Epochs and Evokeds

Let’s start with Events

Collection of timepoints and triggers attached to the EEG recording

```
Brain Vision Data Exchange Marker File, Version 1.0

[Common Infos]
Codepage=UTF-8
DataFile=MMN_1.eeg

[Marker Infos]
; Each entry: Mk<Marker number>=<Type>,<Description>,<Position in data points>,
; <Size in data points>, <Channel number (0 = marker is related to all channels)>
; Fields are delimited by commas, some fields might be omitted (empty).
; Commas in type or description text are coded as "\1".
Mk1=New Segment,,1,1,0,20250429142228342363
Mk2=Stimulus,S  1,140,1,0
Mk3=Stimulus,S  1,385,1,0
Mk4=Stimulus,S  1,629,1,0
Mk5=Stimulus,S  1,873,1,0
Mk6=Stimulus,S  1,1115,1,0
Mk7=Stimulus,S  1,1361,1,0
Mk8=Stimulus,S  1,1605,1,0
Mk9=Stimulus,S  1,1843,1,0
Mk10=Stimulus,S  1,2087,1,0
Mk11=Stimulus,S  1,2325,1,0
Mk12=Stimulus,S  3,2569,1,0
Mk13=Stimulus,S  1,2809,1,0
Mk14=Stimulus,S  2,3052,1,0
Mk15=Stimulus,S  1,3295,1,0
Mk16=Stimulus,S  5,3541,1,0
Mk17=Stimulus,S  1,3782,1,0
Mk18=Stimulus,S  2,4025,1,0
Mk19=Stimulus,S  1,4269,1,0
```

Let’s start with Events

```
events, event_id = mne.events_from_annotations(raw)
```

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Mk12=Stimulus,S  3,2569,1,0
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Mk18=Stimulus,S  2,4025,1,0
Mk19=Stimulus,S  1,4269,1,0
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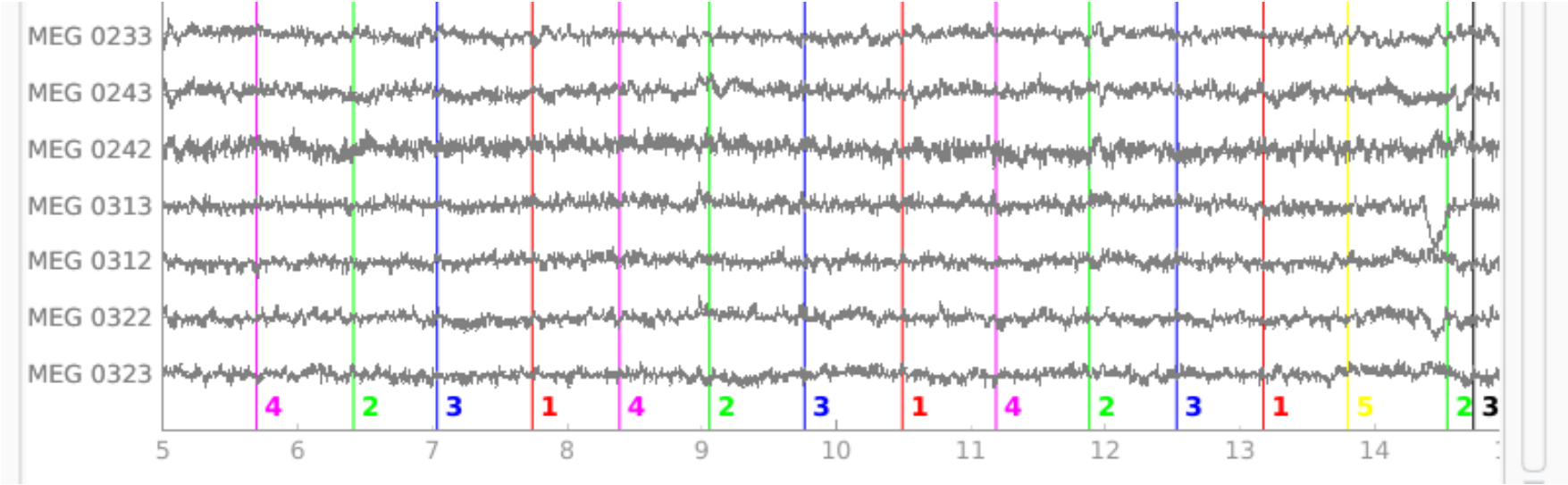
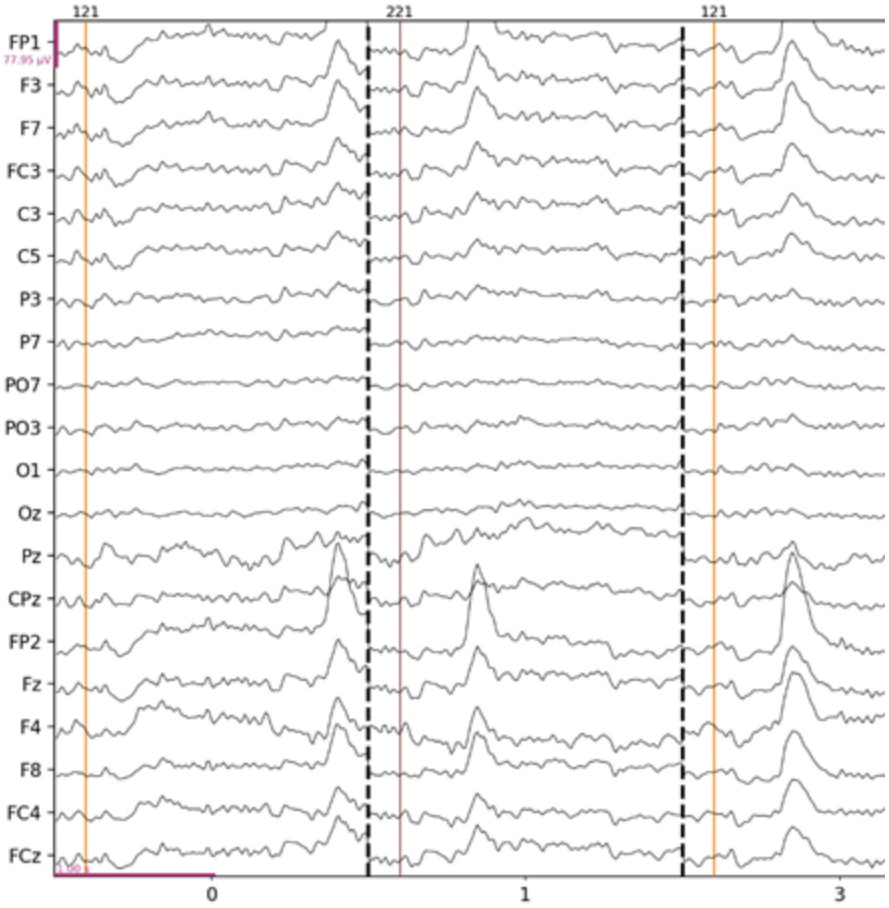
Let’s start with Events

Collection of timepoints and triggers attached to the EEG recording



From Events to Epochs

- Epochs: equal duration time-windows around every event
- Times are selected both before and after the event trigger
- Data is extracted from the raw eeg data file
- Epoch time-window should be shorter than the inter-stimulus-interval (ISI) *



MNE Epochs object

- Similar to Raw object
- Cut into time-windows and indexed in a new dimension ⟶ CONDITIONS
- Most operations that work on the Raw object, also work on Epochs objects (filtering, rereferencing, ICA, etc.)

```
In [2]: epochs.
```

add_channels()	copy	export	pick	proj	set_eeg_reference
add_proj	crop	filename	pick_channels	reject	set_meas_date
add_reference_channels	decimate	filter	pick_types	reject_by_annotation	set_montage
anonymize	del_proj	flat	picks	reject_tmax	shift_time
apply_baseline	detrend	get_channel_types	plot	reject_tmin	standard_error
apply_function	drop	get_data	plot_drop_log	rename_channels	subtract_evoked
apply_hilbert	drop_bad	get_montage	plot_image	reorder_channels	time_as_index
apply_proj	drop_channels	info	plot_projs_topomap	resample	times
as_type	drop_log	interpolate_bads	plot_psd	reset_drop_log_selection	tmax
average	drop_log_stats	iter_evoked	plot_psd_topomap	save	tmin
baseline	equalize_event_counts	load_data	plot_sensors	savgol_filter	to_data_frame
ch_names	event_id	metadata	plot_topo_image	selection	verbose
compensation_grade	events	next	preload	set_channel_types	

```
epochs = mne.Epochs(raw, events, tmin=t_min, tmax=t_max)
```

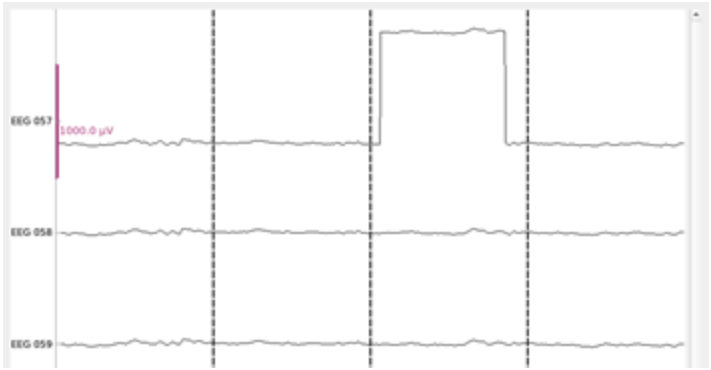
events

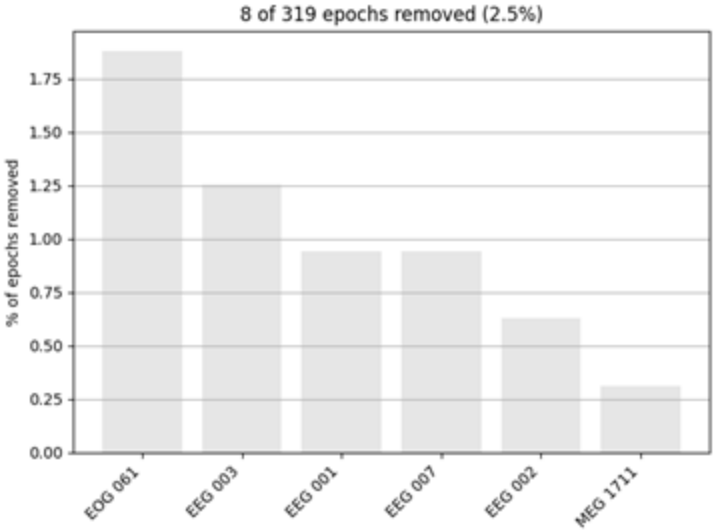
```
array([[     0,      0,  99999],
       [   139,      0,      1],
       [   384,      0,      1],
       ...,
       [477012,      0,      2],
       [477256,      0,      1],
       [477499,      0,      3]])
```

```
epochs = mne.Epochs(raw, events, tmin=t_min, tmax=t_max,
event_id=event_dict, reject=reject_criteria,
flat_criteria=flat_criteria)



reject_criteria = dict(eeg=100e-6)

flat_criteria = dict(eeg=eeg=1e-6)
```

Reject and flat criteria

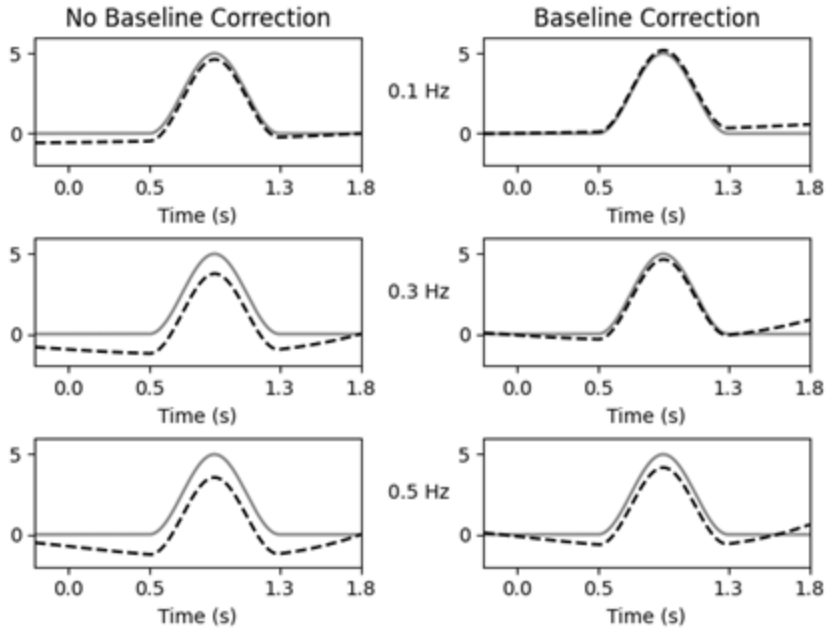
- In some epochs signal amplitude changes can be too large or too small
- These epochs should be “marked as bad” and discarded from future calculations
- Solution: thresholding by setting maximum/minimum acceptable peak-to-peak amplitudes

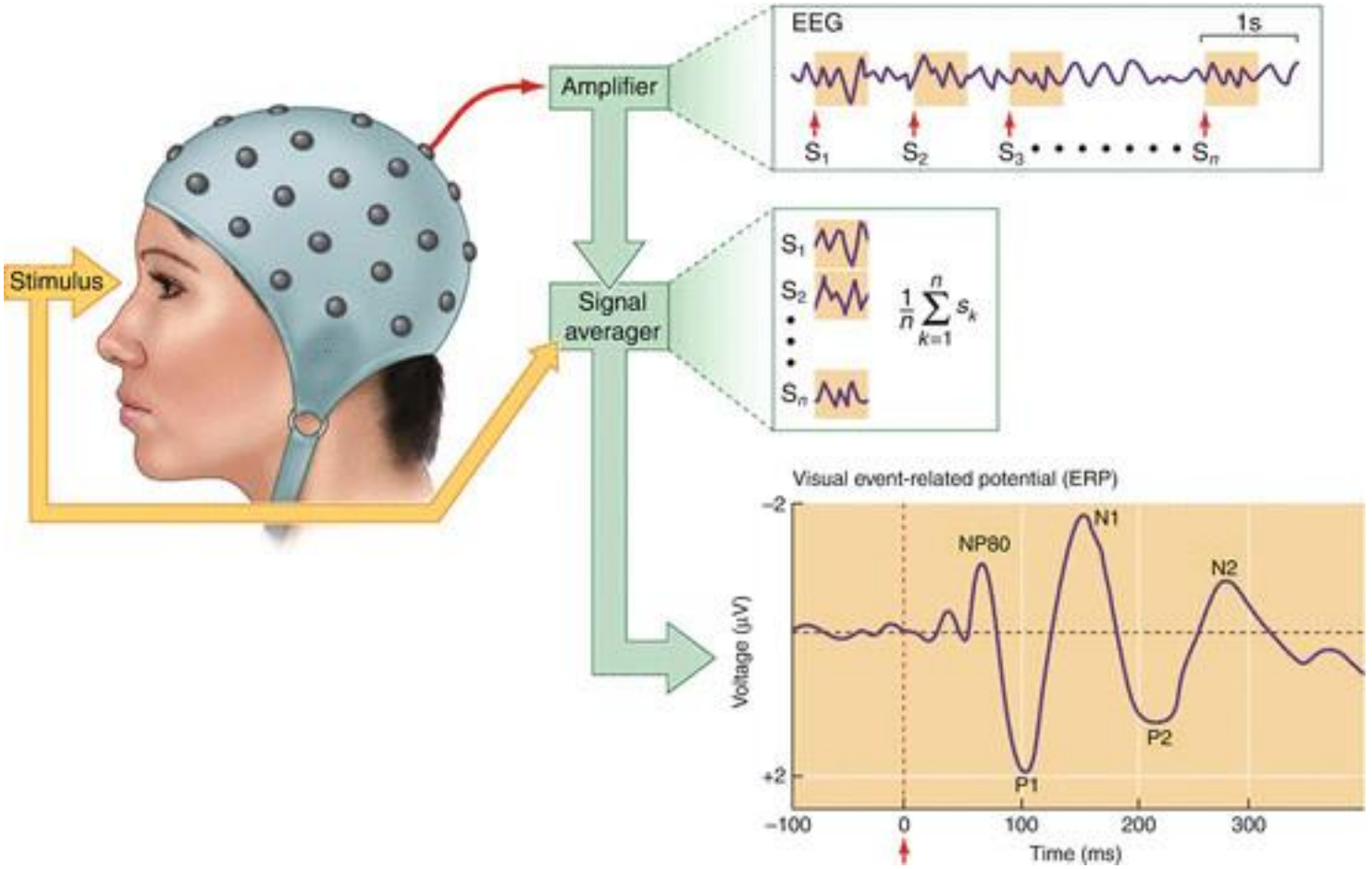




Baseline correction

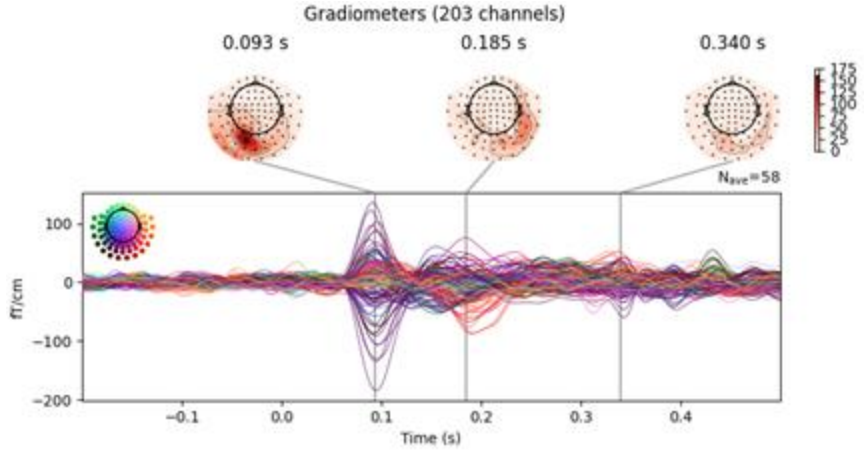
- When epochs are aligned in time their baselines are likely to be at different amplitude levels
- Correction should be applied to set them to a common level
- Baseline correction is done by averaging the signal within a defined time-window before the stimulus event on each channel

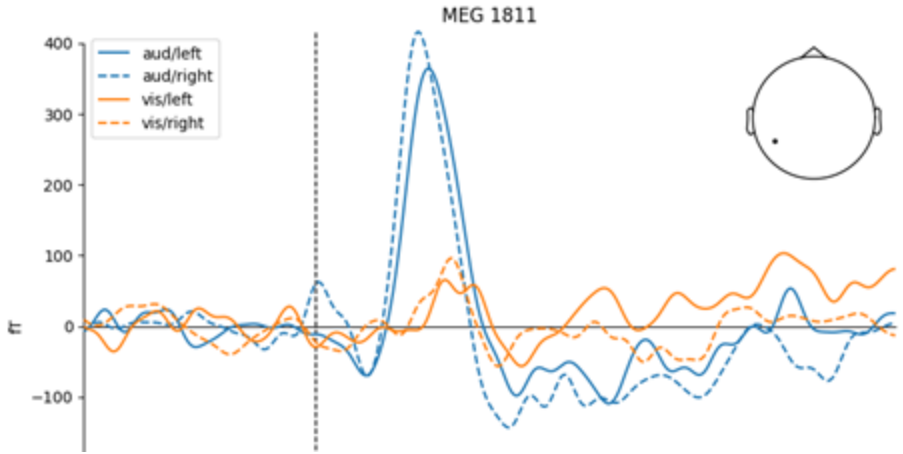



Stimulus
Amplifier
Signal averager
EEG
1s
S_1
S_2
S_3
S_n
$\frac{1}{n}\sum_{k=1}^{n} s_k$
Visual event-related potential (ERP)
NP80
N1
N2
P1
P2
−2
+2
Voltage (μV)
−100
0
100
200
300
Time (ms)

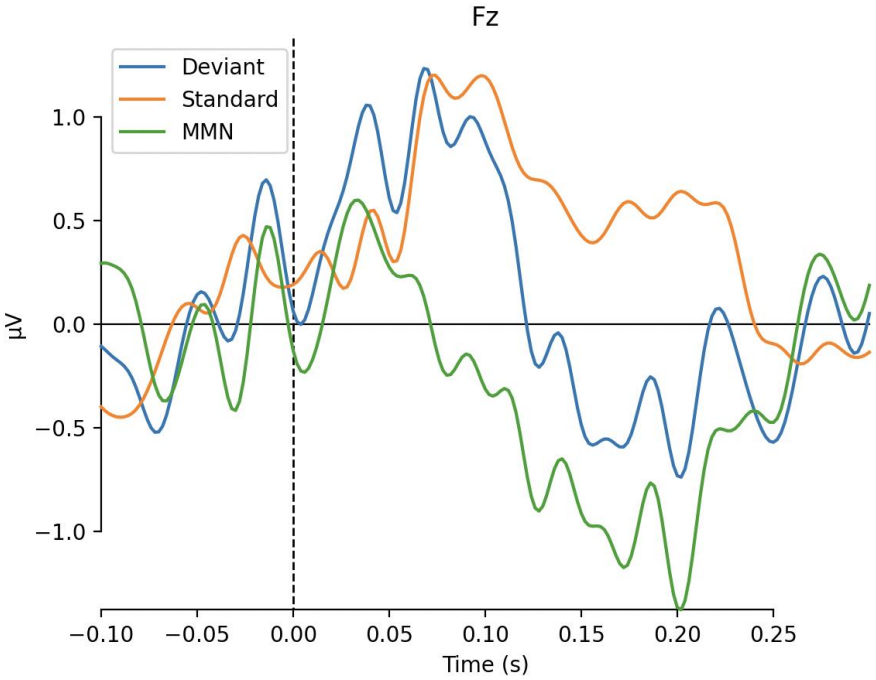
MNE Evoked object

- Evoked is the average of epochs that belong to the same condition
- Multiple evoked objects can be compared in visualisation
- Peak information can be extracted from the averaged/evoked objects

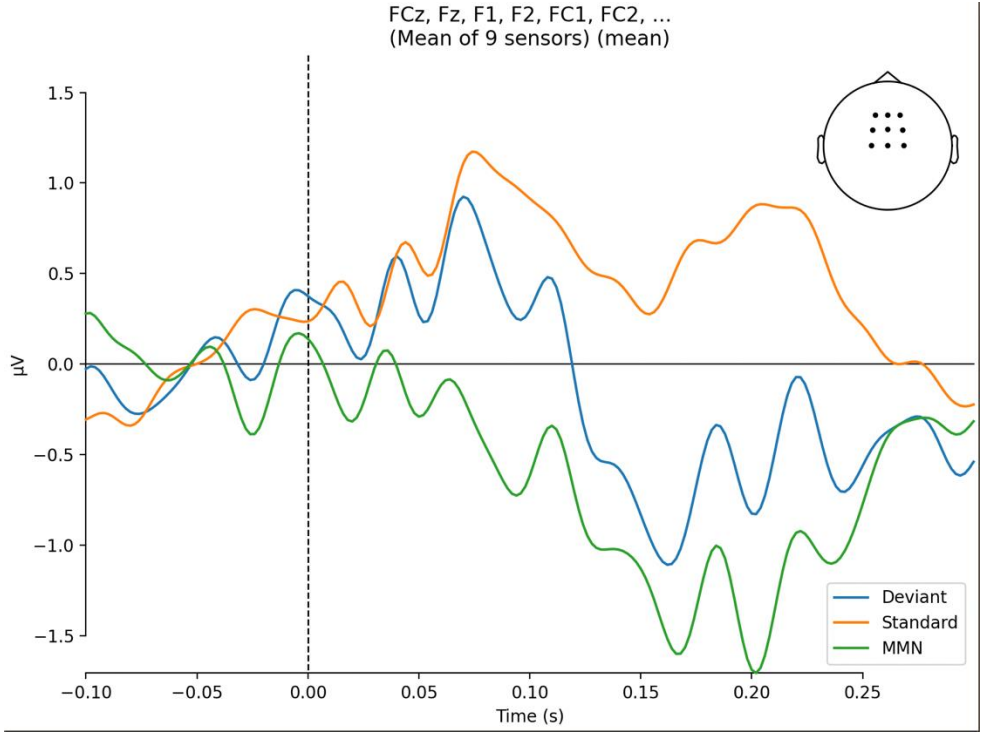




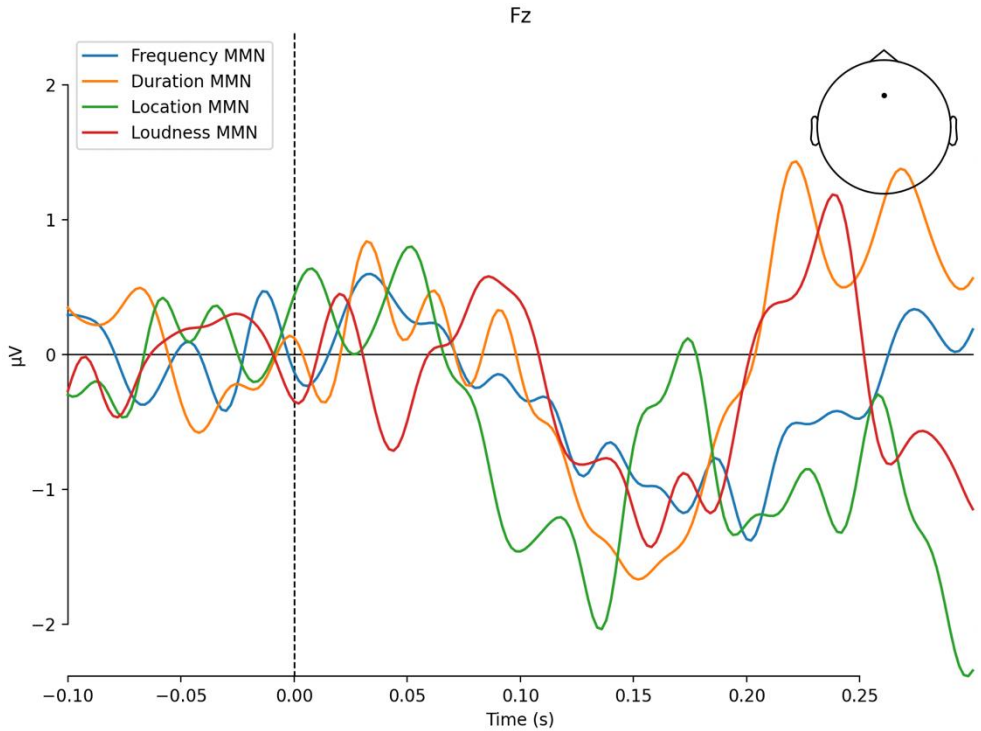
What can you do with the Evoked object?



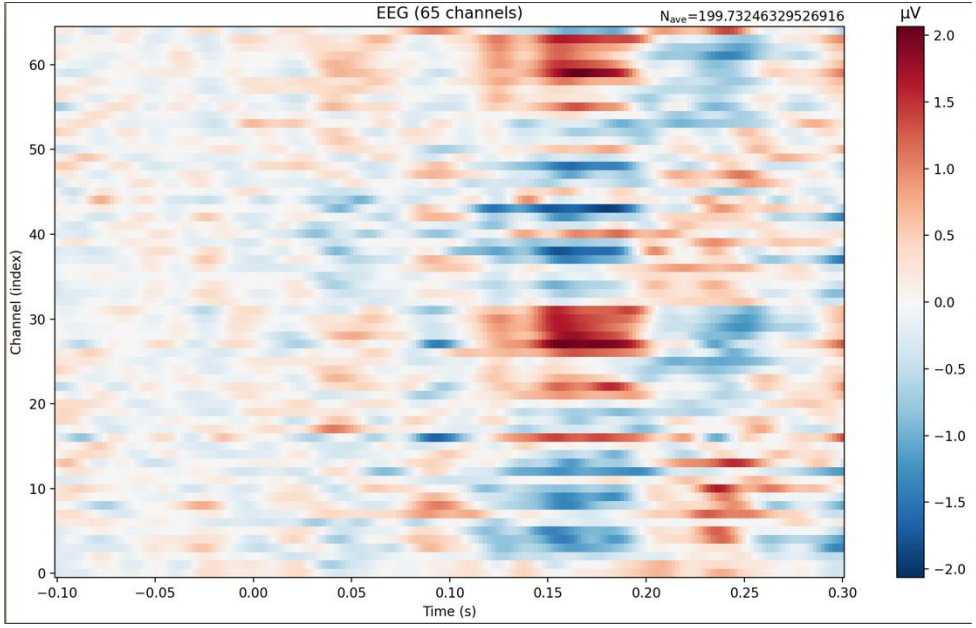

```
mne.viz.plot_compare_evokeds(
    {'Deviant':evokeds['dev_freq'], 'Standard':
evokeds['std_dev_freq'], 'MMN': mmn_freq},
    picks="eeg",
    axes="topo",
)
```




```
mne.viz.plot_compare_evokeds({'Deviant': evokeds['dev_freq'],
                              'Standard': evokeds['std_dev_freq'],
                              'MMN': mmn_freq},
                              combine='mean',
                              legend='lower right',
                              picks=['FCz', 'Fz', 'F1', 'F2', 'FC1', 'FC2', 'C1', 'C2', 'Cz'],
                              show_sensors='upper right',
                              )
```




```
mne.viz.plot_compare_evokeds({'Frequency MMN': mmn_freq,
                              'Duration MMN': mmn_dur,
                              'Location MMN': mmn_loc,
                              'Loudness MMN': mmn_loud}, picks="Fz")
```


EEG (65 channels)
N_ave=199.73246329526916
μV
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
Channel (index)
0
10
20
30
40
50
60
−0.10
−0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Time (s)