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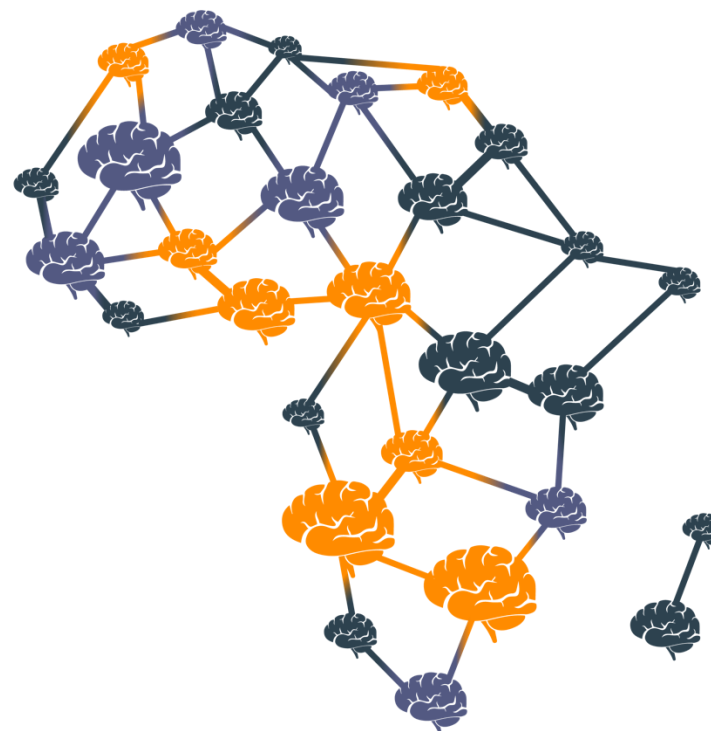
NatMEG



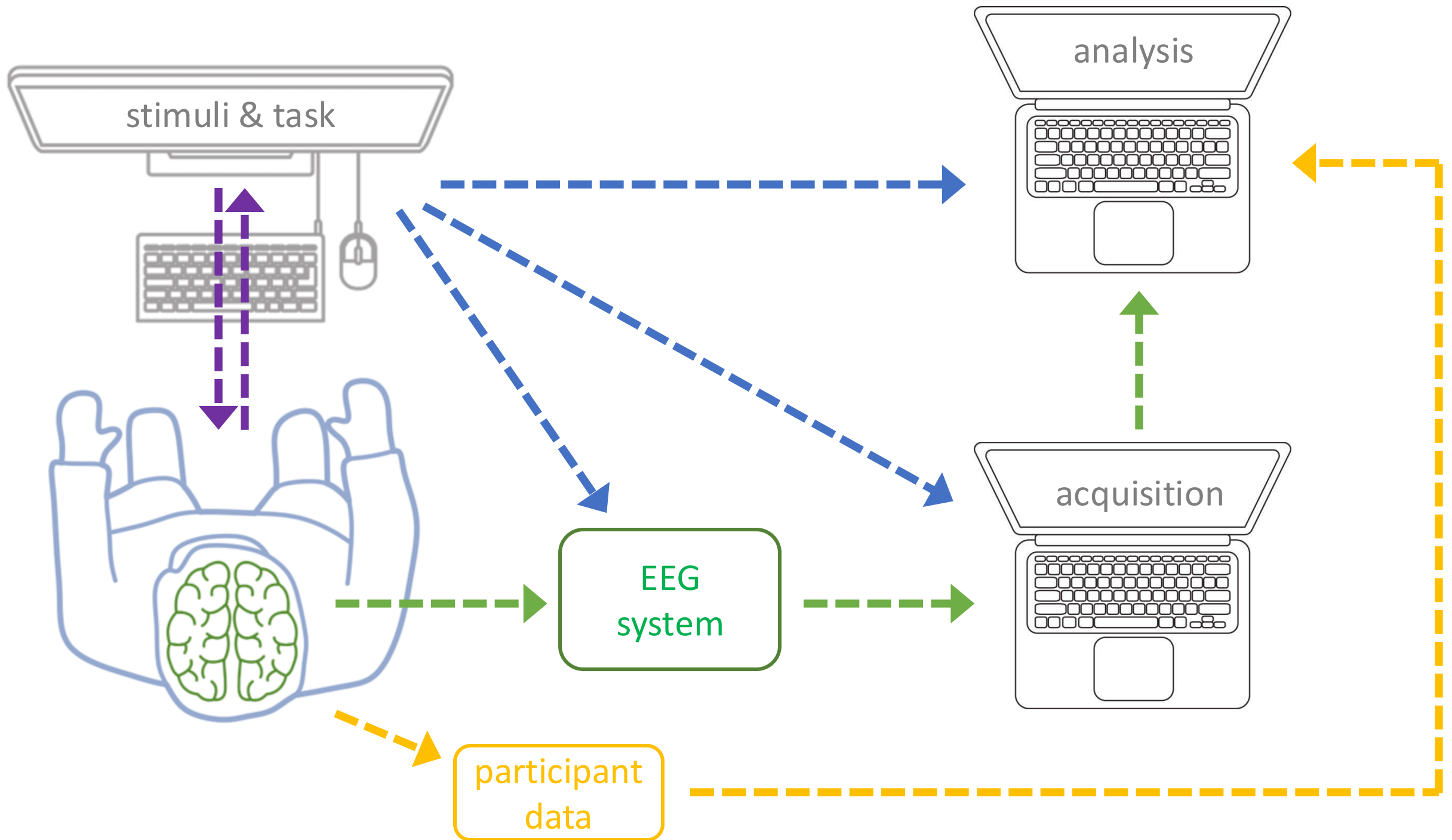
Experimental design, part B

Robert Oostenveld
Mikkel C. Vinding

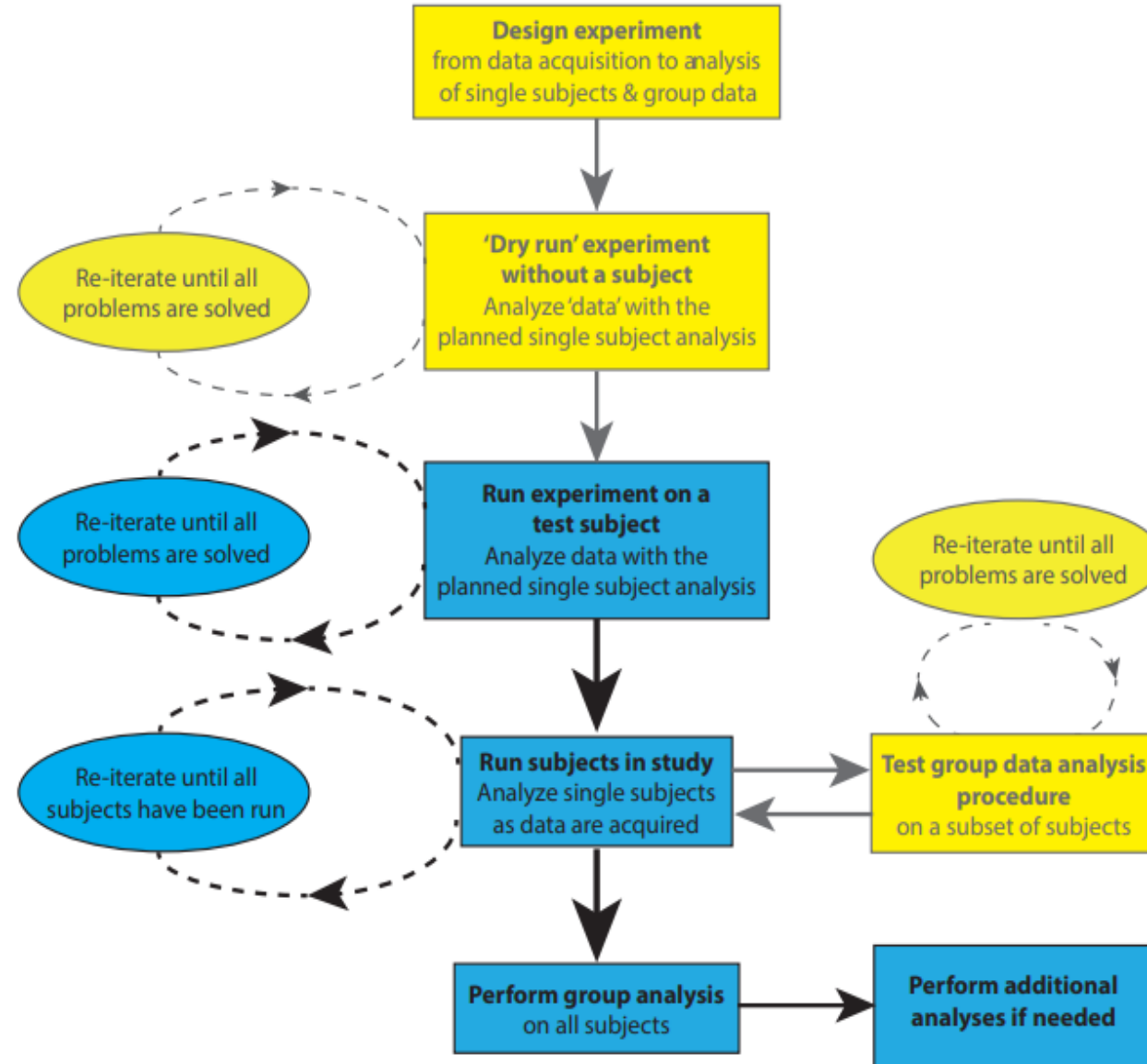
9-14 June 2025
Port Harcourt, Nigeria



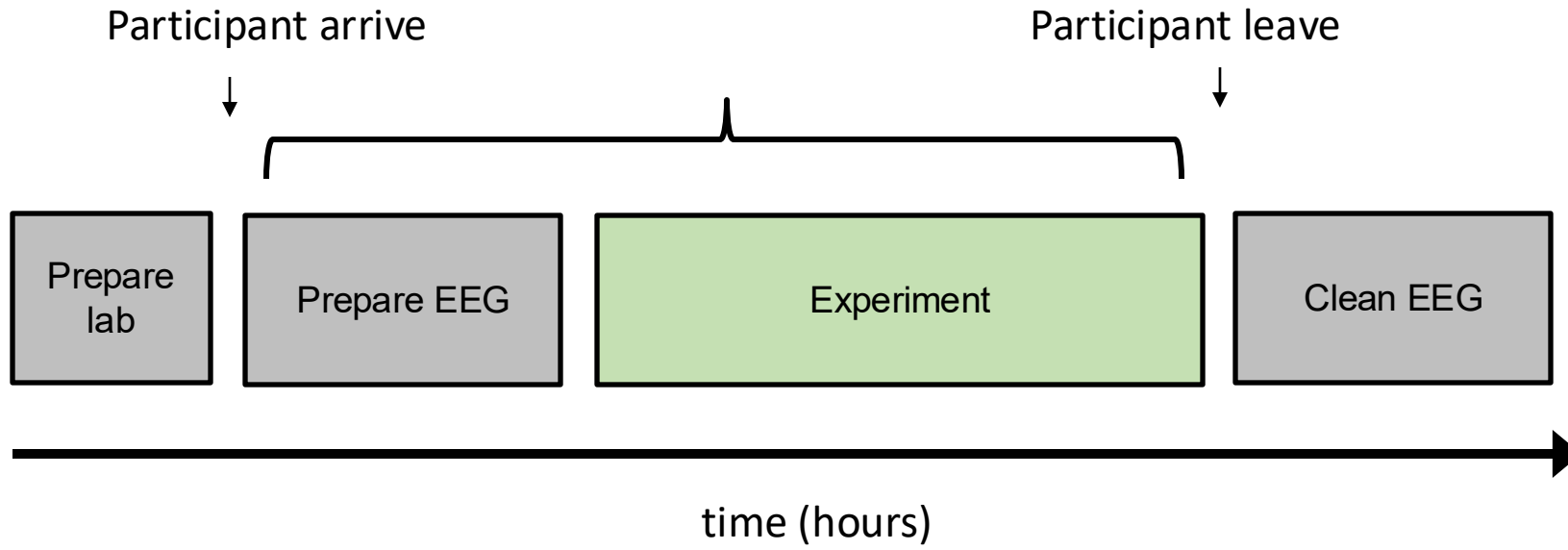
**African
Brain
Data
Network**



EEG workflow



Typical EEG experiment

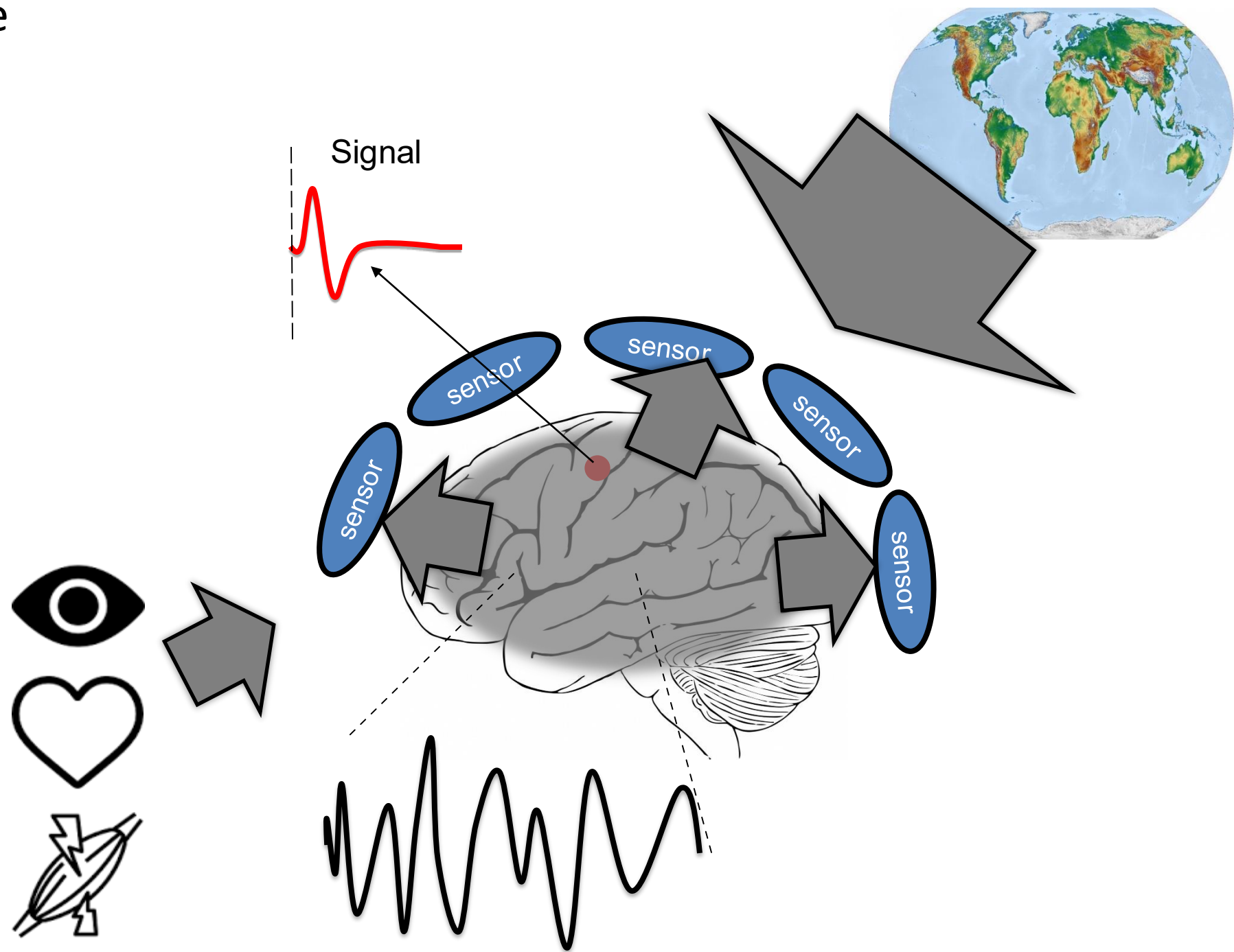


EEG safety

- EEG has no additional risk following standard operating procedure
- Risk: Person-to-person contact
 - Be aware if your participants have known risk factors (e.g., working with certain patient groups)
 - Disinfect hands and equipment
- Risk: participants with prior conditions
 - Know risks in advance
- Clean EEG equipment after use

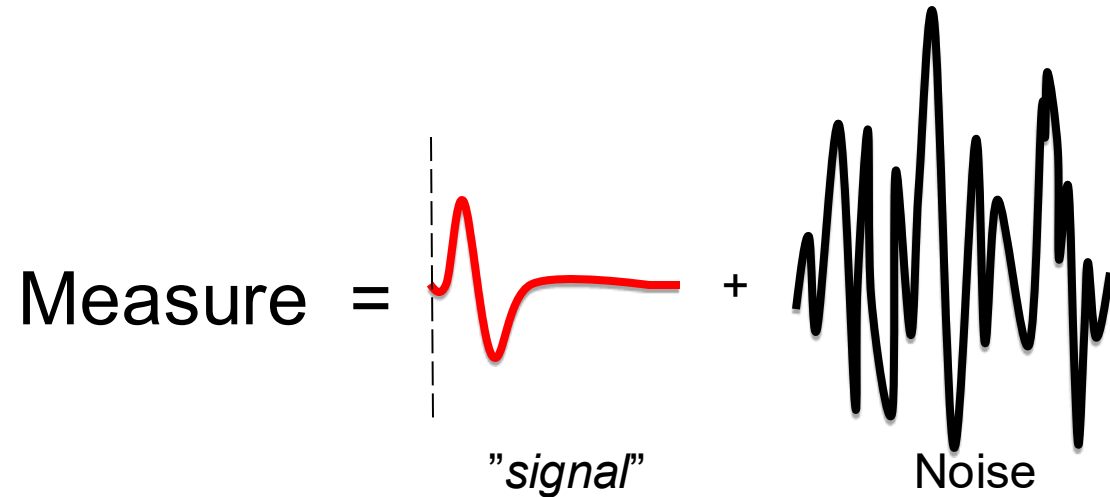
Optimise signal-to-noise in experiments

Signal and noise



Signal-to-noise ratio (SNR)

- **Signal:** electrophysiological activity of interest
- **Noise:** measured activity not of interest



$$SNR = \frac{\text{Magnitude of signal}}{\text{Variance of noise}}$$

How to reduce noise?

Noise is unavoidable! -> Consider how to reduce noise in the experimental design phase

- What to be aware:
 - EEG recording area (medical devices, cables, computers, etc.)
 - Participants (patients, children, etc.)
- Always test and monitor signal quality

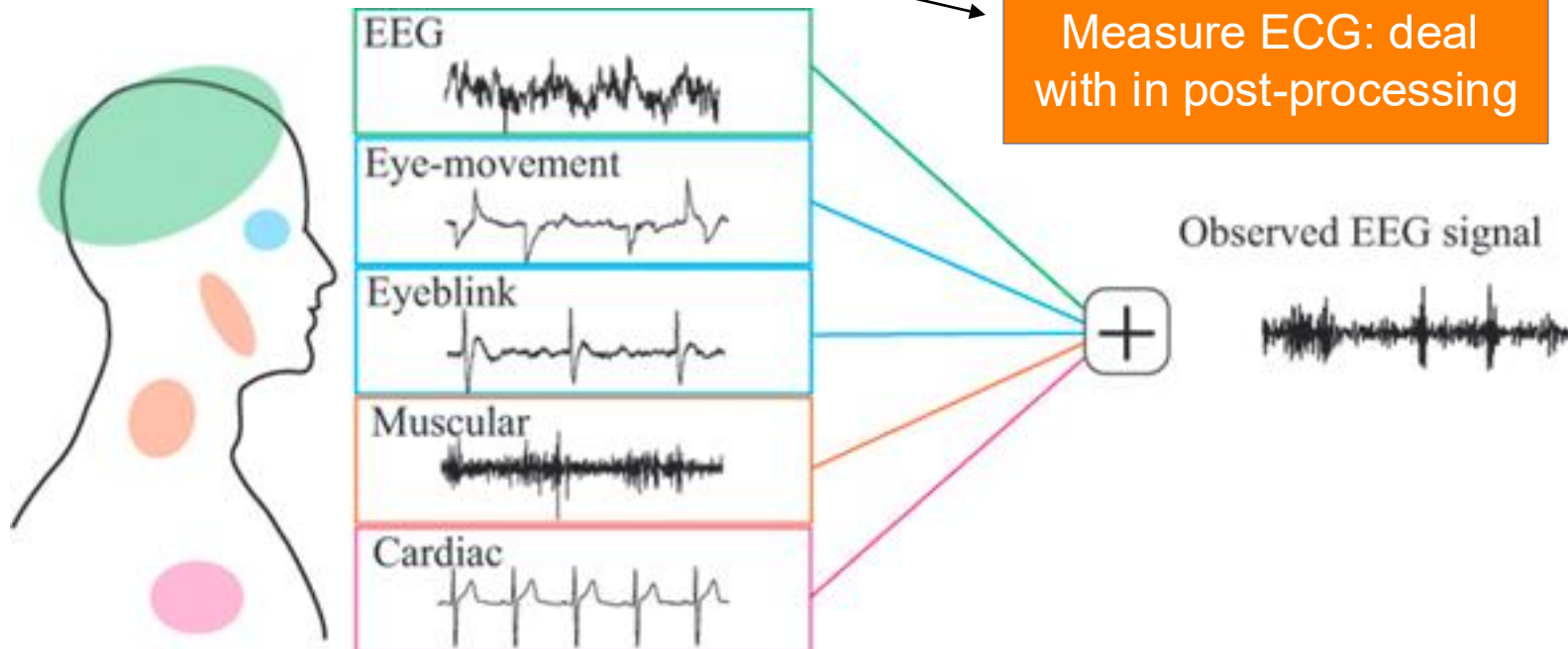
Option #1:
**Deal with sources of
noise while recording**

Option #2:
Deal with noise in
post-processing

How to reduce noise?

- **Biophysical artifacts**

- Eye movements
- Eye blinks
- Muscle activity
- Electrocardiographic



Experimental design:

- Fixation point
- "Blink" screen
- Trial duration

Measure EOG: deal with in post-processing

- Participant positioning
- Participant comfort
- Experiment duration?
- Monitor participant:
 - Movements?
 - Biting?

Measure EMG: for online and post-hoc inspection

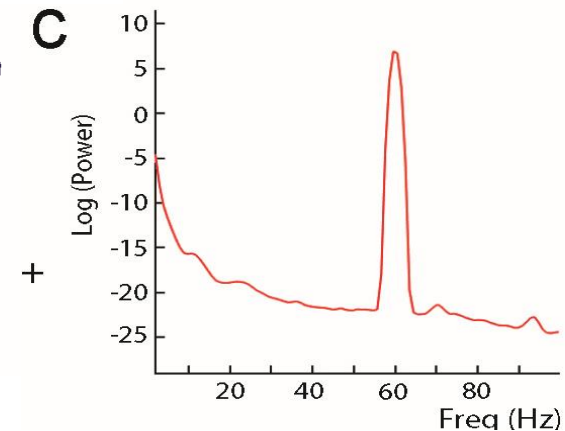
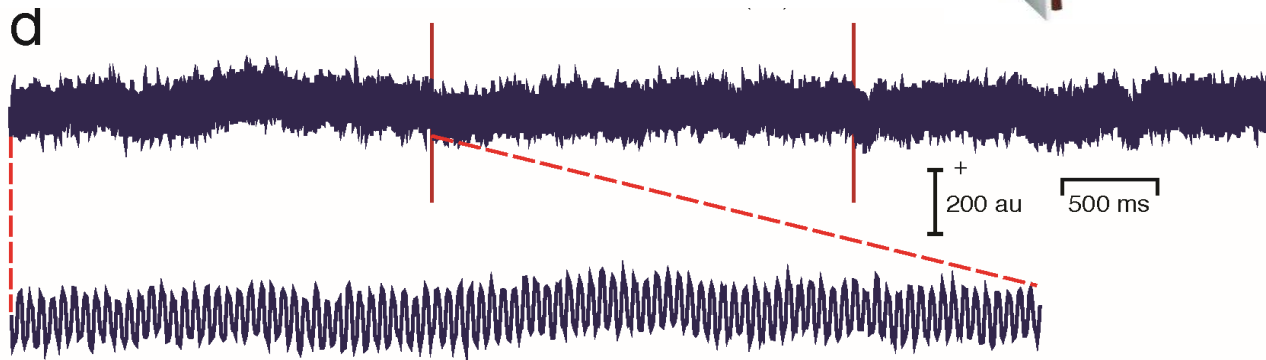
How to reduce noise?

- Biophysical artifacts
 - Eye movements
 - Eye blinks
 - Muscle activity
 - Electrocardiographic
- **Environment noise**
 - Line noise
 - Electric devices



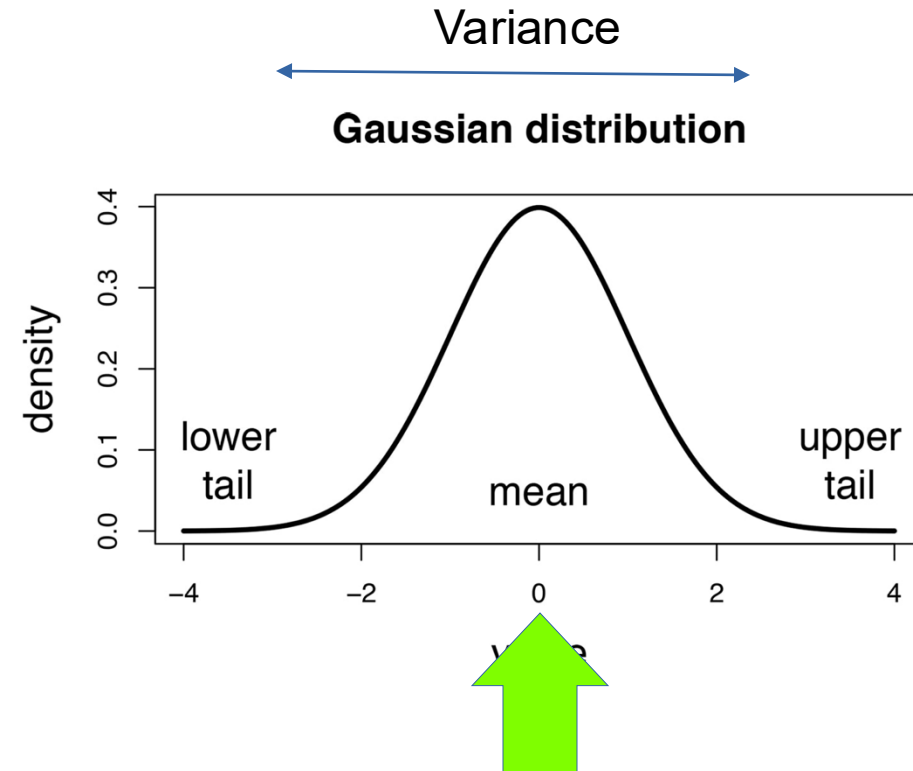
- "Ground" devices
- (Re)move electronic devices
- Move participant
- Shielded room

Post hoc notch filtering



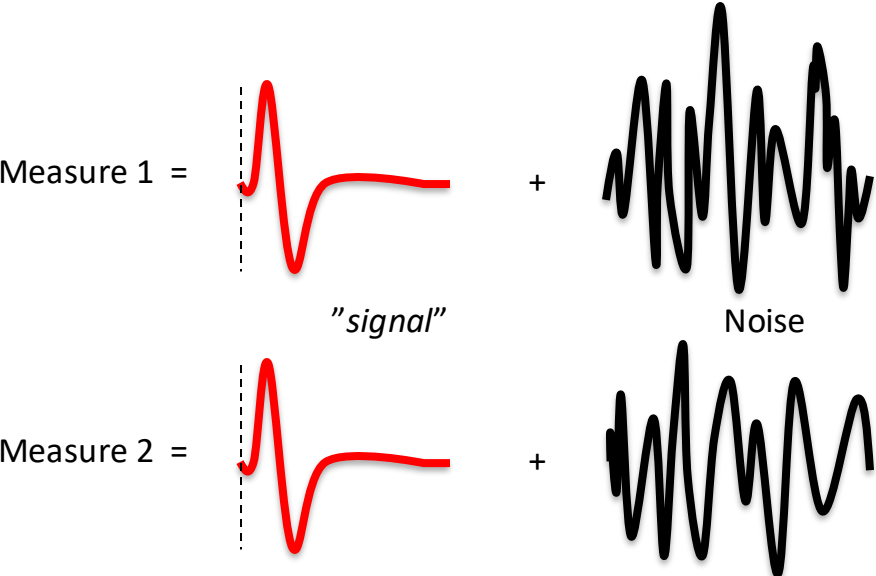
How to reduce noise?

- Biophysical artifacts
 - Eye movements
 - Eye blinks
 - Muscle activity
 - Electrocardiographic
- Environment noise
 - Line noise
 - Electric devices
- **Random noise**
 - Ongoing unrelated brain activity
 - Random environment

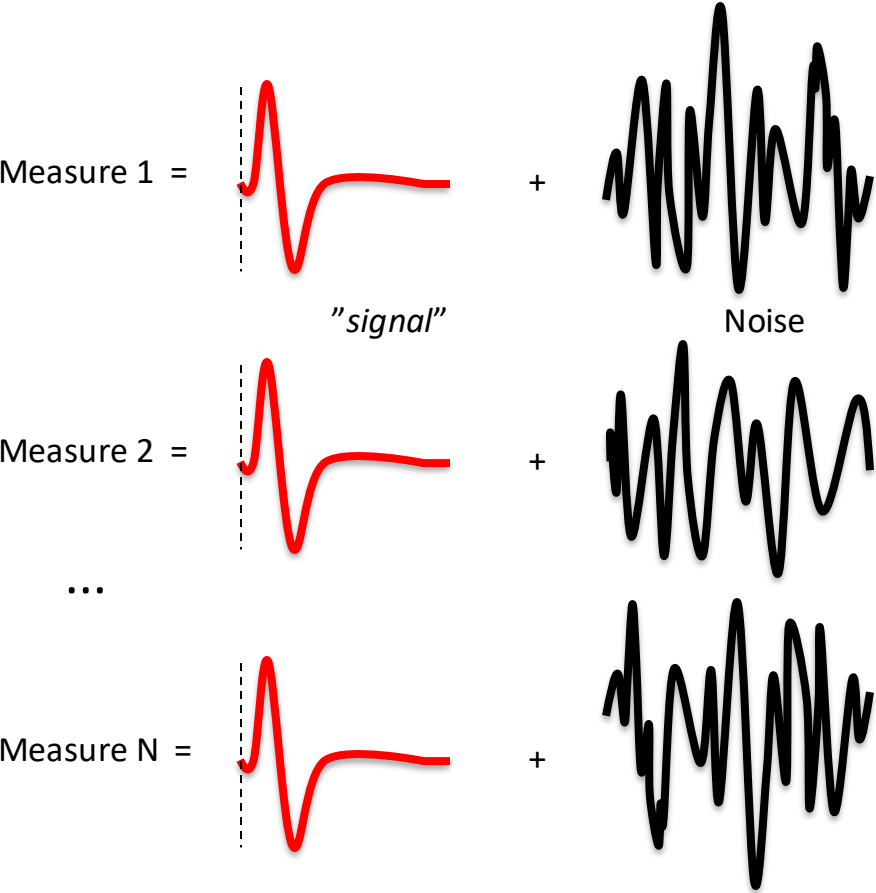


$$N \rightarrow \infty, \quad \text{MEAN}(G(0, \sigma)) \rightarrow 0$$

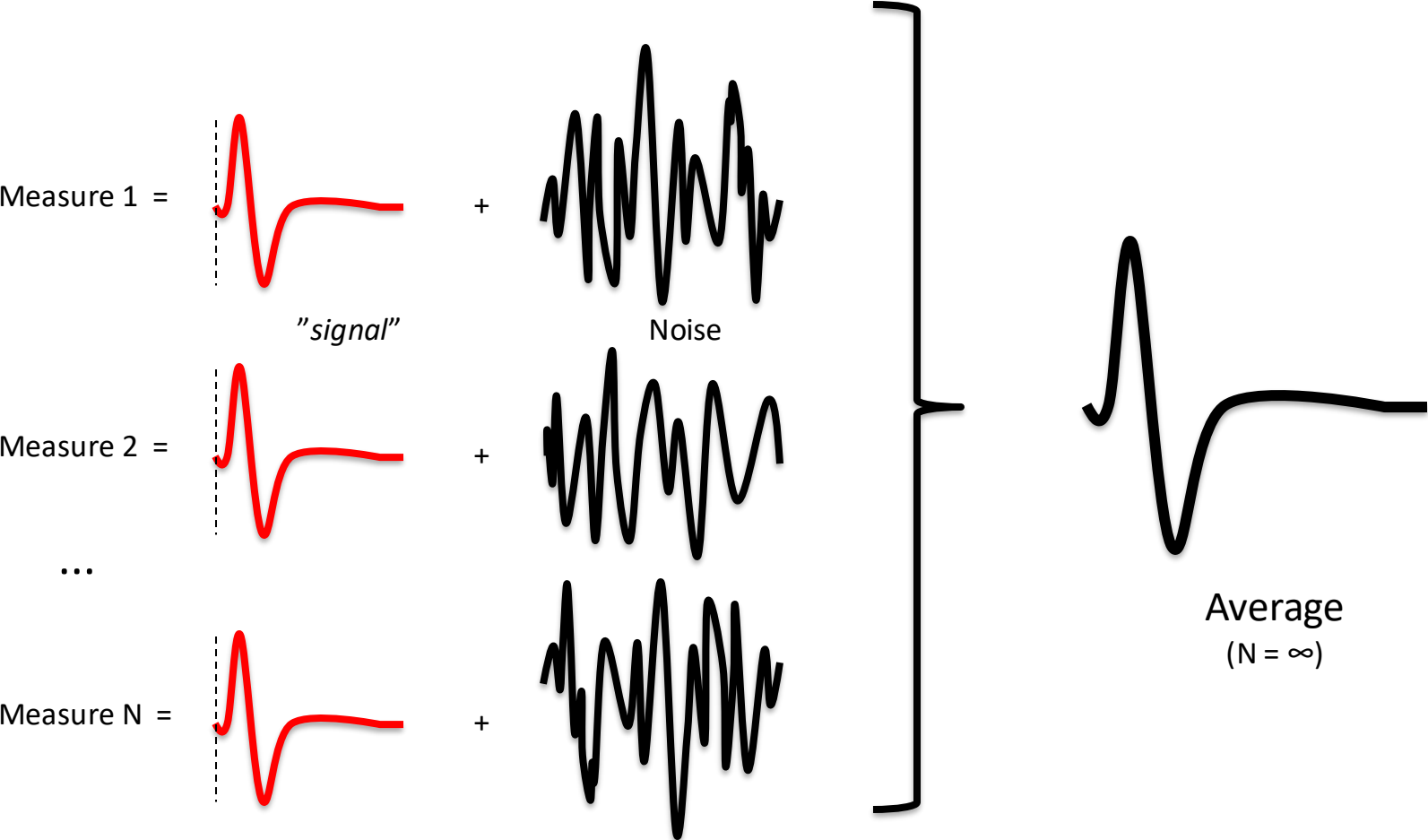
How to reduce noise?



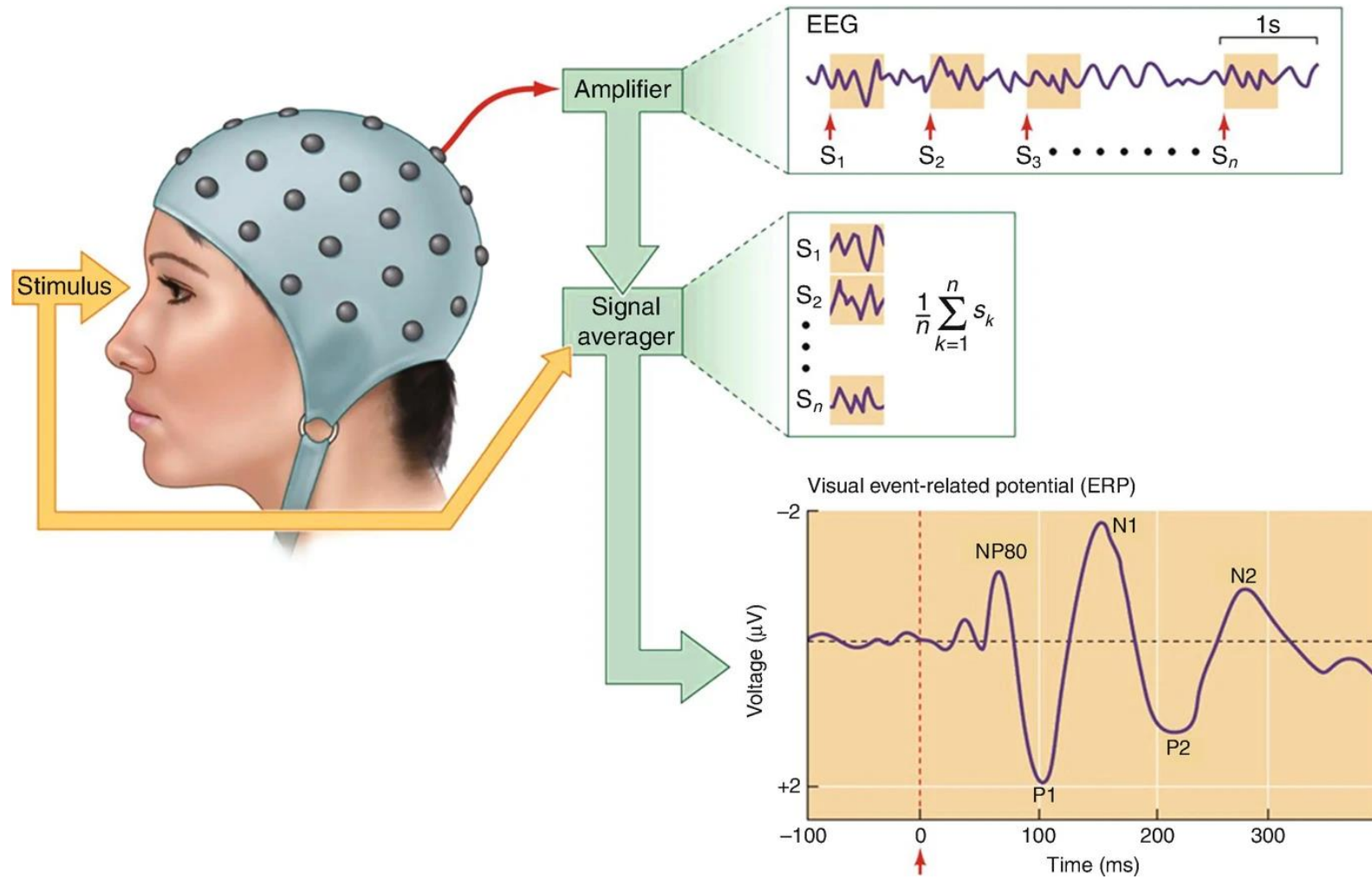
How to reduce noise?



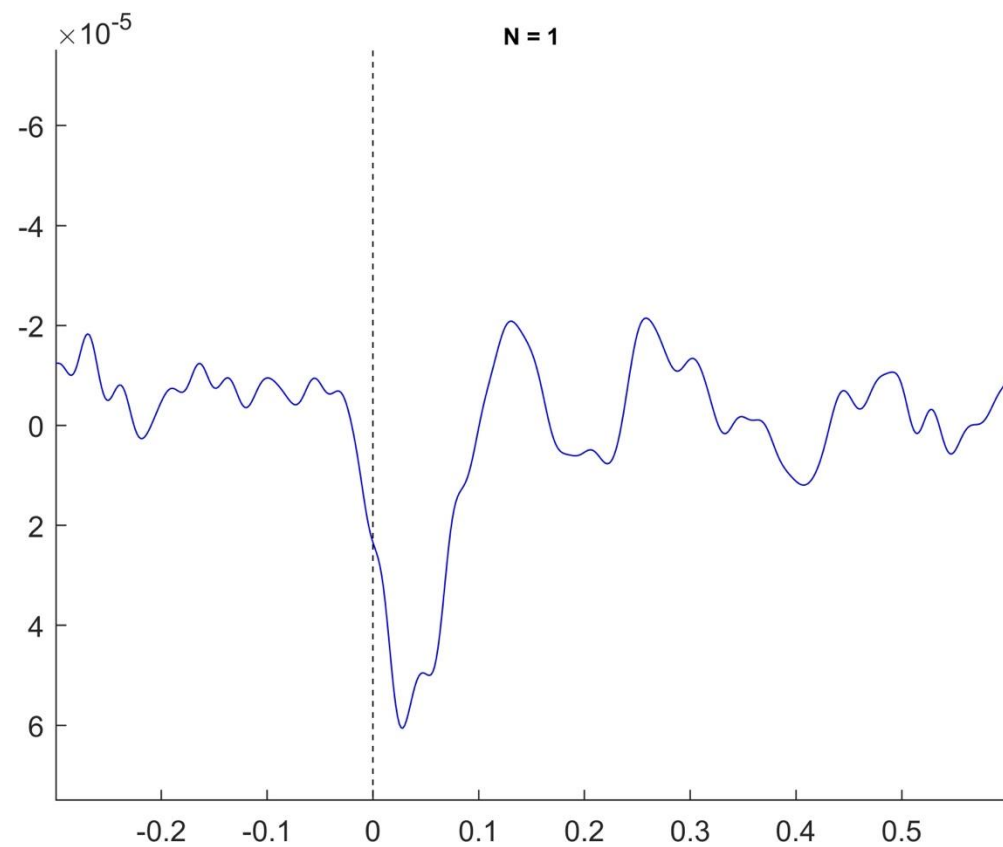
How to reduce noise?



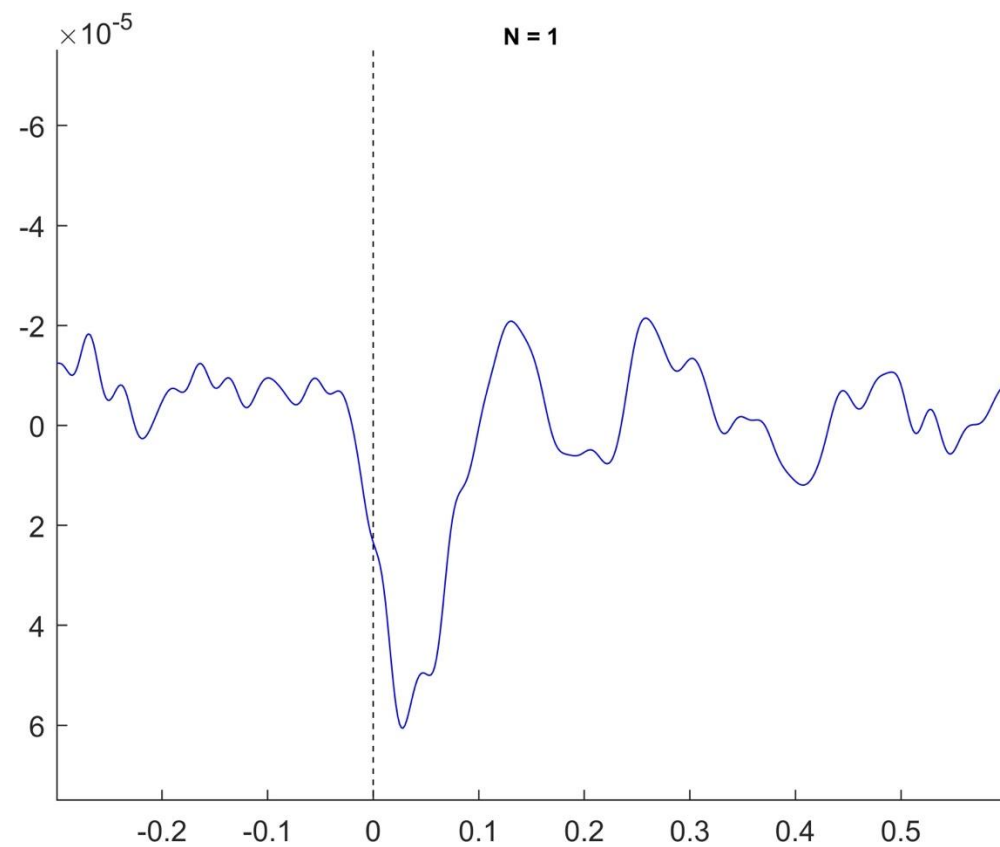
EEG recording and trials



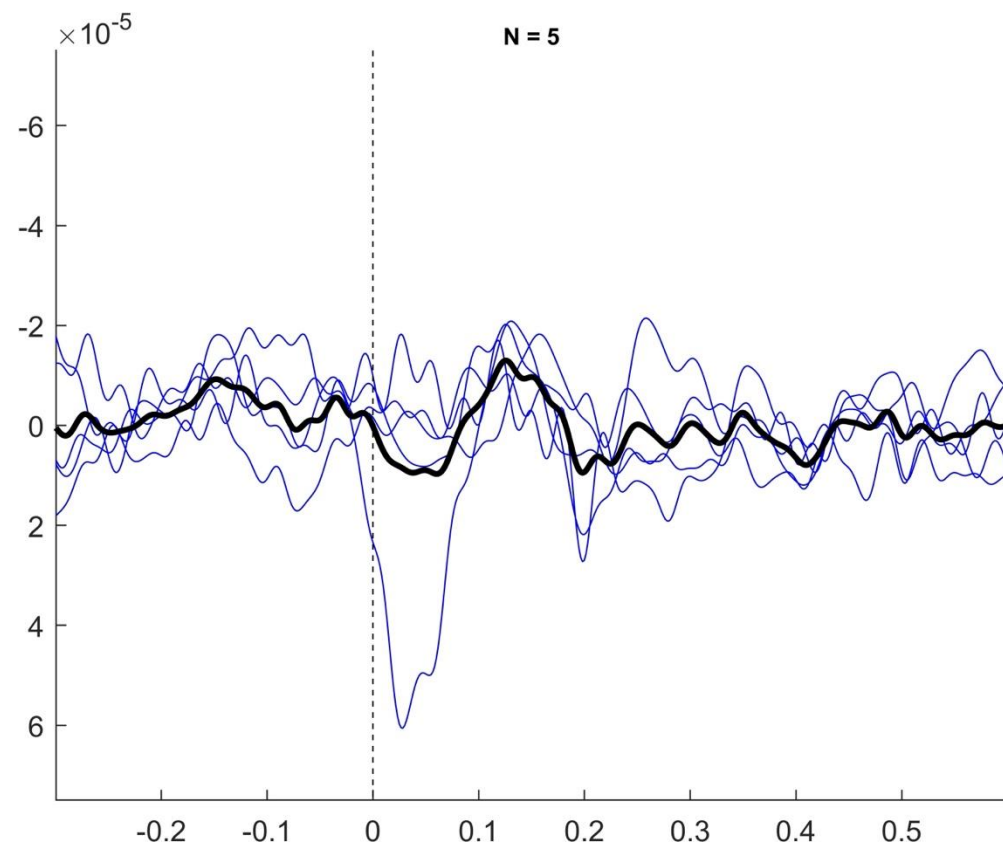
Trials



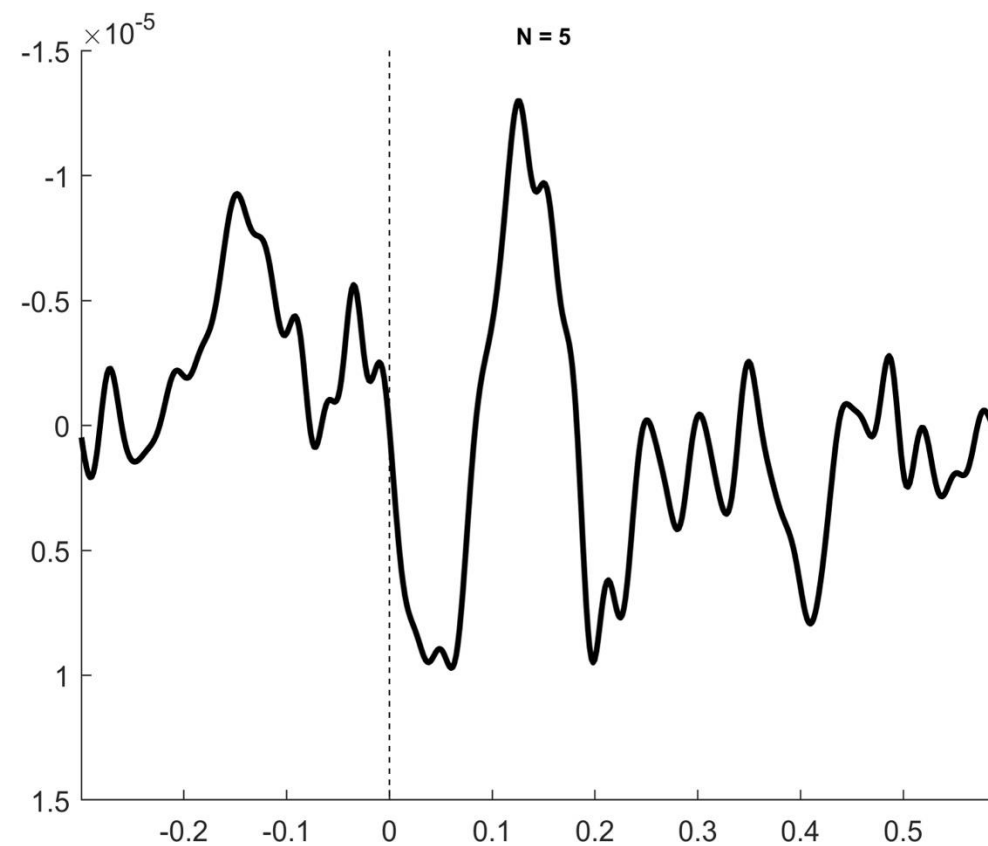
Average



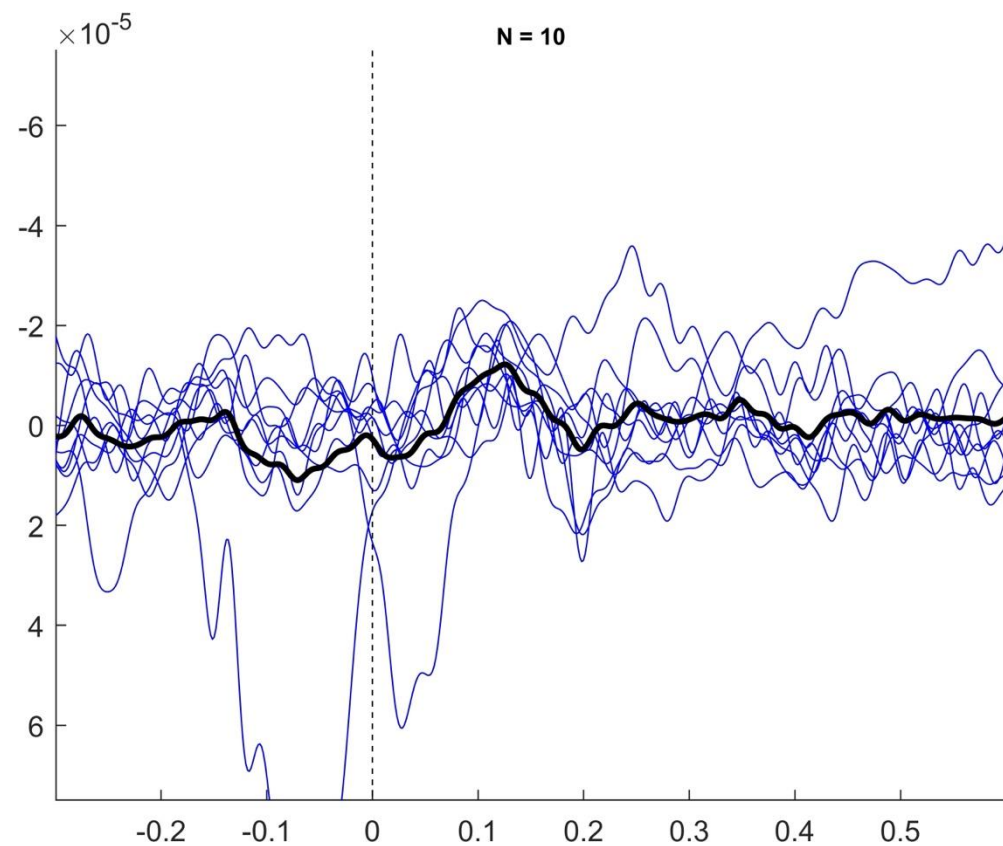
Trials



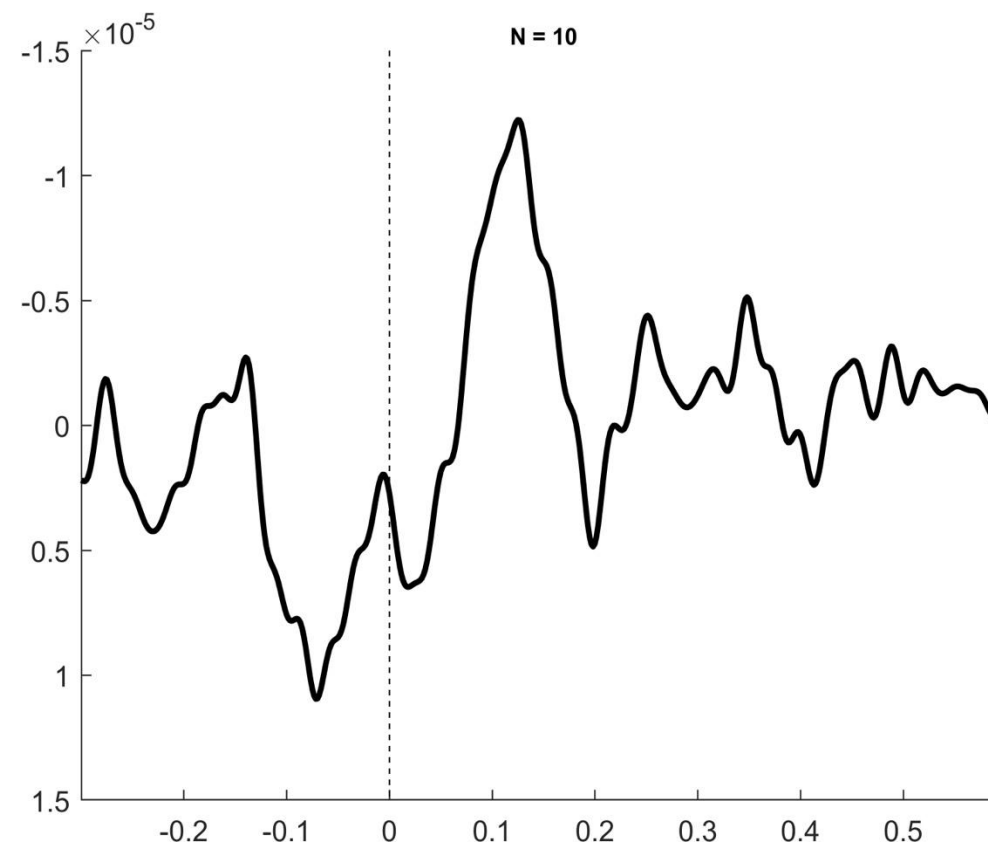
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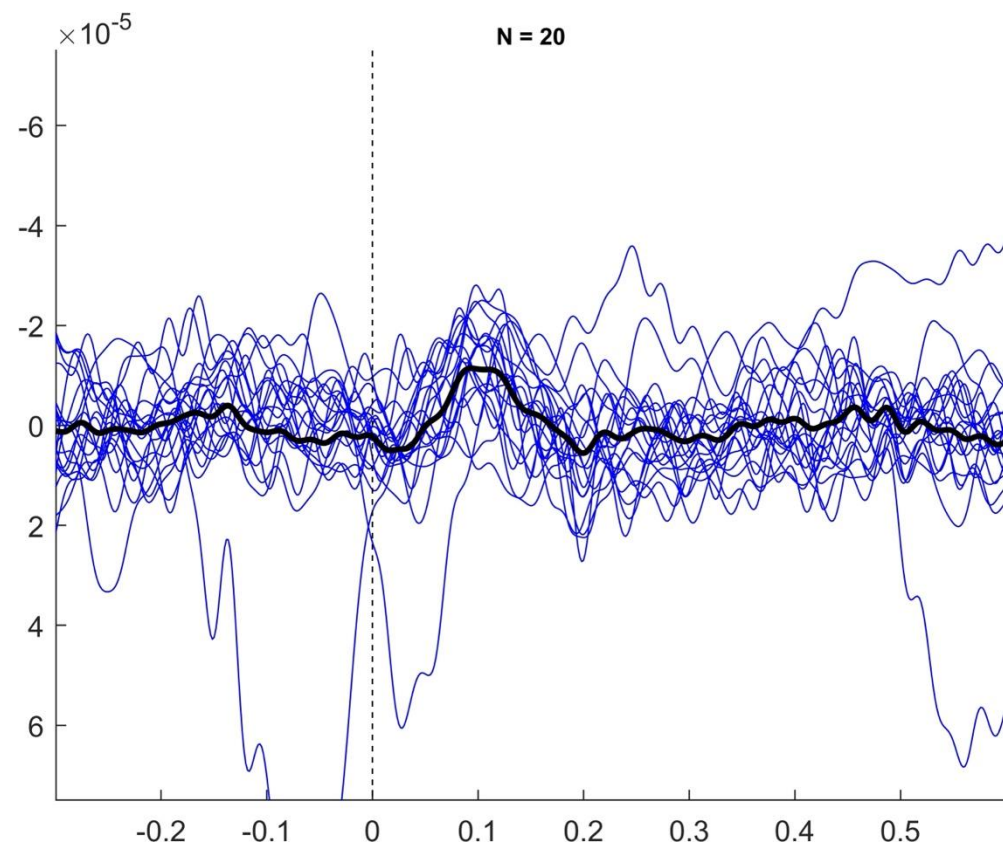
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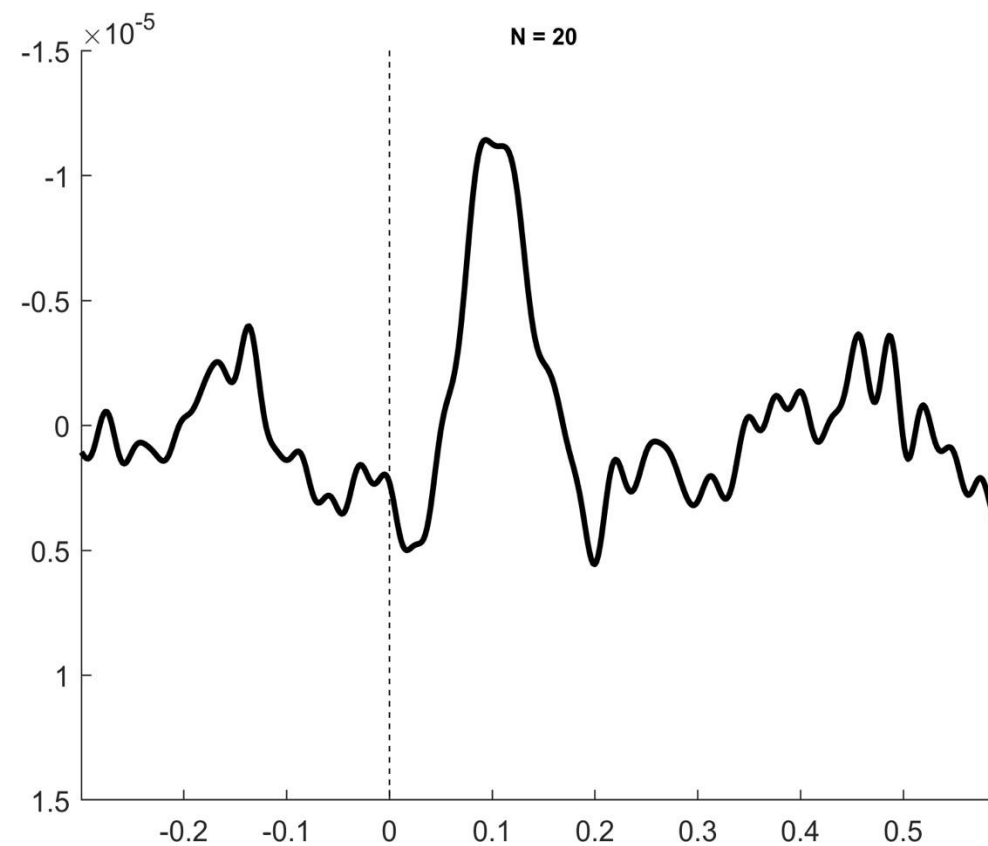
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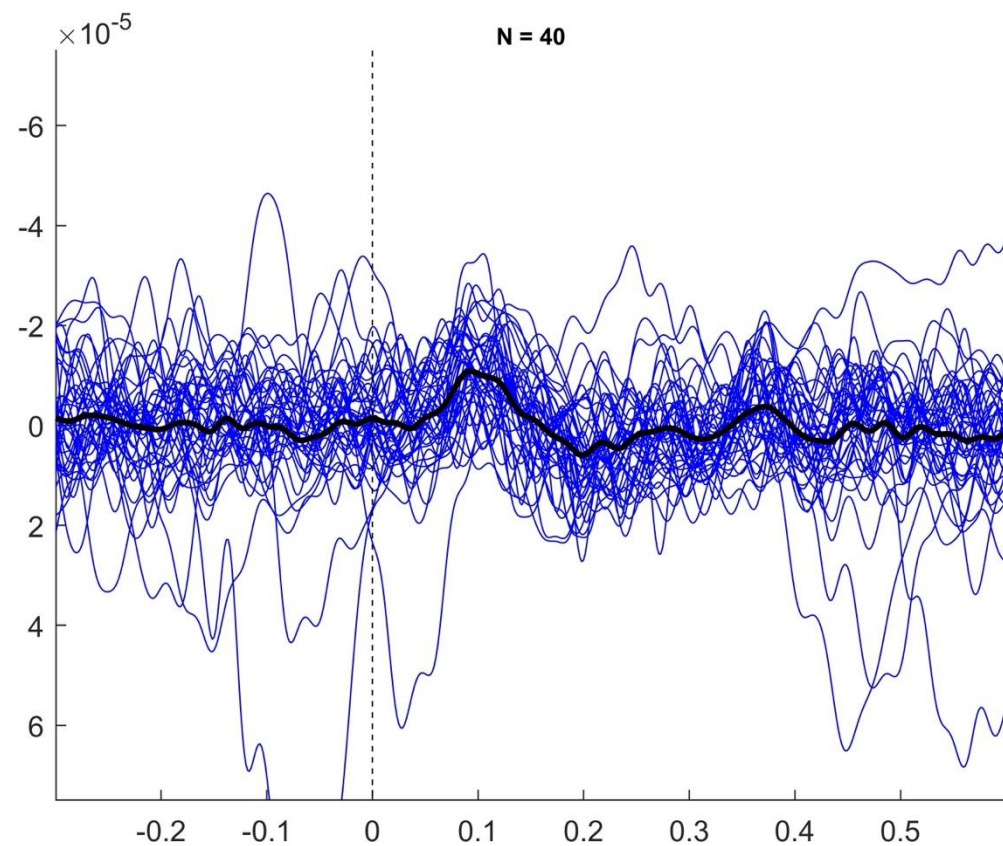
Trials



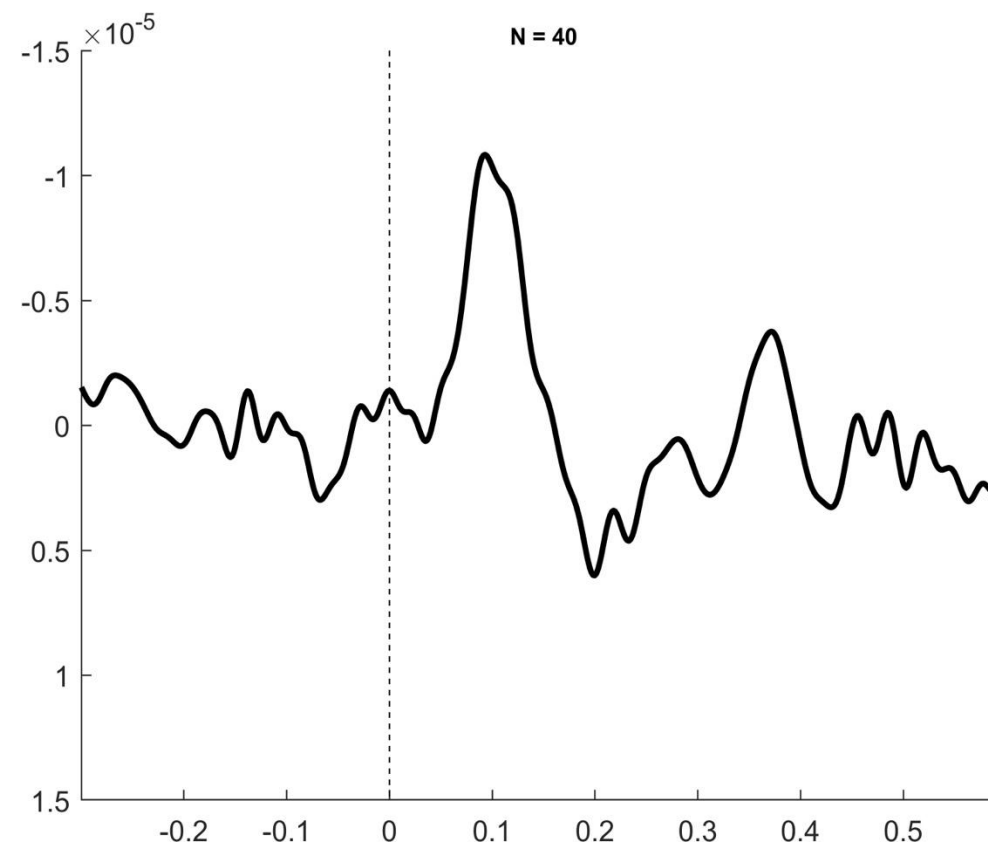
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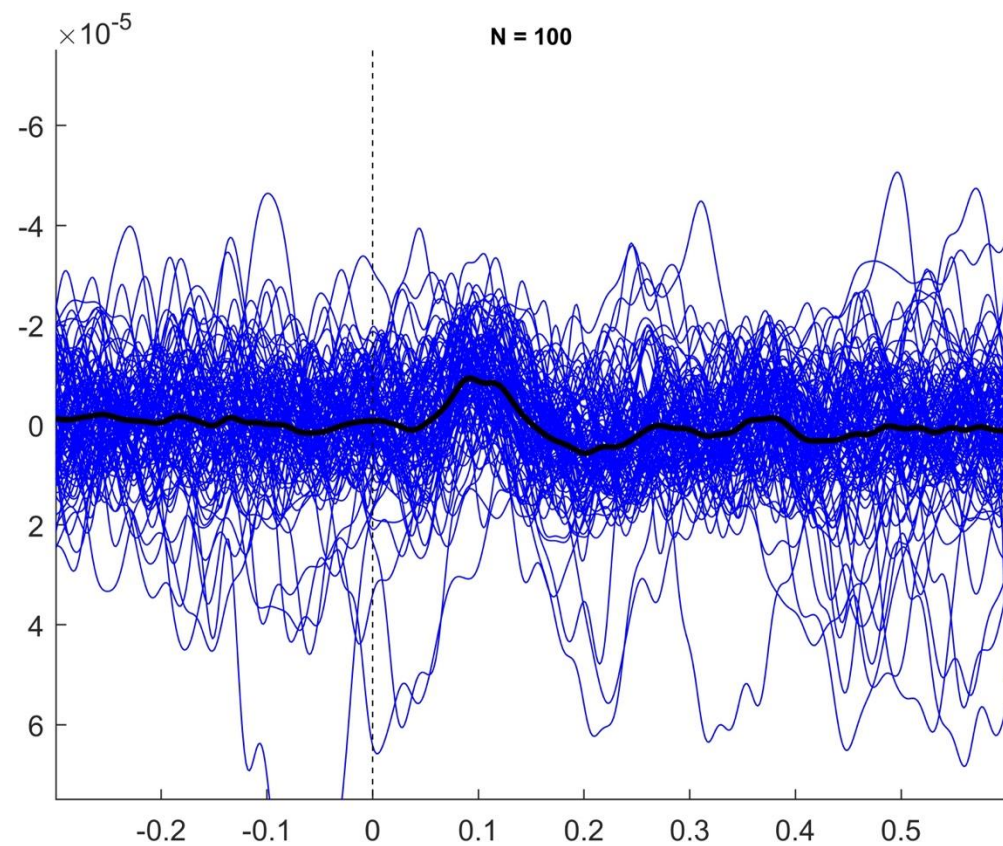
Trials



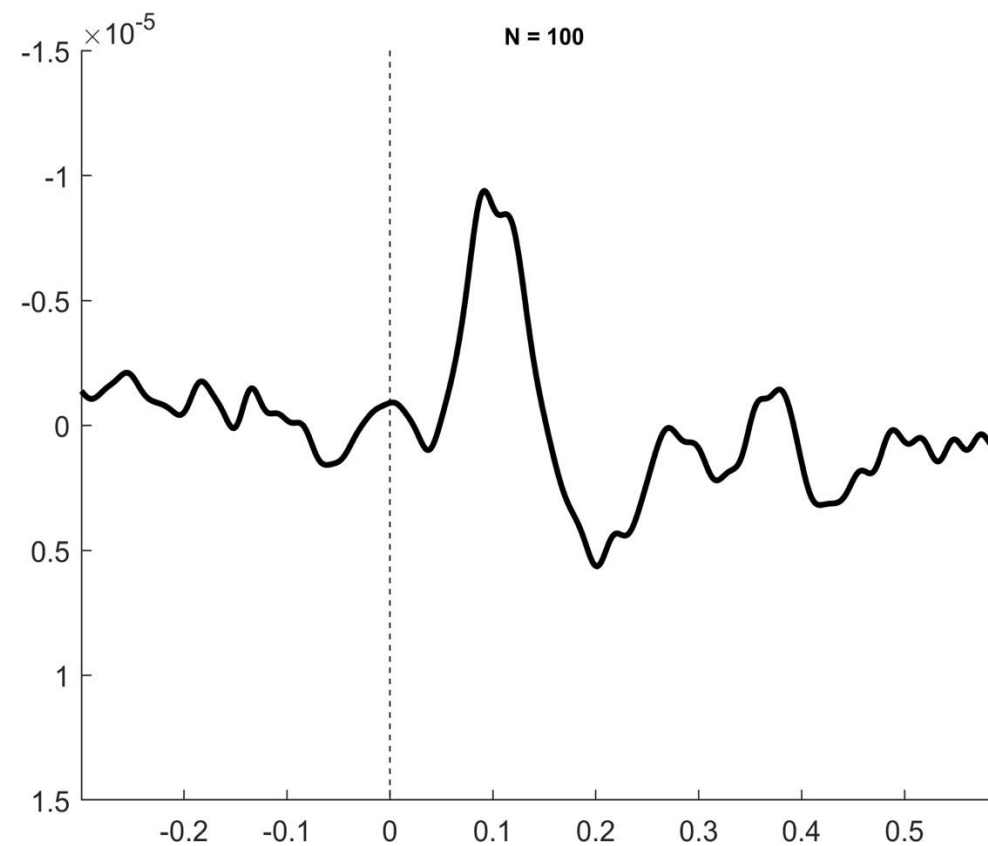
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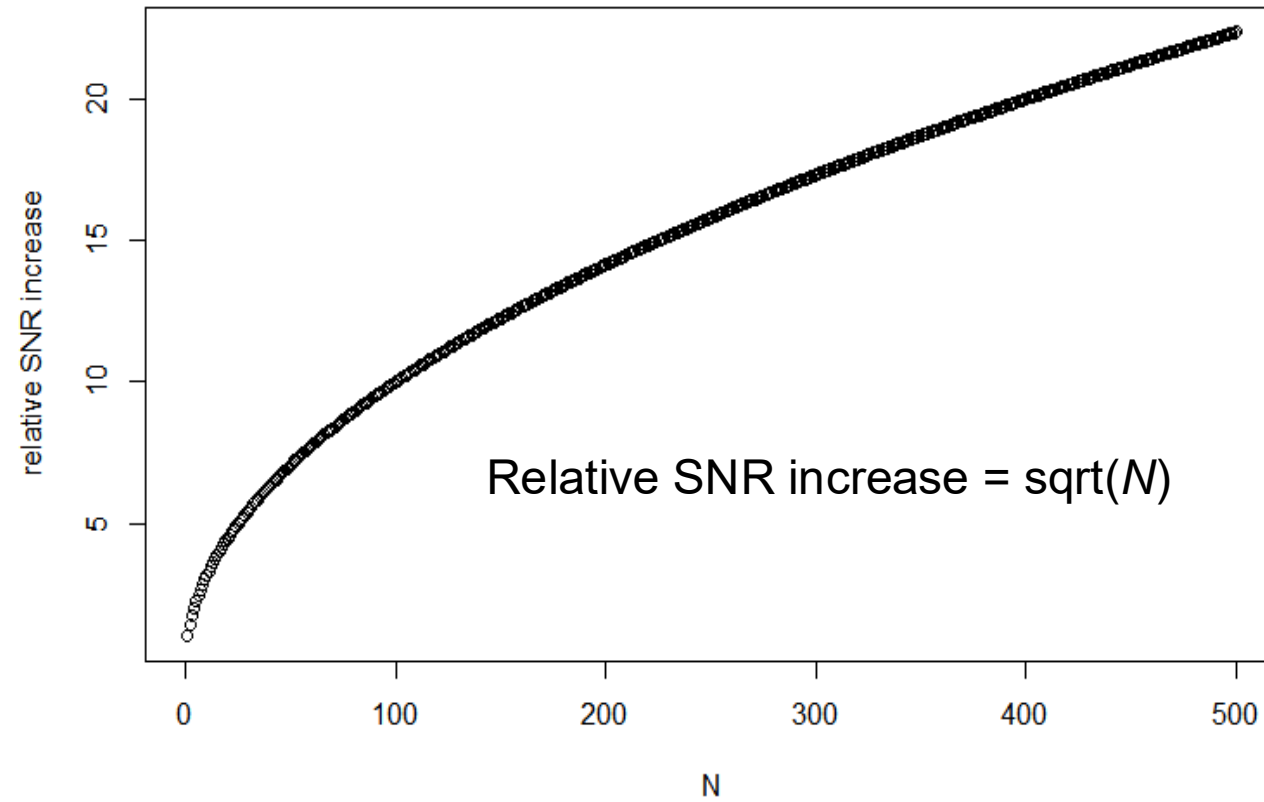
Trials

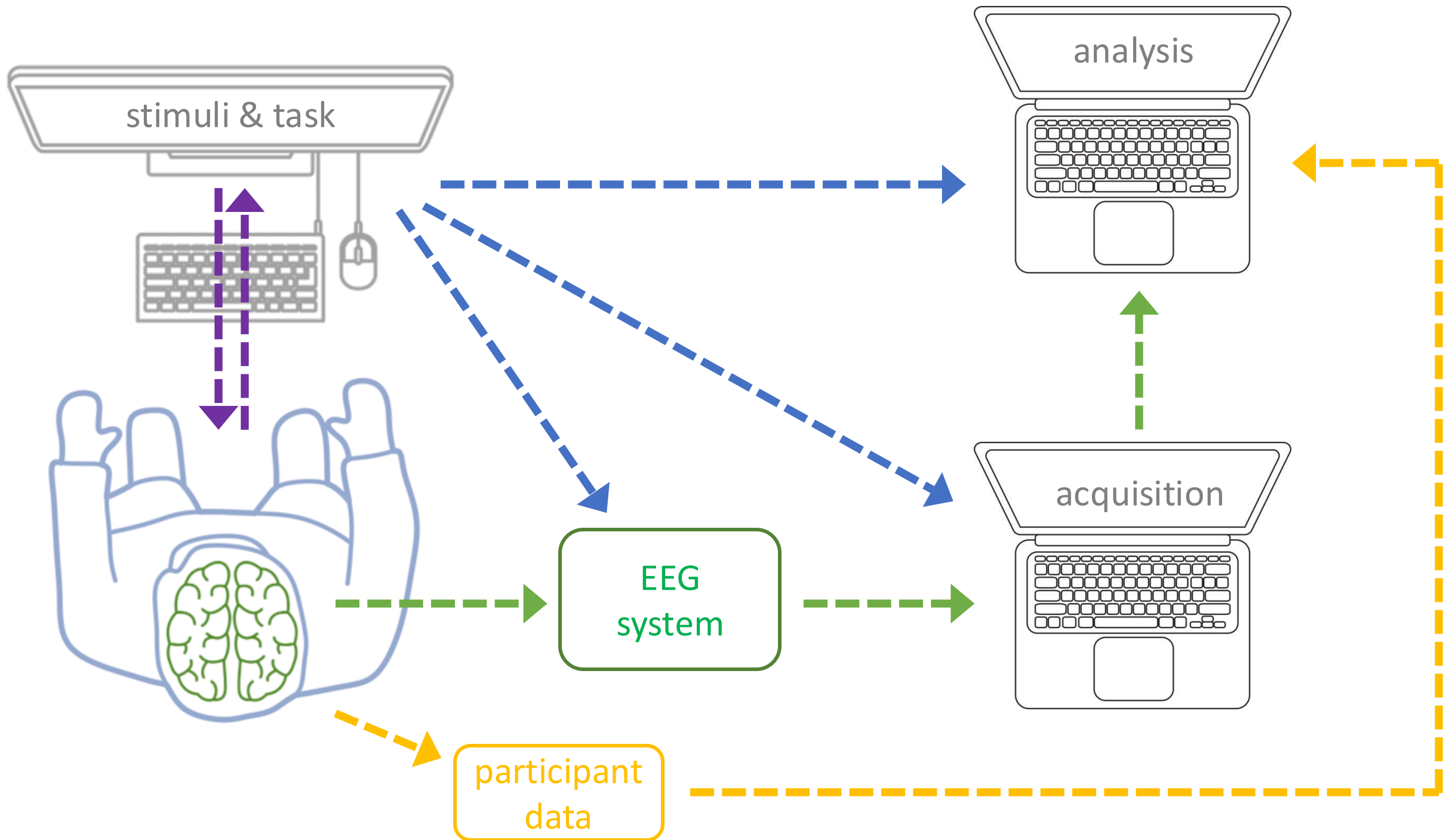


Average



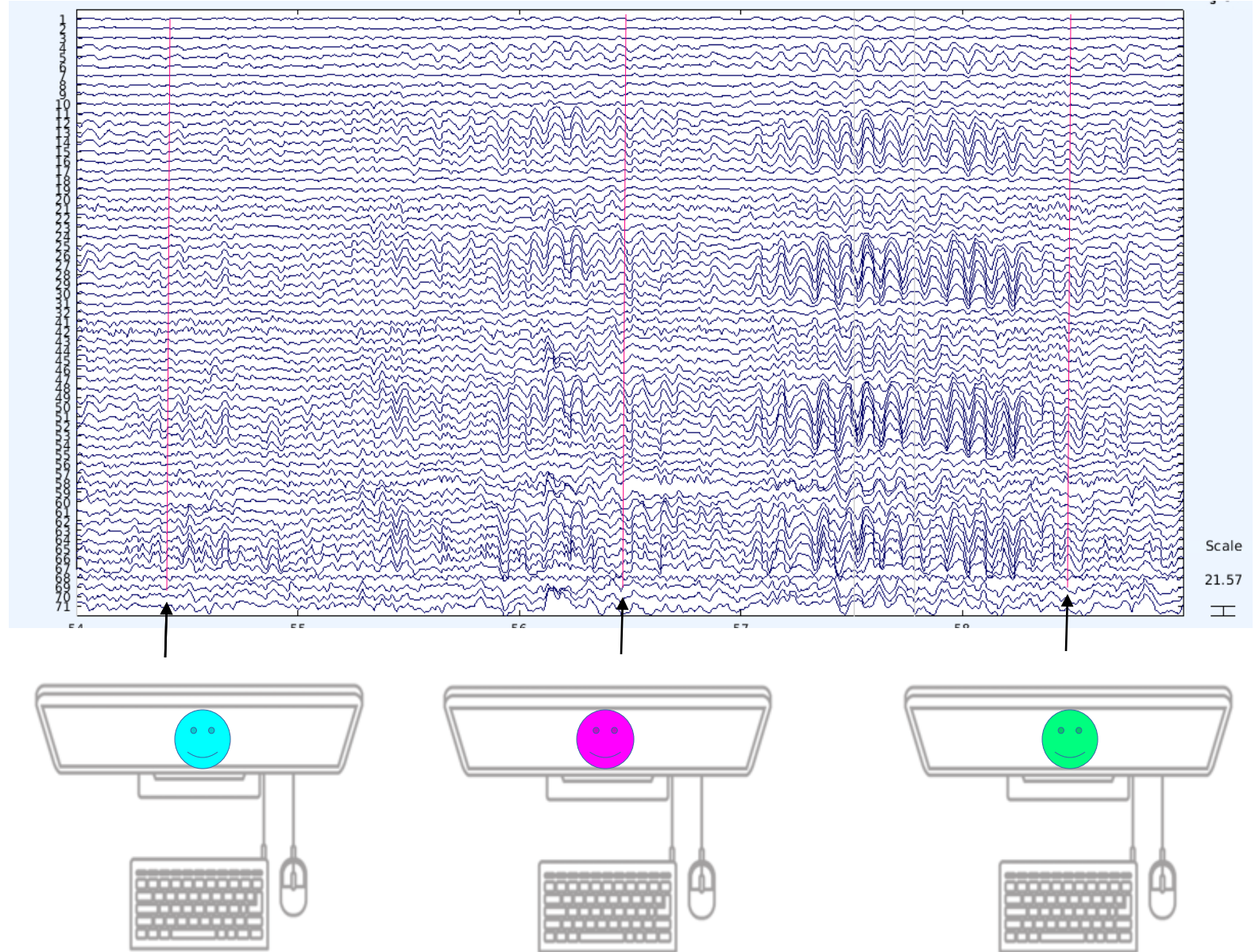
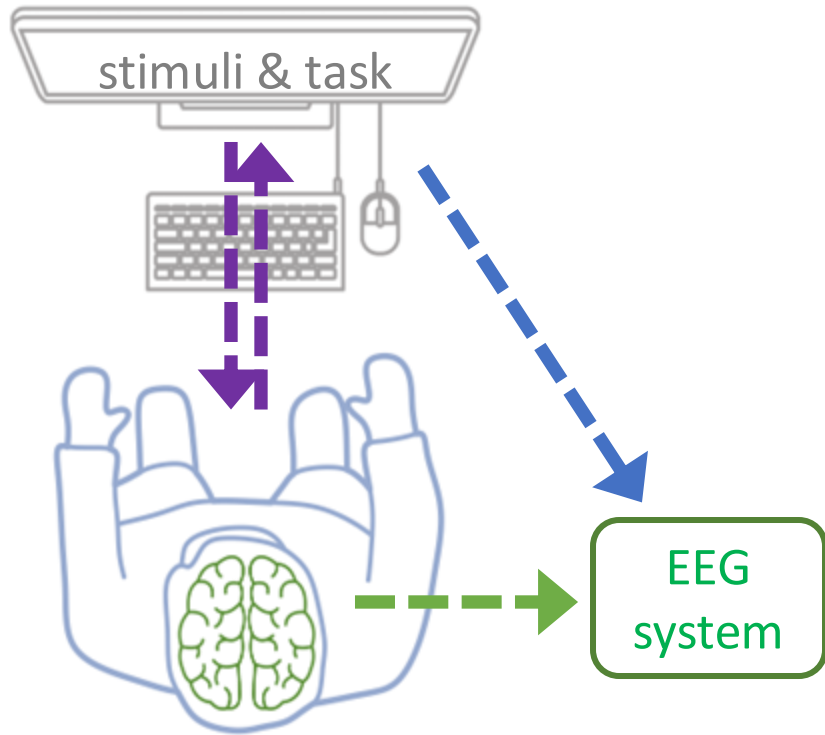
Increasing SNR: number of trials



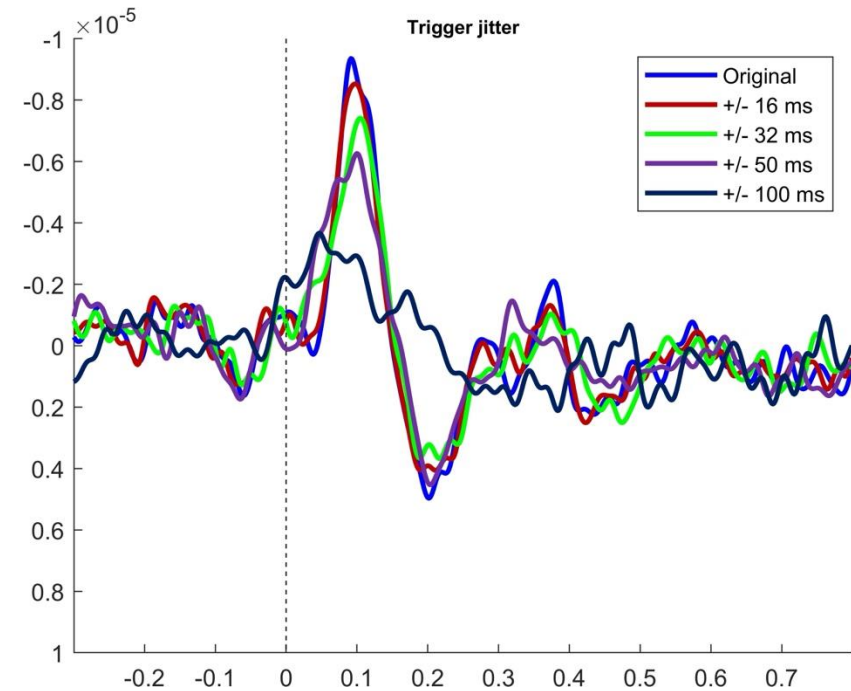
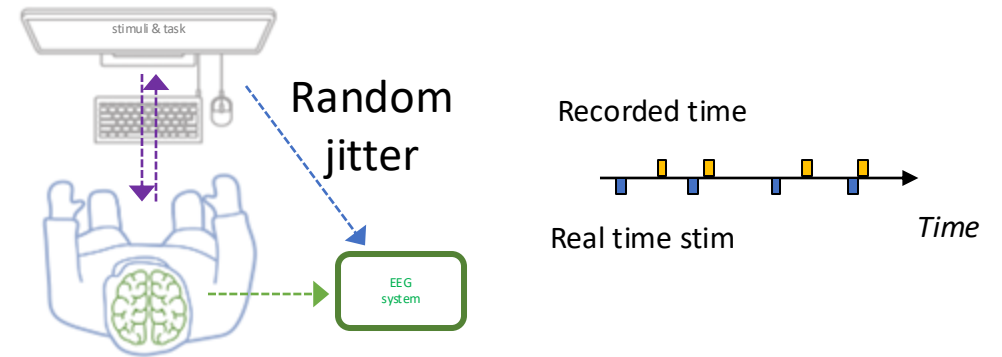
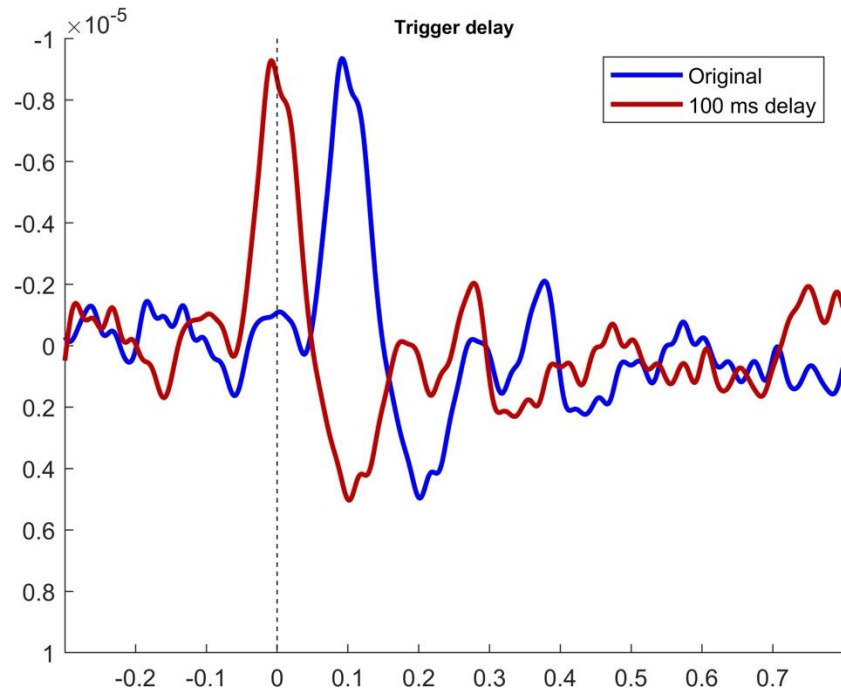
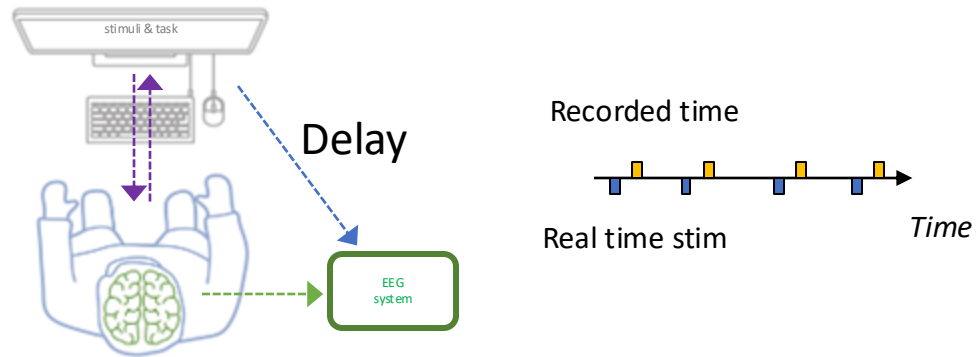


Triggers

Indicates when the relevant activity is expected to happen



Trigger timing



Good lab practice during recording

- Always keep track of protocol!
 - Keep lab notes/logbook: write everything deviating from the protocol
- Monitor EEG data quality
 - Fix bad channels (in breaks)
 - -> Note bad channels, unusual artefacts, technical errors, etc.
- Monitor participant
 - Compliance with tasks and comfort
 - Occurrence of muscle artefacts, jaw artefacts, etc.
 - Tiredness (ask to report occasionally)



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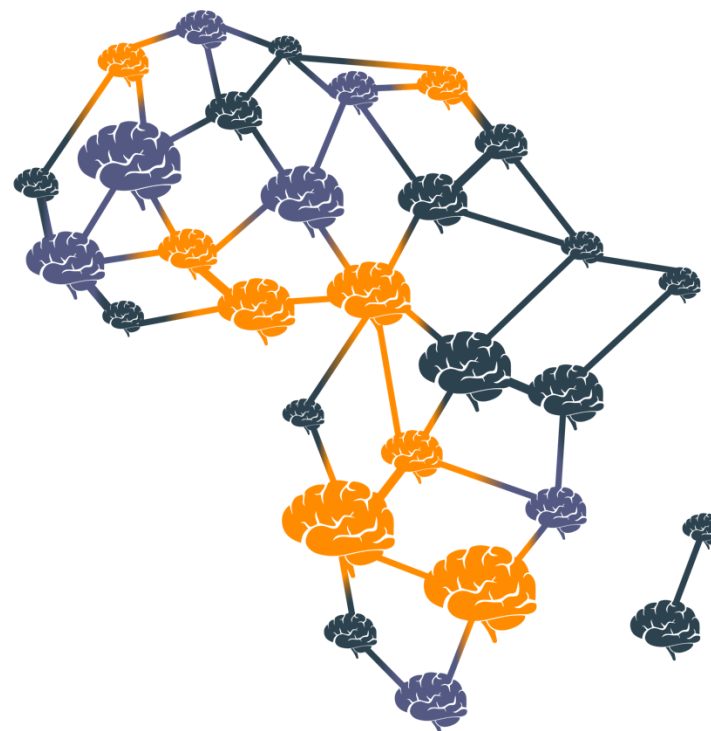
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References

- Hari R, Puce A (2017) MEG-EEG primer. Oxford University Press, New York, NY
- Luck SJ (2014) An introduction to the event-related potential technique, Second edition. The MIT Press, Cambridge, Massachusetts
- Martin RS, Huettel SA (2022) Cognitive Functions as Revealed by Imaging of the Human Brain. In: Pfaff DW, Volkow ND, Rubenstein JL (eds) Neuroscience in the 21st Century. Springer International Publishing, Cham, pp 3087–3113
- Pfurtscheller G, Lopes da Silva FL (1999) Event-related EEG/MEG synchronization and desynchronization: basic principles. Clin Neurophysiol 110:1842–1857
- Puce A, Hämäläinen M (2017) A Review of Issues Related to Data Acquisition and Analysis in EEG/MEG Studies. Brain Sci 7:58.
<https://doi.org/10.3390/brainsci7060058>