

ROI of Active Area

Relative Signal Intensity



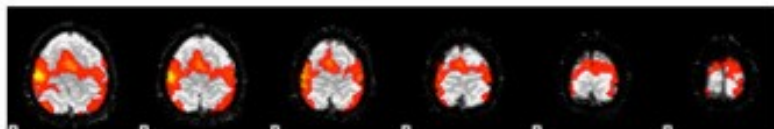
Response to visual stimuli



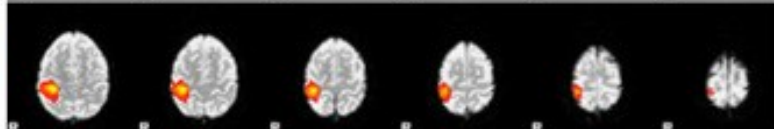
<https://mriquestions.com/visual.html>

Normalization

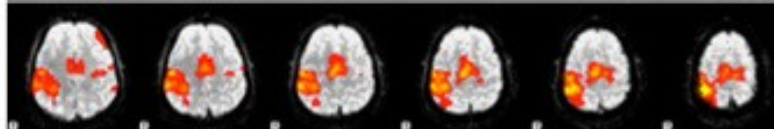
Subject 1



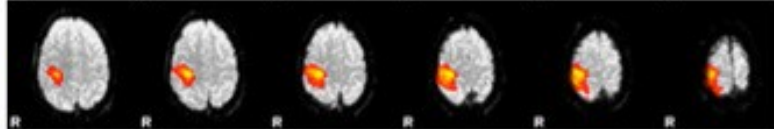
Subject 2



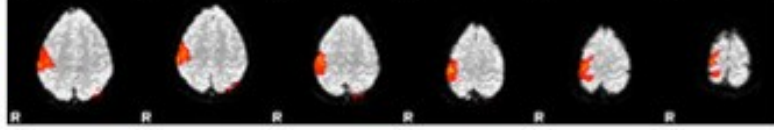
Subject 3



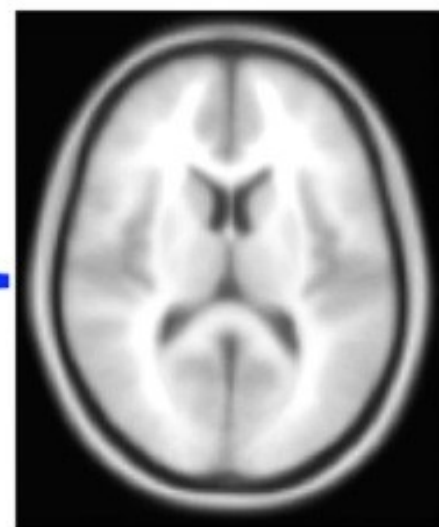
Subject 4



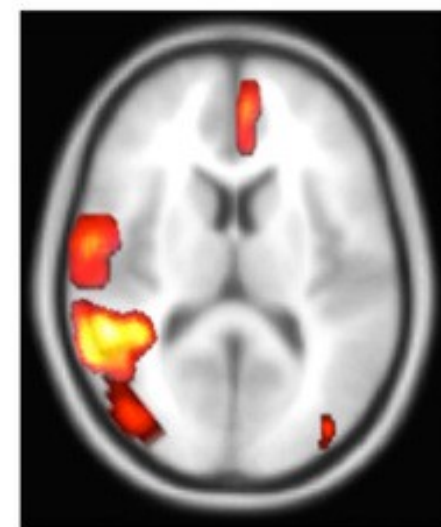
Subject 5



Normalization

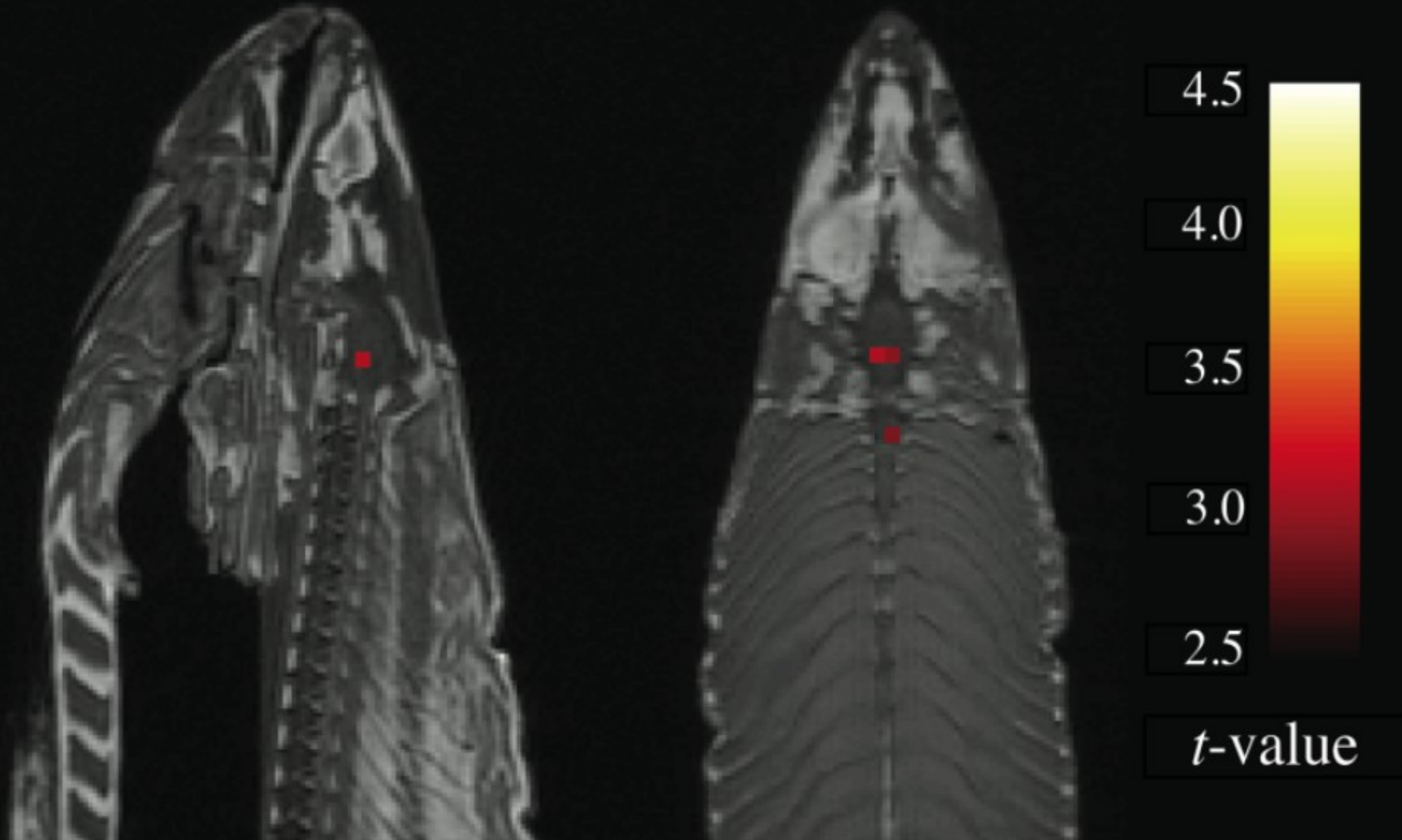


Template



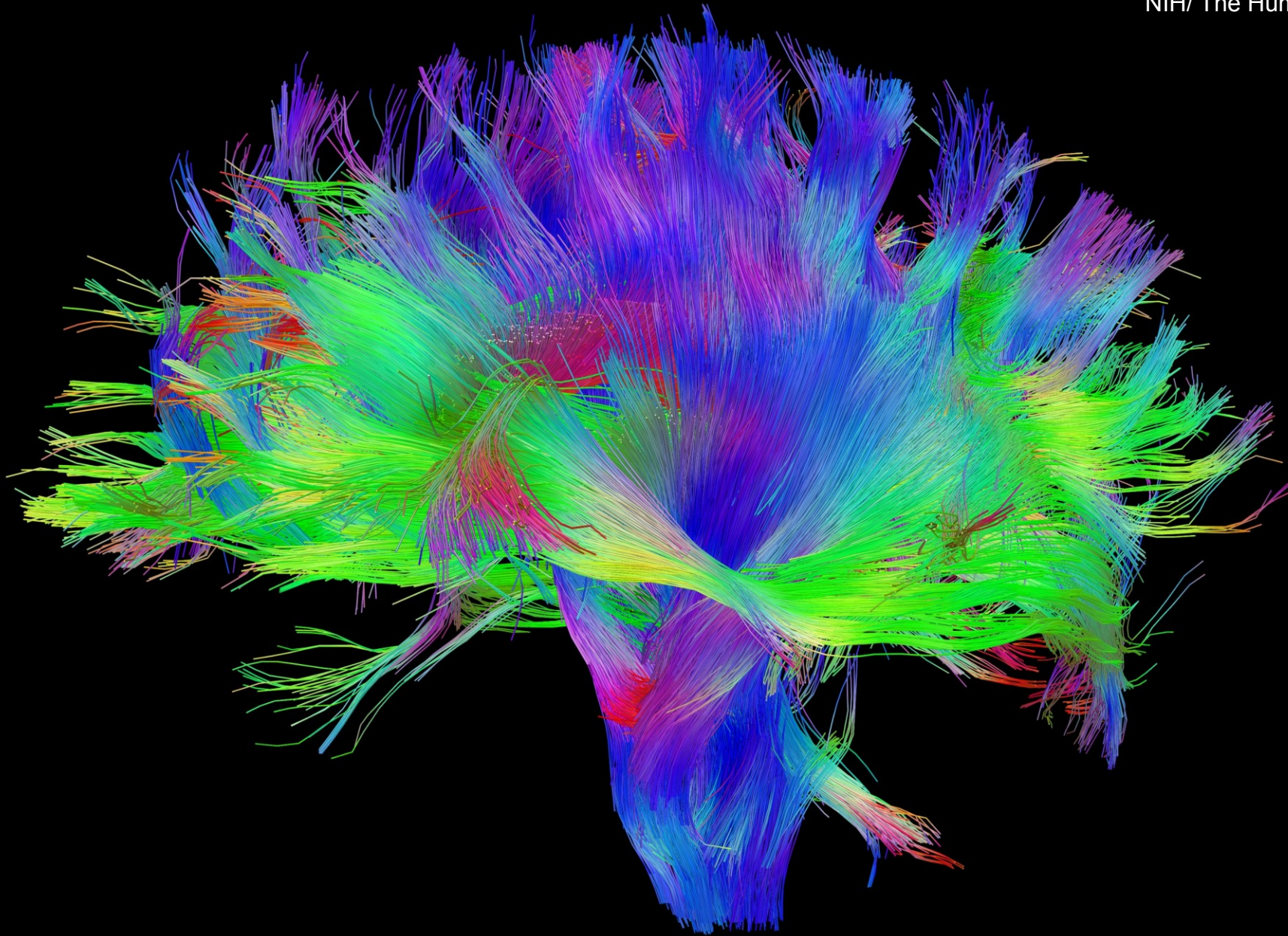
Average activation

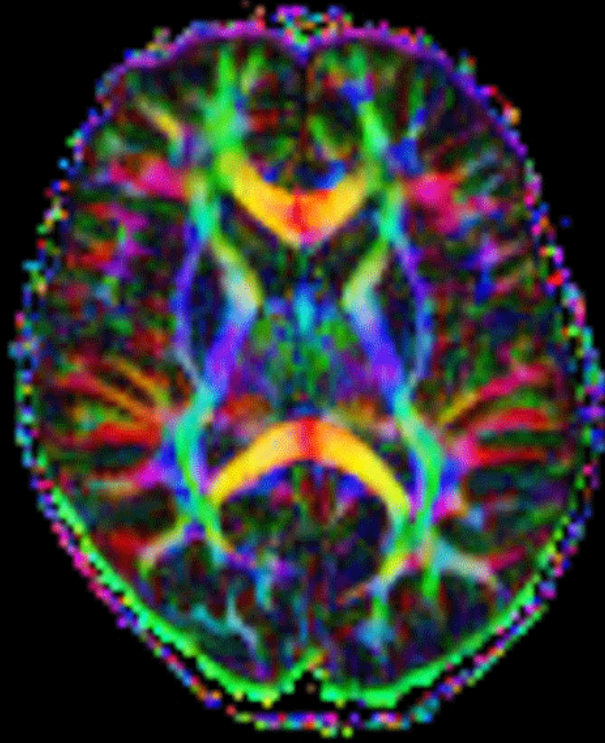
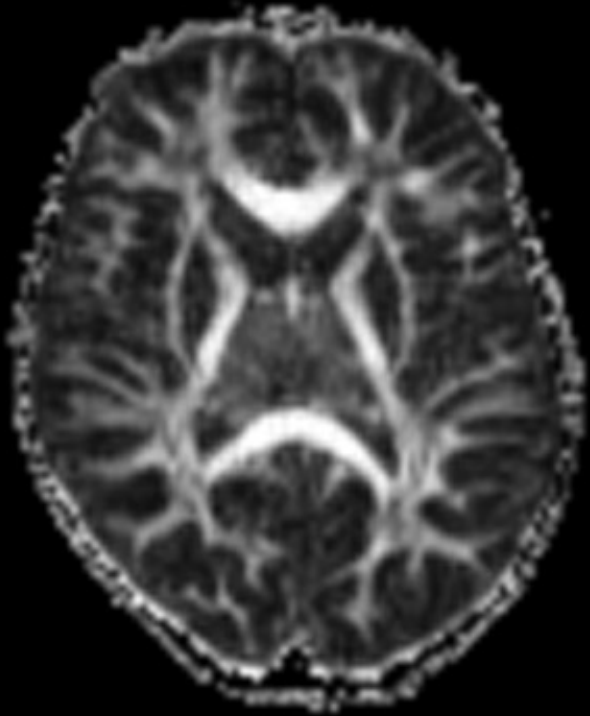
<https://mriquestions.com/registrationnormalization.html>



DTI

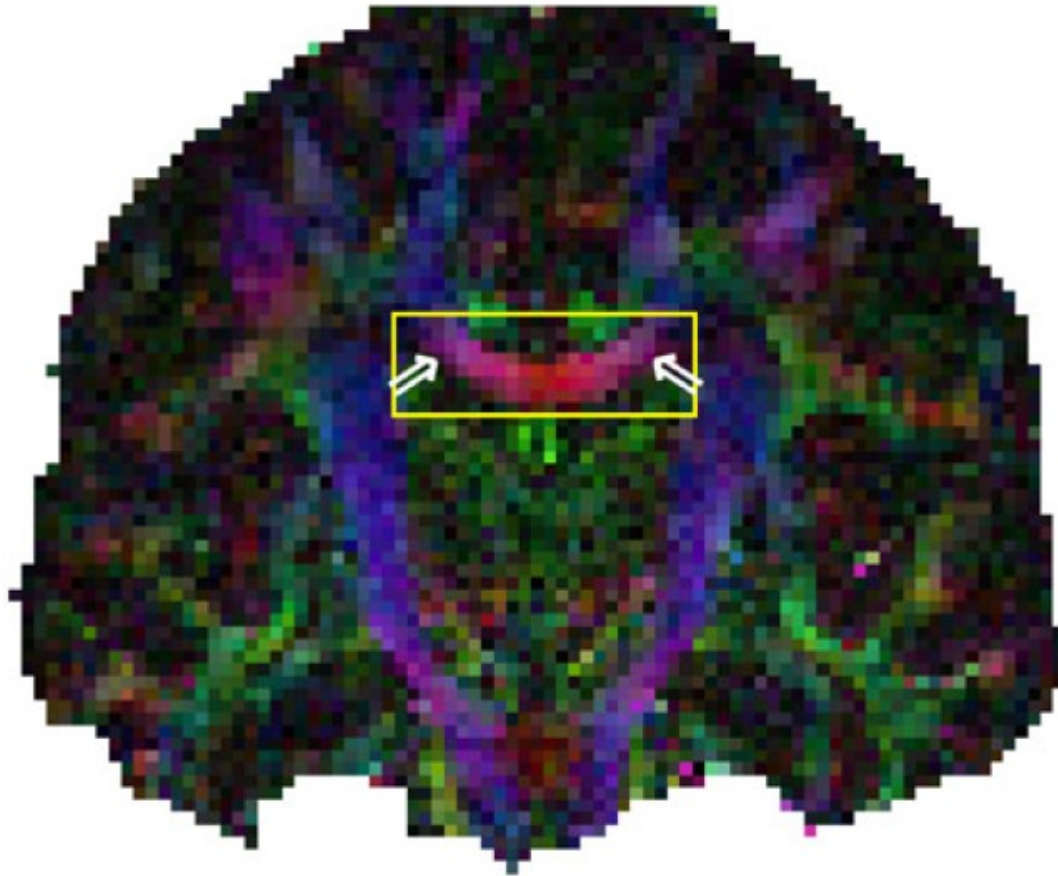
Diffusion Tensor Imaging



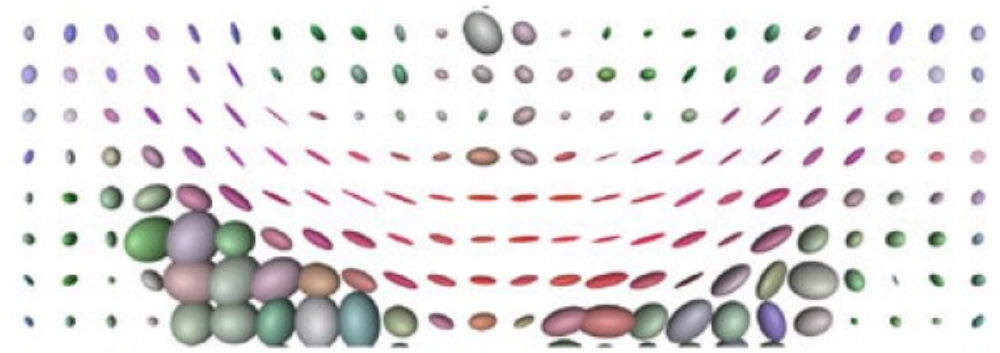


<https://mriquestions.com/dti-tensor-imaging.html>

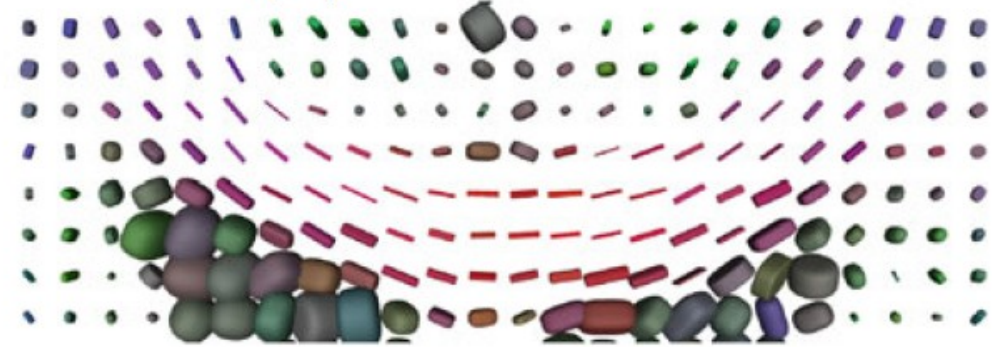
NIH/ The Human Connectome Project



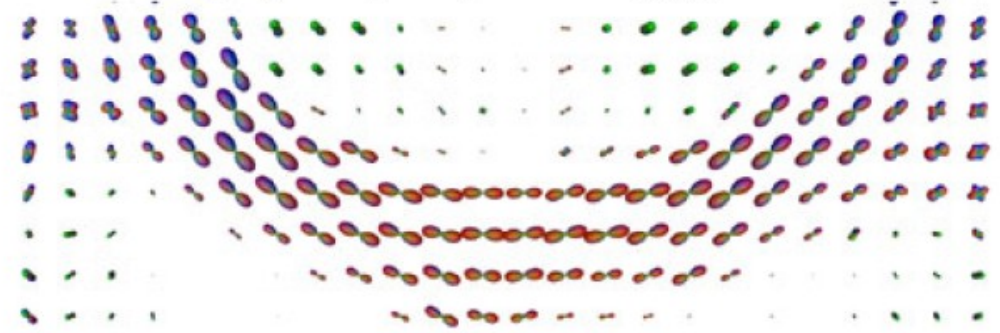
(A) XYZ-RGB color map



(B) Ellipsoid glyphs



(C) Superquadric glyphs

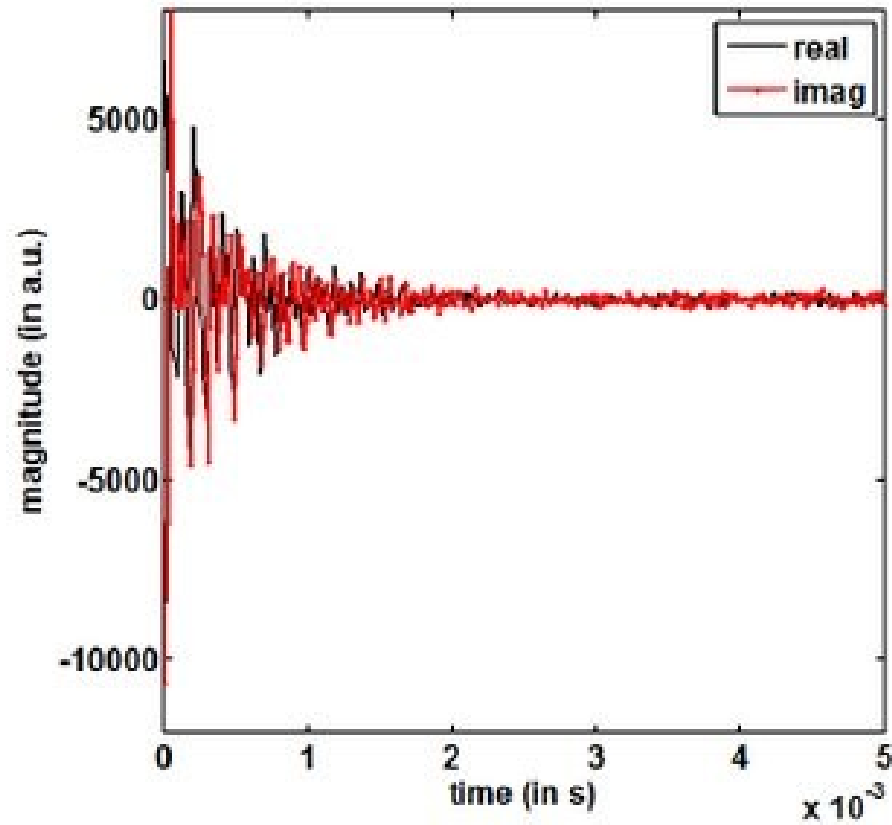


(D) Polar ODF glyphs

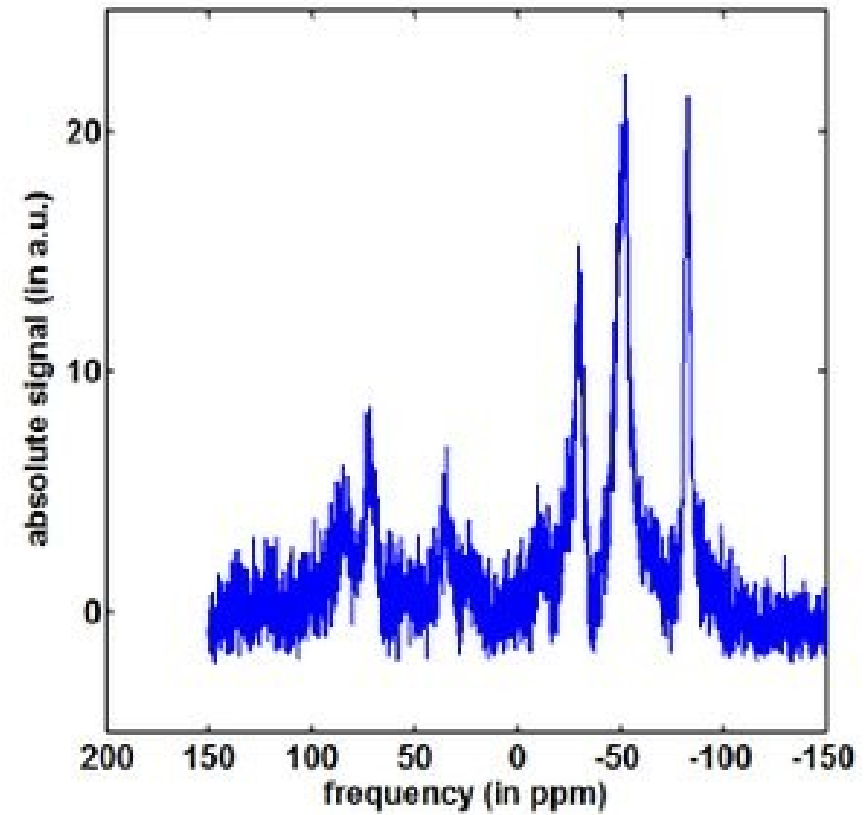
MRS

Magnetic Resonance Spectroscopy

signal



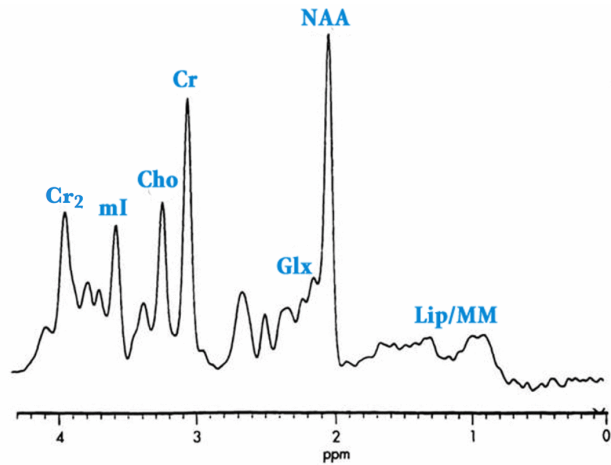
spectrum



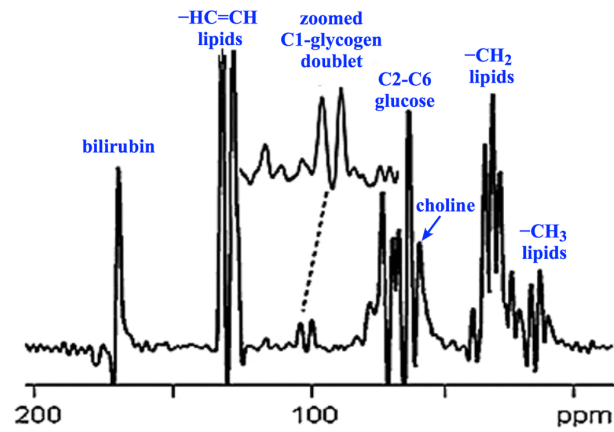
Wetterling F., et al., *Key Engineering Materials* (2013)

Multi-nuclear spectroscopy

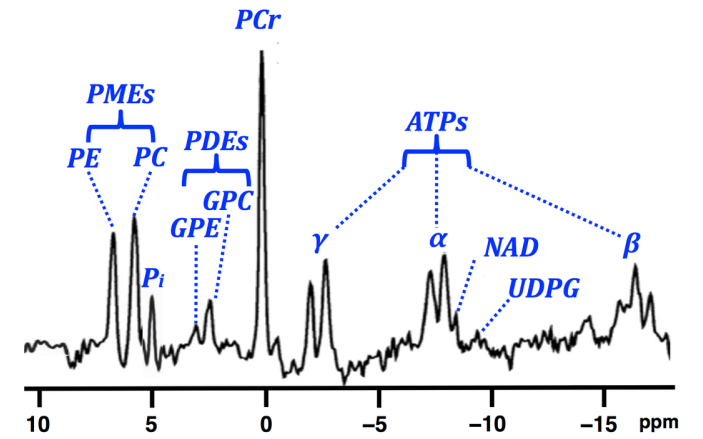
hydrogen



carbon

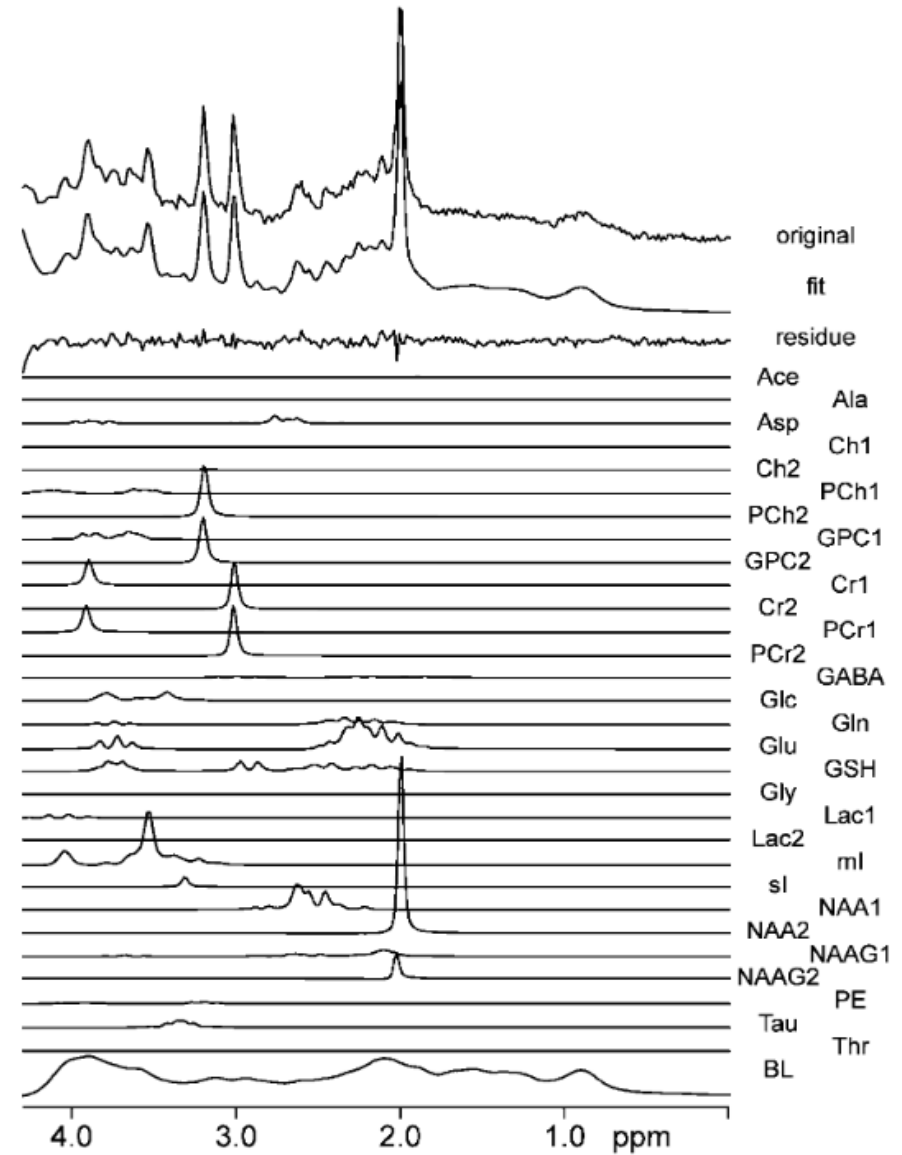


phosphorus



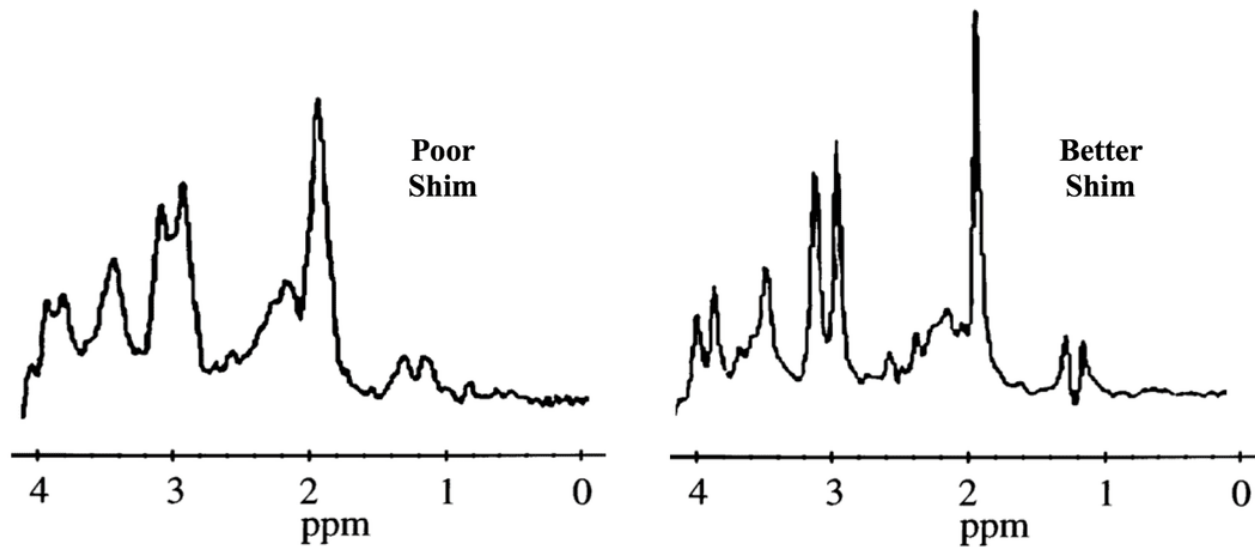
mriquestions.com

Spectroscopic fitting

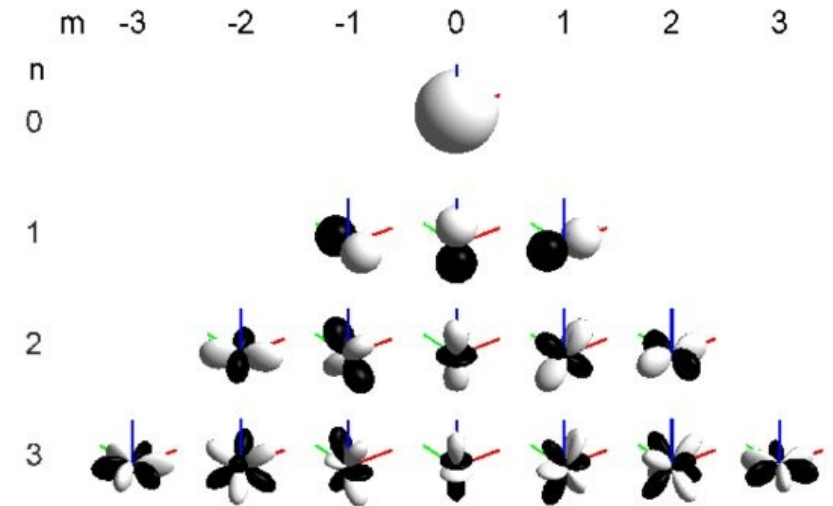


Jansen J. F. A, *et al.*, *Radiology* (2006)

Shimming a.k.a. optimization in 16 dimensional parametric space



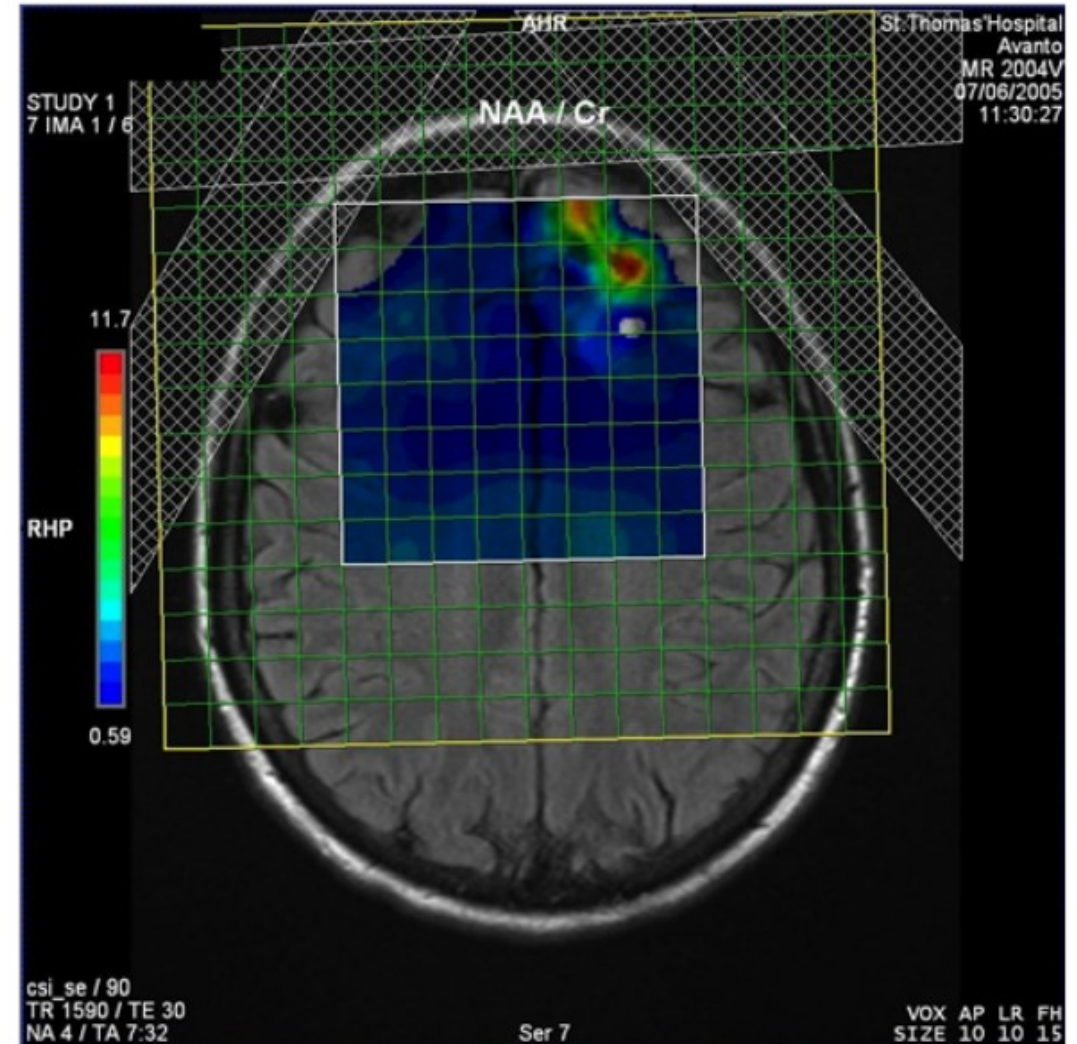
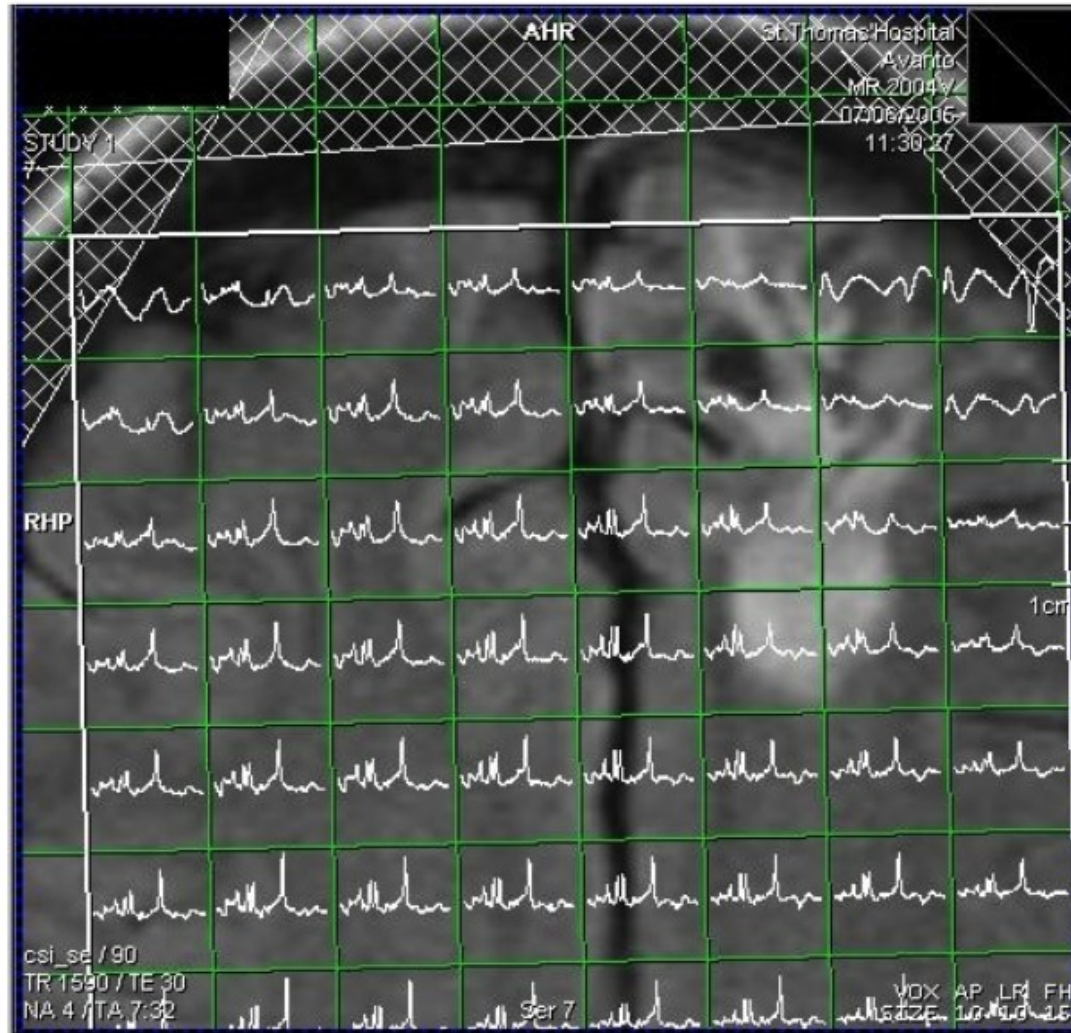
<https://mriquestions.com/sizeshapes-of-peaks.html>



Frank, M., *57th AES Int. Conf.* (2015)

CSI

Chemical Shift Imaging



Keevil, S. F., *Physics in Medicine and Biology* (2006)

CSI: a tumor study

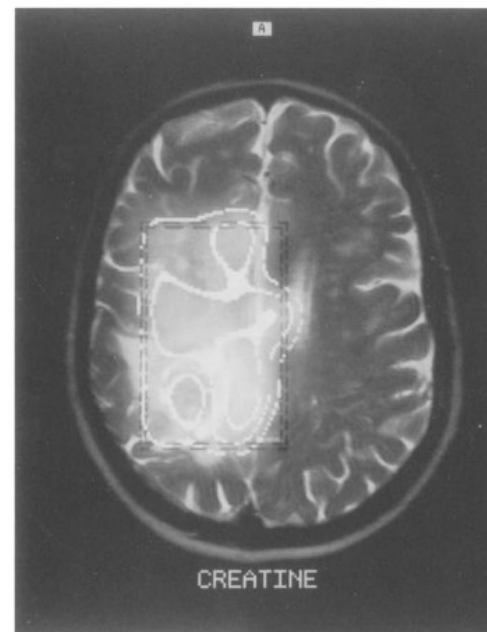
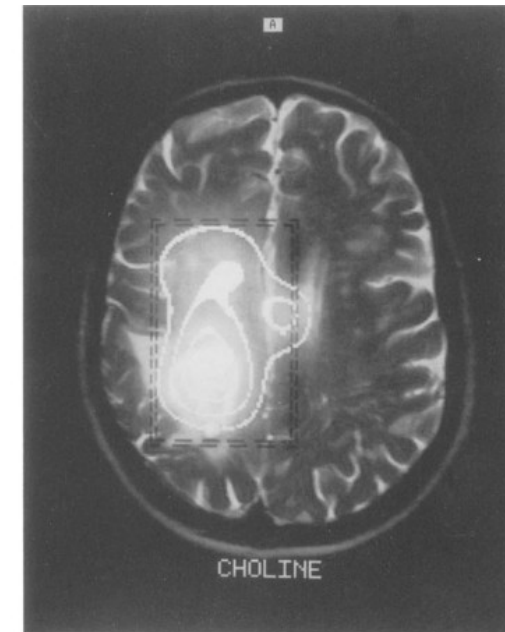
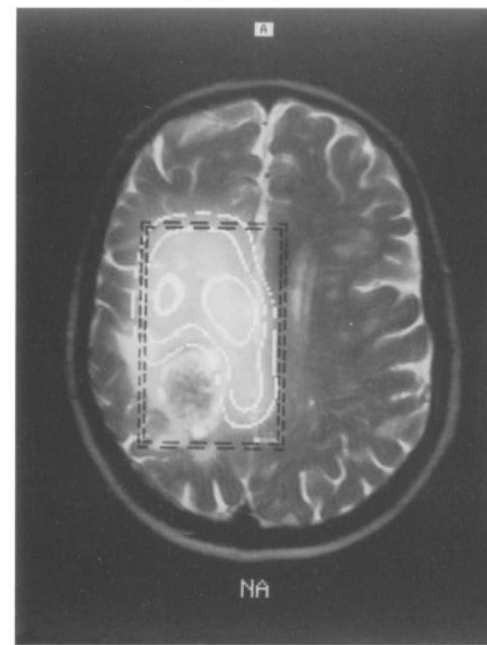


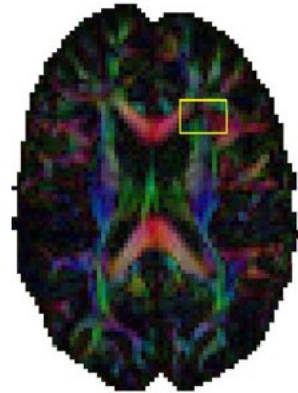
Fig. 1. Metabolic images of a parietal glioblastoma multi-forme. The metabolic images (metabolite concentrations are indicated as signal intensities) and contour maps are superimposed on a T2-weighted TurboSE (spin echo) image of the corresponding slice. The indicated volume of interest (VOI) contains the tumor in the left lower section. **Top left**, N-acetylated metabolite (NA) image. A depletion of NA within the center of the tumor is shown. **Top right**, Choline-containing compounds (CHO) metabolite image. An increase of CHO in the center and the edge of the tumor is visible. **Bottom left**, Creatine and phosphocreatine (Cr) metabolite image that shows reduction of Cr within the tumor center.

Mader, *MAGMA* 1996

Features of MR data

- Multiple processing stages
- Multidimensional matrices
- Complex entries
- Non-uniformly sampled
- Various contrasts encoded within
- **Certain level of uncertainty**

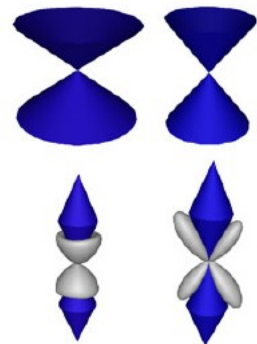
Uncertainty visualization in DTI MRI



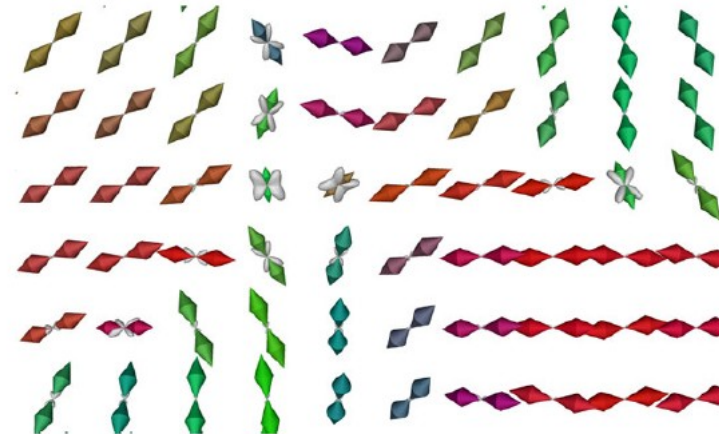
(A) Region of interest



(B) Cones of uncertainty



(C) Closeup from two selected voxels



(D) HiFiVE glyphs

Schultz, T., *NMR in Biomedicine* (2017)

Further reading

- [Interview](#) with Craig Bennett – the dead salmon guy
- [A Bug in fMRI Software Could Invalidate 15 Years of Brain Research](#)
- [Why does the spectroscopy axis run backwards?](#)

Takeaways

- Visualization of multidimensional data might be domain independent
- Visualization of multidimensional data should be domain specific, if needed
- We need to have an insight into every step of MR data processing