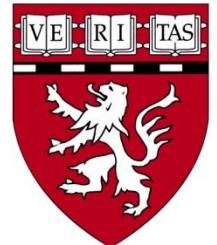


Setting up an MEG and EEG experiment

Sheraz KHAN

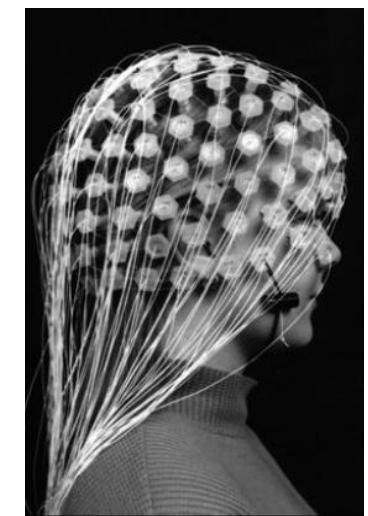
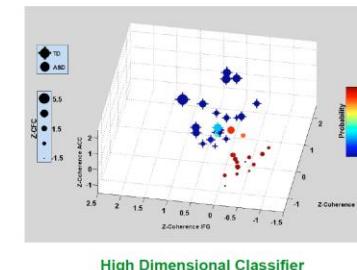
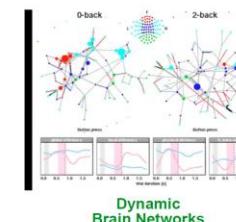
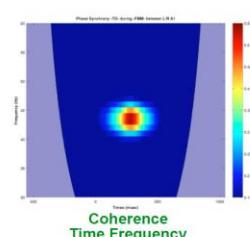
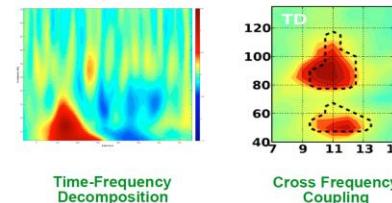
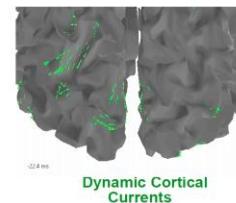
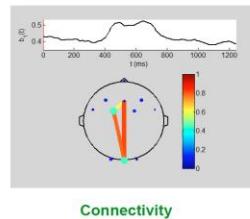
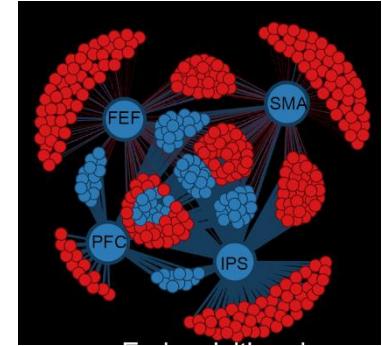
Research Fellow

**Athinoula A. Martinos Center for Biomedical Imaging
MGH/MIT/Harvard**



Overview

- Experimental Paradigms for MEG/EEG
- Testing Experimental Paradigms
- A typical MEG/EEG Visit



Experimental Paradigms for MEG/EEG

Electricalencephalography (EEG)

- Inexpensive
- Portable
- Clinical



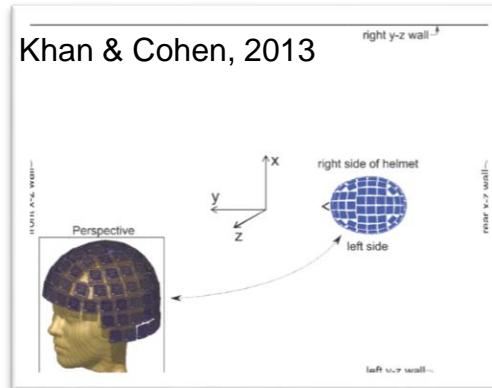
Experimental Paradigms for MEG/EEG

Magnetoencephalography (MEG)

Not distorted by skull and scalp/ Simple modeling

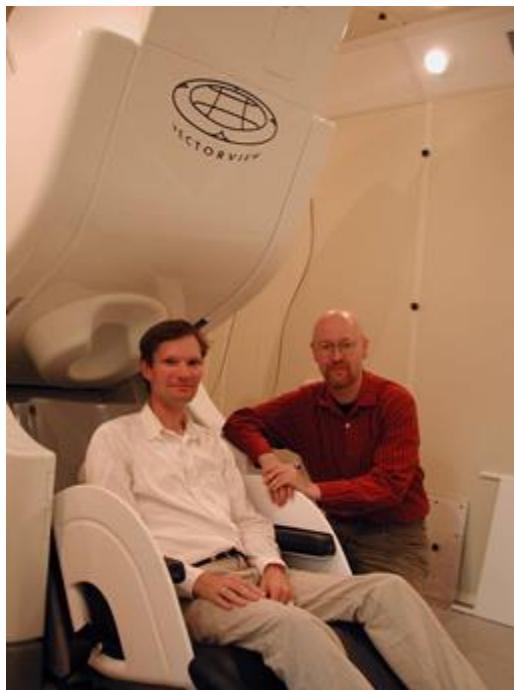
Less preparation time/ Reference free

Best Results combining MEG with EEG (Wood et al, Science, 85)



Experimental Paradigms for MEG/EEG

Upright



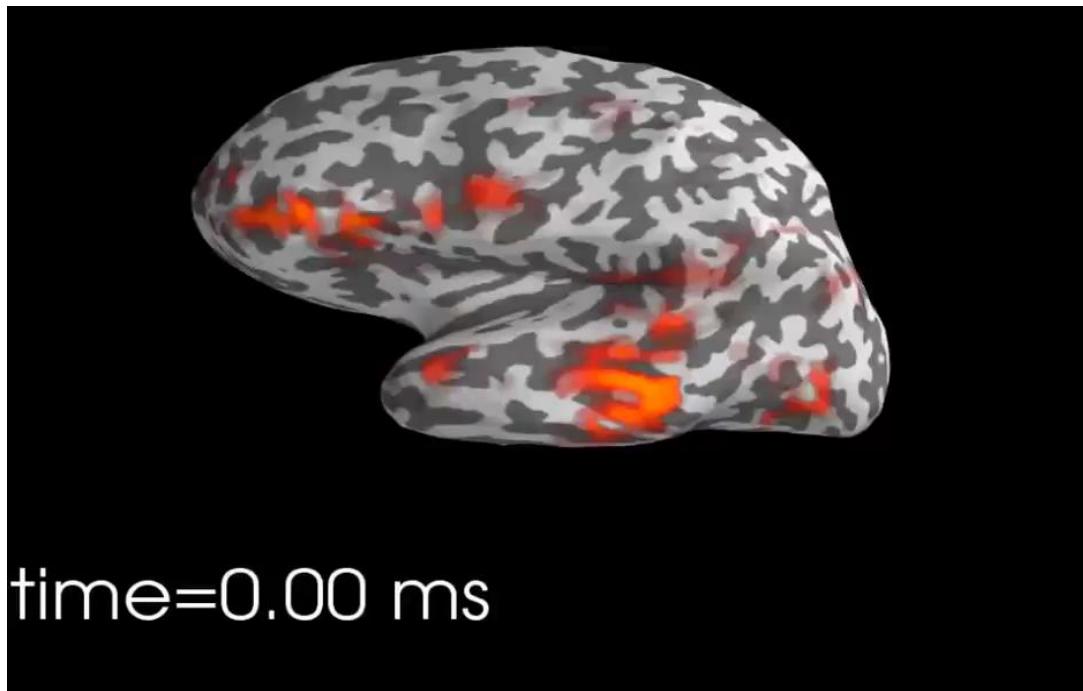
Supine



Experimental Paradigms for MEG/EEG

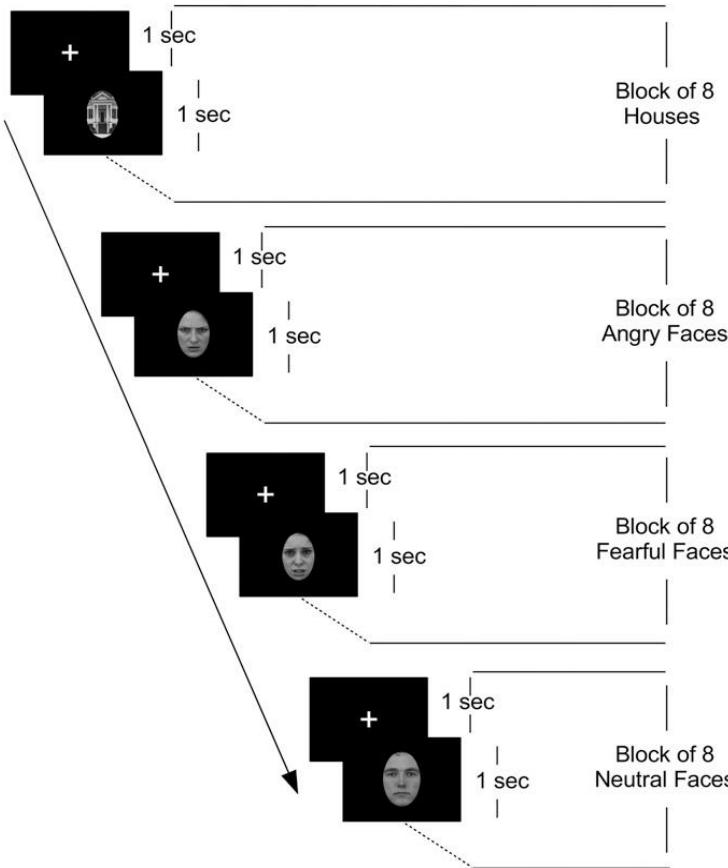
High temporal resolution

- The high temporal resolution of MEG/EEG not only allow us to follow sensory/cognitive events at millisecond resolution but also decipher feedforward from feedback



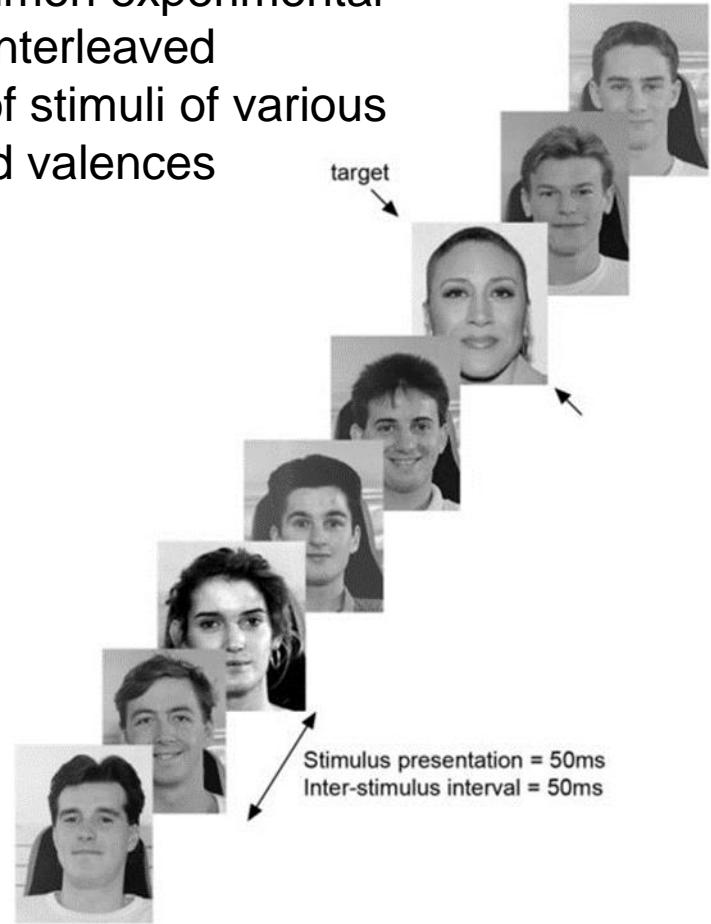
Experimental Paradigms for MEG/EEG

block vs event related design



Block design

The most common experimental design is the interleaved presentation of stimuli of various categories and valences

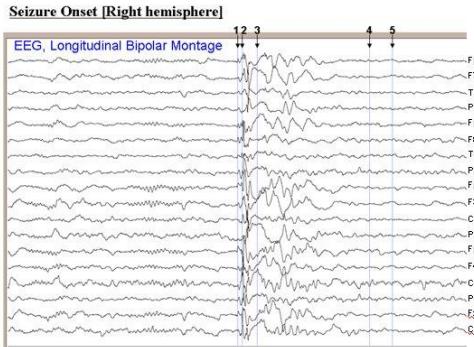


Event related design

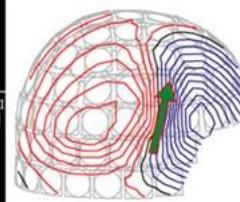
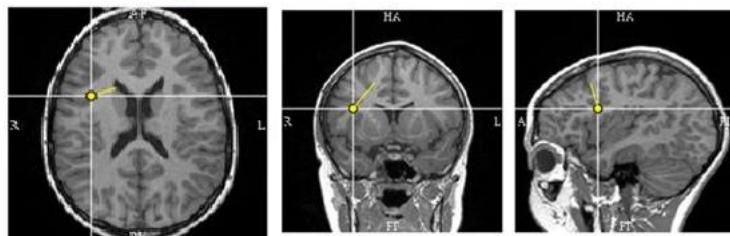
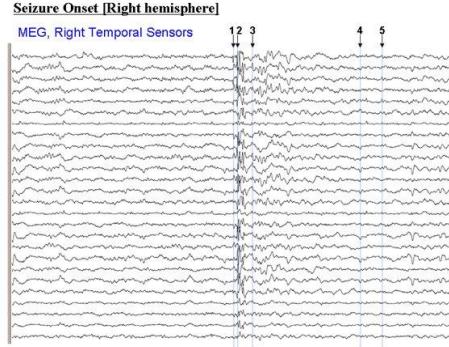
Experimental Paradigms for MEG/EEG

Clinical Applications

EEG Sensor Space



MEG Sensor Space



Dipole Localization

GOOD MORNING AMERICA

Money

Health

Life & Style

Entertainme

Sixty Seizures to None: Young Girl Overcomes Epilepsy

Feb. 3, 2010

By LARA SALAH via



Magnetoencephalography, or MEG, is an imaging technique used by doctors to detect changes in the brain. But unlike other imaging tests, the MEG scanner tracks changes in the brain instantaneously. MEG scans showed that teenager Amanda Momberg's seizures originated in an unusually deep fold in the brain that looked normal on previous brain scans.

Amanda Momberg of Cedarburg, Wis., was 8 years old when she fell to the kitchen floor and experienced her first epileptic **seizure**.

"I would shake on one side and I couldn't talk," she said. "But I would hear people talking to me."

For most of her life, she took medication to **control the seizures**. But in December 2008, at age 16, the medications stopped working. Amanda suddenly started having 60 to 100 seizures a day.



"It was awful," said Amanda's mother, Kathy Momberg. "I was not in control; you couldn't do anything about it."

Doctors hoped surgery would help, but the surgeons' first attempt to remove the part of her brain causing the seizures was not successful.

"That's when the topic of MEG scan came up," said Kathy Momberg.

Magnetoencephalography, or MEG, is an imaging technique used by doctors to detect changes in the brain. But unlike other imaging tests, the MEG scanner tracks changes in the brain instantaneously.

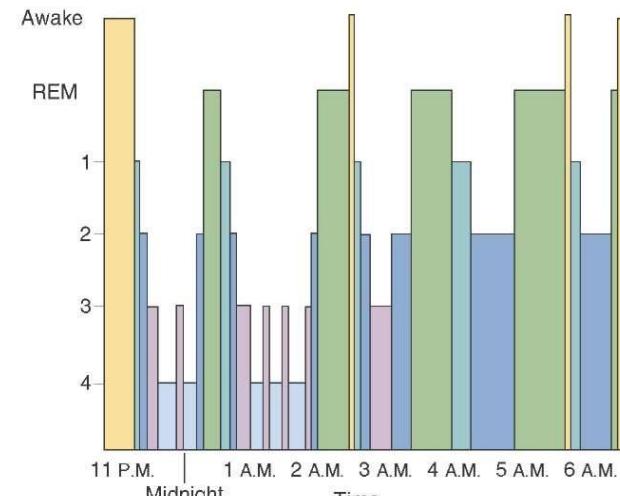
Experimental Paradigms for MEG/EEG

Sleep studies

EEG



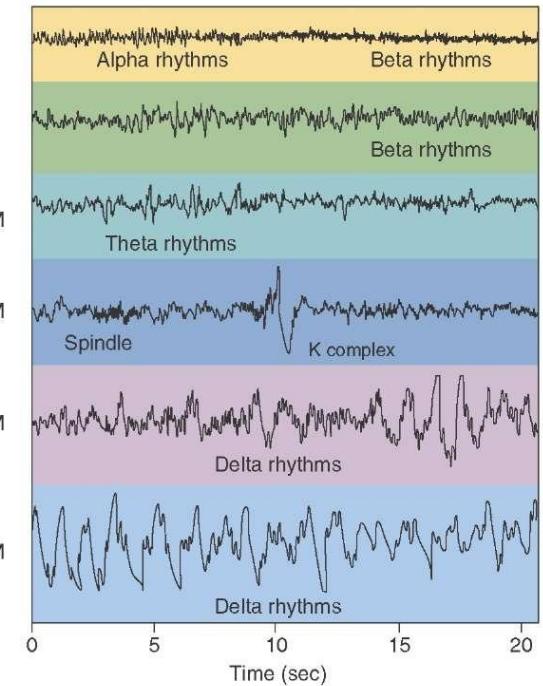
Sleep Cycle



MEG



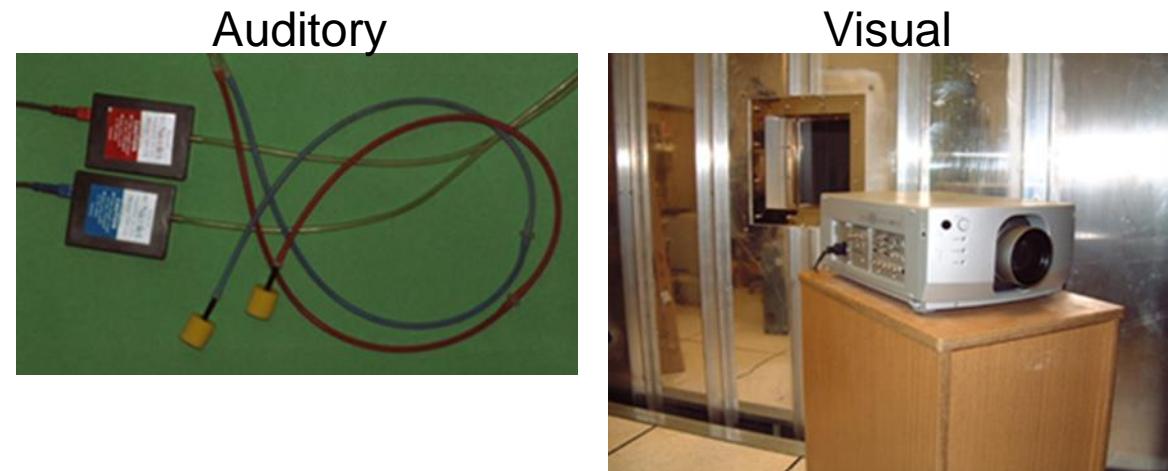
Brain Rhythms
During sleep



Experimental Paradigms for MEG/EEG

Four basic stimulation systems

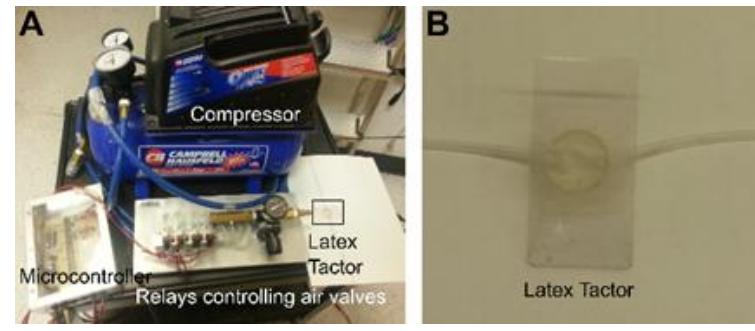
- Auditory
- Visual
- Somatosensory
- Olfactory



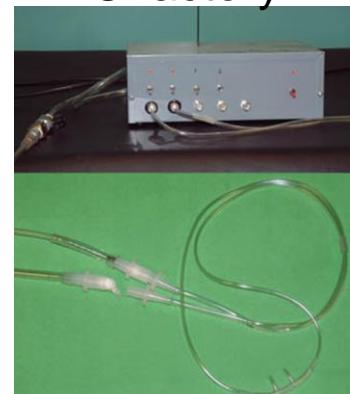
Electrical-Somatosensory



Tactile-Somatosensory



Olfactory

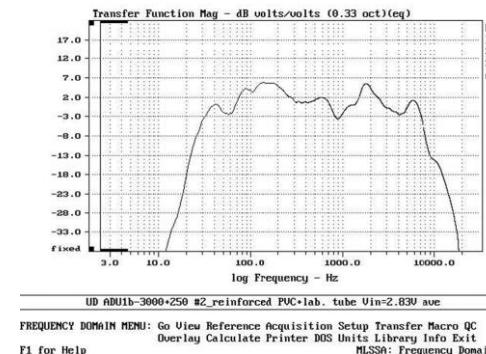


Experimental Paradigms for MEG/EEG

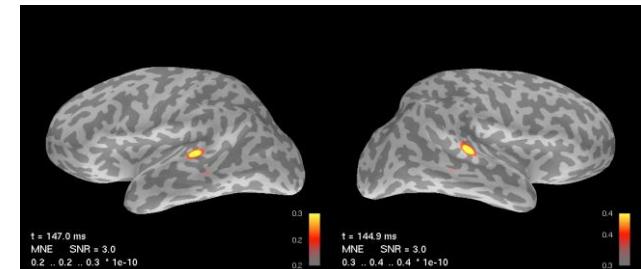
Auditory Experiment



Transfer function

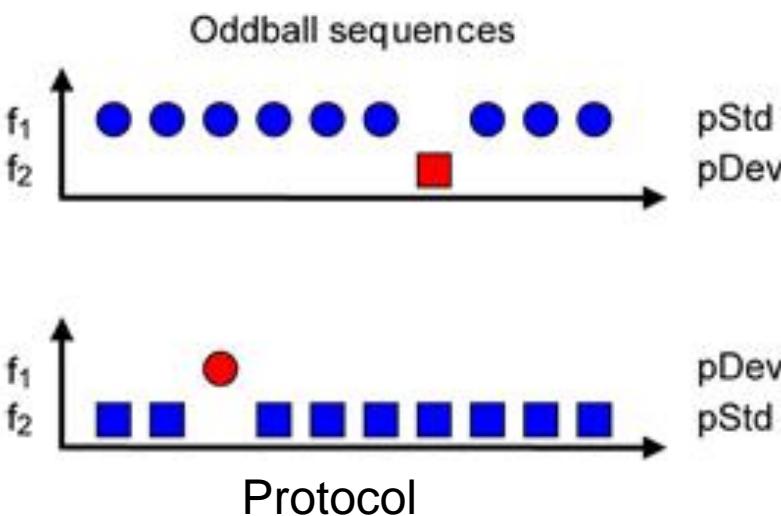
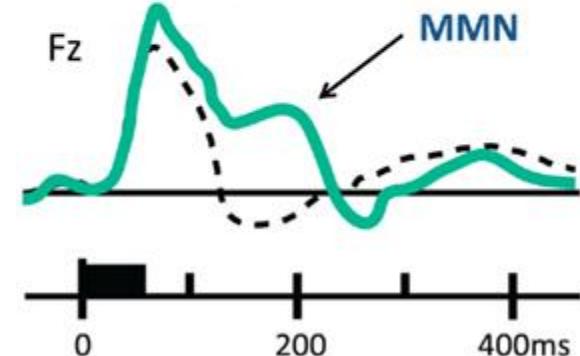


Cortical Responses



A

- 5 μ V — deviant
+ ----- standard

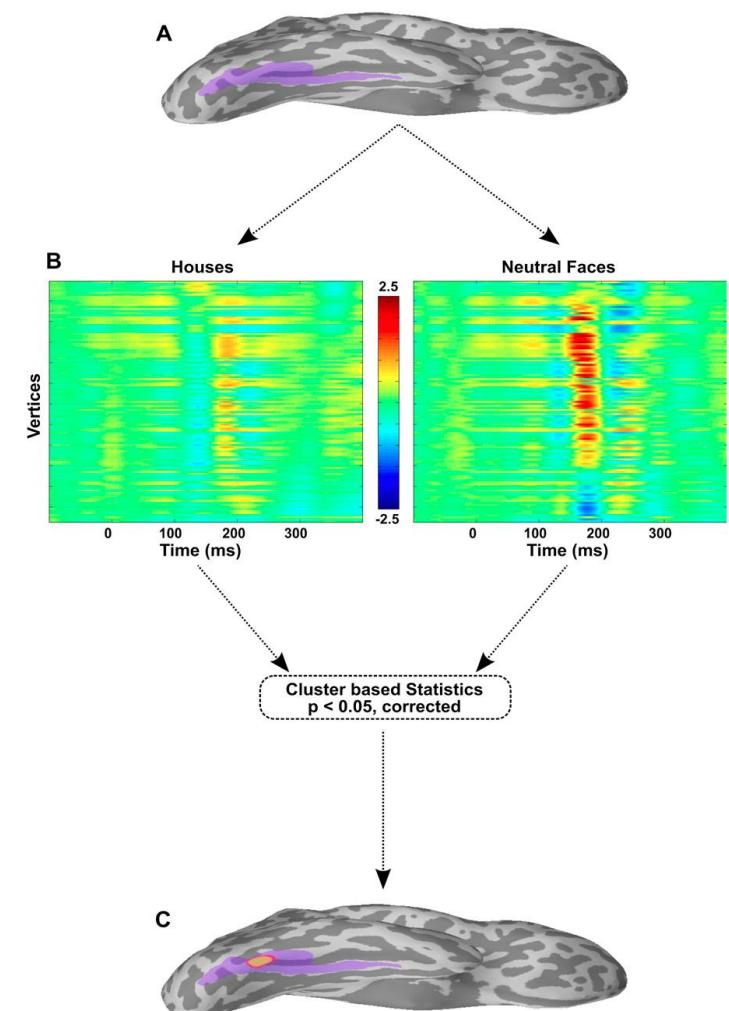


Experimental Paradigms for MEG/EEG

Visual Experiments



Protocol



Khan et al, PNAS ,2013

Experimental Paradigms for MEG/EEG

Somatosensory Experiments



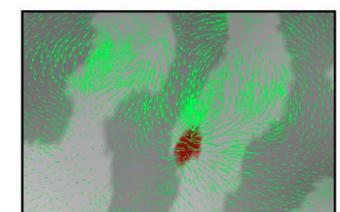
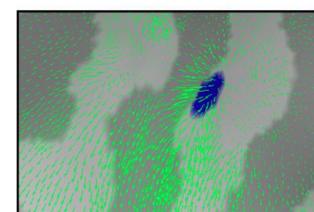
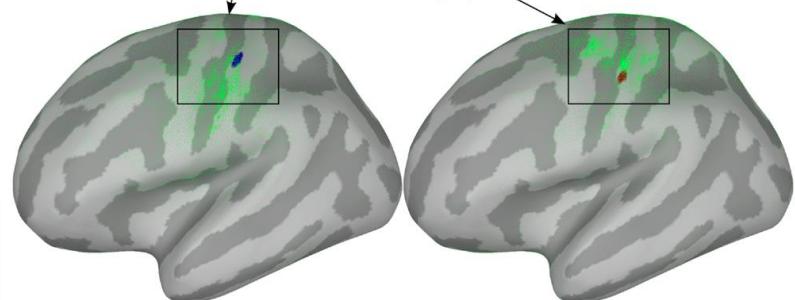
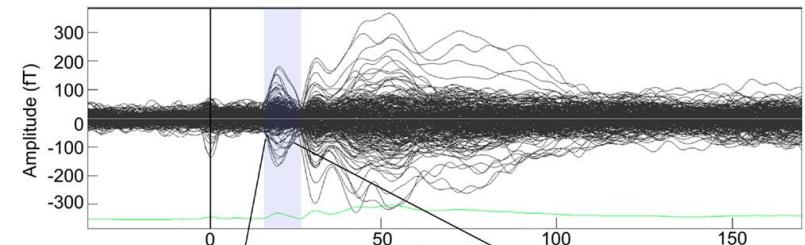
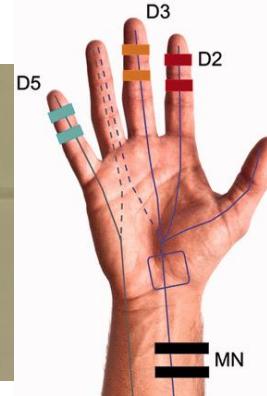
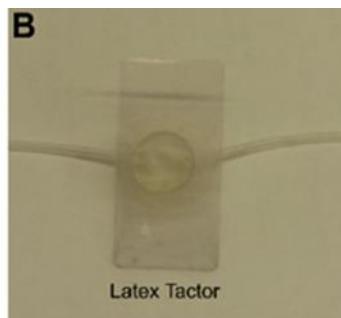
Electrical



Mechanical



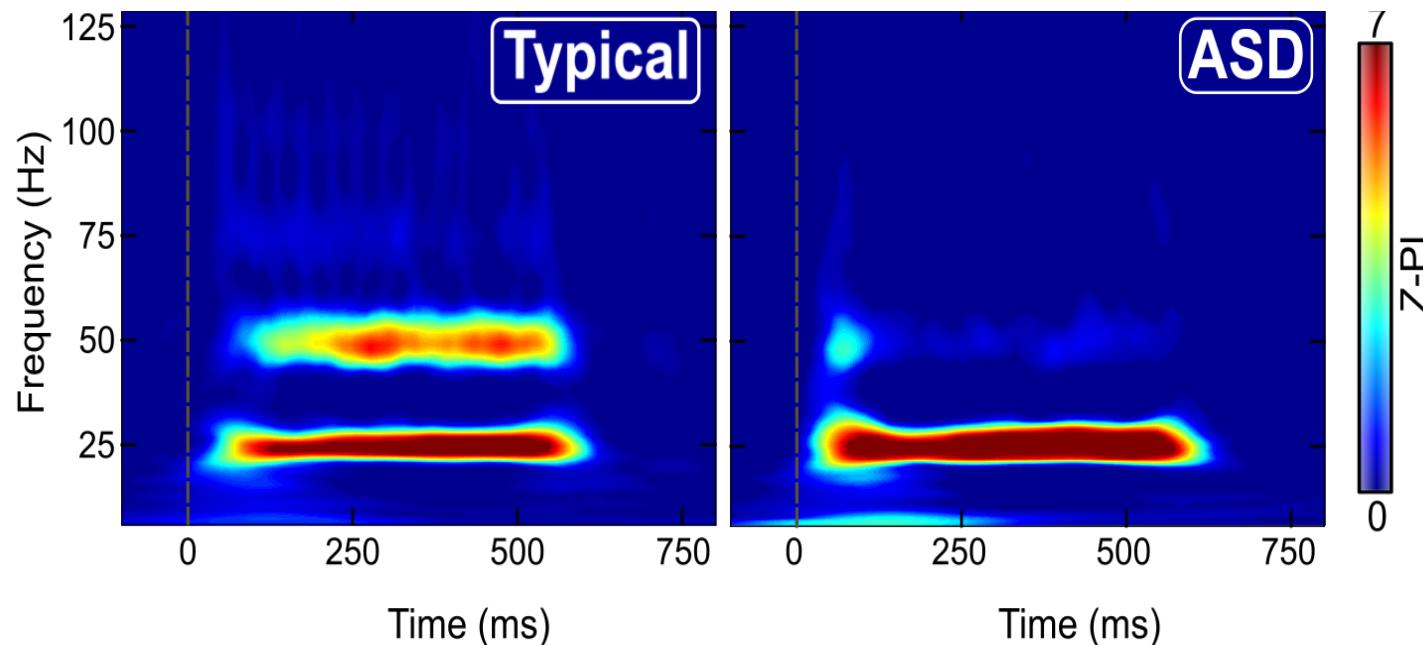
Tactile



Khan et al, Frontiers Human Neuroscience ,2014

Experimental Paradigms for MEG/EEG

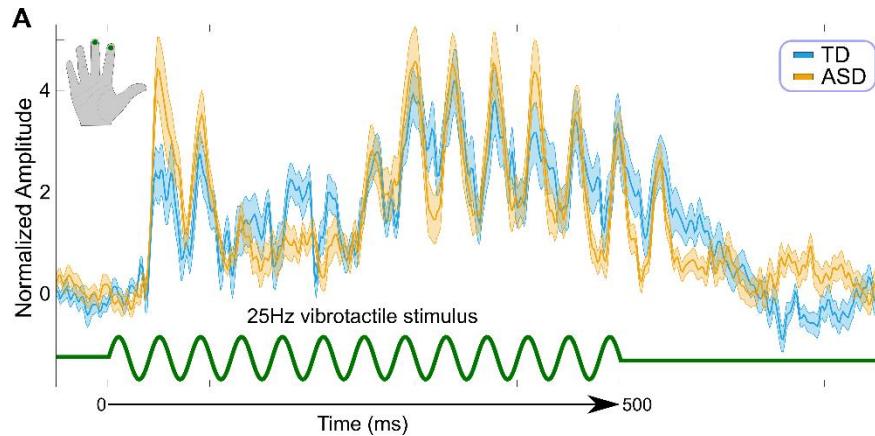
- **Frequency-Tagging:** When stimulus with specific temporal encoding (e.g., visual pattern flickering at a well-defined frequency) may trigger brain responses locked to the stimulus presentation rate and its harmonics.



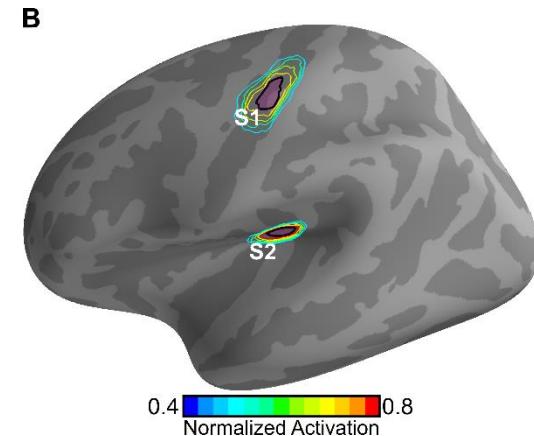
Khan et al, Brain ,2015

Experimental Paradigms for MEG/EEG

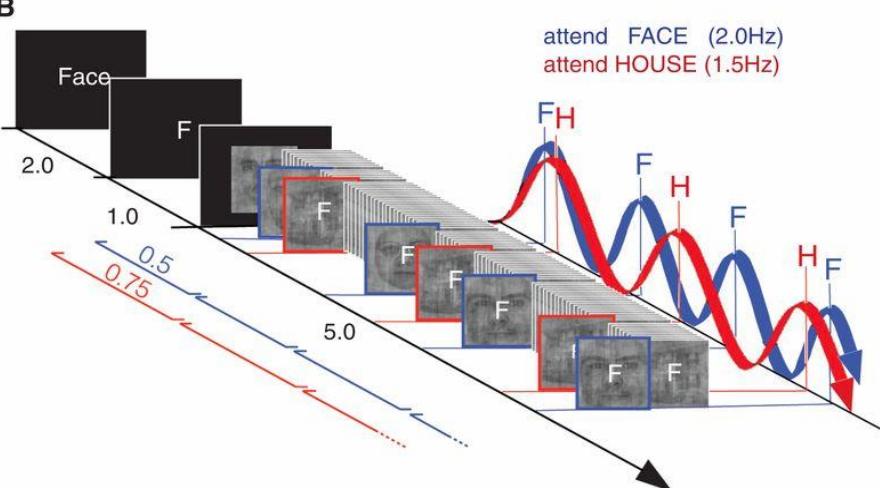
Somatosensory Tagging



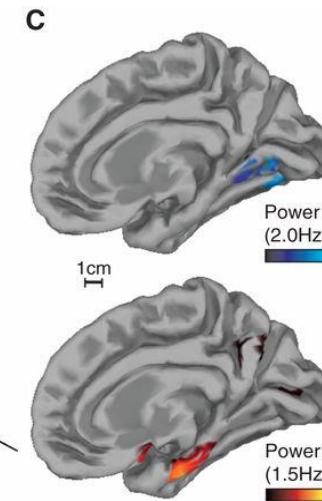
Khan et al, Brain ,2015



Visual Tagging

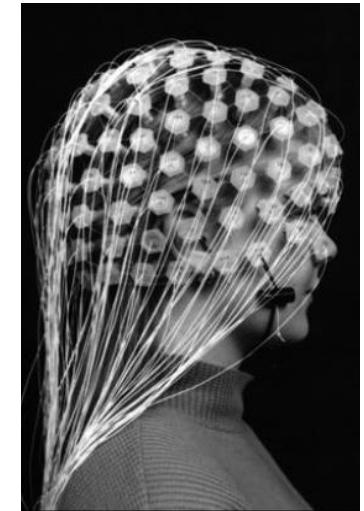
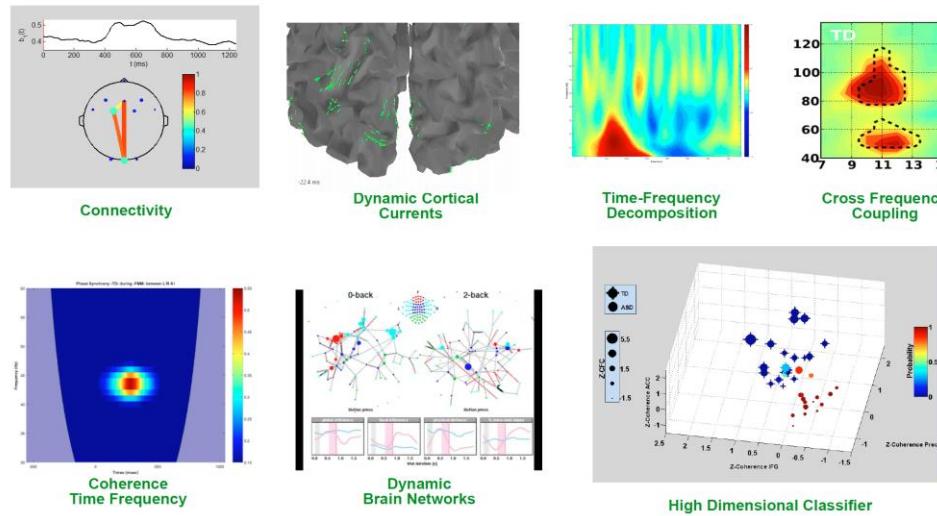
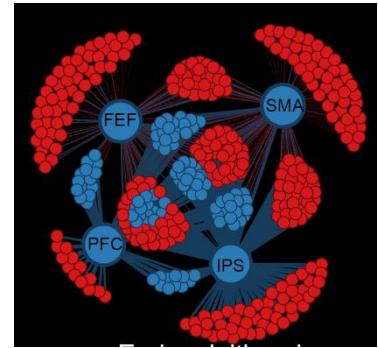


Baldauf et al, Science ,2014



Overview

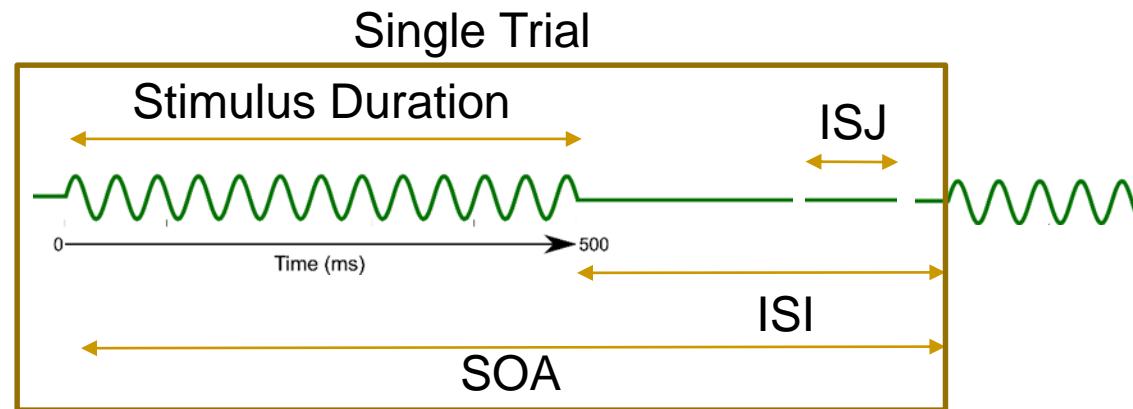
- Experimental Paradigms for MEG/EEG
- Testing Experimental Paradigms
- A typical MEG/EEG Visit



Testing Experimental Paradigms

Adjusting Stimulus Parameters

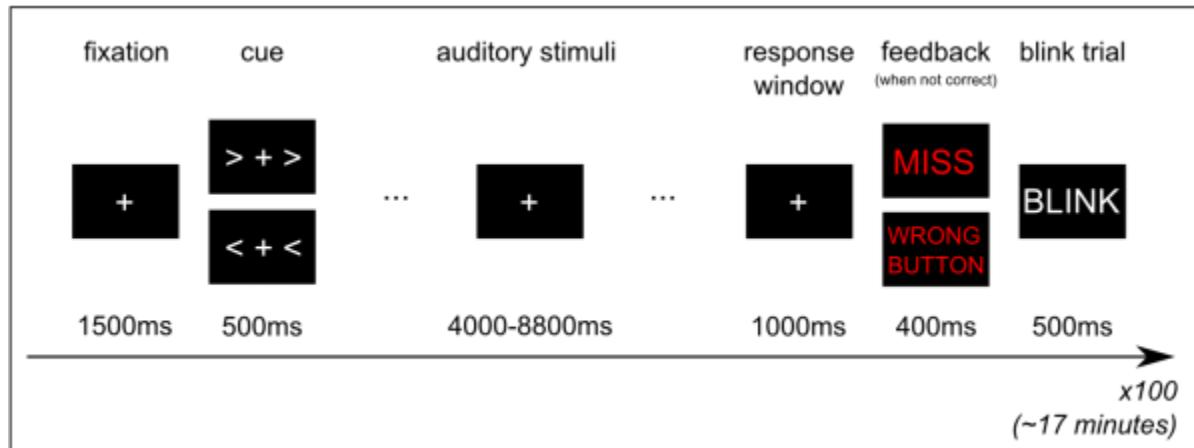
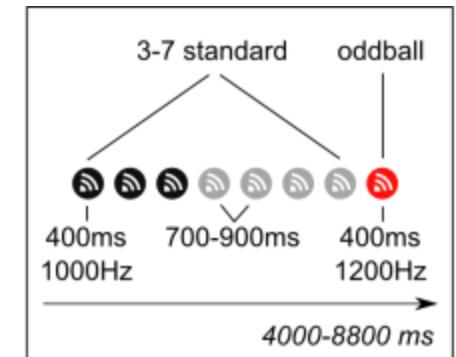
- Trial
- Run
- Stimulus Duration
- Inter-Stimulus interval (ISI)
- Inter-Stimulus Jitter (ISJ)
- Stimulus Onset Asynchrony (SOA)



Testing Experimental Paradigms

Stimulus programming options

- ❑ Open Source
 - Matlab based Psychophysics(psychtoolbox.org)
 - Python based PsychoPy (psychopy.org)
- ❑ Commercial Packages
 - ❑ Presentation (neurobs.com)
 - ❑ Stim2 (compumedicsneuroscan.com)



Testing Experimental Paradigms

Testing Timing, Jitter, Sound level, Brightness

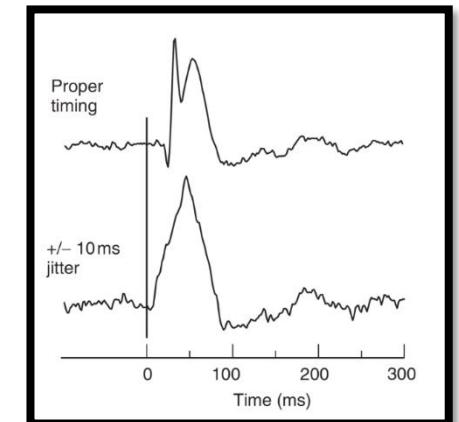
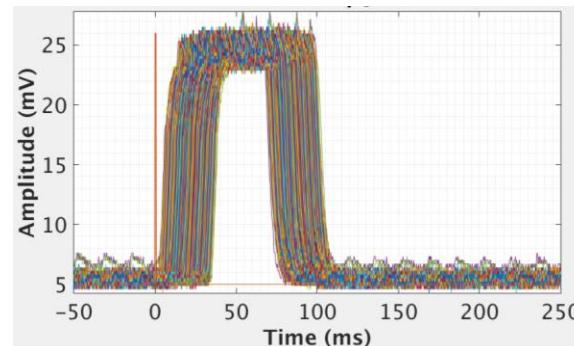
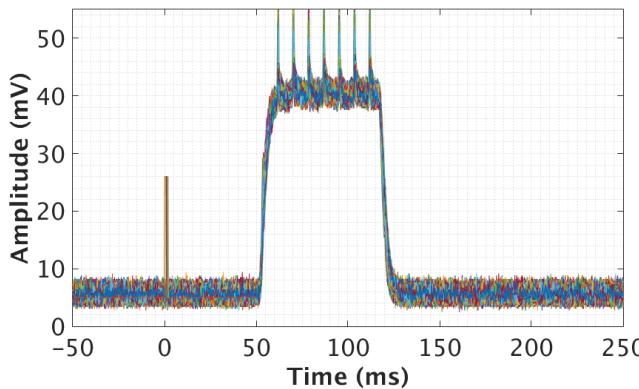
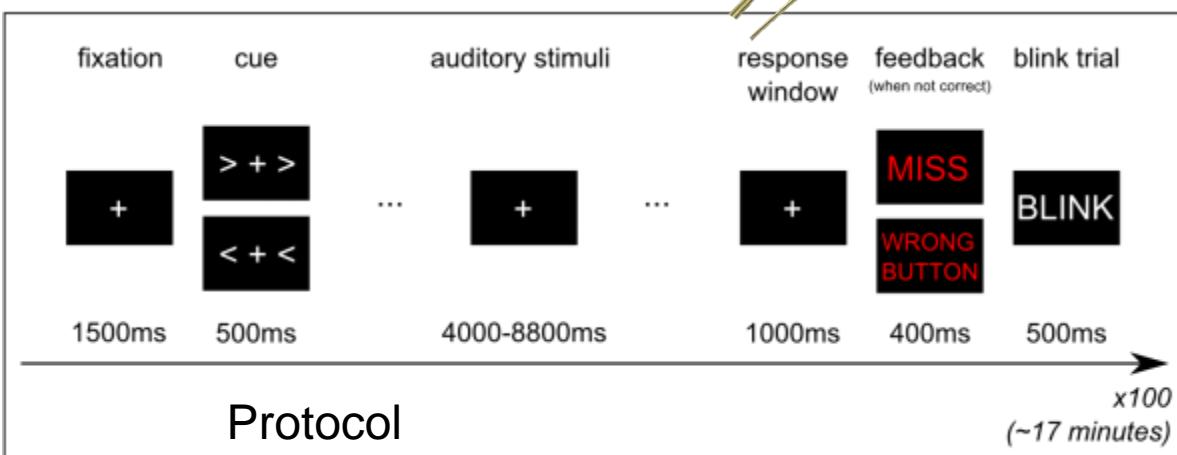


Photo Diode

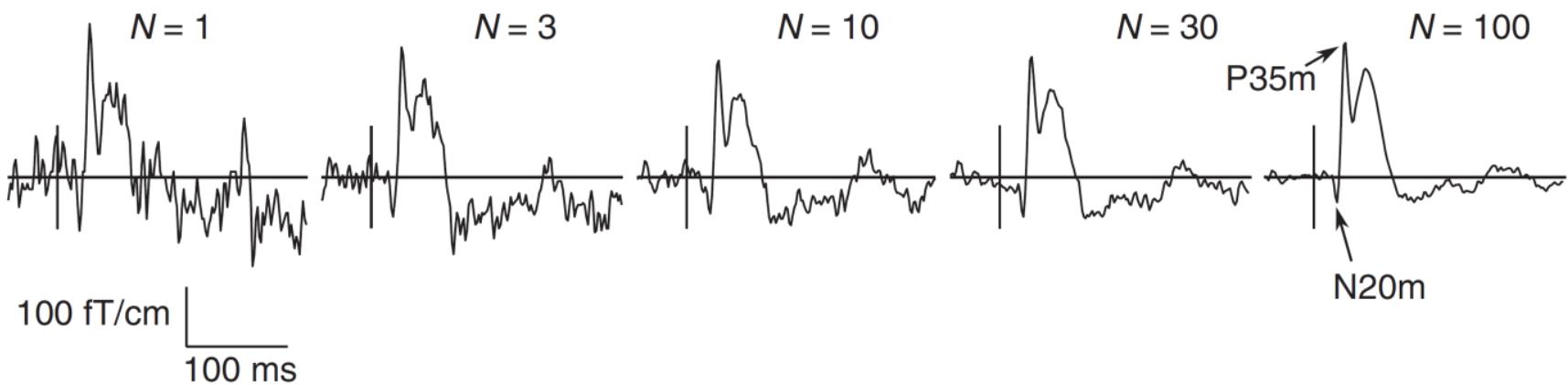


Sound Meter



Timing Accuracy

Averaging evoked fields

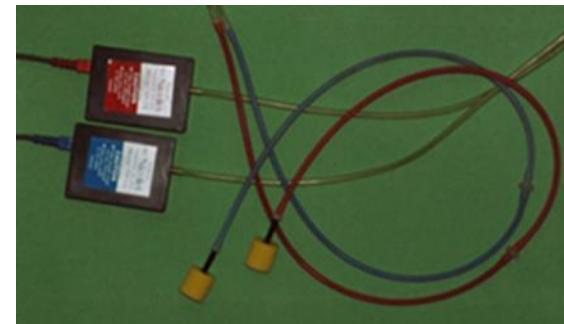


Number of Trials

Testing Experimental Paradigms

Testing Stimulus equipment for Artifact

- Auditory
- Tactile
- Responses Pad



Free (acceleration & EMG)



Squeeze (pressure)



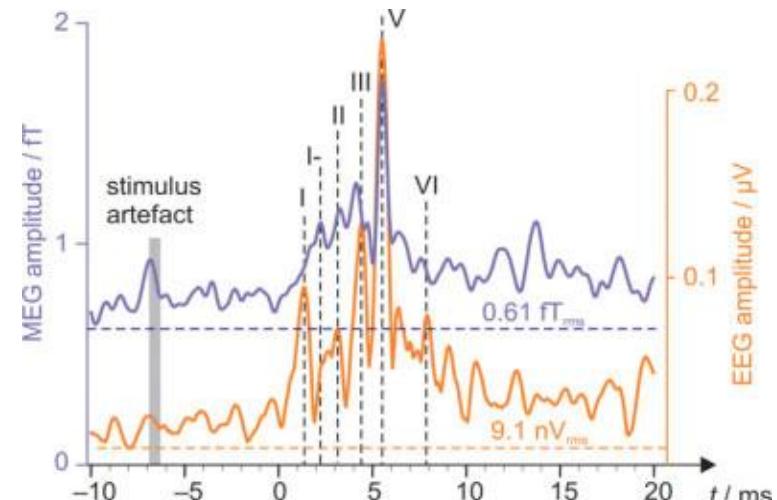
Fixed-pinch (force)



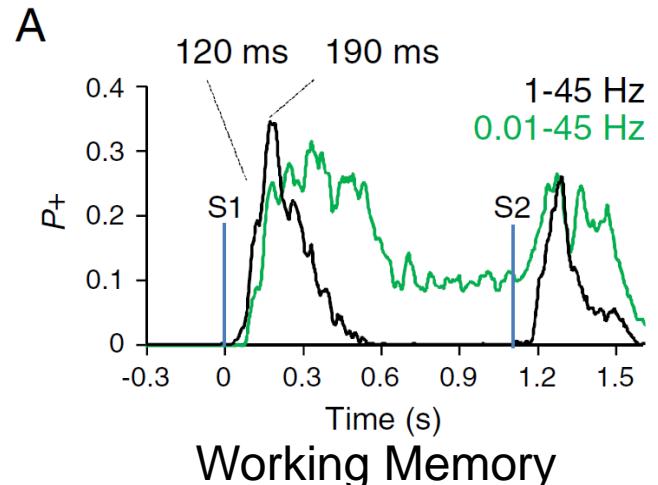
Testing Experimental Paradigms

Adjusting Hardware Setting

- Sampling Rate
- Filter Bandwidth



Auditory Brainstem Responses

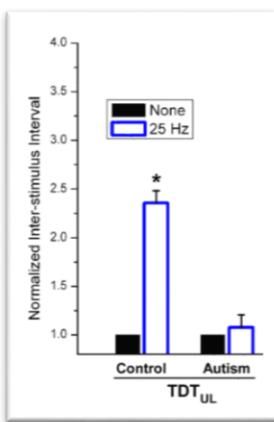
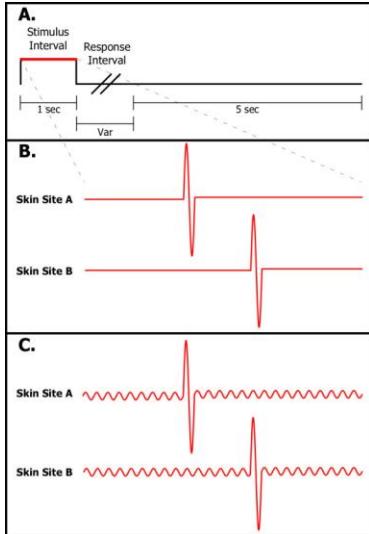


Working Memory

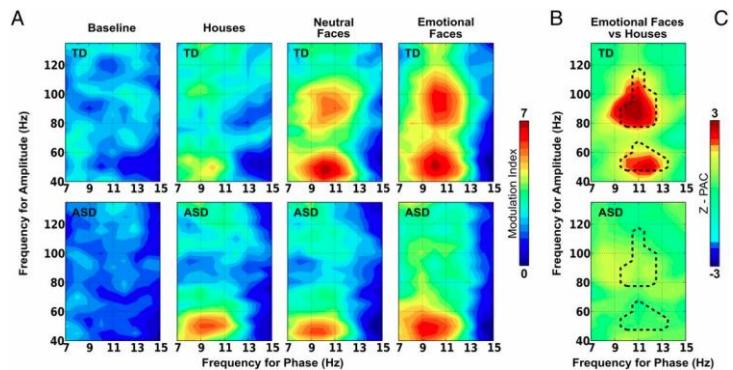
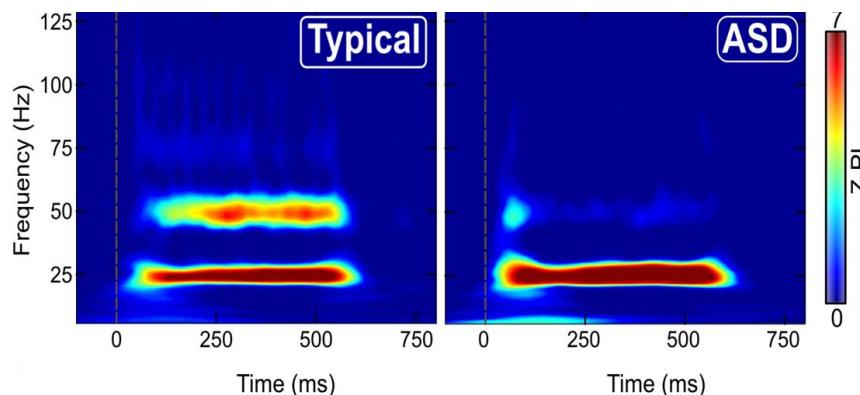
Testing Experimental Paradigms

Behavioral Testing

Somatosensory priming

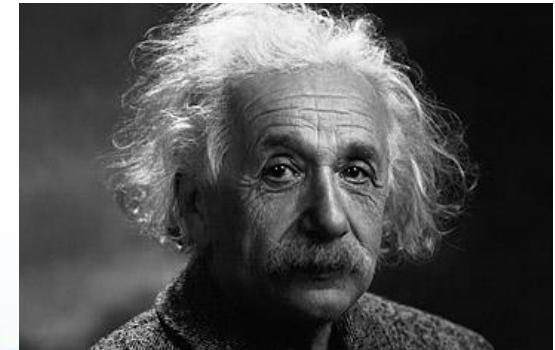


Valence Testing



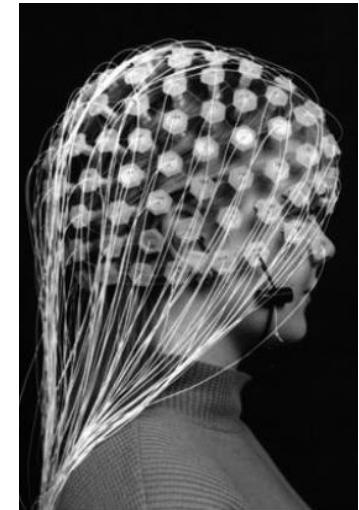
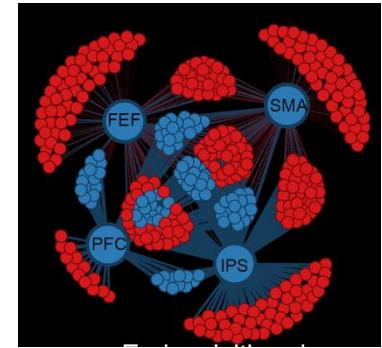
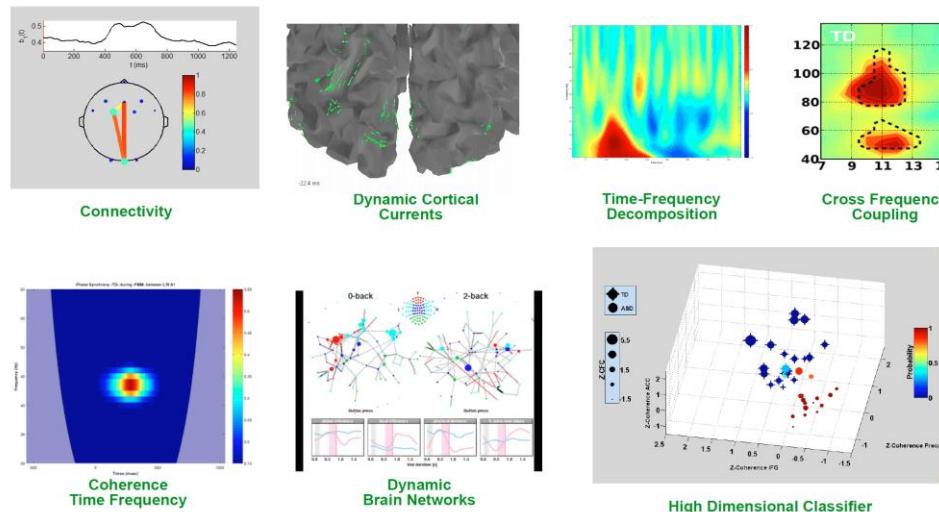
Testing Experimental Paradigms

Population Diversity



Overview

- Experimental Paradigms for MEG/EEG
- Testing Experimental Paradigms
- A typical MEG/EEG Visit



A typical MEG/EEG Visit

A typical visit starts the day before, with a Call or email to the subject to remind:

- Sleep Well
- Not to drink too much coffee or energy drink
- No Makeup
- Weight and if applicable eyeglasses prescription
- Appropriate clothing



	SPH	CYL	AXIS	PRISM	BASE
R	+1.00	-0.75	120	—	—
L	-0.25	+1.00	70	—	—

Add _____
Inter. _____ Near +2.25°



A typical MEG/EEG Visit

Before the Subject arrives

- Preparing EEG cap,
- Extra electrodes
- HPI and digitizer
- Stimulus testing , Auditory gains, brightness, room light.

Digitizer



Trigger Box

Head Position Indicator coils



Electrodes

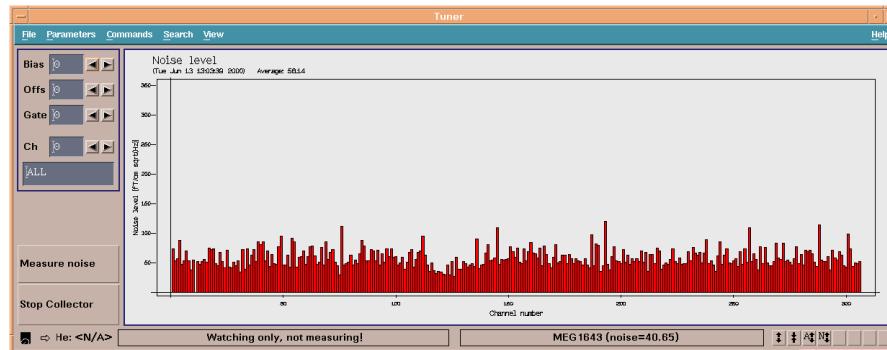
EEG Cap



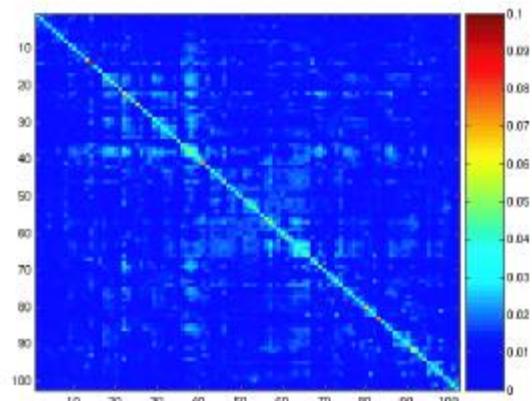
A typical MEG/EEG Visit

Before the Subject arrives

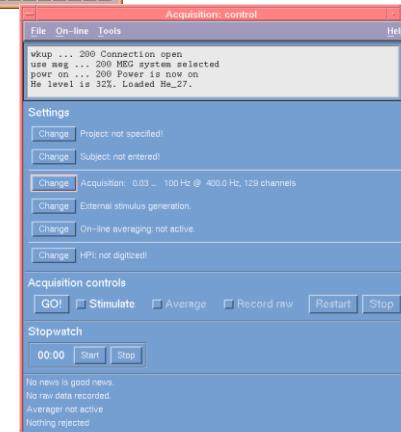
- Tuning Channels
- Acquire Empty room



Tuner



Noise Co-variance matrix



Acquisition software



A typical MEG/EEG Visit

Before the Subject arrives

- Prepare bedding
- Prepare gowns
- IRB/Consent forms



A typical MEG/EEG Visit

After the Subject arrives

- Consent forms
- Explanation of protocols
- Change to gown
- Test Subject for Artifact

Have you ever had a piece of metal go into your eye?	Yes	No
Have you ever been injured by a bullet or shrapnel?	Yes	No
Have you ever had any surgeries? If yes, please describe:		
Approximately how many dental fillings do you have?		
Please check if you have the following:		
Yes	No	
<input type="checkbox"/>	<input type="checkbox"/>	Aneurysm clip (on blood vessel)
<input type="checkbox"/>	<input type="checkbox"/>	Cochlear (ear) implant
<input type="checkbox"/>	<input type="checkbox"/>	Cardiac Pacemaker, pacing wires, implanted cardio defibrillator (ICD)
<input type="checkbox"/>	<input type="checkbox"/>	Artificial heart valve
<input type="checkbox"/>	<input type="checkbox"/>	Metallic stents, filters or coil (cardiac stents, Greenfield filters, etc.)
<input type="checkbox"/>	<input type="checkbox"/>	Other implanted electronics devices (bone growth, spinal cord stimulator, medication pump)
<input type="checkbox"/>	<input type="checkbox"/>	Shunt (spinal or intraventricular)
<input type="checkbox"/>	<input type="checkbox"/>	Any type of prosthesis (leg, eye, etc.)
<input type="checkbox"/>	<input type="checkbox"/>	Artificial limb or joint (including hip or knee replacements)
<input type="checkbox"/>	<input type="checkbox"/>	Pin, screw, nail, wire, or plate in any bone or joint
<input type="checkbox"/>	<input type="checkbox"/>	IUD, diaphragm, or <u>pesary</u>
<input type="checkbox"/>	<input type="checkbox"/>	Non-removable body piercing or jewelry
<input type="checkbox"/>	<input type="checkbox"/>	Permanent makeup
<input type="checkbox"/>	<input type="checkbox"/>	Medication patches (Nicotine, Nitroglycerine)
<input type="checkbox"/>	<input type="checkbox"/>	Dentures (removable)
<input type="checkbox"/>	<input type="checkbox"/>	Orthodontics (if metallic)
<input type="checkbox"/>	<input type="checkbox"/>	Crowns on teeth; posts in teeth
<input type="checkbox"/>	<input type="checkbox"/>	Dental implants
<input type="checkbox"/>	<input type="checkbox"/>	Dental bridge; partial plates; permanent retainer; temporary spacers
<input type="checkbox"/>	<input type="checkbox"/>	Hearing aid (removable)
Other (please describe):		

Screening form

A typical MEG/EEG Visit

Two Types of artifacts:

Biological

Blinks/secedes

Cardiac

Non Biological

Dental

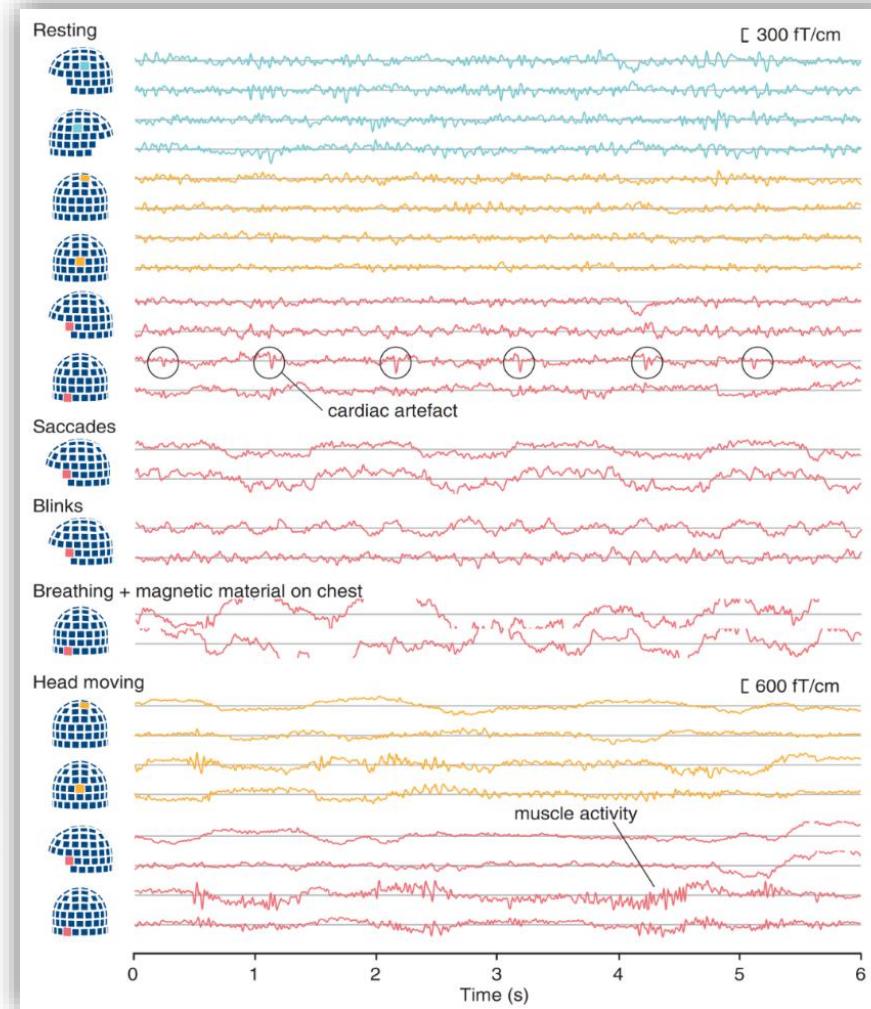
Metal on body (internal/external)

Jewelry

Brain Stimulators



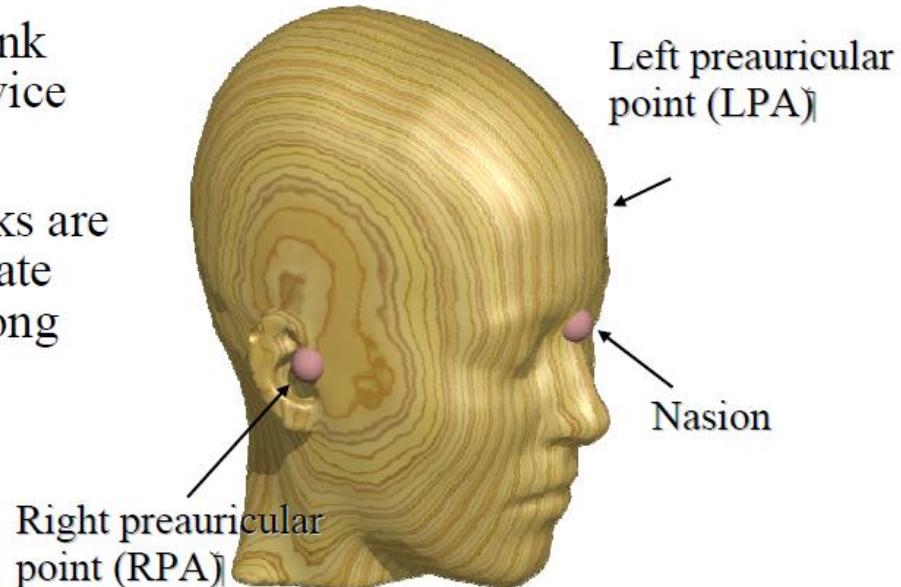
Different artifacts



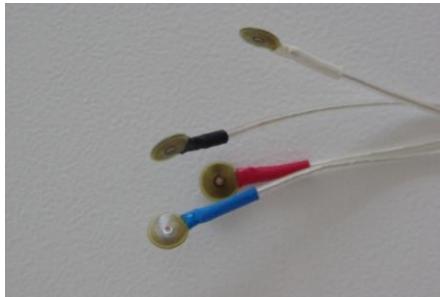
A typical MEG/EEG Visit

Head digitization

- ◆ MEG source locations usually superimposed on anatomical MR images: MEG/MRI co-registration required.
- ◆ *Head coordinate frame* is the link between the MEG and MRI device coordinate frames.
- ◆ 3 common anatomical landmarks are used to define the head coordinate frame. Note: No consensus among MEG vendors for a common coordinate system!



A typical MEG/EEG Visit

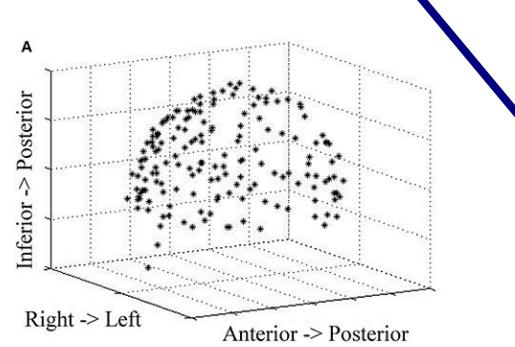
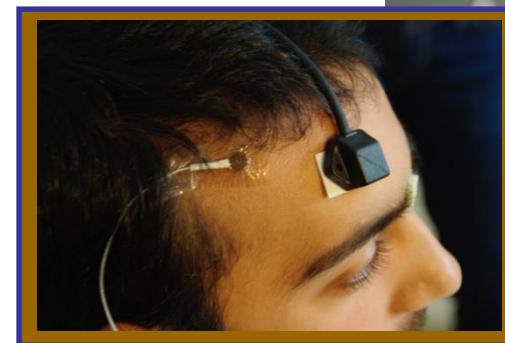


Position coils

Head digitization

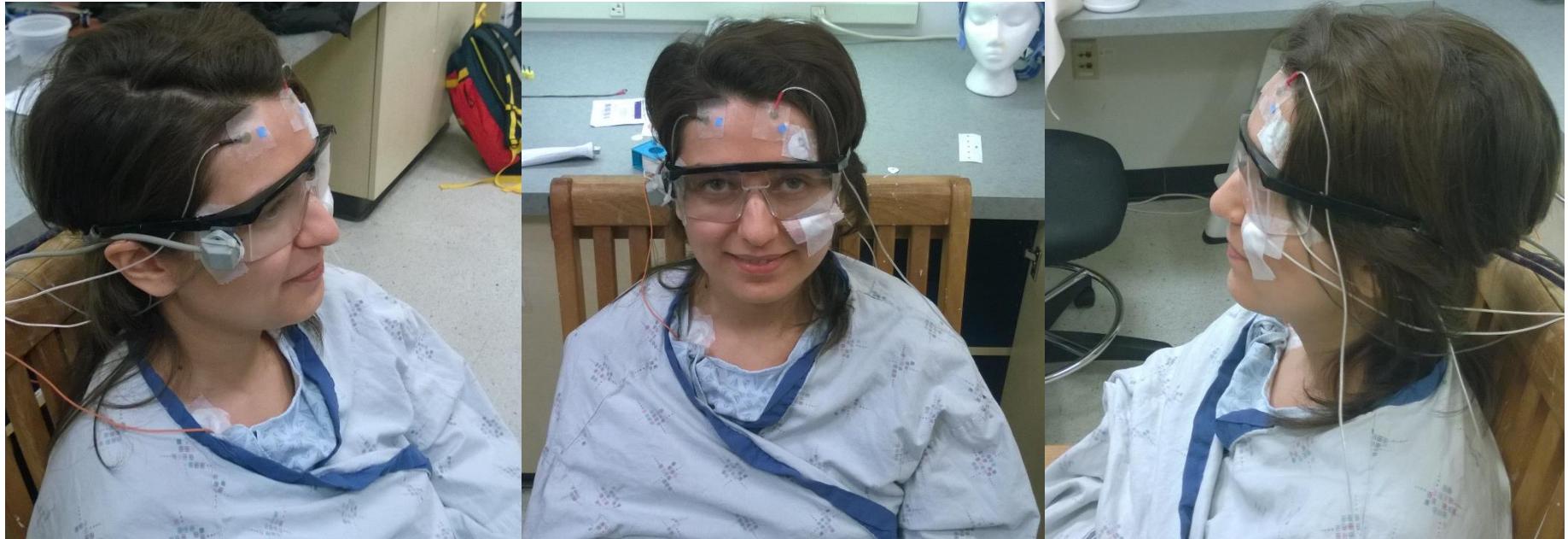
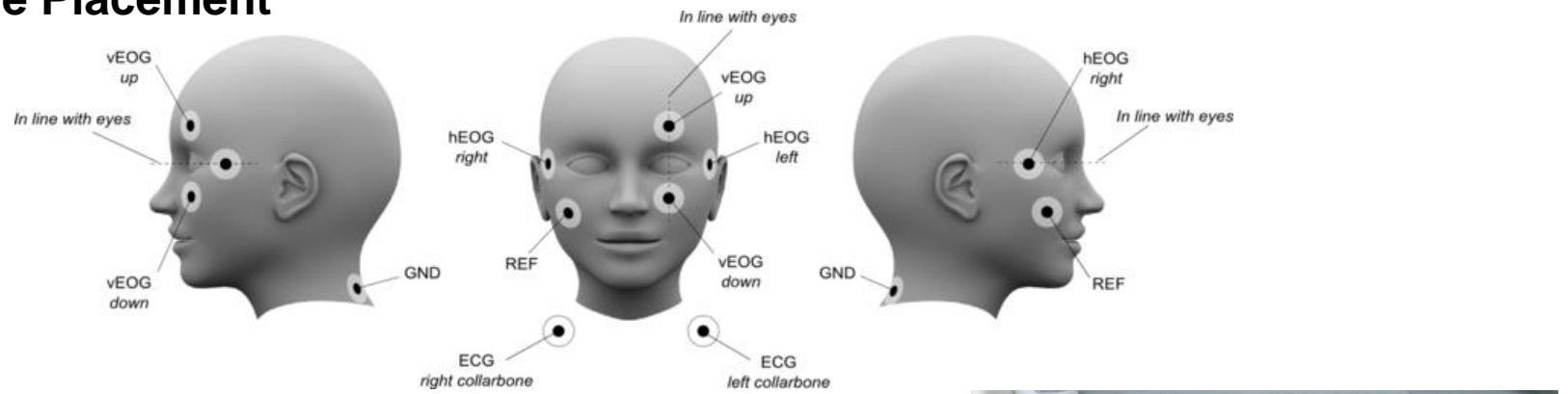


Polhemus Data



A typical MEG/EEG Visit

Electrode Placement



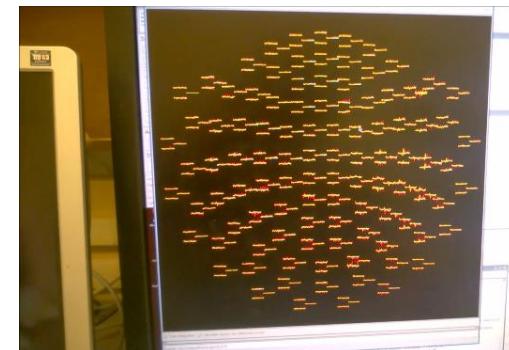
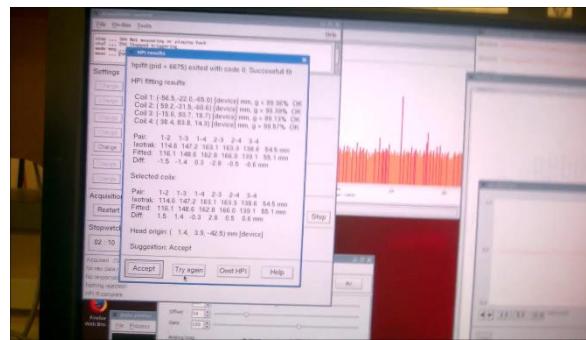
A typical MEG/EEG Visit

During Experiment

- Once you have placed the subject in the MSR close the MSR door
- Use intercom; ask the subject to relax
- Check MEG signals
- Once you start the acquisition and at the beginning of each run, you will be prompted to record HPI
- Once HPI measurement is ok, you can start recording.
- Continuously inspect the quality of your data!
- If individual bad channel appears during the recording, mark it as bad channel



Intercom



A typical MEG/EEG Visit

After Experiment Finishes

- Tell subject you are opening the door
- Remove HPIs and electrodes/EEG cap



Subject coming out

A typical MEG/EEG Visit

After the Subject leaves

- Clean and disinfect the electrodes/EEG Cap and the HPI
- Clean the MEG helmet and chair.
- Switch off the video projector
- Switch off the light in the MSR
- Log out of the acquisition computer
- Take with you any leftover of your presence (used papers,belts....)



A typical MEG/EEG Visit

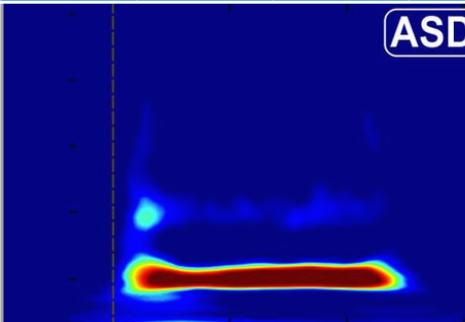


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ASD

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IMAGING AND COMPUTATIONAL CORES

The backbone of the Martinos Center is the Martinos Technology Core, comprising Imaging and Computational Core resources. Together, these develop and provide state-of-the art biomedical imaging and image processing technology and techniques to the Center's research faculty and user community.

The Core resources are fully supported by user fees drawn from research grants, instrumentation grants and industry agreements. The facilities are available for use to all qualified investigators from academic, medical, government and industry labs.

See the [Core Resources](#) page for further information.

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Conflict of Interest Disclosure

Sheraz Khan

Advanced Imaging in Clinical/Translational Neuroscience
Research
April 13-15, 2015

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