

Electrophysiology

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AARHUS UNIVERSITY



IMC
INTERACTING MINDS CENTRE



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 - Magnetoencephalography (MEG)
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 - Permutation test
 - Global field power
5. Optically-pumped magnetometers (OPMs)

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Electrophysiology

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Electrophysiology

Group term for:

- Local field potentials (single cell, multi-unit recordings)
- Electrocorticography (ECoG)
- Electroencephalography (EEG)
- Magnetoencephalography (MEG)

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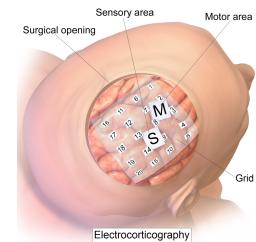
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Electrophysiology

Group term for:

- Local field potentials (single cell, multi-unit recordings)
- Electrocorticography (ECoG)
- Electroencephalography (EEG)
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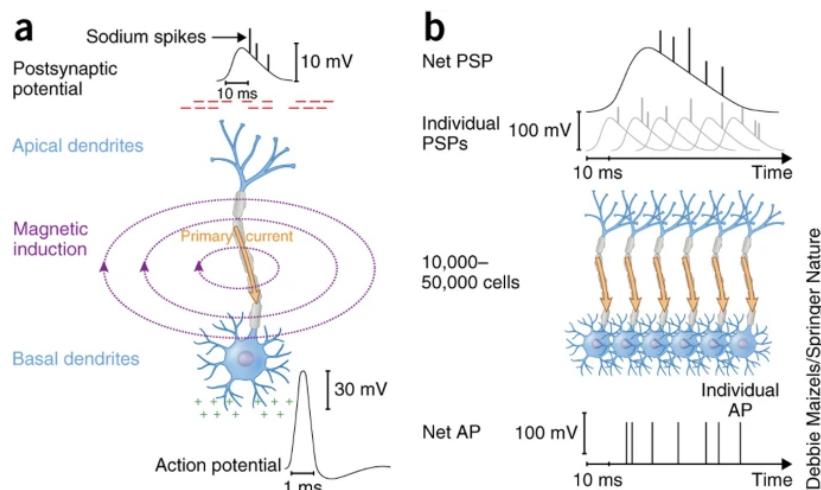
(Figure from <https://en.wikipedia.org/wiki/Electrocorticography>)

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Origin of the EEG & MEG signal



(Figure from Bailetti, 2017)

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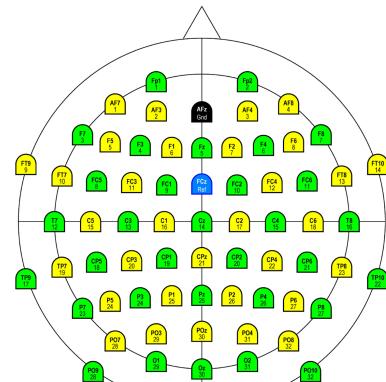
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Electroencephalography (EEG)



Brianproducts cap



Brianproducts acticap standard layout

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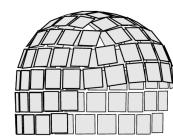
Magnetoencephalography (MEG)



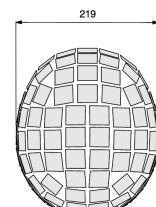
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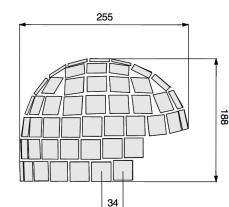
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Sensor array, right frontal view



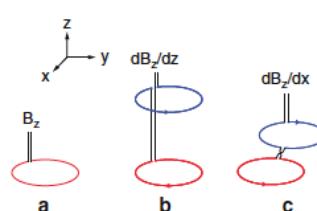
Sensor array, top view



Sensor array, side view.

MEG sensor types

Fig. 3 Typical pickup coils used in MEG measurements.
(a) Magnetometer, (b) axial first-order gradiometer, and
(c) planar first-order gradiometer



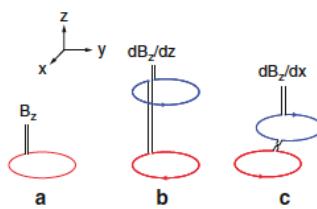
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MEG sensor types

Fig. 3 Typical pickup coils used in MEG measurements.
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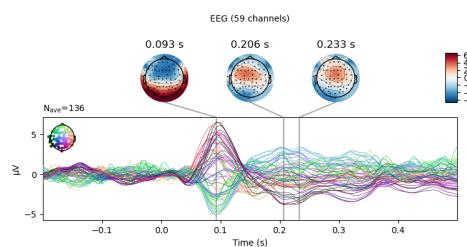
(Fig 3 from Lee & Kim, 2019, Sensors helmet: stock photo)

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Comparing EEG & MEG

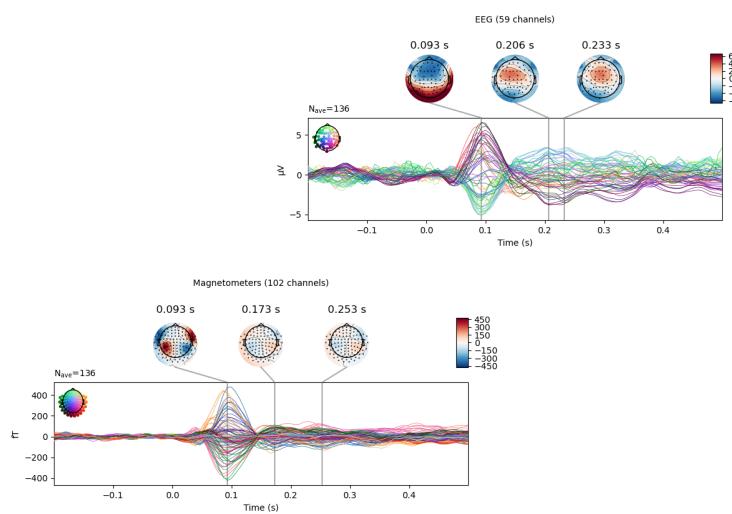


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Comparing EEG & MEG

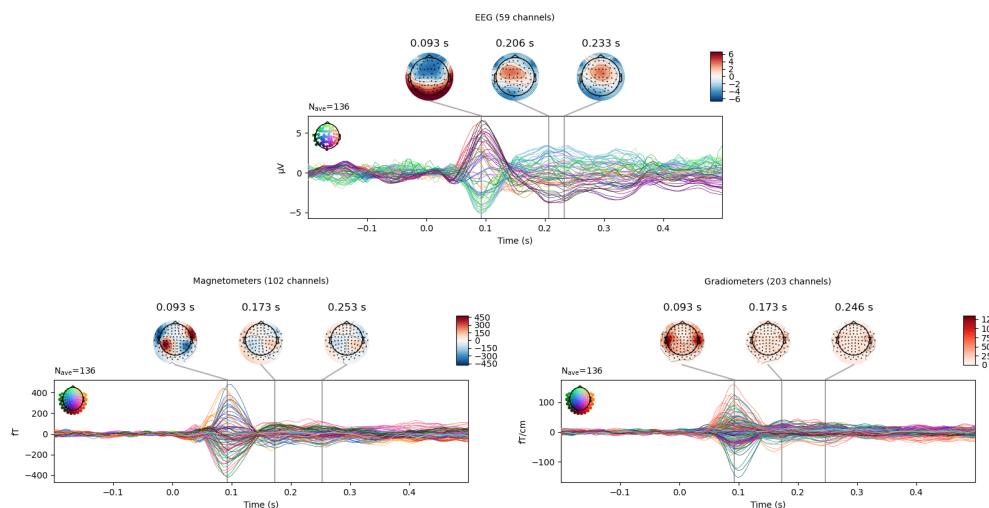


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Comparing EEG & MEG

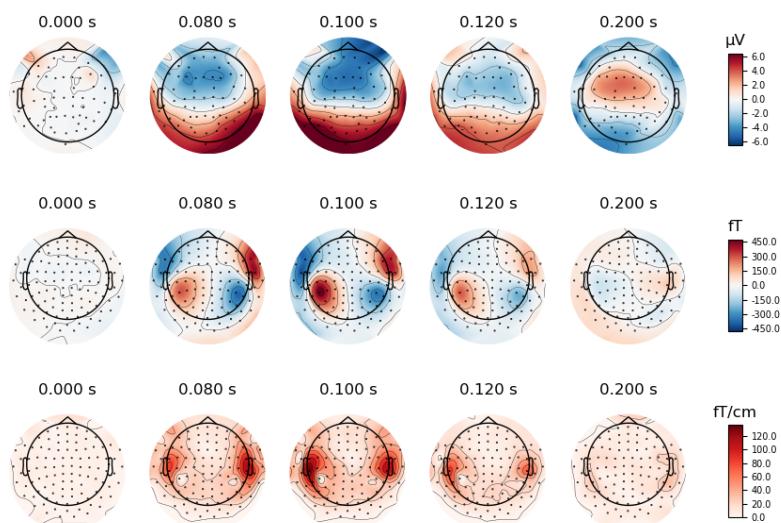


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Comparing EEG & MEG: topographies



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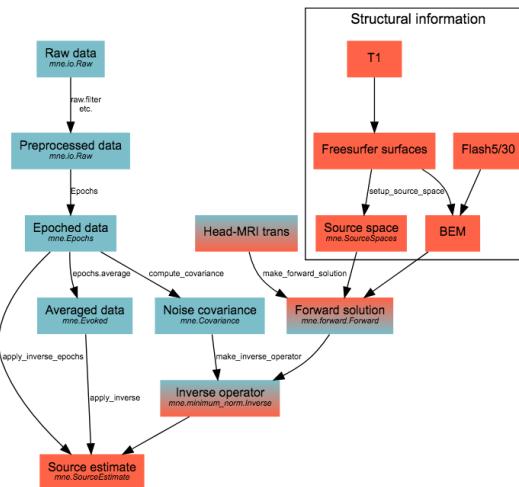
Processing of EEG/MEG data

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Workflow



(Figure from <https://mne.tools/stable/overview/cookbook.html>)

Preprocessing: standard steps

- Lowpass filter

Preprocessing: standard steps

- Lowpass filter
- Highpass filter

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Preprocessing: standard steps

- Lowpass filter
- Highpass filter
- Artefact rejection

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Preprocessing: standard steps

- Lowpass filter
- Highpass filter
- Artefact rejection
 - ▶ Ocular artifacts (EOG)

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Preprocessing: standard steps

- Lowpass filter
- Highpass filter
- Artefact rejection
 - ▶ Ocular artifacts (EOG)
 - ▶ Heartbeat artifacts (ECG)

Preprocessing: standard steps

- Lowpass filter
- Highpass filter
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 - ▶ Ocular artifacts (EOG)
 - ▶ Heartbeat artifacts (ECG)
 - ▶ Power line noise

Preprocessing: standard steps

- Lowpass filter
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Methods:

Preprocessing: standard steps

- Lowpass filter
- Highpass filter
- Artefact rejection
 - ▶ Ocular artifacts (EOG)
 - ▶ Heartbeat artifacts (ECG)
 - ▶ Power line noise

Methods:

- ▶ Thresholding

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Preprocessing: standard steps

- Lowpass filter
- Highpass filter
- Artefact rejection
 - ▶ Ocular artifacts (EOG)
 - ▶ Heartbeat artifacts (ECG)
 - ▶ Power line noise

Methods:

- ▶ Thresholding
- ▶ ICA

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Preprocessing: standard steps

- Lowpass filter
- Highpass filter
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 - ▶ Ocular artifacts (EOG)
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Methods:

- ▶ Thresholding
- ▶ ICA

- (Rereference)

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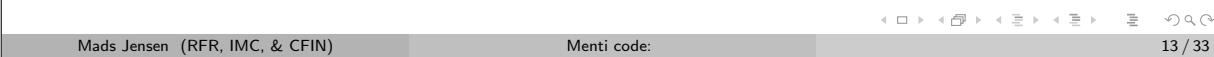


Preprocessing: standard steps

- Lowpass filter
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 - ▶ Ocular artifacts (EOG)
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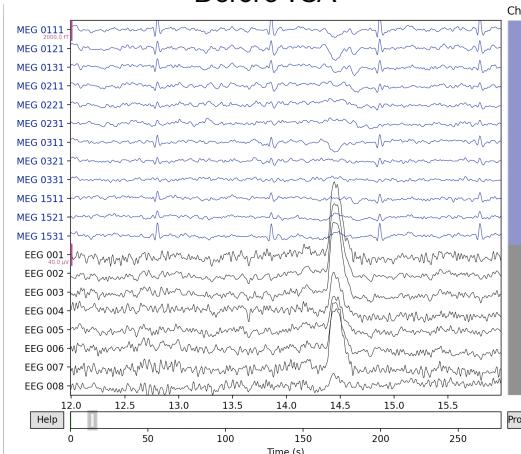
Methods:

- ▶ Thresholding
 - ▶ ICA
- (Rereference)
 - Epoching



ICA

Before ICA

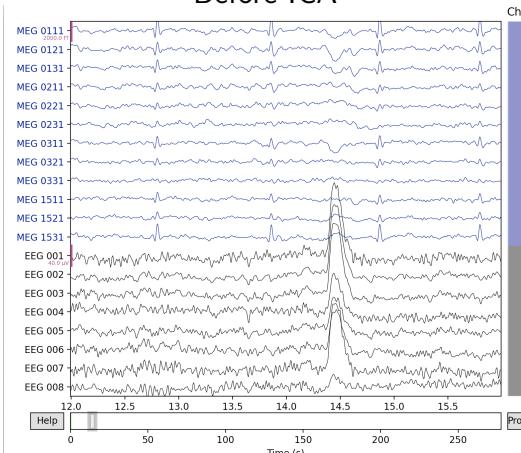


(Figure from https://mne.tools/stable/auto_tutorials/intro/plot_10_overview.html)

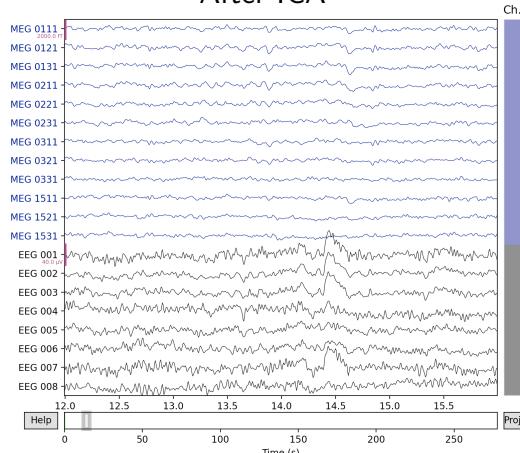


ICA

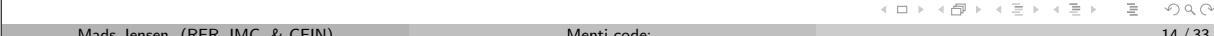
Before ICA



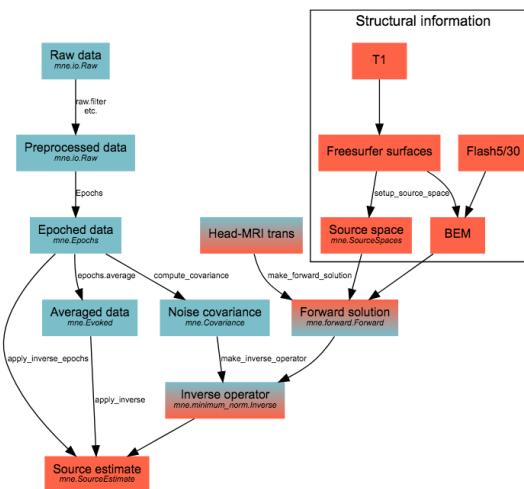
After ICA



(Figure from https://mne.tools/stable/auto_tutorials/intro/plot_10_overview.html)



Workflow



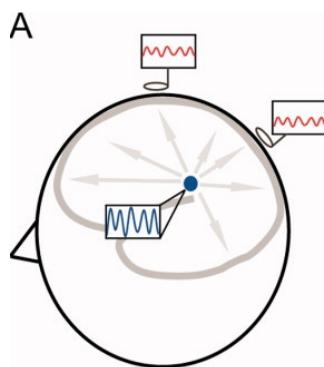
(Figure from <https://mne.tools/stable/overview/cookbook.html>)

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Volume conduction



(Figure from Schoffelen & Gross, 2009)

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Volume conduction

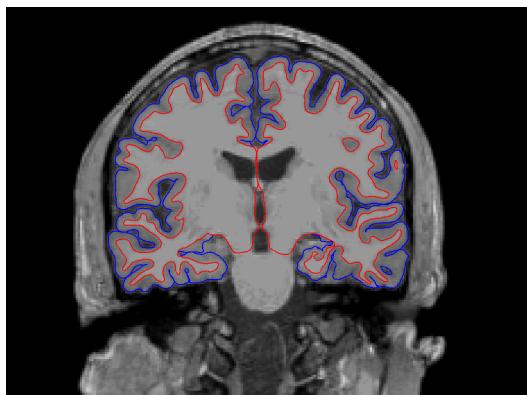


Fig: MNE sample data, made with Freeview

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Volume conduction

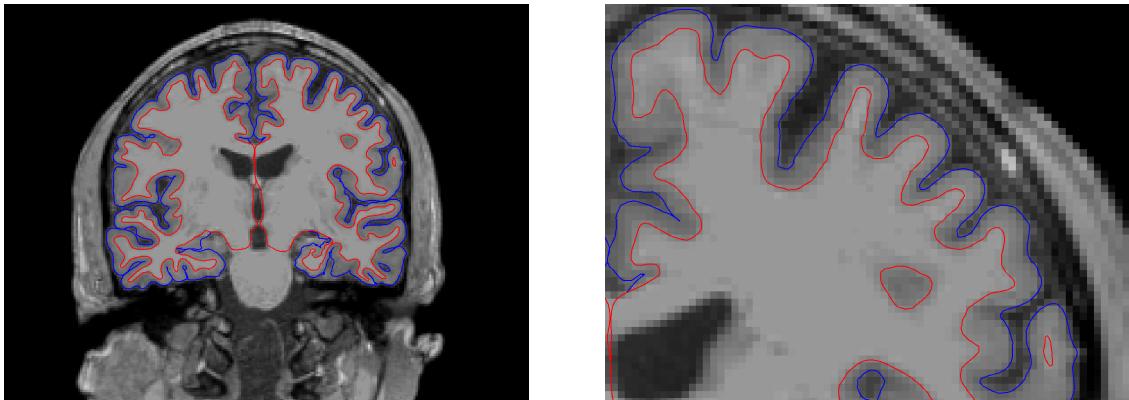


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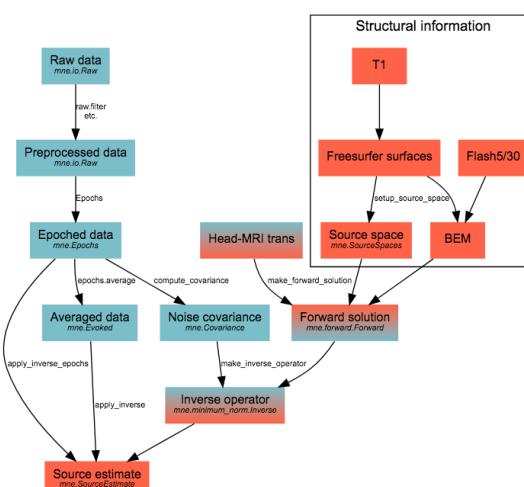
Source reconstruction

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Workflow



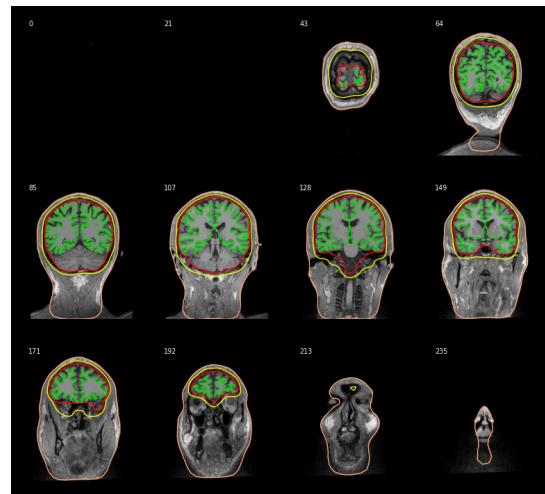
(Figure from <https://mne.tools/stable/overview/cookbook.html>)

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Boundary element method (BEM)



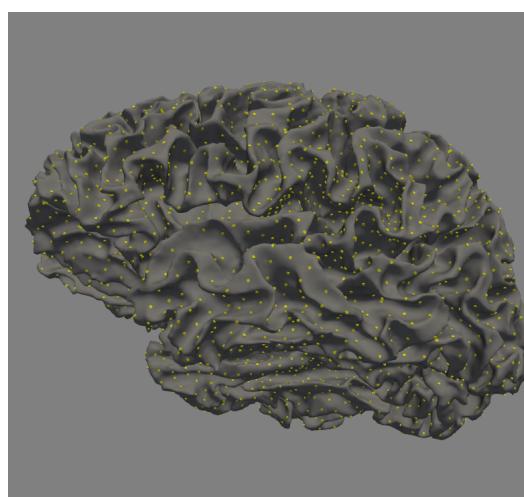
(Figure from https://mne.tools/stable/auto_tutorials/source-modeling/plot_forward.html)

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Surface based source space



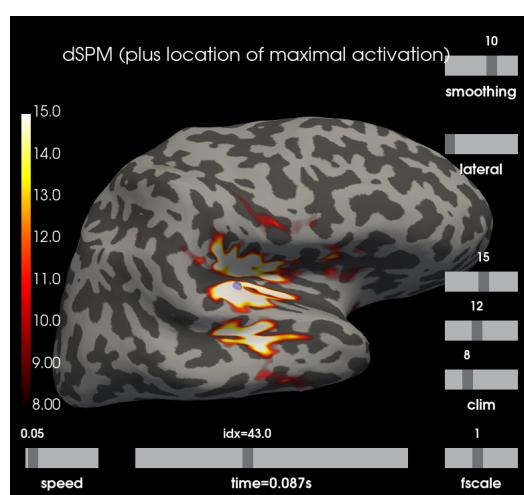
(Figure from https://mne.tools/stable/auto_tutorials/source-modeling/plot_forward.html)

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Source reconstruction: Minimum-norm estimation (MNE)



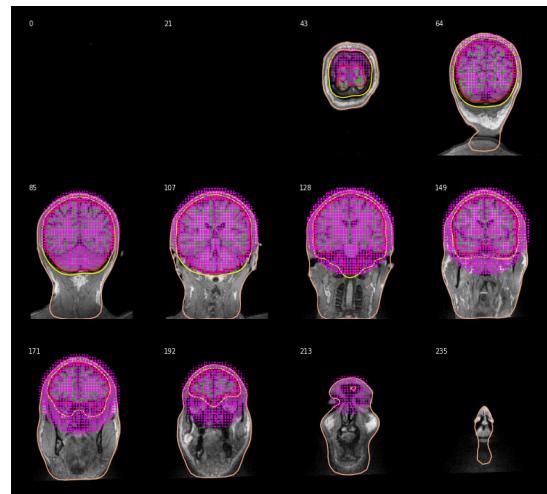
(Figure from https://mne.tools/stable/auto_tutorials/source-modeling/plot_mne_dspm_source_localization.html)

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Volumetric source space



(Figure from https://mne.tools/stable/auto_tutorials/source-modeling/plot_forward.html)

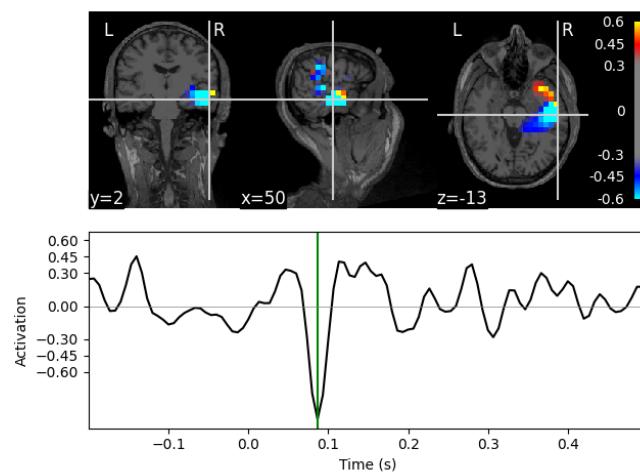


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Source reconstruction: LCMV beamformer



(Figure from https://mne.tools/stable/auto_tutorials/source-modeling/plot_mne_dspm_source_localization.html)



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Statistical assessment of M/EEG data

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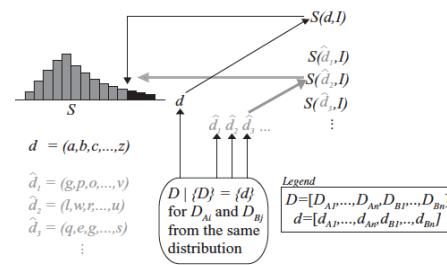
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Permutation tests

Pros:

- Works with non-Gaussian data
- Can handle multiple comparisons problem



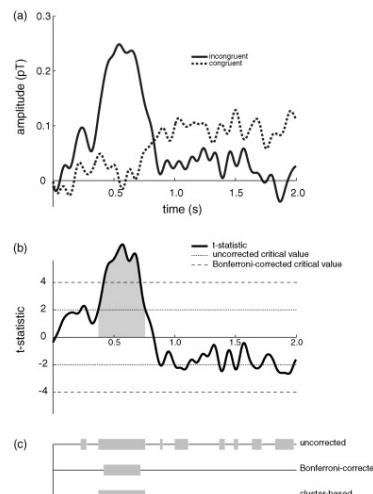
(Figure from Maris, 2012)

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Permutation tests



(Figure from Maris & Oostenveld, 2007)

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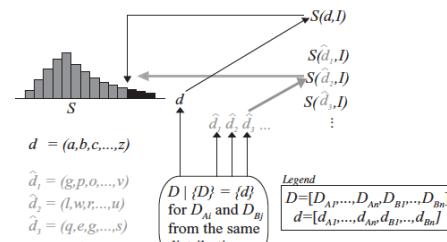
Permutation tests

Pros:

- Works with non-Gaussian data
- Can handle multiple comparisons problem

Cons:

- Only tell us that there is a difference



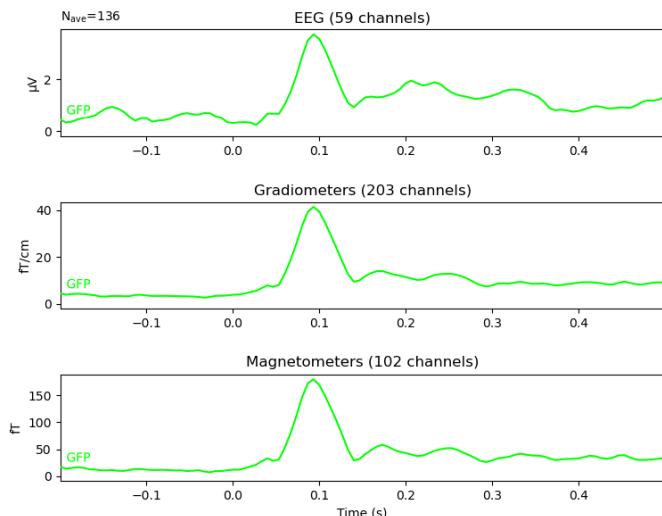
(Figure from Maris, 2012)

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Global field power



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Optically-pumped magnetometers (OPMs)



Optically-pumped magnetometers (OPMs)

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Optically-pumped magnetometers (OPMs)



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Questions?

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References I

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