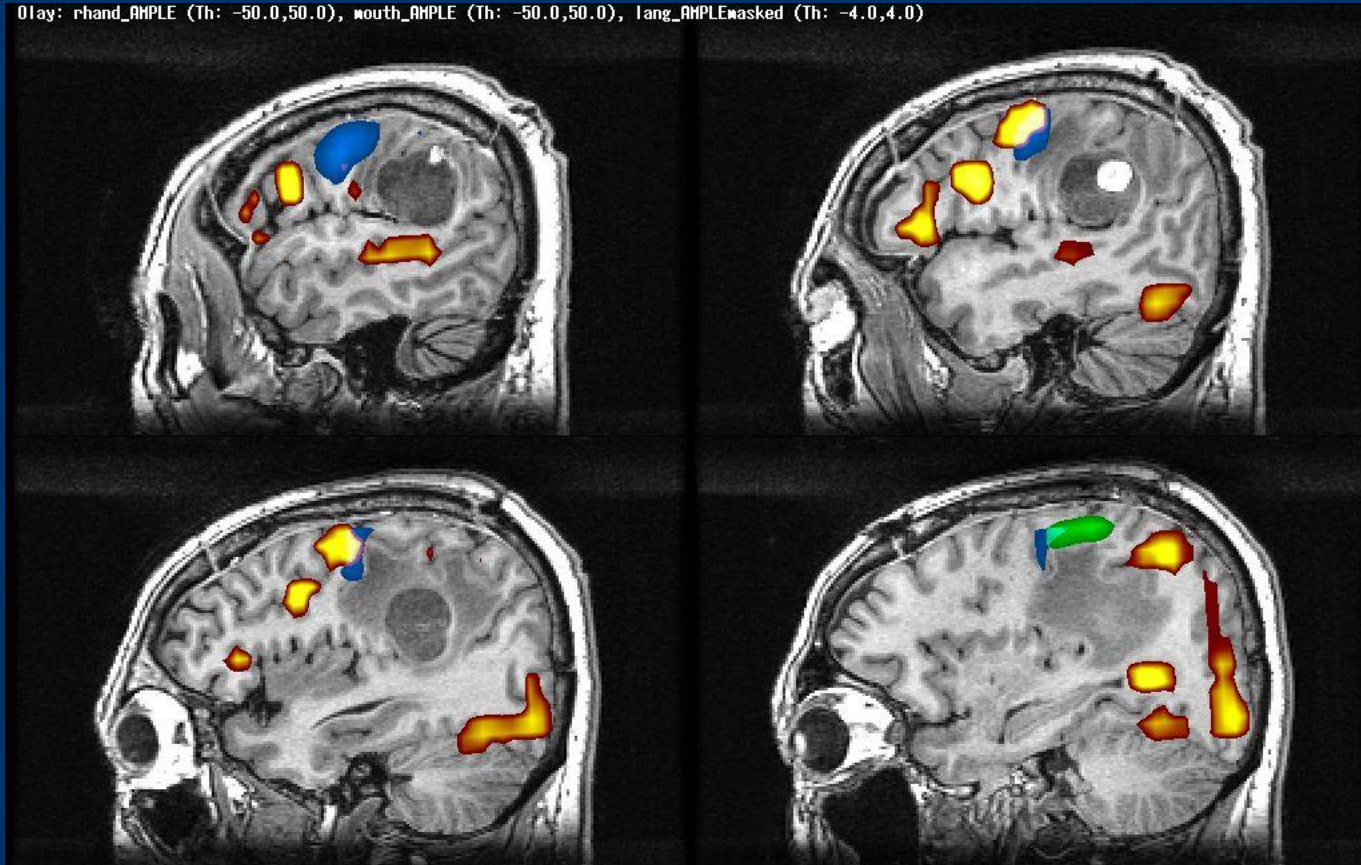# Clinical fMRI & DTI

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Acknowledgements
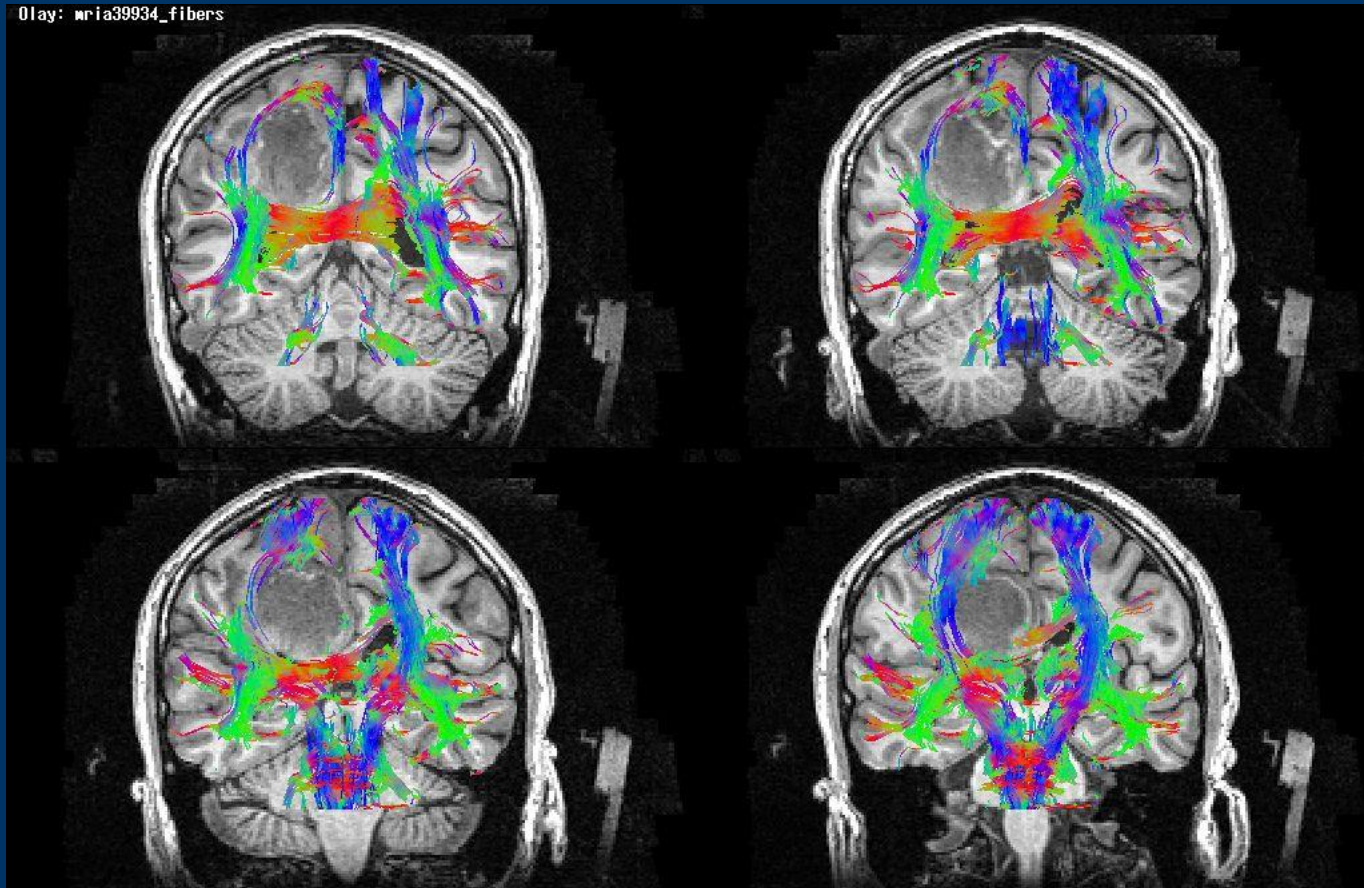
- Allan Friedman, MD - Neurosurgeon
- James Carter, PA – Neurosurgery
- Jeffrey Petrella, MD - Neuroradiologist

- Brain Imaging and Analysis Center
- Department of Radiology
- QIBA – Radiological Society of N. America

Functional MRI (fMRI) is primarily used clinically to map speech and motor function

Diffusion tensor imaging (DTI) is used to map major white matter tracts

fMRI & DTI
Clinical goals

- Determine location and borders of eloquent (essential) cortical areas relative to lesions
- Determine location of major white-matter tracts connecting eloquent areas
- Evaluate risk of post-surgical functional deficits
- Decide whether surgery is advisable
- Plan surgical approach and extent of resection
- Decide whether intraoperative mapping is necessary

fMRI & DTI
Technical goals

- Identify eloquent brain areas

  [sensitivity & specificity]

- Map location relative to anatomy and pathology
  [image registration]

- Evaluate laterality of language dominance
  [relative activation]

- Map edges of areas and proximity to lesion
  [thresholding & quantitative reproducibility]

- Measure brain connectivity *

- Measure brain function (or change in function) *

  * - not yet reliable for clinical use

Clinical fMRI/DTI exam

- 10 min pre-scan assessment and training
- 45 min MRI session
    - 10 min anatomical scans (T1 & FLAIR)
    - 15-20 min fMRI – 3-4 tasks (4 min each)
    - 5 min 30-direction DTI scan
- 30-60 min post-scan image analysis
    - Registration of fMRI and DTI with T1 images
    - fMRI statistical analysis of "active" voxels
    - Overlay of fMRI and DTI on anatomical images
- Neuroradiological interpretation

Tasks involve simple visual cues and alternating block designs

Bilateral hand motion task

Alternating side motion
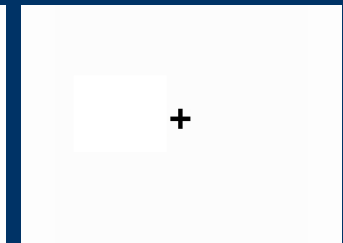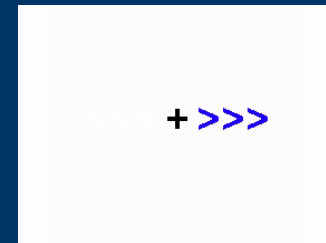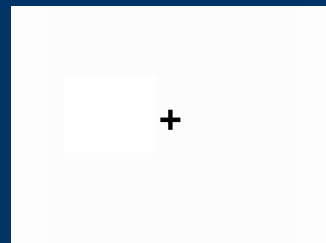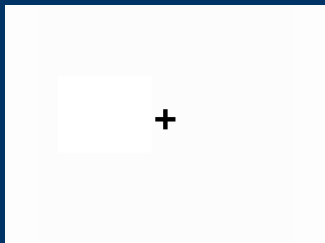
Language mapping – fMRI for locating brain areas involved in speech

Patients perform a silent sentence-completion task

|		
Old MacDonald had a _____ .	vs	Bnd MwjGhdchkj ckr n _____ .
15s		15s

The "task" condition makes the patient use "comprehension", "word finding", and "expressive" speech areas. It also involves vision and eye movement.

The "control" condition attempts to match vision function and eye movement, but with no language components.

Image acquisition

During a ~5-minute fMRI scan the patient performs many cycles of a simple task.
20-30 echo-planar images are acquired every TR (~1.5s),
This yields a time series of ~200 brain image volumes.
Image intensity varies with the task in some voxels.

EPI image

Voxel time courses
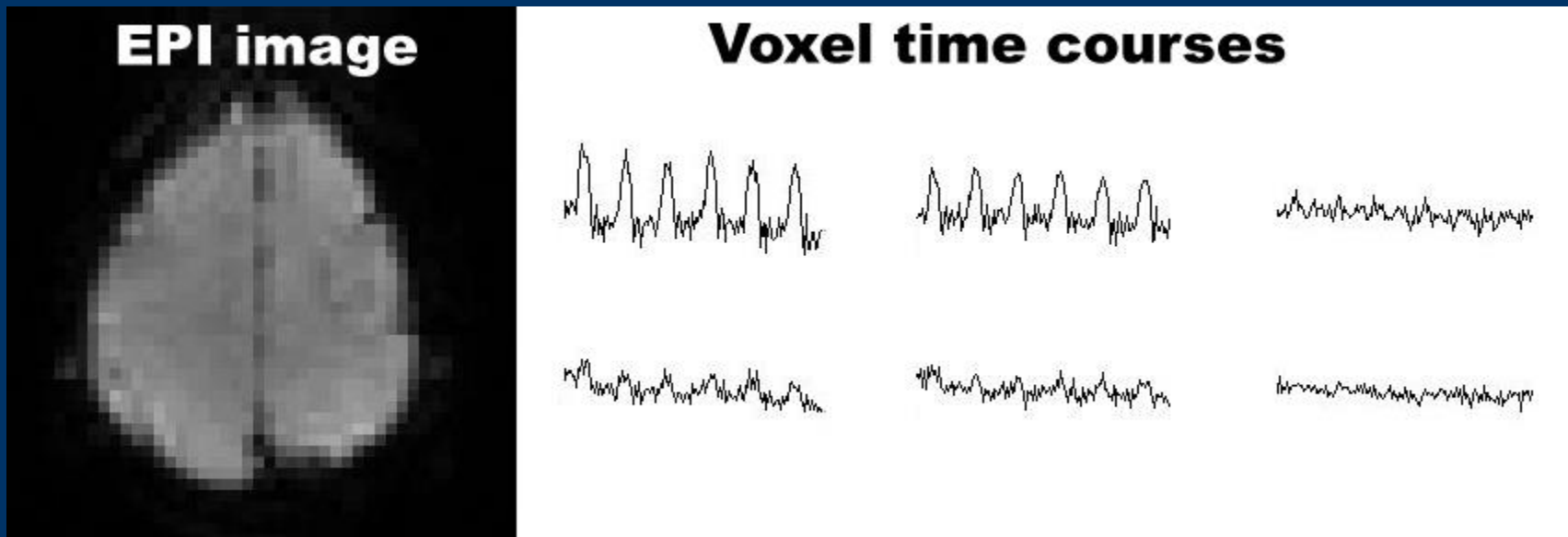
Statistical image processing

Compare the timing of the observed fluctuations in the fMRI images to the expected fluctuations of the BOLD response.

Task timing

Predicted response

Actual response
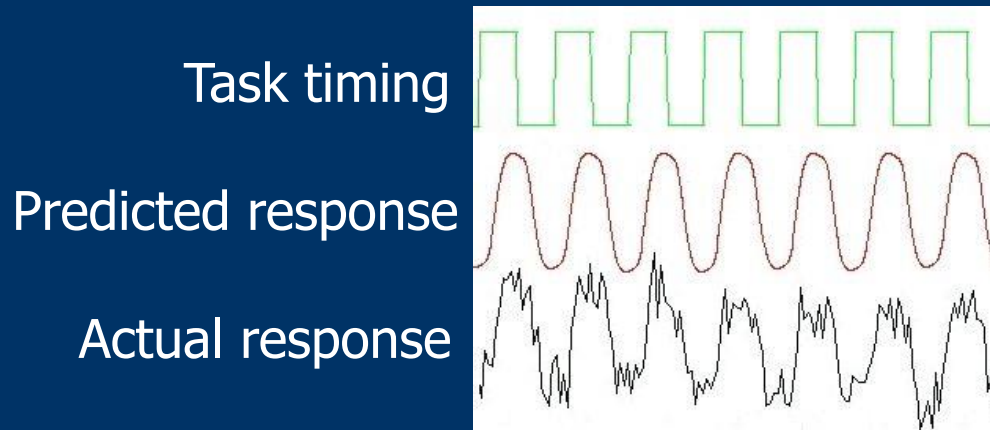
Comparison methods:
- image subtraction
- t-test differences
- frequency analysis (FFT)
- temporal correlation
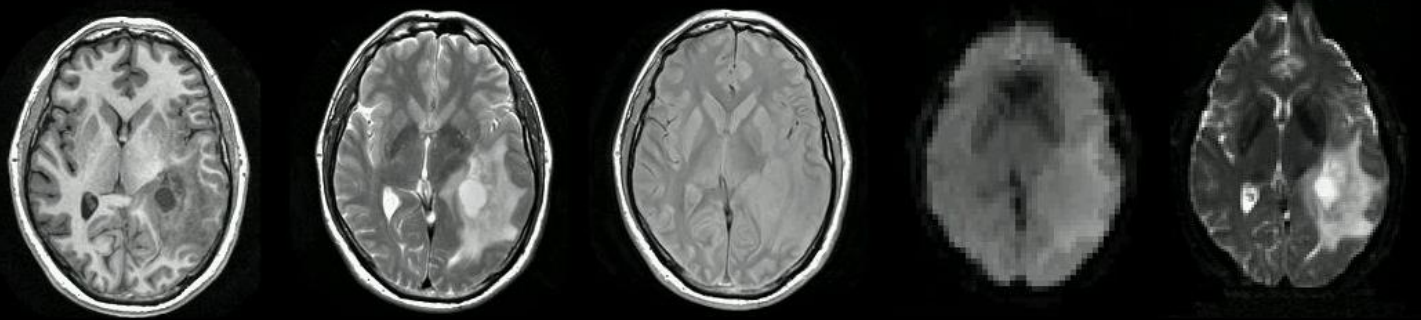- General Linear Model
    (analysis of variance)

Statistical significance identifies "active" voxels
 (statistical value above some minimum threshold)

Thresholded "map" of active voxels is overlaid on MR images

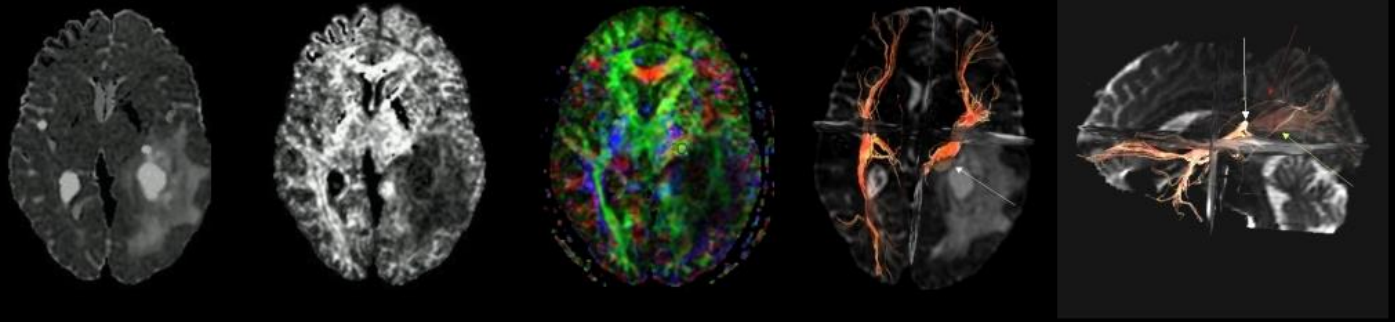# fMRI and DTI maps involve post-processing
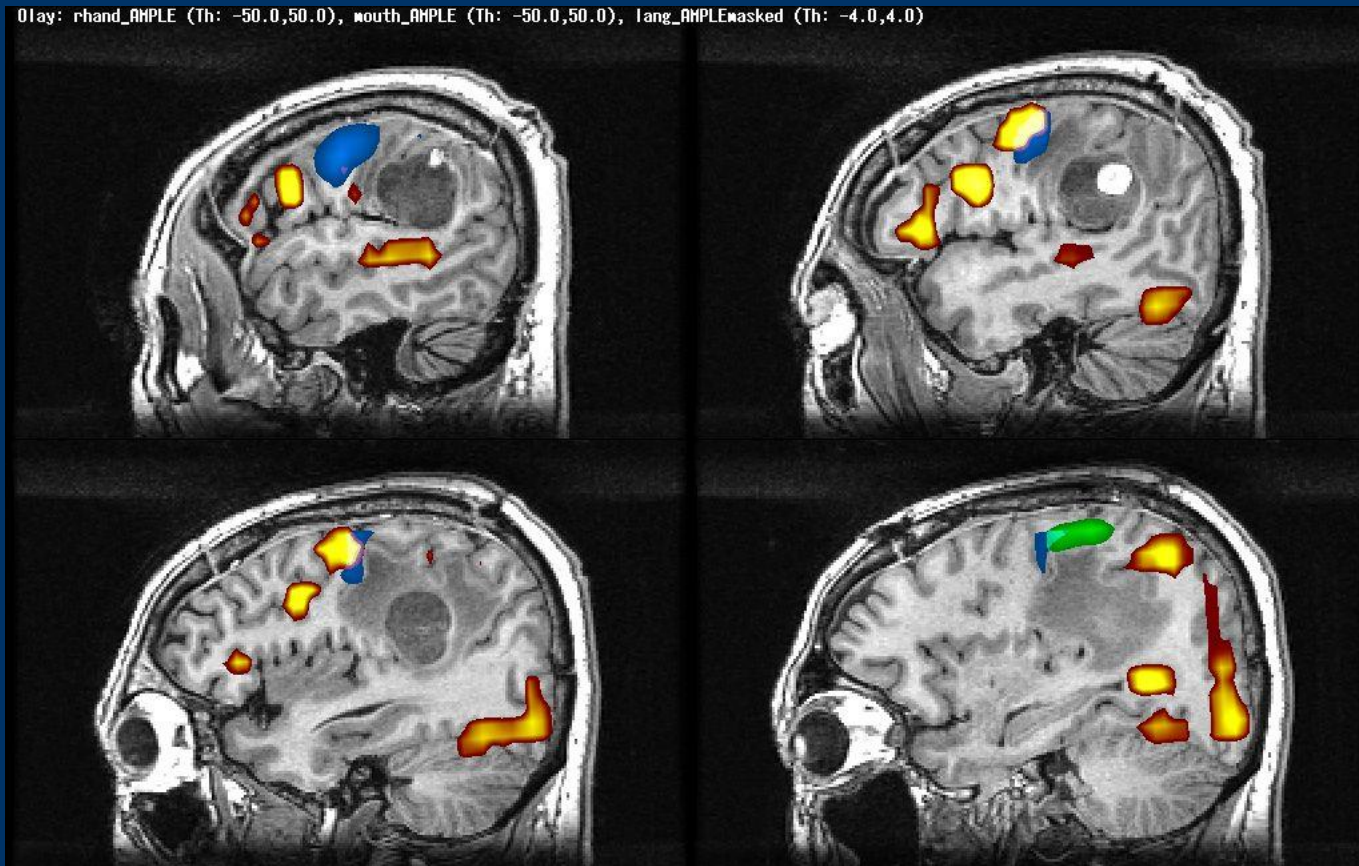

Anatomical Images

fMRI statistical maps, overlaid on anatomy or brain surface
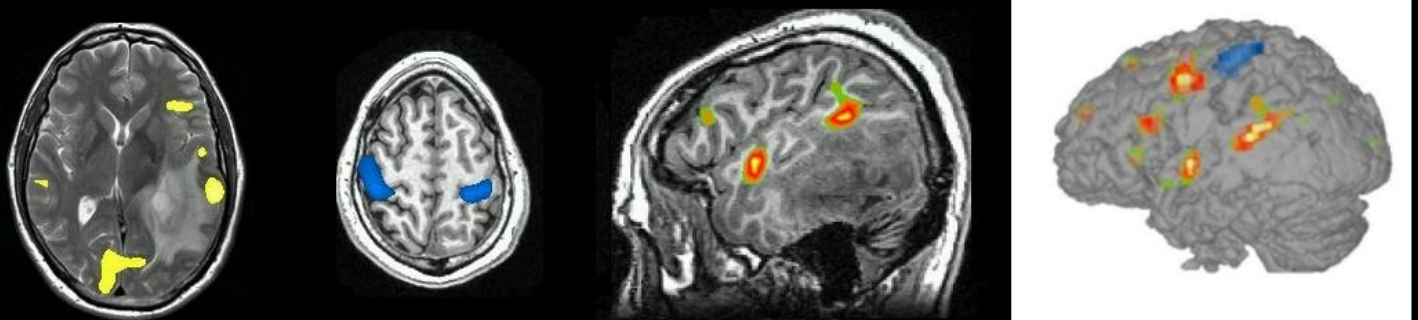
Diffusion maps and white-matter tracts from DTI

Summary fMRI maps can combine multiple task areas and pathology
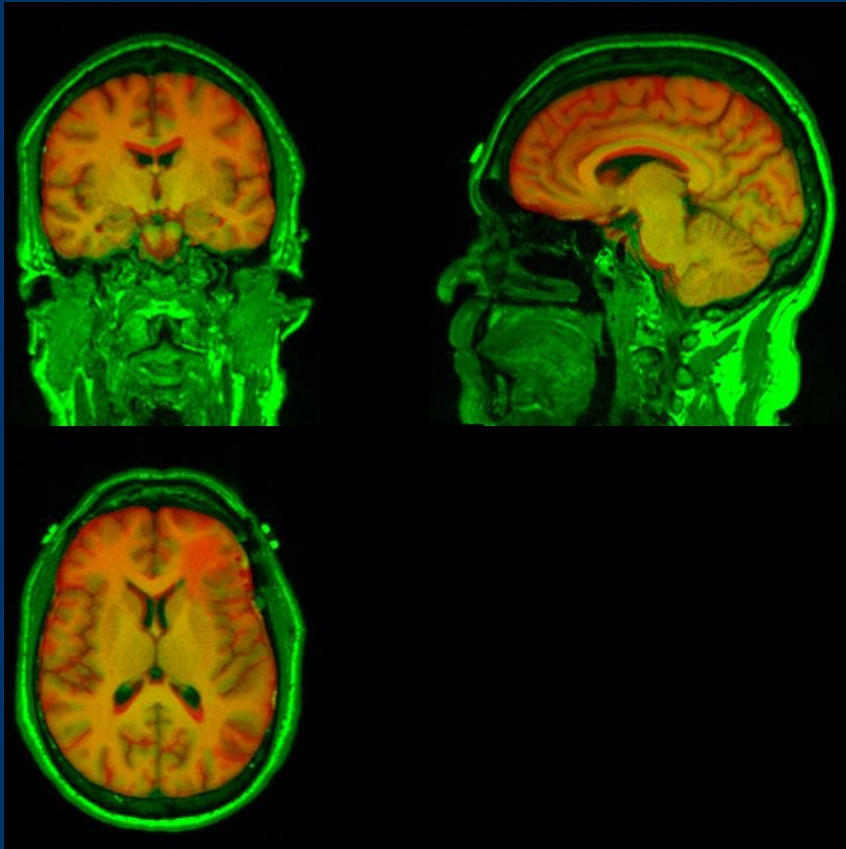

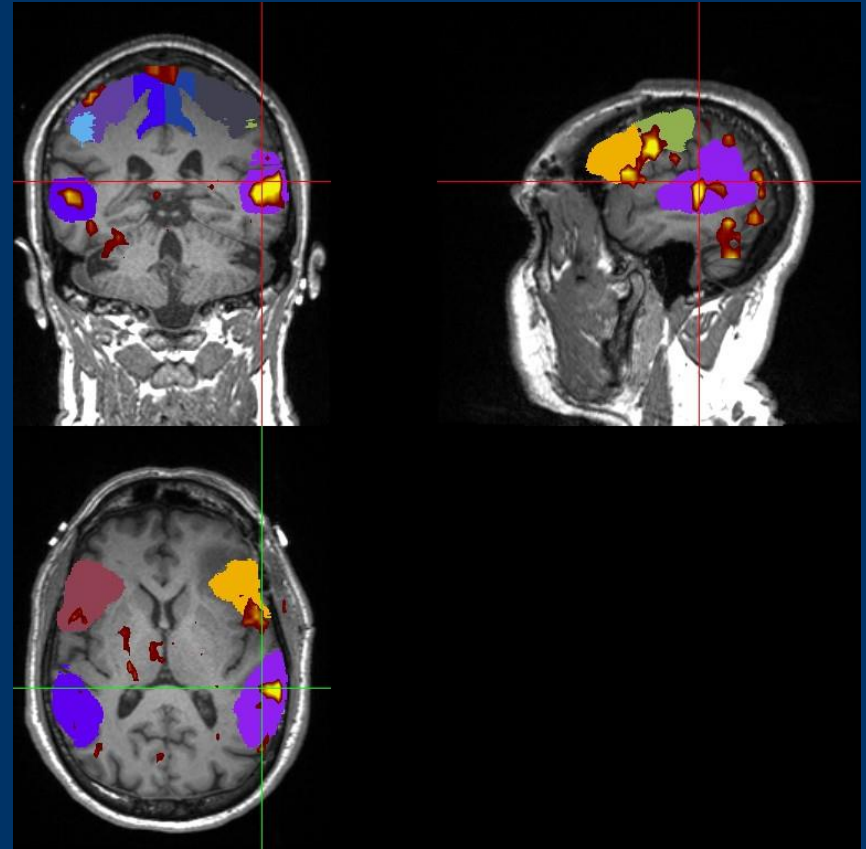
Yellow=Language   Blue=Mouth   Green=Hands
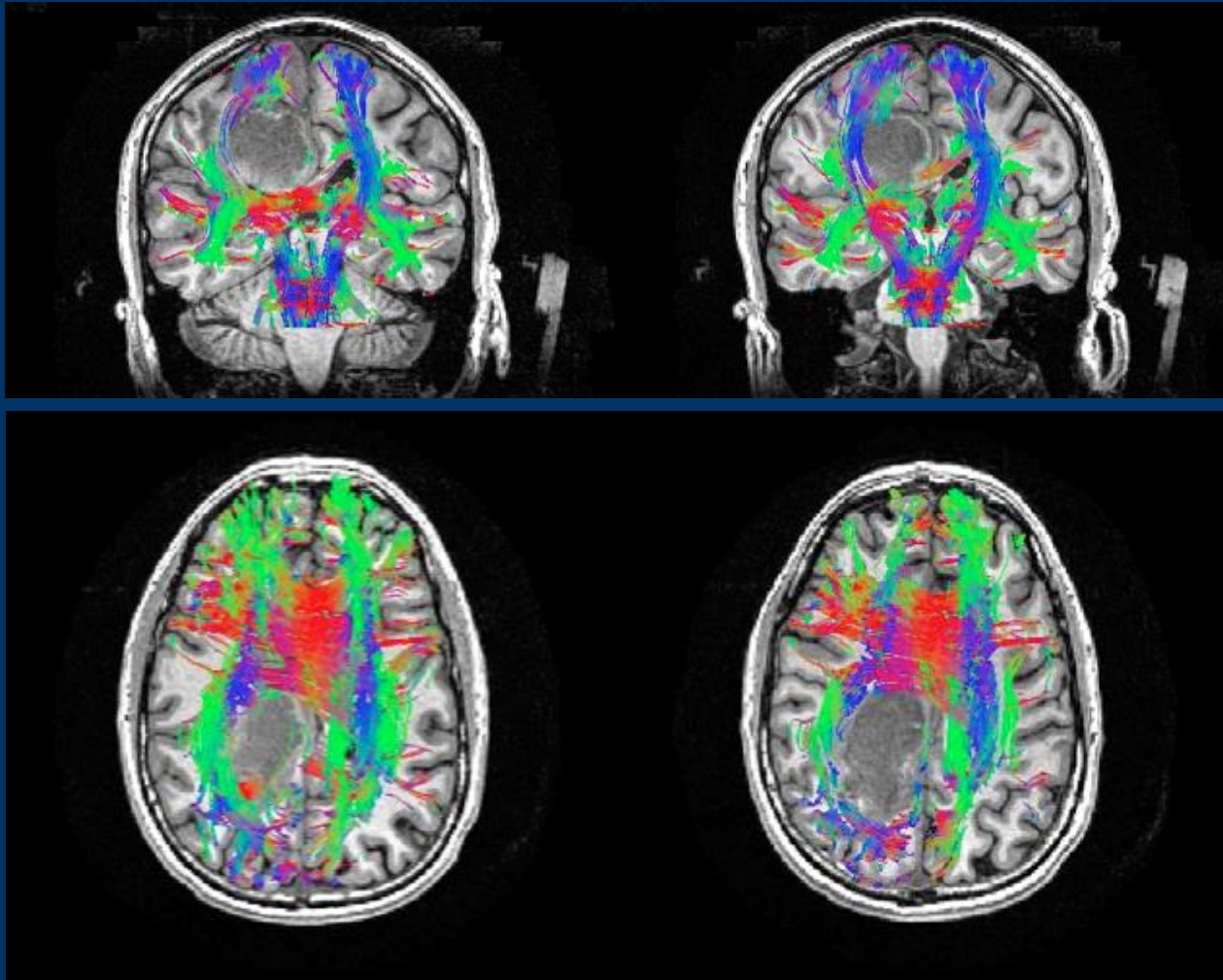
Quantifying fMRI activations

Align atlas brain (MNI152)
to patient brain

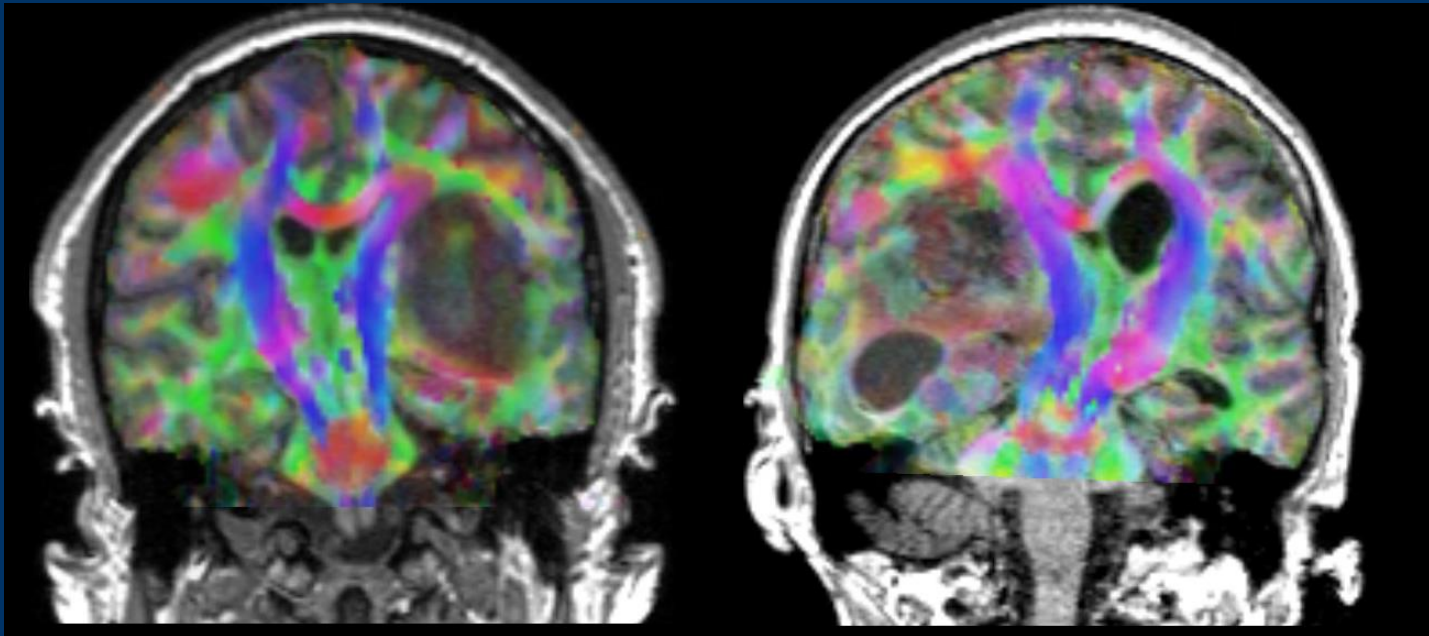Measure activation, L vs R,
in selected ROIs

Laterality Index: (LeftActiv-RightActiv)/LeftActiv+RightActiv)

Overlay DTI fiber tracks on anatomy

3-D DTI fiber-tracks are generated interactively using specialized image processing software
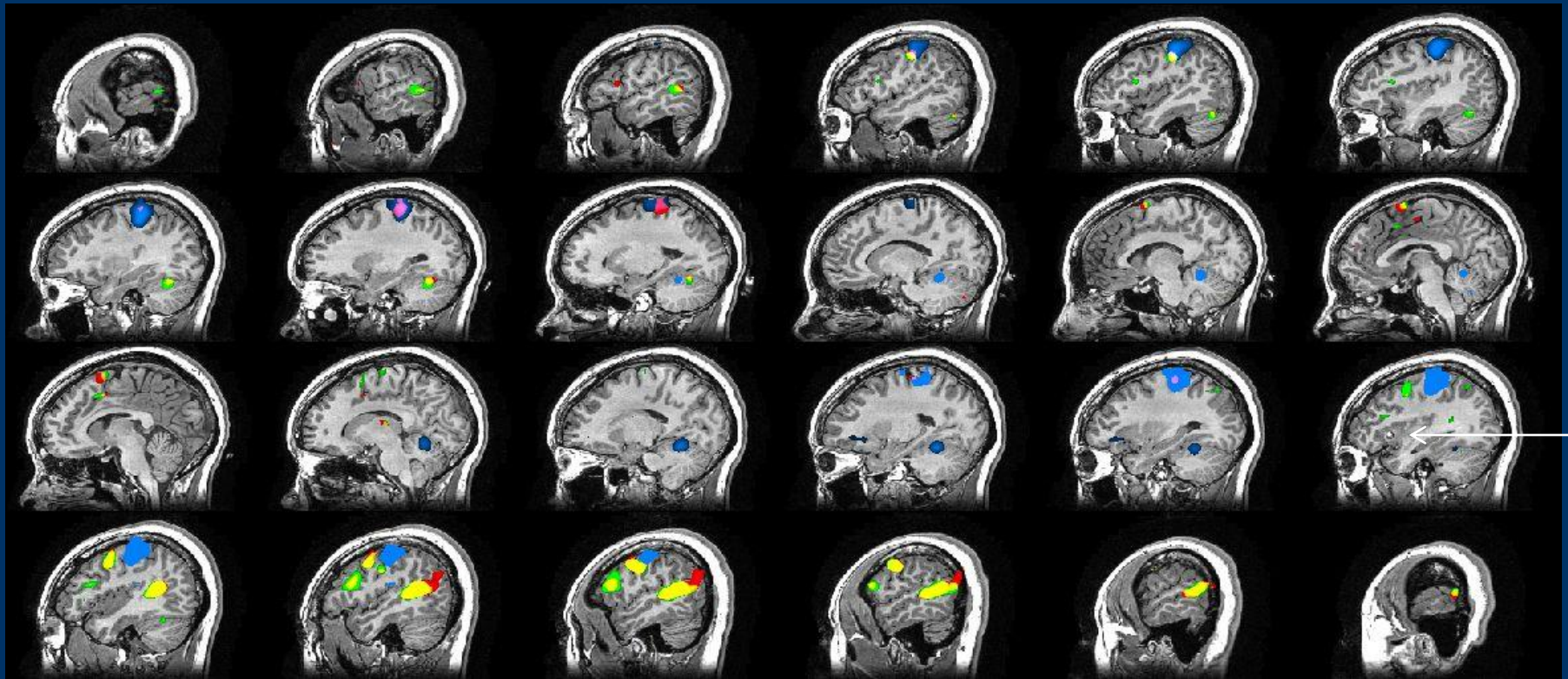
Overlay DTI color-coded FA map on anatomy

Color-coded FA maps are generally produced by
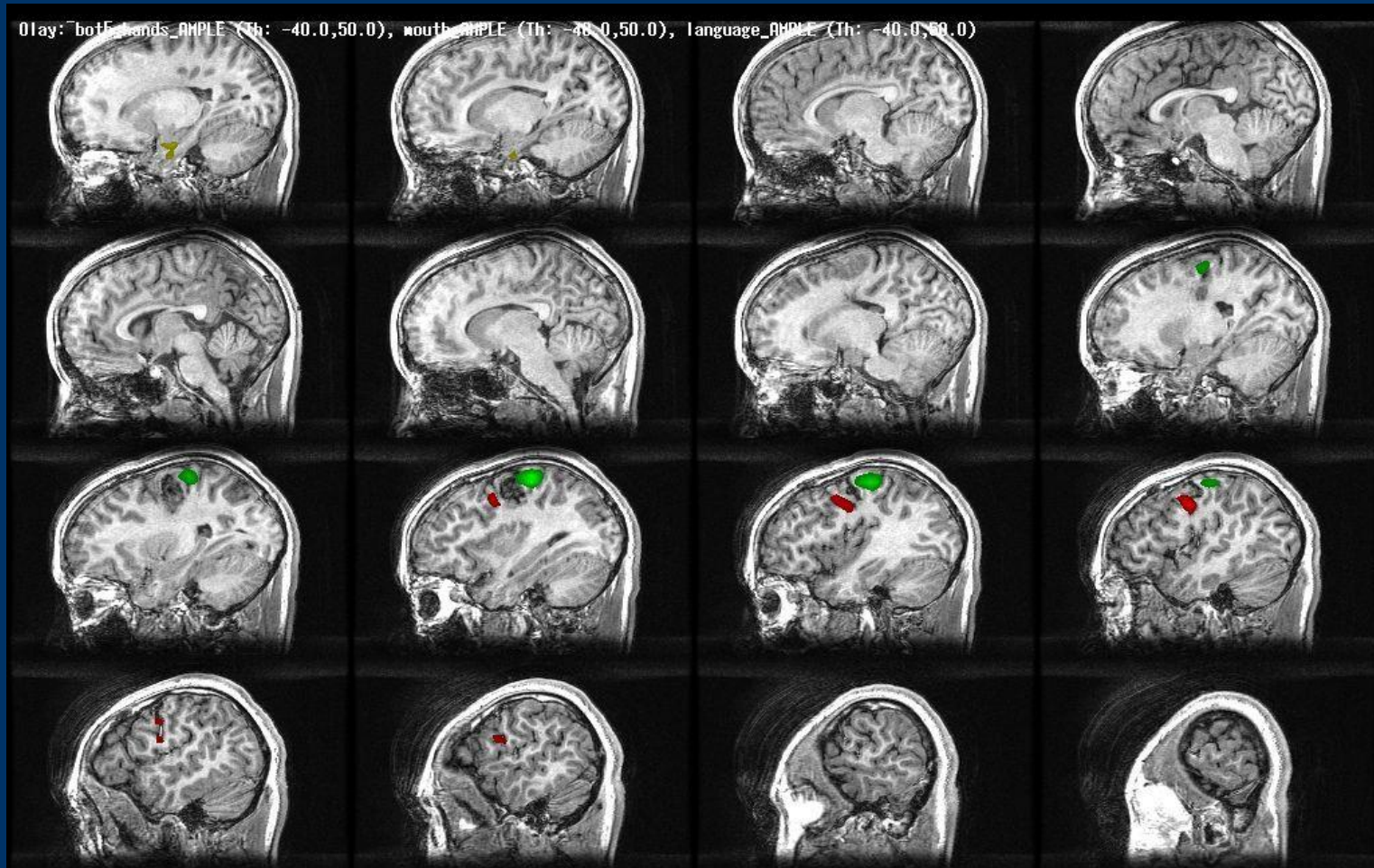MR scanner software automatically at end of scan

Example fMRI results: LH 23yo F with cancer

Yellow – 1st sentence-completion map
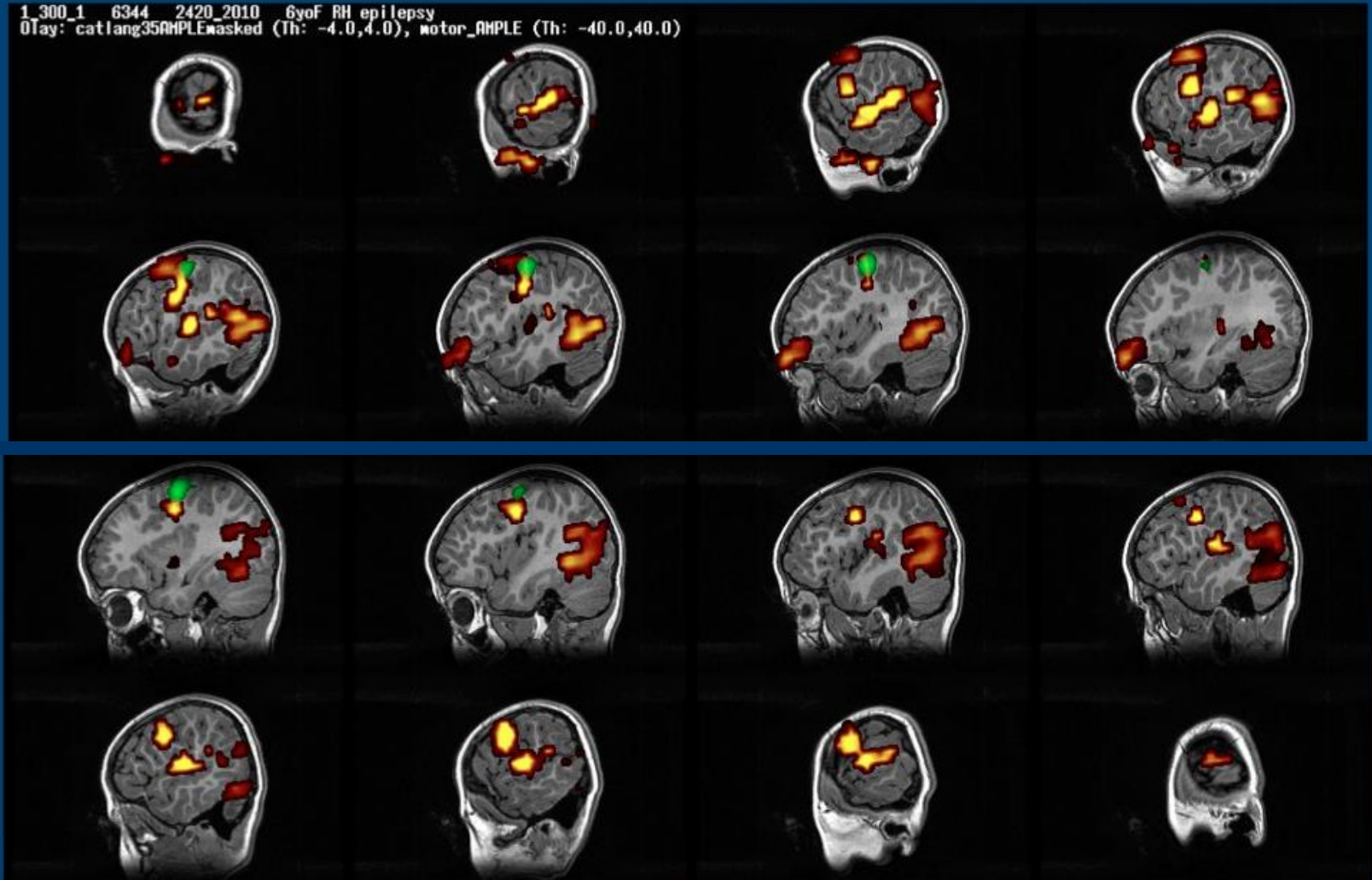Green – 2nd sentence-completion map
Blue – hand movement map

RH 10yo F with AVM

Green – hand movement map
Red – mouth movement map

RH 6yo F with Epilepsy

Yellow/Red – storybook language map
Green – hand movement map