sub-101_1-raw-notch

July 14, 2025

— title: "Preprocessing of High-Density EEG Recordings" format: html: default ipynb: default execute: enabled: true —

1 0. Load parameters

```
[1]: # | tags: [parameters]
     subject = "101"
```

```
[2]: # | tags: [parameters]
     # Injected Parameters
     subject = 104
```

```
[3]: from pathlib import Path
     import os
     import mne
     import matplotlib.pyplot as plt
     import numpy as np

     from spectral.preproc import (
         load_data,
         zapline_clean,
         apply_pyprep,
     )
     from spectral.utils import ProjectPaths, print_timestamp, load_config

     mne.viz.set_browser_backend("matplotlib")
     # mne.viz.set_browser_backend("qt")
     mne.set_config("MNE_BROWSER_THEME", "light")

     # Initialize paths for your subject
     subject_id = 101  # or whatever subject you're working with
     paths = ProjectPaths(subject_id)

     # Create all directories
     paths.create_directories()

     # This is analysis output, so it goes in the analysis folder
```

```python
specparam_path = paths.analysis / "specparam"
specparam_path.mkdir(exist_ok=True)

# Print paths to verify
print_timestamp("Setting up project paths")
paths.show()
```

Using matplotlib as 2D backend.

Created directories for sub-101
Project root: /Users/daniel/PhD/Projects/psd-paths
Setting up project paths: 2025-07-14 23:42:45

Paths for sub-101
Project Root: /Users/daniel/PhD/Projects/psd-paths

    analysis   : /Users/daniel/PhD/Projects/psd-
paths/data/derivatives/sub-101/analysis
    data   : /Users/daniel/PhD/Projects/psd-paths/data/raw/sub-101
    epochs   : /Users/daniel/PhD/Projects/psd-
paths/data/derivatives/sub-101/epochs
    figures   : /Users/daniel/PhD/Projects/psd-paths/outputs/sub-101/figures
    logs   : /Users/daniel/PhD/Projects/psd-
paths/data/derivatives/sub-101/logs
    outputs   : /Users/daniel/PhD/Projects/psd-paths/outputs/sub-101
    preprocessed : /Users/daniel/PhD/Projects/psd-
paths/data/derivatives/sub-101/preprocessed
    processing   : /Users/daniel/PhD/Projects/psd-paths/data/derivatives/sub-101
    reports   : /Users/daniel/PhD/Projects/psd-paths/outputs/sub-101/reports

This file contains preprocessing files after downsampling them.

2 1. Preprocess raw data

```python
# Load the configuration
config = load_config()

# Access the bad channels list
bad_channels = config["preprocessing"]["channels_to_remove"]
print(f"Channels to remove: {bad_channels}")

fline = [50, 100]   # Line noise frequencies
h_freq = 40
l_freq = 1

filter_params = {
    "l_freq": l_freq,
```

```
    "h_freq":h_freq,
    "h_trans_bandwidth": "auto",
    "fir_window": "hamming",
    "fir_design": "firwin",
    "phase": "zero",
    "picks": ["ecg", "eeg"],
}

raw = load_data(subject_id, data_path=paths.data).resample(
    250, method="polyphase", verbose=True
)
total_duration = raw.times[-1]

raw_filtered = (
    raw.copy()
    .resample(250, method="polyphase", verbose=True)
    .drop_channels(bad_channels)
    .notch_filter(freqs=[fline], method="fir",  picks=['eeg', 'ecg'])
    .filter(**filter_params)
    .crop(tmin=3.0, tmax=total_duration - 3, include_tmax=True)
)
```

Channels to remove: ['E67', 'E73', 'E82', 'E91', 'E92', 'E102', 'E111', 'E120',
'E133', 'E145', 'E165', 'E174', 'E187', 'E199', 'E208', 'E209', 'E216', 'E217',
'E218', 'E219', 'E225', 'E226', 'E227', 'E228', 'E229', 'E230', 'E231', 'E232',
'E233', 'E234', 'E235', 'E236', 'E237', 'E238', 'E239', 'E240', 'E241', 'E242',
'E243', 'E244', 'E245', 'E246', 'E247', 'E248', 'E249', 'E250', 'E251', 'E252',
'E253', 'E254', 'E255', 'E256']
Loading data from: /Users/daniel/PhD/Projects/psd-
paths/data/raw/sub-101/ses-01/eeg/sub-101_ses-01_task-rest_eeg.set

Loaded 258 channels, 300.4 seconds of data
Identified ECG channels: ['ECG']
Removed 'VREF' channel.
Applying GSN-HydroCel-256 montage…

Polyphase resampling neighborhood: ±2 input samples

Sampling frequency of the instance is already 250.0, returning unmodified.

Filtering raw data in 1 contiguous segment

Setting up band-stop filter

FIR filter parameters

Designing a one-pass, zero-phase, non-causal bandstop filter:

- Windowed time-domain design (firwin) method

- Hamming window with 0.0194 passband ripple and 53 dB stopband attenuation

- Lower transition bandwidth: 0.50 Hz

- Upper transition bandwidth: 0.50 Hz

- Filter length: 1651 samples (6.604 s)

```
[Parallel(n_jobs=1)]: Done  17 tasks      | elapsed:    0.0s
[Parallel(n_jobs=1)]: Done  71 tasks      | elapsed:    0.1s
[Parallel(n_jobs=1)]: Done 161 tasks      | elapsed:    0.2s
```

Filtering raw data in 1 contiguous segment

Setting up band-pass filter from 1 - 40 Hz

FIR filter parameters

Designing a one-pass, zero-phase, non-causal bandpass filter:

- Windowed time-domain design (firwin) method

- Hamming window with 0.0194 passband ripple and 53 dB stopband attenuation

- Lower passband edge: 1.00

- Lower transition bandwidth: 1.00 Hz (-6 dB cutoff frequency: 0.50 Hz)

- Upper passband edge: 40.00 Hz

- Upper transition bandwidth: 10.00 Hz (-6 dB cutoff frequency: 45.00 Hz)

- Filter length: 825 samples (3.300 s)

```
[Parallel(n_jobs=1)]: Done 205 out of 205 | elapsed:    0.2s finished
[Parallel(n_jobs=1)]: Done  17 tasks      | elapsed:    0.0s
[Parallel(n_jobs=1)]: Done  71 tasks      | elapsed:    0.1s

[Parallel(n_jobs=1)]: Done 161 tasks      | elapsed:    0.2s
[Parallel(n_jobs=1)]: Done 205 out of 205 | elapsed:    0.2s finished
```

```python
[5]: fig, ax = plt.subplots(figsize=(10, 5))
     raw_psd = raw_filtered.compute_psd(
         fmax=60.0, method="welch", picks="eeg", exclude="bads"
     ).plot(average=False, picks="eeg", exclude="bads", show=False, axes=ax,
       ↪amplitude=False)
     ax.set_title(f"sub-{subject_id} PSD")
```

Effective window size : 8.192 (s)

Plotting power spectral density (dB=True).

sub-101 PSD
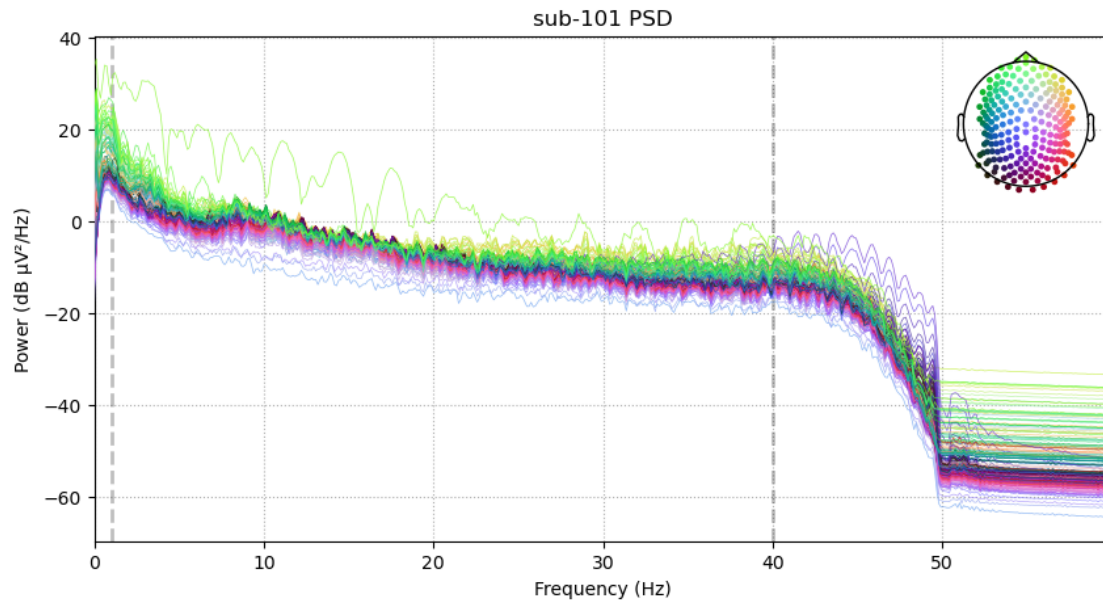
```
[6]: iter_param = {
         "n_iter_max": 100,
         "win_sz": 12.5,
         "spot_sz": 6,
     }

     filter_params = {
         "l_freq": 1,
         "h_freq": 100,
         "h_trans_bandwidth": "auto",
         "fir_window": "hamming",
         "fir_design": "firwin2",
         "phase": "zero",
         "picks": ["ecg", "eeg"],
     }

     raw = load_data(subject_id, data_path=paths.data)
     total_duration = raw.times[-1]

     raw_zap = (
         raw.copy()
         .drop_channels(bad_channels)
         .filter(**filter_params)
         .crop(tmin=3.0, tmax=total_duration - 3, include_tmax=True)
     )
```

```
zap = zapline_clean(raw_zap, fline=50.0, ntimes=3, method="line",␣
  ↪iter_param=iter_param)
```

Loading data from: /Users/daniel/PhD/Projects/psd-
paths/data/raw/sub-101/ses-01/eeg/sub-101_ses-01_task-rest_eeg.set

Loaded 258 channels, 300.4 seconds of data
Identified ECG channels: ['ECG']
Removed 'VREF' channel.
Applying GSN-HydroCel-256 montage…

Filtering raw data in 1 contiguous segment

Setting up band-pass filter from 1 - 1e+02 Hz

FIR filter parameters

Designing a one-pass, zero-phase, non-causal bandpass filter:

- Windowed frequency-domain design (firwin2) method

- Hamming window

- Lower passband edge: 1.00

- Lower transition bandwidth: 1.00 Hz (-6 dB cutoff frequency: 0.50 Hz)

- Upper passband edge: 100.00 Hz

- Upper transition bandwidth: 25.00 Hz (-6 dB cutoff frequency: 112.50 Hz)

- Filter length: 6601 samples (6.601 s)

[Parallel(n_jobs=1)]: Done   17 tasks | elapsed: 0.1s

[Parallel(n_jobs=1)]: Done   71 tasks | elapsed: 0.4s

[Parallel(n_jobs=1)]: Done 161 tasks | elapsed: 0.9s

[Parallel(n_jobs=1)]: Done 205 out of 205 | elapsed: 1.1s finished

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/dss.py:120: RuntimeWarning: divide by zero encountered in
matmul
  c2 = (eigvec0 @ W).T @ c1 @ (eigvec0 @ W)
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/dss.py:120: RuntimeWarning: overflow encountered in matmul
  c2 = (eigvec0 @ W).T @ c1 @ (eigvec0 @ W)
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/dss.py:120: RuntimeWarning: invalid value encountered in matmul
```

```
    c2 = (eigvec0 @ W).T @ c1 @ (eigvec0 @ W)
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:126: RuntimeWarning: divide by zero encountered in matmul
```
  todss = eigvec0 @ W @ eigvec2
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:126: RuntimeWarning: overflow encountered in matmul
```
  todss = eigvec0 @ W @ eigvec2
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:126: RuntimeWarning: invalid value encountered in matmul
```
  todss = eigvec0 @ W @ eigvec2
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:129: RuntimeWarning: divide by zero encountered in matmul
```
  N = np.sqrt(np.diag(todss.T @ c0 @ todss))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:129: RuntimeWarning: overflow encountered in matmul
```
  N = np.sqrt(np.diag(todss.T @ c0 @ todss))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:129: RuntimeWarning: invalid value encountered in matmul
```
  N = np.sqrt(np.diag(todss.T @ c0 @ todss))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:132: RuntimeWarning: divide by zero encountered in matmul
```
  pwr0 = np.sqrt(np.sum((c0 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:132: RuntimeWarning: overflow encountered in matmul
```
  pwr0 = np.sqrt(np.sum((c0 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:132: RuntimeWarning: invalid value encountered in matmul
```
  pwr0 = np.sqrt(np.sum((c0 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:133: RuntimeWarning: divide by zero encountered in matmul
```
  pwr1 = np.sqrt(np.sum((c1 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:133: RuntimeWarning: overflow encountered in matmul
```
  pwr1 = np.sqrt(np.sum((c1 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/meegkit/dss.py:133: RuntimeWarning: invalid value encountered in matmul
```
  pwr1 = np.sqrt(np.sum((c1 @ todss) ** 2, axis=0))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/scipy/linalg/_basic.py:1648: RuntimeWarning: divide by zero encountered in matmul
```
  B = (u @ vh[:rank]).conj().T
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-packages/scipy/linalg/_basic.py:1648: RuntimeWarning: overflow encountered in matmul

```
  B = (u @ vh[:rank]).conj().T
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: invalid value encountered
in matmul
```
  B = (u @ vh[:rank]).conj().T
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/matrix.py:629: RuntimeWarning: divide by zero encountered
in matmul
```
  return X @ mixin
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/matrix.py:629: RuntimeWarning: overflow encountered in
matmul
```
  return X @ mixin
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/matrix.py:629: RuntimeWarning: invalid value encountered
in matmul
```
  return X @ mixin
```

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:182: RuntimeWarning: divide by zero encountered in
matmul
```
  z[…, t] = R[…, t] @ V
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:182: RuntimeWarning: overflow encountered in matmul
```
  z[…, t] = R[…, t] @ V
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:182: RuntimeWarning: invalid value encountered in
matmul
```
  z[…, t] = R[…, t] @ V
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/covariances.py:412: RuntimeWarning: divide by zero
encountered in matmul
```
  R = V @ R # np.dot(np.squeeze(V), np.squeeze(R))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/covariances.py:412: RuntimeWarning: overflow encountered
in matmul
```
  R = V @ R # np.dot(np.squeeze(V), np.squeeze(R))
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/utils/covariances.py:412: RuntimeWarning: invalid value
encountered in matmul
```
  R = V @ R # np.dot(np.squeeze(V), np.squeeze(R))
```

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:195: RuntimeWarning: divide by zero encountered in
matmul
```
  z = multishift(R[…, t], shifts, reshape=True) @ regression
```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:195: RuntimeWarning: overflow encountered in matmul
```
  z = multishift(R[…, t], shifts, reshape=True) @ regression
```

```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/meegkit/tspca.py:195: RuntimeWarning: invalid value encountered in
matmul
  z = multishift(R[…, t], shifts, reshape=True) @ regression
```

Power of components removed by DSS: 0.55

Power of components removed by DSS: 0.00

Power of components removed by DSS: 0.00
Creating RawArray with float64 data, n_channels=205, n_times=294398

    Range : 0 … 294397 =   0.000 …   294.397 secs

Ready.

[7]:
```python
filter_params = {
    "l_freq": 1,
    "h_freq": 40,
    "h_trans_bandwidth": "auto",
    "fir_window": "hamming",
    "fir_design": "firwin2",
    "phase": "zero",
    "picks": ["ecg", "eeg"],
}

zap_filtered = zap.filter(**filter_params).notch_filter(
    freqs=[50], phase="zero", method="iir"
)

fig, ax = plt.subplots(figsize=(10, 5))
raw_psd = zap_filtered.compute_psd(
    fmax=60.0, method="welch", picks="eeg", exclude="bads"
).plot(average=False, picks="eeg", exclude="bads", show=False, axes=ax,
  ↪amplitude=False)
ax.set_title(f"sub-{subject_id} PSD")
```

Filtering raw data in 1 contiguous segment

Setting up band-pass filter from 1 - 40 Hz

FIR filter parameters

Designing a one-pass, zero-phase, non-causal bandpass filter:

- Windowed frequency-domain design (firwin2) method

- Hamming window

- Lower passband edge: 1.00
```

- Lower transition bandwidth: 1.00 Hz (-6 dB cutoff frequency: 0.50 Hz)

- Upper passband edge: 40.00 Hz

- Upper transition bandwidth: 10.00 Hz (-6 dB cutoff frequency: 45.00 Hz)

- Filter length: 6601 samples (6.601 s)


```
[Parallel(n_jobs=1)]: Done   17 tasks       | elapsed:     0.1s
[Parallel(n_jobs=1)]: Done   71 tasks       | elapsed:     0.5s
[Parallel(n_jobs=1)]: Done  161 tasks       | elapsed:     1.1s
[Parallel(n_jobs=1)]: Done  205 out of 205 | elapsed:     1.4s finished
Filtering raw data in 1 contiguous segment
Setting up band-stop filter from 49 - 51 Hz
```


IIR filter parameters

Butterworth bandstop zero-phase (two-pass forward and reverse) non-causal filter:

- Filter order 16 (effective, after forward-backward)

- Cutoffs at 49.38, 50.62 Hz: -6.02, -6.02 dB

Effective window size : 2.048 (s)

Plotting power spectral density (dB=True).

[7]: Text(0.5, 1.0, 'sub-101 PSD')

sub-101 PSD

```
[8]: bad_channels_by_ransac = apply_pyprep(zap_filtered, output="dict", as_dict=True)
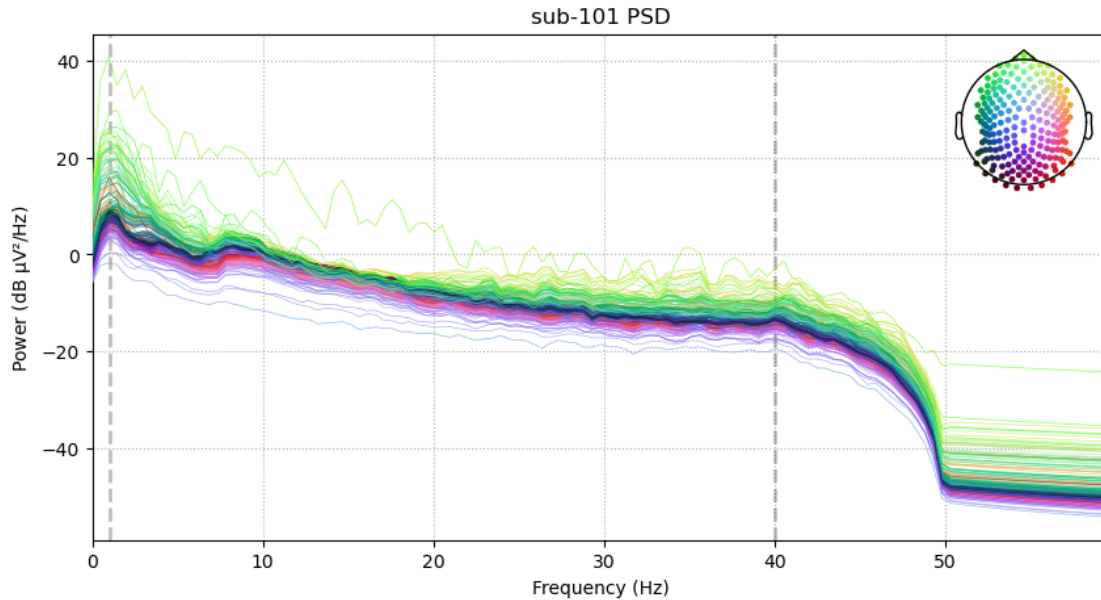
     print(bad_channels_by_ransac["bad_all"])
```

NOTE: pick_types() is a legacy function. New code should use inst.pick(…).

Setting up high-pass filter at 1 Hz

FIR filter parameters

Designing a one-pass, zero-phase, non-causal highpass filter:

- Windowed time-domain design (firwin) method

- Hamming window with 0.0194 passband ripple and 53 dB stopband attenuation

- Lower passband edge: 1.00

- Lower transition bandwidth: 1.00 Hz (-6 dB cutoff frequency: 0.50 Hz)

- Filter length: 413 samples (3.304 s)


```
[Parallel(n_jobs=1)]: Done   17 tasks      | elapsed:    0.0s
[Parallel(n_jobs=1)]: Done   71 tasks      | elapsed:    0.1s
[Parallel(n_jobs=1)]: Done  161 tasks      | elapsed:    0.1s
[Parallel(n_jobs=1)]: Done  204 out of 204 | elapsed:    0.1s finished
```

```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: divide by zero
encountered in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: overflow encountered
in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: invalid value
encountered in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
```

```
Executing RANSAC
This may take a while, so be patient…
```

```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/pyprep/ransac.py:526: RuntimeWarning: divide by zero encountered in
matmul
  eeg_predictions[…, sample] = np.matmul(interp_mat, data[reconstr_idx, :])
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/pyprep/ransac.py:526: RuntimeWarning: overflow encountered in matmul
  eeg_predictions[…, sample] = np.matmul(interp_mat, data[reconstr_idx, :])
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/pyprep/ransac.py:526: RuntimeWarning: invalid value encountered in
matmul
  eeg_predictions[…, sample] = np.matmul(interp_mat, data[reconstr_idx, :])
```

```
Finding optimal chunk size : 202
```

```
Total # of chunks: 1
```

```
Current chunk:
```
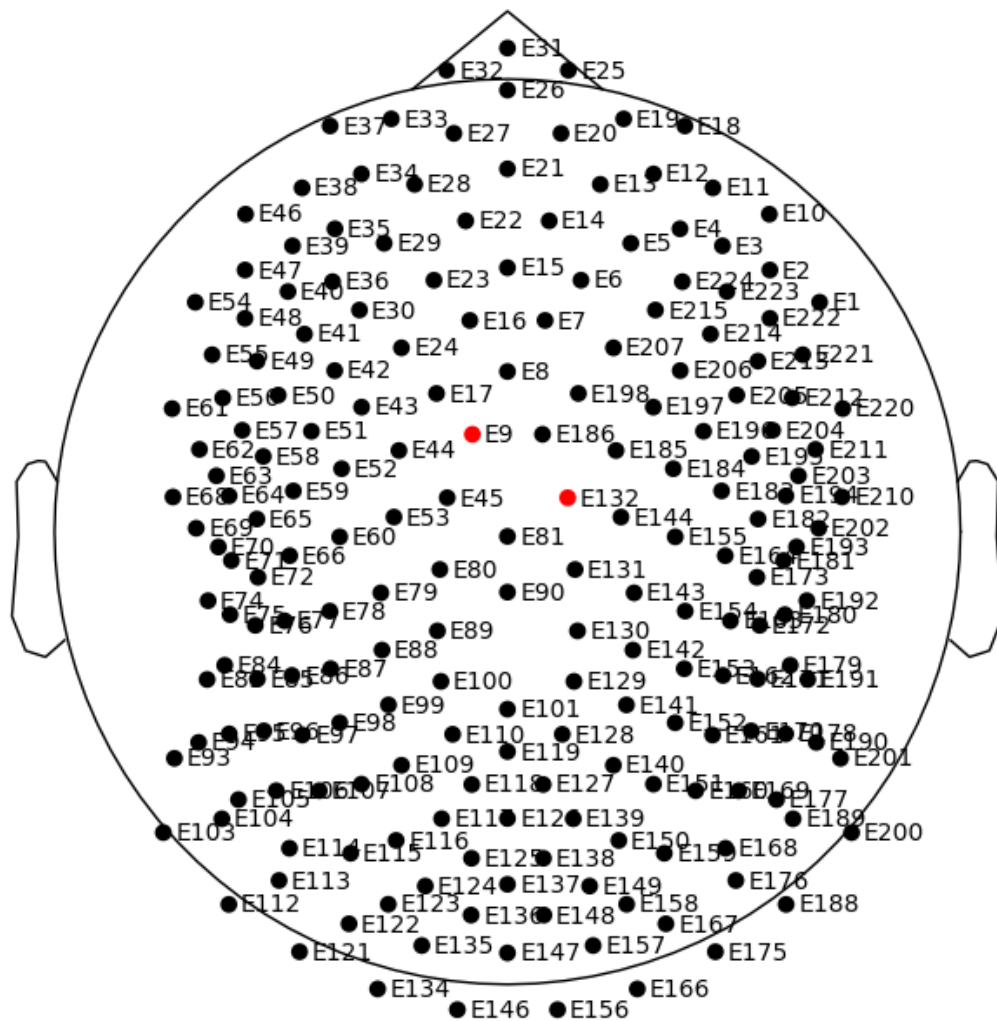
```
1
```

```
RANSAC done!
```
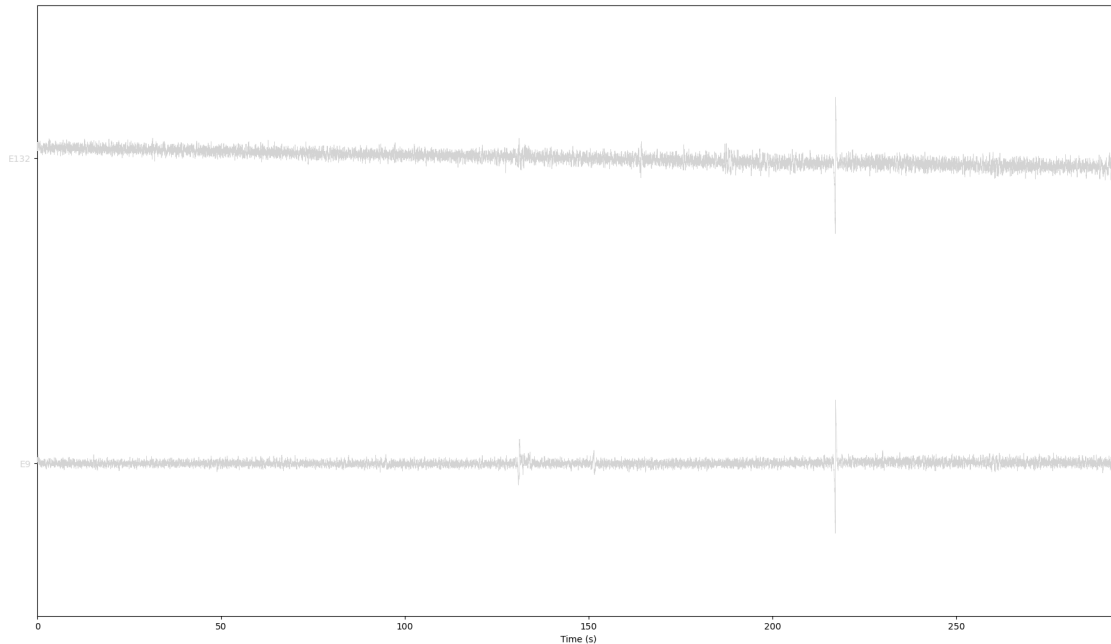
```
['E132', 'E9']
```

```
[9]: zap_ransac = zap_filtered.copy()
     zap_ransac.info["bads"].extend(bad_channels_by_ransac["bad_all"])
     sensor_plot = zap_ransac.plot_sensors(show_names=True)
     zap_ransac.copy().pick(bad_channels_by_ransac["bad_all"]).plot(
         duration=300.0,
         scalings=dict(eeg=1e-4),
         show_scrollbars=False,
     )
     zap_ransac.save(
         f"{paths.preprocessed}/sub-{subject_id}_filtered_raw.fif", overwrite=True
```

)

Overwriting existing file.

Writing /Users/daniel/PhD/Projects/psd-paths/data/derrivatives/sub-101/preprocessed/sub-101_filtered_raw.fif

Closing /Users/daniel/PhD/Projects/psd-paths/data/derrivatives/sub-101/preprocessed/sub-101_filtered_raw.fif

[done]

[9]: [PosixPath('/Users/daniel/PhD/Projects/psd-paths/data/derrivatives/sub-101/preprocessed/sub-101_filtered_raw.fif')]

```python
[10]: from spectral.epochs import create_epochs, get_reject_log

# raw_annotated = raw_pyprep.copy()
epochs = create_epochs(zap_ransac, overlap=1.5)

reject_log = get_reject_log(epochs, resample=125, n_interpolate=[1],␣
  ↪consensus=[0.35])
reject_plot = reject_log.plot("vertical")


# Drop channels with more than 40% bad epochs
BADS_THRESHOLD = 0.40

bads = np.logical_or(reject_log.labels == 1, reject_log.labels == 2)
```

```python
bad_channel = bads.mean(axis=0)
# print(bad_channel)
epochs.info
channel_names = epochs.info["ch_names"]
bad_channels_by_epochs = [
    name for name, value in zip(channel_names, bad_channel) if value >␣
 ↪BADS_THRESHOLD
]
print(
    f"Additional {len(bad_channels_by_epochs)} bad channels found:{
        bad_channels_by_epochs
    }"
)


# epochs.info["bads"].extend(bad_channels_by_epochs)
try:
    bad_channel_plot_additional = epochs.plot(
        picks=bad_channels_by_epochs,
        scalings=dict(eeg=1e-4),
        show_scrollbars=False,
    )
except Exception as e:
    print(f"An error occurred: {e}")
```

Not setting metadata

83 matching events found

No baseline correction applied

0 projection items activated

Using data from preloaded Raw for 83 events and 5001 original time points …

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: divide by zero
encountered in matmul
  newdata[sl] = newdata[sl] - A @ coef
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: overflow encountered
in matmul
  newdata[sl] = newdata[sl] - A @ coef
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: invalid value
encountered in matmul
  newdata[sl] = newdata[sl] - A @ coef

0 bad epochs dropped

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: divide by zero encountered

```
in matmul
    B = (u @ vh[:rank]).conj().T
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: overflow encountered in
matmul
    B = (u @ vh[:rank]).conj().T
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: invalid value encountered
in matmul
    B = (u @ vh[:rank]).conj().T
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: divide by zero
encountered in matmul
    interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: overflow encountered
in matmul
    interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: invalid value
encountered in matmul
    interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: divide by zero
encountered in matmul
    inst._data[…, bads_idx, :] = np.matmul(
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: overflow encountered
in matmul
    inst._data[…, bads_idx, :] = np.matmul(
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: invalid value
encountered in matmul
    inst._data[…, bads_idx, :] = np.matmul(

fitting finished

Dropped 7 epochs: 36, 37, 38, 39, 61, 62, 82
```
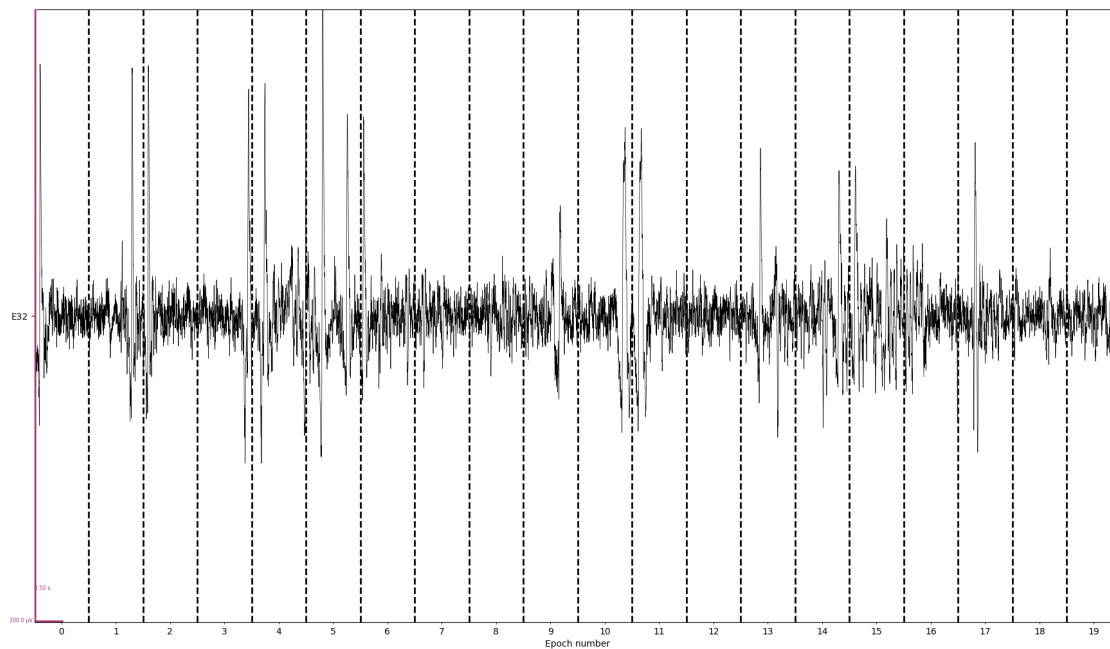
Additional 1 bad channels found:['E32']


```
[11]: import matplotlib.pyplot as plt

      # Create a figure with two subplots
      fig, axs = plt.subplots(2, 1, figsize=(10, 10))
```

```python
epochs_plot_psd = (
    epochs[reject_log.bad_epochs]
    .compute_psd(method="welch", picks="eeg", fmax=50.0, exclude="bads")
    .plot(
        average=False,
        picks="eeg",
        exclude="bads",
        show=False,
        amplitude=False,
        axes=axs[0],
    )
)
axs[0].set_title("Power Spectral Density for Bad Epochs")

epochs_plot_psd = (
    epochs[~reject_log.bad_epochs]
    .compute_psd(method="welch", picks="eeg", fmax=50.0, exclude="bads")
    .plot(
        average=False,
        picks="eeg",
        exclude="bads",
        show=False,
        amplitude=False,
        axes=axs[1],
    )
)

axs[1].set_title("Power Spectral Density for Good Epochs")


# Get the y-limits of both plots
ylim1 = axs[0].get_ylim()
ylim2 = axs[1].get_ylim()

# Set the same limits on the y-axis for both plots
axs[0].set_ylim(min(ylim1[0], ylim2[0]), max(ylim1[1], ylim2[1]))
axs[1].set_ylim(min(ylim1[0], ylim2[0]), max(ylim1[1], ylim2[1]))


plt.show()
```

Effective window size : 2.048 (s)
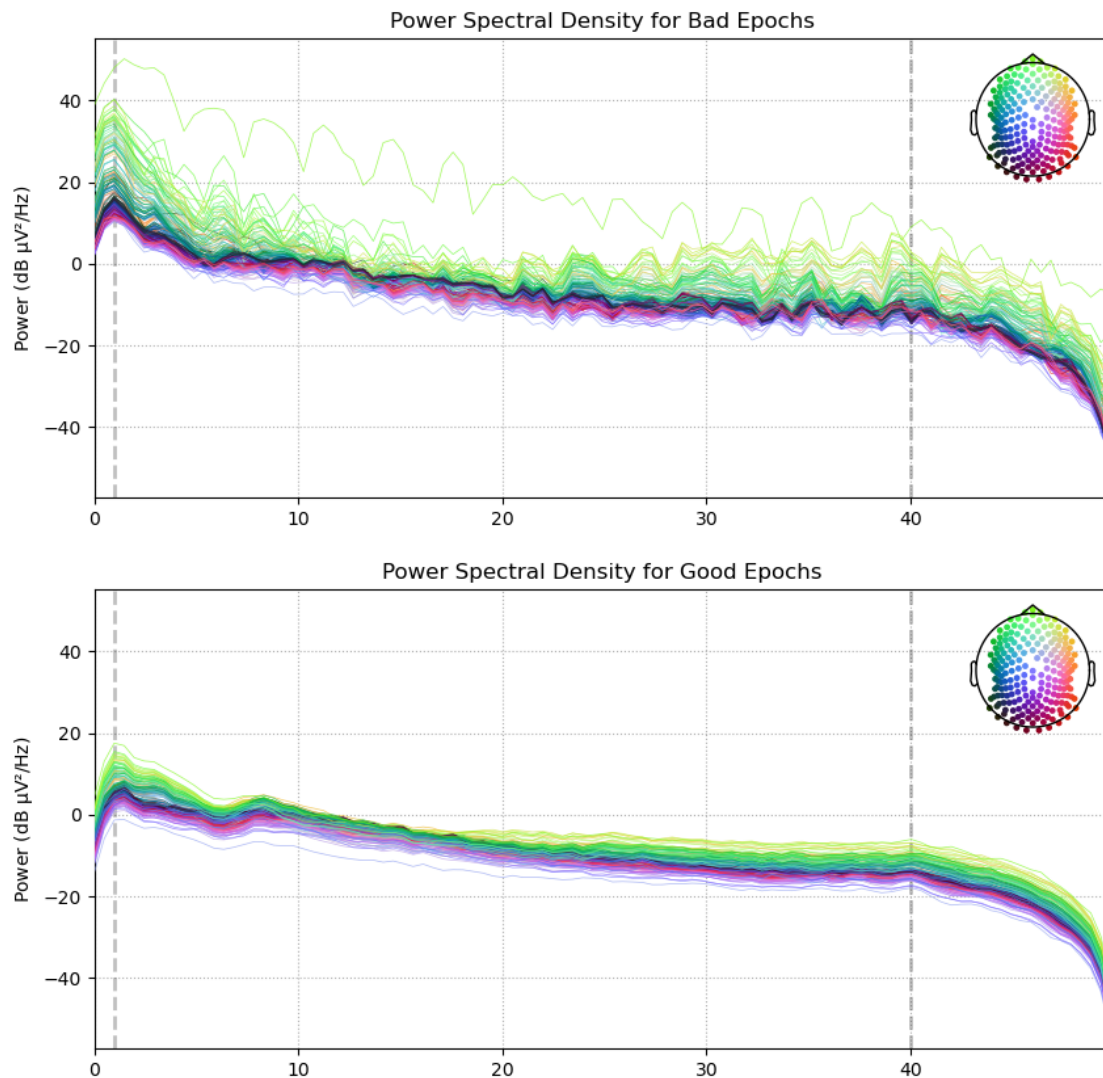
Plotting power spectral density (dB=True).

Averaging across epochs before plotting…

Effective window size : 2.048 (s)

Plotting power spectral density (dB=True).

Averaging across epochs before plotting…

Power Spectral Density for Bad Epochs

Power Spectral Density for Good Epochs

[12]:
```python
# Assuming 'raw' is your MNE raw object
# Get the list of all channels
all_channels = epochs.info["ch_names"]

# Get the list of bad channels
bad_channels = epochs.info["bads"]

# Get the list of good channels
good_channels = [ch for ch in all_channels if ch not in bad_channels]

# Get the indices of the good channels
good_channels_indices = [all_channels.index(ch) for ch in good_channels]
```

```python
# Define the chunk size
chunk_size = 30

# Create chunks of the good channels
chunks = [
    good_channels_indices[i : i + chunk_size]
    for i in range(0, len(good_channels_indices), chunk_size)
]


# Now you can iterate over the chunks
for chunk in chunks:
    # Do something with the chunk
    # print(chunk)
    mne.viz.plot_epochs(
        epochs=epochs[reject_log.bad_epochs],
        picks=chunk,
        show=False,
        scalings=dict(eeg=1e-4),
        n_channels=chunk_size,
        show_scrollbars=False,
    )
```
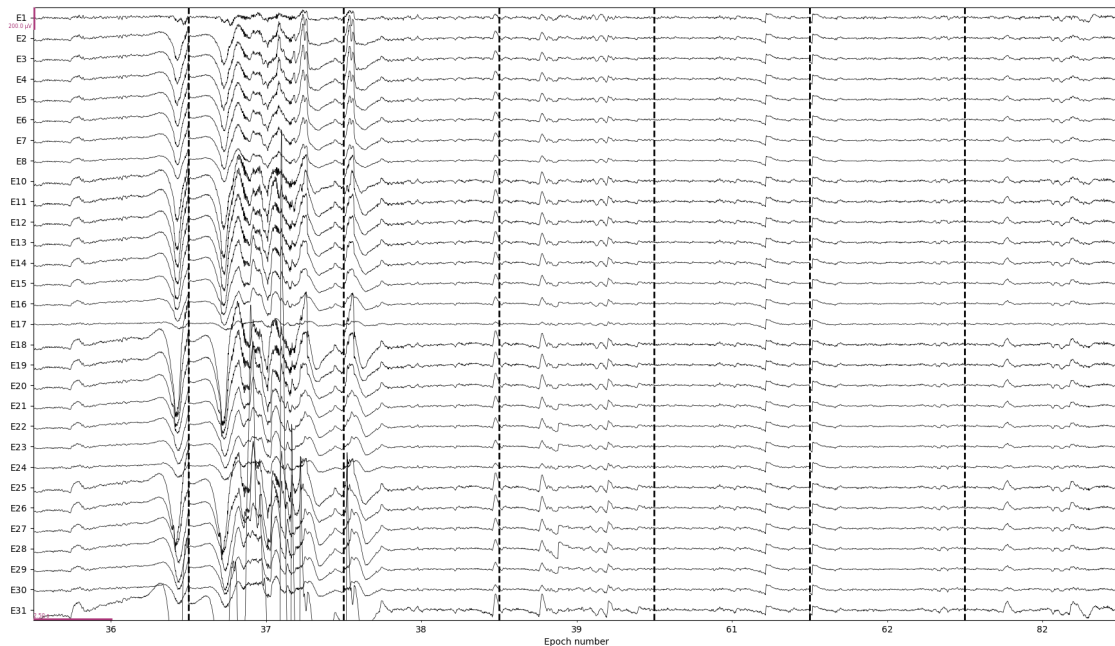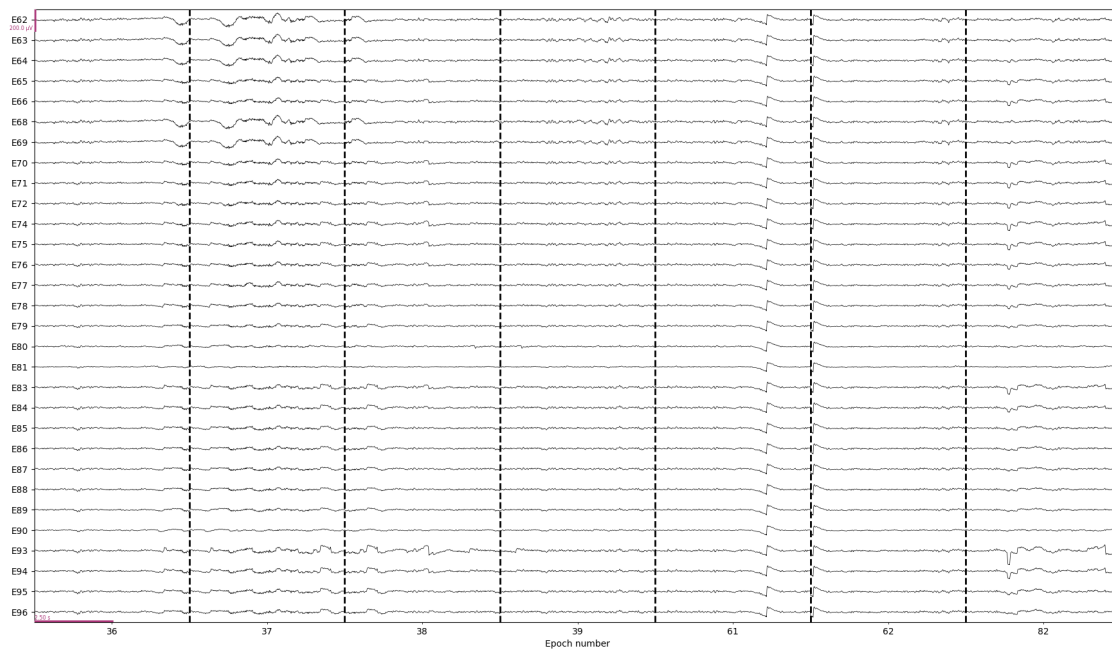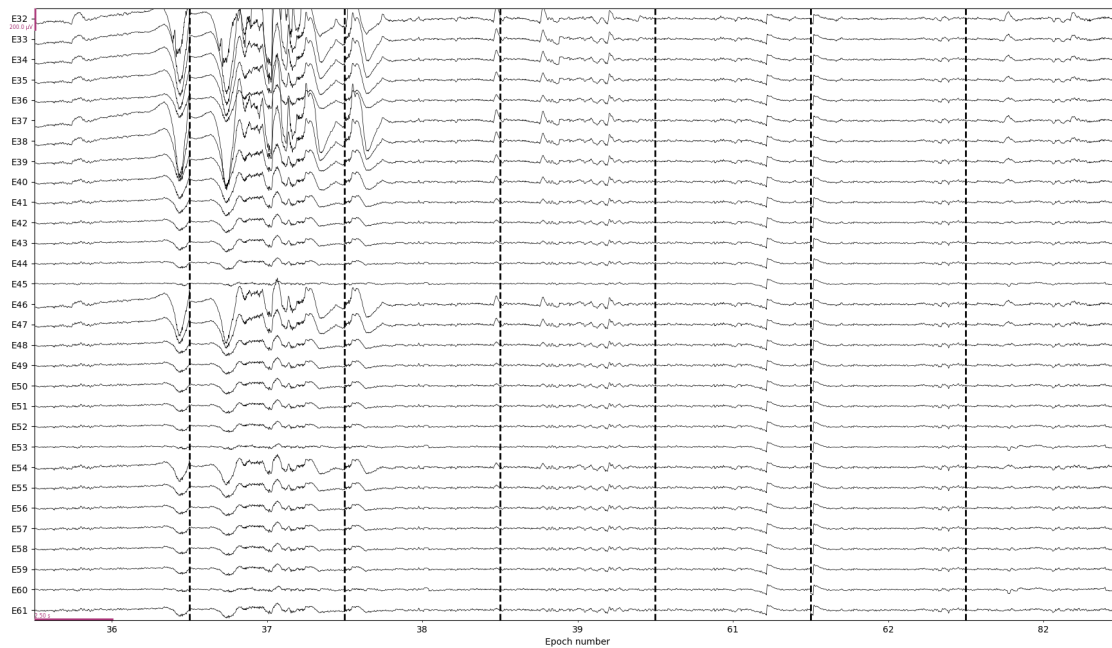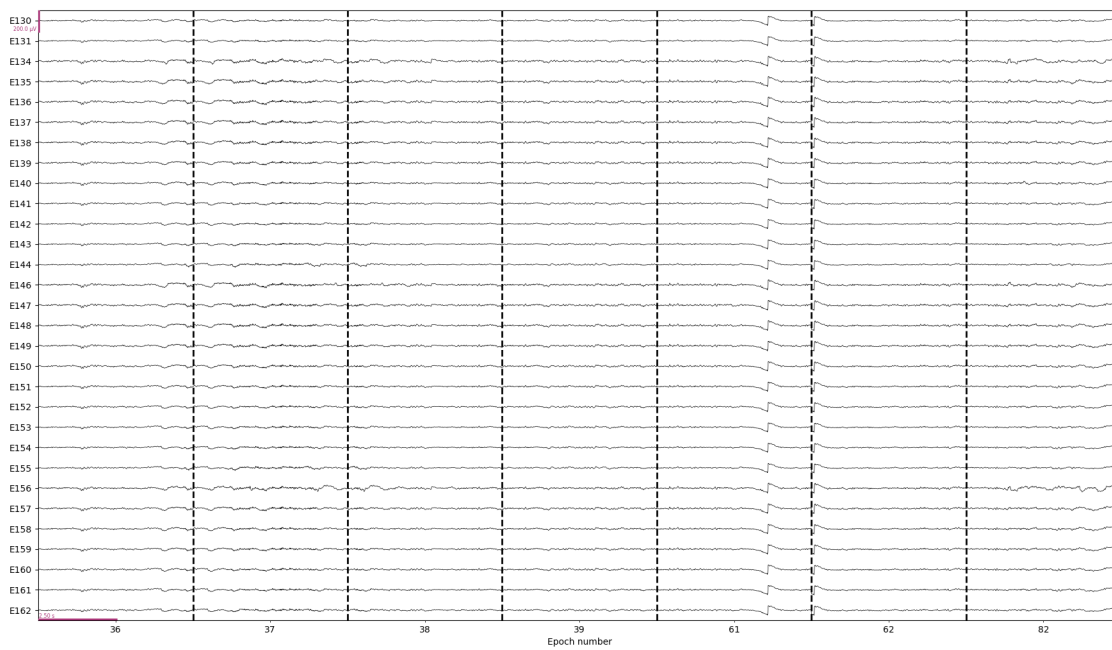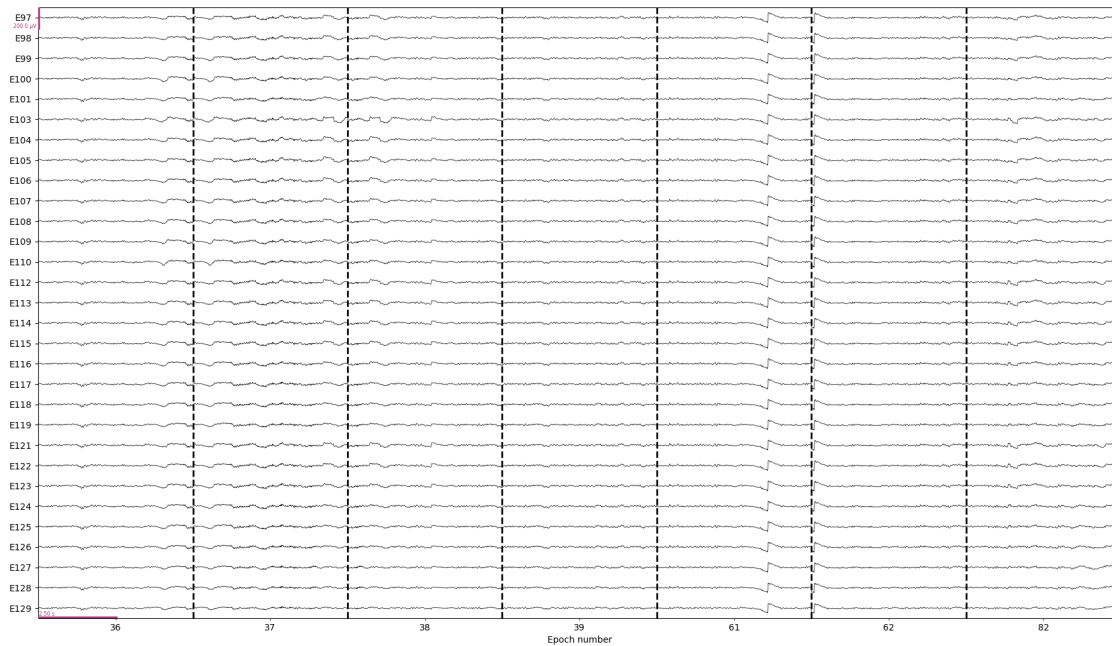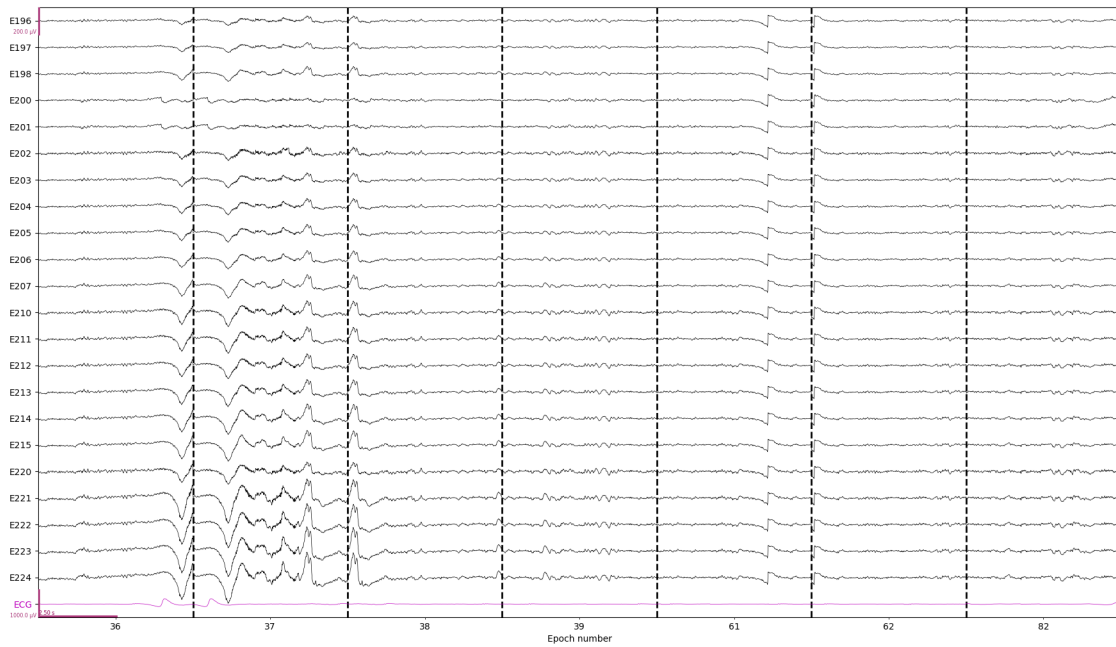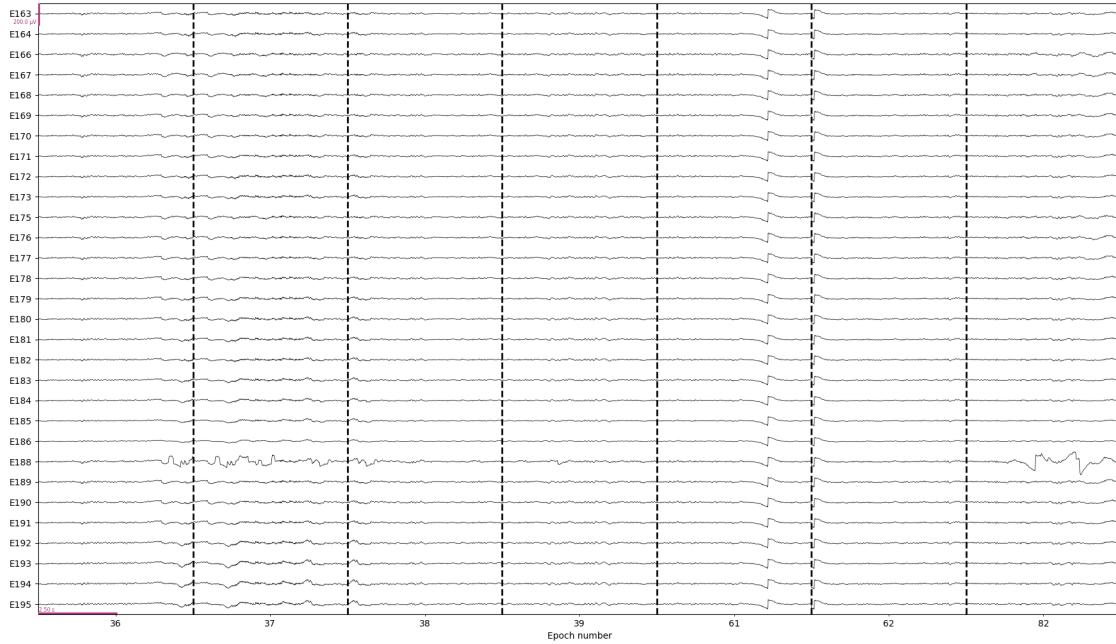
```
[13]: print(f"Sub{subject_id} - removed {sum(reject_log.bad_epochs)} epochs")
      print(f"Sub{subject_id} - retained {len(epochs[~reject_log.bad_epochs])}
       ↪epochs")

      epochs_good = epochs[~reject_log.bad_epochs]
```

```python
epochs_good.save(
    f"{paths.epochs}/sub-{subject_id}_good_epochs-epo.fif", overwrite=True
)
```

Sub101 - removed 7 epochs

Sub101 - retained 76 epochs
Overwriting existing file.

Overwriting existing file.

[13]: [PosixPath('/Users/daniel/PhD/Projects/psd-
paths/data/derrivatives/sub-101/epochs/sub-101_good_epochs-epo.fif')]

```python
[14]: from spectral.epochs import create_epochs, get_reject_log
from spectral.preproc import reject_log_to_annotations, load_config

def find_bad_segments(raw: mne.io.Raw,
                      epoch_length: float = 1.0,
                      overlap: float = 0.0,
                      resample_sfreq: int = 125) -> mne.Annotations:
    """
    Identifies bad data segments using short epochs and autoreject.

    Args:
        raw (mne.io.Raw): The raw MNE data object, minimally filtered.
        epoch_length (float): The length of the short epochs for artifact␣
    ↪detection.
        overlap (float): The overlap between short epochs.
        resample_sfreq (int): The frequency to resample to before running␣
    ↪autoreject.

    Returns:
        mne.Annotations: MNE annotations marking the identified bad time␣
    ↪segments.
    """
    print(f"Finding bad segments using {epoch_length}s epochs...")

    # 1. Create short epochs for artifact detection
    epochs = create_epochs(raw, length=epoch_length, overlap=overlap)

    # 2. Get the reject log from these short epochs
    reject_log = get_reject_log(epochs, resample=resample_sfreq, consensus=[0.
    ↪35])

    # 3. Convert the reject log to annotations
    bad_annotations = reject_log_to_annotations(reject_log, epochs)
```

```python
        print(f"Found {len(bad_annotations)} bad segments to be marked.")
        return bad_annotations




raw_for_ar = raw_filtered.copy()
epochs = create_epochs(raw_for_ar, length=3, overlap=1.5)
reject_log = get_reject_log(epochs, resample=125, consensus=[0.35])

# --- 5. Annotate Bad Segments in the Original Raw Data ---
# Convert the log of bad epochs to annotations
bad_annotations = reject_log_to_annotations(reject_log, epochs)
# Add these annotations to the *original* raw data
raw.set_annotations(raw.annotations + bad_annotations)
raw.save(
    f"{paths.preprocessed}/sub-{subject_id}_annoted.fif", overwrite=True
)
```

Not setting metadata

195 matching events found

No baseline correction applied

0 projection items activated

Using data from preloaded Raw for 195 events and 751 original time points …

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: divide by zero
encountered in matmul
  newdata[sl] = newdata[sl] - A @ coef
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: overflow encountered
in matmul
  newdata[sl] = newdata[sl] - A @ coef
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/signal/_signaltools.py:4247: RuntimeWarning: invalid value
encountered in matmul
  newdata[sl] = newdata[sl] - A @ coef

2 bad epochs dropped

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: divide by zero encountered
in matmul
  B = (u @ vh[:rank]).conj().T
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: overflow encountered in
matmul
  B = (u @ vh[:rank]).conj().T

```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/linalg/_basic.py:1648: RuntimeWarning: invalid value encountered
in matmul
  B = (u @ vh[:rank]).conj().T
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: divide by zero
encountered in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: overflow encountered
in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:116: RuntimeWarning: invalid value
encountered in matmul
  interpolation = np.hstack([G_to_from, np.ones((n_to, 1))]) @ C_inv[:, :-1]
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: divide by zero
encountered in matmul
  inst._data[…, bads_idx, :] = np.matmul(
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: overflow encountered
in matmul
  inst._data[…, bads_idx, :] = np.matmul(
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/channels/interpolation.py:128: RuntimeWarning: invalid value
encountered in matmul
  inst._data[…, bads_idx, :] = np.matmul(

/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/mne/bem.py:1115: RuntimeWarning: Mean of empty slice.
  radius_init = radii.mean()
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/numpy/_core/_methods.py:145: RuntimeWarning: invalid value encountered
in scalar divide
  ret = ret.dtype.type(ret / rcount)
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/numpy/_core/fromnumeric.py:3860: RuntimeWarning: Mean of empty slice.
  return _methods._mean(a, axis=axis, dtype=dtype,
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/numpy/_core/_methods.py:137: RuntimeWarning: invalid value encountered
in divide
  ret = um.true_divide(
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/_lib/pyprima/common/preproc.py:198: UserWarning: COBYLA: Invalid
RHOBEG; it should be a positive number; it is set to 1
  warn(f'{solver}: Invalid RHOBEG; it should be a positive number; it is set to
{rhobeg}')
```

```
/Users/daniel/.pyenv/versions/psd-paths-3.13/lib/python3.13/site-
packages/scipy/_lib/pyprima/common/preproc.py:202: UserWarning: COBYLA: Invalid
RHOEND; it should be a positive number and RHOEND <= RHOBEG; it is set to 1e-06
  warn(f'{solver}: Invalid RHOEND; it should be a positive number and RHOEND <=
RHOBEG; it is set to {rhoend}')
```

fitting finished

Dropped 22 epochs: 0, 14, 31, 35, 37, 49, 83, 84, 85, 86, 87, 88, 89, 92, 93,
143, 144, 169, 170, 174, 191, 192

Overwriting existing file.

Writing /Users/daniel/PhD/Projects/psd-
paths/data/derrivatives/sub-101/preprocessed/sub-101_annotated.fif

```
/var/folders/xq/sl7xjp_95qx7wfngy6s6vvg00000gn/T/ipykernel_84835/671639093.py:45
: RuntimeWarning: This filename (/Users/daniel/PhD/Projects/psd-
paths/data/derrivatives/sub-101/preprocessed/sub-101_annotated.fif) does not
conform to MNE naming conventions. All raw files should end with raw.fif,
raw_sss.fif, raw_tsss.fif, _meg.fif, _eeg.fif, _ieeg.fif, raw.fif.gz,
raw_sss.fif.gz, raw_tsss.fif.gz, _meg.fif.gz, _eeg.fif.gz or _ieeg.fif.gz
  raw.save(
```

Closing /Users/daniel/PhD/Projects/psd-
paths/data/derrivatives/sub-101/preprocessed/sub-101_annotated.fif

[done]

[14]: [PosixPath('/Users/daniel/PhD/Projects/psd-
      paths/data/derrivatives/sub-101/preprocessed/sub-101_annotated.fif')]

[15]: ```python
print(bad_annotations)
```

<Annotations | 22 segments: bad_autoreject (22)>