EEGLAB Processing

Data import
Basic ERP visualization
• Start Matlab
• Add the EEGLAB folder to your Matlab path:
The EEGLAB Matlab software

main graphic interface
Pre-processing pipeline

1. Collect high-density EEG data (>30 chan)
2. Import into EEGLAB
3. Import event markers and channel locations
4. Re-reference/down-sample (if necessary)
5. High pass filter (~0.5 – 1 Hz)
6. Examine raw data
7. Identify/reject bad channels
8. Reject large artifact time points
9. Run ICA (next talk)
Importing a dataset

Tip for Biosemi users:
Use the ‘BDF plugin’ version of the Biosemi BDF/EDF importer
Imported EEG data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filename</td>
<td>none</td>
</tr>
<tr>
<td>Channels per frame</td>
<td>73</td>
</tr>
<tr>
<td>Frames per epoch</td>
<td>85504</td>
</tr>
<tr>
<td>Epochs</td>
<td>1</td>
</tr>
<tr>
<td>Events</td>
<td>none</td>
</tr>
<tr>
<td>Sampling rate (Hz)</td>
<td>256</td>
</tr>
<tr>
<td>Epoch start (sec)</td>
<td>0.000</td>
</tr>
<tr>
<td>Epoch end (sec)</td>
<td>333.996</td>
</tr>
<tr>
<td>Reference</td>
<td>unknown</td>
</tr>
<tr>
<td>Channel locations</td>
<td>No (labels only)</td>
</tr>
<tr>
<td>ICA weights</td>
<td>No</td>
</tr>
<tr>
<td>Dataset size (Mb)</td>
<td>26.7</td>
</tr>
</tbody>
</table>
Pre-processing pipeline

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Import data events

- Import events from Matlab array or ASCII file
- Import events from data channel
- Import from Presentation event file
- Import events from E-Prime event file
- Import events from Neuroscan event file

(Often imported automatically during data import)
Appearance of an event channel in raw data
Imported data events

If event import was successful, you will see an appropriate number here.
Sample data: basic P300 paradigm

**File**

SimpleOddball.set

**Data**

68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

**Task**

speeded button press response to star shape (no response to circle shape), 100 ms presentation duration, 200 trials
Import channel locations

7 file formats supported (Polhemus, BESA, …)
Import channel locations

Channel information ("Field_name"): 
- LEYE: 45.1543, 0.54374, 0.79487, 0.79517, -0.15585, 45.1543, -7.8725, 1.1379
- Cartesian Z ("Z")
- Spherical horizon angle ("sph_theta")
- Spherical azimuth angle ("sph_phi")
- Spherical radius ("sph_radius")
- Channel type (EEG)
- Reference
- Index in backup locations' structure

Channel number (of 71)
- Channel indices
  - Type (e.g., EEG)
  - 1:71

Plot 2-D, Plot radius (0.2-1, [auto])
- Nose along +X
- Plot 3-D (xyz)
Imported channel locations
Pre-processing pipeline

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Run ICA (next talk)
Re-reference data (if necessary/desired)

For example, average reference
Re-reference data (if necessary/desired)

OR, re-reference to (i.e.) 'linked mastoids'
Save new dataset, keep old one
Multiple active datasets (ALLEEG)
Resample data (if necessary)
Remove unwanted channels
Pre-processing pipeline

Collect high-density EEG data (>30 chan) → Import into EEGLAB → Import event markers and channel locations

Re-reference/down-sample (if necessary) → High pass filter (~0.5 – 1 Hz) → Remove line noise (if necessary)

Identify/reject bad channels → Reject large artifact time points → Run ICA (next talk)
Load an existing dataset
Filter the data (if necessary/desired)

Lower cut off frequencies require longer stretches of continuous data

High-pass needed for ICA
Pre-processing pipeline

Collect high-density EEG data (>30 chan) → Import into EEGLAB → Import event markers and channel locations

Re-reference/down-sample (if necessary) → High pass filter (~.5 – 1 Hz) → Remove line noise (if necessary)

Identify/reject bad channels → Reject large artifact time points ➔ Run ICA (next talk)
<table>
<thead>
<tr>
<th>Plugin</th>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPLABfilters</td>
<td>1.00</td>
<td>Interface ERPLAB filters (requires separate ERPLAB install)</td>
</tr>
<tr>
<td>Clealline</td>
<td>1.21</td>
<td>Automatic artifact rejection</td>
</tr>
<tr>
<td>BERGEN</td>
<td>1.1</td>
<td>Removal of fMRI-related gradient artifacts from simultaneous...</td>
</tr>
</tbody>
</table>

**Installed plugins**

<table>
<thead>
<tr>
<th>Plugin</th>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>brainmovie</td>
<td>0.1</td>
<td>Brainmovies (command line only)</td>
</tr>
<tr>
<td>commap</td>
<td>2.00</td>
<td>New version 1.03 available. Click update to install.</td>
</tr>
<tr>
<td>eeg_toolbox</td>
<td>1.0</td>
<td>Interface EEG toolbox functions for ERP peak detection</td>
</tr>
<tr>
<td>fMRIlib</td>
<td>1.21</td>
<td>Remove fMRI artifacts from EEG</td>
</tr>
<tr>
<td>MP_clustering</td>
<td>1.00</td>
<td>Measure projection clustering of ICA components</td>
</tr>
<tr>
<td>MutualInfoClustering</td>
<td>1.00</td>
<td>Mutual information clustering</td>
</tr>
<tr>
<td>StudyEnvtopo</td>
<td>6.9</td>
<td>Add envtopo capabilities to STUDY</td>
</tr>
<tr>
<td>VisEd</td>
<td>1.05</td>
<td>New version 1.04 available. Click update to install.</td>
</tr>
<tr>
<td>iirfilt</td>
<td>1.02</td>
<td>Non linear filtering</td>
</tr>
<tr>
<td>locesta</td>
<td>1.1</td>
<td>New version 1.0 available. Click update to install.</td>
</tr>
</tbody>
</table>
Remove line noise (Cleanline)
Plot channel spectra

Channel index(ices) to plot:
Spectral options (see spectopo() help):

freqrange [2 30]
Filter comparisons

0.5 Hz high-pass filter

0.5 Hz high-pass filter
50 Hz low-pass filter

0.5 Hz high-pass filter
Cleanline
Scroll channel data
Scroll channel data

- Channels, time, events
- Sec/epoch
- Event markers
- Scroll buttons
- Scaling
Pre-processing pipeline

Collect high-density EEG data (>30 chan) → Import into EEGLAB → Import event markers and channel locations

Re-reference/down-sample (if necessary) → High pass filter (~0.5 – 1 Hz) → Remove line noise (if necessary)

Identify/reject bad channels → Reject large artefact time points → STOP!

Save your dataset here; you will import ICA weights to this dataset later

Run ICA (next talk)
Visualizing ERPs

- Epoch data according to different event types
- Reject epochs containing artifact
- Various plot types (channel and scalp topography)
Extract epochs

>> eeg_eventtypes(EEG)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>201</td>
<td>60</td>
</tr>
</tbody>
</table>
Extract epochs
Select a subset of epochs

‘0’ because the subject did not miss any targets
Save dataset (optional)

'Do not overwrite current dataset'

Or save later from menu
Scroll (epoched) channel data
Reject epochs with artifact

Click anywhere within an epoch to select it for rejection
Reject data epochs
## Reject data epochs

### Mark trials by appearance
- **Scroll Data**
- **Marked trials**

### Find abnormal values
- **Upper limit(s) (μV)**
  - 25
- **Lower limit(s) (μV)**
  - 25
- **Start time(s) (ms)**
  - -1000
- **Ending time(s) (ms)**
  - 1996
- **Electrode(s)**
  - 1:31

### Find abnormal trends
- **Max slope (μV/epoch)**
  - 50
- **R-squared limit (0 to 1)**
  - 0.3
- **Electrode(s)**
  - 1:31

### Find improbable data
- **Single-channel limit (std. dev.)**
  - 5
- **All channels limit (std. dev.)**
  - 5

### Find abnormal distributions
- **Single-channel limit (std. dev.)**
  - 5
- **All channels limit (std. dev.)**
  - 5

### Find abnormal spectra (slow)
- **Upper limit(s) (dB)**
  - 25
- **Lower limit(s) (dB)**
  - -25
- **High frequency(s) (Hz)**
  - 50

### Plotting options
- Show all trials marked for rejection by the measure selected above or checked below:
  - Abnormal appearance
  - Abnormal values
  - Abnormal trends
  - Abnormal distributions
  - Abnormal spectra

### Additional notes:
- **Visual inspection**
- **Probability**
Reject data epochs

Exceeds channel standard dev. max
Reject data epochs
Visualize ERP in rectangular array
Visualize ERP in topographic array
Visualize ERP scalp distribution
Visualize channel ERPs in 2D

Figure 2

Simple Oddball targets rej
Visualize channel ERPs in 3D
Exercises (continuous data)

- Load SimpleOddball.set
- Rereference data to average reference
- Hi-pass filter the continuous data, then save
- Epoch the data on circles (event type 1) and stars (event type 2)
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Save ‘clean’ epoched datasets for circles and stars
EEGLAB Processing

Data cleaning for ICA
Pre-processing pipeline

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5. High pass filter (~0.5 – 1 Hz)
6. Remove line noise (if necessary)
7. Identify/reject bad channels
8. Reject large artifact time points
9. Run ICA (next talk)
Retrieve or reload continuous EEG dataset
Comments and dataset history

Also:
>> EEG.comments
or
>> EEG.history
Manually identifying bad channels

1) Identify bad channel
Manually identifying bad channels
Manually identifying bad channels
Auto-detection of noisy channels
Auto-detected noisy channel
Removing channel(s)

If not checked, will result in dataset with one channel
Removing channel(s)

• You may prefer to interpolate bad channels rather than remove them altogether

• The loss in dimensionality will affect the ICA decomposition

• Usual solution:
  – Delete the bad channels before running ICA
  – STUDY tools will do much of this automatically (interpolate missing channels, etc)
Pre-processing pipeline

Collect high-density EEG data (>30 chan) → Import into EEGLAB → Import event markers and channel locations

Re-reference/down-sample (if necessary) → High pass filter (~0.5 – 1 Hz) → Remove line noise (if necessary)

Identify/reject bad channels → Reject large artifact time points → Run ICA (next talk)
Reject continuous data

Equivalent
Reject continuous data

Click and drag with mouse over noisy data to reject
Rejecting data for ICA

To prepare data for ICA:

- Keep stereotyped artifacts (like eye blinks)
- Reject large muscle or otherwise strange events...
Fast (but sloppy) artifact rejection
Fast (but sometimes sloppy) artifact rejection
Pre-processing pipeline

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6. Remove line noise (if necessary)
7. Identify/reject bad channels
8. Reject large artifact time points

Run ICA (next talk)
**Exercises**

- Load a previously filtered version of SimpleOddball.set

- Identify bad channel(s) using auto-detection tool; plot channel properties of flagged channels

- Identify and remove non-task portions of continuous data; see if the previously flagged channels are still identified as bad

- Scroll the epoched data and perform visual rejection of epochs

- Explore the automated artifact rejection tools