MRI SAFETY CONSIDERATIONS

This slide show is available as a video at http://www.cognitiveneuro.org/SafetyLinks.php

The purpose of this talk is to alert all personnel working in MRI to the safety hazards associated with the MR scanner and to offer a set of guidelines for the safe use of the equipment.

No one should ever enter the MRI magnet room unaccompanied by a safety trained individual. Becoming safety certified requires several steps. You should learn about, and understand, the special and often non-intuitive risks of MRI. This video will help to provide that information and is the first step in the process. Secondly, you must take a written test based on the materials in this video. Finally, you must demonstrate your ability to work safety in the lab during a practical exam.

Certification to use the equipment must be renewed annually.

MRI is generally considered a safe modality. However, there have been multiple deaths and injuries at MRI centers. Working in the restricted area without training places you, your subjects and the operation of the center overall at risk. Misuse may cause expensive damage to the instrument. While we expect you to enjoy performing your studies at the center, we also expect you to be respectful of the serious risks involved if the instruments are used improperly.

We have drawn on a variety of sources to create this instructional video, including materials developed by the MRI manufacturers, and by several MRI safety organizations. Most of these contents refer are common to all MRI devices, though some are quite specific to the Staglin Center environment.

AN INCIDENT

Michael Colombini, *six years old*, was undergoing an MRI at Westchester County Medical Center when an oxygen canister was turned into a guided missile by the powerful MRI magnet. The canister was drawn into the magnet core while the boy was in the machine.

AN INCIDENT

Michael Colombini Lived to be Six Years Old.

GENERAL FACTS

- The MRI is ALWAYS ON
- The Static Field has *no known* Biological Safety Risks

  but…
- There Have Been Numerous Disabilities and **Deaths**
- Most MRI Safety Hazards are Non-Intuitive
- Almost all MRI Accidents are Preventable
- Radio Frequency Energy Deposition May be High
- Cryogen Venting Can **Kill** by Suffocation
- High Voltages Exist Throughout the Facility

OVERVIEW

- Principles of Operation
  - *Three Electromagnetic Fields*
- Instrument Risks
- External Device Risks
- Patient/Subject Risks
- Consenting
- Minimizing Exposure
- Human Factors
- Reporting
- Resources

Learning a bit about the principles by which the MRI operates will help you to understand the sources of risk. This video offers instruction in the hazaards associated with the MRI itself. We then consider the dangers created by external devices brought into the environment, that are the cause of the majority of patient safety incidents.

Some people, especially children, ill and elderly patients, offer additional risk. You should learn how to anticipate these problems and to take prospective action to minimize such risk.

Consenting is an essential step to using the scanner legally, to minimize safety risks to the subject and to fully inform your subjects of the potential hazards in accepting an MRI exam.

In some cases, choosing appropriate scanning parameters can minimize the exposure of your subjects to the high energy components of the exam and thereby minimize the attendant risks.

The overwhelming majority of problems in MRI are the result of simple human factors: Failure to attend to the environment and the others in it, and failures to understand the responsibilities of each individual in regards to MRI safety.

It is important to everyone involved that any injuries or other incidents are reported properly. There are also special reporting requirements for the IRB that you should be aware of.

Finally, at the end of this video you will be directed to a set of potentially valuable resources to find more, and more current, information.

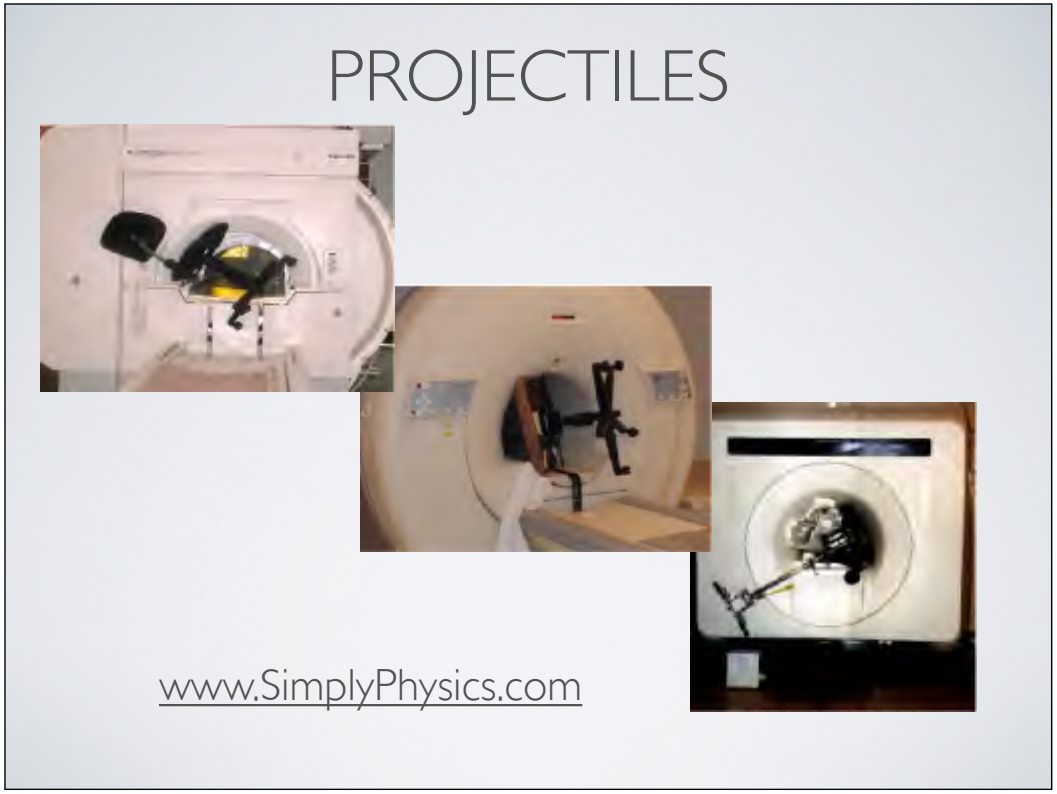
SAFETY

Stored Energy Equivalent to **2 kg** of TNT

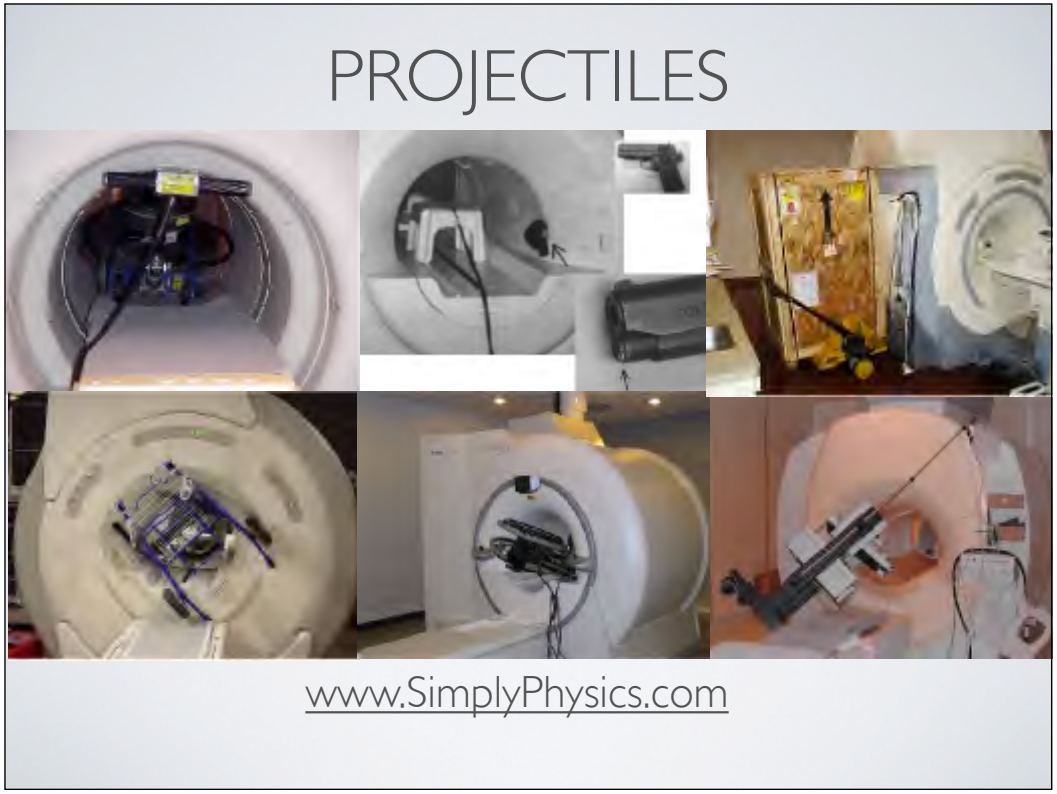
High field MRI instruments are based on superconducting magnets. Current is injected into wire that is cooled to a few degrees above absolute zero to create a magnetic field. A 3 Tesla magnet stores over 10 megajoules of energy in this current, equivalent to 2 kg of TNT, or the energy of a fully loaded semi truck traveling at 100 kilometers/hour. Further energy is contained in liquid helium coolant, which boils off violently if heated even slightly.

In rare instances these instruments have exploded as a result of improper handling.

Although it is possible to shut down a superconducting magnet, under ordinary circumstance it is ALWAYS on, even when the computer console is turned off, and even in the even of a power outage. In fact, the only time that a superconducting magnet is NOT on would be at delivery, at removal, or following a catastrophic quench. The MRI magnet is ALWAYS on.



An astonishing variety of objects have been pulled into MR systems. Here are a few chairs and a floor buffer (one of many floor buffers).



The middle panel in the top row shows a gun that found its way into the instrument (and discharged). A large rack of equipment, a walker, a wheelchair and a physiological monitoring system.

Never attempt to remove objects from the magnet on your own. Doing so is hazardous to yourself and can cause further damage to the instrument. Pulling out objects like those above would very likely require a winch or other mechanical removal equipment. If a device should come apart in the process ferromagnetic components can become lodge within the equipment and require a complete magnet quench, which is extremely costly in both time and money. Despite your potential embarrassment it is far better to avoid creating more trouble. If you find something lodged in the magnet, you should inform both CCN personnel and Siemens immediately.

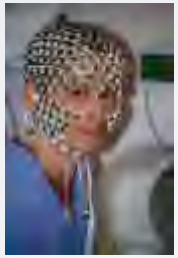
There are now standards for labeling of devices used in the vicinity of MR systems. The ASTM has created three classes: MR Safe, MR Conditional and MR Unsafe.

MR Safe objects typically are made of plastic, rubber, wood or other non-magnetic and non-metallic materials. The important classes

Importantly, there are certain patient care devices such as wheelchairs and gurneys that may be used safely in the MRI environment. Under no circumstances should you bring any outside gurneys or wheelchairs into the MRI lab area. Subjects should be moved to the safe devices while outside of the MRI console room.

ASTM MRI LABELING

MR CONDITIONAL. Poses no known hazards under specific conditions of use, such as field strength, position, etc...



MRI Conditional devices have been tested in the MRI environment under very specific conditions of use, including instrument field strength, location in the room, position on the body etc... Most MRI fire extinguishers are labeled “Conditional” reflecting the fact that caution is still required in their use. The Stagin center has available an MRI-compatible EEG devices that has conditional labeling. This instrument may only be used after receiving separate training.

Most devices should be assumed to be MR Unsafe, unless specifically labeled otherwise. This specific label usually is applied to objects that are intended to be used in an MRI facility but not in the magnet room. MR Unsafe labeling is relatively rare, and you should not assume that the lack of such labeling suggests that the devices are safe.

SHORT TERM BIOEFFECTS

No scientifically confirmed harmful short-term bioeffects related to exposures to strong static magnetic fields

At 3 Tesla, reported effects include:

- Vertigo
- Headaches
- Metallic Taste
- Nausea

To date, there have been controlled studies that have shown any evidence of harmful bioeffects from exposure to the magnetic fields typical of human imaging systems. For this reason, the FDA has labeled exposure to static - non-varying - magnetism a non-significant risk at field strengths up to 8 Tesla for adults and up to 4 Tesla for children.

However, at higher clinical field strengths, at 3 Tesla and above, a variety of transient effects have been reported including:
Vertigo or dizziness
Headaches and
Metallic Taste

At even higher magnetic fields people have reported other sensory phenomena such as phosphenes, or light flashes, especially if they move rapidly within the field.

WHAT ARE THE HAZARDS?

Projectiles account for 10% of reported safety incidents.

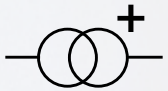
10% are from Implanted Devices

71% are burns!

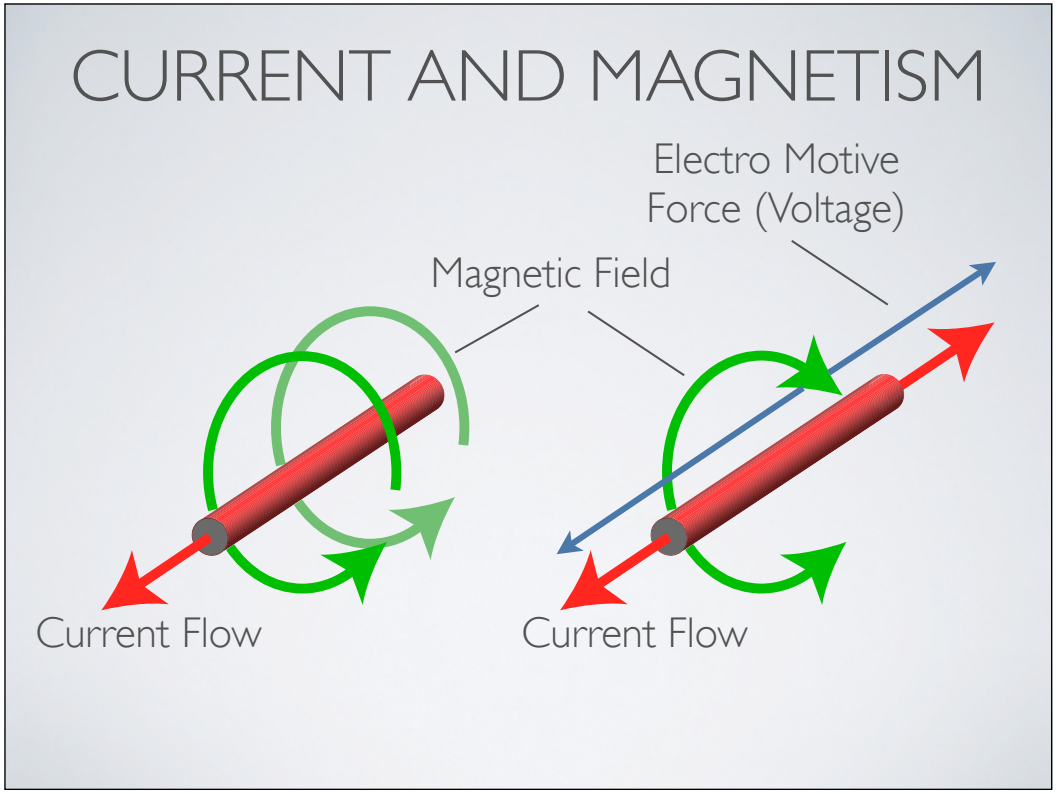
Despite the drama of MRI projectiles and implanted medical, these make up together just 20% of the reported incidents. The overwhelming majority of the real subject and patient harm is in the form of burns. The next section of this video explains why and how such burns occur. We will first introduce some simple electrical concepts.

CURRENT

- Electrical Kinetic Energy is called Current
- Current is the motion of charge
- Current Flows "through" conductors
- Current is Usually Denoted as, *i*
- The Unit of Current is "Amperes" or amps.



Current refers to the flow of charged particles - usually electrons - through a conductor. Current is a form of kinetic energy. In electrical circuits, current is usually given the symbol, i. It is measured in units of Amperes or amps. One amp is a rather large amount of current: enough to light a 100 watt lightbulb or to drive a large pump.



Current and magnetism are related intimately and, through relativistic analysis are reflections of the same phenomenon. In particular, the flow of current through a electrical conductor creates a magnetic field that wraps around the conductor and is proportional to the amount of flowing current. Equivalently, placing a conductor in a time-varying magnetic field creates an electromotive force that causes current to flow within the conductor. This, in fact, is the basis for most electrical power generation in which magnets are moved through coils of wire to create large amounts of current.

RESISTANCE

- Current flowing through a path experiences *Resistance*.
- Less current flow through higher resistance:

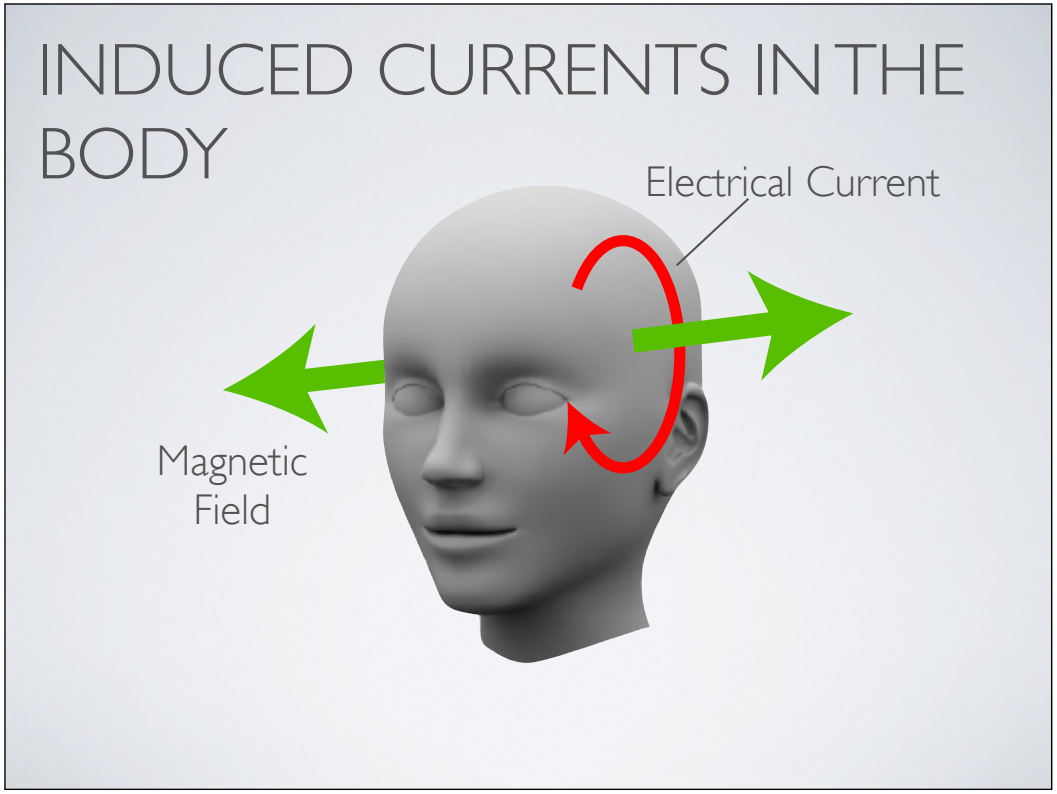
  Larger resistance -> less current

- Energy is dissipated (lost) to that resistance
- Power $= iV = i^2R = V^2/R$

Resistance describes the property, common to most materials, that they impede the flow of electrical current, almost as a small diameter pipe impedes the flow of water within it. As resistance is increased higher voltages are needed to push current through a material.

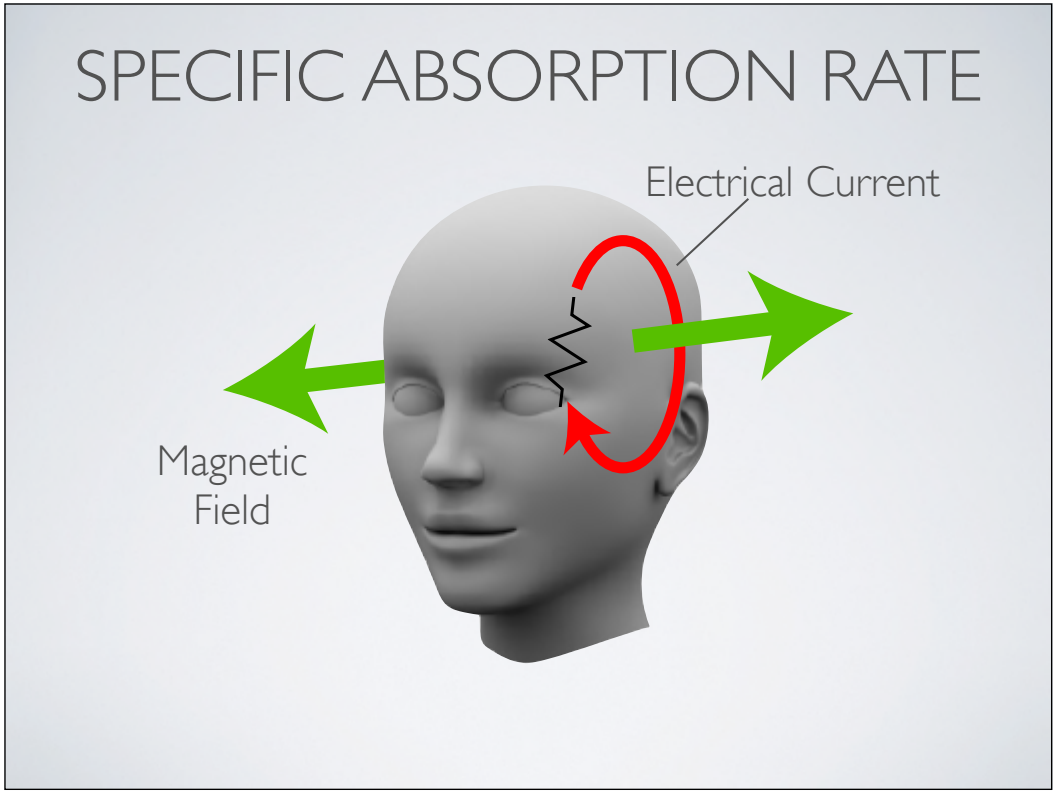
Common resistors for electrical devices look like the banded object here. In circuit diagrams resistors are drawn as a series of jagged lines.

When current flow through a resistor, the kinetic energy is lost in the form of heat. The power that is dissipated can be calculated as the product of the current through the device and the voltage across it.

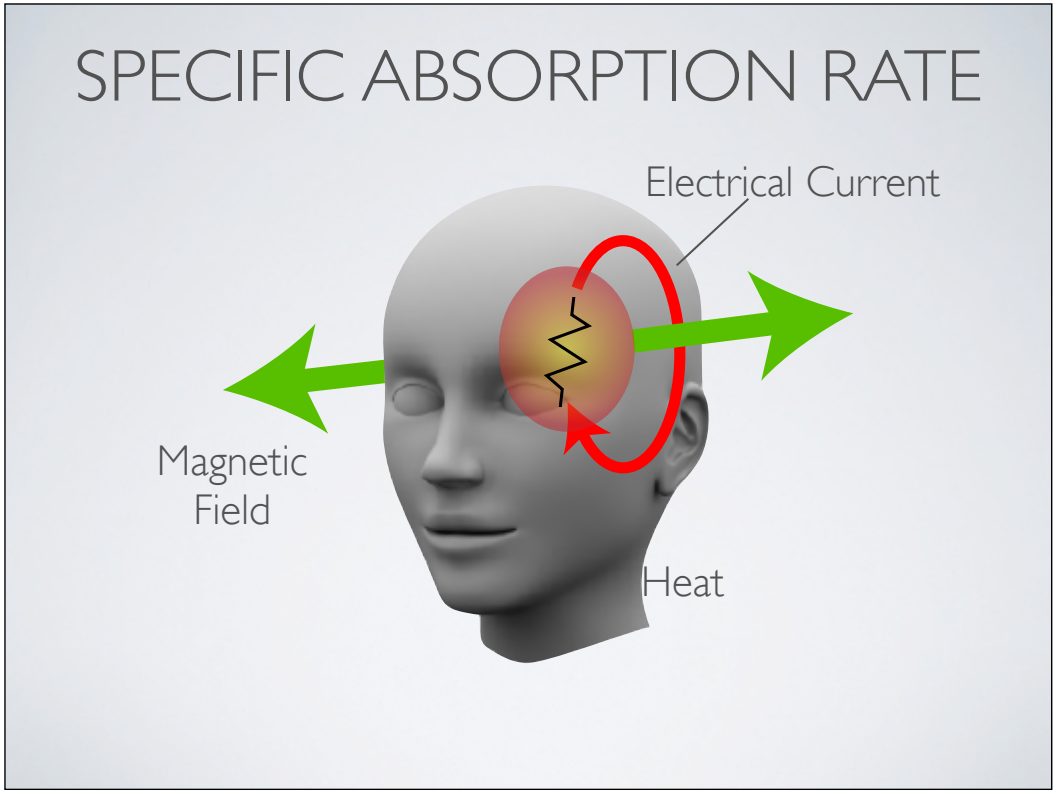


This discussion of current, voltage and resistance is important in understanding the heating that can take place in an MRI instrument.

In order to form images, time varying fields in the form of radio pulses (and gradient pulses) are needed. As these fields pass through the conductive tissues of the body they generate electrical currents that circulate within body tissues.



The body tissues are resistive however, so that the circulating current loses energy to the body in the form of heat ...



The rate at which the body absorbs heat energy during scanning is known as the “Specific Absorption Rate” or S.A.R.

S.A.R. is carefully monitored during MR scanning, but for these measurements to be accurate several assumptions must be met. First, the body weight of the subject must be entered correctly, as the allowed dose varies by body weight. Second, the calculations assume that there are no foreign conductive objects in the MR field, and finally, it is assumed that the instrument is functioning properly.

It is unfortunately not unusual for subjects and patients to receive very serious burns during scanning - almost always as the result of someone using in improper and unsafe device in the instrument. Standard EKG leads have led to many serious burns, as have physiological monitoring devices not designed specifically for MRI use. Surgical halos that are not marked MR Safe are simply not to be allowed into the immature - even if they are made of materials such as aluminum or stainless steel that are not attracted to the magnetic field.

In a few cases, body tattoos and other forms of permanent makeup have become very hot during MRI scanning and have caused skin burns, though these are usually very mild. If a subject has permanent makeup of this kind, they must be advised of the additional risk and their acknowledgement must be document. As suggested in the video that we just saw, people sometimes use water soaked sponges placed over the tattoos as a form of cooling. In no cases is it normal for the skin to become uncomfortable hot during scanning, and the subject should be told to squeeze the patient alert ball if they feel any discomfort.

It is very important to understand that in our Siemens Trio system, that during scanning of the head, the entire body is exposed to high power RF signals. Heating can occur in any part of the body during a head scan.

RF SAFETY

- Prevent skin-skin contact
- Keep sufficient distance between RF coil cables and skin
- Keep RF coil cables straight and avoid loops
- Keep RF coil cables parallel to the magnet bore
- Keep RF coil cables and ECG/VCG cables separated
- Never use damaged coils

Please remember these rules for RF safety:

Avoid skin to skin contact that might create a low resistance electrical current loop

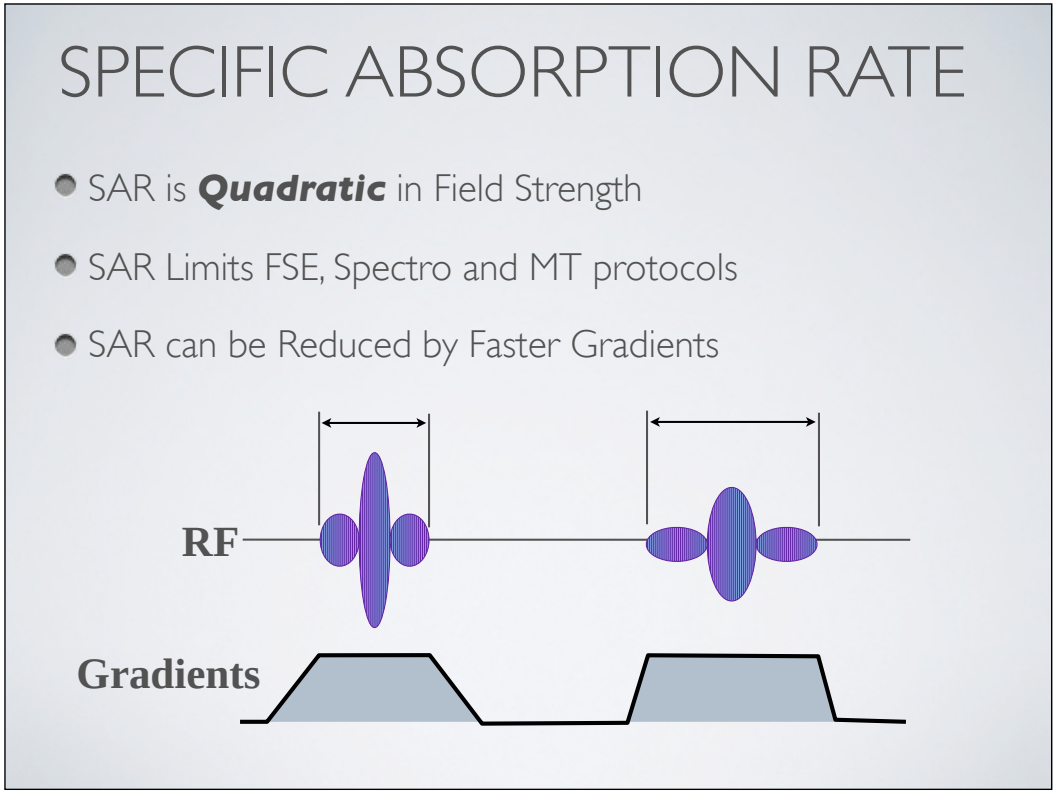
At radio frequencies, current can pass through a vacuum and across insulated wires. Keep a sufficient distance between the RF cables and the skin

Avoid any crossing or looping of RF cables by running them in straight lines

It is a good idea to run all cables parallel to the magnetic field - along the tube that makes up the magnet bore.

Keep cables from different components, such as EKG, RF and EEG separated

If the cables for an RF coil appear even slightly damaged, do not use it. Call service instead.



SAR bears a quadratic relationship to field strength. Compared to operation at 1.5 Tesla, the equivalent imaging sequence at 3 Tesla deposits four times the power. Operation at 7 Tesla uses more than 20 times as much power.

SAR limits are implemented by the scanner software and may impose specific limitations to certain MR pulse sequences, particularly fast spin echo, spectroscopic and magnetization transfer protocols.

To a certain extent SAR may be reduced in instruments that have more rapid gradient switching as these allow the RF pulses to be delivered for a longer time at a lower amplitude. You might see this effect in switching between regular or fast mode and “whisper” mode on the scanner.

RULES

- FDA Says:
  - <8T for Adults and <4T for children is non-significant risk
  - S.A.R. Limited by Temperature OR Power
    - < 0.1°C Core Temperature Increase
    - < 0.5°C Local Temperature Increase
    - < 2W kg

    First Level
  - Acoustic Noise < 140 dB (ouch!)
  - Gradient Switching
    - 20 T/sec for Normal mode or Direct Determination on Humans

To void injuries, the S.A.R. and other exposures delivered during an MRI exam is limited by several national and international bodies. In particular, the US FDA has published these standards:

Operation at less than 8 Tesla for adults and less than 4 Tesla for children is considered a non-significant risk.

S.A.R. may be limited by either body temperature changes of by power delivered by the scanner. In general, measurement of body temperature is not practical, therefore the power level limits, which are very conservative, are used instead. Specifically, the FDA recognizes first level operation as a non-significant risk when RF power of less than 2 Watts/kg is used.

The MR scanner can be quite loud. The FDA allows scanners to produce noise levels of 140 decibels, as long as adequate hearing protection is used.

As we will discuss later, the rapidly switched imaging gradients may cause sensory effects, and so are limited to a rate of 20 Tesla/second

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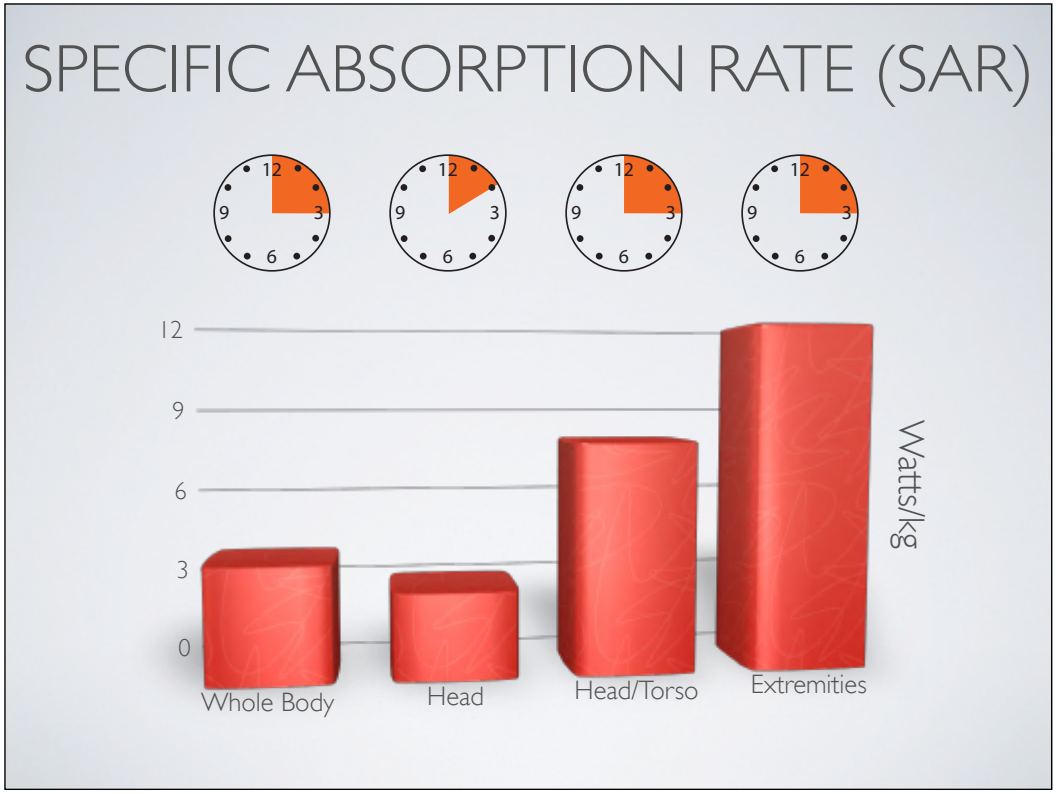


In addition to the maximum power limit, the FDA limits the duration of exposure to the RF power to fifteen minutes at the approved level for all body parts *except* the head, where the limit is a ten minute continuous exposure. This allows the body a cool down period between scans so that the natural cooling of the body can compensate for any temperature increase. The FDA does not specify the duration of cooling.

FACTORS THAT INCREASE SAR

- Fast Spin Echo/RARE Sequences
- Short Echo Spacing, Long Echo Train Length
- Short tr or Many-Slice Spin Echo Scans
- Inversion Pulses: E.g., MP-RAGE
- Long Sequences
- Magnetization Transfer
- Saturation Pulses

Specific Absorption Rate is increased by several user adjustable parameters.

Fast Spin Echo, or RARE, sequences use long trains of very brief high flip angle 180° RF pulses and therefore deposit considerable RF energy.

Within such sequences, very short echo spacing and/or long echo train lengths increase SAR

As the number of rf slices per second is increased so is SAR.

Inversion, or 180° pulse use deposit considerable energy. Such pulses precede each cycle of the MP-RAGE sequence making it, too, a high SAR study.

When sequences are very long, the body may not have time for adequate cooling. You may see this effect when, for example, very large matrix sizes are used.

Magnetization transfer is an imaging method that prepares the tissue by using long trains for RF pulses and can result in substantial heating. Some sequences, for example volume localized spectroscopy, may use multiple preparatory saturation pulses to remove unwanted tissue signal, thereby increasing SAR.

Each of these parameters are to a certain extent adjustable.

CONTROLLING SAR IN FAST SPIN ECHO

- Increase the Echo Spacing
  - Allows more time for tissue cooling
  - *Increases minimum te and blurring*
- Decrease the Echo Train Length
  - *Increases imaging time*
- Increase the TR
  - *Increases Imaging Time*
- Reduce the number of slices
  - *Reduces volume coverage*

For example, in Fast Spin Echo sequences the echo spacing parameter may be increased at a slight cost in minimum te and additional blurring

Decreasing the echo train length will reduce S.A.R., but will also result in a longer imaging time.

Increasing the tr hepls, but also increases imaging time.

The number of slices may also be reduced, though it will of course reduce the tissue coverage.

CONTROLLING SAR

- In MP-RAGE Small Increases in TE can help
- In Spin Echo Imaging, increase tr or decrease number of slices
- Use SAT pulses only when needed
- BOLD EPI Scans are Intrinsically low S.A.R. studies
- Allow Cool Down after High SAR studies
- Do not use excess blankets, clothing or covering
- Advise subjects that significant heating is NOT normal

Other High SAR sequences also have adjustable parameters. We have found that even small increases in te can reduce SAR to acceptable levels in MP-RAGE sequences

In conventional spin echo sequences tr may be increased, or the number of slices decreased.

SAT pulses of various kinds are options in many sequences. Minimize their use to lower S.A.R.

Interestingly, BOLD EPI scans as used in fMRI are intrinsically relatively low S.A.R. studies

It is always a good idea to allow a brief cool down period for the subject after high S.A.R. studies

The natural cooling of the body is very effective in healthy individuals. However, covering the subjects in blankets, or wearing heavy clothing reduces the efficiency of body cooling

Be sure that your subjects understand that it is not normal to become uncomfortably warm during an MRI exam.

THERMOREGULATION PROBLEMS

- Diabetes
- Obese Patients
- Cardiovascular Disease
- Fever
- Hypertension
- Old Age
- Diuretics
- Beta Blockers
- Sedatives
- Muscle Relaxers

Certain individuals are at much higher risk of problems from S.A.R. Specifically, these conditions may present additional cause for concern:

Diabetes

Obsesity

Cardiovascular disease

Fever

Hypertension

Old Age

Use of diuretics

Use of beta blockers

Sedation

and use of muscle relaxers.

If you subject has any of these conditions you must pay particular attention and in many cases you should consult a physician before scanning.

UNSAFE POPULATIONS

- Mechanical
  - Aneurysm Clips
  - Shrapnel in Eyes or Brain
  - Recent Implants in Soft Tissue
  - Piercings (?)
- Thermal
  - Implanted Leads or Wires
  - Certain Makeup
  - Hair Weaves
  - Almost ANY Electrical Conductor

There are certain subjects who should never be scanned.

Mechanical problems include

Aneurysm clips from recent surgeries

Metal shrapnel in the eyes or brain (which have led to blindness in the MRI in the past)

Recent implants of any kind in soft tissues

Body piercings - if possible these should be removed prior to scanning.

Additional thermal problems occur with

implanted leads or wires

Certain types of makeup - in general makeup should be removed prior to scanning

Hair weaves, many of which contain metal

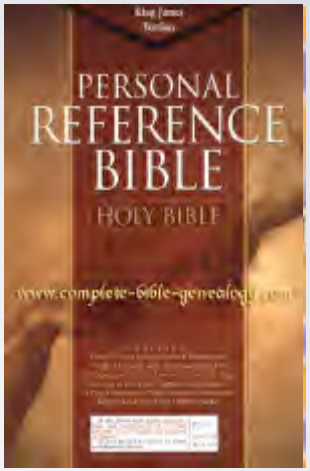
and almost any electrical conductor present with the subject.

DEVICE HAZARDS

- Movement or Displacement
- Heating
- Altered Device Performance
- Artifacts

Common Problems include

- Aneurysm Clips
- Stents
- Pacemakers
- Surgical Wires
- Dental Appliances
- Shunts/Drains
- Heart Valve Prosthetics
- NeuroStimulators
- Permanent Contraceptives



Foreign devices cause a host of difficulties including

displacement within the body causing bleeds and other problems

heating as mentioned previously

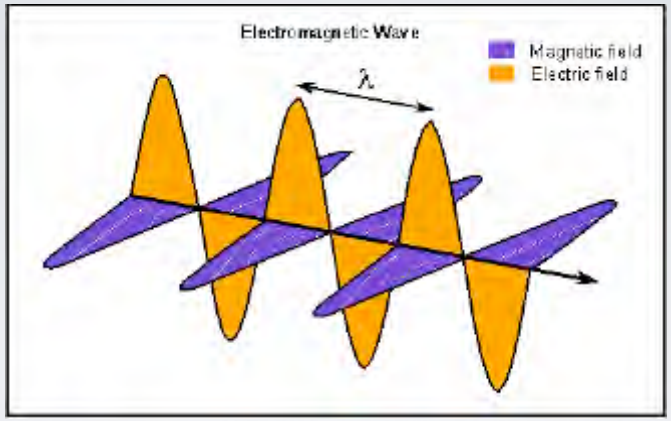
altered imaging performance

and many imaging artifacts.

For us, the “Reference manual for magnetic resonance safety, implants and devices” by Frank Shellock is our bible for evaluating such devices.

If, on interview, your subject states that they have any form of medical implant or other difficult to remove device, you should find out as much as possible about the device from the subject or their physician. You should then look up the device in the manual and finally consult with CCN personnel before scanning.

ELECTROMAGNETIC WAVES



http://atomic-molecular-optical-physics.suite101.com

RF travels in the form a an electromagnetic wave. The wavelength, denoted here with a Greek lambda, depends on the RF frequency and the speed of light.

ANTENNA RESONANCE

- Occurs when antenna length bears half integer relation to RF wavelength
- Effective Antenna Length depends on Material Properties and Shape
- Wavelengths:
  - 3T: 2.3 meters
  - 1.5T: 4.6 meters
- Hazards may *Increase* or *Decrease* with field strength
- Do NOT Assume that A Device is Safe Because it has been Used Before

The phenomenon of coil heating is often very complex. Almost any conductor is capable of acting as an antenna. When the effective length of the conductor becomes comparable to the RF wavelength (or to half of the wavelength) a resonance condition may occur in which large currents are passed. These currents can pass through body tissues and can create considerable heating.

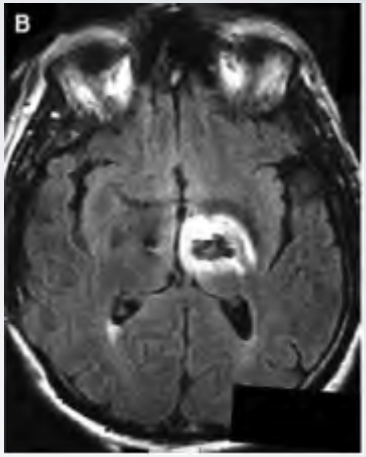
The effective antenna length itself depends on the material properties shape

Because the wavelength of the RF signals depends on the MR field strength,

devices safe on one instrument may be unsafe on another. In particular, it is entirely possible for a device to be safe at 3 Tesla and unsafe at 1.5 Tesla, and vice versa. These unsafe conditions can be very narrowly constrained, so that a small motion of a piece of wire can cause orders of magnitude difference in safety

It is very important NOT to assume that a device that was used without trouble under one condition is safe in another.

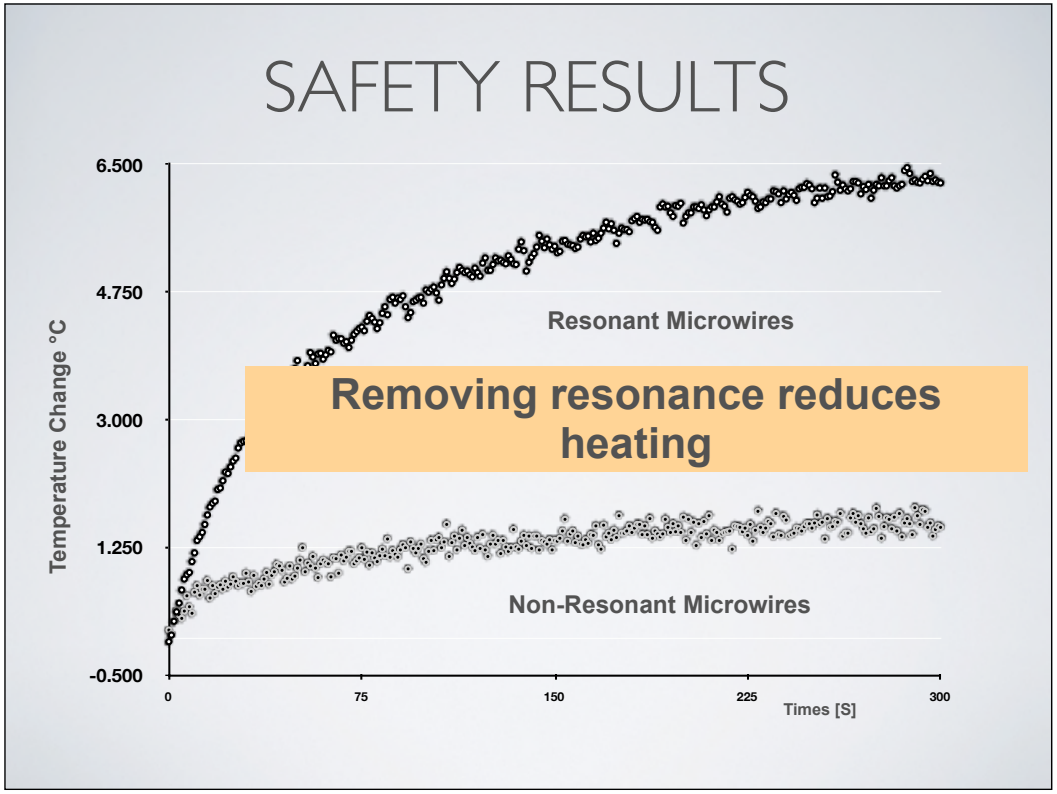
DEEP BRAIN STIMULATION (DBS) ELECTRODES



T2-weighted MRI scan of the brain showing edema around the left DBS electrode.

Implanted wires present a special hazard. For example, the systems used for deep brain stimulation provide excess wire length. When implanting the electrodes the physician is given little instruction in how to manage the remaining wire. In this case, the physician looped the excess wire in the head. The MRI image at the right shows severe burns in the brain that occurred in a subsequent MRI scan. Notice that only one side was effected strongly, presumably because the resonant properties of the two sides differed as a result of the physical configuration of the leads.

Scanning of subjects with implanted leads of any kind: brain stimulators, neurostimulators, cardiac wires, vagal nerve stimulation etc... is never to be undertaken without prior written permission from senior personnel at the Center for Cognitive Neuroscience and then only with medical supervision and carefully prepared and signed informed consent.

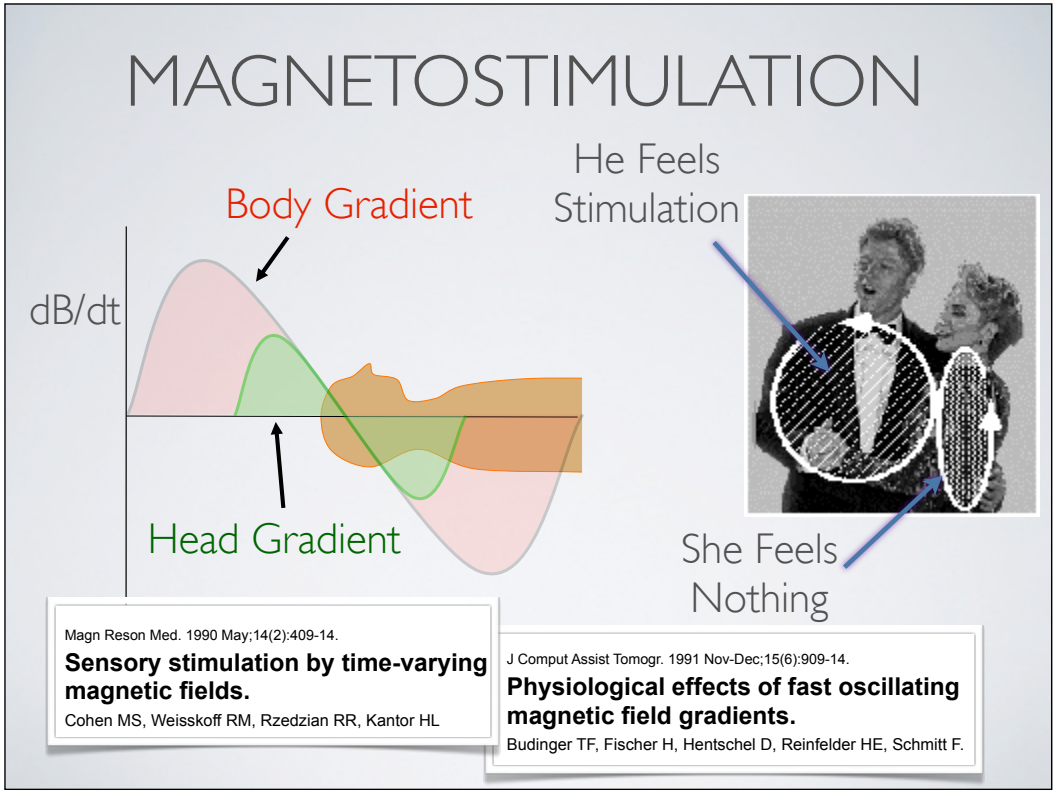


These data, collected at UCLA, demonstrate the temperature changes created during an MRI scan. The only difference between these data sets was the actual length of the wire leads, bringing the system from a safe to a very unsafe range of operation.

ACOUSTIC NOISE

- Ear Protection is Always Required
- Ear Plugs and/or Noise Reducing Headset
- Always Ask Subject about Noise Level

Again, the scanner is noisy. Without earplugs the noise levels can create hearing loss. Be sure that you give your subjects ear protection of some sort.

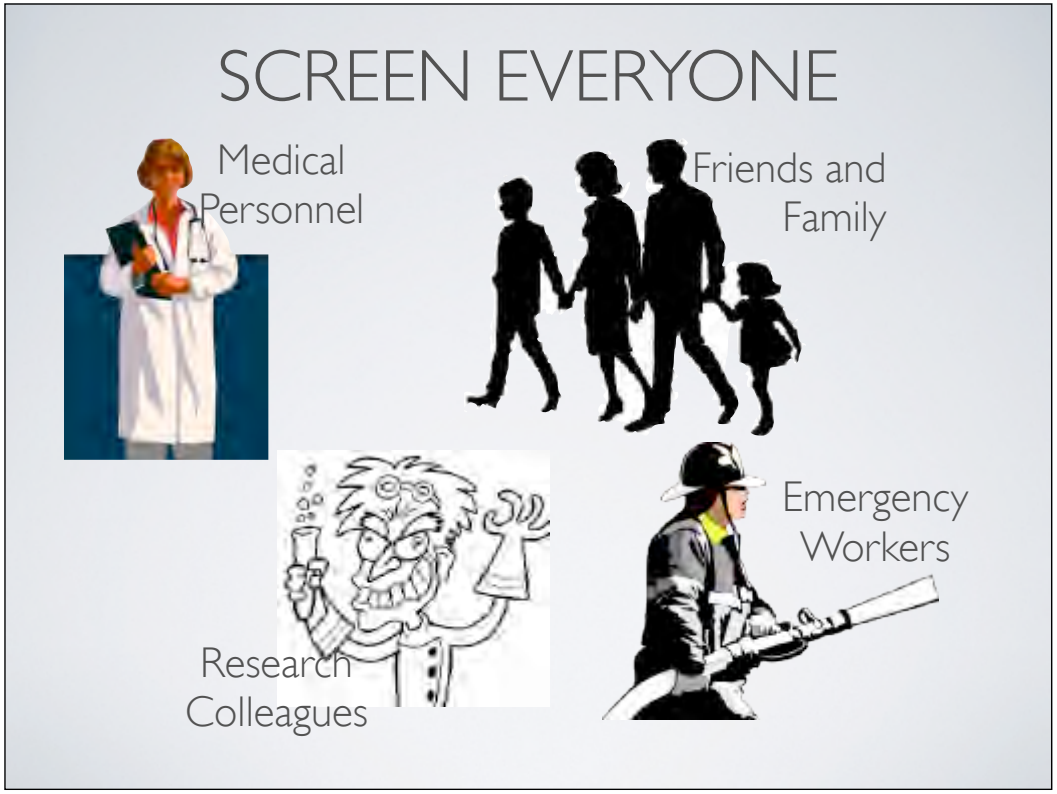


When operating, the MRI scanner uses gradient coils to create time varying magnetic fields that are used for spatial localization. These time varying fields are of much lower frequency than the RF fields and do not result in heating. However, as they go through the body, they can cause relatively large currents to flow. These currents have been shown to result in sensory stimulation when changed at a rate near 60 Tesla per second. However, the actual threshold depends on the cross sectional area through which the fields pass. Thus, larger people are more likely to feel this effect. The phenomenon depends on the orientation of the body with respect to the field as well.

There are a few things to remember here.

First, there is no evidence to suggest that these effects are hazardous at levels up to 50 times that allowed in the scanner

However, the threshold of just noticeable sensation and the threshold of significant pain and discomfort are not greatly different.



Anyone entering the imaging suite must be screened, including:
Medical Personnel - The presence of a white coat does not convey knowledge of MRI safety
Friends and Family - who generally do not belong in the Scanner suite
your Research colleagues
and Emergency Workers

Never Assume that anyone is MR safe
Emergency Workers pose a special problem and you must be prepared to block their entry for your own safety.

The following video clip covers important topics in patient interview and consent.

PATIENT INTERVIEW

- Metallic Foreign Body?
- Permanent Cosmetic or Tattoo?
- Prior Surgery?
- Wig or Hair Weave?

Remember to carefully ask each subject about:

Metallic foreign bodies

Permanent cosmetics or tattoos

Prior surgeries

Possible pregnancy

The use of a wig or hair weave.

PREGNANCY

- No Known Pregnancy Effects
- ISMRM and ACR:
  - MRI Is Acceptable in Pregnancy to Address Clinically-Important Questions
  - Acceptable Regardless of Trimester
  - Informed Consent Should be Obtained

Although there is no known risk to mother or fetus as a result of MRI scanning, imaging of pregnant subjects is highly discouraged, though in rare cases may be given special approval.

The American College of Radiology and the International Society for Magnetic Resonance in Medicine have issued these guidelines:

MRI is acceptable in pregnancy to answer clinically important questions

There is no special consideration for the trimester of pregnancy

Informed consent is needed for any scanning of pregnant women.

SUBJECT CONSENT

- Consent is Required for ALL Human Subjects at the Staglin Center.
- IRB Documents must be Current and on File Prior to Scanning.
- Subject Consent Should be Obtained in Private
  - Personal Medical Information is Confidential
  - Some Questions may be Personal
- Subjects Should not be Exposed to Extra Risk for Research Scans.
- Any Potential Safety Risk Must be Evaluated by Senior Personnel.

Note that informed consent is mandatory for all human subjects at the Staglin Center for Cognitive Neuroscience for both MRI and for EEG.

In order to be allowed to schedule exams, you must have current and valid IRB documents on file with the center.

Despite the way it may have appeared in the video you just saw, informed consent should always be obtained in a private setting. Note that the personal medical information you acquire is confidential and protected by HIPAA guidelines. Some of the questions, for example those about pregnancy, drug use, or piercings, may be quite personal and the answers you obtain may be more accurate if obtained in a private interview.

By definition, the MRI scans performed at the Staglin center are for research purposes and not for clinical benefit. In general, there is little justification therefore to exposing your subjects to any elevated risk. Subjects should not be coerced into being scanned in the first place or asked to stay for “just a few more minutes.” Please respect your subjects

If anything about your protocol results in elevated risks, it must be cleared by the CCN senior personnel.

SUBJECT PREPARATION

Ask subjects to wear loose comfortable clothing:

- Sweat Pants
- Track Suits
- T-Shirts
- Scrubs

Your subject's physical and emotional comfort are an important part of safe scanning. Before inviting subjects to the lab, you should

Ask subjects to wear loose and comfortable clothing such as sweat clothes, track suits, t-shirts or scrubs

SUBJECT COMFORT

"Twenty-five percent of the participants experienced moderate to severe anxiety during the MRI scan.

Prescan scores on the Claustrophobia Questionnaire (CLQ: Rachman and Taylor, 1993) significantly predicted participants' distress during the scan; pain and anxiety sensitivity did not."

Claustrophobia and the Magnetic Resonance Imaging Procedure

Heather K. McIsaac,[1,3] Dana S. Thordarson,[1] Roz Shafran,[1] S. Rachman,[1] and Gary Poole[2]

Journal of Behavioral Medicine, Vol. 21, No. 3, 1998

Claustrophobia is a very common event during MRI studies occurring in some forms in as many as 25% of clinical exams.

It is apparently far less common in functional MRI and research scans, perhaps because the subjects are in closer contact with the experimenter during the exam.

SUBJECT COMFORT

- Don't Drink (coffee) and Scan
- Ask Subjects to Void Before Scanning
- Tell Your Subjects What to Wear and How to Dress
- Avoid Asking for, "Just one More" Scan
- Stay in Contact
- Avoid Restraints
- Offer Music or Videos

Several general guidelines can help to reduce the probability of claustrophobia in your subjects.

Make sure that they are not physically uncomfortable by asking them not to drink lots of liquids before the exam and to empty their bladders

Avoid the subjects becoming to warm or uncomfortable by ensuring that they are wearing loose and light clothing

Do not push your subjects if they wish to stop

Keep in contact with your subjects by frequently checking on them over the intercom between scans and by asking how they are.

Unless absolutely necessary, avoid physically restraining your subject in any way

Providing music, videos or other distractions is very effective to reduce the sense of isolation that exacerbates clautrophobia

SUBJECT PREPARATION

Remove all:

- Metallic Personal Belongings
- Hearing Aids
- Watches
- Jewelry
- Clothing with Metal Fasteners
- Makeup
- Void before scanning.

In all cases, prior to scanning, your subject's must remove all

Metallic personal belongings

Hearing aids

Watches

Jewelry

Clothing with metal fasteners

and metallic makeup.

It may be a courtesy to your subjects NOT to put on makeup prior to the exam.

Subjects should be told to avoid drinking fluids, especially diuretics such as coffee before the exam. Remind your subjects to void their bladders before getting in to the scanner.

SUBJECTS MUST REMOVE THE FOLLOWING:

- Cell phones
- Beepers
- Watches
- Jewelry
- Prostheses
- Wigs
- Hairpins
- Barrettes
- Metallic Rx patches

EMERGENCY PROCEDURES

- Press the switch appropriate to the emergency
- Evacuate the subject immediately
- Inform rescue workers of the magnetic field dangers
- Only use MR-compatible equipment
- Document the emergency or accident

IN THE EVENT OF A QUENCH

- Subject and MR personnel vacate room **Immediately**
- Inform rescue workers **Immediately**
- Inform service engineers **Immediately.**

RECOMMENDATIONS

- Ensure regular equipment maintenance
- Create emergency plans
- Conduct emergency exercises
- Provide precise emergency documentation
- Provide non-magnetic tools for cleaning and emergency service

THE BIGGEST RISK

- The Biggest Risk is Inattentiveness
- Never Defer Responsibility for Safety to Someone Else in the Room

Aug. 1, 2001 Michael Colombini was undergoing an MRI, or magnetic resonance imaging, at Westchester County Medical Center last Friday when an oxygen canister was turned into a guided missile by the powerful MRI magnet. The canister was drawn into the magnet core while the boy was in the machine. The result was a fatal blow to the child's head.

The nurse who carried the oxygen canister into the room where Colombini was being scanned mistakenly believed the canister was made of a nonmagnetic material, like aluminum.

While the MRI devices are not intrinsically safe, by far the biggest risks in MR imaging are the result of inattentiveness on the part of the operator.

Always be alert to potential safety problems.

In general, it is a good idea to have a single individual chiefly responsible for safety when scanning as a group or team,

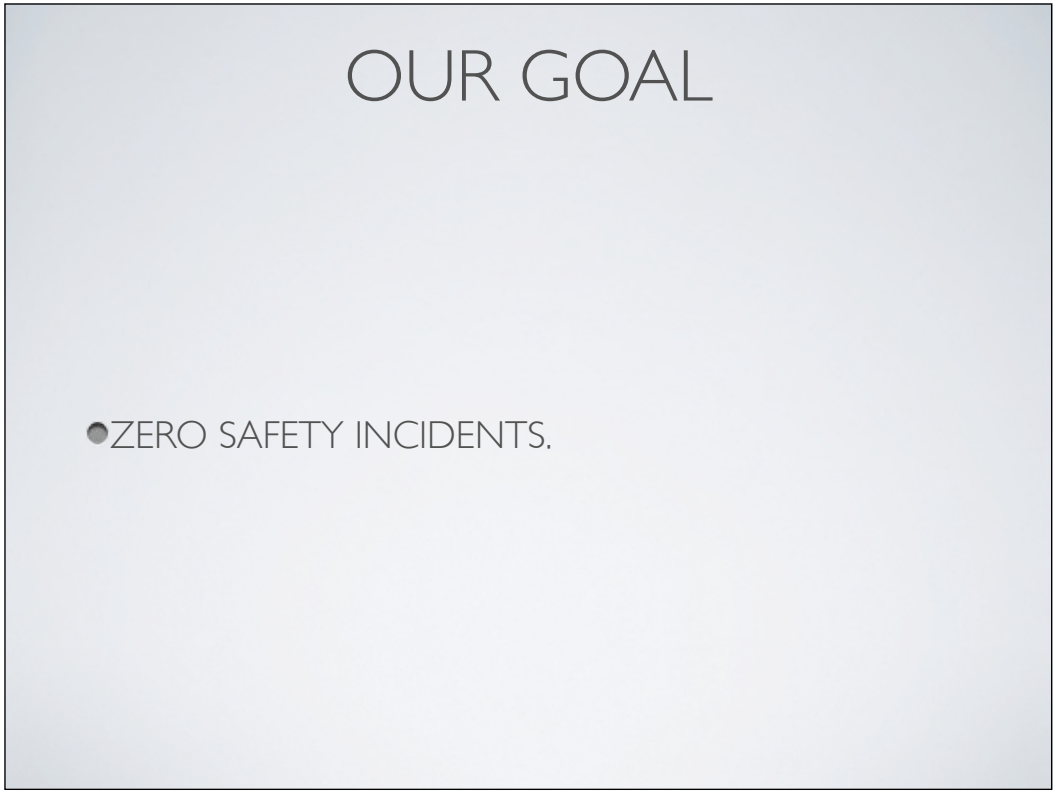
However, Any trained personnel in the scanner area have shared responsibility for safety and this can never be deferred, You are always entitled to question people coming in and out of the magnet room to ensure that they are properly prepared and are not carrying unsafe items.

click

click

When Michael Colombini suffered a fatal injury it was clearly a result of negligence, but whose? One interpretation of this event is that the operator saw an authority figure enter the scanner suite and accepted without question that he or she was cognizant of the problem. They clearly were not.

Do not allow yourself to be the passive player ultimately responsible for a serious accident.



To date, there have been few if any reports of serious safety problems from non-medical research use of MR imaging. This is remarkable, as many novices and non-professionals now perform MR scans.

You should be aware that a single serious event will not result simply in the loss of your privileges but potentially in the loss of our ability to keep the center running and could compromise the entire endeavour of research scanning for cognitive sciences.

Never expose yourself or your subjects to any unnecessary risks.

Again, we want it to be a pleasure to work at the Center for Cognitive Neuroscience and are eager to make the environment as conducive to your work and productivity as possible. However, safety will always be our serious concern and must be yours.

SAFETY RESOURCES

http://www.semel.ucla.edu/staglin

YOUR INFORMATION RESOURCE
FOR MRI SAFETY, BIOEFFECTS,
AND PATIENT MANAGEMENT
MRIsafety.com
THE DEVELOPMENT OF THIS SITE WAS SUPPORTED BY AN UNRESTRICTED EDUCATIONAL GRANT PROVIDED BY
BRACCO
LIFE FROM INSIDE

IMRSER
Institute for Magnetic Resonance Safety, Education, and Research

http://users.fmrib.ox.ac.uk/~peterj/safety_docs/index.html

RESOURCES

- Questions: Mark Cohen, mscohen@ucla.edu, or other senior members of the Staglin Center

- These slides are available on line at:

http://www.semel.ucla.edu/staglin and
http://www.cognitiveneuro.org/SafetyLinks.php

If you have any questions about this material, please contact Mark Cohen (mscohen@ucla.edu) or other senior personnel in the center. We are eager to help and we will share your questions, and our answers, for other users in the future.

The slides associated with this video can be found online at the Staglin center website by following the appropriate safety links. At the end of this video, we have included a number of links to further information on MRI safety.