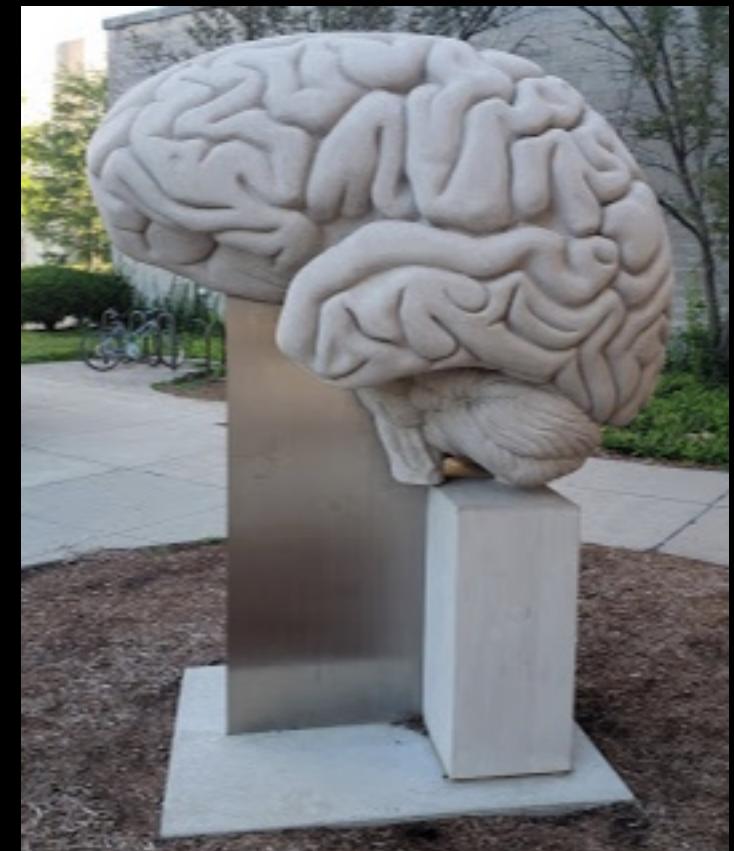
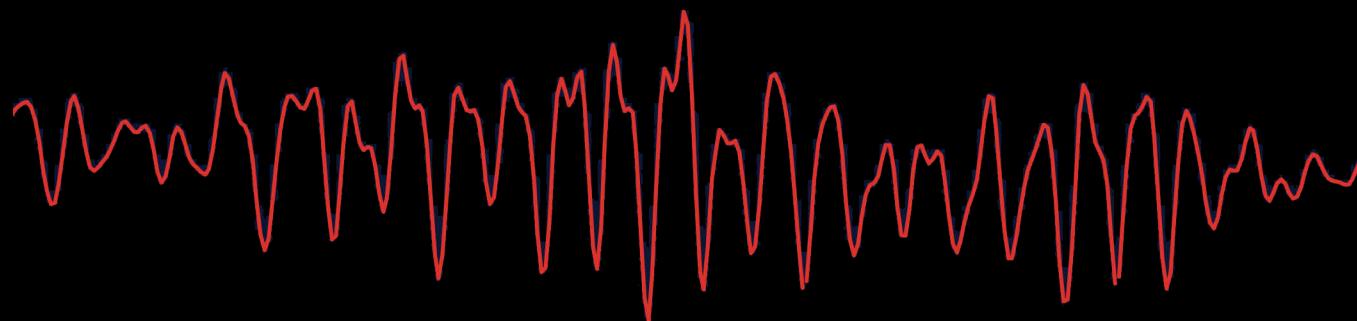


EEG devices: What's out there & for which application?

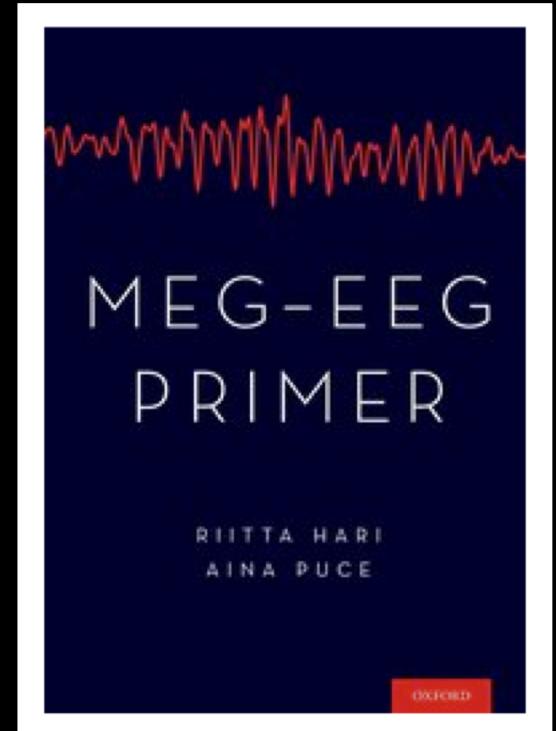
Aina Puce, Psychological & Brain Sciences
Indiana University, Bloomington, USA



OHBM2020 Education Course 13th July 2020:
EEG data acquisition & appropriate data pre-processing: not so basic after all?

Aina Puce has no commercial interests to declare with respect to any EEG/MEG hardware/software

Aina Puce has co-authored a book with Riitta Hari for Oxford University Press



Take home message: brief

Garbage in, garbage out

Take home message: unpacked

- Maintaining *signal quality* during MEEG data acquisition will always win out over any *post hoc* artifact removal method
- Use an MEG/EEG system that is most *appropriate* for *your* scientific question

Roadmap

- 2 live EEG examples showing some challenges in EEG data acquisition
- What to consider once the scientific question has been identified?
- Portable EEG vs non-portable EEG systems?
- Supercooled MEG vs OPM MEG?
- Combined MEG & EEG studies: challenges

What to consider when identifying the scientific question to be asked

- EEG, MEG, MEG/EEG: why?
 - High/low density sensor arrays? Source modeling or not?
 - Portable vs fixed system? Nature of experiment?
 - Combine with other modalities: fMRI, NIRS, TMS, infrared eye tracking etc?
- Keep data acquisition as simple as possible – don't use a method just because it is cool

Portable EEG systems

Consumer-based systems

Neurofeedback: meditation/sleep/sports

Apps for computer & smartphone

Emotiv
5, 14 ch



Limited capability to export raw data in various formats, may include GPS & gyro

Muse
4ch



NeuroSky
1 ch

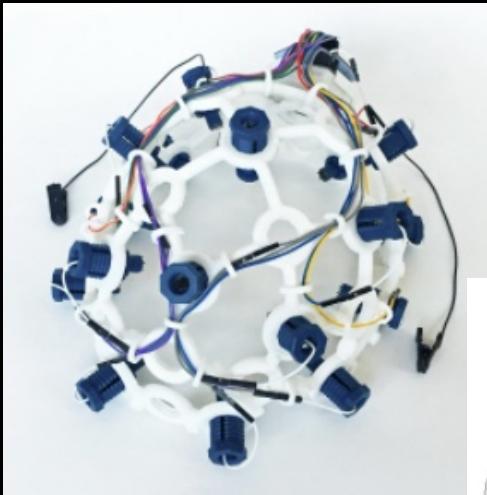


A LIVE EEG RECORDING
[Muse & Mind Monitor smartphone app]

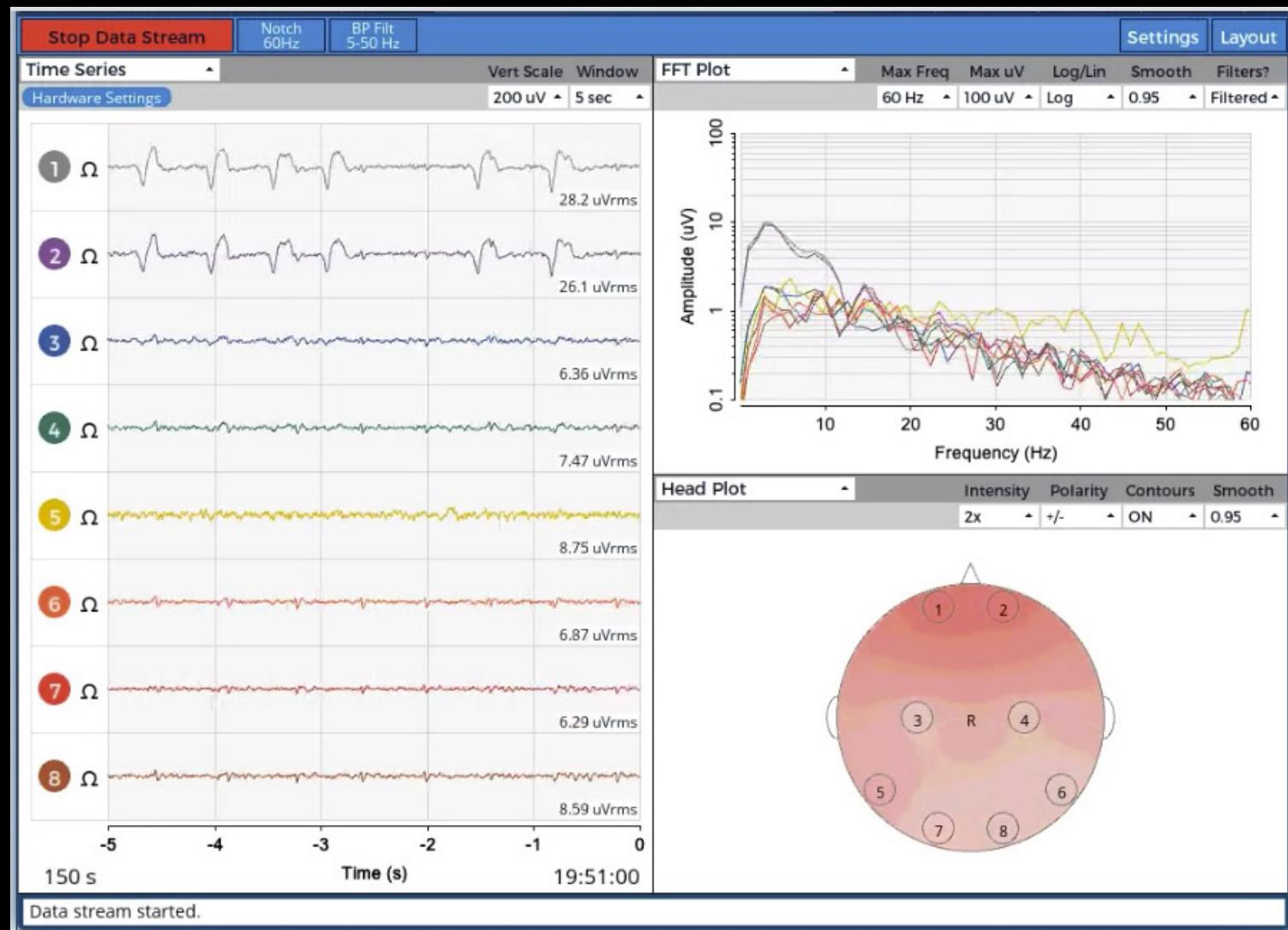
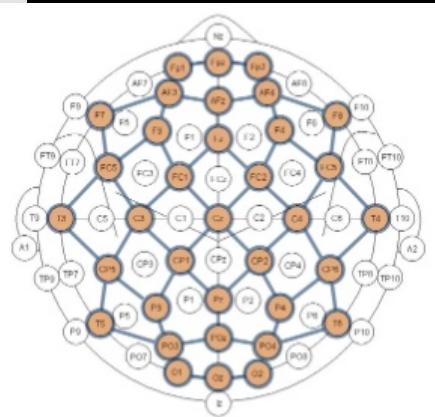
Portable EEG systems

Open Source system
OpenBCI
8-16 ch

<https://github.com/OpenBCI>



3D printable caps



Portable EEG systems

Wet & dry electrode options, higher sampling rates



Wearable sensing
Dry elec 7 – 24 ch

Use with VR

Neuroelectrics.com Enobio EEG 8-32 ch

mbraintrain .com 24 ch

g.Nautilus Pro 8-32 ch

BioSemi 16 ch

Brain Products GmbH Live Amp 8-32 ch



Advanced Brain Monitoring
B-Alert EEG system 10-24 ch



AntNeuro;
Tablet in backpack 8-32 ch



<https://imotions.com/blog/eeg-headset-prices/>

Portable EEG systems

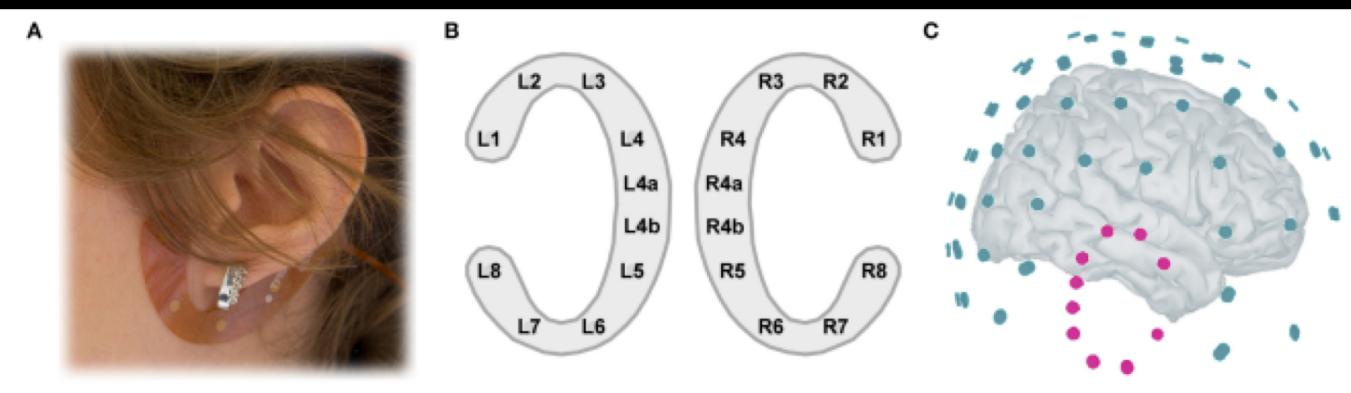
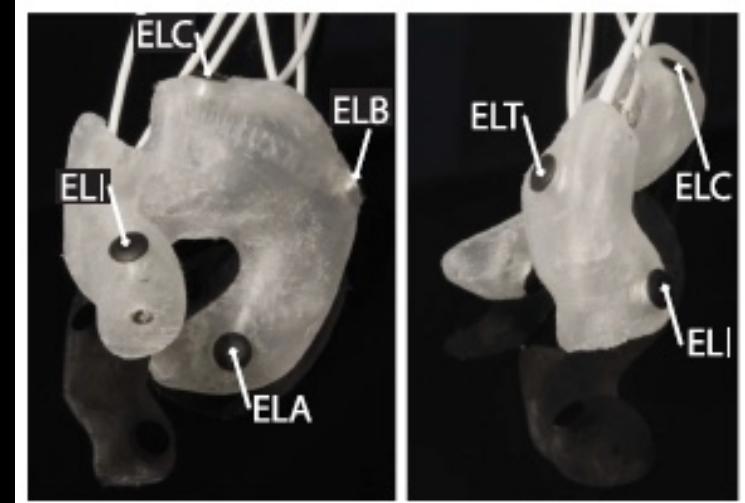
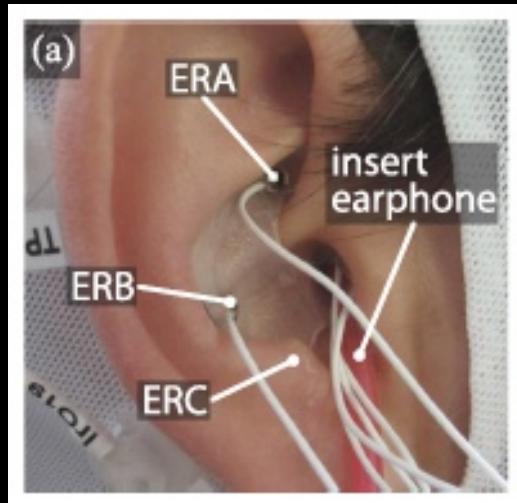
C-shaped EEG electrode array around the ear for 'discrete recording'



cEEGrid
Wet Ag/AgCl elec 10 ch;
used with
mbraintrain.com amps

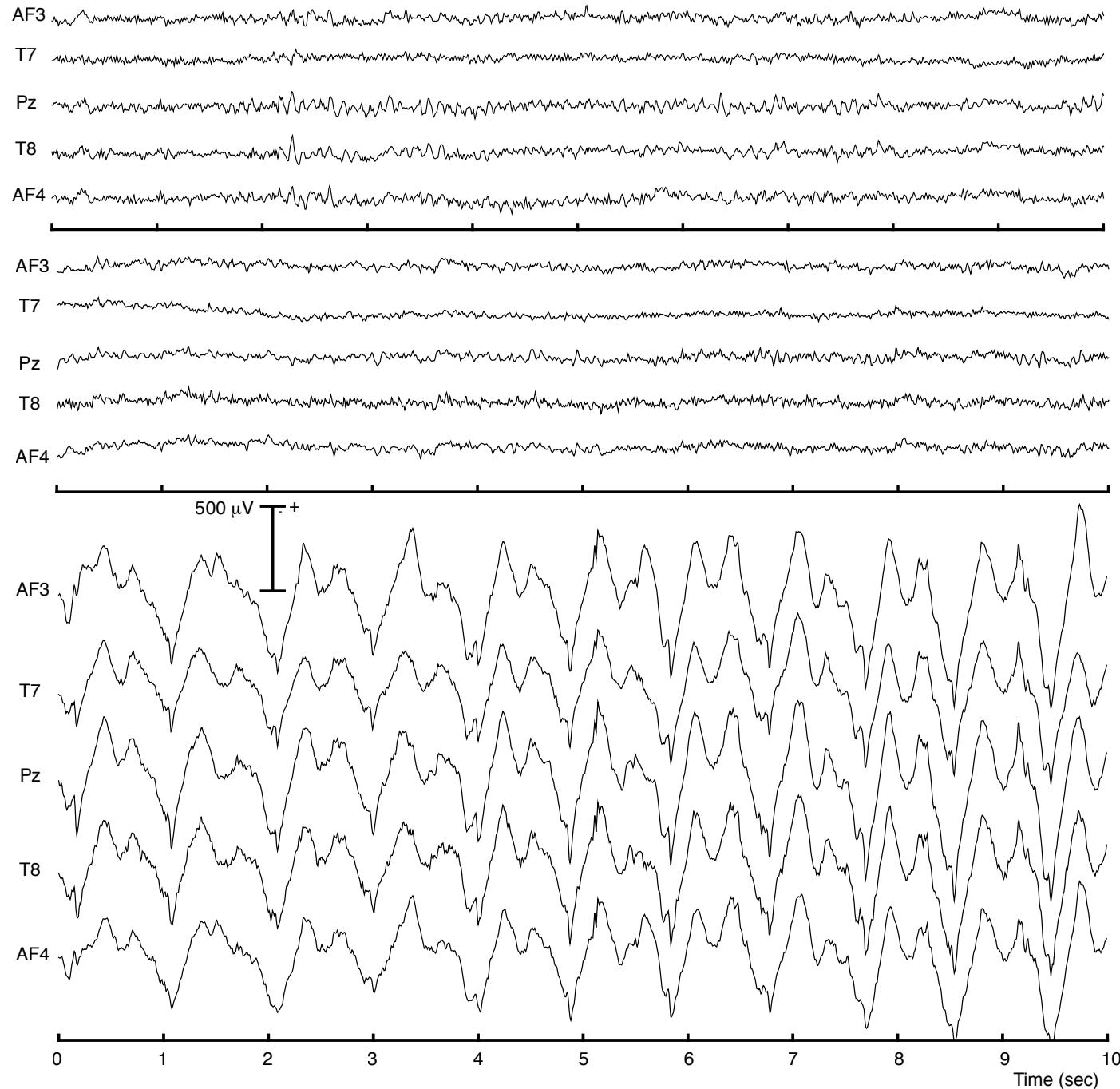
from Mirkovic et al *Front Hum Neurosci* 2016

Ear insert EEG electrodes: for auditory system applications & for improving source modelling



Ear-EEG: electrodes with soft earpiece;
dry Ti elec IrO₂ coating, 6 possible recording
sites; used with TMSi MOBITA EEG amp &
earbud auditory stim [3M E-A-RTONE GOLD]

from Kappel et al *IEEE Trans Biomed Eng* 2019



Additional challenges “in the wild”

Additional artifacts e.g. walking



Interference from other
devices

Portable or fixed system EEG?

- Why choose one over the other?
 - Source modeling? Fixed systems typically have higher density, with electrode position mapping
 - Need very clean EEG signals? With fixed systems subjects typically immobile in lab, away from sources of interference
 - Need interactions with environment? Use portable EEG
- Challenges with low density systems?
 - Artifact elimination is more difficult

MEG: high-density [supercooled] or lower-density room temperature?

- Why choose one over the other?
 - Similar logic & challenges to EEG
- Room temperature MEG: optically pumped magnetometers [OPMs] are sensors



Combined MEEG studies [fMRI, TMS etc.]

- Challenges: additional sources of artifacts
- Consider recording additional data focusing on artifacts themselves
- Input for machine learning algos & then perform artifact rejection on real data?

Take home message

- Maintaining *signal quality* during MEEG data acquisition will always win out over any *post hoc* artifact removal method
- Use an MEG/EEG system that is most *appropriate* for *your* scientific question for getting the highest fidelity data!
- Consider recording additional data ‘showcasing’ artifacts to aid development of novel machine-learning inspired artifact removal methods

A LIVE EEG RECORDING

[CGX (prev. Cognionics) 8 ch EEG system & software]



Many thanks to Dr. Ben Ramsden, Indiana University, for loaning his EEG recording system, setting up this data collection, & for sharing the data!