EEG Preprocessing in EEGLAB (cont.)

EEGLAB

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Data Cleaning for ICA

Variant 1: Continuous Data
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:

- Reject large muscle or otherwise strange events...
- Keep
- ... but keep stereotyped artifacts (like eye blinks)
Automatic rejection of continuous data

Clean_rawdata plugin of EEGLAB
Automatic rejection of continuous data

```python
EEG = clean_artifacts( EEG, 'Highpass', 'off', ...
    'ChannelCriterion', 'off', ...
    'LineNoiseCriterion', 'off', ...
    'BurstCriterion', 30, ...
    'WindowCriterion', 0.3);
```
Automatic rejection of continuous data
Pre-processing pipeline

Collect EEG data → Import into EEGLAB → Import event markers and channel locations

Re-reference/down-sample (if necessary) → High pass filter (~.5 – 1 Hz) → Examine raw data

Identify/reject bad channels → Reject large artifact time points → Run ICA and reject components

Done
Independent Component Analysis

\[ x = \text{scalp EEG} \quad W = \text{unmixing matrix} \quad u = \text{sources} \]

\[ W^*x = u \]

\[ x = W^{-1}u \]

\[ W^{-1} \text{ (scalp projections)} \]
Running ICA

Task 1
Run ICA

Task 2
Evaluating ICA Components
“Secrets” to a good ICA decomposition

- Garbage in… garbage out (it’s not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
- High-pass filter to remove slow drifts (no low-pass filter needed)
- Remove bad channels
- Data must be in double precision (not single)
- Data should be full rank
Preprocessed Dataset

EEGLAB v2022.1

File    Edit    Tools    Plot    Study   Datasets    Help

#8: sub-01_avref resampled

Filename: none
Channels per frame: 61
Frames per epoch: 48094
Epochs: 1
Events: 153
Sampling rate (Hz): 100
Epoch start (sec): -0.0004
Epoch end (sec): 480.988
Reference: average
Channel locations: Yes
ICA weights: No
Dataset size (Mb): 18.1

Dataset 1: sub-01_ses-meg_task-facerecognition_run-01_proc-sss_meg
Dataset 2: sub-01_avref
Dataset 3: sub-01_avref resampled
Dataset 4: sub-01_avref resampled highfilt
Dataset 5: sub-01_avref resampled highlowfilt
Dataset 6: sub-01_avref resampled highlowfilt_ASRremchan
Dataset 7: sub-01_avref resampled highlowfilt_ASRremchan_avref
✓ Dataset 8: sub-01_avref resampled highlowfilt_ASRremchan_avref_ASR

Select multiple datasets
## ICA options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘extended’</td>
<td>0</td>
<td>1 is recommended to find sub-gaussians</td>
</tr>
<tr>
<td>‘stop’</td>
<td>1e-7</td>
<td>final weight change → stop</td>
</tr>
<tr>
<td>‘lrate’</td>
<td>determined from data</td>
<td>too small → too long… too large → wts blow up</td>
</tr>
<tr>
<td>‘maxsteps’</td>
<td>512</td>
<td>more channels → more steps</td>
</tr>
<tr>
<td>‘pca’</td>
<td>0 or EEG.nbchan</td>
<td>Decompose only a principal data subspace</td>
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</tbody>
</table>
Faster ICA option

ICA algorithm to use (click to select)

- Infomax runica.m (default)
- Infomax runica.m conservative (slow)
- Infomax picard.m
- FastICA picard.m (fastest)
- SOBI (sobi.m function)
- SOBI (sobi.m function)

Commandline options (See help messages)

- Reorder components by variance (if that's not already the case)

Use only channel type(s) or indices

- ... types
- ... channels

Help
Cancel
Ok
ICA options

EEG = pop_runica( EEG , 'runica', 'extended',1, 'pca', EEG.nbchan-1);

Faster option:

EEG = pop_runica( EEG , 'picard', 'maxiter', 500, 'pca', EEG.nbchan-1);
Runica progress…
Results of ICA Decomposition in EEG struct

```
struct with fields:
    setname: 'sub-01_ses-meg_task-facerecognit:
    filename: 'wh_S01_run_01_preprocessing_data_
    filepath: '/Users/johanna/Library/CloudStor:
    subject: 'sub-01'
    group: ''
    condition: ''
    session: []
    comments: 'Original file: /Volumes/GoogleDr:
    nbchan: 61
    trials: 1
    pnts: 47826
    srate: 100
    xmin: 0
    xmax: 478.2503
    times: [0 10.0000 20.0000 30.0000 40.0000]
    data: [61x47826 single]
    icaact: [60x47826 single]
    icawinv: [61x60 double]
    icasphere: [61x61 double]
    icaweights: [60x61 double]
    icachansind: [1 2 3 4 5 6 7 8 9 10 11 12 13 14
    chanlocs: [61x1 struct]
    urchanlocs: [74x1 struct]
    chaninfo: [1x1 struct]
    ref: 'average'
    event: [1x264 struct]
    urevent: [1x259 struct]
    eventdescription: {'' '' '' ''}
    epoch: []
    epochdescription: {}
    reject: [1x1 struct]
    stats: [1x1 struct]
    specdata: []
    specicaact: []
    splineline: ''
    icasplinefile: ''
    dipfit: []
    history: 'EEG.etc.eeglabvers = '2021.0'; '
    saved: 'no'
    etc: [1x1 struct]
    run: []
    datfile: ''
```
Results of ICA Decomposition in EEG struct

icaact: [60×47826 single]
icawinv: [61×60 double]
icasphere: [61×61 double]
icaweights: [60×61 double]
Source activation = unmixing * Channel data

Channel data = mixing (topo) * Source activation

EEG.icaact = (EEG.icaweight * EEG.icasphere) * EEG.data

EEG.data = EEG.icawinv * EEG.icaact
Running ICA

Task 1
Run ICA

Task 2
Evaluating ICA Components
Now what…?

Part 1
Getting an overview of your ICs

Part 2
Classifying/Evaluating ICs
Now what…?

Part 1
Getting an overview of your ICs

Part 2
Classifying/Evaluating ICs
A convenient ‘trick’…

Use ‘Inspect/label components by map’ to survey components

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Change sampling rate
Filter the data
Re-reference the data
Interpolate electrodes

Inspect/reject data by eye
Reject data using Clean Rawdata and ASR

Decompose data by ICA
Inspect/label components by map
Classify components using ILabel
Remove components from data

Extract epochs
Remove epoch baseline

Source localization using DIPFIT
Run AMICA
post AMICA utility

Reject comp. by map -- pop_selectcomps

Components to plot:

Note: in the next interface, click on buttons to see component properties and label them for rejection. To actually reject labelled components use menu item “Tools > Remove components” or use STUDY menus.
An interactive overview of ICs
Step 0: Quality of Decomposition

BAD ICA Components

ICA Components
Examining IC Properties

<table>
<thead>
<tr>
<th>1</th>
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</table>

**Continuous data**

**Activity power spectrum**
Plot IC Properties

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Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Channel time-frequency

Component properties (scroll)
- Component activations
- Component spectra and maps
- Component maps

Component properties
- Component ERP image
- Component ERPs
- Component time-frequency

Component index(ices) to plot: 2

Spectral options (see spectopo() help):
'freqrange', [2 40]

Help
Cancel
Ok

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IC Properties

IC Topography
topoplot()

ERP Image & ERP
erpimage()

Power Spectrum
spectopo()
Part 1
Getting an overview of your ICs

Part 2
Classifying/Evaluating ICs
  Eye Artifacts
  Muscle Artifacts
  Other Artifacts
Evaluating ICs

• Over time, most EEGLAB users develop a *heuristic* sense of which ICs might be brain vs. artifact.

• Heuristics are generally based on:
  • Topography
  • Component Activities (scroll)
  • ERP
  • Power Spectrum

• IC Classification can be used to ‘clean’ data—study likely brain activity without artifacts

• *There are new efforts to automate this process, but doing it by hand is a good place to start to build intuition* — **IC Label plugin**
IC1 - eyeblink
IC1 - eyeblink

- Low frequency activity
- Classic frontal eye-blink topography
- Sporadic large biphasic pulses
Plot → Component Activations (scroll)
IC 1 Activation – eyeblink

Sporadic large biphasic pulses
IC 6 - cardiac

Cardiac-like topographies:
Shallow gradient = extremely distant source

Unusual, peaky spectrum (often peaks ~5, 10 Hz)

Periodic spikes (~1 / sec)
IC 6 - cardiac

Periodic spikes (~1 / sec)
IC 8 – Muscle

Narrowly spaced dipolar topography (consistent with superficial source)

High frequencies dominate power spectrum

Noisy ERP/ERP Image
IC 8 Activation – Muscle
IC 33 – Bad channel

Punctate topography (single channel)

Sporadic ERPIMAGE activity (sometimes just a single large spike)
IC classification so far…
IC Label plugin

Select which version of ICLabel to use:

- Default (recommended)

[Ok]
IC Label plugin

ans =

struct with fields:

    classes: {'Brain' 'Muscle' 'Eye' 'Heart' 'Line Noise' 'Channel Noise' 'Other'}
    classifications: [63x7 single]
    version: 'default'

ans =

    63x7 single matrix

    0.0003  0.0009  0.9871  0.0006  0.0000  0.0011  0.0100
    0.9992  0.0001  0.0000  0.0001  0.0002  0.0000  0.0004
    0.9989  0.0000  0.0001  0.0001  0.0001  0.0000  0.0008
    0.9998  0.0000  0.0000  0.0000  0.0000  0.0000  0.0001
    0.9963  0.0001  0.0000  0.0001  0.0009  0.0000  0.0026
    0.2034  0.0008  0.0004  0.7153  0.0024  0.0013  0.0763
    0.8176  0.0021  0.0002  0.0098  0.0213  0.0003  0.1487
    0.3447  0.5817  0.0021  0.0046  0.0003  0.0174  0.0492
    0.9953  0.0002  0.0000  0.0004  0.0019  0.0001  0.0022
View extended component properties
View extended component properties
IC Label plugin

IC1 - pop_prop_extended()

IC1 Activity Power Spectrum

Scrolling IC1 Activity

Continuous Data

% scalp data var. accounted for: 20.1%

ICLabel
- Brain: 0.0%
- Muscle: 0.1%
- Eye: 98.7%
- Heart: 0.1%
- Line Noise: 0.0%
- Channel Noise: 0.1%
- Other: 1.0%

RMS uV per scalp channel

Power 10*log10(uV^2/Hz)
Practice Labeling...

https://labeling.ucsd.edu/tutorial
Save dataset
Thank You!