Center for Functional Magnetic Resonance Imaging (CFMRI)
University of California, San Diego

Safety Guidelines for Conducting Magnetic Resonance Imaging (MRI) Experiments Involving Human Subjects

July 2026

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1. Introduction

This manual outlines the safety standards and procedures for conducting magnetic resonance imaging (MRI) experiments involving human subjects and biomedical studies at the UCSD Center for Functional MRI (CFMRI).

The manual provides a brief overview of the CFMRI facilities, including the imaging modalities available. It also includes a brief introduction to the principles of MR imaging as background for understanding the risks associated with MRI experiments.

Subsequent sections are organized around the key topics and requirements that must be addressed before a researcher begins work at the CFMRI. Before scanning, research teams must:

1. Obtain a CFMRI Operator Certificate, including current safety and operator training.
2. Obtain approval of the study protocol from the Center's Administrative and Science teams.
3. For human studies, provide the Center with an approval letter from the UCSD Human Research Protections Program/Institutional Review Board (IRB).
4. For animal studies, provide the Center with an approval letter from the UCSD Institutional Animal Care and Use Committee (IACUC).
5. Establish individual Calpendo accounts for the PI, all operators, and all research coordinators. Shared accounts are not allowed.

2. Facilities and Access

The CFMRI is dedicated solely to research and is not a medical facility.

The Center houses four MRI scanners, including three 3 Tesla whole-body imaging systems used for human and larger-animal studies, as well as a 7 Tesla small-animal scanner.

1. **3.0T Scanner, 3T West** – Siemens MAGNETOM Cima.X
2. **3.0T Scanner, 3T East** – Siemens MAGNETOM Prisma
3. **3.0T Scanner, 3T Keck** – GE MR750 Discovery
4. **7.0T Scanner** – Bruker with NEO Console; 20 cm bore for small-animal imaging

All systems are equipped for state-of-the-art high-resolution 2D and 3D structural imaging, dynamic imaging, including echo planar imaging, and magnetic resonance spectroscopy (MRS).

The Center is located in the W.M. Keck Building on the main UCSD campus at 3130 Biomedical Sciences Way (Map to CFMRI), adjacent to the Basic Science Building and the animal vivarium. The building is approximately 7,000 square feet and includes four magnet bays, a machine shop for RF and gradient coil construction, an electronics shop, and office space for faculty, staff, postdoctoral fellows, and students.

The building is ordinarily open on weekdays from 8:00 AM to 5:00 PM. Because limited support is available outside of normal business hours, individuals must be current CFMRI-certified scanner Operators to request card-reader access to the CFMRI outside normal weekday hours.

Note: The outside doors are locked outside of normal business hours, including weekdays from 5:00 PM to 8:00 AM and all day on weekends. Under no circumstances should doors be propped open or access cards be shared.

2.1 Operator Certification

Only individuals who have successfully completed the Center's training program may perform MR scanning at the CFMRI. The training program includes MRI safety lectures and supervised individual instruction, with an emphasis on both safety procedures and basic scanner operations.

Individuals who complete the program receive a CFMRI-Certified Operator Certificate. To maintain certification, Operators must complete annual MRI safety training through a web-based quiz. Operators must also remain current with scanner policies and operating procedures, including any required updates and complete at least one scan within the previous four months.

During MRI research studies, the CFMRI-Certified Operator listed in Calpendo is responsible for implementing the Center's safety guidelines on site. Any CFMRI-Certified Operator associated with a project in Calpendo may reserve scan time for that project.

To be added to a project in Calpendo, please contact Johnsie Donaldson at jdonaldsonii@health.ucsd.edu.

Additional details are available in the Center's policies regarding magnet room access, Operator status, and PI-related activities.

3. Principles of MR Imaging

Magnetic resonance imaging (MRI) is a highly flexible technique used to create images of the human body. Hydrogen nuclei, or protons, behave like small magnets. When a subject lies inside the scanner's magnetic field, these protons tend to align with the field. When properly excited, the protons precess, or rotate, producing a measurable signal that can be detected by a nearby receiver coil. The frequency of this precession is proportional to the local magnetic field. By making the magnetic field vary across the body, signals from different locations can be distinguished based on their frequency, allowing images to be reconstructed.

There are three basic components of an MRI system:

1. A large, static magnetic field, such as the 3 Tesla field used by the Center's human MRI scanners.
2. Radiofrequency (RF) coils, which are used to transmit energy to excite the MR signal and to receive the resulting signal.
3. Gradient coils, which are rapidly pulsed on and off to produce linear variations in the magnetic field for spatial encoding.

MRI techniques involve pulsing currents through the RF and gradient coils. For this reason, a particular MRI technique is often referred to as a pulse sequence. By varying the pulse sequence, MRI can produce a wide range of images with different spatial and temporal resolutions, as well as substantially different contrast between tissues.

The main magnetic field is produced by a large magnet with an inner diameter of 60 cm. A computer-controlled patient table moves in and out of the magnet bore to position the subject at the center of the scanner. For brain imaging, the subject's head is positioned within an RF head coil.

Functional MRI (fMRI) is used to measure changes in blood oxygenation and blood flow that accompany neural activity. When a particular area of the brain becomes active, the local blood supply becomes more oxygenated. This change in oxygenation affects the local MR signal, allowing fMRI to map patterns of activation in the working human brain.

For functional MRI studies, three main types of imaging are typically used:

1. **Localizer:** Brief images, approximately 20 seconds each, are acquired in three orthogonal planes to identify structural landmarks and plan the locations for subsequent imaging. A localizer typically takes about 1 minute, although additional localizers may be required if the subject needs to be repositioned.
2. **High-resolution anatomical imaging:** A 3D imaging sequence is used to acquire high-resolution images of the entire brain, commonly at approximately 1×1×1 mm resolution. The pulse sequence is typically a 3D gradient-echo sequence, often with inversion preparation, and usually requires approximately 6–8 minutes.
3. **Rapid dynamic imaging:** Dynamic images are acquired while the subject performs the selected task or rests, depending on the study design. The pulse sequence is typically an echo planar imaging (EPI) method, with in-plane resolution of approximately 3–4 mm and slice thickness of approximately 3–6 mm. In many cases, each image is acquired after a single RF pulse, with a maximum image acquisition rate of approximately 12 images per second. Each dynamic imaging run typically lasts 3–8 minutes.

A full fMRI experimental session generally consists of a localizer, one or more high-resolution anatomical scans, and approximately 3–6 dynamic imaging runs. Total session time typically ranges from 45–90 minutes.

4. Potential Risks

The primary established hazard associated with MR imaging is the strong force that the magnet can exert on ferromagnetic objects. For this reason, ferromagnetic objects are not permitted near the magnet, where they could become projectiles.

In addition, each subject must complete the standard MRI screening process to determine whether they have any implanted materials, devices, or other conditions that may pose a risk. Screening forms are available on the CFMRI website. If there is any uncertainty about the safety of an implanted material or device, the subject must not be scanned until the concern has been reviewed and cleared according to CFMRI policy.

MRI does not use ionizing radiation. However, there are four areas of potential concern for which the FDA recommends prudent safety limits:

1. Exposure to the static magnetic field
2. Exposure to the radiofrequency (RF) field, which can cause tissue heating
3. Exposure to rapidly switched magnetic fields, which can produce nerve stimulation
4. Acoustic noise

4.1 Exposure to the Static Magnetic Field

The U.S. Food and Drug Administration (FDA) considers MRI systems with static magnetic field strengths up to and including 8 Tesla for adults, children, and infants older than one month of age to be non-significant risk (NSR) devices, provided they meet standard safety criteria. MRI systems operating above 8 Tesla are categorized as significant risk (SR) devices and require more rigorous regulatory oversight, including an Investigational Device Exemption (IDE). This distinction is not based on proven biological harm at higher field strengths, but rather on the more limited clinical safety data available at those levels.

The CFMRI's 3T magnetic fields are within FDA guidelines for clinical imaging and fall within the non-significant risk category.

In high magnetic fields, rapid movement of the head can cause dizziness, vertigo, nausea, or a metallic taste. For this reason, the scanner table moves slowly into the magnet bore, and subjects are encouraged to remain still while in the region of the static magnetic field. The Operator must ensure that rapid movements are minimized as the subject enters and exits the magnet bore. During scanning, head motion is restrained using padding placed between the subject's head and the RF head coil, or by other appropriate support.

Metallic implants and loose metal objects are not permitted inside the magnet room unless authorized by CFMRI staff. No metallic implants, or loose metal objects are permitted inside the magnet room unless authorized by CFMRI Staff (Contact Aaron Jacobson: ajacobson@ucsd.edu, Conan Chen: coc004@health.ucsd.edu, Ryan Barnes: r2barnes@health.ucsd.edu, Stephan Jordan: sjjordan@health.ucsd.edu).

Superconducting magnets use cryogens to super-cool the electrical wires that generate the static magnetic field. The cryogen is typically liquid helium, which has a temperature of approximately −269°C, or −452°F. On rare occasions, a sudden boil-off of cryogen, known as a quench, may occur. A quench is usually accompanied by a loud rushing noise and results in the rapid loss of the magnetic field.

Expanding helium gas can rapidly displace oxygen in the room. The Center's magnet rooms are equipped with dedicated exhaust vents designed to safely vent cryogen vapors outdoors. However, if the venting system fails during a quench, there is a serious risk of oxygen displacement, asphyxiation, frostbite, and hazardous room pressure changes.

If the vents fail during a quench, the emergency evacuation procedure outlined below must be followed immediately.

Quench with Vent Failure

A magnet quench can result in the release of cryogen vapor into the magnet room if the vent fails; white clouds of vapor appear in the magnet room. Cryogens released during a quench can cause asphyxiation, frostbite, or injuries due to panic. Magnet quenches are indicated by a loud noise, warning message, or the tilting of an image on the image screen. It is critical to have a well-planned method to quickly remove the patient and all personnel from the magnet room if a quench should occur.

Use this procedure in case of a sudden cryogen release into the magnet room.

1. **Do not panic.**
   - Staying calm helps you remain focused so you are able to safely remember and follow your planned method of action.
2. **Using the intercom, tell the patient to stay calm and remain on the table.**
   - Tell the patient that someone will be in shortly to offer assistance.
3. **Turn on the magnet room exhaust fan.**
   - Some systems vent automatically and there is no fan to turn on.
4. **Prop open the door between the operator room and hallway.**
   - This promotes air circulation.
5. **Prop open the door to the magnet room.**
   - If helium is venting in the room, the magnet room door may not open.
   - If the door cannot be opened, break the window to the magnet room to relieve pressure.
6. **Enter the magnet room and help the patient exit.**
   - If a gurney or wheelchair is needed to remove the patient, make sure it is a non-ferrous type.
   - When exiting, stay near the floor where the oxygen will be and immediately exit the magnet room.
7. **Evacuate all personnel from the area until the air is restored to normal.**

4.2 Exposure to the RF Field and Tissue Heating

The radiofrequency (RF) fields used in MRI consist of non-ionizing electromagnetic radiation and do not pose the same type of risk as x-rays or radioactive tracer techniques. However, RF fields can deposit energy into tissue and cause tissue heating.

The FDA guidelines indicate that MRI is considered non-significant risk when the specific absorption rate (SAR), which is the amount of RF energy deposited into body tissues, does not exceed the following limits:

1. 4 W/kg averaged over the whole body for 15 minutes
2. 3.2 W/kg averaged over the head for 10 minutes
3. 8 W/kg in any gram of tissue in the head or torso for 15 minutes
4. 12 W/kg in any gram of tissue in the extremities for 15 minutes

The pulse sequences used at the Center are similar to standard clinical pulse sequences, and local protocols are designed to ensure that RF energy deposition remains below federal safety guidelines. The scanner software calculates the expected SAR before a scan begins. If the estimated SAR exceeds safe limits, the system prevents the scan from running until the parameters are adjusted.

Because SAR estimates depend in part on the subject's weight, **an accurate weight must be entered into the scanner before scanning**. Entering a falsely low weight may cause the scanner's safety limits to be reached prematurely, preventing the scan from running. Conversely, entering a falsely high weight may cause the scanner to underestimate SAR, which could increase the risk of excessive tissue heating.

The Center's scanners are equipped with RF power monitoring systems that track both instantaneous, or peak, RF power and time-averaged RF power delivered to the RF transmit coil. These systems help ensure that the pulse sequence remains within safety limits, even in the event of equipment malfunction.

To reduce the risk of RF burns, subjects must not be scanned under the following conditions:

1. The subject is wearing damp clothing or clothing that contains metallic threads, such as antimicrobial "silver" athletic wear.

2. The subject's skin is in direct contact with the scanner bore, exposed circuitry, or the RF transmit coil surface.
3. The subject is wearing a transdermal medication patch with metallic foil backing.
4. The subject's arms or legs are crossed in a way that could create a conductive loop.
5. Unconnected receive coils, ECG leads, looped cables, or other conductive loops are present inside the scanner (Sammet, 2016)

Subjects with compromised thermoregulation may have a reduced ability to dissipate heat and should be monitored with particular care. This may include subjects with cardiovascular disease, hypertension, diabetes, obesity, advanced age, fever, or impaired ability to perspire.

To support heat dissipation, the scanner room temperature should be maintained at or below 70°F, or 21°C, during scanning.

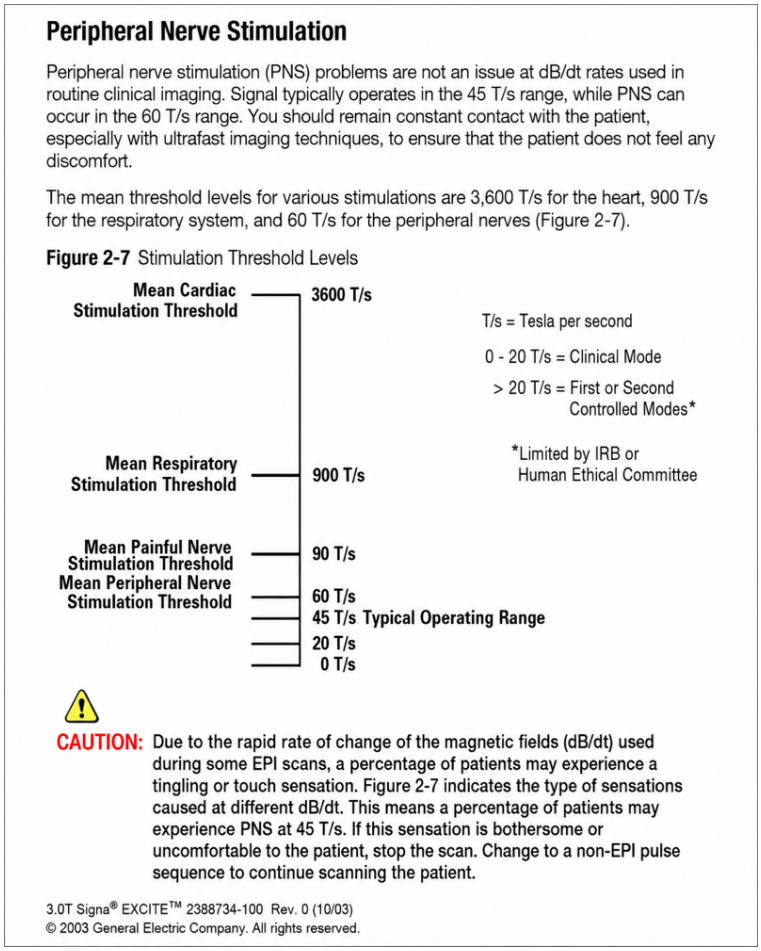
For the human MRI scanners, the standard ambient conditions for the examination room are:

1. Operating temperature: 18°C–22°C, or 64°F–72°F
2. Relative humidity: 30%–60%, non-condensing

4.3 Exposure to Rapidly Switched Magnetic Fields: Nerve Stimulation

The gradient coils used for imaging produce time-varying magnetic fields, described by the slew rate, or dB/dt. If sufficiently strong, these fields can produce peripheral nerve stimulation. Stimulation can occur in peripheral nerves, muscle, and blood vessels. The FDA guideline is that switched gradient fields pose a significant risk if the dB/dt is sufficient to produce severe discomfort or painful stimulation.

- The mean painful nerve stimulation threshold, the level at which half of subjects are likely to report painful stimulation, is 90 Tesla/second.
- The mean peripheral nerve stimulation threshold, the level at which 50% of subjects may report a tactile sensation or metallic taste, is 60 Tesla/second.
- The slew rate of a typical scan is 45 Tesla/second.



Peripheral Nerve Stimulation

Peripheral nerve stimulation (PNS) problems are not an issue at dB/dt rates used in routine clinical imaging. Signal typically operates in the 45 T/s range, while PNS can occur in the 60 T/s range. You should remain constant contact with the patient, especially with ultrafast imaging techniques, to ensure that the patient does not feel any discomfort.

The mean threshold levels for various stimulations are 3,600 T/s for the heart, 900 T/s for the respiratory system, and 60 T/s for the peripheral nerves (Figure 2-7).

Figure 2-7 Stimulation Threshold Levels

CAUTION: Due to the rapid rate of change of the magnetic fields (dB/dt) used during some EPI scans, a percentage of patients may experience a tingling or touch sensation. Figure 2-7 indicates the type of sensations caused at different dB/dt. This means a percentage of patients may experience PNS at 45 T/s. If this sensation is bothersome or uncomfortable to the patient, stop the scan. Change to a non-EPI pulse sequence to continue scanning the patient.

3.0T Signa® EXCITE™ 2388734-100 Rev. 0 (10/03)

Gradient slew rates are limited in the pulse sequence software used for fMRI to help ensure that subjects do not experience discomfort. On the GE 3.0T MR750 and Siemens 3T Prisma systems, if the pulse sequence involves a slew rate greater than 20 Tesla/second, the Operator is prompted with a system warning regarding nerve stimulation. If a prescribed pulse sequence would exceed the maximum allowable value, the software will not accept the prescription and will prompt the user to modify the prescription or parameter values.

Following any scan session in which a subject reports somatosensory, painful, or motor stimulation, the subject should complete a peripheral nerve stimulation form. Forms are available electronically through the Nerve Stimulation Form link, and hard copies are available in each control room.

4.4 Acoustic Noise

When current is pulsed through a gradient coil within a magnetic field, the coil acts somewhat like a loudspeaker, creating a sharp tapping sound at the characteristic frequency of gradient pulsing, typically around 1 kHz. Sound levels are most intense during dynamic imaging, which requires rapid gradient switching.

Sound pressure levels at the center of a gradient coil have been measured in the range of 122–131 dB SPL for a 3T scanner during echo planar imaging (Foster et al., 2000). The FDA guideline is that acoustic noise poses a significant risk if peak acoustic noise exceeds 140 dB. For the pulse sequences used on CFMRI scanners, acoustic levels are below this limit.

In addition, all individuals entering the magnet bore must use adequate hearing protection in the form of earplugs. The earplugs used at the Center are rated to reduce acoustic noise by 30 dB. Earplugs must be used during scanning to keep sound exposure below 99 dB.

The subject always has the right to end the study at any time if the acoustic noise is unacceptable.

5. Risk Management

Operators must be trained and must demonstrate competence in the operation of the MRI scanner, including knowledge of MRI-related risks and the ability to respond appropriately to emergency situations.

5.1 Subject Screening

Each scanning session usually lasts approximately 1–1.5 hours. Before arriving at the Center, each subject must be screened to ensure that there are no contraindications for MRI. The Center recommends that subjects be screened three times, as follows:

1. **Initial recruitment:** When the subject is first recruited for a study, they should be screened for any contraindications to MRI. This early screening provides adequate lead time to investigate any “yes” responses on the screening form. It also helps prevent cancellation of scanner sessions due to subject incompatibility, which may involve penalties. Use the 3.0T MRI Initial Subject Recruitment/Advance Screening Form.
2. **Arrival at CFMRI:** Before entering the magnet room, every subject must again be carefully screened for any implanted material or other condition that could constitute a risk in the scanner. The subject will be asked to complete the checklist again under the supervision of the Operator, and each item will then be verbally confirmed. If the subject is unsure about the answer to any checklist question, they must not be scanned. No one may enter the magnet room unless they have completed a screening form. Subjects

attending repeat visits must complete a new screening form for every visit; the form is valid for only 24 hours. Use the 3.0T MRI Pre-procedure Screening Form.

3. **Immediately prior to scanning:** Immediately before taking the subject into the scan room, a third pre-procedure checklist is completed. This form serves as an aide-memoire for the Operator and re-lists the absolute contraindications to MRI, as well as a checklist to confirm that the subject has removed all metal objects from their person and pockets. All subjects, especially children and individuals with diminished cognitive competence, must be screened with a hand-held metal detector to determine whether they may have overlooked metal on their person. Use the 3.0T MRI Operator's Checklist.

Pregnant women are excluded from studies at the Center. Although "to date there are no known deleterious effects related to the use of MR procedures during pregnancy" (Puris, Chetrit, & Katorza, 2025), FDA guidelines indicate that the safety of MR for imaging the fetus has not been established.

Women of child-bearing age may be scanned only if the project includes an IRB-approved method to exclude pregnant subjects. The age range and gender distribution of subjects should be provided in the IRB application, along with the method used to exclude pregnancy, such as a questionnaire, pregnancy test, gender/age restriction, or other approved procedure.

5.2 Equipment Screening

Any behavioral, physiological, or other equipment to be brought into the magnet room must be approved for MR compatibility by CFMRI staff. For approval, contact Aaron Jacobson at ajacobson@ucsd.edu.

Approved devices must be positioned in the MRI scan room before the subject enters the scan room.

5.3 Staffing Requirements for MRI Research Sessions

The Center for Functional MRI (CFMRI) will assess the complexity of each MRI study, including the equipment, procedures, and subject population involved, to determine the minimum number of certified MRI scanner Operators and trained imaging team staff required to safely and effectively conduct each session.

Due to the complexity of some research studies, multiple staff members may be required to be on site and actively assisting during MRI sessions. This determination will be made on a case-by-case basis by CFMRI staff.

5.4 Subject Positioning

If there are no contraindications for MRI, the subject will lie on the scanner bed just outside the magnet opening and be positioned in the head coil. A step-by-step description of subject placement is provided in Appendix 1. A brief synopsis is presented here.

Foam pads or towels will be placed around the subject's head for stabilization. Alternative head movement constraints may be used, provided that the subject's comfort is maintained. The subject will be given earplugs and instructed in their proper use. For some studies, the subject may also wear headphones.

When needed, a button-press response box or joystick will be positioned so that it can be manipulated by the subject. No cables should touch the subject's skin. Looped cables should not be placed near the subject. Any unused cables, transmit or receive coils, or other unused equipment should be removed from the bore and from the RF coil.

If, at any time, a subject becomes unable to tolerate the procedure, the exam will be terminated. Subjects will remain in constant voice contact with the Operator through the intercom system. Subjects who cannot communicate reliably with the Operator should not be studied.

5.5 Subject Monitoring

For all subjects and studies, the Operator is responsible for continuously monitoring the subject's status throughout the scan session.

In the magnet room:

1. When appropriate, the window blinds should be open for visual monitoring.
2. The video monitoring system should be on.
3. The intercom should be set at a level sufficient to hear the subject.

In addition, the subject should be given the squeeze bulb and trained in its use. To minimize unnecessary squeezing of the bulb, the squeeze bulb may be taped to the subject's thigh. Use

of a pulse oximeter is also strongly recommended, as it provides an additional mechanism for monitoring the subject's status.

Given the potential risks of peripheral nerve stimulation and overheating associated with rapid dynamic imaging, the Operator should frequently ask about the subject's comfort and the room temperature. Typically, verbal contact should be made with the subject before each scan.

For additional monitoring requirements related to children, see Section 9.

5.6 Limit on Scans in a Single Subject

Although there are no known long-term cumulative effects of exposure to the electromagnetic fields used in MRI, it is prudent to limit the number of studies performed on a single individual. The recommended consent form asks subjects to specify the number of MRI examinations they have undergone during the previous year, including both research and medical MRI examinations.

The Center recommends that investigators limit studies on a single subject to no more than six MRI examinations within any one-year period. For some studies involving unique subjects, additional scans may be required to meet the scientific goals of the experiment. In these cases, a separate justification for the larger number of studies should be included in the IRB application and in the proposal submitted to the Center.

5.7 Number of Personnel in the Magnet Room

MRI is extremely safe, and no adverse event is anticipated when proper safety procedures are followed. As described above, the primary risk is from metallic objects brought into the scanner room that could become projectiles.

To minimize this risk, nonessential personnel are excluded from the scanner room to help ensure that no ferromagnetic objects are brought near the magnet. In each scan room, the 5 Gauss field limit is marked on the floor. No one may enter the magnet room unless they have been screened and checked for metal objects by the Center-Certified Operator running the console.

National reviews of the few cases in which metal objects have caused injury during a scan have identified confusion about who had the authority and responsibility to prevent metal objects from

entering the scanner room. At the UCSD Center for Functional MRI, the Center-Certified Operator has the ultimate authority to enforce safety standards.

5.8 Confidentiality of Subject Records

All subject records will be kept confidential. At the beginning of each study, the Principal Investigator (PI) will provide the Operator with a subject number for each subject. This number will be recorded in the computer database for that scanner, along with a record of each pulse sequence used for the study. This record will be archived.

No identifying information will be stored, except for the number provided by the PI. In this way, the subject's anonymity is preserved while allowing the Center to maintain records of the procedures used in each study.

5.9 CFMRI Safety Audit

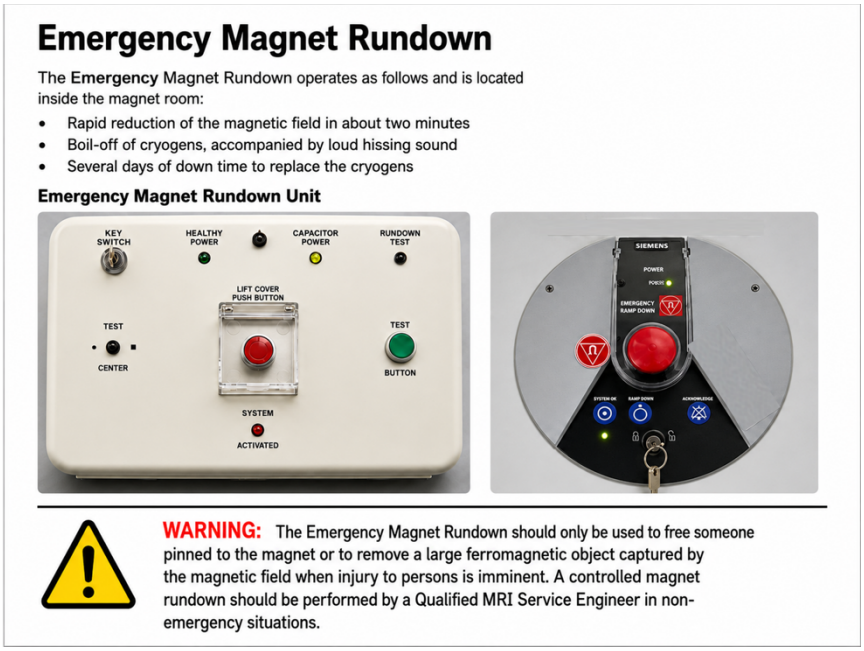
Staff members from the Center may occasionally audit scan sessions to verify compliance with the Center's safety policies. Unscheduled use of the scanner poses a safety risk, especially after hours.

Scanner usage will be audited to ensure that use of the scanner complies with the Calpendo schedule and that proper screening forms are submitted with each scan.

6. Emergencies

In the event of an emergency, a Center staff member should be contacted immediately for assistance. If a staff member is not available, the Operator should contact the numbers listed on the Emergency Call List posted in each console room.

If a metal object traps a subject in the magnet bore and the subject cannot be removed without quenching the magnet, press the Magnet Rundown System button on the side wall as one enters the magnet room.



See the figure (right). Within approximately one minute, the magnetic field will drop to a level at which metal objects can be removed. Although this is a measure of last resort, quenching is further justified if a subject has been injured.

The Center is not a medical facility. Emergencies at the Center should be treated as they would be in any other UCSD academic facility.

In the event of a fire, rescue, police, or medical emergency at the Center:

1. Call **911** or **44357**. This reaches Campus 911, not the general 911 number. The Operator should call the fire department, campus security, or other emergency responders as appropriate.

   If the Operator does not know the Center's location, provide the following information:

Center for Functional MRI

W. M. Keck Building #822 (3130 Biomedical Sciences Way)

North side of Biomedical Sciences Way at the south end of the Basic Science Building – across the road from the Skaggs Pharmacy Building

Phone: (858) 822-0577 (3T West Console room)

(858) 822-0580 (3T East Console room)

Online map to the Center CFMRI Map

2. Release the MRI bed from the scanner and roll it into the hallway outside the scan room to ensure that emergency personnel do not go near the magnet. All Center-trained Operators must have experience with this maneuver before being certified.
3. Administer CPR as needed. An Automated External Defibrillator (AED) and First Aid Kit are available in the atrium between the two 3T console rooms.

6.1 Fire in the Magnet Room

If a fire occurs in the magnet room:

1. Press the **Emergency Off** button. This is the red button on the upper left side of the console keyboard. There are also Emergency Off buttons on each side of the front magnet facing. Pressing the button cuts power to the magnet room and removes electrical power to all components of the system other than the static magnetic field and the Magnet Shutdown Unit.

2. Evacuate the subject.
3. Pull the fire alarm and call Campus 911.
4. Use the **white fire extinguishers** to contain the fire. The white extinguishers are located in the magnet rooms and are magnet safe. The red extinguishers should **not** be taken into the magnet room.

As a general rule, only attempt to extinguish a fire that is not taller than your waist. In the presence of a larger fire, evacuate all individuals to a safe location.

When the fire department arrives, Center personnel must determine whether firefighters need to bring ferromagnetic objects into the magnet room. If ferromagnetic equipment must enter the room, quench the magnet by pressing the button on the Magnet Rundown Unit. The Magnet Rundown Unit is located on the side wall as one enters the magnet room.

7. Contact with Bodily Fluids

The Center's general rule governing contact with bodily fluids is to use Universal Precautions. See Appendix 4.

Universal Precautions begin with the assumption that all research participants may harbor a contagious disease and that only trained staff should manage the cleanup of bodily fluids. Research groups are expected to have personnel available to clean up and dispose of small amounts of blood, urine, and other fluids.

When larger amounts of fluids need to be managed, or if assistance is needed after hours, call Environment, Health and Safety at x43660.

8. Visitors

Visitors are not permitted in the magnet rooms without prior approval from the center MRI Safety team and/or the center director. For inquiries, please contact Aaron Jacobson at ajacobson@ucsd.edu

9. Scanning of Children

Use of the Mock Scanner is strongly encouraged for studies involving children. In addition to training related to study procedures, the subject should also be trained on safety and communication procedures, including how to use the squeeze bulb, how to talk with the Operator, and how to signal the Operator if there is a problem.

All researchers involved with pediatric scanning are required to familiarize themselves with issues specific to scanning children. These include assent and consent, techniques for increasing compliance in children, testing limits for children, use of the Mock Scanner, strategies for working with anxious subjects, and how to determine whether an older child needs someone in the room.

9.1 Research Subjects Under the Age of 9

For children under the age of 9, an adult monitor must remain in the magnet room with the child throughout scanning. In addition, an adult monitor must remain in the magnet room with any child under the age of 13 who exhibits anxiety or requests accompaniment.

As part of routine procedure, the Operator should ask the child whether they would prefer to be accompanied in the scanner. If there is any doubt about the child's ability to follow safety instructions while in the magnet room, an adult monitor must remain in the magnet room.

The adult monitor must be one of the following:

1. A certified Operator.
2. A research assistant who is safety certified.
3. A parent or legal guardian who has undergone safety screening and has been instructed in the use of the safety squeeze bulb.

The adult monitor should have a squeeze bulb to notify the Operator if there is a problem. The adult monitor must also wear both earplugs and protective earmuffs while in the magnet room.

Research Subjects Under the Age of 13

For imaging sessions involving subjects under the age of 13, there should be at least two safety-certified adults present at each scan session. One adult is the Operator. The second adult should be either an Operator or a safety-certified researcher, including faculty, staff, or students, who can assist with monitoring the subject.

If additional children, such as siblings, are present during the scan session, a third adult should be available to monitor their activities, ensure their safety, and ensure that others working at the Center are not disturbed.

Research Subjects 13 Years and Older

For subjects 13 years and older who exhibit diminished cognitive capacity and may not be able to follow safety instructions while in the magnet room, an adult monitor must remain in the magnet room with the subject throughout scanning.

The monitor must be one of the following:

1. A certified Operator.
2. A research assistant who is safety certified.
3. A parent, legal guardian, or legally authorized representative who has undergone safety screening and has been instructed in the use of the safety squeeze bulb.

The monitor should have a squeeze bulb to notify the Operator if there is a problem. The monitor must also wear both earplugs and protective earmuffs while in the magnet room.

10. Summary of Safety Guideline

1. Certification

- All console Operators must complete the Center's Operator training and safety courses, including required updates.
- All console Operators must earn and maintain a Center-Certified Operator certificate.
- To maintain active certification, an Operator must maintain safety training through the annual online web-based quiz and regularly perform research scans at UCSD, with a minimum of four months of currency. Center scan staff will monitor Operator activity.
- Research Assistants who are not Operators, but who are essential to the running of a research study, may enter the scan room if they are safety trained. This includes completion of the Center safety lecture, the annual web-based safety quiz, and any required updates.

2. Line of Authority

- Everyone in the magnet suite is responsible for ensuring safety.
- The Center-Certified Operator running the console has the ultimate authority to enforce safety standards.
- The Center-Certified Operator running a study is the Operator listed in Calpendo. Any changes to the Operator for a particular study must be reflected in Calpendo.
- No one may enter the magnet room without approval from the Center-Certified Operator.

3. Subject Policies

- Specific IRB approval and Center Director approval must be obtained to study individuals less than 3 years old.
- Only individuals who can be studied without anesthesia may be scanned at the Center.
- Women of child-bearing age may be studied at the Center only for protocols that have IRB approval. The submitted IRB protocols must include the proposed age range and gender distribution of subjects to be studied, as well as the means used to establish that a subject is not pregnant.

- Studies involving pregnant women or patients taking fertility treatments must be specifically approved by the IRB and the Center Director.
- All research subjects may be scanned only after an approved IRB protocol has been obtained.
- Subjects with metal fragments in the brain, eye, auditory canal, spinal cord, or internal organs may not enter the magnet room.
- Subjects who screen positive for shrapnel or bullets outside of the areas listed above may be studied after the location of the objects has been documented on the anatomical diagrams included in the screening checklist. As with all subjects, these individuals must be monitored for temperature comfort.
- Subjects with whom reliable communication cannot be maintained may not be scanned at the Center.
- In the event of an accident that might expose any research subject or research personnel to bodily fluids, Universal Precautions should be followed. Universal Precautions emphasize that all individuals should be assumed to be infectious for blood-borne diseases such as hepatitis B. A description of Universal Precautions is included in the Appendix.

4. Screening

- Subjects should be screened for implanted or attached medical devices or other objects. Screening should use approved forms and should occur during study recruitment and again each time a subject enters the magnet room.
- Only a Center-Certified Operator should perform the screening prior to a study.
- A hand-held metal detector should be used for all subjects to determine whether they have overlooked metal objects. This is especially important for patients with diminished cognitive competence and children.
- Individuals who screen positive for implanted or attached medical devices should not be allowed into the magnet room unless prior approval is obtained from CFMRI staff and/or the Safety Officer.
- To permit an individual who screens positive for implanted or attached medical devices to enter the magnet room, the name of the device, its manufacturer, and its part number must be identified. After the device is identified, documentation of its MR compatibility and safety is required.

5. Study Devices

- CFMRI scan staff must review the safety of any behavioral or physiological device used as part of a study before it enters the magnet room.
- Device approval must be documented using the MR Device Compatibility Form, and approved devices must be tagged to show that they have been approved.
- Approved devices must be positioned in the scan room before any subjects are positioned on the magnet table or in the vicinity of the magnet.
- Special care must be taken when positioning any wires attached to the device. Wires should not touch the research subject. Wires should be kept straight and should not contain loops.
- Unused transmit or receive coils must be removed from the magnet bore and bed.

6. Emergencies

- Release the table latch and pull the subject out of the bore.
- Release the MR bed and roll it into the hallway between the 3T scanners. All Center-trained Operators must have experience with this maneuver before being certified.
- Call 911.
- The Center does not support a crash cart.
- Administer CPR as needed. An AED is available between the 3T console rooms. All Operators are encouraged to obtain CPR training.
- Use the Safety Kit to manage minor injuries. Gloves should be used when managing minor cuts.
- Manage fires with the white extinguisher. Turn off electrical power to the scanner using the red emergency buttons on the console or body of the scanner. Close doors to contain smoke and flames.
- Do not quench, or perform an emergency rundown of, the magnetic field unless a subject is trapped by a metallic object in the scanner and is injured or in danger of becoming injured.

7. Visitors

- Visitors are not permitted inside the magnet rooms without permission from the Center Director.

8. Peripheral Nerve Stimulation and Other Sensory Effects

- If the patient complains of pain or discomfort, including headache, stop the scan immediately. If the pain is not due to a biomechanical cause, such as awkward body placement or poor placement of neck or head supports, terminate the study. If the discomfort is due to a biomechanical cause, the study may continue if the cause is corrected.
- If the patient complains of tingling, a light touch sensation, or muscle twitching, stop the scan and assess the extent of discomfort. If the discomfort cannot be minimized, the study must be terminated.
- Use the Report of Patient Peripheral Nerve Stimulation Form to document complaints of unexplained discomfort or pain immediately after the subject has been removed from the scanner room. Copies of the form should be sent to CFMRI staff and the Center Safety Officer.
- During informed consent and again prior to entry into the magnet room, subjects should be informed that they should report excessive warmth, visual flashes, dots, scintillations, or tactile sensations to the scan Operator during an MR study.

9. Acoustic Noise

- All individuals entering the magnet bore must be provided adequate hearing protection. Earplugs and headphones can meet this standard and reduce audible noise exposure to less than 99 dB.
- When earplugs are used to provide hearing protection, only Center-approved earplugs should be used.
- Earplugs must be disposed of after each subject is scanned.

10. Radiofrequency Fields

- Each person’s weight must be entered into the appropriate program field before starting a scanning session. This is a critical safety step.
- The patient fan should be on at all times to maintain adequate airflow through the bore.
- The Console Operator should periodically ask whether the subject is too warm or too cold during the study.

- Subjects should not be scanned if they have damp clothing, come in contact with the RF circuitry of an RF coil surface, come into contact with a looped wire, or if unconnected receive coils or other cables have not been cleared from within the RF transmit coil.
- Use non-conducting pads when needed. Position the subject's hands at their sides and ensure that the legs are not crossed.
- Place foam between the subject and the bore.
- When using surface coils, place a sheet or pillowcase between the coil and the patient's skin.
- Removable eye makeup must be washed off prior to scanning.
- Subjects with permanent eyeliner or other metallic ink tattoos may be scanned only after informed consent has been obtained under an approved IRB protocol. Such subjects must be informed of the risk of skin irritation. Maintain close communication with these subjects during the scan and be ready to terminate the exam if symptoms develop.
- Jewelry should be removed prior to scanning. On a case-by-case basis, the Console Operator may decide whether rings may be worn during a scan.
- Scans should not be performed if the magnet room is warmer than 21°C, or 70°F.
- Do not interfere with the performance of the RF power monitor.
- Head studies producing SAR values greater than 3.2 W/kg must be approved by the Center Director and must have IRB approval.

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Electronic Resources

International Electrotechnical Commission: www.iec.ch

Shellock/Baccaco MRI Safety website: www.MRIsafety.com

Appendices

1. Patient Positioning: Surface or Phased Array Coils
2. Center Map and Directions
3. Peripheral Nerve Stimulation Form
4. Descriptions of Universal Precautions
5. 3T MRI Initial Subject Recruitment/Advance Screening Form
6. 3T MRI Operator's Checklist

Appendix 1
Patient Positioning

Quick Steps: Position a Patient with a Surface or Phased Array Coil

1. Remove any other coil or unused accessory device from the magnet.
2. Place comfort pads on the table to make the patient comfortable.
3. Place a clean cotton sheet over the comfort pads.
4. Position the patient on the table and place the coil over the area of interest.
5. Use additional pads as needed to immobilize the patient and improve comfort.
6. Provide the patient with the Patient Alert Bulb and explain how to use it.
7. Provide earplugs after all instructions have been given.
8. Instruct the patient to close their eyes.
9. Press Align Light to turn on the red laser light.
10. Move the table in slowly until the crosshair of the alignment light is centered over the area of interest.
11. Press Landmark to communicate the center of the region of interest to the system.
12. Press Move to Scan to move the patient to isocenter, the center of the magnet.
13. Place thermal pads where the patient touches the bore to help prevent warming.
14. Proceed with the scan prescription, selecting the appropriate coil type and name.

Appendix 2

Directions to the UCSD Center for Functional MRI

Directions:

- Exit Interstate 5 at La Jolla Village Drive – West
- After crossing Villa La Jolla drive, take the ramp from the right lane onto Gilman Drive – North.
- Merge onto Gilman Drive northbound.
- After passing the South Parking Structure, turn right onto Biomedical Sciences Way.
- The W.M. Keck Building is on the left.
- Parking instructions for research participants can be found here.

Appendix 3

Peripheral Nerve Stimulation Form

Report of Patient Peripheral Nerve Stimulation Form

Report Date _____ **Date of MR Exam** _____

Facility Name _____ **Scanner Manufacturer/Model** _____

Name of Reporting Health Care Professional _____

Patient Age _____ **Patient Weight** _____ **Patient Height** _____

Patient Pathology _____ **Patient Medications** _____

Exam Number _____ **Series Number** _____

Scan Parameters

PSD (GRE, SE, FSE, EPI, IR) _____

TR (ms) _____ **TE (ms)** _____ **FOV (cm)** _____

Slice Thickness (mm) _____ **Interslice Spacing (mm)** _____

Slew Rate (T/m/s, if known) _____ **Frequency Encoding Direction (RL, AP, SI)** _____

Stimulation Information

Were patient's hands clasped? _____ **dB/dt (% peripheral nerve or T/s)** _____

Stimulation Severity
(1 = very mild, 2 = mild, 3 = uncomfortable, 4 = very uncomfortable) ☐ 1 ☐ 2 ☐ 3 ☐ 4

Stimulation Description and Location

Appendix 4
Universal Precautions

1. Barrier protection should be used at all times to prevent contamination of skin and mucous membranes with blood, body fluids containing visible blood, or other body fluids to which Universal Precautions apply. These include cerebrospinal, synovial, pleural, peritoneal, pericardial, and amniotic fluids, as well as semen and vaginal secretions.

    - Barrier protection should be used with **all tissues**.
    - The type of barrier protection used should be appropriate for the procedure being performed and the type of exposure anticipated. Examples of barrier protection include disposable lab coats, gloves, and eye and face protection.

2. Gloves must be worn when there is potential for hand or skin contact with blood, other potentially infectious material, or items and surfaces contaminated with these materials.
3. Face protection, such as a face shield, should be worn during procedures that are likely to generate droplets of blood or body fluid in order to prevent exposure to the mucous membranes of the mouth, nose, and eyes.
4. Protective body clothing, such as disposable laboratory coats or Tyvek coats, should be worn when there is potential for splashing of blood or body fluids.
5. Hands or other skin surfaces should be washed thoroughly and immediately if contaminated with blood, body fluids containing visible blood, or other body fluids to which Universal Precautions apply.
6. Hands should be washed immediately after gloves are removed.
7. Care should be taken to avoid accidental injuries from needles, scalpel blades, laboratory instruments, and other sharp items when performing procedures, cleaning instruments, handling sharp instruments, or disposing of used needles, pipettes, and similar items.
8. Used needles, disposable syringes, scalpel blades, pipettes, and other sharp items must be placed in puncture-resistant containers marked with a biohazard symbol for disposal.

Appendix 5

3T MRI Initial Subject Recruitment / Advance Screening Form

File completed form with PI

3.0 T MRI RECRUITMENT / ADVANCED SCREENING FORM	UCSD Center for fMRI, 9500 Gilman Drive, La Jolla, CA 92093-0677 Tel: (858) 822-0513 Fax:(858) 822-0608

This form to be used for: Primary screening of research subjects being recruited by principal investigator (File completed form with PI)

Instructions for completing this form, and duplicate forms available from http://cfmri.ucsd.edu/forms.html

Principal investigator / Lab _____

Subject Weight _____ Subject Number _____

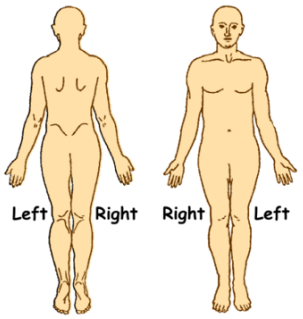
Name _____
Last name First name M.I.

Birthdate _____ Email Address _____

Address _____ City _____

State _____ Zip Code _____

Phone (____) _____ (____) _____ (____) _____
Home Work Cell/Pager



Some of the following items may be hazardous to your safety or may interfere with the MRI exam. Please check the correct answer for each of the following. If you checked yes, please give more information. E.g., Type of material? How long ago? Use the diagram to indicate where on your body?

1.	☐ Yes ☐ No	Do you have a heart pacemaker?
2.	☐ Yes ☐ No	Is there a possibility of metal in your head? (e.g. aneurysm clips, do not include dental work)
3.	☐ Yes ☐ No	Is there a possibility of metal in your eyes or have you ever needed an eyewash having worked with metals?
4.	☐ Yes ☐ No	Do you have an implanted medical device? (cochlear implant, metal ear tubes, tens unit, bone stimulator, insulin or other medication pump, automatic defibrillator, internal pacing wires).
5.	☐ Yes ☐ No	Have you had any metallic dental implants (posts, crowns) within the last 6 weeks?
6.	☐ Yes ☐ No	Have you had any bone, tendon, spine or joint surgery within the last 6 weeks?
7.	☐ Yes ☐ No	[*Research subjects only:*] Do you weigh more than 300 lbs (135 kg)?

8.	☐ Yes ☐ No	Is there any possibility that you may be pregnant?
9.	☐ Yes ☐ No	Do you suffer with claustrophobia?
10.	☐ Yes ☐ No	Do you have any medical problems when you lie flat on your back? (breathing problems, back pain, nausea)
11.	☐ Yes ☐ No	Do you have an IUD that may contain copper, or a contraceptive diaphragm?
12.	☐ Yes ☐ No	Have you had any stents, clips or surgery to any of any of your vessels (carotid artery vascular clamp, coronary stent, aortic clips, IVC filter, coils for blocked arteries)
13.	☐ Yes ☐ No	Do you have metal anywhere else in your body? (spinal rods, dental work, piercings, shrapnel, buckshot, bullets) – please indicate where on your body using the diagram above
14.	☐ Yes ☐ No	Do you have any piercings that can't be removed?
15.	☐ Yes ☐ No	Do you have a cerebrospinal fluid (CSF) shunt? (treatment for hydrocephalus or water on the brain)
16.	☐ Yes ☐ No	Do you have tattooed eyeliner, tattooed eyebrows or Bigen hair dye?
17.	☐ Yes ☐ No	Have you had any previous surgery? (give details, and indicate where on your body using the diagram above) Details: Date: / / Details: _____ Date: / /
18.	☐ Yes ☐ No	Have you had any medical condition that has prevented you from completing an MRI exam in the past?
19.	☐ Yes ☐ No	[*If medications or other substances are administered:*] Do you suffer with asthma or allergies to any medication?
20.	☐ Yes ☐ No	Do you have a transdermal medicated patch? (nicotine patch, contraceptive patch, medicated pain relief patch)
21.	☐ Yes ☐ No	Do you wear a hearing aid or dentures?
22.	☐ Yes ☐ No	Are you wearing athletic clothing or compression garments with “silver-technology” or marketed as antimicrobial (e.g., Lululemon, Athleta, Columbia “Omniheat”, Under Armour, Tommy Copper, Juzo USA)?
23.	☐ Yes ☐ No	Are you wearing magnetic eyeliner, mascara, or false eyelashes?

_____ _____ / /
Name of person completing form (please print) Signature Date

_____ _____ / /
Name of CFMRI safety personnel reviewing form (if secondary review needed) Signature Date

Appendix 6

3T MRI Operator's Checklist

File completed form with CFMRI

3.0 T MRI OPERATOR CHECKLIST	UCSD Center for fMRI, 9500 Gilman Drive, La Jolla, CA 92093-0677 Tel: (858) 822-0513 Fax:(858) 822-0608
This form to be used for: Last minute checks by MRI scanner operator immediately before subject enters the scan room *Instructions for completing this form, and duplicate forms available from http://cfmri.ucsd.edu/forms.html*	

Principal investigator / Lab _____ Subject Number _____ Height _____ Weight _____

IRB protocol # _____ Date of MRI study _____/_____/_____ Time of MRI study _____

Operator _____

⚠ **Certify that there are no absolute contraindications to MRI…….**

1.	☐ Yes ☐ No	Do you have a heart pacemaker?
2.	☐ Yes ☐ No	Is there a possibility of metal in your head? (e.g. aneurysm clips, do not include dental work)
3.	☐ Yes ☐ No	Is there a possibility of metal in your eyes or have you ever needed an eyewash having worked with metals?
4.	☐ Yes ☐ No	Do you have an implanted medical device? (cochlear implant, metal ear tubes, tens unit, bone stimulator, insulin or other medication pump, automatic defibrillator, internal pacing wires).
5.	☐ Yes ☐ No	Have you had any metallic dental implants (posts, crowns) within the last 6 weeks?
6.	☐ Yes ☐ No	Have you had any bone, tendon, spine or joint surgery within the last 6 weeks?
7.	☐ Yes ☐ No	[*Research subjects only:*] Do you weigh more than 300 lbs (135 kg)?

***** If any of the above are checked "yes, the subject CAN NOT enter the scanner *****

⚠ **Last-minute checks…….**

☐ Yes ☐ No	All pockets are empty	☐ Yes ☐ No	Credit cards
☐ Yes ☐ No	Keys / coins	☐ Yes ☐ No	Pens
☐ Yes ☐ No	Use Restroom	☐ Yes ☐ No	Belt
☐ Yes ☐ No	Hair pins / barrettes	☐ Yes ☐ No	Metal Buttons
☐ Yes ☐ No	Watch / Jewelry	☐ Yes ☐ No	Clothing with metal (underwire bra)
☐ Yes ☐ No	Safety pins	☐ Yes ☐ No	Shoes with metal shank / toecap
☐ Yes ☐ No	Paper clips	☐ Yes ☐ No	Hearing aid
☐ Yes ☐ No	Glasses	☐ Yes ☐ No	Removable dentures
☐ Yes ☐ No	Piercings	☐ Yes ☐ No	Nicotine or other patch
☐ Yes ☐ No	Wigs / extensions	☐ Yes ☐ No	Implant held in place by a magnet
☐ Yes ☐ No	Anti-microbial athletic clothing	☐ Yes ☐ No	Magnetic eyelashes / magnetic makeup

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⚠ **Use the metal detector**

⚠ **Ear plugs in place and working**