

Manual for the MEG Laboratory at the MGH Martinos Center

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I: MEG Laboratory Basic Information

Location and Contact Information

You can find us on the web at:

<http://www.nmr.mgh.harvard.edu/martinos/research/meg/index.php>

The MEG lab is part of the Martinos Center at the MGH-CNY (Charles Navy Yard) campus, Building 149. Our address is:

MEG Laboratory MGH/MIT/HMS Martinos Center for Biomedical Imaging 1st Floor
Building 149, 13th St Charlestown, MA 02129 Tel: x6-8517 (617-726-8517) Fax:
x6-8626 (617-726-8626)

We are located on the first floor near the West entrance. From this entrance, we are the second door on the right (next to the mailing office). If you enter through the East entrance, continue walking to the other side of the building, pass the cafeteria, and you will see our lab on the left (right before you reach the West entrance doors).

For directions by car, subways, and shuttle bus, please refer to the link on our web page or:

<http://www.nmr.mgh.harvard.edu/martinos/contact/directions.php>

Measurement Time Signup

All time requests for the MEG/EEG are to be submitted electronically, using a system similar to that of the magnets. Further scheduling information can be found in the section "Working in the MEG lab" under Reserving Measurement and Analysis Time. The same link can be found on our web page in Resources under "[Imager and Facility Schedules](#)."

MEG E-mail List

The main source of information about events in the lab is the megscan mailing list (megscan@nmr.mgh.harvard.edu). Announcements about the machine, upcoming meetings, scheduling changes, etc will be sent to this list. To join the megscan mailing list, go to the following link:

<http://mail.nmr.mgh.harvard.edu/mailman/listinfo/megscan>

Notice Board

When in the lab, check the marker board for important phone numbers to call for assistance.

Reference and Instruction Manuals

Vectorview's manuals can be found on the shelving in the lab as well as on our website as pdfs. Various stimulus system manuals can also be found in the lab. Tech support will be available to all new users, but please familiarize yourself with the stimulus and Vectorview manuals (in addition to this introductory manual) before beginning any recordings.

II: Working in the MEG Laboratory

The following is intended to provide you with a basic set of guidelines for good laboratory practice. Because so many people will be in and out of the lab on a regular basis, it is of crucial importance that everyone follows these guidelines. Our hope is that by familiarizing yourself with the lab and its practices, time will not be lost and hazards resulting from careless oversights will be avoided.

Reserving Measurement and Analysis Time

Possible tech-supported measurement times are:

- Weekdays from 9am-noon and 1-4pm Non-supported times are available:
- Weeknights from 4-10pm
- Weekends from 9am-10pm

You can adjust slot times depending on your needs. Wednesday and Thursday mornings are reserved for clinical recordings, thus this block of time is unavailable for sign-up when we have patients scheduled. The current calendar can be viewed from the link on our website or:

<https://www.nmr.mgh.harvard.edu/facility/schedule/index.html>

When to Submit a Request All time requests are to be submitted electronically. All researchers must formally request time on the MEG at every schedule change period. Schedules are revised every 3-4 months. A call for scanning time requests will be announced via email to the megscan list several weeks prior to the finalization of the new schedule (the schedule is renewed every February, July and November).

New requests can be submitted at any time. However, because the website is checked regularly only during official rescheduling periods, those submitting requests at any other time must notify [Karen Dervin](#) via email in addition to completing the web-based request form. All new investigators must submit a New Research Proposal prior to requesting measurement time.

Information to submit When requesting scan time, the Principal Investigator will be asked to provide the following information for billing purposes:

- Project title or grant title
- Fund number and active dates
- For non-MGH funds, name of contact billing person at outside institution
- List of authorized users of the account

Special Requests We will make every attempt to accommodate special requests with each new schedule (e.g. requests for daytime scan hours with technical support), however, with the growing number of studies vying for time, we ask that users consider their special request carefully, and be flexible and reasonable.

Cancellation Procedure Please use the online calendar to cancel your slot and do so at least 24 hours in advance, so that other users can use that time. Please make every effort to keep these incidents to a minimum by calling your subjects to confirm their appointments, making sure they know when and where to report for the study, and how they can reach you at any time. In case of last minute cancellations, please email mri-time@nmr.mgh.harvard.edu with cc'ing [Nao](mailto:nao@nmr.mgh.harvard.edu)

Use it or lose it Past efficiency in use of assigned measurement time will be taken into consideration each time the schedule is re-made. Frequent non-use of scheduled scan time indicates a problem that should be discussed before additional time slots are allocated, and may result in a reduction of a user's assigned time in the next iteration of the schedule. It may also indicate that a more flexible scheduling policy is needed. After each scheduling period, history of use will be reviewed carefully for the purpose of improving efficiency.

Billing This is the new Martinos Center policy that MEG users need to log in to MEGACQ/acquisition program as soon as they start occupying the lab. However, due to the longer length of preparation time, EEG users log in from the time of digitization. Training, development, nor pilot time will be billed.

MRI Requests MEG subjects will need an MR image of their brain so that the MEG information can be integrated with their personal anatomy. Images are taken here at the Martinos center, and signup is online.

IRB/HIPAA Compliance

Please refer to our website under "IRB/HIPAA compliance" for more detailed information on human studies before requesting measurement time.

It is the responsibility of each investigator and their staff to understand and abide by the policies of the Partners Human Research Committee and the Martinos Center regarding human subjects research. The Martinos Center has assembled a packet of pertinent documents that we recommend you read and share with your staff. These documents are available at the Martinos Center office and on the Internet.

Investigators performing human studies at the Martinos Center must submit documentation of compliance with HRC regulations. *We cannot assign measurement time or allow use of the MEG without IRB documentation!!* This information will be kept in the investigator's file at the Martinos Center and used by the Martinos Center staff to verify adherence to protocol. Please help us keep this information up to date.

****Laboratory Safety****

No matter how important the study, safety always comes first. The usual rules of any lab apply to the MEG, but some additional points unique to using MEG are worth stressing. No measurements should be made prior to reading the following section!

Before Entering the Magnetically Shielded Room (MSR) Subjects may not enter the MSR without signing a consent form. Anyone entering the MSR must first "de-metal" (empty pockets; remove jewelry, watches, wallets, cell phones, beepers, hairclips; leave pens, clipboards etc. outside). Don't use paper clips or other small metal objects (staples, etc.) around the MSR; they tend to land on the floor and find their way inside the room.

MSR Guidelines and Safety

Protecting Vectorview from Magnetic Contamination

The Vectorview system is comprised of 306 thin-film superconducting interference devices (SQUIDs). The sensors are

ultra-sensitive in that they can pick up changes in a magnetic field in the range of femto Teslas. Because of this sensitivity, the Vectorview is placed inside a MSR.

Although wearing metal objects while in the MSR is not harmful to the individual, bringing magnetic objects close to the Vectorview can cause trapped flux in the SQUIDs, which can lead to a long and expensive service break which would cause an obvious delay in measurements. Thus, before entering the MSR, we require that you remove any potentially magnetic objects. These include belts, keys, watches, coins, hair barrettes and pins, eyeglasses, and pieces of clothing with magnetic parts. Also, to prevent any magnetic dust from getting into the MSR, always remove your shoes before entering. Objects such as cell phones, pagers, cameras, flashlights, or any other electrical equipment are strictly forbidden. *Never* take a bar magnet inside the MSR.

When arranging for visitors or experimental subjects to come to the MEG lab, please inform them of these restrictions and see that they are appropriately prepared. You can refer them to our website under “Resources” or to the following website for information on how to prepare for an MEG/EEG study:

<http://www.nmr.mgh.harvard.edu/martinos/opportunities/volunteerFAQs.php>

Subjects who may arrive unprepared (eg, have magnetic parts on their clothing that cannot be removed) will be issued non-magnetic clothing supplied by the hospital.

Do not touch Vectorview unnecessarily, and keep a respectful distance (0.5 m) from the device. Furthermore, to prevent microscopic magnetic particles from causing spurious results, do not attach anything (eg, tape) to the Vectorview helmet.

Do not leave any equipment in the MSR (other than the projector screen, auditory and somatosensory stimulators, and response pads). Place experimental equipment instead in one of the cabinets outside the MSR, on the sink-side of the room, and be sure to clearly label each item, so that your equipment is not misplaced or borrowed.

Moving the Vectorview Gantry

The gantry can be in one of two positions, upright (sitting) or supine (lying down). The gantry is usually in the upright position, but in the supine position for clinical patients on Wednesday or Thursday mornings. The gantry is lifted or lowered by pushing two buttons that are located on the back of the gantry. When these buttons are pushed, the gantry is lifted or lowered by ropes that are connected to a motor outside the MSR. During measurements, the gantry rests on two claws, both of which can hold at least four times the weight of the gantry. However, when the gantry is lifted or lowered, it hangs from the ropes only, and should something unexpected happen the whole unit (~270 kg) could fall down and seriously injure someone. Thus it is important to understand the following process to avoid such an injury. If you have never moved the gantry before or if you feel uncomfortable doing so, please alert Nao and she will assist you.

There are four “traffic lights” behind the gantry that indicate whether or not it is safe to place a subject under the dewar. The green light indicates that the gantry is resting safely on the claws; you may place a subject under the dewar *only* when the green light is lit. The yellow light indicates that there is either tension in the ropes (eg, during lifting or lowering) or that the gantry is in an extreme position where it shouldn't be. The red light indicates that something is wrong, and you should contact service personnel.

If you notice that the green light is *not* lit, and the subject is already seated under

the dewar, first remove the subject and only afterwards should you move the gantry. *Never* move the gantry while the subject, chair, or bed is under the dewar!

Once moved, allow approximately 30 minutes for the system to settle before tuning and beginning any measurements.

Positioning the Subject Chair and Bed

The MEG chair is simply pushed into the opening beneath the dewar; no locking mechanism is needed. Similarly the bed is pushed against Vectorview, but in order to keep it from moving, the wheels should be locked.

Do not bring wheel chairs into the MSR. Instead, first place the subject on the bed outside of the MSR, and roll the bed inside the room.

Monitoring the Subject from Outside the MSR

During measurements, you can communicate with the subject by means of a two-way intercom system. Hit 1 to turn on the system, M to speak to the subject, and C to turn off the system. You will be able to hear the subject without pressing any additional buttons, although while you press M you will be unable to hear him or her. Additionally, you can monitor the subject by watching them on the TV monitor.

Never leave a subject or patient unsupervised in the MSR! If someone is inside the MSR and you are alone, do not leave the measurement room even for a short while. Someone must be available for help if the subject suddenly has an attack of illness, or if something unexpected happens.

Liquid Helium Familiarize yourself with the section of the Vectorview manual that concerns the properties of liquid helium. It is highly unlikely that you would encounter such dangers while running a study due to the ventilation system installed in the MSR. However, it is important to keep these properties in mind while present for the helium fill, for example. Such properties include (1) its extremely low temperature when liquid (-279 C), (2) its ability to replace oxygen in the air, and (3) its tendency to expand in an explosive manner when transforming from liquid to gas at room temperature. The cryogenic dewar of the Vectorview, which contains maximally 80 L of liquid helium, has several mechanisms to ensure that the dewar does not leak. However, if you hear any hissing sounds coming from the Vectorview, leave the MSR and contact one of the technologists.

Food and Beverage No food or beverage is allowed inside the MSR!! You may bring food/beverage into the lab, but do NOT bring them inside the MSR.

Emergency Stop In the event that someone is trapped inside the MSR (and neither the inside nor the outside buttons will open the door), there is a red and yellow emergency stop button on both the inside and outside of the MSR that will release the door so that it can be pushed open manually.

Serious Emergencies For fire, acute illness, or other serious emergencies, the general emergency telephone number is 911. The number for MGH security is 617-726-5400 (x6-5400). Remain calm, answer questions clearly, and do not hang up before permitted to do so. Everyday first-aid items such as band-aids, gauze, and alcohol are located in the cabinet marked Subject Prep Supplies and the Tan/Black Code Cart.

III: Computers and Stimulus Systems

This section is meant to act as a general overview of each of the computers in the lab and the software they have to offer, as well as the stimulus systems with which to present stimuli.

Acquisition Computer: MEGACQ (HP Unix)

To log into MEGACQ, use your lab's group name (ie, acqstuf) and corresponding password. You will also be prompted to enter billing information once you begin the acquisition program; these names are identical to those used with the MRIs. (If you do not already have such a name, this means you have not submitted your IRB and thus should not have access to the MEG system).

Once logged in, you will see at the bottom of the desktop a task bar containing several icons. Users should only need to use the Application Manager icon (on the right, looks like a file drawer). Under this folder click on the Neuromag icon, and you will find the following programs of interest:

Manuals Manuals for most Neuromag applications can be found here
(as well as on the MEG website) Acquisition Data
acquisition program, which runs on the MEGACQ workstation only Plotting Data
plotting program used mainly for viewing on-line averaging of the data Source
Modeling Data analysis program for dipole fitting Graph Tool used
mainly for signal analysis of spontaneous data MEG-MRI-integration Program for
visualization of dipoles on MR images MRI-segmentation Program for
manipulating MR images MNE Data analysis program for calculation and
visualization of minimum norm
estimates ViewBrain Program for viewing the surface
of the brain

MEG Workstation Computers (Linux)

A HP workstation, MEGACQ and a Linux computer, megws3 are located in the MEG lab and have all the required Neuromag software installed for MEG data analysis. MEGACQ can be used for analyzing data while simultaneously recording a subject, as well as burning data onto CDs, but we prefer that people not use MEGACQ due to the risk of interfering with measurements.

Stimulus Computers

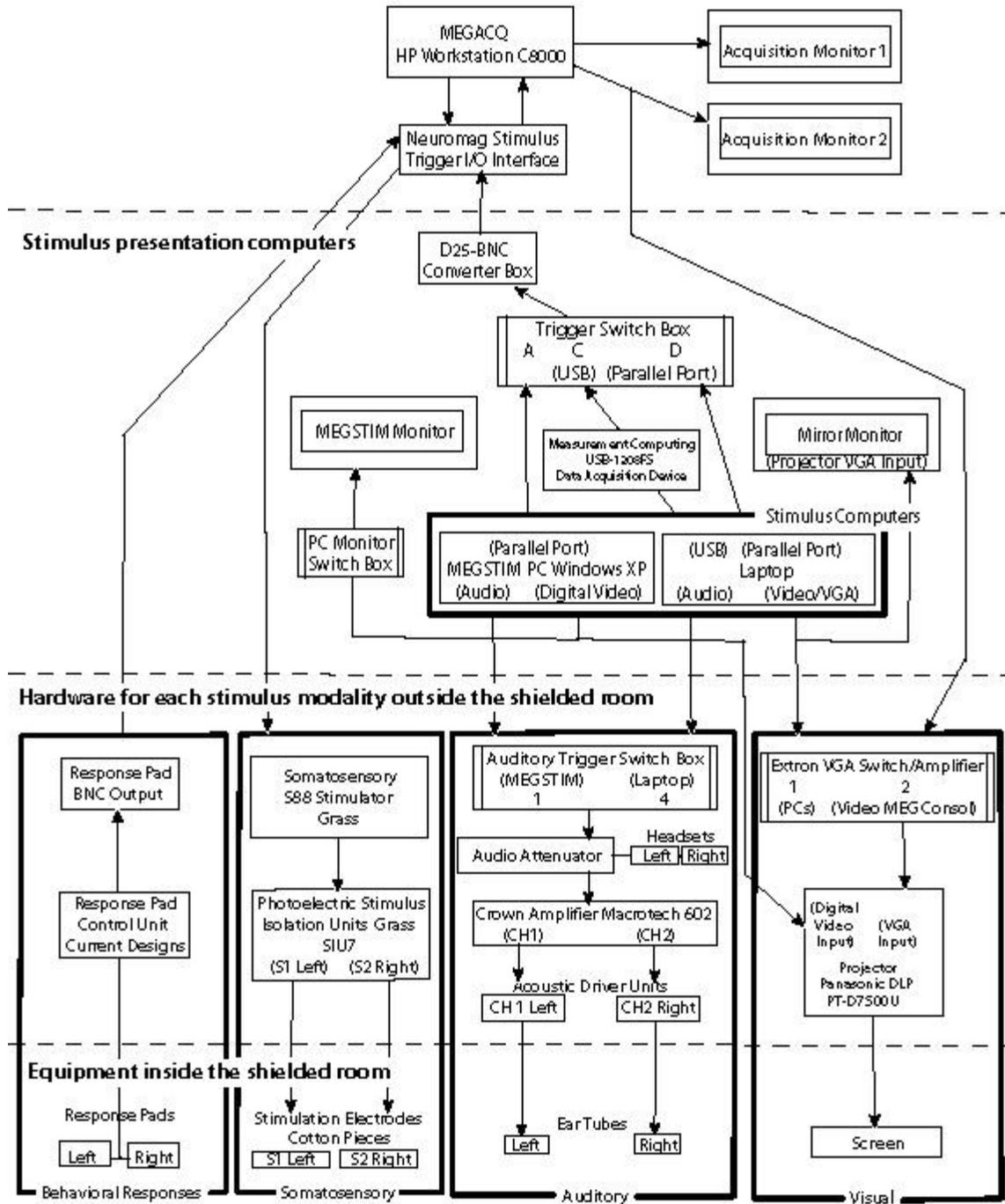
- PC (Windows 98): Presentation 11.0, 0.92, 0.76, 0.55, Psychtoolbox (Matlab 7.1) (MEGSTIM NEW)
- Laptops: feel free to use laptops for any software we do not offer

Due to the fact that different computers are used on a daily basis and all must send and receive triggers, a switch box has been set up to eliminate the need to constantly switch cables. Simply turn the switch box knob to the appropriate cable, and double check that your triggers are being sent and received properly.

There are three settings for the switch box: A "MEGSTIM (NEW)", C "USB-1208SF" and D "LAPTOP PARALLEL PORT". Laptops users can use either a gray cable labeled "LAPTOP PARALLEL PORT" or a white USB cable. There is also a white internet cable. For the projector input, use the blue cable and change the setting for projector input on the projector remote control: RGB2 for your own laptop and AUX for the MEGSTIM (NEW).

MEG STIMULUS SYSTEM DIAGRAM

Acquisition computer and its trigger pulse I/O interface



Triggers

Typically stimulus presentation scripts are written with stimulus codes like those in the left column marked "Event." However, the MEG acquisition software accepts stimulus codes as binary triggers, which for our purposes can be represented by the numbers in the right column. When users first come in to test out their paradigms, they should be sure that while their scripts are coded with event numbers, they are actually seeing trigger combinations light up on the trigger box. Similarly, users will need to set up an acquisition file on MEGACQ (the MEG acquisition computer) so that the acquisition program expects to receive the same triggers being produced by the stimulus computer. Unfortunately, online (real-time) averaging can only be done for the first 17 events listed below. (Many more events are possible, however, and *will* be collected offline).

IV: Subject Preparation and Experimental Setup

Before beginning any measurement, several steps must be taken to prepare the subject and the acquisition system. An overview of these steps is as follows:

Consenting the Subject You MUST receive the subject's consent before he or she can begin the study. Also, for subjects measured post 4/14/03, they must sign both an Authorization form and acknowledge that they have received a copy of the Privacy Rule. Please make two copies of each of these documents: one for the subject

and one for the MEG lab. Leave the latter copy in the drop slots located outside the MSR.

De-

PC Event Code	Trigger Combination
1	1
2	2
3	12
4	3
5	13
6	23
7	123
8	4
9	14
10	24
11	124
12	34
13	134
14	234
15	1234
Response 1 (16)	5
Response 2 (32)	6
Offline Event Codes:	Trigger Combinations:
16	5
17	15
18	25
19	125
20	35
21	135
22	235
23	1235
24	45
25	145
26	245
27	1245
28	345
29	1345
30	2345
31	12345
32	6
33	16 etc.

metalling Have the subject empty pockets, remove all jewelry, glasses, wire-bras, etc and take off shoes. All subjects are required to wear hospital-issued pants, and if necessary (due to non-removable metal on shirts), subjects can be provided with tops and robes. Those subjects requiring glasses will be given special non-magnetic frames and lenses.

Experimenters should also de-metal to the extent of removing items from pockets, jewelry, ID tags, etc, and most importantly anything electronic. (It is not necessary to remove glasses so long as you do not bring your face especially close to the sensors).

EEG cap If you will be using the EEG cap, position it on the head and prepare all the electrodes before proceeding to the following steps. See the EEG manual for detailed instructions.

Applying EOG Electrodes (This step should be completed whether or not the EEG cap is used)

All supplies for applying EOGs, the EEG cap, and HPI coils can be found in the cabinet marked "daily preparation supplies." Check the cabinet to the right of it (extra prep supplies) for extras when a product runs out.

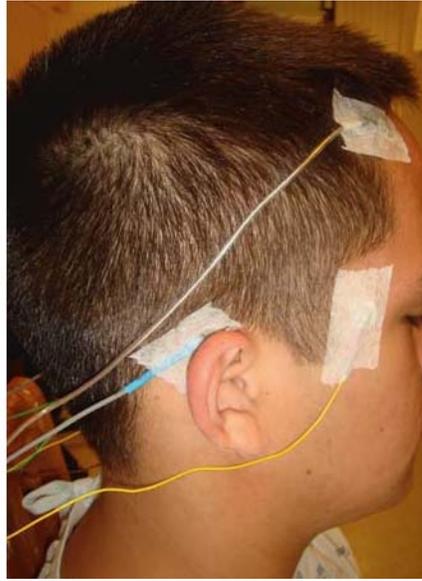
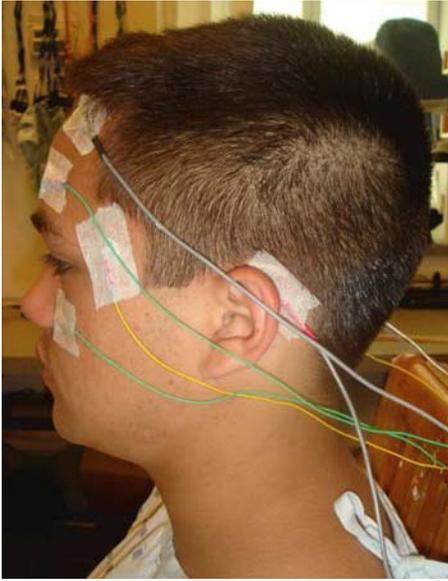
With a Q-tip and Nuprep abrasive gel, cleanse the skin where the electrodes will be placed. Next place a generous amount of EC2 cream into the cup of the electrode, and affix it to the face with micropore (paper) tape.

Typically five electrodes will be used: two pairs of bipolar electrodes (horizontal and vertical) to monitor eye movements, and a ground (typically an area of the collarbone is used). If using the EEG cap, a reference electrode will be needed which is generally placed on the nose.

So that the leads do not pull or become tangled, it is a good idea to tape them all together onto the subject's left shoulder. (Leads will be plugged into the portion of Vectorview to the left of the subject).

Impedances should then be checked; the impedance meter is on the shelf above the EEG supplies. Plug in the ground (or reference, if using the cap) electrode to one of the bipolar slots, and compare all other electrodes to this one. Typically you're looking for an impedance of under 5 k Ω , although for some subjects this is nearly impossible and less than 10 k Ω is acceptable.

Applying HPI Coils If not using an EEG cap, the four HPI coils should be placed in four specific locations to maximize distance between them: two on each side of the forehead (right below the hairline) and one behind and above each ear, ensuring that, once the subject is in the machine, all coils will be inside the dewar and not below it. The coils require no paste, and should be affixed using both double-sided rings and micropore tape.



HPI (4 gray leads) positions without EEG cap 2 horizontal EOG electrodes (yellow leads) and 2 vertical EOG electrodes (green)

If using the EEG cap, it is again necessary to place the coils as far apart as possible, but in this instance they will be attached directly to the cap rather than to the subject's skin. The double-sided rings can be used, but rather than using micropore tape, use the transpore (plastic) tape since it better adheres to the cap.

As with the EOG electrodes, it is a good idea to tape the HPI leads to the subject's



shoulder, this time to the right side.

HPI (4 gray leads) positions with EEG cap 2 horizontal EOG electrodes (yellow leads) and 2 vertical EOG electrodes (red)

Starting the Acquisition Program In the Neuromag folder, open the Acquisition program. You will be prompted to enter your nmr account, password and 3-digit billing code; it is at this point that you will begin to be charged for your time (unless you are using development or pilot time).

First, load your project and settings; details on how to use the program are below in the section entitled "Data Acquisition." These settings should have been previously created and saved so that time is not wasted while the subject is present. Once the necessary settings are loaded and double-checked, you are ready to register the subject (details below).

At this time it is also a good idea to begin filling out a "run sheet" (kept in the shelving in the lab beside the telephone). This form is used to record more specific details about the subject and his or her measurement, such as noisy channels, the name of the data files, etc. These forms are for your personal use and thus do not need to be copied and kept in the MEG lab.

Subject Registration With the HIPAA regulations we have made several changes in how to register subjects, so be sure to follow these steps in order to be compliant!

- Press the second "Change" button marked Subject
- At the top of the window, select *Subject Type: Patients*, and *Accessible to group: acqxxxx* (This is very important since it will enable you to access to your data after collected.)
- Enter name, birth year, sex, and handedness (height/weight can be skipped)
- In the box marked *HIS ID* enter a unique subject code (e.g. halg014)
 - This code will automatically be used as the directory name for megraid
 - Save filenames with this code as well

Digitization Once registration is complete, you are ready to digitize the subject. In the Acquisition program, press the sixth "Change" button marked Digitize. At this point you will be prompted to digitize cardinal landmarks, HPI coils, electrodes, and extra head points. The polhemus system, which is used for digitization, is located in a cabinet labeled "Polhemus". Instructions for using the system are as follows:

- Have the subject sit in the wooden chair
- Move all rolling chairs and other objects with large metal components away from the chair and polhemus
- Slide the chair sensor into the back of the chair, with the cable pointing downwards
- Position the goggles on the subject's head, being careful not to cover up any electrodes or HPis. It is critical that the goggles are tight and do not move once digitization has begun
- Turn on the polhemus and be sure that both cabinet doors are open
- In the Acquisition program, select the last "Change" button which will take you through digitization
- At the top of the screen, hit the "Coordinate frame alignment" button; you are now ready to begin digitization
- In any order, digitize the three cardinal landmarks (nasion plus right and left pre-auricular points, see below) by pointing to each and simultaneously clicking the button on the stylus. It is a good idea to check that the two ear points are within a maximum (absolute value) distance of 3mm.



Right PA. For the Nasion mark the lowest indentation above the crown on the nose as shown here.



Left PA

- After the third point has been digitized, you will hear two beeps instead of one—this is simply to indicate that you are done digitizing a section. If at any point during the digitization of the different sections you hear two beeps (*before* the last point), you have accidentally pushed the stylus button twice and should start over. Instructions on how to do this are further below.
- To move on to the next section (HPI coils), there is no need to click anything else; you will simply be prompted to begin digitizing HPI.
- Digitize the four HPI coils in

any order. Be *very* careful when digitizing these points, as they can come back to haunt you later if not done properly the first time!

- Next, if using the EEG cap, digitize the electrodes *in order*, starting with the reference electrode. A map of electrode locations can be found in the folders for screening forms.
- If not using the cap, you will *not* be prompted to digitize any electrodes (unless you failed to rename any of your facial electrodes as EOG rather than EEG).
- Finally, you will be asked to digitize additional head points. It is a good idea to make a straight line down the forehead and nose, as the nose is easily identifiable in the subject's MRI. An extra 20 or so points from the head should be taken by making a spiral; these will also be used in conjunction with the MRI.
- When finished, hold the stylus about a meter away from the subject and press the button.
- If at any point you should make a mistake, you can hold the stylus away, press the stylus button, and then click on the button at the top of the section you would like to do again. This will clear any points taken in a given field, allowing you to start over. (It will not clear points in previous fields).

Connecting HPI, Electrodes, etc to Vectorview The plug for the HPI coils is inserted into the “subject’s” right side of Vectorview. The plug has a small notch on it; this should be placed downwards, and the whole plug should be positioned so that extra spaces are on the right. The earphones are also plugged in on the subject’s right into the slot labeled “auditory stim out.”

All electrodes are plugged in on the subject’s left. For EOG and other bipolar electrodes, be sure to pair them together correctly (eg, vertical with vertical and not vertical with horizontal), although which goes in (+) and which goes in (-) is unimportant. Ground and reference are plugged into the same location labeled ground and reference, respectively. If using the EEG cap, the cap’s connectors should be plugged into the slots with corresponding numbers.

If doing an auditory study, be sure to place the earphones in the subject’s ears before pushing the subject up into the helmet. The foam insulation for the earphones can be found in the cabinet marked “daily prep supplies.” To adjust volume, use the audio attenuator in the stimulus cabinet to the left of the acquisition machine.

Placing Subject in the Helmet The pump for the chair is located on the “subject’s” right; the longer lever pushes the chair up; the shorter one lowers it. Subjects should be pushed up far enough so that they can feel pressure on the top and back of their head. It is important to have subjects first slouch down and get comfortable so that they do not do so later and slip down in the helmet.

If using the bed, lock the wheels and move only the upper portion of the bed. This way subjects can position themselves comfortably, and you can easily slide them into the helmet until their head touches the back.

Subject Instructions Before exiting the MSR, be sure to remind the patient of both the general MEG instructions as well as any instructions specific to your task. General instructions include:

- For auditory studies, focus on a point on the wall or a fixation cross displayed on the screen; for visual studies, focus on the fixation cross.
- For any kind of stimulus, try not to blink while stimuli are being presented or while responding.
- Do not move once the measurement has begun, even during breaks!! (This is due to the fact that, if presenting several runs which you will later average together or compare, it is important that the subject does not change his or her head position at any time, including any large movements of the limbs since this is also bound to alter head position).
- To communicate with the experimenter, simply speak aloud; there is a microphone built into the machine. However, you should avoid speaking during a measurement, unless it is an emergency.

V: Data Acquisition

For a detailed description of the acquisition software and how to create your acquisition settings, see the Vectorview manual, section five (this manual can be found online as well as in the MEG lab).

Entering Task and Subject Info:

- Open the Acquisition program in the Neuromag folder.
- There is a list of six “Settings” buttons with which to modify the measurement:
 - Change: Project
 - Change: Subject
 - Change: Acquisition
 - Change: Stimulus Generation
 - Change: Online Averaging
 - Change: HPI
- Click on **button 1** to select a project. Most project names are simply PIs, thus selecting a project is equivalent to selecting a user directory; in order to load the settings for a specific PI’s study, you’ll need to proceed to the next step:
 - Go to File and select “Load Settings.” This is where you will find a list of all the studies in your user directory. Select the appropriate study, and your settings will automatically be loaded.
 - Click on **button 2** to enter subject information. Please see section IV for details on how to register subjects.
 - The next three categories (buttons 3-5) should not need to be modified each time you run a subject, only when originally designing your paradigm or updating it.
 - Click on **button 6** to begin digitizing the subject (directions for digitization are above).

Beginning a Measurement:

- Below the six “Settings” buttons is a series of buttons marked “Acquisition Controls,” which read from left to right: GO, Stimulate, Average, Record Raw, Restart, and Stop
- Hitting GO will start acquisition. (It may be up to ~30 seconds before you see any channel activity, so be patient!)
- Once the channels come up, it will take several more seconds for them to settle; you can shorten this process by going to “Tools” and “Reset Channels.”
- Before beginning stimulation and recording any data, briefly browse through all channels to make sure that none are showing artifact. To do this, click “Selection” at the bottom of the raw display window (which automatically popped up on the right monitor when you started the Acquisition program). You will then see a list of channels, grouped both by location or number; either is suitable for looking at the channels.
- If you do find channels showing artifact, the most common fix is heating the sensor. Do this by going to “Tools” and “Squiddler.” Type in the appropriate channel number, making sure to hit enter afterwards. In the “Commands” menu, select “Heat Sensor” and shortly afterwards “Reset All.”
- If heating does not help, try adjusting one or several of the three parameters in the Squiddler window: Bias, Offset, or Gate. To better view the changes you are making, go to “Mode” and “Tune,” and on the raw data window, hit the “xy” button. Once you have finished tuning, go back to “Mode” and select “Meas.”
- If you feel uncomfortable using Squiddler or are not sure what the parameters mean, please ask Nao for help before making any changes!

Measuring HPI

- Once all channels look fine, you are ready to measure the subject's head position. A window prompting you to do this will have automatically popped up after hitting GO. In this window hit the "Measure" button, and wait several seconds until a new window with the HPI results pops up.
- If everything went well, the suggestion at the bottom of the window will say "Accept." After accepting, you are ready to begin recording. Occasionally you will find that one out of the four HPIs is not OK, yet the suggestion is still "Accept." This is true because the system only requires three functioning HPIs; however, having all four function properly is preferred in the event that one fails, in which case you will still receive the "Accept" suggestion and be able to move ahead.
- If less than three HPIs are OK, the suggestion will be to "Redo HPI." In the event that you receive the Redo message, keep re-measuring the HPI and see if things improve. If not, ask the subject to move his or her head slightly in the helmet, and try measuring again. If the suggestion is still Redo, you may need to remove the subject from the MSR and see if one or more of the HPIs have come loose.

Recording Data

- At this point you should have your stimuli ready to present to the subject. Before beginning presentation, however, be sure to hit the “Average” and “Record Raw” buttons; this will ensure that all trials are included in data collection.
- As stimuli are presented and the subject responds, you will see a list of trials (or “epochs”) collected for each different category designated in the online-averaging setup.
- If a trial is excluded from the average, a message indicating why is displayed at the top of the Acquisition window. Most often trials are rejected due to eye blinks, which would show as EOG 61 or 62. If an MEG channel is frequently causing rejections, attempt to heat or fix otherwise before beginning the next run. (However, never heat a channel while actually recording data).
- If you feel that the subject is blinking too much and you want to restart the run, de-select the Average and Record Raw buttons, and hit “Restart.” This will clear all data collected and allow you to speak with the subject, re-measure HPI, and begin recording again.
- When the run is over, hit STOP and save your data (details on saving are below). Most likely you will be collecting several runs, so after saving your data, simply hit GO again and follow the above steps.

VI: Saving Data

At the end of a measurement, hitting “Stop” in the acquisition window will automatically bring up a window prompting you to save your data—first evoked and then raw data (if both were collected). Data is saved directly to a raid rather than the local disk. The default option is to save to whichever of the raids (megraid 63) is currently in use.

Simply name your file and hit save, using names that distinguish between evoked and raw files as well as between runs. For example, for subject halg001 in run number one of the task “Memory” you could name your files:

halg001_mem01 halg001_mem01_raw

Your data, saved in fiff format, will then be found in the appropriate megraid under MEG, the project name, subject code, and date. For example:

/space/megraid/50/MEG/ahlfors/subj_001/061024/

CD Writing

You may leave your data on the megraid, but it is of course always a good idea to backup your data. To burn your data to a CD after saving to one of the raids, use the analysis computer, megws3 - CDs are by the scratch papers. You can simply drag and drop files into the CD creator window and burning them using the GUI program. A CD holds approximately 25 minutes of raw data. Alternatively, the following commands would work remotely.

- First go to the directory where your data is saved, e.g. the path mentioned above
- Type in the command **/space/orsay/8/users/megenv/bin/burn_meg.pl** (adding this path to your .cshrc can save time)
- or if using megws2 type **/space/orsay/8/users/megenv/bin/burn_meg2.pl**
- You will first be prompted to write a path for your directory. If you are already there, simply hit enter. (Disregard the warning about writing to scratch)

- The program will check the size of all the files you request to burn and automatically partition them into sets of <= 700MB. Once it has done so, it will let you know the total number of CDs required, and ask you to insert the first CD.
- An example is below:

```
megws1: foxed[1] cd /space/megraid/50/MEG/ahlfors/subj_001/061024/ megws1:
foxed[2] /space/orsay/8/users/megenv/bin/burn_meg.pl
```

Path(s) to files to back up (separate w/ space) A leading '.' in the path will be stripped for the CD directory names [curr dir] WARNING: You don't have write access to /scratch

BUILDING DISK IMAGE (this can take a long time!)

Insert a fresh 700 MB disk and press <enter>

VII: Leaving the Lab

So that all users can enjoy a clean, organized, and efficient environment, please be sure to go through the following checklist after each measurement.

- Log out of the Acquisition program so that you are not billed for cleanup time
- Log off of MEGACQ so that the next group can login
- Return all items used inside the MSR (eg, response pads, auditory tubes, stimulating electrodes) to their proper storage locations. When removing the foam from the audio tubes, do NOT throw away the small white plastic connectors.
- Return settings for the stimulus systems back to the standard settings (eg, audio attenuator and somatosensory settings).
- Turn off the projector if used. Directions for powering off the new DLP are below:
 - Do this by pressing on OFF button twice from the remote
 - DO NOT turn the power off from the side switch, wait until after the lamp cools down before touching this switch. (~15mins)
 - Detailed instructions for powering off the projector are taped to the wall.
- Clean the inside of the helmet with a paper towel wet with Envirocide (disinfectant) or alcohol wipe after EEG cap use.
- Shut the MSR door.
- Remove all two-sided tape from HPI coils and wipe with adhesive remover pads (in pink box or alcohol wipes).
- Soak (~30mins) and then clean EOG electrodes/EEG cap with a toothbrush so that NO paste or gel remains. Then soak the cap in the disinfectant for a few minutes, being sure to rinse, pat and hang up when done.
- Hang electrodes up so that they do not get tangled.
- Place soiled linens in the hamper.
- Report any empty or near-empty supplies, as well as broken equipment, to Nao.
- Take all your personal belongings with you.
- Check that the room is clean (or cleaner than when you arrived!)

Additionally, if you are the last person to run a study that day, please turn off the intercom, TV monitor and MSR light and during the summer time leave all the three AC **on**.

VIII: Data Analysis

Data can be analyzed in two basic ways: using one of the several programs offered on the Neuromag acquisition computer, and using the MGH in-house analysis streams.

For detailed descriptions of these programs, see the Neuromag software manuals (found on our website as pdfs). Each of the following programs can be used *while* you collect data, and are an excellent means of feedback about your paradigm and how the subject is performing.

Plotting

Use this program to view averaged evoked responses. Here you can manipulate several files at a time to create subtractions, averages, weighted averages, etc.

Graph

Graph is used to view and perform various signal analyses (eg, filtering, re-averaging, spectral analysis, etc) of raw data.

Source Modeling

This program, used in conjunction with *MRI Lab* (also called MEG-MRI Integration), allows you to fit dipoles to MEG data and display the results on the subject's MRI.

In-House Analysis Streams

The stream is used as a distributed source analysis and outputs "MEG movies" of minimum norm estimates (MNE) or dSPM which show changes in brain activity over time. Manuals can be found on our website as "MNE software manual" or "Analysis manual for the old NMR stream (mature)."

IX: Frequently Asked Questions

How is head movement dealt with in MEG? Is this related to how I should collect my data in terms of one block or several runs?

Unlike MRI, there is no motion correction for MEG. Head position is measured at the beginning of a run only and thus is not continuously monitored.

- If the subject's position changes, a sensor located at point X with respect to the head will move to point Y, and the sensor will now measure activity from a different brain area.
- Because head movement is always bound to occur, it is a good idea to take as many head position measurements as possible by breaking your study up into several runs.
 - Benefits
 - Because several head position measurements are taken, you have a better idea of when to what degree the movement occurred (under 1cm is usually

acceptable).

- ⑩ You can still use data collected prior to large movements, whereas if collecting data in one block and the amount of head movement is unacceptable, all data is unusable.
 - ○ Should an error occur in your program 50 minutes into your study or the subject sneezes, talks, etc, you don't have to completely start over or lose the data altogether.
- • Drawbacks
 - ○ From many users' experience, subjects tend to move more when there are long breaks between runs and they know data is not being collected.
- ⑩ One way to avoid this would be to insert breaks into your paradigm long enough to save your data but short enough so that the subject still believes data is recorded.
 - • You may want to create an instruction screen telling the subject to rest their eyes (blinking as much as they want) but to please remain still.
- ○ Because of possible movement, data taken over several runs should not necessarily be averaged together in sensor space.
- ⑩ Head position and waveform comparison across runs should always be taken into consideration before averaging.
 - ○ Splitting an experiment into several runs creates more work in terms of data analysis because grand averages must be created for each condition.

Using multiple runs has many benefits, but a few drawbacks as well:

- ⑩ We believe it is worth the extra effort of comparing head position and waveforms to know that you have collected quality data rather than assuming head position was minimal throughout one large block.

Therefore, the general consensus seems to be that inserting breaks into your paradigm which allow ample time for saving data and measuring head position (~30 seconds) is the best method of compensating for head movement.

An additional point discussed was using a bite bar to control head movement, allowing for breaks with repositioning of the head back to the original location.

- This method is available but has not been used for a while, if you need more details contact Nao.
 - Many people find bite bars to be unpleasant, so it may be useful to find a regular group of subjects that are comfortable using them.

Similarly, using gauze to wrap around the head, small pads, pillows, or some sort of inflatable cushion were mentioned as options to stabilize the head and reduce movement.

The point was made that subjects may be less likely to move while lying down. (Although for long measurements the seated position may ultimately be more comfortable).

- This could be a benefit for people running the same study in fMRI who want to replicate subject position.
- There is a drawback to this method:
 - Subjects inevitably feel sleepy during imaging studies. Having your subjects lie down and become increasingly tired may therefore not be the best idea.
 - ⑩ Drowsiness is a state that should be avoided in any study, but especially in MEG because of the resulting alpha activity.

Continuous head position monitoring (being developed in Finland) was also discussed as a future possibility.

- However, continuous monitoring does not equal motion correction; it simply allows you to know at all times where the head is but does not correct for movement.
- Thus this will be most useful for people looking at single events, eg epileptic spikes, rather than averaging across many trials.

How do I obtain access to the Neuromag software to view my waveforms, fit dipoles, etc?

Currently all Neuromag software can be run through several Linux workstation computers and MEGACQ in the MEG lab.

- You can remotely log onto MEGACQ through any Linux machine, but we prefer that people not use MEGACQ due to the risk of interfering with measurements.
- xplotter, xfit, graph, mrilab, cliplab, seglab, maxfilter, and maxfilter_gui can be all used with Linux thanks to Matti.

I'm about to begin analyzing my data, who should I go to for help? Are there any manuals I can reference?

Periodically we will be giving seminars on MEG analysis, but these will be broad overviews of all the different programs and not step-by-step tutorials of each. The best option would be to receive detailed instruction from your more experienced collaborators and to refer to one of the several manuals available online at <http://www.nmr.mgh.harvard.edu/martinos/research/meg/resources.php>.

(We periodically hold training sessions for various analysis techniques, announced through megscan).

How is billing handled?

In order to use the MEG system, you must have an account assigned to you by Karen Dervin. You will not be able to receive any type of account without IRB approval. Currently there are three different kinds of accounts used:

- Development (free): to be used when designing your study to work with the MEG system; i.e., setting up stimuli, testing out triggers, etc.
- Pilot (free): if you do not have the money to fund a study, or if you simply want to run a few test subjects before beginning your true study (such data will not be published), use this account.
- Funded (\$\$): to be used for actual studies (e.g., data expected to be published).

What is the benefit of using EEG? How many channels should I use?

There are many excellent reference papers comparing MEG to EEG, several of which can be found on the MEG website.

- The short answer to this question is that the sensitivity of MEG and EEG to different sources is complementary, particularly because EEG is able to see radial sources.
- Another benefit is that EEG has no head movement issues.
- Additionally, if you are more familiar with how the EEG component looks, it is a good idea to collect EEG and use it to better understand your MEG findings.

A decision regarding how many EEG channels to use depends on why you will be using the data.

- If you want to compare your EEG data to previous ERP studies, using 5-10 electrodes may be acceptable, and a 64 or 128 channel cap may be overkill.
- If you are using your data for source analysis, then the 64/128 caps are very helpful.

The integration of MEG and EEG data was discussed, and the consensus seems to be that the integration software exists and is working, but needs much more testing before it is available to users.