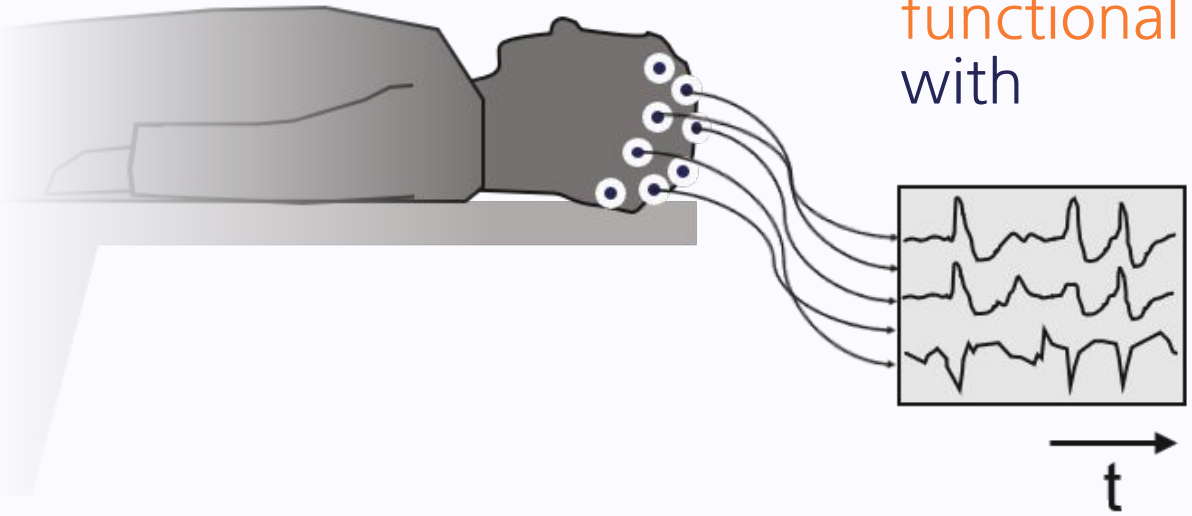
icometrix

A primer on functional brain imaging with



Electro-Encephalo-Graphy

Simon Van Eyndhoven

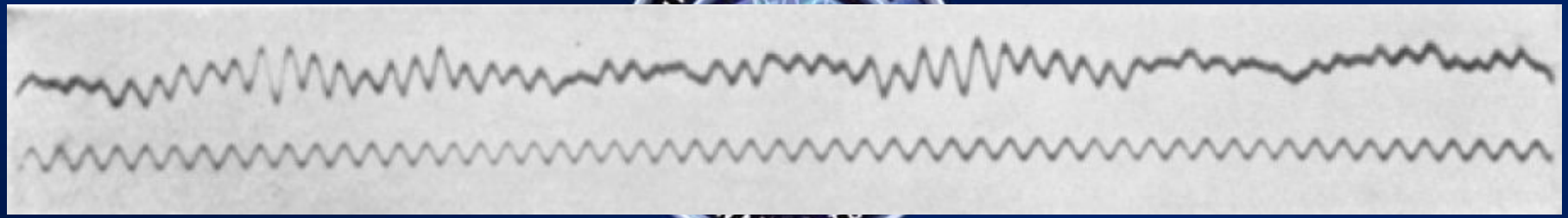
When was the first human electroencephalogram recorded?

A: 1924

B: 1941

C: 1977

D: 1992



When was the first human electroencephalogram recorded?

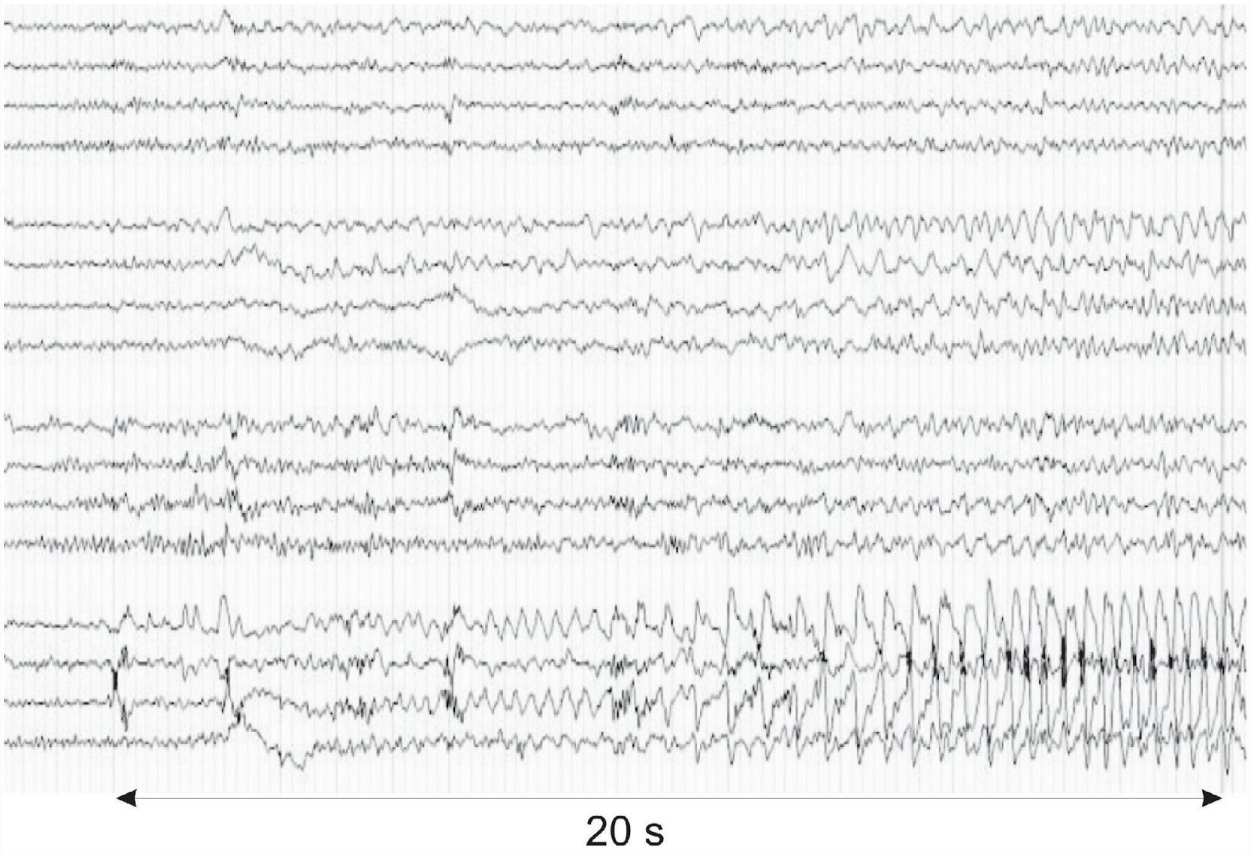
A: 1924 (!) by Hans Berger

B: 1941: medical ultrasound

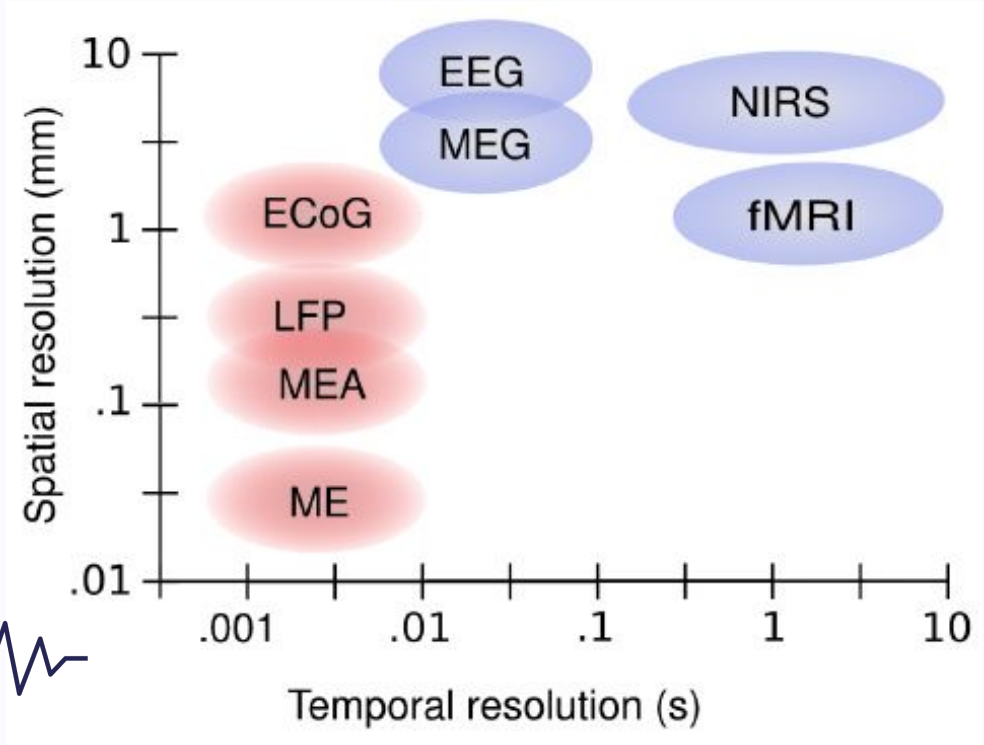
C: 1977: anatomical MRI

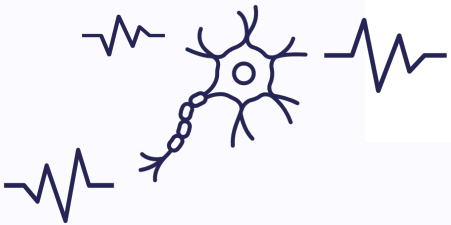
D: 1992: fMRI, fNIRS

What EEG measurements look like today

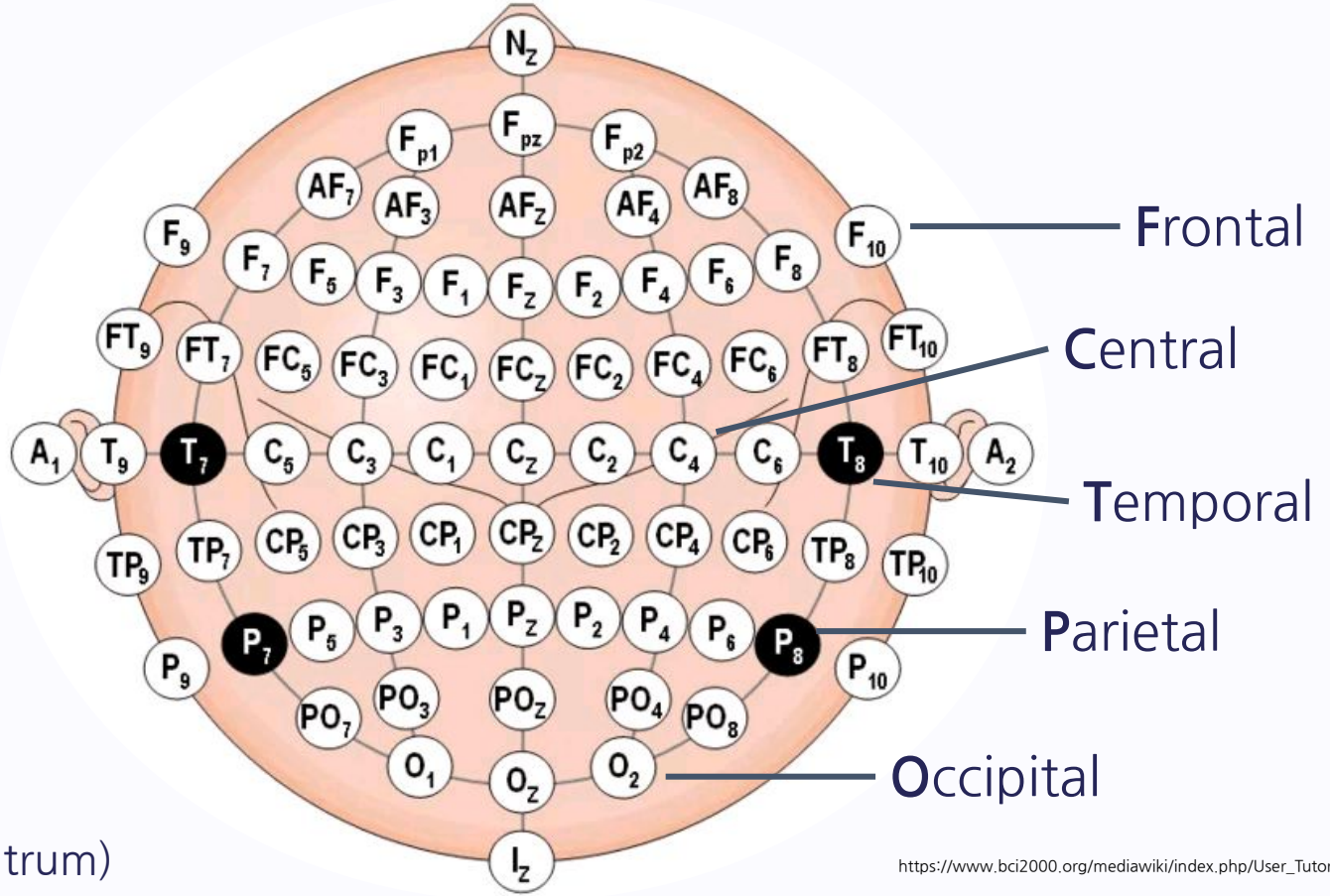


While old, EEG is still a very relevant functional measurement modality!





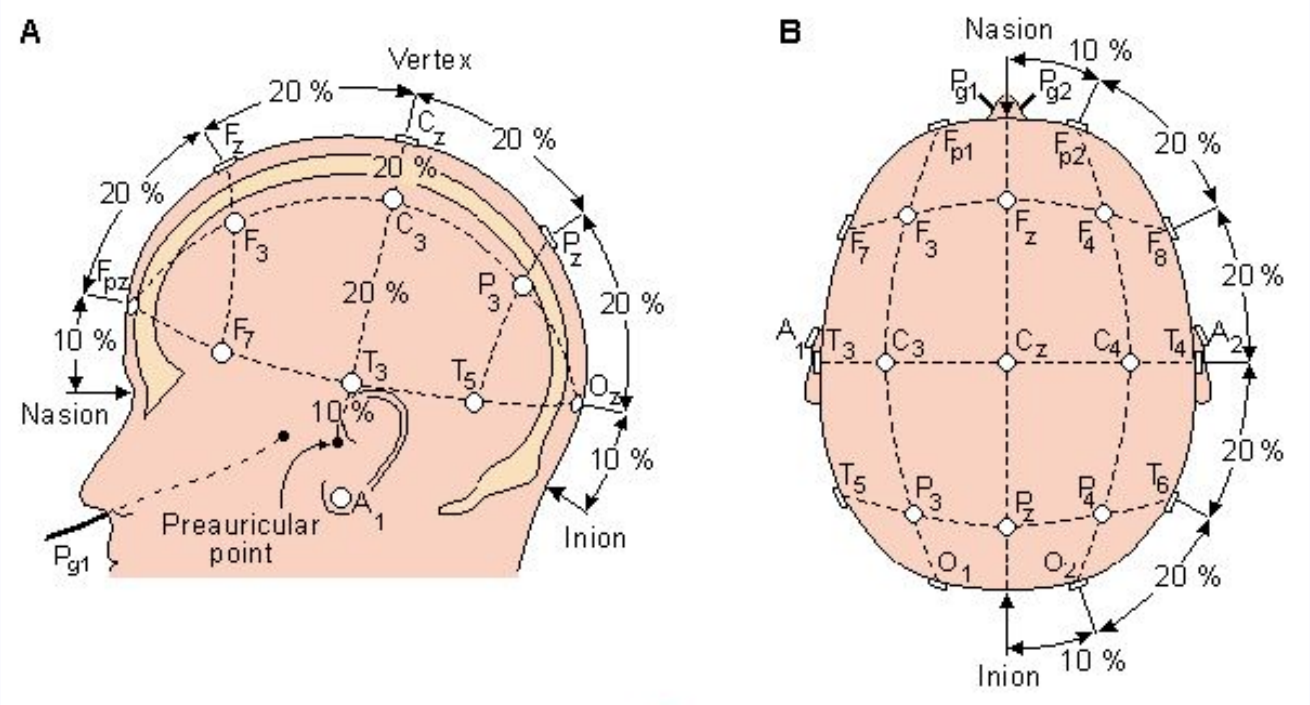
Typical research EEG montages employ 64 electrodes



PS:
uneven = left
even = right
midline = z (Zentrum)

https://www.bci2000.org/mediawiki/index.php/User_Tutorial:EEG_Measurement_Setup

Reference placement of electrodes is often based on the “10-20 system” (or variants)

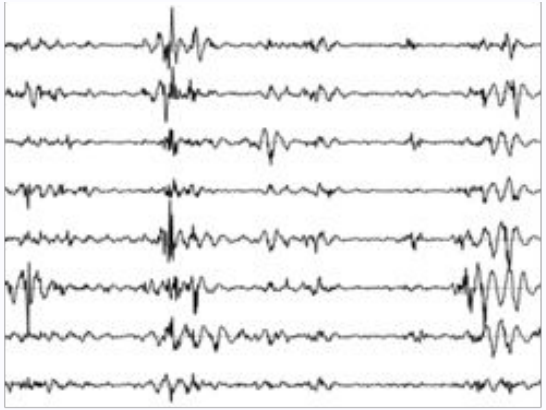


https://www.bci2000.org/mediawiki/index.php/User_Tutorial:EEG_Measurement_Setup

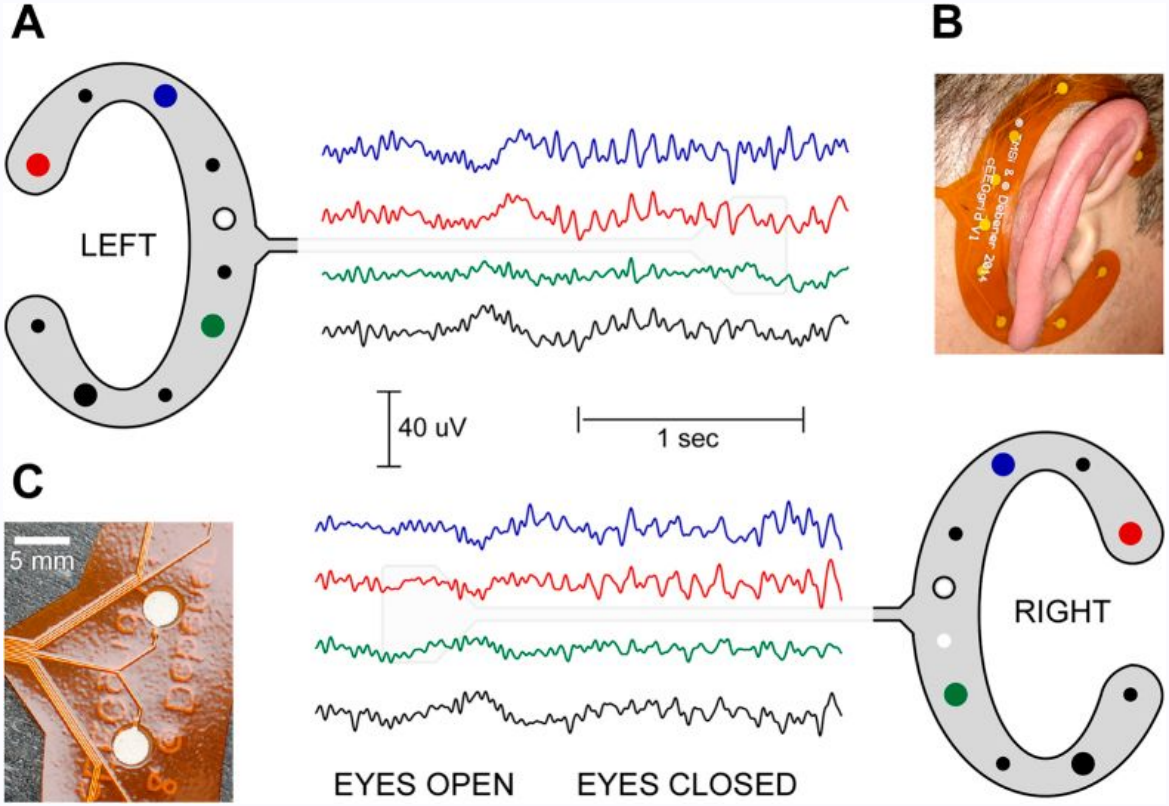
High-density EEG caps exist, but pose many technical challenges…

Can you guess how long the setup takes? ;-)

Pediatric / neonatal EEG is (necessarily) more economical



Trend: miniaturization for wearable EEG



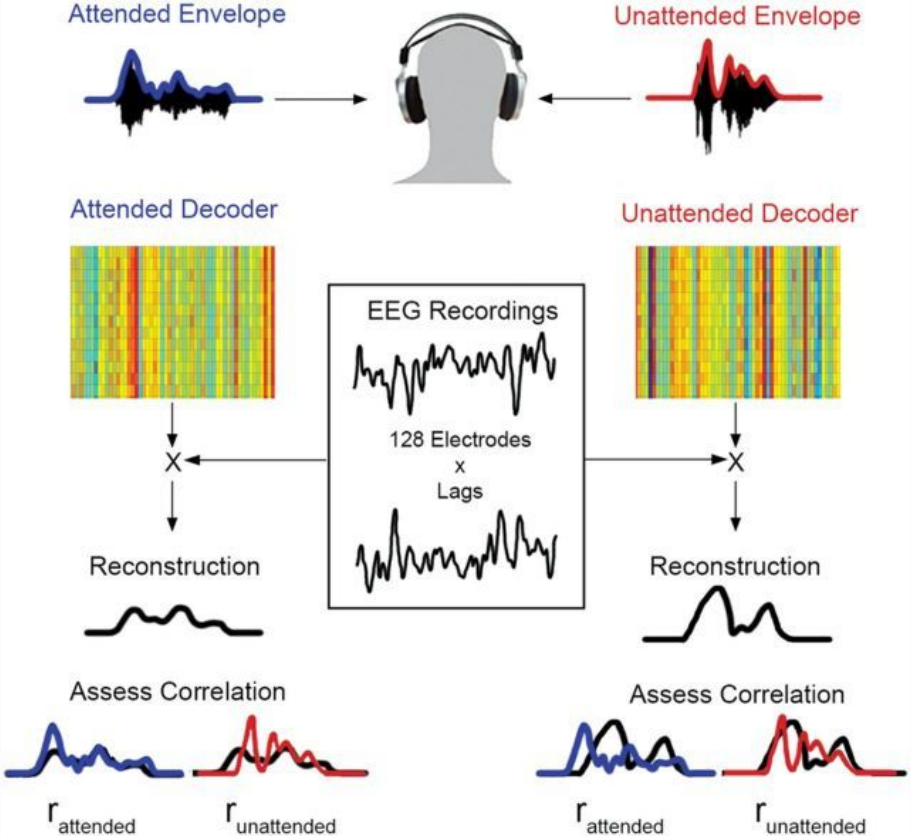
the “cEEGrid” setup

https://dx.doi.org/10.1038%2Fsrep16743

Trend: miniaturization for wearable EEG

in-ear EEG

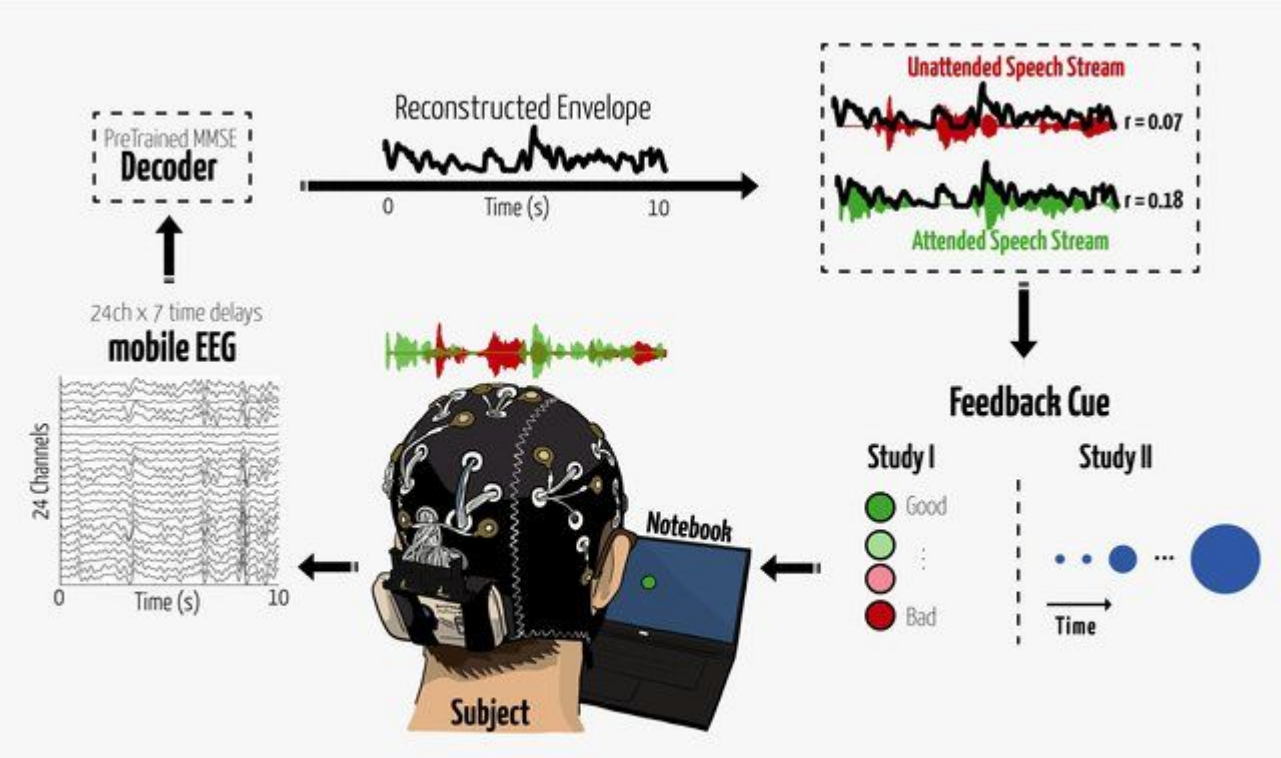
EEG as a workhorse in Brain Computer Interfacing (BCI)



auditory attention detection in a “cocktail party” environment

https://doi.org/10.1093/cercor/bht355

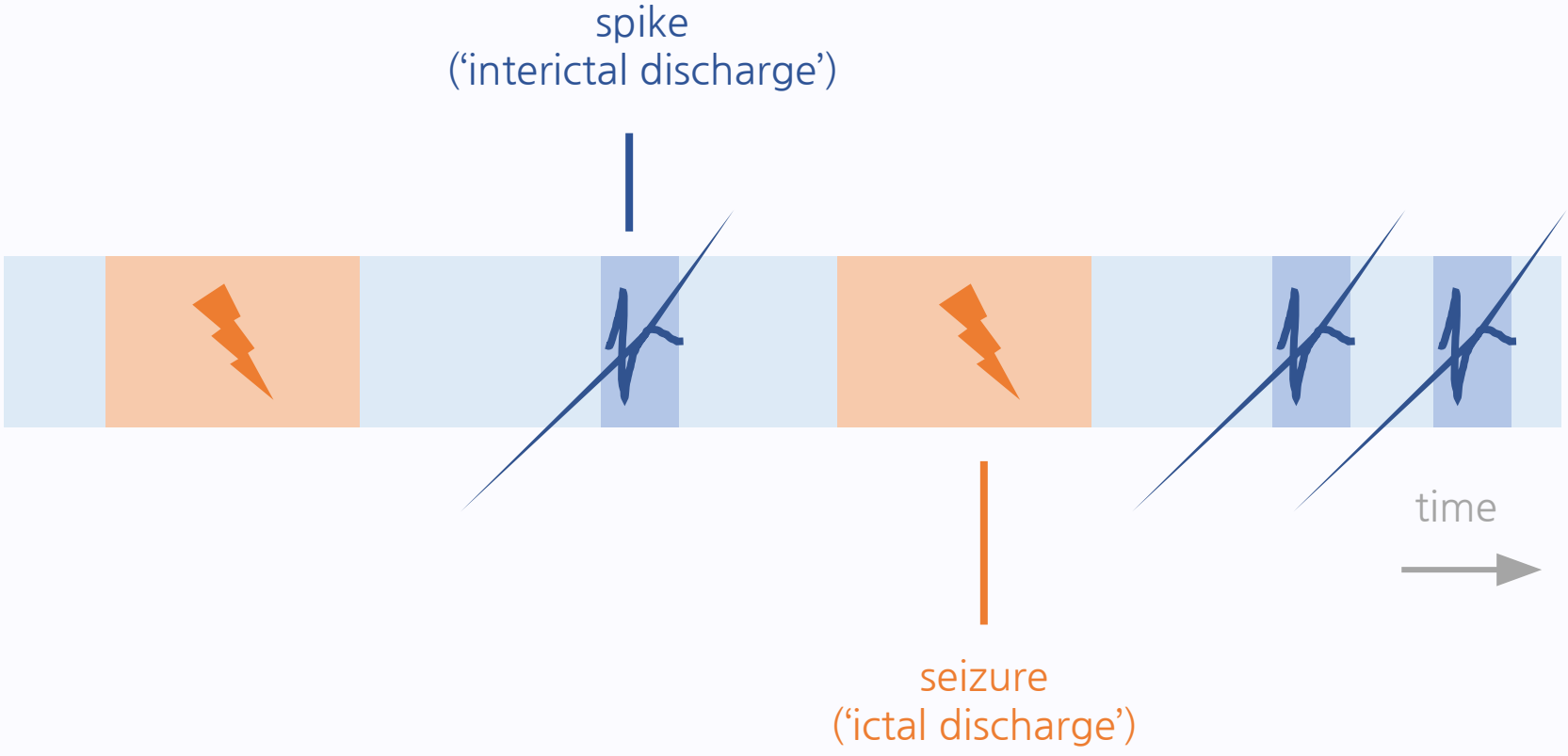
EEG as a workhorse in Brain Computer Interfacing (BCI)



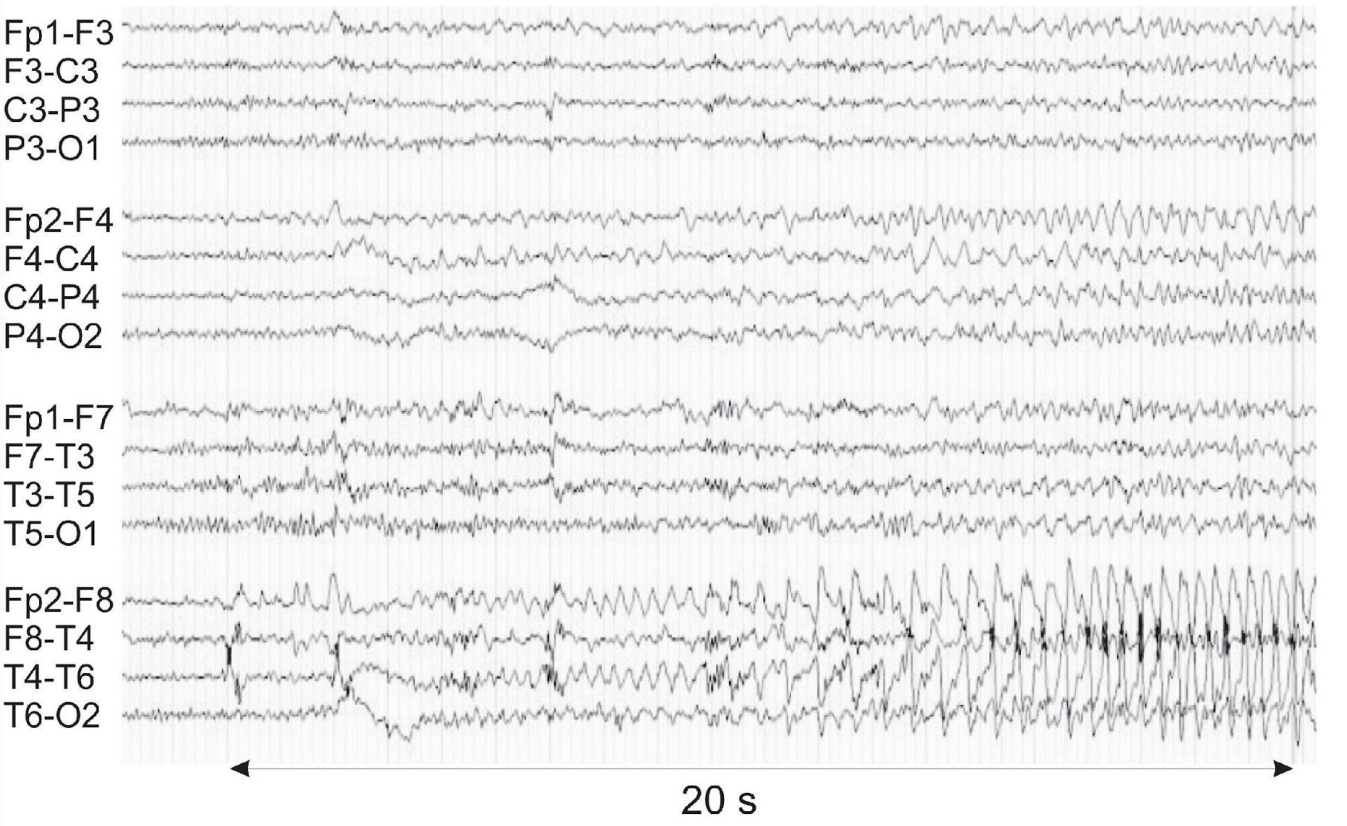
auditory attention detection with neurofeedback in a “cocktail party” environment

https://doi.org/10.1101/218727

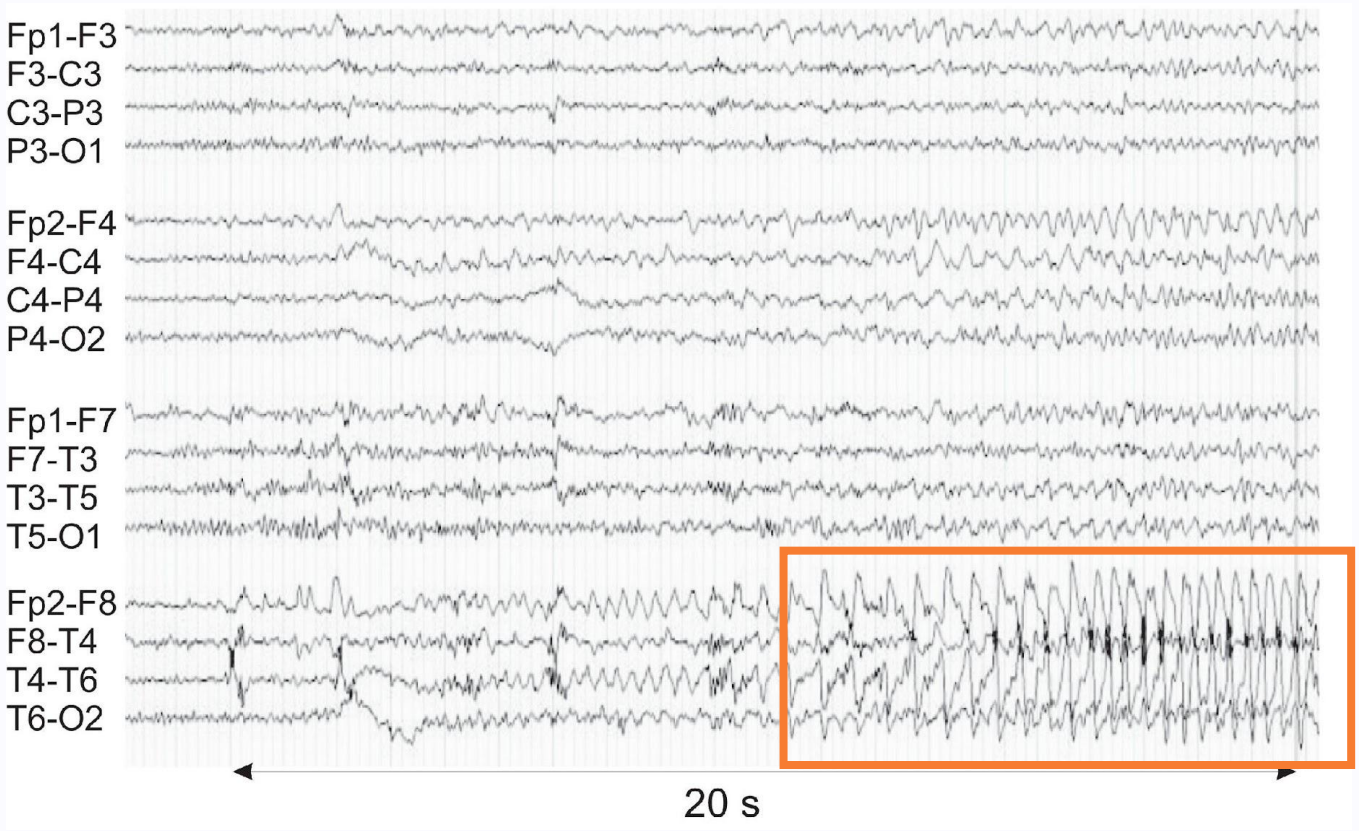
EEG as a workhorse in epilepsy monitoring



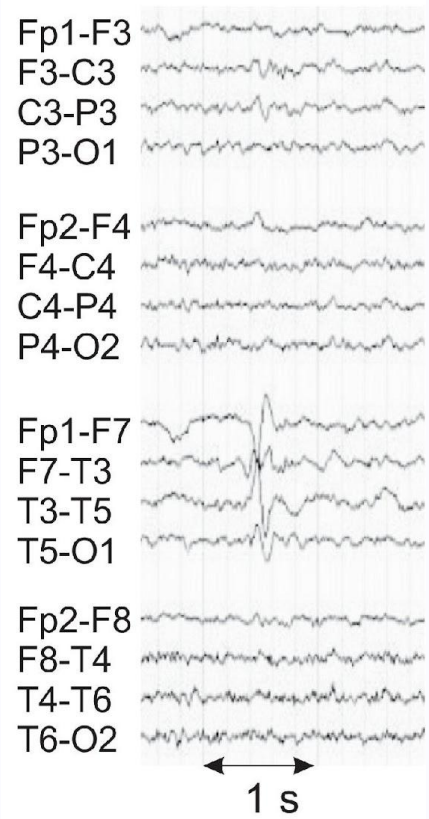
EEG as a workhorse in epilepsy monitoring



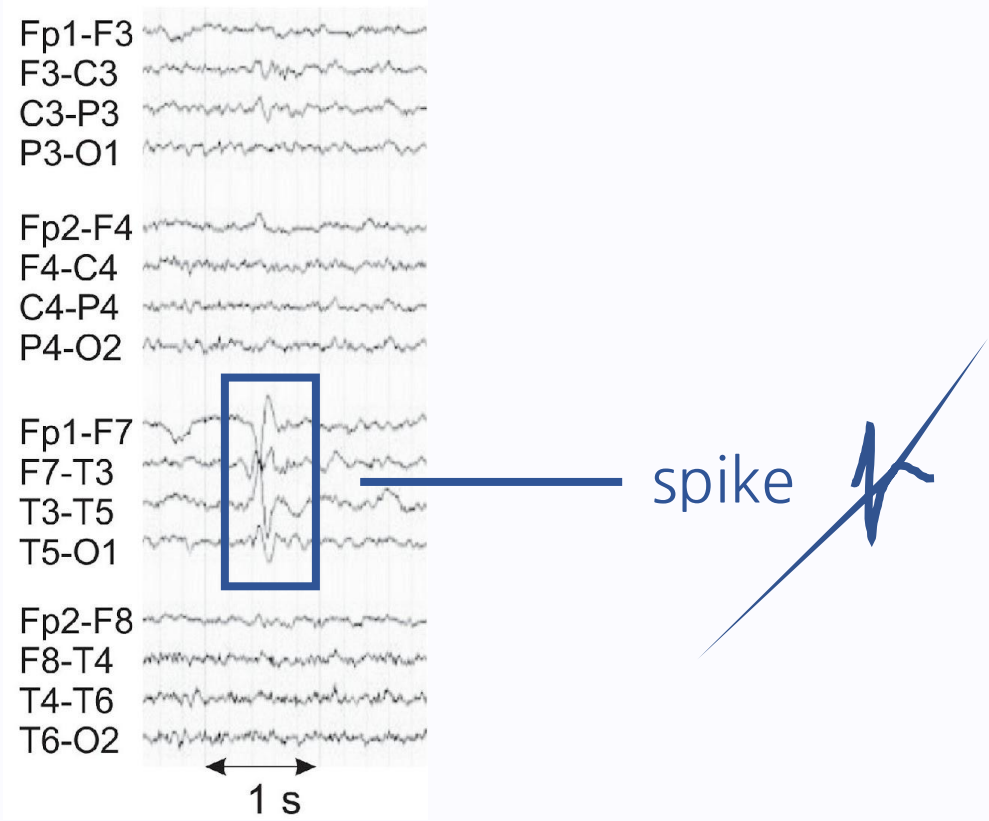
EEG as a workhorse in epilepsy monitoring



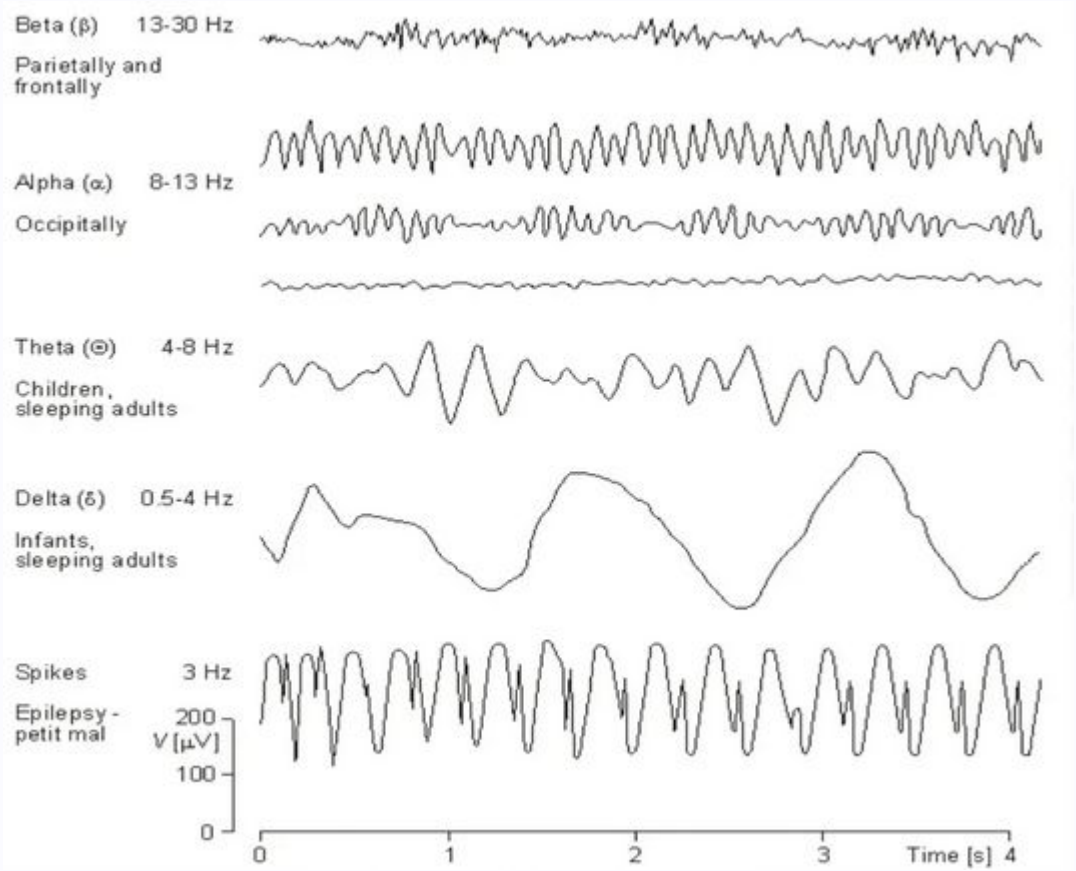
EEG as a workhorse in epilepsy monitoring



EEG as a workhorse in epilepsy monitoring



Interpretation is commonly done via a ‘standard’ set of frequency bands



EEG analysis =

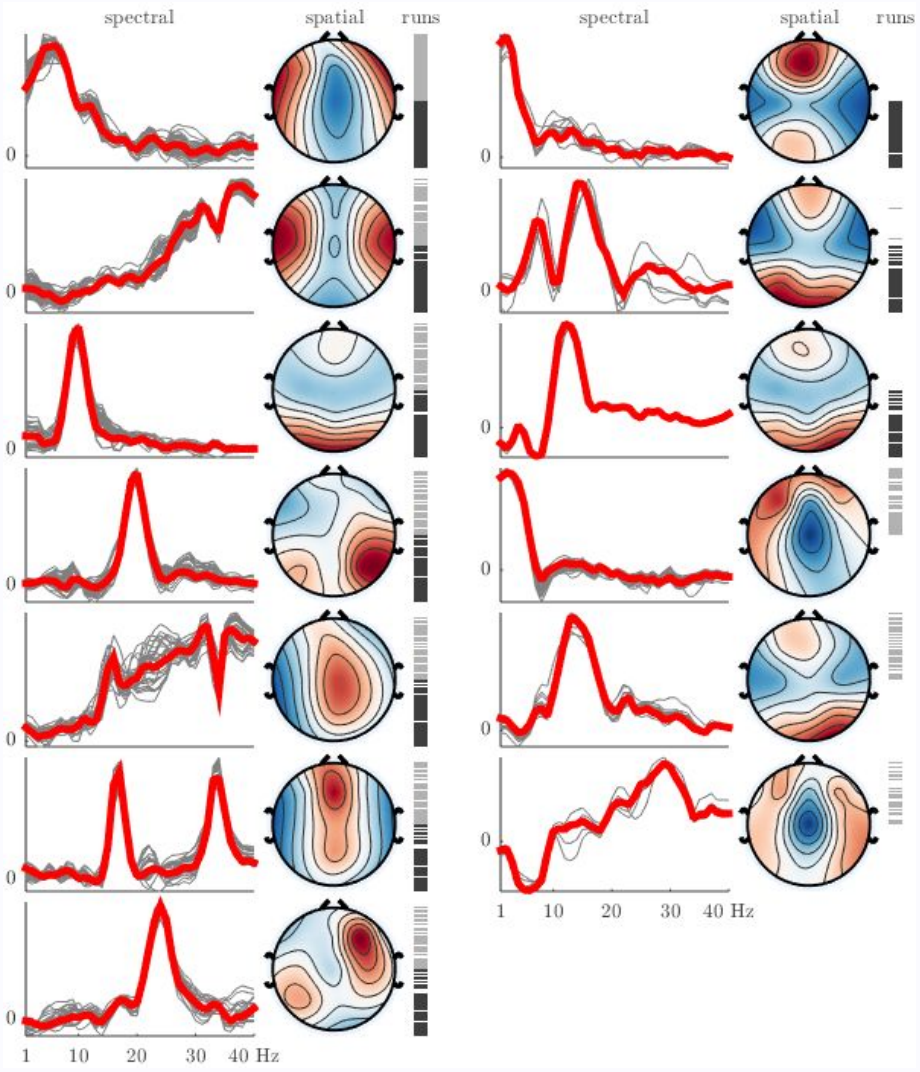
spectral frequency bands

\+

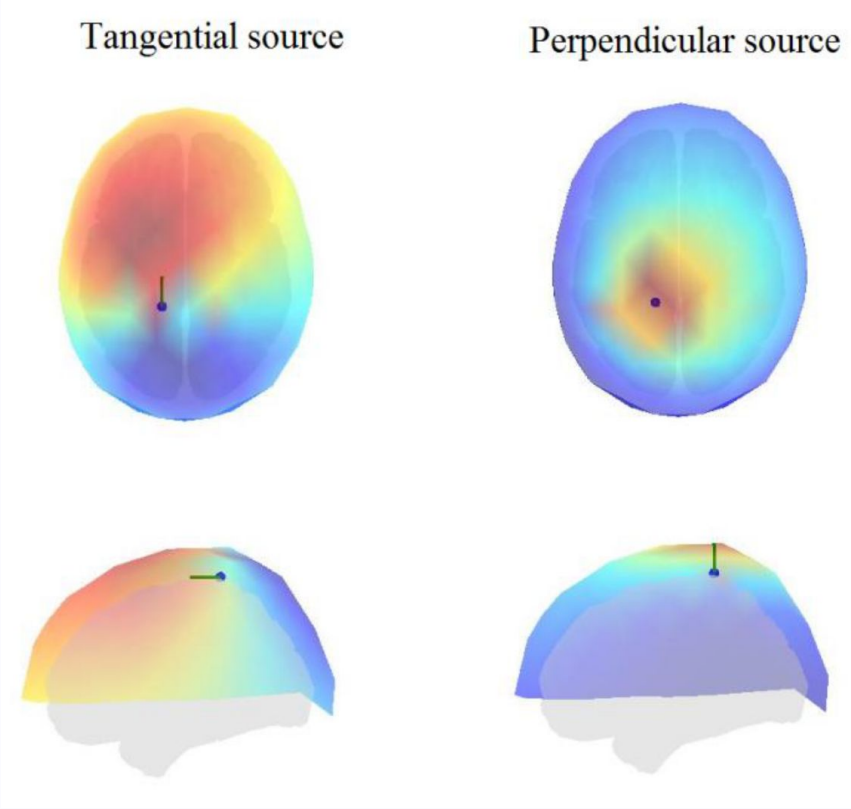
spatial topology

\+

temporal waveforms

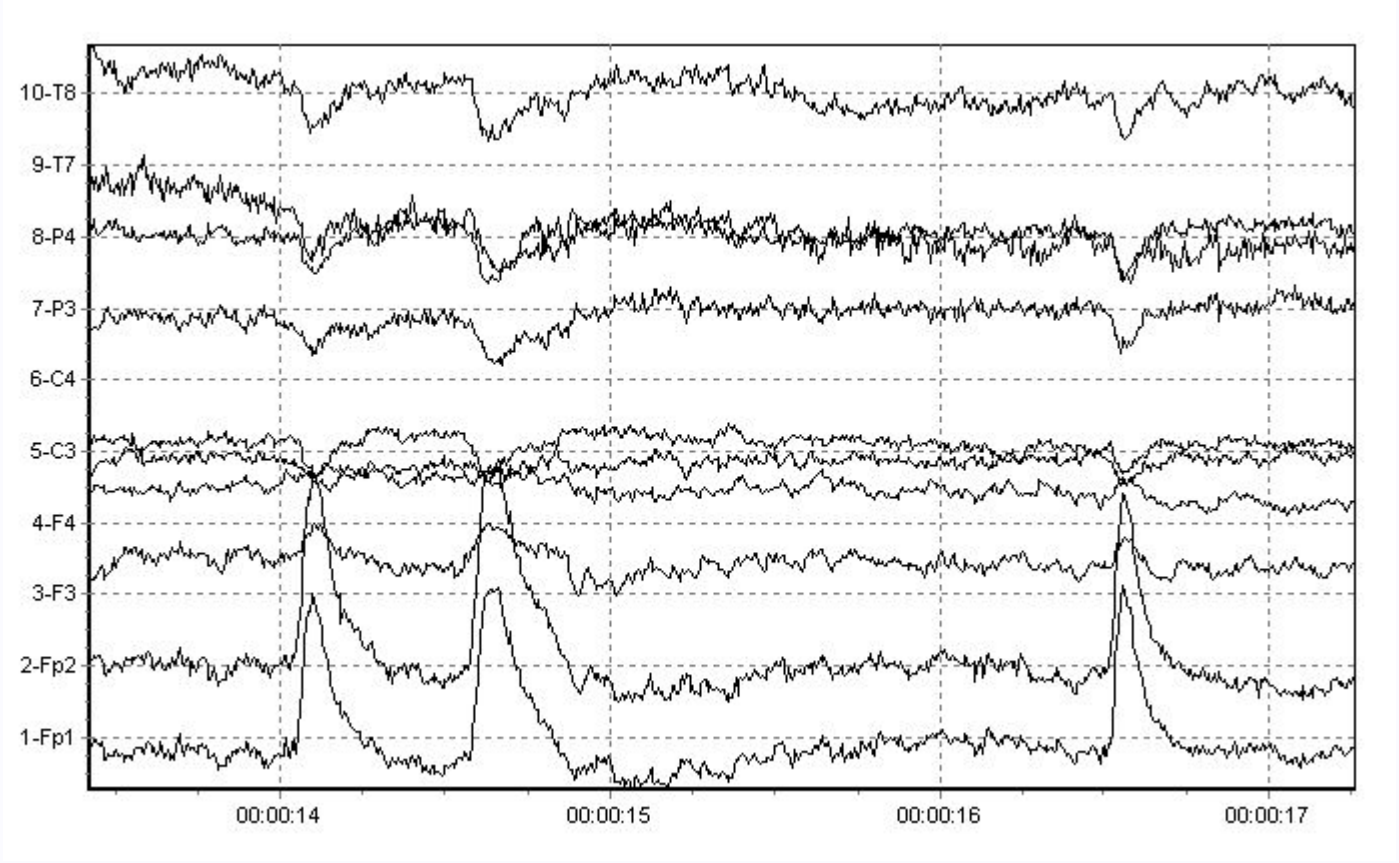


Volume conduction leads to strong spatial correlation between measured signals

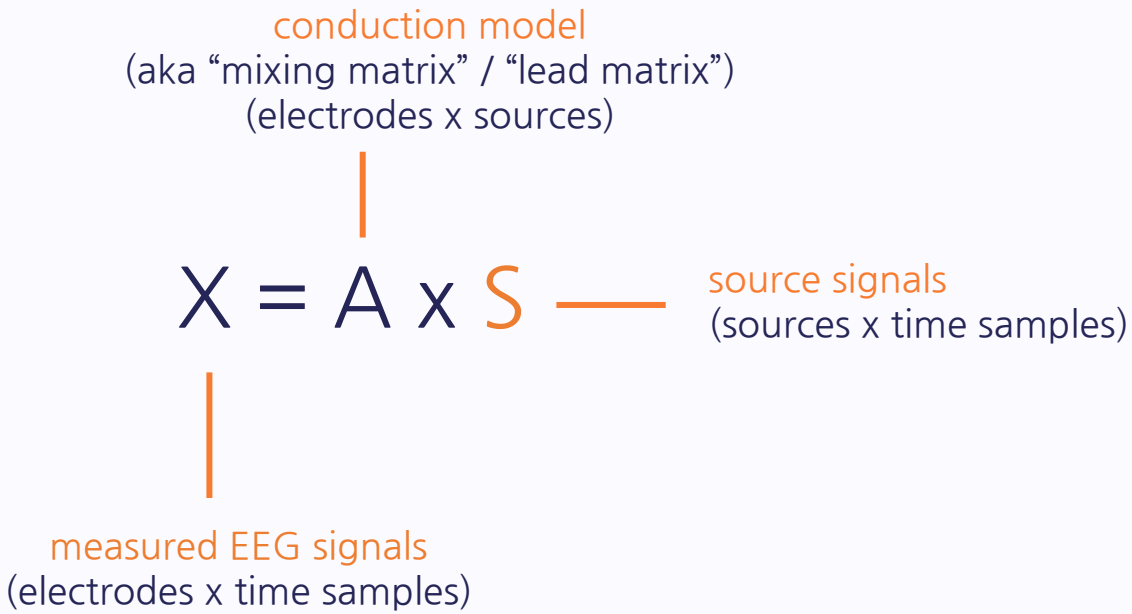


https://doi.org/10.1007/s10548-016-0538-7

Volume conduction leads to strong spatial correlation between measured signals ... harming data quality and interpretation



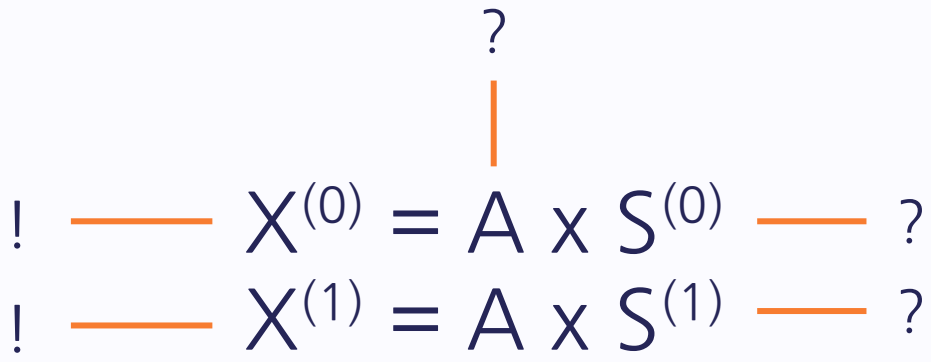
Volume conduction leads to strong spatial correlation between measured signals
... and to a ubiquitous model for EEG signal processing



Volume conduction leads to strong spatial correlation between measured signals
... and to a ubiquitous model for EEG signal processing

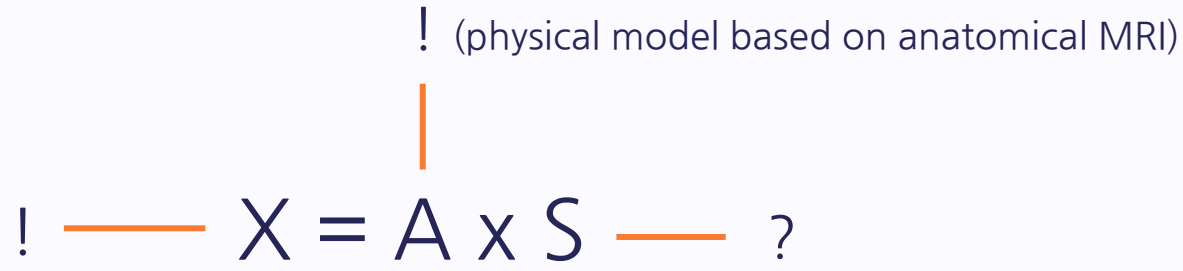
blind source separation: unsupervised
(e.g. independent component analysis (ICA))

Volume conduction leads to strong spatial correlation between measured signals
... and to a ubiquitous model for EEG signal processing



EEG decoding: supervised, task-aware filtering
(e.g. common spatial patterns (CSP))

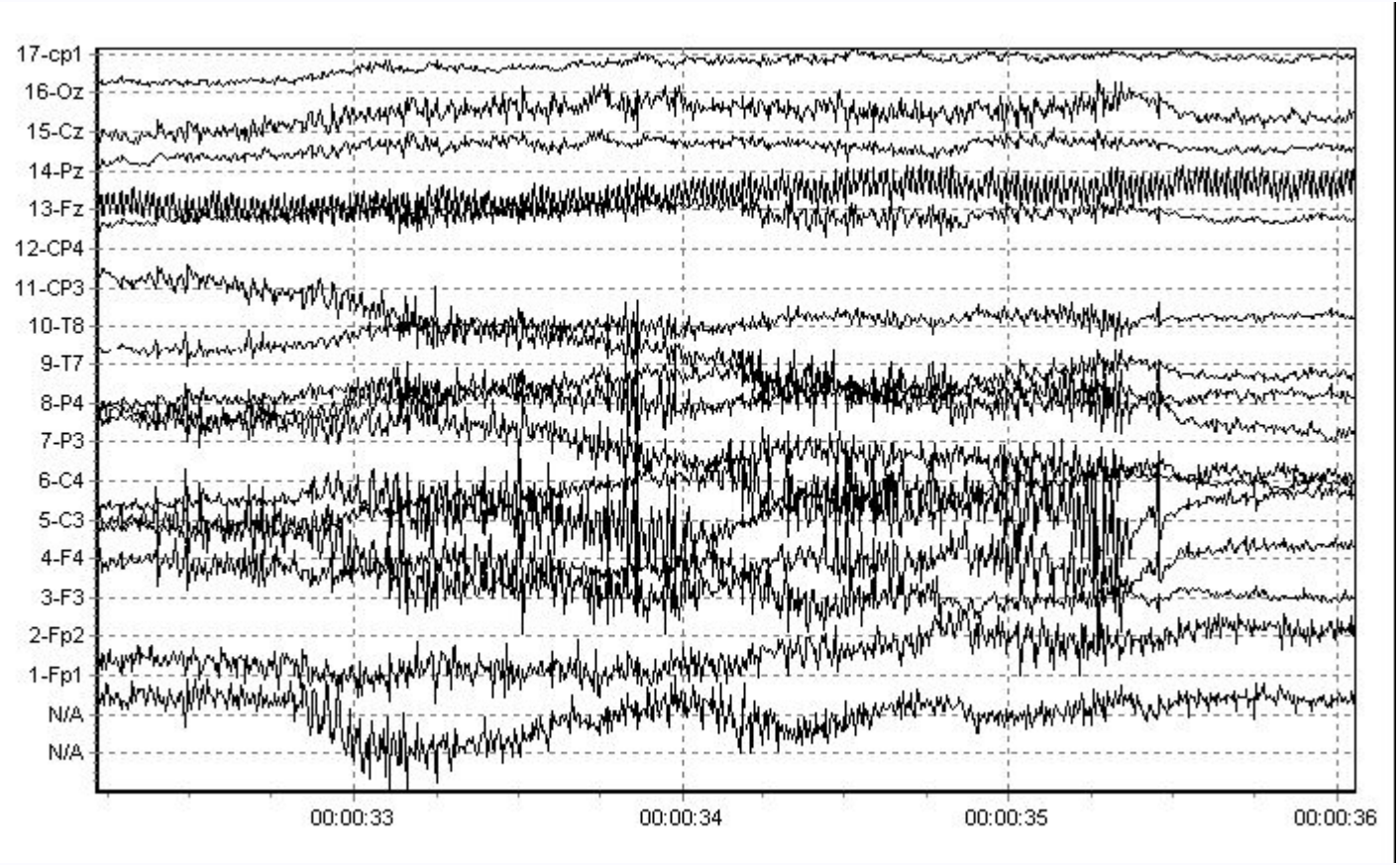
Volume conduction leads to strong spatial correlation between measured signals
... and to a ubiquitous model for EEG signal processing



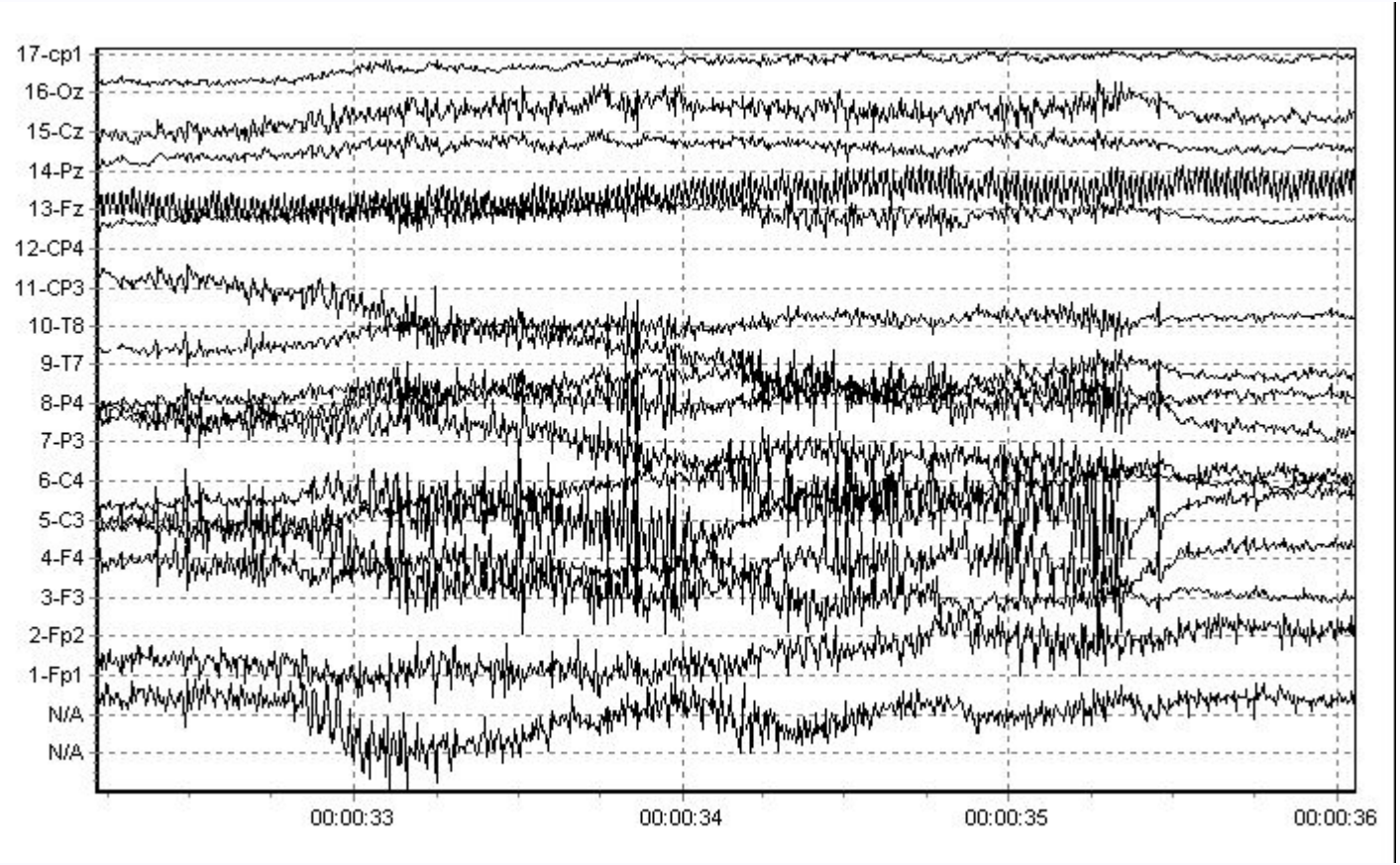
EEG source imaging: solving the “inverse problem”
(e.g. electromagnetic tomography (LORETA))

A practitioner’s guide to EEG: recognizing artifacts in the wild

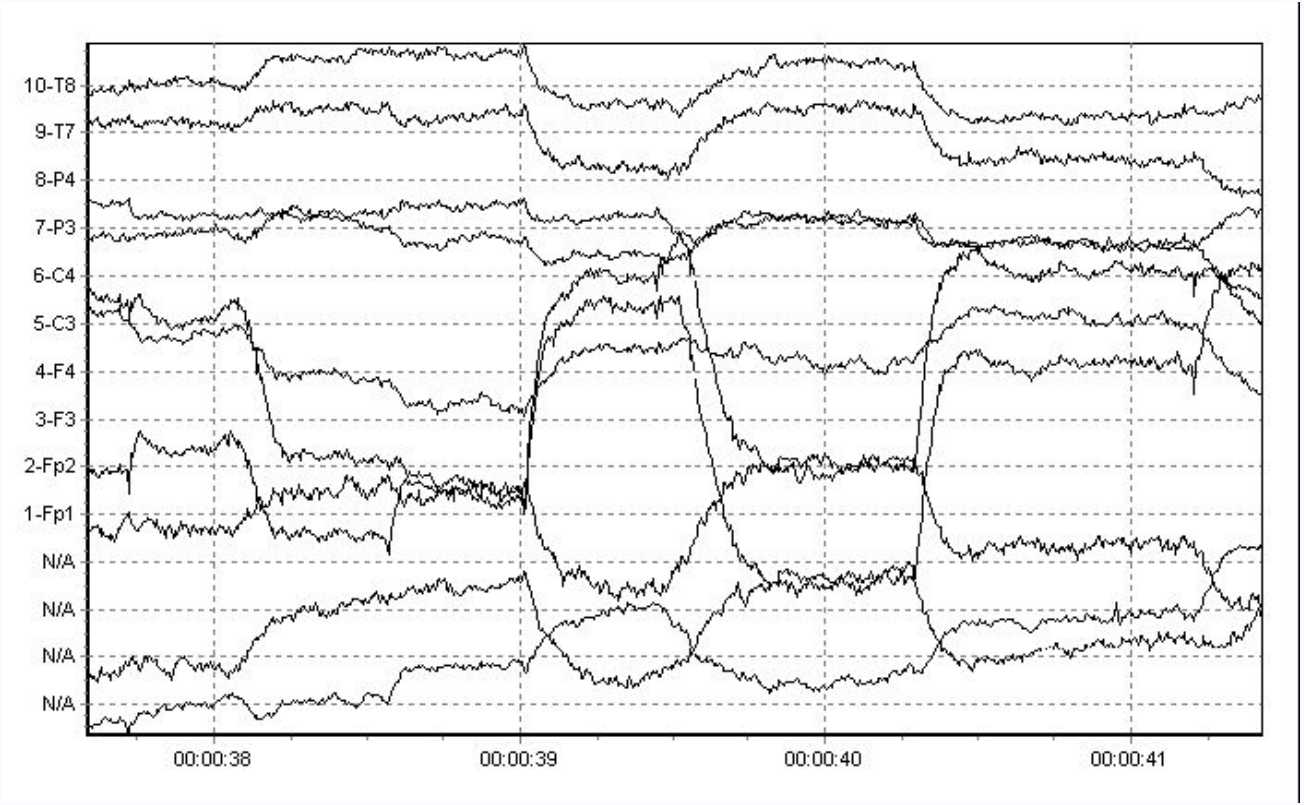
Guess the artifact…



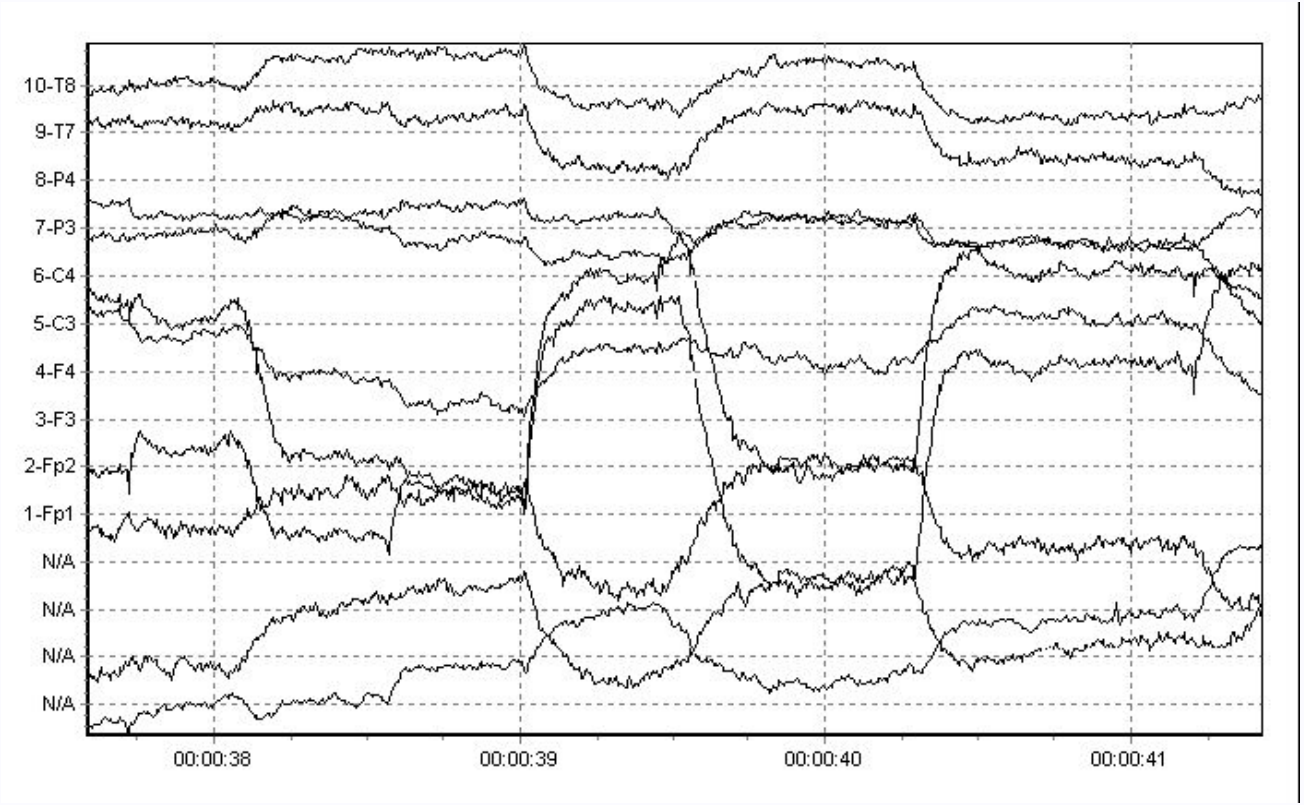
Muscle = electromyogram artifact (EMG)



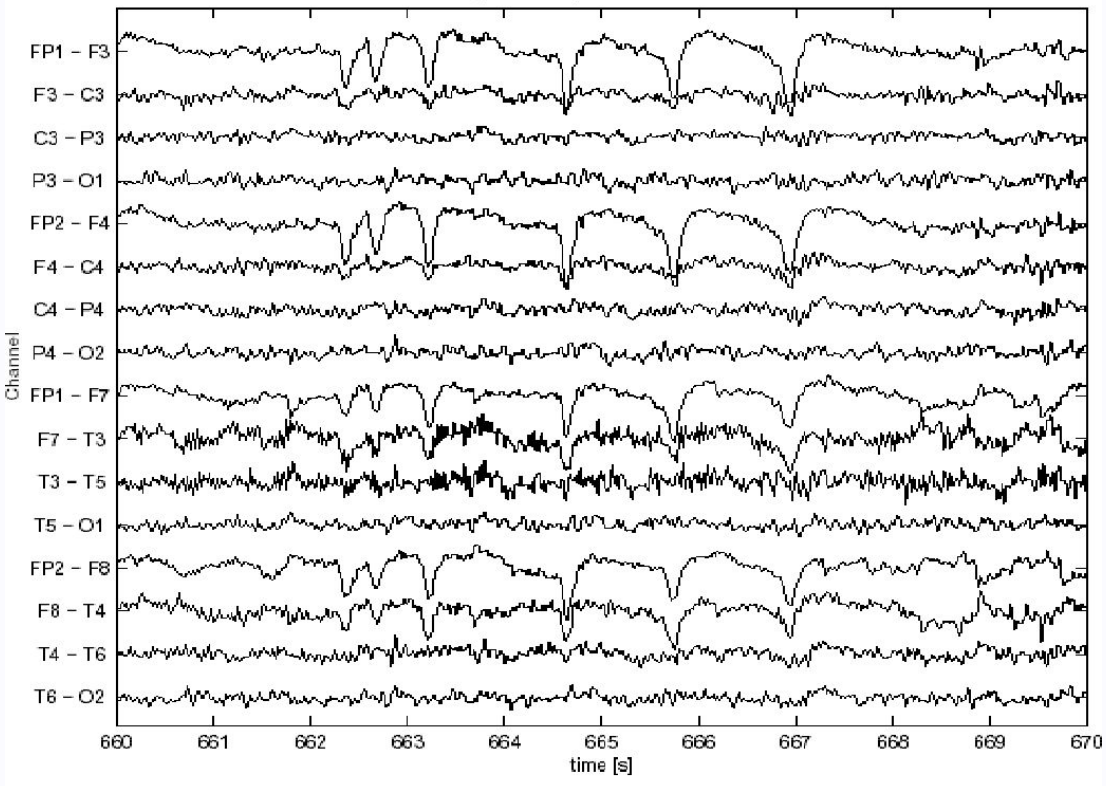
Guess the artifact…



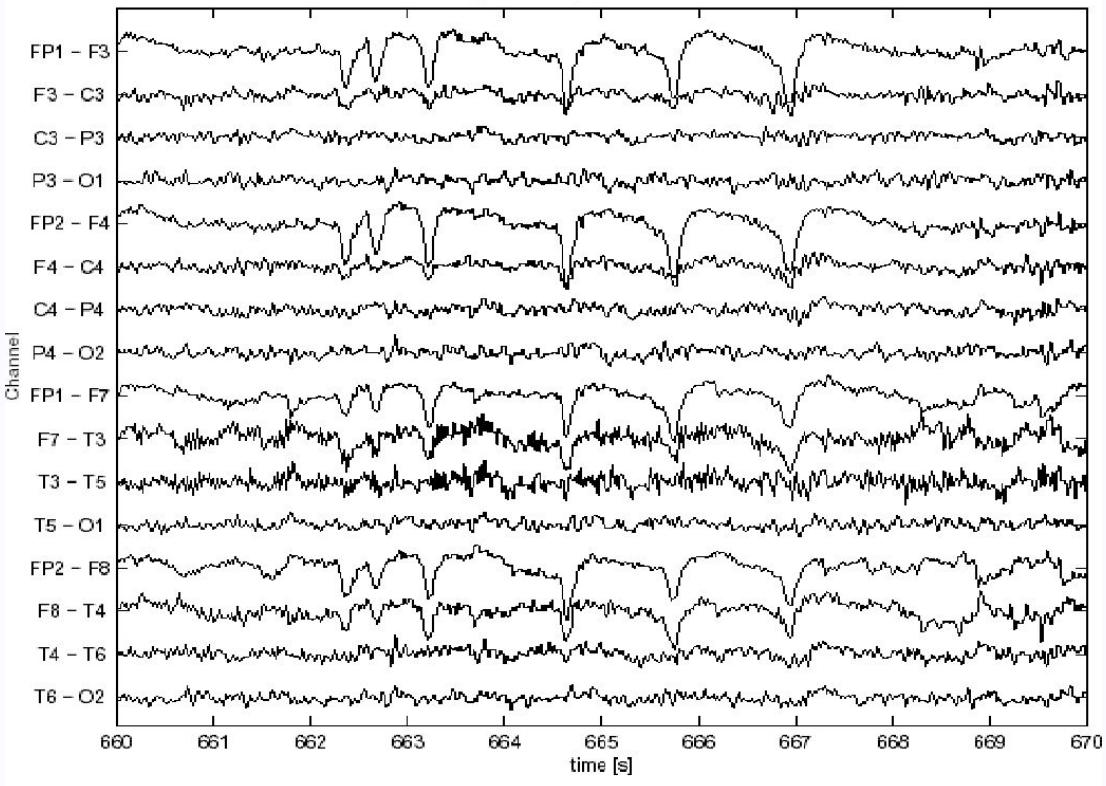
Eye movements (“saccades”) = electro-oculogram (EOG)



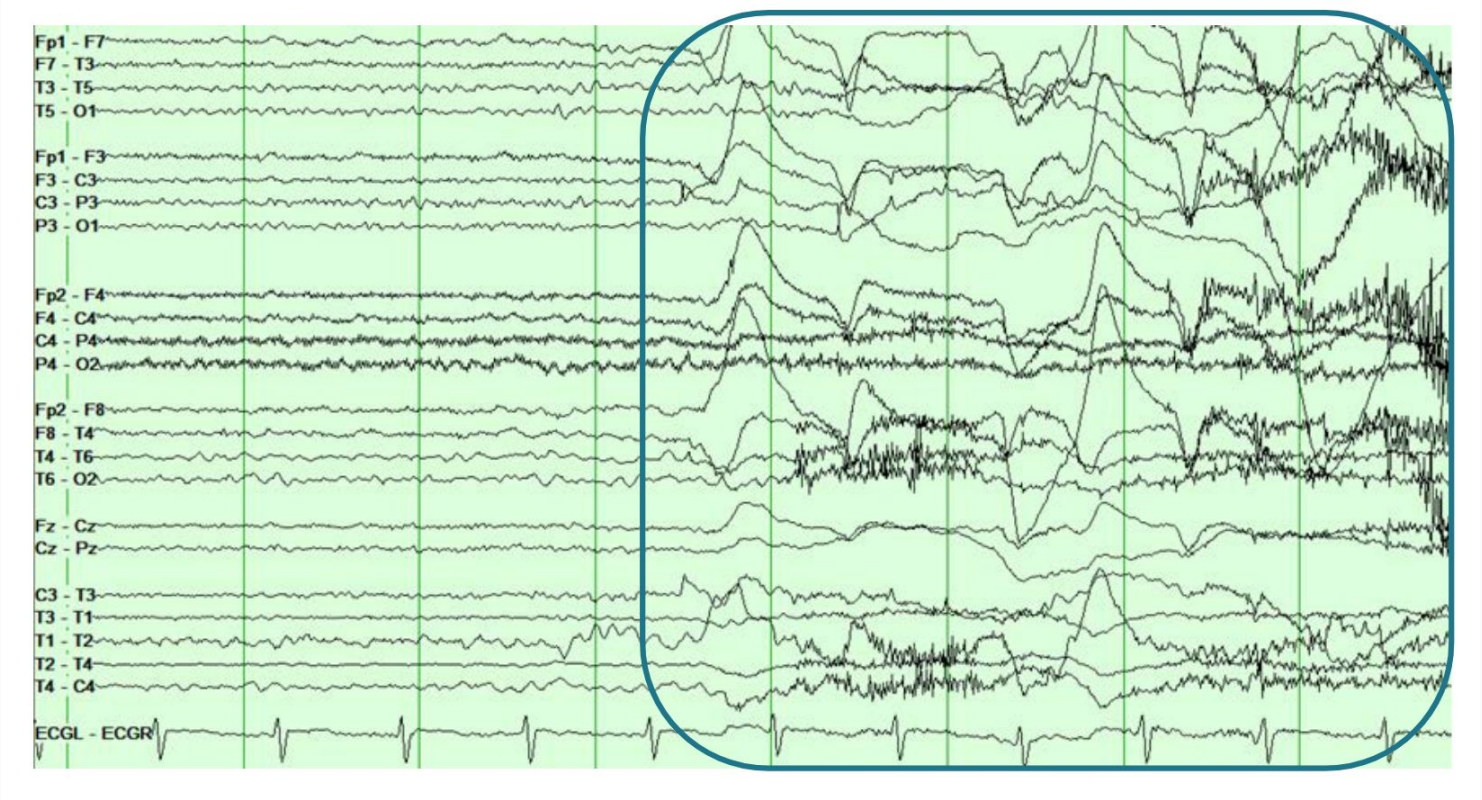
Guess the artifact…



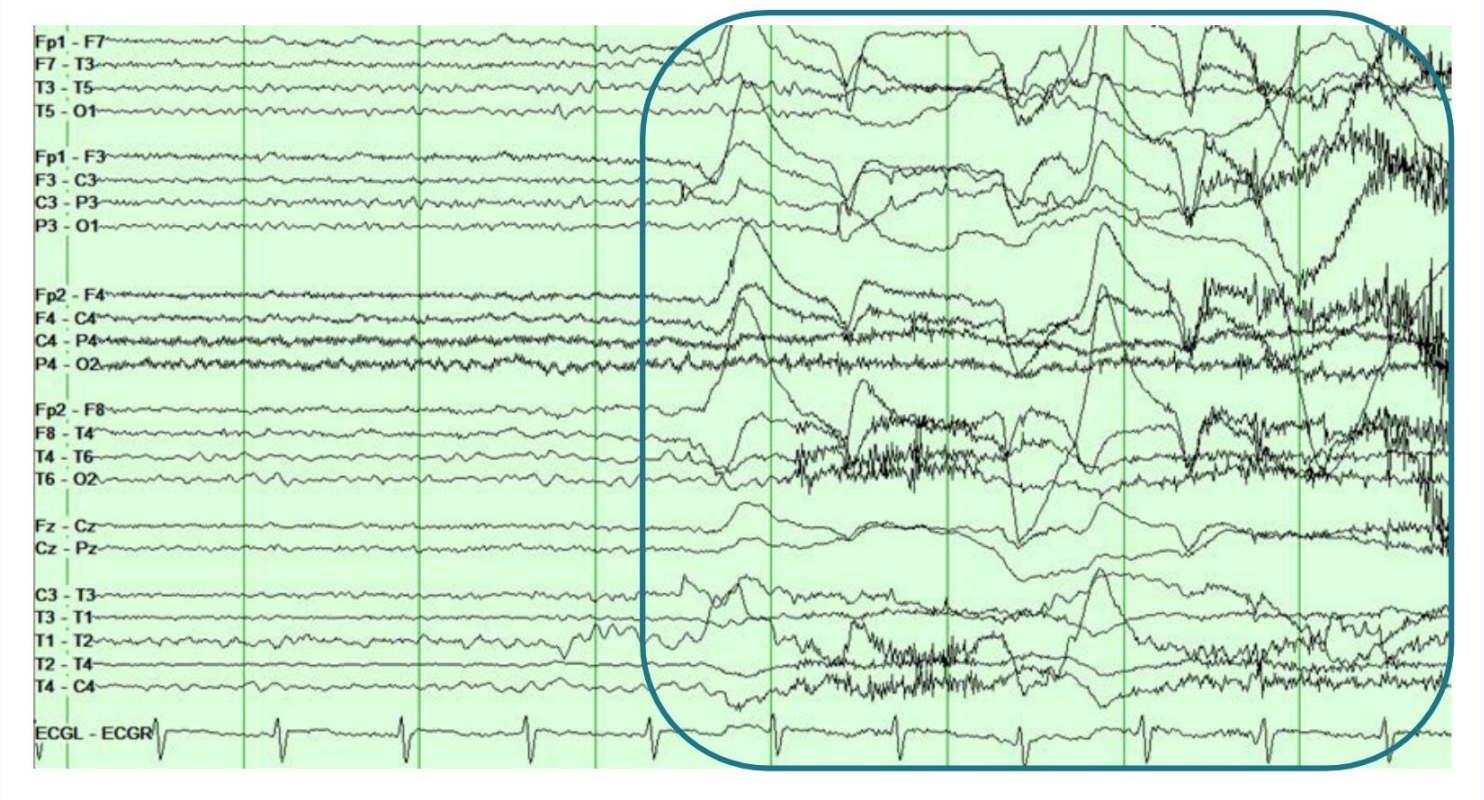
Eye blinks = electro-oculogram (EOG)



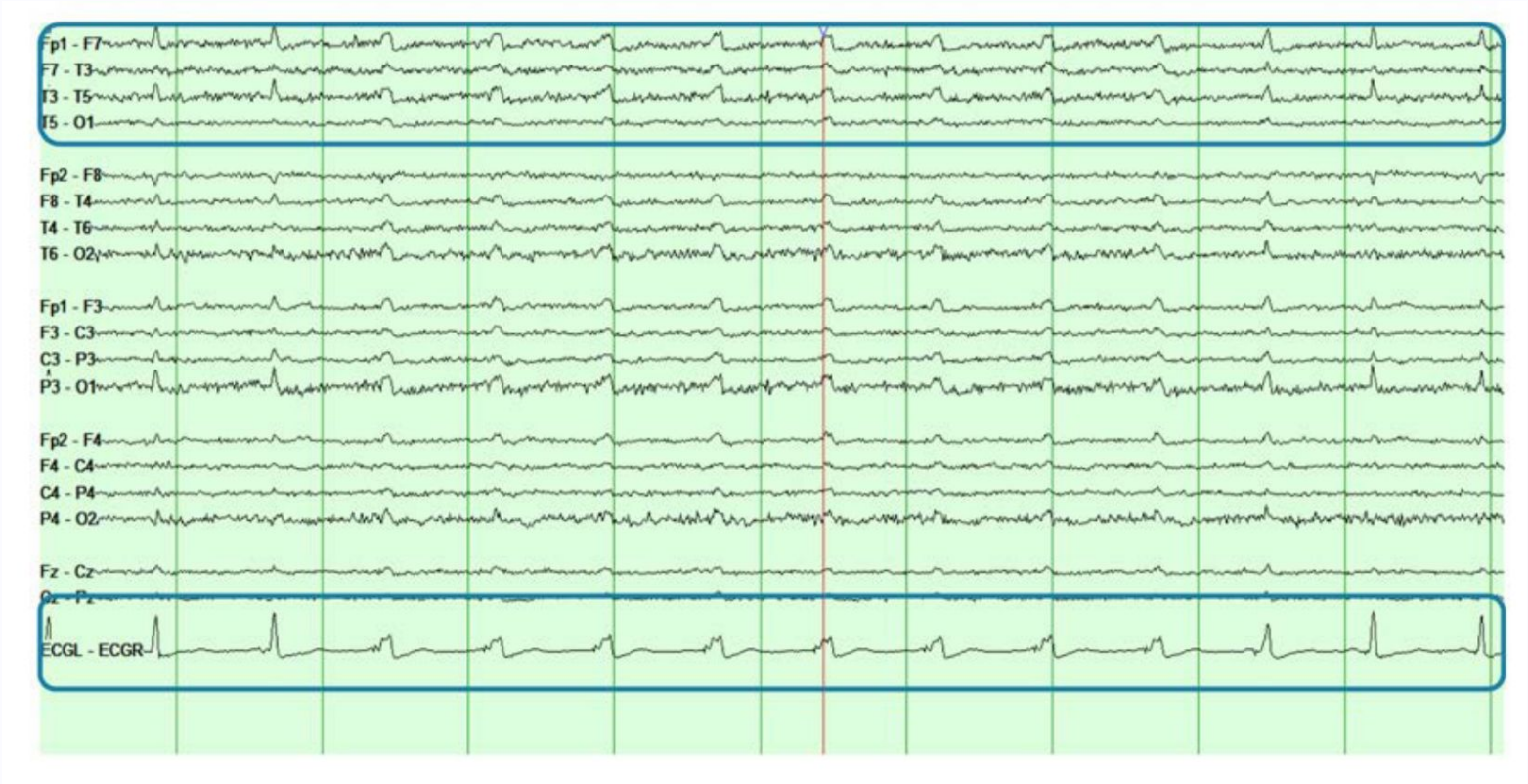
Guess the artifact…



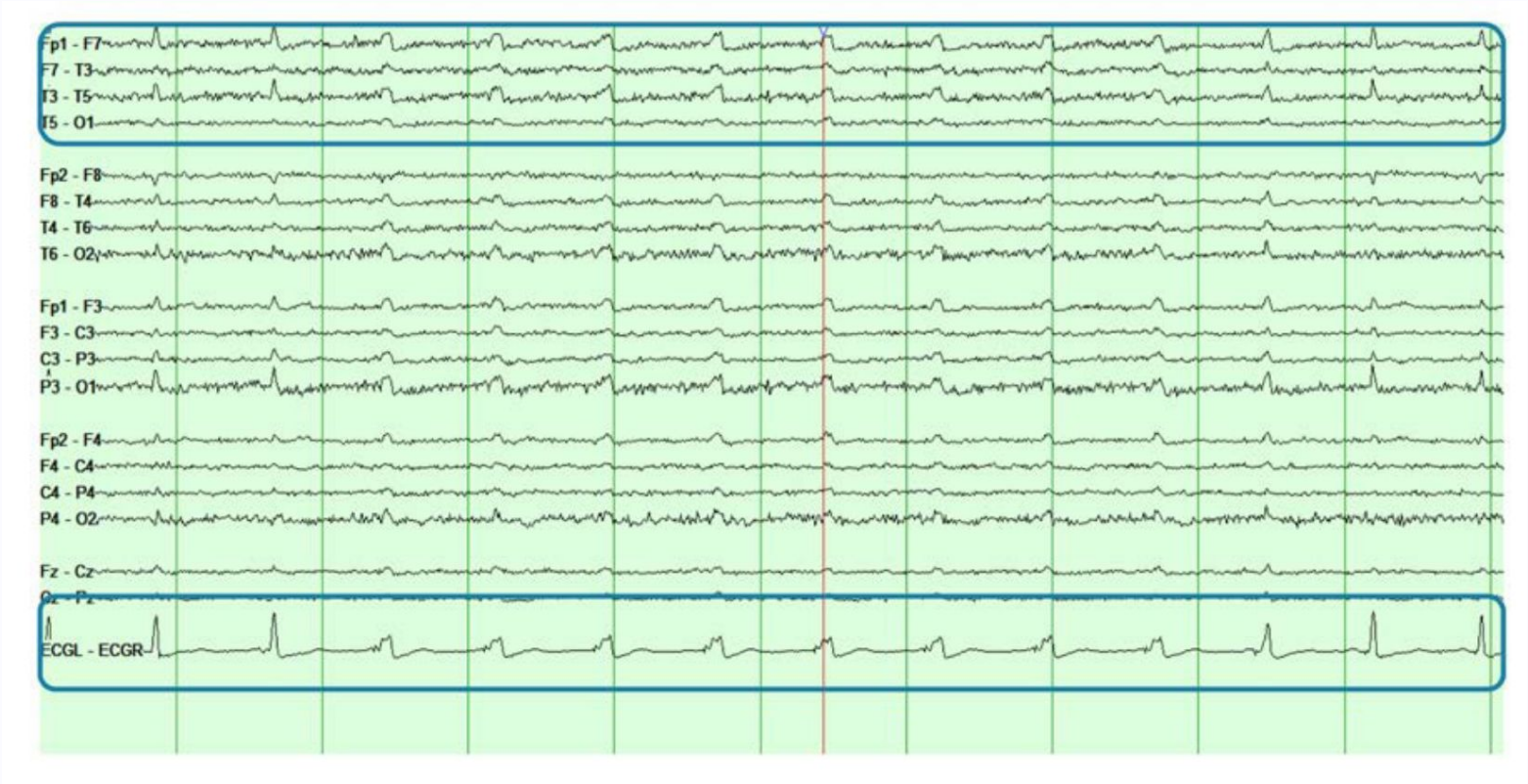
Movement (electrodes relative to scalp) artifact



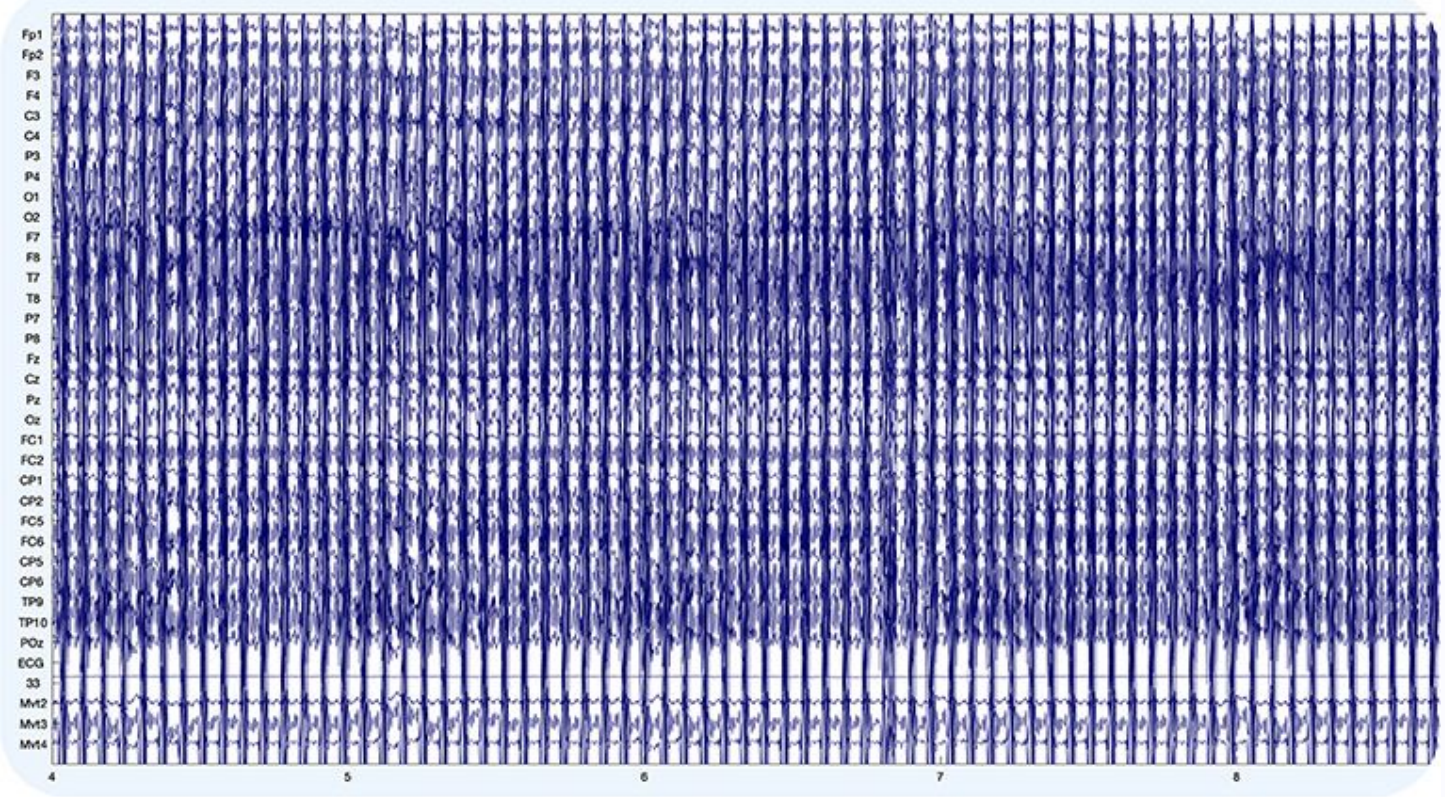
Guess the artifact…



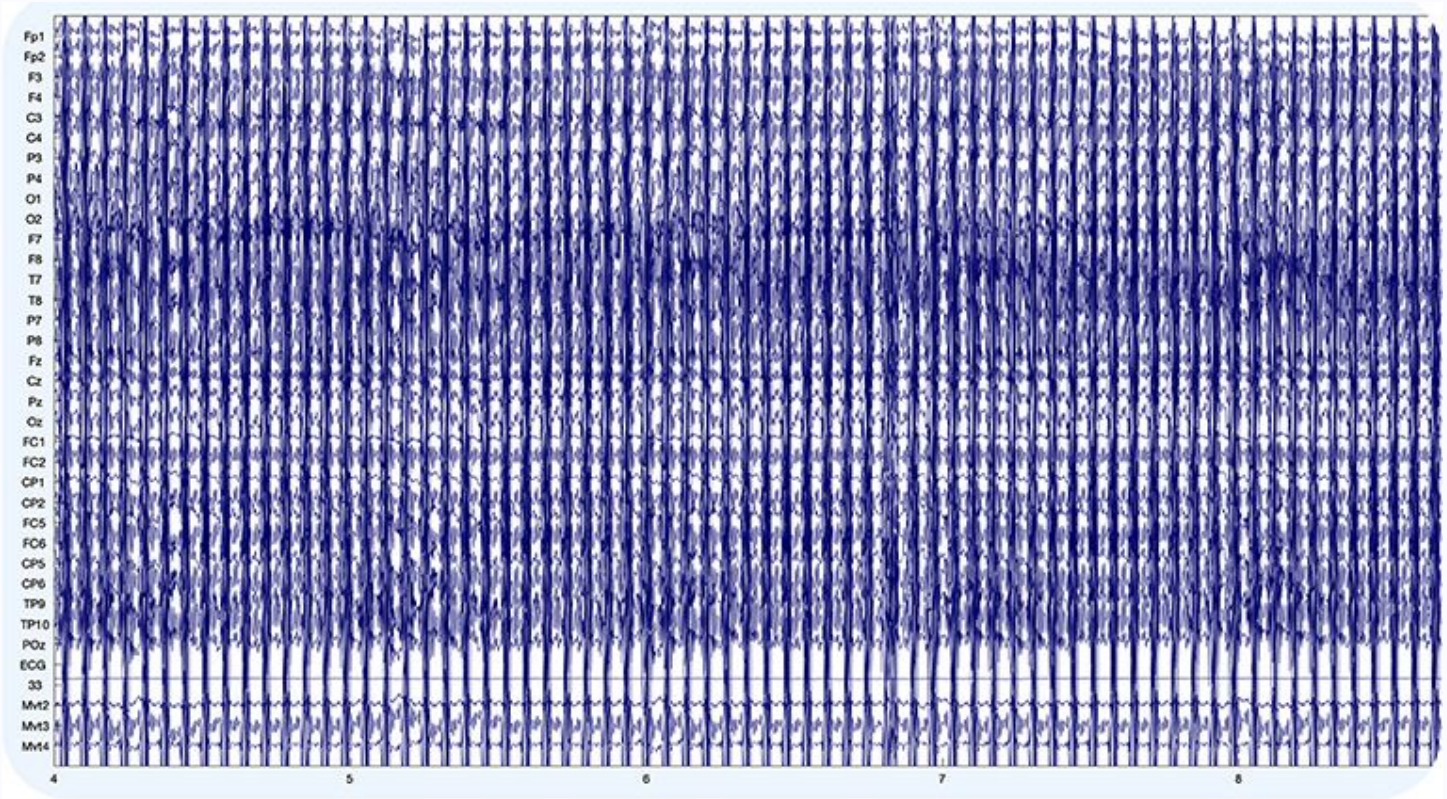
Heart beats = electrocardiogram (ECG) artifact



Guess the artifact… (yes, it's EEG) tip: recorded inside MRI scanner!

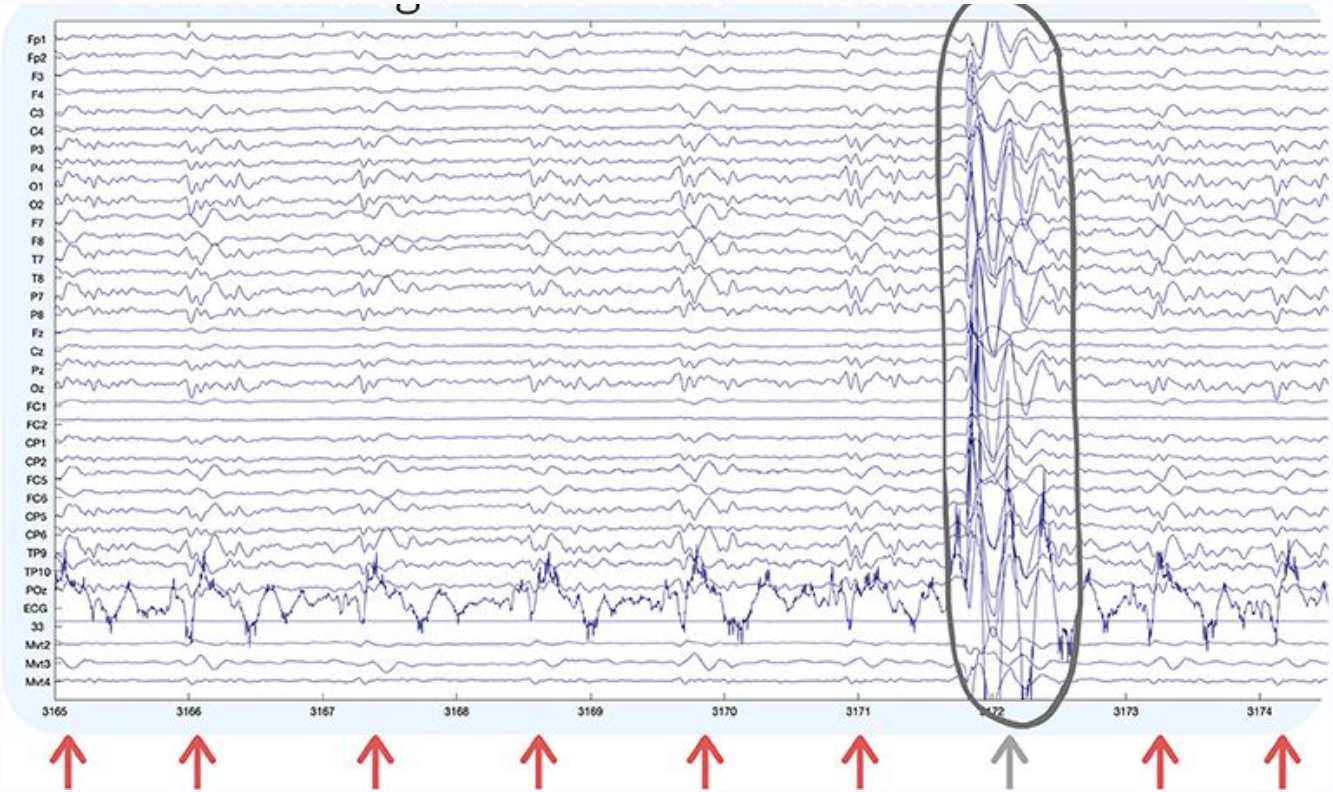


Gradient artifacts (MR gradient switching) (~Faraday's law)

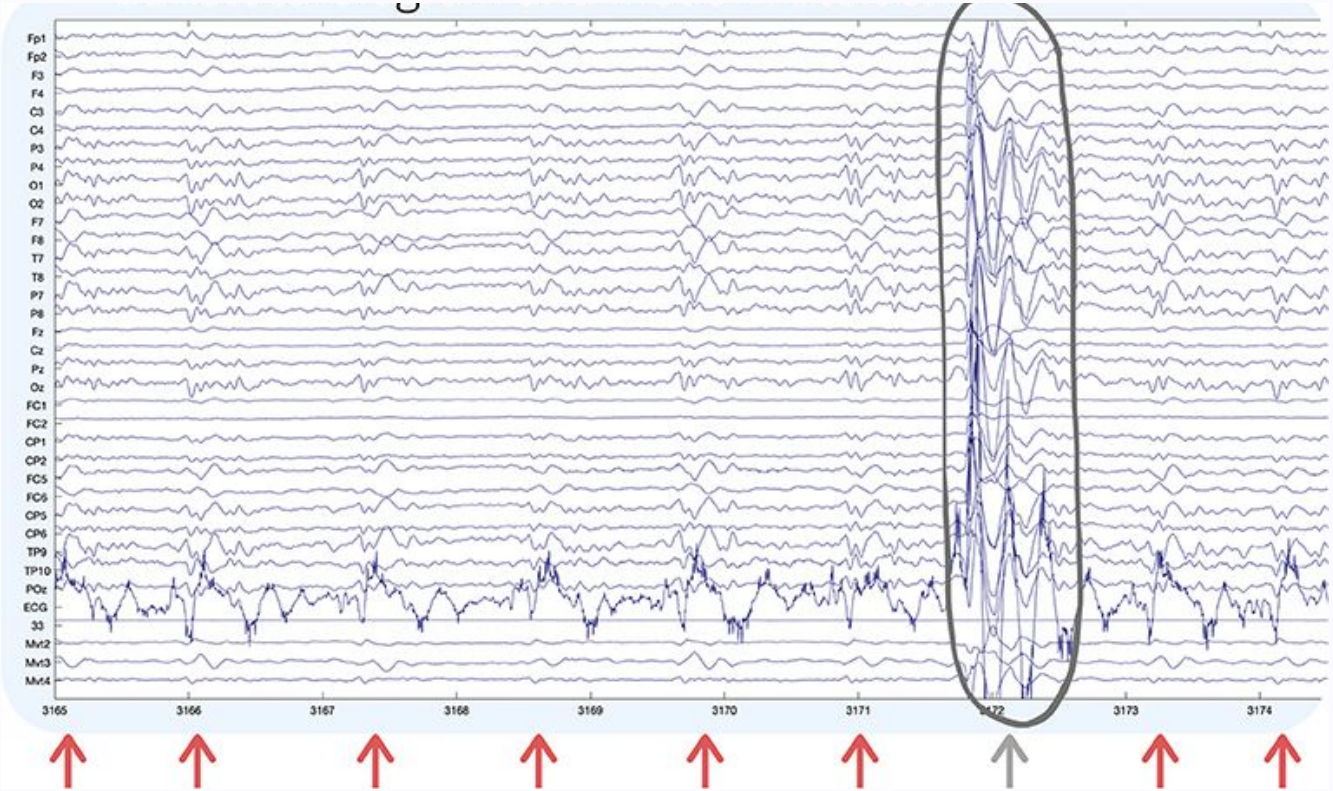


Guess the artifact...

tip: recorded inside MRI scanner!



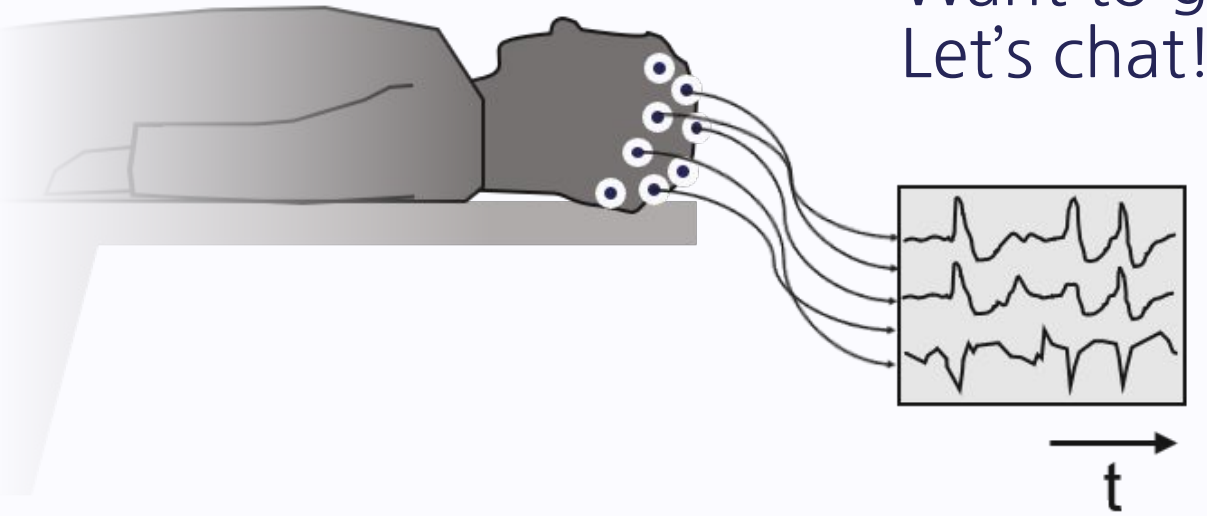
Ballistocardiagram (BCG) and motion artifacts (~Faraday's law)



PS: Feasible to correct/remove most of these artifacts satisfactorily with signal processing techniques!

(pick your favourite Python/Matlab toolbox)

icometrix



Want to go in more depth? Let's chat!

Simon Van Eyndhoven
simon.vaneyndhoven@icometrix.com