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

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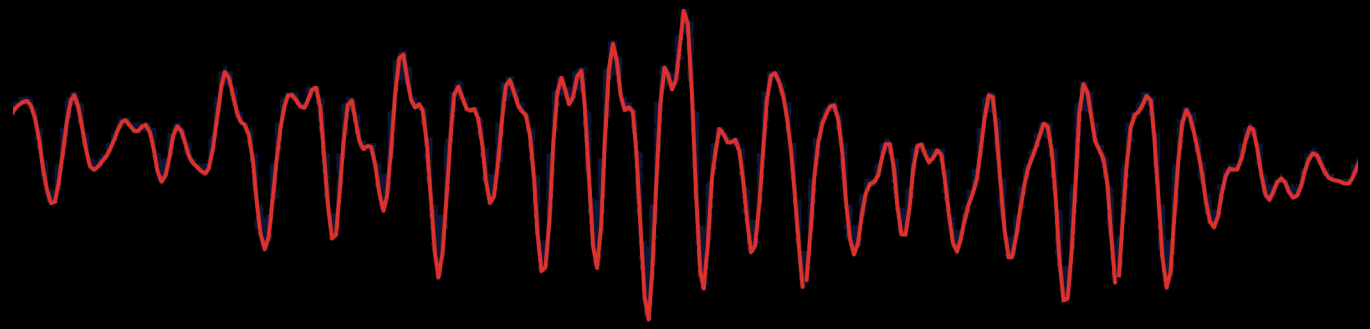
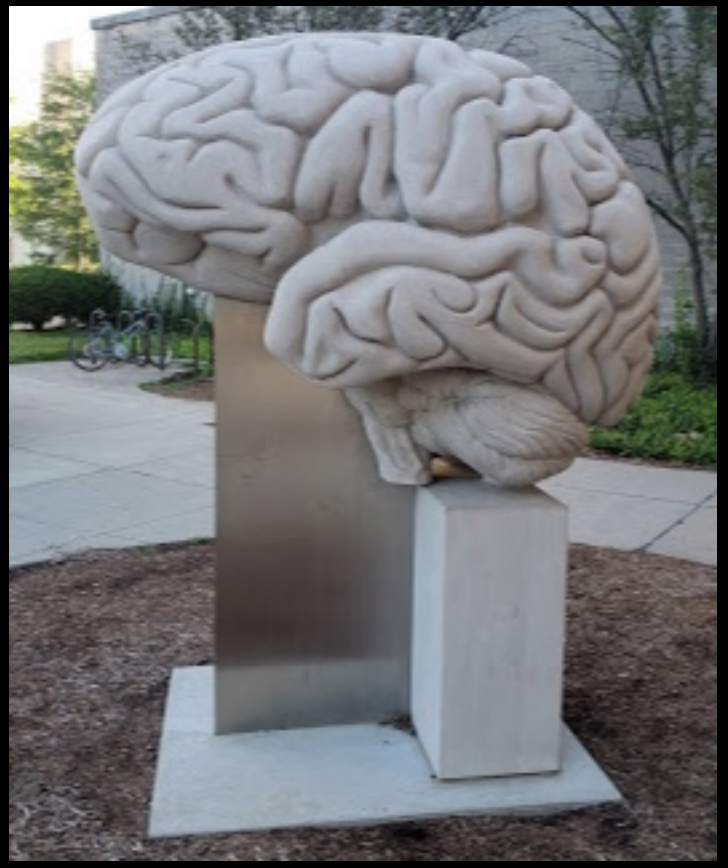
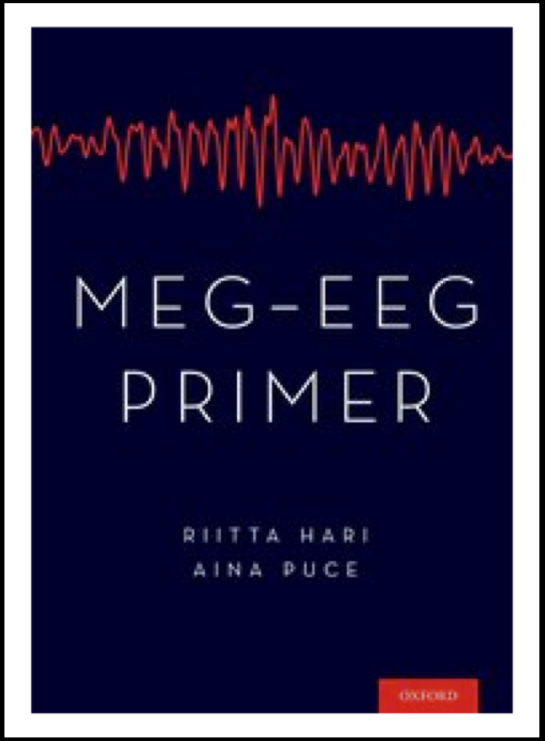




OHBM2020 Education Course 13th July 2020:
EEG data acquisition & appropriate data pre-processing: not so basic after all?

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

- Live ongoing 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 OBM MEG?
- Combined MEG & EEG studies: challenges

A LIVE EEG RECORDING
[Muse]

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 acqusition 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

Muse

5ch

Emotiv

5, 14 ch

NeuroSky

1 ch

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

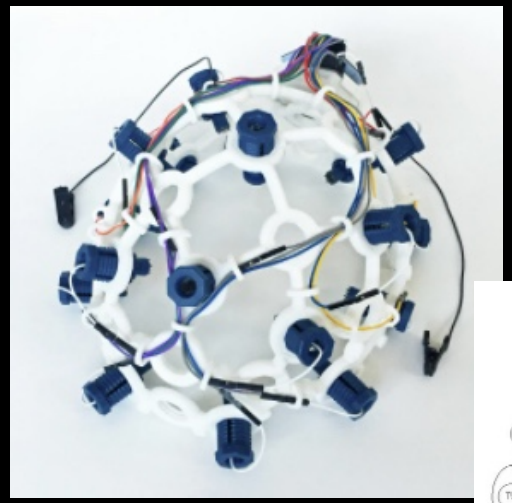
Portable EEG systems

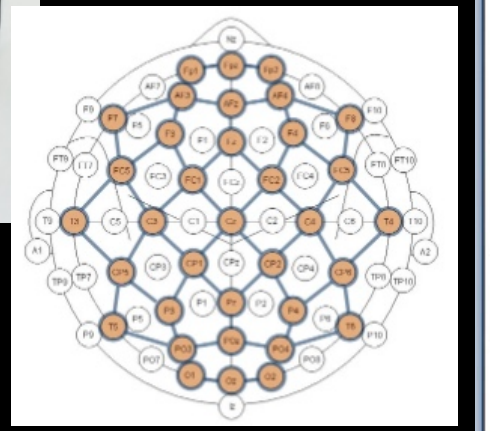
Open Source system

OpenBCI

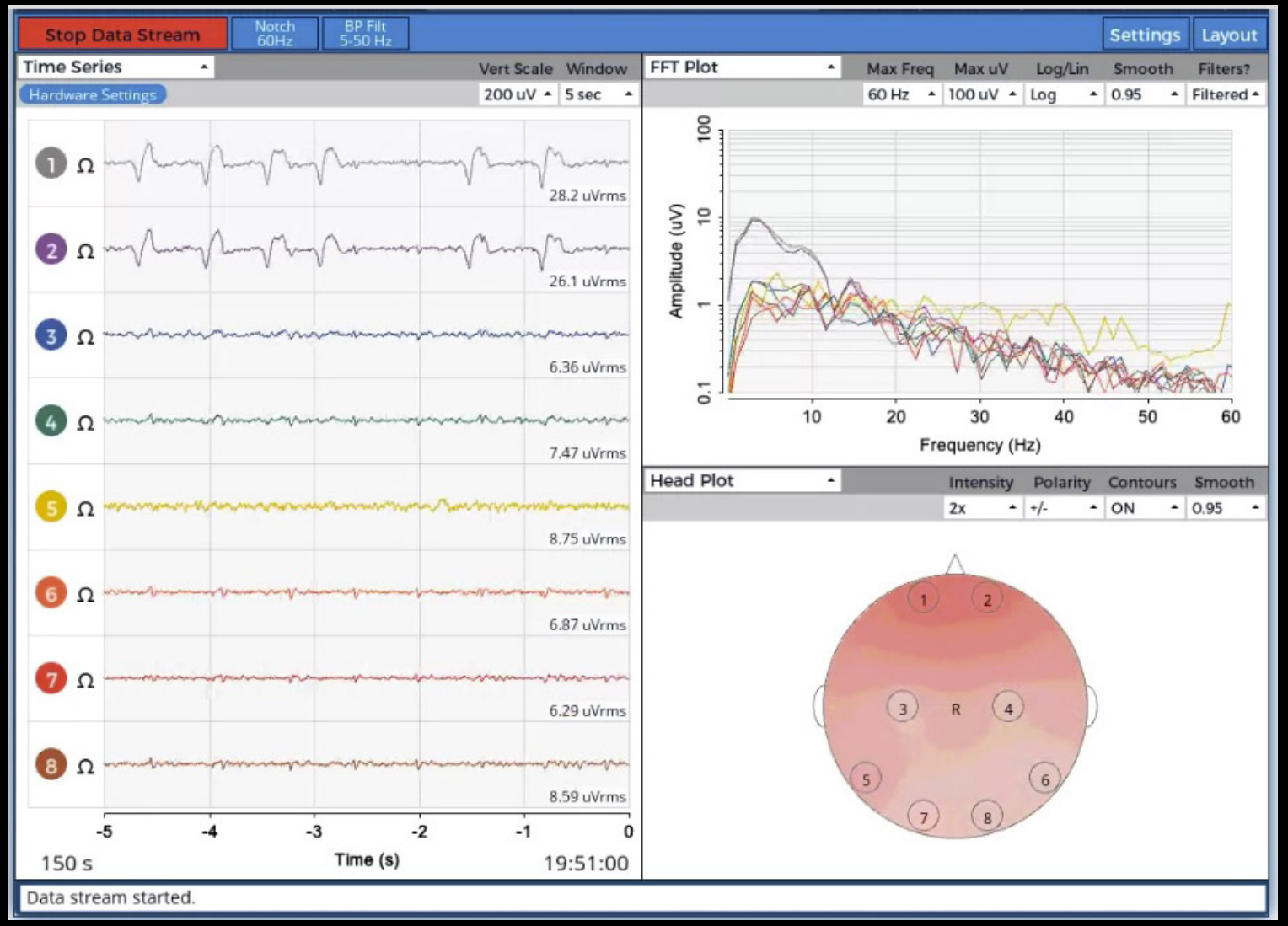
8-16 ch

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

AntNeuro;
Tablet in backpack 8-32 ch
Mini handheld 8 ch

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

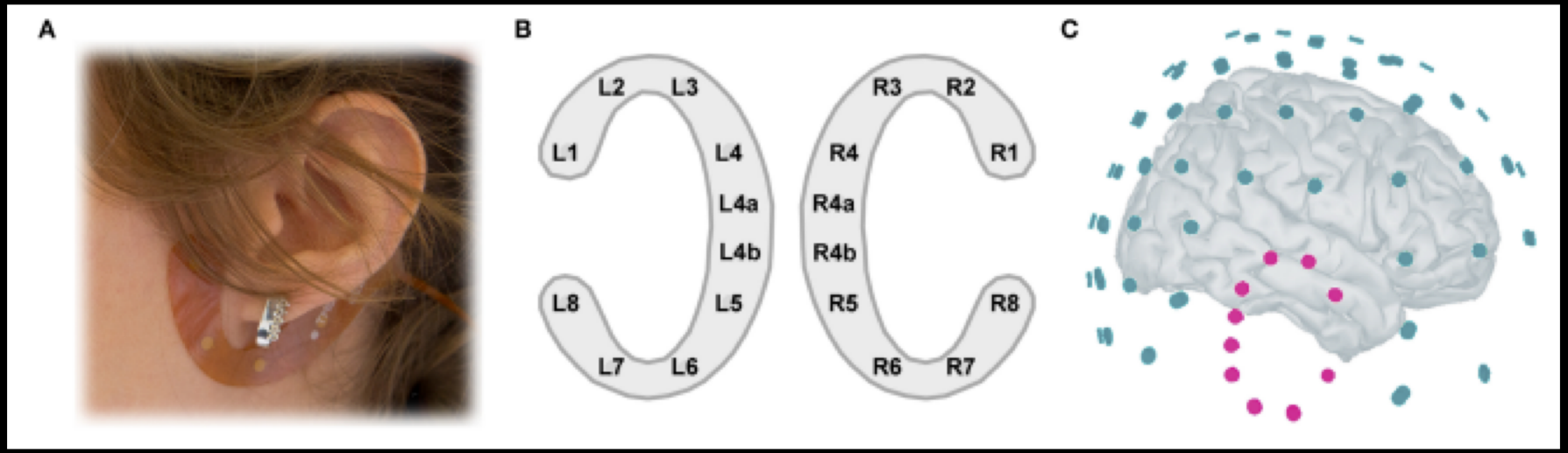
https://imotions.com/blog/eeg-headset-prices/

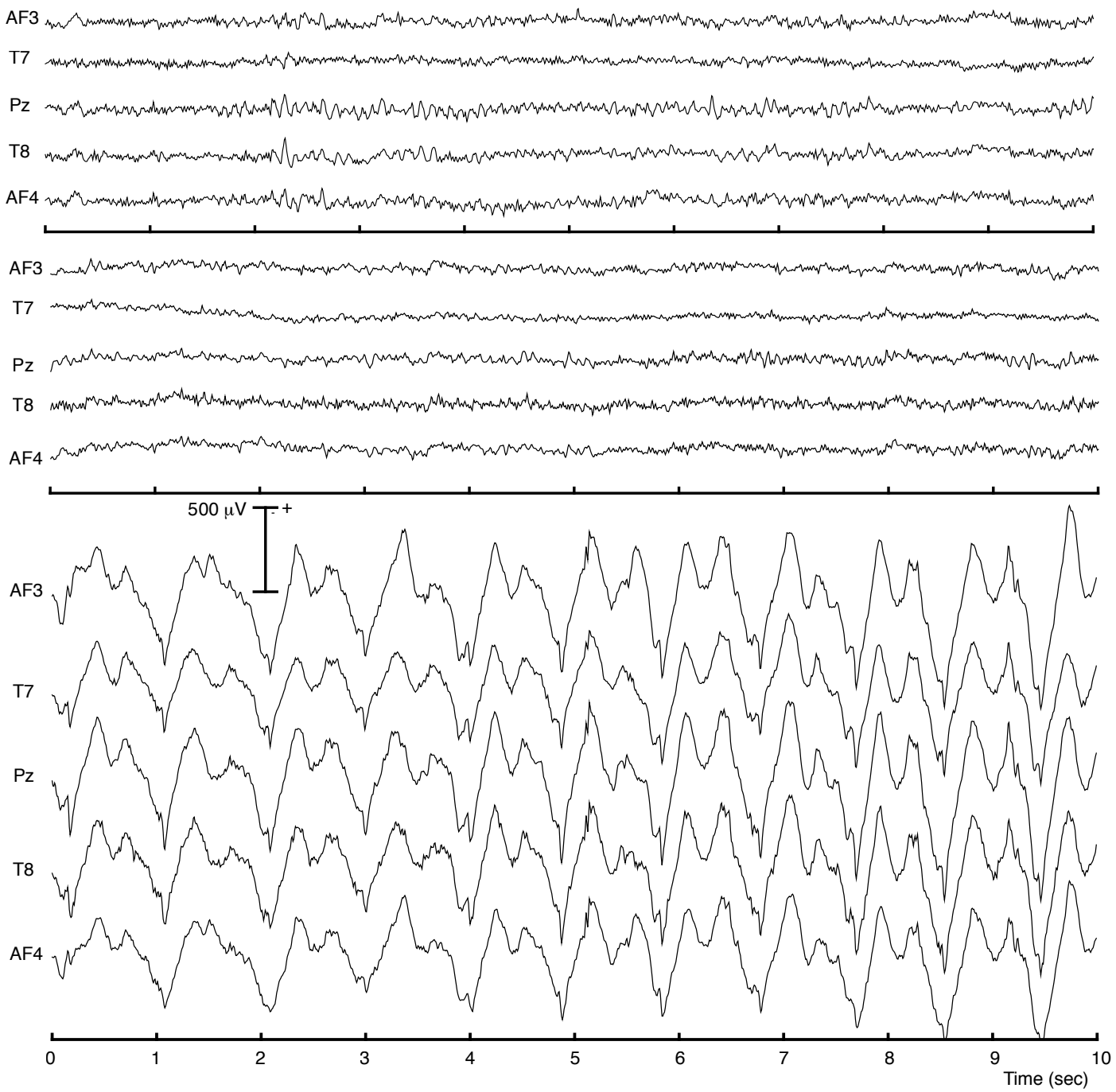
Portable EEG systems

C-shaped EEG electrode array for ‘discrete recording’

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

from Mirkovic et al *Front Hum Neurosci 2016*





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
  - Future strategies: machine learning algos train on artifact samples?

A LIVE EEG RECORDING [Cognionics]

Many thanks to Dr. Ben Ramsden, Indiana University, for setting up this recording & collecting the data!

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

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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