

C I B S R

Center for Interdisciplinary Brain Sciences Research

STANFORD UNIVERSITY



MRI Simulator Reference Manual

Revised May 31, 2011

Introduction

The MRI simulator (Psychology Software Tools, Inc.) is designed to parallel the experience a participant will encounter during an actual MRI scan. The simulator consists of a 12-foot mock scanner with a 6-foot tapered bore, motorized table, head coil, visual and auditory presentation systems, and equipment for monitoring subject response to the training procedure. Two speakers are placed within the bore in order to deliver prerecorded gradient sounds to the subject. Behavior analysis and therapy techniques are used to counter-condition fear or anxiety experienced in response to the imaging equipment and procedures. In brief, this process involves careful control of the salient stimuli in the imaging environment, systematic gradual exposure to the equipment, personnel, and sensations involved in image acquisition.

We employ differential reinforcement of the child's efforts to inhibit body motion when instructed to do so. The differential reinforcement procedures used to train motion control are derived from Dr. Reiss' previous work with scan preparation and are implemented with the assistance of a computer-assisted measurement and feedback device. Using this equipment, head movement can be measured with accuracy to .5 mm/sec. The child is able to listen to music, hear a story or watch a movie during the training. This "entertainment" serves as both a distraction and immediate reinforcement for inhibiting movement. That is, if the participant exceeds a pre-set movement criterion, the entertainment is automatically interrupted for a brief interval to provide both immediate feedback and a contingent consequence for motion. The entertainment resumes when movement is again inhibited below the established criterion. The movement criterion can be adjusted according to the participant's current ability and gradually made more stringent as training progresses. Tangible prizes are awarded at the end of each training session. The entire training process usually can be accomplished in one to three 30- to 60-minute training sessions.

Accomplishments and Future Goals

The MRI simulator and the potentiometer were constructed in 2000/2001, and moved and seismically bolted to its new location in Grant Building Rm S085 in December 2010. Since its construction, forty-four mock scanning sessions were conducted on thirty-two neuroimaging subjects with bipolar disorder, autism, Turner syndrome, and developmental delay of unknown etiology, resulting in the below standardized protocol. Since then, there have been hundreds of mock scan sessions done on a wide population of subjects across a variety of projects in our lab and amongst collaborators. Scanned populations include the ones mentioned above, as well as children and adults with fragile X syndrome, velo-cardio-facial syndrome, post-traumatic stress disorder, Williams syndrome, obsessive compulsive disorder, and more.

Mock scan sessions have been found to be extremely helpful in familiarizing the participant with the MRI sounds, environment, and amount of stillness needed to achieve a good scan. To help decrease the anxiety associated with an unfamiliar, large machine and loud noises, we will be

incorporating an optional fabric covering that may be used at both the simulator and the real scanner. This space-like fabric will simulate a friendlier scenario such as “entering a spaceship” and “exploring space”.

Goals of the session

The duration of mock scans and the number of breaks given will depend on the participant’s age and length of expected protocol at the real scanner. Try to get 15 minutes of scanning prior to giving the first break outside the machine. Aim for 30-40 minutes of scan time. If the participant is to be scanned on the same day as the simulator session, aim for no more than 25 minutes of simulation scan time as to avoid exhausting the participant prior to the real scan.

Once the child is able to stay in the simulator for a total of 30 minutes with a 1mm cut-off criterion (and a maximum of 5 video shut-offs during a 10 minute scan), he is probably ready for the actual scan. At that point, aim for 5 minutes of mock scanning without the video, so that he is accustomed to being in the scanner listening to the MRI noise without the video stimulus. For children with borderline ability to remain still (video shuts off more than 8 times over the course of a 10 minute scan) or those who improve over the course of the session but are still too fidgety, ask the parents to bring them back for another mock scan session.

NOTE

If you have difficulty following this protocol for a subject, or you have any unusual experiences at the simulator session, please write a detailed email about it to the simulator manager so that we may continue to refine the protocol and benefit from your knowledge.



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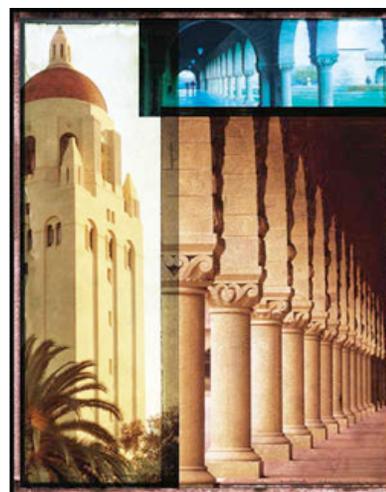
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Overview Of The Simulator Procedures

Prior to Simulation Day:

- 1) Prior to mock scan and family visit, a video of the MRI session is sent to the family. Instructions are given to parents on how to prepare the child for the simulator session.
- 2) MRI sounds and additional preparatory video/materials may be viewed on the simulator webpage:



<http://cibsr.stanford.edu/participating/HomePreparation.html>

Scheduling:

- **Steps:**
 1. Get added onto the Google scheduling calendar & Stanford listserve (mri_simulator@lists.stanford.edu).
 - a. Contact the Simulator Manager with your name, research group, research purpose, Stanford email, and Gmail address.
 2. Check both calendars:
 - a.  [CIBSR Simulator Calendar](#)
 3. Record selected session times on the “CIBSR Simulator Calendar”
 - a. Insert: “project name (your initials)”

Day of Simulation:

- 1. Arrive at Grant Building Rm. S085 with family. **Ask family to take a seat in the holding room.**
- 2. Prior to bringing the child into the mock scanner, you should **prepare the stimulator**. This includes placing a pillowcase (covering the foam padding) in the head-coil and laying a sheet on the simulator mattress (fig1.1).



Fig 1.1. Sheets are stored on the black book shelf in the simulator room

- 3. **Show apparatus to child**, including computer, head coil, on/off switch, tunnel, potentiometer, and sound system (fig. 1.2).



Fig 1.2 The simulator bore and potentiometer

4. **Explain the reward** (fig. 1.3.) the child will receive for completing the mock scan; continue to reinforce this during the mock scan session.



Fig 1.3. A selection of toys are kept in the simulator suite

5. Have the child **choose a movie** to watch during the session (fig.1.4). Explain that the movie will not be finished and the sounds may not be heard, and that it is important to keep still. You may use YouTube as well.

Explain that the movie will shut off for a brief moment if the child moves above a certain threshold.

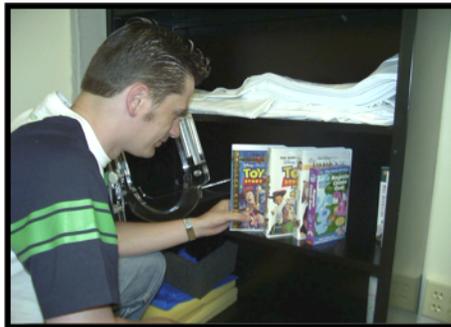


Fig 1.4. A selection of DVDs are kept on the black book shelf in the simulator room.

6. **Ask the child to remove his shoes, accessories (i.e. earrings, watch, hair ties), belt, and empty all pockets.** Do this as you would at a regular scan session to remove potential metal components.

MRI Simulator Setup Procedure

- 1) **To display movies:** Insert selected DVD into the computer and open PowerDVD and select “Play” (fig.2.1.a). Then re-size the DVD window to the upper left corner window as specified by the green tape. *Do not open LabVIEW yet.

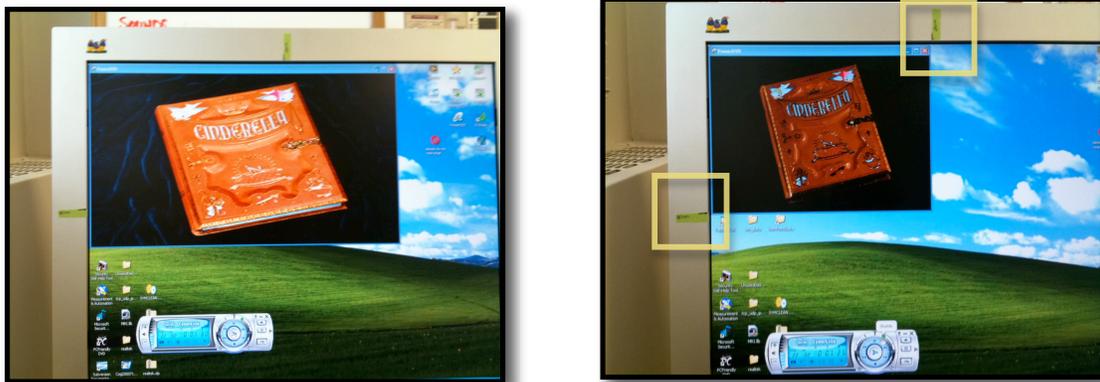


Fig 2.1a. PC screen setup to display movies. Participants will only see this upper left hand corner of the screen.

To display PC (E-prime): You will need to display the whole screen to your participant. You should **not** be using the potentiometer during this time. Skip step 4) if you are displaying E-Prime.

To display from your laptop: When using a laptop, attach the blue connector cable (next to the blue box on the ledge) to your laptop (fig. 2.1.b).



Fig 2.1b. Connect blue cable attached to this blue box to your laptop to display your laptop screen. Toggle blue box to select “3”.

- 2) **Turn on the power strip** (fig. 2.2). The switch light on the power strip is illuminated when the power is on. This turns on the lights and fan within the bore.



Fig 2.2. The power strip is under the simulator bore.

- 3) **Test the AVerMedia** (fig. 2.3). Unplug and re-plug-in the white RCA cable on the AVerMedia to reset the input.



Fig 2.3. Connect RCA cable to appropriate AVerMedia jack (next to the computer) indicated by white tape.

- 4) **Configure AVerMedia** *do **NOT** do this for E-Prime games* (fig. 2.4). Turn **"zoom"** ON & leave "overscan" ON.

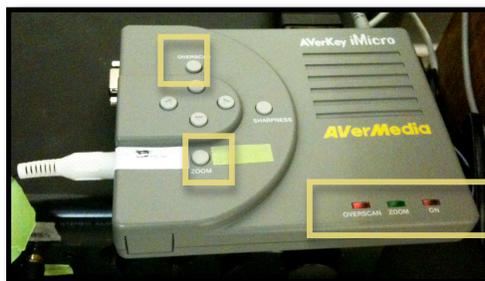


Fig 2.4. Lights should be **red** for "overscan" & "on", **green** for "zoom".

Note:

If "overscan" light is blinking, unplug everything from it and *correctly* re-plug them in one at a time until it stops blinking. If it doesn't, call the sim manager to restart the computer or troubleshoot.

- 5) **Select the appropriate settings** (fig. 2.5a & b).

On the **blue box**, choose connection **2** to source display from the PC screen. Select connection **3** to source display from a laptop.



Fig 2.5a. Select display input: “2” for movie/PC and “3” for laptop.

Turn on TV screen w/ silver switch indicated by green arrow to make sure the display is working (fig. 2.5b). Then unplug the AC/DC adapter on the screen if it is connected.



Fig 2.5b. Green arrow for switch & yellow box shows AC/DC adapter.

- 6) **Tell the child he will be listening to sounds from a number of scans** – several 5 min. (Track 4) and several 10 min. scans (Track 6), with an optional break in the middle when they can come out of the machine (depending on the child’s ability to hold still).



Fig 2.6. Child sitting on top of the scanner bed.

- 7) **Have the child sit on the scanner bed. Insert earplugs into child's ears & put on headphones.** If necessary, use a round toy in the toy cabinet to simulate a squeeze ball, sponges to simulate the heart rate monitor, belt for the respiratory belt, and the button box for the functional tasks. Lay down the **massage mat** which will simulate the shaking of the 3T2 during the DTI sequence.



Fig 2.7. Respiratory belt, sponges for heart rate monitor, and “squeeze ball”.

- 8) Once the child lies down, **have him push himself into the headcoil** while keeping his hands flat by his side.



Fig 2.8. Subject with the head in coil.

- 9) **Move the bed into the tunnel** using the right-most switch as indicated (fig. 2.9). Watch out for the cables attached to the TV screen so that they do not catch under the table.



Fig 2.9. Use rightmost switch indicated by blue arrow.

- 10) Once the child is inside the bore, **attach tape on all sides of the suction cup**. Move potentiometer into the headcoil (just above the child's head) and **secure suction cup to the child's forehead**. Make sure the potentiometer arm is angled correctly (fig 2.8) with the yellow arrow pointing into the scanner. The potentiometer arm should have room to move (retaining the inverted "V" shape). If the arm is extended such that the angle is $>90^\circ$, measurements may not be accurate.



Fig 2.10 The potentiometer and a member of staff moving potentiometer into a good angle

NOTE: See separate instructions for LabView, potentiometer, and MRI sounds setup in Chapter 3.

- 11) Make sure the child is comfortable in the tunnel and that his abdomen would not block the projector beam from throwing light onto the screen in the actual scanner.
- 9) Ask the child to move his hands and legs into a comfortable position; remind them not to move head or extremities during scans.
- 10) Remind the child that the movie/screen will turn off for a few seconds at first when you start LabVIEW, and later on if they move too much.

ONCE YOU'RE DONE...

1. Switch **TV screen OFF**
2. **If** battery icon shows up on the TV screen, the battery is low. Please, **plug in** AC/DC adapter to TV screen
3. On AverMedia box, turn **"zoom" OFF** & leave **"overscan" ON**
4. Turn **white powerstrip OFF**

CONTINUE TO CHAPTER 3

LabView • MRI Sounds • Potentiometer Operation

ψ Start the video before opening LabView. The video won't start if LabView is already opened on the computer.

Setting up LabView:

- 1) Double click “LabVIEW” icon on the desktop.

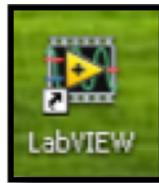


Fig 3.1. LabView located on desktop

- 2) Click “training.vi” at the Labview prompt.

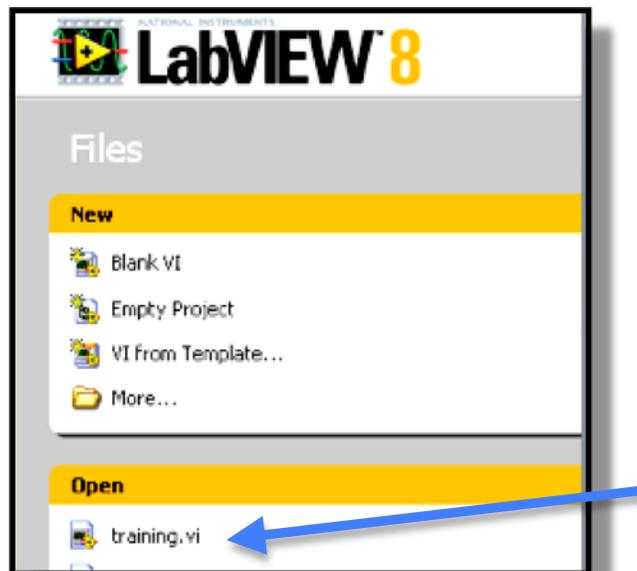


Fig 3.2. Click “training.vi” once LabView is opened.

3) Fill in session parameters. Suggested parameters shown below (fig. 3.3.)

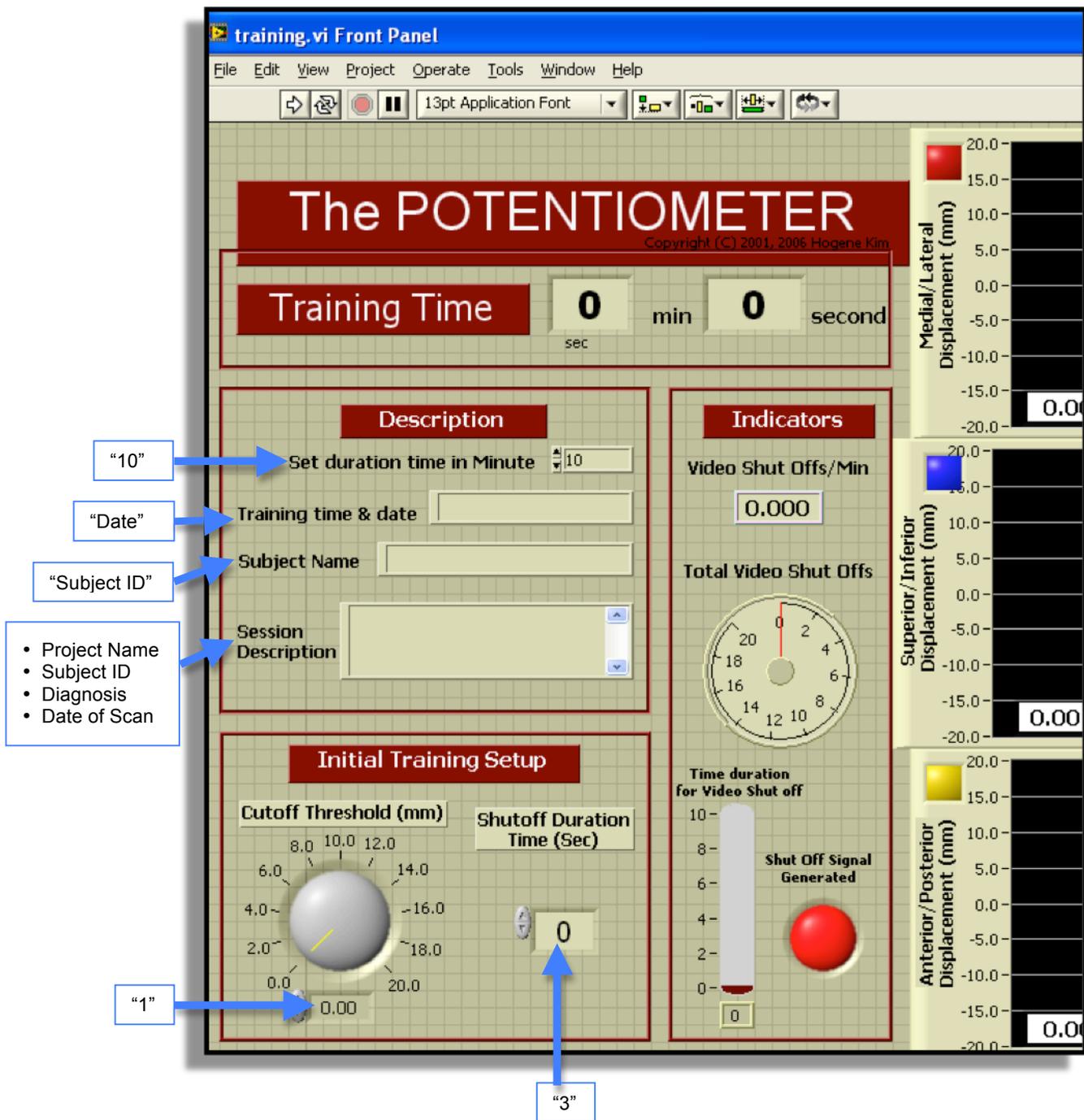


Fig 3.3. Fill in parameters using this LabView potentiometer GUI. Arrows indicate available parameters. Explanations for each parameter in Appendix A1 "LabView Parameters".

- 4) Select “Operate” → “Run” at the top of the window.

Enter appropriate file name. Do **NOT** click “OK” until you are ready with the potentiometer & MRI sounds. Otherwise, the program will start immediately.

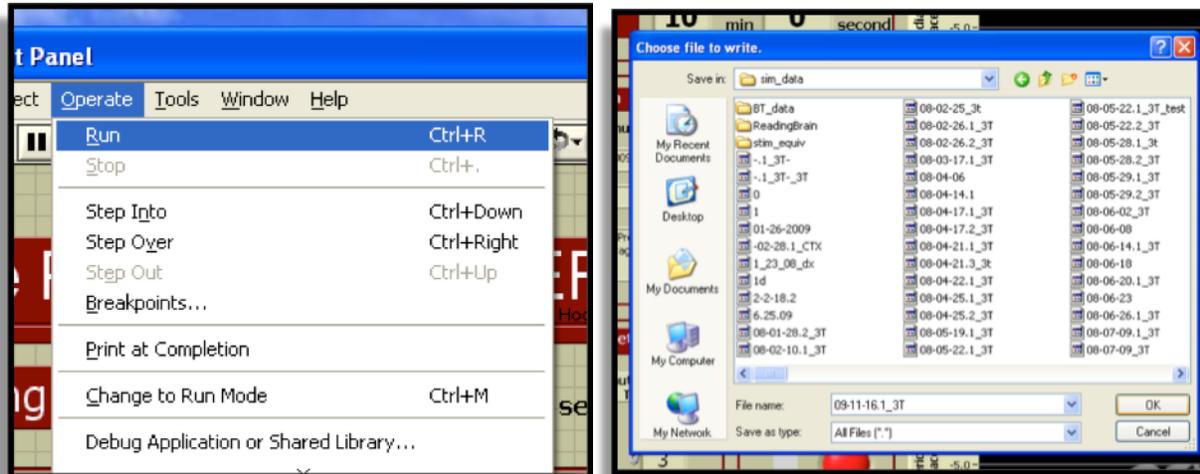


Fig 3.4. Remember the program will start as soon as you click “OK” so make sure you have the audio ready, prepared the child, and attached the potentiometer before clicking “OK”.

Note: Files should be saved as “YY-MM-DD.(simSession#)_(scannerToBeUsed)” e.g. “09-12-11.1_3T”.

Attaching the Potentiometer:

- 5) Once you have situated the child in the head coil and moved him into the scanner, **place the potentiometer on the head coil.**



Fig.3.5. The potentiometer attached to the forehead of subject

The potentiometer must be placed with the **yellow arrow pointing** into the scanner and the base adjusted parallel beneath it. Also, check that the

potentiometer arm is at an angle so it has room to move. If the arm is stretched out ($>90^\circ$), it won't measure movement accurately.

Note: If the suction cup does not rest well on the child's forehead, be sure to attach tape to the underside of the suction cup for stability.

MRI Sounds:

- 6) Let the child know how long the scan will be, then open **iTunes** and select the Track matching the duration time you entered into LabVIEW. **(For a 10-minute scan, select Track #6. For a 3- or 5-minute scan, select Track #4. For a 1-minute scan, select Track #2.)** Remember to check the sound in the headphones before playing the track & DVD. These sounds will be louder than the DVD sounds, participants are able to hear both.

Track 01	"Intro to the MRI"	
Track 02	"MRI Sounds-mixed"	[1 min]
Track 03	"Intro to the Structural Scan"	
Track 04	"Structural Sounds"	[5 min]
Track 05	"Intro to the Functional Scan"	
Track 06	"Functional Sounds"	[10 min]
Track 07	"3T2 DTI Sounds"	[10 min]

Start Potentiometer Recording:

- 7) To start the potentiometer recording, **click "OK"** on the LabView window after you have entered the filename ("Operate" → "Run" → "OK").

Note: If the potentiometer fails, a bell at the head of the bore may be used to discourage movement and provide feedback to the child.

- **Sit behind scanner**, monitor head movement, and give **verbal feedback** during and after the scans. ("Remember not to move your head... keep your hands down.")
- *Optional*—After the child has learned how to keep the video on at 1mm cut-off criterion and you are confident he can restrain himself from moving excessively, do at least 5 minutes of scanning with the video off so that they get used to being in the simulator without the video stimulus.

After the Simulation & Clean Up

Moving the Child Out:

- 1) Before moving the table out of the simulator, you must first detach the potentiometer from the child's forehead and move the potentiometer off the headcoil before moving the table.



- 2) **Move the scanner bed out** of the bore by flipping the right-most switch on the simulator.
- 3) Once the bed is out, give the child positive feedback.
- 4) Have child collect belongings and put his shoes back on. Then have him return to the waiting area while you finish cleaning up.

Clean Up:

- 1) Return DVD to shelf. If E-Prime was used, be sure to exit out of the programs but do **not** shut down the computer.
- 2) Use wipe to disinfect potentiometer's suction cup.
- 3) Turn off the power strip.
- 4) Remove and place used linen into laundry basket.
- 5) Lock the door and turn off the suite's lights as you exit the suite.

LabView Parameters:

- **Set duration time in Minute** – duration of simulated scan in minutes (change this for each scan). Make sure this corresponds with the selected MRI sounds track duration.
- **Training time & date** – enter date of simulator session.
- **Subject Name** – subject's ID number or initials (for HIPAA purposes)
- **Session Description** – project name, subject ID/initials, diagnosis, and date of simulation
- **Cutoff Threshold** – for a typical child, **start this at 1mm**. If threshold too high for child, increase this to 2mm until child grows accustomed to being in the scanner.

This is the amount of movement allowed in any of the three directions (x, y, and z) before the video shuts off, increments are in mm up to 1 cm. (Note: this control can be adjusted mid-scan.) The goal is to have the child at least stay still enough to not trigger the video shutoff at the 1mm threshold. If you can't get the video to work, you may have forgotten to set this threshold.

- **Shutoff Duration Time (Sec)** – it is best to **set this to 3 seconds**. This is a measure of how long (in seconds) the subject must hold still before the video comes back on (always expect an additional 1 second lag). If the child moves more than the cutoff criterion will allow, the potentiometer will count up to the set video shutoff duration before the video turns back on, thus acting as a feedback mechanism to the child. The red circle below flashes each time the video shuts off.

Note: The child must hold still for the full video shutoff time or else the video shut off is again triggered.

- **Video Shut Offs** – This records the number of times the video goes off during the scan. It returns to 0 at the beginning of each scan.
- **Displacement boxes on right** - Once started, the program will show child's movement in the three directions by sampling every second. The motion will be shown in the three right boxes. Whenever a specific direction's displacement is above the set threshold, the corresponding colored box will light up.

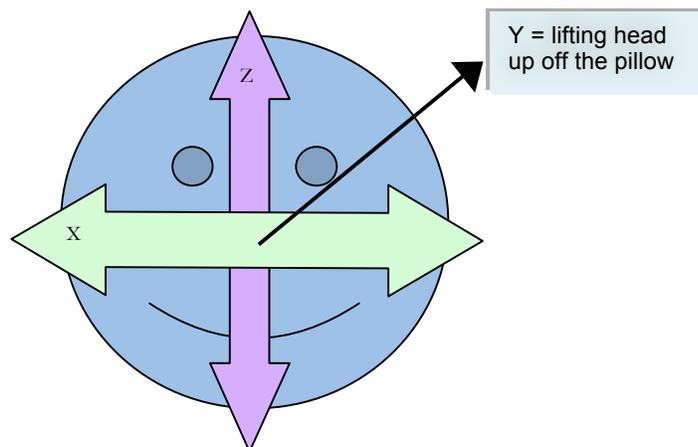
Important Potentiometer Notes:

ψ Other items to be aware of when working with the potentiometer:

- At the beginning of a scan, the subject must hold still for at least 2 seconds in order to establish a set-point (the video will go off as this is being established). Each time the subject moves and shuts off the video, a new set-point is established and the cut-off criterion is based on the new set-point.

- If you would like to **see your data output**- go into your folder through My Computer and choose WordPad version. (It is a plain text output.) The output includes: Time in seconds, the x coordinate, the y coordinate, the z coordinate, and the cut-off criterion for that second. At the bottom of the WordPad output, you will find the number of video shut-offs during the scan.

- Directionality of head movement in potentiometer:



Note

After 10,000 uses the relay switch will need to be replaced in the potentiometer. This will be apparent because the video feedback system won't work and the potentiometer won't record movements along the three axes. If this happens, let the Sim Manager know immediately. Hogene Kim, the potentiometer's creator, has labeled the relay switch in the potentiometer box.

Troubleshooting Guide:

If you are unsure of what to do or have tried all of the following tactics to no avail, contact the Simulator Manager immediately.

A. Video/E-Prime Not Displayed on Sim Screen

- 1) Make sure LabVIEW is closed before playing movie in PowerDVD. Then restart LabVIEW.
- 2) Check the blue box settings: “2” for video & E-Prime to be displayed; “3” for laptop to be displayed.
- 3) Disconnect & reconnect white RCA cable from the AVerMedia.
- 4) Disconnect & reconnect the RCA cable on the sim television screen.



Fig.A3.1. RCA cable on left side.

- 5) Check if overscan light on AVerMedia is blinking. If so, unplug all the cables and re-plug it in one at a time correctly until it stops blinking. If it does not stop blinking, call the sim manager to troubleshoot or restart the computer.

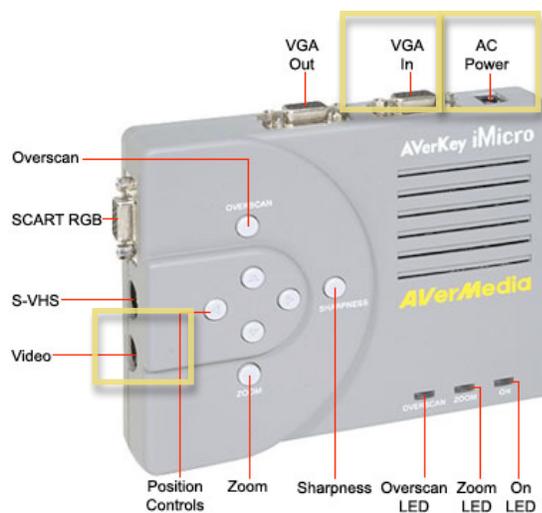


Fig.A3.2. AVerMedia—highlighted areas are where the white RCA cable, VGA, and power should be inserted (left to right).

B. Potentiometer Not Recording

- 1) Restart LabView
- 2) Call Sim Manager to report the problem. Continue with simulation using the bell located at the bore's head to deter visible movement.

C. Frozen E-Prime/Computer

NEVER reboot or shutdown the computer (call Sim Manager for help).

Make sure you always use **"Ctrl+Alt+Shift"** to interrupt a running E-Prime game.

- 1) "Ctrl+Alt+Delete" and use the process manager to end the problematic process (be careful of what you choose to end!)

D. Scan Bed Not Moving

- 1) Make sure the sim is plugged in to the side wall socket.
- 2) Note the position of the middle switch on the scan bed controller panel. Toggle the middle switch on the scan bed moving panel (fig.A3.3) and retry the rightmost switch.



Fig.A3.3. Middle switch to toggle indicated by blue arrow. Switch to activate scan bed (rightmost switch) indicated by green arrow.