


Quick Guide fMRI summary (for experienced users)

InVivo Computer (Windows PC)

Log in: **Sensavue** Password: **sensavue***

Turn on magnet room TV screen (power box ->



Start CIGAL using the green “CIGAL” icon  on desktop

(If the menu does not appear soon, press <Enter>)

Display eyechart on magnet room screen

Check display box – backwards ‘R’ next to “fMRI” label should be lit

Train patient on tasks

Explain tasks using fMRI tablet, get them relaxed. They should understand instructions but don't need to memorize them

Tablet has prerecorded instruction videos for both English and Spanish tasks

Take time for training – explaining the tasks is very important

Check vision – find suitable MR glasses if can't see examples on tablet

Check reading and movement abilities

Put patient in scanner

Turn on and set up monitor (Sensavue screen can be close to scanner)

Use scanner headphones (so they will hear instructions)

Put extra pads beside ears to keep head still (should feel snug)

Adjust mirror (install normally on Siemens, reversed on GE)

Make sure the pt can see the eyechart and read the “KRMH” line

Press spacebar on fMRI keyboard and ask if patient hears "testing" in headphones

– if not, adjust volume of scanner headphones

Scanning

Select fMRI protocol

Note: Show pt CIGAL “slide show 1” on screen during anat scans

Run Localizer, sagittal T1 (MPRAGE or SPGR), axial FLAIR

T1 should be sagittal, no tilt

FLAIR on Siemens is straight axial, no tilt

On Siemens, put bottom of FLAIR Rx at bottom of cerebellum

(Need to scan significant air above head to reduce wraparound)

On GE, FLAIR will be same oblique axial slices as functionals

On Siemens 3T, prescribe "Shim" as same slices as functionals

Functional Rx are oblique axials (AC-PC); must include lesion

Locate lesion in T1 images

If there is no obvious lesion Rx is bottom of temporal lobe upwards

Need to let “shim” prep (~1 minute) but can “skip” actual scan

Do functional scans – at least 1 language and 1 motor task (details below)

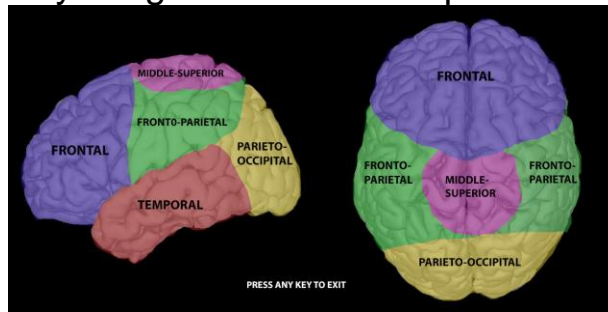
After functionals, do axial tensor DTI scan for all patients

Straight axial images (no tilt) – Rx top slice near top of brain (not skull)

No task – can show patient “slideshow 2” (5min) to reduce fidgeting

Functional scans

Can select "All Tasks" or select the "Tasks by Anatomy" option in CIGAL
Select "Show Anatomy Image" to see this map:



For deep tumors (e.g. insula, midbrain) select Temporal.

Task selection

Use menu to select brain region closest to the patient's lesion

1st task scan should be: "Sentences – Run 1"

2nd task scan should be: "Both Hands Motor"

3rd task scan depends on where the lesion is:

Middle Superior: "Left foot" if lesion is on right, "Right foot" if left

Otherwise: Do "Sentence 2" task (similar to Sentence 1)

May need to redo "Hands" if map was bad

Before each task, do "Practice" version from menu

While practice runs, patient should hear recorded instructions.

If not, you should remind them what to do.

Also remind them to relax and stay still

To run real task:

Select it from "Paradigm" menu, click Okay (screen goes black)

On GE scanner, do "Prep scan" to get scanner ready

On Siemens, ready when it says "continue"

Starting scan and task (both GE and Siemens):

Start the scanner first, it will start to countdown from 4:06

At exactly 4:00, press the spacebar on the task computer

Look at the patient screen to make sure task started

To stop CIGAL task before the end, press 'q' (for quit)

During scan, check real-time fMRI results on scanner console (see below)

At end of scan, click Okay in CIAGL window to save task information

Bring up 'fMRI Review' website on separate workstation

URL: hawking.biac.duke.edu/fmri

Read instructions on website page if unfamiliar

Username: mrtech Pwd: brainmap

Diffusion Tensor Scan

Always do DTI (tensor) scan (details in Scanning section above).

Check fMRI results during scan

Siemens:

Open scanner's "Inline display" window 

Check for clusters of yellow dots in language or motor areas

Brain covered with yellow means pt is too stressed

Brain surrounded by yellow ring means head motion

If really bad after 1 minute, stop scan and tell pt to relax and stay still

GE:

Go to Tools screen on console

First time: Select "Service Desktop Manager"; then click "C shell"

In C shell command window, enter command:

`initfmri`

For each functional series, enter:

`rtmap X` (where X is the series number)

Transfer images

Best to send each scan series after it has completed.

Siemens:

Send to PACS:

T1 and FLAIR (don't need to send 'ND' versions)

the 1st and 6th (EvaSeries GLM) of 7 series for each functional EPI scan

all Ax Tensor series

all optional series scanned (e.g. post-contrast, etc)

GE:

Send all imgs to PACS

fMRI Review Website

2-3 mins after sending series to PACS images should appear on website

Each task will show head motion plot and brain activity map

If brain map looks okay (QA value > 10 and reasonable blobs) then

motion probably doesn't matter

Enter handedness (RH, LH, Ambi)

Enter Comment (optional) if the scan was unusual

Jim will be watching website as well and will add his QC comments

Troubleshooting

CIGAL not doing anything – press <Enter> key

Stop CIGAL task before end – press 'q' key (quit)

No sound from computer – check volumes, then cables (!?)

Help – contact Jim Voyvodic cell: (919) 260-3449 email: jim.voyvodic@duke.edu

fMRI Manual -- Table of contents

Quick guide

- Short summary for experienced users

Site Preparation

- Scanner room setup

- fMRI computer – hardware and software

Patient Preparation

- Training the patient

- Putting patient into scanner

- Keys to successful fMRI

- Organization of brain function

Scanning Protocol

- Siemens Protocol

- GE Protocol

- Running a fMRI task

- Real-time fMRI maps – Siemens

- Real-time fMRI maps – GE

- Sample fMRI maps

- DTI scan

- Sending images – Siemens

- Sending images – GE

Training

- Language tasks

- Motor tasks

Site preparation

Scanner room setup

Inside the magnet room there is:

An MR-compatible video monitor

This gets moved behind the magnet for fMRI scanning

It can be as close to the magnet as you want

The monitor power supply on the floor against the wall.

This should not be too close to the magnet

The power on/off switch on this box turns on/off the video monitor

We don't usually use the Sensavue headphones nor the button boxes

Use the normal patient headphones instead

Head-coil needs mirror mounted to see the flat panel screen

On Siemens scanner attach mirror normally but move to see screen

On GE scanner attach mirror in reverse orientation and adjust mirror

fMRI computer – Hardware Overview

fMRI uses InVivo's patient entertainment system (SensaVue) to tell the patient what to do. The Sensavue equipment consists of the following components next to the scanner console:

A Windows computer, monitor, keyboard, and mouse

A communication box




Must be on in order for the patient monitor to work



Verify correct display orientation – backwards 'R' next to "fMRI" label should be lit

A button control box (white "Lumina" box behind the communication box) should be on but is not usually used

Running the CIGAL task software

When logged in on the Windows computer you should see a green CIGAL icon  on the desktop (it may also appear on the task bar at the bottom).

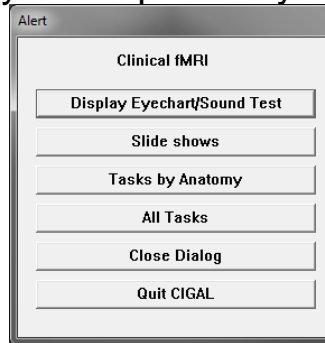
Double-click the green CIGAL icon on the desktop (or single-click the icon in the task bar) to start the task software program.

(CIGAL is Duke software written by Jim Voyvodic – it is not from InVivo).

CIGAL should fill the monitor with a mostly gray screen. There will be a user-interface menu in the middle of the screen:

[Note: If the screen is blank when it shouldn't be, or CIGAL pauses unexpectedly at anytime, press the <Enter> key]

The user-interface should be fairly self-explanatory.



Display EyeChart/Sound test:

This just puts an eye-doctor's letter chart on the screen.

Put it on when the patient is getting ready; make sure s/he can see the screen okay.

Letters will look backwards to you, but should look correct in patient's mirror.

If s/he can read the "K R M H" line that is good enough

(everything else will be at least that big).

If the patient can't read KRMH you should give them a pair of the plastic eye glasses (a full set is in a black binder in the control room)

Pressing the <spacebar> on the keyboard will cause the word "testing" to play through the headphones. Use this to make sure the patient can hear.

Ask what they hear, they should say they hear "testing".

If you just ask if they can hear okay they may just think you mean can they hear you, so they say yes even if nothing came through the headphones.

To end the eyechart, press 'q' or <ESC> on the keyboard.

Slide shows:

Each "slideshow" is a set of pretty pictures to look at during anatomical scans.

Tell the patient they can look at the screen or close their eye, whichever they prefer. There is nothing to do during the pictures.

There are 2 slideshows, one is 10 minutes and the other is 5 minutes

To start a slideshow, select it from the menu, then press any key (except 'w') on the keyboard to start the pictures

To stop the slideshow before the end, press 'q' on the keyboard

"Tasks by Anatomy" or "All Tasks"

Choose "tasks by anatomy" to see selected recommended tasks depending on where the patient has a brain lesion.

Choose "all tasks" to see a bigger list of all tasks

Click “Other Languages” or “Other Tasks” for more options

Practice tasks

There is a short practice version of each task to remind the patient what to do. Run the corresponding practice immediately before scanning a task

To run a practice, select it from the menu, then press any key (except ‘w’) on the keyboard to start it

fMRI tasks

Select tasks from the list of options. All tasks run for 4 minutes.

Specific tasks selected will depend on the patient (see Organization of brain function) but usually include “Sentence Run 1” and “Both hands” tasks.

To run any task:

Choose task from CIGAL menu – it will pause until scanner gets to 4:00 mark

Let the patient know the scanner is about to start

Start scanning – watch the scan time clock

When the clock counts down to 4:00, press CIGAL’s spacebar to start the task

Synchronizing the task and scanner is very important.

If the task starts before 4:01 or after 3:59 (scan time) you should stop and restart

Press ‘q’ on the task computer to abort the task

Patient preparation

Training the patient

fMRI depends on the patient performing simple tasks while the scanner is running. It is essential that they understand what they need to do BEFORE entering the magnet.

There is an iPad tablet with pictures and videos to help train the patient

Pictures are in Photos in the “fMRI” album

Training videos are in Videos (both English and Spanish videos are available)

In the screening room you should show the patient each task and make sure they can do it reasonably well. Most patients will do a Language task and a Hand motor task. They may do other tasks depending on the location of the lesion (see Organization of Brain Function).

The following is a typical training session:

“If you have had an MRI scan before this will be similar, except that for part of the scan we will give you simple tasks to perform so that we can see what part of your brain you use to do different things.”

“All the time that you are inside the scanner you will be able to look through a mirror to see a big computer screen.”

“For the first 10 minutes or so, there is nothing for you to do except stay still. We will put some photographs on the screen so you have something to look at. You can either look at the photographs or close your eyes and rest, whichever you prefer.”

[show sample photographs on tablet or from “Training” section of manual]

“When it’s time to do a task, we will tell you. You will look at the screen to see what to do and when to do it.”

[Now show the patient the tasks they will do – see tablet or “Training” pages]

“Don’t worry about remembering these instructions. When it’s time to do a task we will go over the instructions again to make sure you are ready.”

“This is not a test, just relax and do the best you can.”

Testing eyesight

If the patient wears eyeglasses you should check whether they will need glasses to see the video screen in the scanner. Have them take off their glasses and show them the eyechart picture in this manual (see Training).

If they can't read the eyechart (KRMH line) you will need to have them try the MR-compatible lenses until you find a pair that helps them read.

There is a full set of corrective lenses with a plastic frame in a binder in a drawer in the control room.

Putting patient into scanner

The patient goes into the scanner the same as for any other brain scan, except for the following:

- 1) If the patient needs eyeglasses, put the plastic glasses on when they are lying down.
- 2) Put on the scanner headphones – they need them to hear task instructions
- 3) Put extra padding to keep the head still (wedges next to the ears work well). Patients will tend to move during tasks so make sure the padding is snug (but comfortable)
- 4) Give them the squeeze ball but suggest they let go of it when it is time to do the hand movement scan (put it so it will not fall if let go)
- 5) Attach the mirror to the head coil and adjust so they can see the screen.
On Siemens: attach mirror as normal but slide forward so they use the back mirror to see the video screen
On GE: attach the mirror backwards so they can use the moveable portion to see the video screen
Both: put your head between the mirror and the monitor and adjust the mirror until you can see the patient's eyes. They should then be able to see the whole screen when you get out of the way. Adjust the mirror until they can see the screen comfortably.
They should be able to see the "KRMH" line in the middle of the eyechart display (assuming you have put the eyechart on the screen).
Reassure the patient that if they can see that (KRMH) they will be fine
- 6) Make sure they can still see the screen after being moved inside the bore

Keys to successful fMRI

1. Try to help the patient relax.

Tension causes motion, poor task performance, and strange activation patterns in the brain. If you can get them to laugh during the training session the scans will work better.

2. Make sure they can do the tasks.

Show them at least one full cycle of each task during the training session and have them actually do it.

Many patients ask questions because they are worried about doing things correctly – be reassuring.

Some (eg. doctors and lawyers) will feel the practice is not important – admit that the tasks are boring but they do need to be done properly in order to see where they occur in the brain

If they can't do a reading task, give them an audio version of the same task, or a picture-based task (for kids).

3. Make sure they keep their head still

Add extra padding wedges to hold the headphones in place.

For foot movement tasks, elevate the ankle so that the foot can move freely

4. Watch the real-time brain activation signal on the console

You should see a few clusters of yellow dots in appropriate brain regions (see Sample Activation Maps).

Lots of yellow dots around the edge of the brain indicate head motion. Remind them to stay still; start over if it is too bad.

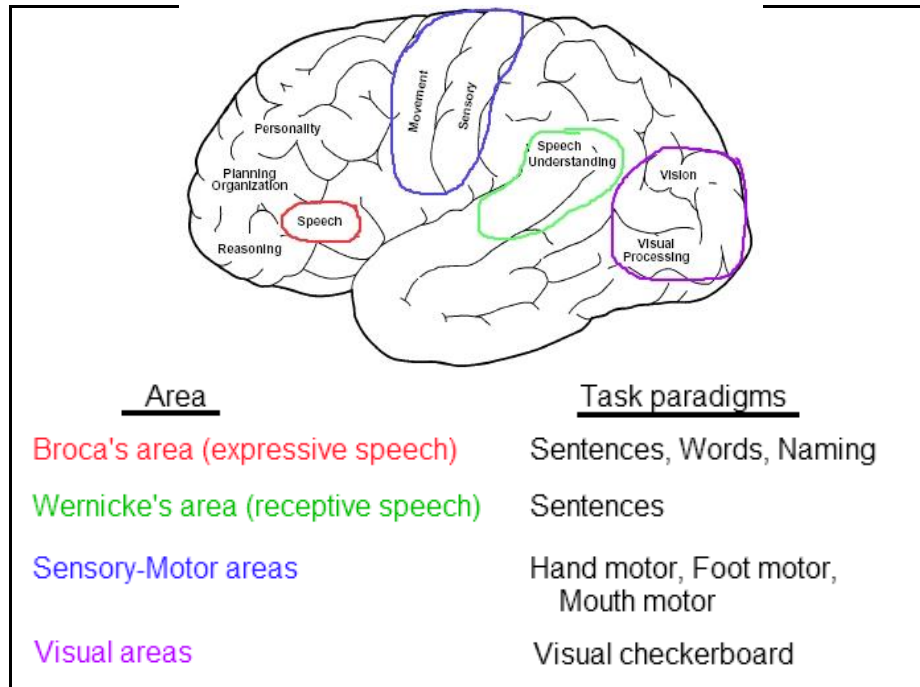
Lots of yellow dots all over the brain indicate stress. Remind them to relax; start over if it is too bad.

5. If a scan has problems, talk to the patient then try again.

Ask if they have questions. Help them to relax (“don't try too hard”), and remind them to stay still.

Organization of Brain Function

The goal of clinical fMRI is to locate specific areas of brain function, particularly areas controlling language (speech) and movement. If those areas are damaged during brain surgery it can have devastating consequences for the patient's subsequent quality of life. Neurosurgeons need to know, therefore, if those areas are close to the region they plan to resect. Knowing where the lesion is can indicate which brain functions need to be mapped with fMRI.

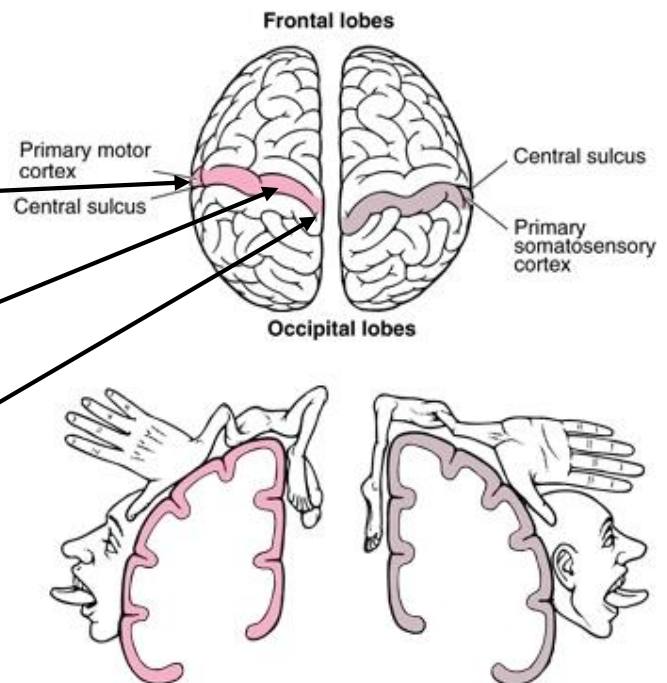


Organization of the sensory-motor strip:

The face and mouth area is inferior frontal and more lateral.

The hand area is large, near the top of the brain.

The foot area is small and near the midline.



Scanning Protocol

The scanning protocols for Siemens 3T and GE 1.5T are similar. During the anatomical (“standard sequences”) part of the protocol you can show the patient the 10 minute “Slideshow” in CIGAL’s Paradigm menu.

Siemens scanner

Protocol name: Brain – fMRI Latest

Standard sequences:

Localizer

T1 MPRAGE – Brain in center; Sagittal; Do not tilt in any plane

FLAIR – Whole brain; No tilt; Leave ~1cm air at top of skull to avoid wrap

“Shim” EPI – This is for prescribing functionals and doing extra shimming

26 slices, oblique axial; tilt only in sagittal view to line up brain

Make sure this includes the lesion:

All of temporal lobe if primarily for language

Top of brain if primarily for motor

Prepping for the “shim” will take a couple of minutes; when it is ready to scan you can click “skip”; now the scanner is ready for the EPI tasks

The slice prescription from “shim” will be copied to all the EPI scans

GE Scanner

Protocol name: Brain fMRI

Standard sequences:

Localizer

T1 SPGR – Brain in center; Sagittal; Do not tilt in any plane

FLAIR – 21 slices, oblique axial; tilt only in sagittal view to line up brain

Make sure this includes the lesion:

All of temporal lobe if primarily for language

Top of brain if primarily for motor

Increase from 4mm to 5mm thick if large head

You will copy the FLAIR prescription for all the EPI scans

fMRI scans

The scanning protocol (both Siemens and GE) contains several EPI task scans. All task scans listed have identical scanning properties; they differ only in their names. It is important that the name of the scan agrees with the task the patient performs; otherwise it is very difficult to interpret the images that are acquired. If necessary, rename a scan to match its task.

Selecting fMRI tasks

You will never run all tasks

“Sentence Language” as first functional scan

“Hand motor” as second functional scan

Third functional scan:

For a frontal or temporal lesion do “Sentence language run 2”

For fronto-parietal lesion near midline, do “Foot motor”

For a lateral fronto-parietal lesion, do “Mouth motor”

Practicing a fMRI task

Immediately before running any task, you should show the patient the short “practice” version of that task (in CIGAL’s Paradigm menu).

Select the practice task from CIGAL’s Paradigm menu, “Okay” when asked,

Press <spacebar> to start the practice

For the sentence and both hands practice task the patient will hear pre-recorded instructions.

For foot or mouth practice tasks you will need to talk to the patient as there are no pre-recorded instructions.

“Can you see the cross okay?”

“When the picture starts to flash, go ahead and move your foot/mouth – keep moving as long as the pictures are flashing.

“Keep your leg/head still, only move your foot/mouth”

Watch to see that the movement is correct. It should start on cue, move the hand or foot smoothly and fully, s/he should not lift the arm or leg, and s/he should stop when the stimulus stops (approximately).

For all tasks:

“Relax, and remember to keep your head totally still all the time”

Scanning a fMRI task

Select the task from CIGAL’s Paradigm menu


The “Ready to scan” window should say 4:00 (or 4:06 on GE); click “Okay”

On GE: You should “Prep” the scanner before starting task

Start scan, then and press the <spacebar> when the scan clock gets to 4:00.

If you need to stop the task before the end, press ‘q’

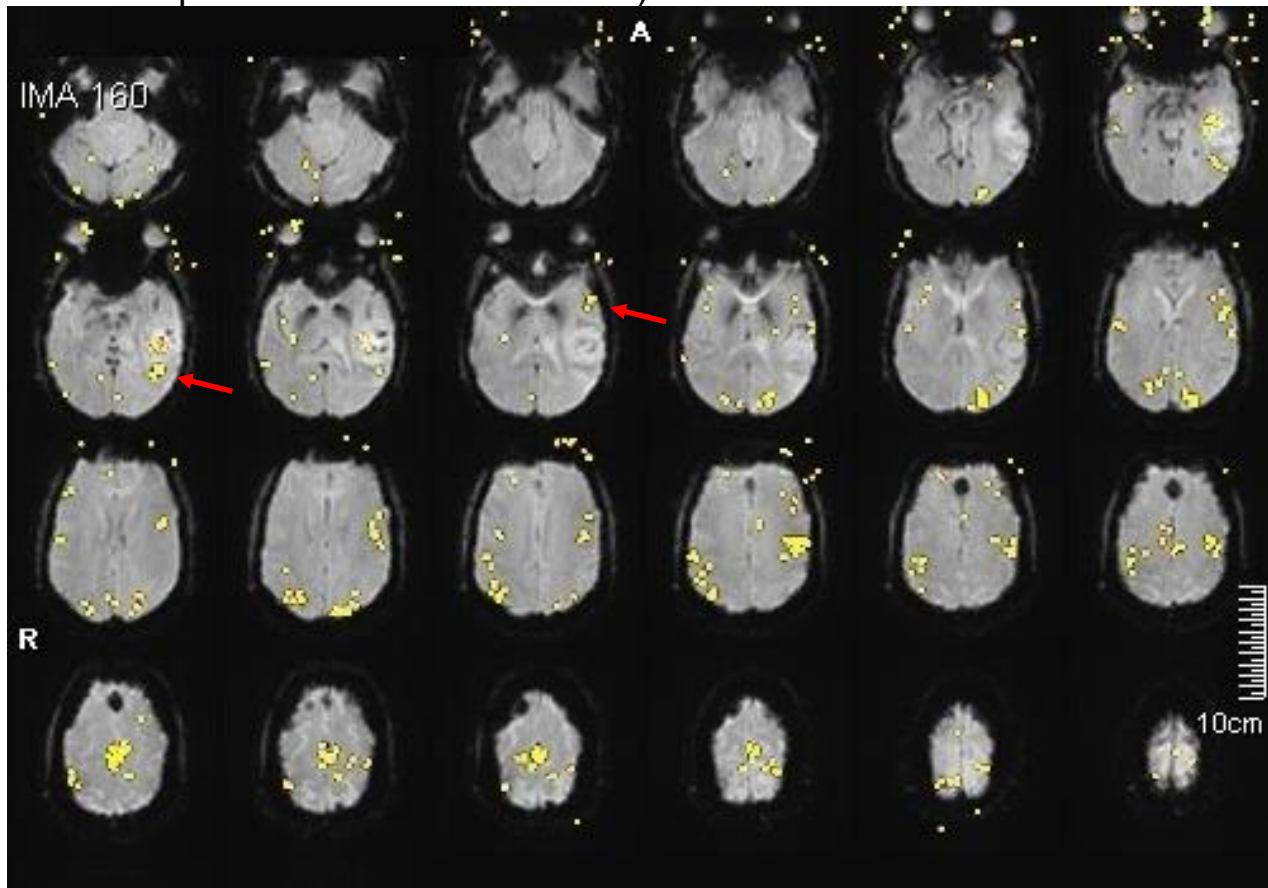
Real-time fMRI maps – Siemens

While the fMRI task is being scanned, click the "Inline Display" icon  on the Siemens console. This will open a new window to show the brain activation map. The window will be blank until about 20 seconds into the scan.

Brain regions that are "active" (signal changes with task) should appear as clusters of yellow dots. Single yellow dots on their own can be ignored. The pattern of dots may vary at first but should stabilize as the scan proceeds.

Check for clusters of yellow dots in language or motor areas

A good language (sentences) map will look something like this (the red arrows point to clusters in the speech areas on the left side):

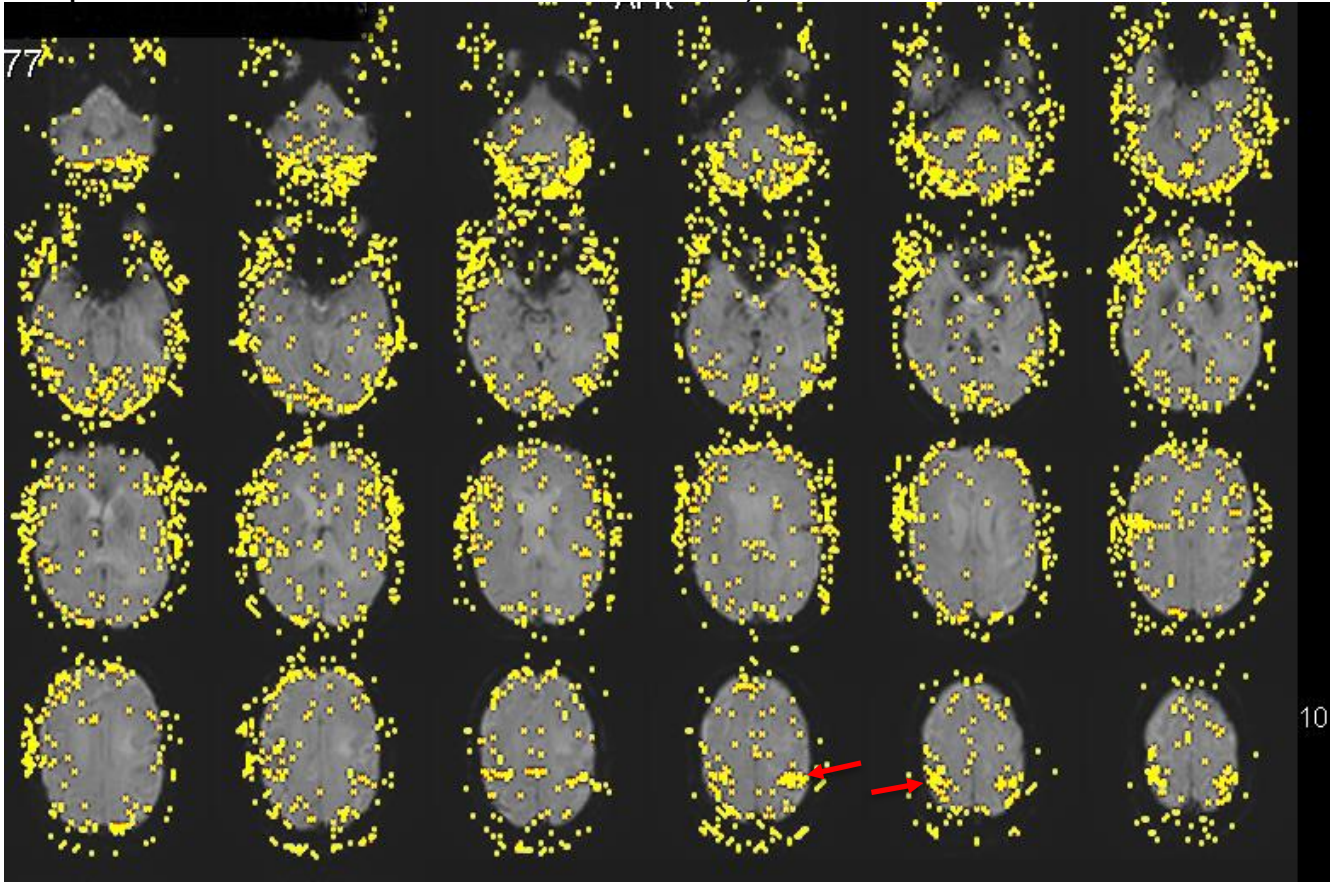


If the brain is covered with yellow it usually means the pt is too stressed.
If the brain is surrounded by a thick yellow ring it means the head is moving.
If you see excessive stress or motion after 1 minute, and can't see clusters in language or motor areas, stop the scan and tell the pt to relax and stay still.

Stop the CIGAL task by pressing 'q' on its keyboard.

Retry the scan after talking to the patient.

This is an example of a hand motor map that is good enough, but not great (the red arrows point to clusters in the hand motor cortex):



The yellow dots outside the brain are probably due to jaw muscles and eye movement; they are distracting but not a major problem. Yellow dots covering the brain making it hard to see the important clusters is a problem.

fMRI Review Website

2-3 mins after sending series to PACS images should appear on website

Each task will show head motion plot and brain activity map

If brain map looks okay (QA value > 10 and reasonable blobs) then motion probably doesn't matter

Enter handedness (RH, LH, Ambi)

Enter Comment (optional) if the scan was unusual

Jim V will usually be watching website as well and will add his QC comments

Real-time fMRI maps – GE

The GE scanner in the DMP does not have GE fMRI analysis software.

It does have customized fMRI software from the BIAC (written by J Voyvodic) that will display head motion plots and brain activation maps while scanning.

To use this software, do the following:

- 1) After starting your first fMRI scan, open the tools display (icon next to the browser icon)
- 2) Select the “Service Desktop Manager” tab
- 3) Click the “C shell” option to open a command window
- 4) In the command window that pops up, enter:
initfmri
- 5) Then enter:
rtmap X -- where X is the current series number
for example: rtmap 6
This will use fScan to display a brain function map and a head motion plot
- 6) The scan will stop automatically, after the scan ends:
Click the “Exit” option in the “fscan” window
(if you are still scanning this may take awhile to respond)
(you can force fScan to close with <Control>C in the command window)
- 7) Return to the scanning window for the next scan series
- 8) After you start the next fMRI scan, return to the Tools screen
Close the previous display if it is still open (click “Exit”)
Run “rtmap” again with the new series number
- 9) After the last functional you can close the command window

Saving fMRI task data

When the task ends

A dialog box will appear for saving the task information.

There should be a “scan name” to indicate what the patient was doing.
(e.g. “right foot motion”)

Add a Comment if anything unusual happened.

DTI scan

Do axial tensor DTI scan for all patients (no task; slide show 2)

Straight axial images (no tilt) – prescribe with top of stack near top of brain

No task – can show patient “slideshow 2” (5min) to reduce fidgeting

Transfer DICOM images

Scanner images should be sent to PACS at the end of each series

QC processing starts after images get to PACS so the sooner you send images the better

Siemens:

Send all images to PACS

EXCEPT: “ND” anatomical images

2nd, 3rd, 4th, 5th, and 7th task EPI series

Each task generates 7 series – just send 1st and 6th (EvaSeries GLM)

GE:

Send all images to PACS

Running the fMRI tasks

Each task lasts 4 minutes

Task names should match scan series names
(rename series on scanner if necessary)

Start the task.

Select the task from the “Paradigm” menu

For the “Sentence” task, use “Run 1” the first time

If you need to repeat the task, use “Run 2” for new sentences

A “Ready to scan” window will pop up to show the scan time.

Press “Okay”

Make sure the scanner is ready

On GE, you must “prep” the scan at this point

Manual start (this is more reliable than the automatic start):

Start the scanner first, when it’s scan clock counts down to 4:00 press the spacebar on the CIGAL computer to start the task

If you need to stop a task before the end, press ‘q’ to quit

Otherwise it should stop at the same time the scanner stops

Watch real-time brain activation on the scanner console.

See page titled “Real-time fMRI maps” (Siemens or GE)

When the task ends

A dialog box will appear for saving the task information. Add a Comment if anything unusual happened.