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: Double-click green “CIGAL” icon on desktop
   (If the menu does not appear soon, press <Enter>)
Display eyechart on magnet room screen

Train patient on tasks
Check vision – find suitable MR glasses if necessary
Check reading and movement abilities
Explain tasks using fMRI tablet, get them relaxed, ask for questions
   Take time for this – explaining the tasks is very important

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 any key on fMRI keyboard and ask if patient hears “testing” in
   headphones – if not, adjust volume of scanner headphones

Scanning
Select fMRI protocol
   Note: Can show pt “slide show 1” on screen during anatomical 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 GE, FLAIR will be same oblique axial slices as functionals
   On Siemens, put bottom of FLAIR Rx at bottom of cerebellum
      (Need to scan significant air above head to reduce wraparound)
On Siemens 3T, prescribe "Shim" as same slices as functionals
   Need to let “shim” prep (~2 minutes) but can “skip” actual scan
Functional Rx should be oblique axials (AC-PC); must include lesion
   Locate lesion in T1 images (check scan order to see if it's listed there)
      If there is no obvious lesion Rx is bottom of temporal lobe upwards

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

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:
   Frontal: Do "Word" task
   Temporal: Do "Sentence 2" task (similar to Sentence 1)
   Middle Superior: "Left foot" if lesion is on right, "Right foot" if left
   Other: Redo "Hands" if map was bad, otherwise do "Sentence 2"

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

During scan, check real-time fMRI results on scanner console (see below)
At end of scan, save task information on PC
For 1st task, ask if patient is Right or Left handed and enter RH or LH
(or BH if both) in the Comments box.
If there were problems make a short note in the Comments box
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 excessive 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:
    - rtmapp X (where X is the series number)

Transfer images
You can send each scan series after it has completed.

Siemens:
- Send to both PACS and DynasuiteNeuro:
  - localizer
  - T1
  - FLAIR
    - the 1st and last of 7 series for each EPI scan (1st plus Mean and t-map)
    - the 1st Ax Tensor series (and GRE field map if done)
- Send only to PACS:
  - all extra Ax Tensor data series (ADC, FA, etc)

GE:
- Send to both PACS and DynasuiteNeuro:
  - Loc
  - T1
  - FLAIR
  - DTI
- Send only to DynasuiteNeuro:
  - All functional EPI scans
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

Flat panel monitor on rolling stand
  Needs to be placed behind scanner when in use
  (Must be at least 3 feet away from magnet or it may flicker)

Power supply for monitor (white box on floor)
  Make sure LED is on – Switch is near the power cable

Audio headphones (use scanner headphones on Siemens and GE)

Button boxes (not used for most fMRI tasks)

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 (ESys) to tell the patient what to do. The ESys equipment consists of the following components next to the scanner console:

  Two Windows computers, one on top of the other
    (only the top computer is used, or bottom if top is broken)

  A communication box (black “InVivo” box on top of the computers).
    On/off switch is on the back of the box (upper right)

  A button box control box (white “Lumina” box on top of others)
    On/off switch is on the back of the box (upper right)
    (this box is normally not used)

  Touch screen monitor, keyboard, and mouse

  Video switch (flat box with 2 big buttons under or behind the monitor)
    This switches the monitor, keyboard, and mouse between the 2 ESys computers. It is not used if only one computer is being used

  Audio switch (behind monitor or main scanner console)
    Switches scanner headphones between music and fMRI
Turning on ESys fMRI equipment

First, check whether the fMRI computer is already on – wiggle the mouse or press <Enter> on its keyboard. If it’s on you’ll see something on the monitor.

If the fMRI computer is already on:

1) Check the display power box on the floor in the magnet room
   - turn it on if the LED on the box is off
2) If the flat panel monitor in the magnet room remains black, check that the black communication box on top of computers is turned on (LED on)
   - turn it on if the LED is off; the switch is on the back of the box

If the fMRI computer is not on:
Check its blue power light. If on, press and hold power button until it shuts off.

Turn on the equipment in this order:

1) Turn on the display power supply box on the floor in the magnet room
2) Turn on the black communication box on top of the computers
   (switch is on the back of the box, near the top)
3) Turn on the fMRI computer
   (switch is the horizontal metal button near center)
4) If you will use the scanner to start the tasks, turn on the white button “Lumina” box controller (sitting on top of the ESys computers)
   - you can leave that box off if you will start the tasks manually

Note: If you turned on the “Lumina” box and the cursor arrow starts jumping around on the monitor you need to either turn off that box (and start the tasks manually), or else unplug and then replug the USB cable for the white Lumina box. This is the black USB connector plugged into the front of the computer; just pull it out and then put it back in. That should stop the cursor jumping. If it doesn’t, leave that box turned off and start the task “manually” (see Running fMRI Tasks, below).
Logging in and adjusting display settings

Logging in:
If you are not logged in you will see the main log-in screen
(users: eSys, Admin, fMRI, Tech, …)

Log in as user:   tech
Password:          techtech1   (or it may be "tech1" or just "tech")

When logged in you should see a green “CIGAL” icon on the desktop. If you don’t it probably means that the monitor and keyboard are seeing the bottom ESys computer. To switch to the top ESys computer, press the big round buttons on the video switch box (under the monitor in CC; behind the monitor in DMP) until you get a different display (you may need to wiggle the mouse or press <Enter> on the keyboard to wake up the display).

Note: Logging in as “tech” will bypass the InVivo software and let you use Duke’s “CIGAL” software for fMRI, or Windows MediaPlayer for DVDs. If you want to use InVivo’s software for fMRI or playing DVD’s go to the page titled “Running the E-Sys software”

The following assumes you have logged in as “tech” and see the CIGAL icon.

Adjusting display settings:
Make sure the monitor in the magnet room is on.
If not, see “Turning on Equipment” page.
Make sure the monitor in the magnet room is configured properly
(it probably will be if the computer was already on)

If the text on the patient screen is too small (or picture is too small):
Right-click on the desktop and select “NVidia Control Panel”
Select “Change resolution” settings
Click on the magnet room video display: “M 300”
Make sure the resolution setting is: 1200 x 800 (native)
Accept change if asked. Then close the control panel.
Running the CIGAL task software

After logging in as “tech” you should see a green CIGAL icon on the desktop.

Double click the green CIGAL icon to start the task software program.
(This is Duke software written by Jim Voyvodic – it is not from InVivo).

CIGAL should fill the monitor with a mostly gray screen. The only thing you should need to use is the “Paradigm” pull-down menu.
[Note: If CIGAL pauses unexpectedly at anytime, press the <Enter> key]

Use the “Paradigm” menu to find:

**EyeChart:**
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.
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 that you should give them a pair of the plastic eye glasses (a full set is in a black binder in the control room)

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

**Slideshows:**
Each “slideshow” is just photographs 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

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.
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.

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 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 “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) comfortably 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 cupboard 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
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.

<table>
<thead>
<tr>
<th>Area</th>
<th>Task paradigms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca's area (expressive speech)</td>
<td>Sentences, Words, Naming</td>
</tr>
<tr>
<td>Wernicke's area (receptive speech)</td>
<td>Sentences</td>
</tr>
<tr>
<td>Sensory-Motor areas</td>
<td>Hand motor, Foot motor, Mouth motor</td>
</tr>
<tr>
<td>Visual areas</td>
<td>Visual checkerboard</td>
</tr>
</tbody>
</table>

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
       24 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
   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 an anterior frontal lesion do “Word language”
For a 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

While running the practice, talk to the patient (make sure they hear you):
For the sentence task:
“Can you see the words okay?”
“Remember to read the whole sentence to yourself and add a word at the end that makes sense. Do not say they words out loud or move your mouth. Just think about talking to yourself. Repeat the sentence in your head if it is still there.”
“When you see nonsense just look at the screen and relax – try to let your mind go blank”

For hand or foot movement tasks:
“Can you see the hands (or cross) okay?”
“When the picture starts to flash, go ahead and move your hands (foot/mouth) – keep moving as long as the pictures are flashing.
"keep your arm/leg still, only move your hands/foot"

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 must “Prep” the scanner before starting task – Important!
Start scan and press the <spacebar> to start the task at the same time
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.
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

Sample fScan Display
Saving fMRI task data

When the task ends
   A dialog box will appear for saving the task information.
   Make sure there is 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
   Siemens:
      Send to both PACS and DynasuiteNeuro:
         localizer, T1, FLAIR, the 1st series for each functional scan (1st of 7 series), the 1st Ax Tensor series (and GRE field map if done)
      Send only to PACS:
         all extra Ax Tensor data series (ADC, FA, etc)
   GE:
      Send to both PACS and DynasuiteNeuro:
         Loc, T1, FLAIR, Ax Tensor
      Send only to DynasuiteNeuro:
         All functional EPI scans
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):
   Press the computer's spacebar and start the scanner at the same time

Automatic start (needs "Lumina" box on top of computer turned on):
   Press ‘w’ on the keyboard for CIGAL to wait for the scanner
   The task should start automatically when the scanner starts
      On Siemens, there will be a 6 sec delay before the task starts

   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.