Independent Component Analysis

\[ x = \text{scalp EEG} \]

\[ W = \text{unmixing matrix} \]

\[ u = \text{sources} \]

\[ W^* x = u \]

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

\[ W^{-1} \text{ (scalp projections)} \]
## Runica 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>
</tr>
</tbody>
</table>

Other algorithms: binica, jader, erica, sobi, acsobiro
Runica progress...

Input data size [33.133175] = 33 channels, 133175 frames/n
Finding 33 ICA components using extended ICA.
Kurtosis will be calculated initially every 1 blocks using 6000 data points.
Decomposing 122 frames per ICA weight ((1089)^2 = 133175 weights. Initial learning rate will be 0.001, block size
Learning rate will be multiplied by 0.98 whenever angledelta >= 60 deg.
More than 32 channels; default stopping weight change 1E-7
Training will end when wchange < 1e-07 or after 512 steps.
Online bias adjustment will be used.
Removing mean of each channel ...
Final training data range: -171,806 to 179,094
Computing the sphering matrix...
Starting weights are the identity matrix ...
Sphering the data ...
Beginning ICA training ... first training step may be slow ...
step 1 - lrate 0.0001000, wchange 16,85061324, angledelta 0.0 deg
step 2 - lrate 0.0000100, wchange 0.26780405, angledelta 0.0 deg
step 3 - lrate 0.0000100, wchange 0.79058223, angledelta 104.0 deg
step 4 - lrate 0.0000980, wchange 0.68770031, angledelta 147.2 deg
step 5 - lrate 0.0000960, wchange 0.62849071, angledelta 146.5 deg
step 6 - lrate 0.0000941, wchange 0.73967959, angledelta 150.7 deg
step 7 - lrate 0.0000922, wchange 0.73727229, angledelta 151.6 deg
step 8 - lrate 0.0000904, wchange 0.74051387, angledelta 137.9 deg
step 9 - lrate 0.0000886, wchange 0.74536317, angledelta 156.0 deg
step 10 - lrate 0.0000868, wchange 0.72101402, angledelta 143.7 deg
step 11 - lrate 0.0000851, wchange 0.14690114, angledelta 102.5 deg
step 12 - lrate 0.0000834, wchange 0.11822100, angledelta 114.3 deg
step 13 - lrate 0.0000817, wchange 0.75552966, angledelta 100.6 deg
step 14 - lrate 0.0000801, wchange 0.26739750, angledelta 109.1 deg
step 15 - lrate 0.0000785, wchange 0.12123251, angledelta 94.2 deg
step 16 - lrate 0.0000763, wchange 0.10285606, angledelta 110.7 deg
step 17 - lrate 0.0000754, wchange 0.09770499, angledelta 118.6 deg
step 18 - lrate 0.0000739, wchange 0.09544428, angledelta 117.1 deg

Sorting components in descending order of mean projected variance ...
Permuting the activation wave forms ...
Evaluating ICA components

Component Scalp Maps & Activity

Component ERP

Component spectral power

Component ERP images

Component ERSP & Coherence

Exercise...
Where is the ICA decomp?
Plot ICA scalp maps
>> help topoplot
plot a topographic map of a scalp data field in a 2-D circular view
(looking down at the top of the head) using interpolation on a fine
cartesian grid. Can also show specified channel location(s), or return
an interpolated value at an arbitrary scalp location (see 'nocplot').
By default, channel locations below head center (arc_length 0.5) are
shown in a 'skirt' outside the cartoon head (see 'plotrad' and 'headrad'
options below). Nose is at top of plot; left is left; right is right.
Using option 'plotgrid', the plot may be one or more rectangular grids.

Usage:
>> topoplot(datavector, EEG.chanlocs); % plot a map using an EEG chanlocs structure
>> topoplot(datavector, 'my_chanlocs'); % read a channel locations file and plot a map
>> topoplot('example'); % give an example of an electrode location file
>> [h grid_or_vol plotrad_or_grid, xmesh, ymesh]= ... 
   topoplot(datavector, chan_locs, 'Input1','Value1', ...);

Required Inputs:
- datavector - single vector of channel values. Else, if a vector of selected subset
  (int) channel numbers -> mark their location(s) using 'style' 'blank'.
- chan_locs - name of an EEG electrode position file (>> topoplot example).
  Else, an EEG.chanlocs structure (>> help pop_editset)

Optional inputs:
- 'maplims' -> scale map colors to +/- the absolute-max (makes green 0);
  'maxmin' -> scale colors to the data range (makes green mid-range);
  [lo hi] -> use user-defined lo/hi limits (default: 'absmax')
- 'style' -> plot colored map only
  'contour' -> plot contour lines only
  'both' -> plot both colored map and contour lines
  'fill' -> plot constant color between contour lines
  'blank' -> plot electrode locations only (default: 'both')
- 'electrodes' - 'on', 'off', 'labels', 'numbers', 'ptslabels', 'ptsnnumbers'. To set the 'pts' marker,
  see 'Plot detail options' below. (default: 'on' -> mark electrode locations
  with points (',') unless more than 64 channels, then 'off').
- 'plotchans' - vector of channel indices to use in making the head plot.
  (default: [] -> plot all chans)
- 'plotgrid' - [channels] Plot channel data in one or more rectangular grids, as
  specified by [channels], a position matrix of channel numbers defining
  the topographic locations of the channels in the grid. Zero values are
given the figure background color; negative integers, the color of the
Plot ICA scalp maps
Compare 'good' and 'bad' scalp maps
Scroll component activities

Activity like this that is not separated by ICA should be removed and ICA run again for better decomposition.
Plot ICA component properties

ERP Image

Trial 1
Trial 2
Trial 3
Trial 4
Reviewing component properties
Component scalp maps/properties
Export ICA weights

File will contain the weights*sphere matrix
Importing ICA weights
Evaluating ICA components

Component Scalp Maps & Activity

Component ERP

Component spectral power

Component ERP images

Component ERSP & Coherence

Exercise...
Component ERPs
Definition: The data envelope

Data (all channels)

Data envelope (max/min traces)
IC contributions to ERP envelope
Evaluating ICA components

Component Scalp Maps & Activity

Component ERP

Component spectral power

Component ERP images

Component ERSP & Coherence

Exercise...
Plot component power
Plot component power
Evaluating ICA components

Component Scalp Maps & Activity

Component ERP

Component spectral power

Component ERP images

Component ERSP & Coherence

Exercise...
Component ERP image
ERP Image basics

ERP Image

by default, sorted by time-on-task (1\textsuperscript{st} trial, 2\textsuperscript{nd} trial, ...)

Trial 1

Trial 2

Trial 3

Trial 4
ERP Image basics

Trial 1:

Trial 2:

No Smoothing

Smoothed across 10 Trials
ERP Images: smoothing across trials

![Graph showing ERP Images with moving averages 1, 2, and 10.](image-url)
Component ERP Images

Phase-sorted image
Component ERP Images

Phase-sorted alpha power
Component ERP

36

Component ERP Images

10  12

10  12

0.01

'ampsort', [0  0  10  12]

>> help erpimage

'ampsort' = [center_m,s prcnt, freq, maxfreq] Sort epochs by amplitude.

(See 'phasesort' above). If ms_center is 'Inf', then sorting is by mean power across the time window specified by 'sortwin' below. If third arg, freq, is < 0, sort by mean power in the range [ abs(freq)  maxfreq ].

Phase-sorted 
alpha power

Same data: Sorted by alpha amplitude

Phasesorted
alpha power
Component ERP Images

Same sorting order: Amplitude vs. activations
Evaluating ICA components

<table>
<thead>
<tr>
<th>Component</th>
<th>Scalp Maps &amp; Activity</th>
<th>ERP</th>
<th>Spectral Power</th>
<th>ERP Images</th>
<th>ERSP &amp; Coherence</th>
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</table>

Exercise...
Plot IC ERSP

Component 1 power and inter-trial phase coherence (faces, epochs)

ERSP (dB)

Frequency (Hz)

20 40

Time (ms)

0 500 1000

ERP

Frequency [Hz]

20 40

Time (ms)

0 500 1000

ITC

Bootstrap significance level (Ex: 0.01 -> 1%)

Optional newtime0 arguments (see Help)

- 'padratio', 2, 'plotphase', 'off', 'winsize', 250

Plot Event Related Spectral Power

Plot Inter Trial Coherence
IC cross coherence
IC cross coherence

Be sure to mask by bootstrap significance limits
Exercise

• **ALL**
  Load faces_3.set or faces_4.set, epoch, reject noise

• **ALL**
  - From the GUI, plot component ERPs with maps
  - Pick an interesting IC/ERP (e.g. component contributing to N170) and plot an ERP image of it
  - Try sorting by RT or phase, is there any relationship to the IC activation pattern? What about power in a frequency band of choice?

• **Advanced**
  - Plot cross coherence between two selected Ics studied above
  - Compare this result with cross coherence between two channels that are highly weighted in the respective ICs