Artifact rejection and running ICA

Task 1
Reject bad channels

Task 2
Reject continuous data

Task 3
Reject data epochs

Task 4
Run ICA

Task 5
Plot components

Exercise...
Task 1
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Exercise...
Load/scroll data

```matlab
>> EEG = pop_loadset('faces_3.set', '...
data\');
>> [ALLEEG EEG CURRENTSET] = eeg_store(ALLEEG, EEG, 0);
```
Reject bad channels

```matlab
>> pop_eegplot(EEG, 1, 1, 1);
```
Reject bad channels (manually)

```matlab
EEG = pop_select(EEG, 'nochannel', [19 24]);
```
Reject bad channels (automatic)

```matlab
>> EEG = pop_rejchan(EEG, 'elec', [1:33], 'threshold', 2, 'norm', 'on', 'measure', 'prob');
```
Reject bad channels

Optionally change default dataset name
Artifact rejection and running ICA

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Exercise...
Reject continuous data

Equivalent!!
Reject continuous data

Click and drag with mouse over noisy data to reject
Reject continuous data

To prepare data for ICA:

- Reject large muscle or otherwise strange events...
- Keep stereotyped artifacts (like eye blinks)
Artifact rejection and running ICA

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Exercise...
Extract Epochs (review)
Extract epochs (review)

\[
>> \text{EEG} = \text{pop\_epoch} (\text{EEG}, \{'\text{face}', '\text{object}'\}, [-1 2],... '\text{newname}', 'faces\_3\_epochs',... '\text{epochinfo}', 'yes');
\]

\[
>> \text{EEG} = \text{pop\_rmbase} (\text{EEG}, [-100 0]);
\]

\[
>> [\text{ALLEEG EEG CURRENTSET}] = \text{pop\_newset} (\text{ALLEEG}, \text{EEG},... \text{CURRENTSET}, '\text{setname}', 'faces\_3\_epochs');
\]
Reject data epochs

- Change sampling rate
- Filter the data
- Re-reference
- Reject continuous data by eye
- Extract epochs
- Remove baseline
- Run ICA
- Remove components
- Automatic epoch rejection
- Reject data epochs
  - Reject data using ICA
  - Locate dipoles using BESA
  - Locate dipoles using DIPFIT 2.x
  - Laplacian
- FMRIB Tools
- Grand average datasets
- Locate dipoles using LORETA
- PCA plugin

Reject data (all methods)
- Reject by inspection
- Reject extreme values
- Reject by linear trend/variance
- Reject by probability
- Reject by kurtosis
- Reject by spectra
- Export marks to ICA reject
- Reject marked epochs
Reject data epochs

**Visual Inspection**

- Mark trials by appearance
- Find abnormal values:
  - Upper limit(s) (uV)
  - Start time(s) (ms)
  - Electrode(s)
- Find abnormal trends:
  - Max slope (uV/epoch)
  - Electrode(s)
- Find improbable data:
  - Single-channel limit (std. dev.)
  - Electrode(s)
- Find abnormal distributions:
  - Single-channel limit (std. dev.)
  - Electrode(s)
- Find abnormal spectra (slow):
  - Upper limit(s) (dB)
  - Low frequency(s) (Hz)
  - Electrode(s)

**Probability**

- Lower limit(s) (uV)
- Ending time(s) (ms)
- Currently marked trials
- R-squared limit (0 to 1)
- Currently marked trials
- All channels limit (std. dev.)
- Currently marked trials
- All channels limit (std. dev.)
- Currently marked trials
- Abnormal appearance
- Abnormal values
- Improbable epochs
- Abnormal distributions
- Abnormal trends
- Abnormal spectra
Reject data epochs

Probability (± 5 stds)

Visual inspection
Plot channel measures over time

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark trials by appearance</td>
<td></td>
</tr>
<tr>
<td>Scroll Data</td>
<td></td>
</tr>
<tr>
<td>Marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Find abnormal values</td>
<td></td>
</tr>
<tr>
<td>Upper limit(s) (uV)</td>
<td>25</td>
</tr>
<tr>
<td>Starting time(s) (ms)</td>
<td>-1000</td>
</tr>
<tr>
<td>Electrode(s)</td>
<td>1:31</td>
</tr>
<tr>
<td>Calc / Plot</td>
<td></td>
</tr>
<tr>
<td>Lower limit(s) (uV)</td>
<td>-25</td>
</tr>
<tr>
<td>Ending time(s) (ms)</td>
<td>1996</td>
</tr>
<tr>
<td>Currently marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Find abnormal trends</td>
<td></td>
</tr>
<tr>
<td>Max slope (uV/epoch)</td>
<td>50</td>
</tr>
<tr>
<td>Electrode(s)</td>
<td>1:31</td>
</tr>
<tr>
<td>Calc / Plot</td>
<td></td>
</tr>
<tr>
<td>R-squared limit (0 to 1)</td>
<td></td>
</tr>
<tr>
<td>Currently marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Find improbable data</td>
<td></td>
</tr>
<tr>
<td>Single-channel limit (std. dev.)</td>
<td>5</td>
</tr>
<tr>
<td>Electrode(s)</td>
<td>1:31</td>
</tr>
<tr>
<td>Calculate</td>
<td></td>
</tr>
<tr>
<td>All channels limit (std. dev.)</td>
<td></td>
</tr>
<tr>
<td>Currently marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Find abnormal distributions</td>
<td></td>
</tr>
<tr>
<td>Single-channel limit (std. dev.)</td>
<td>5</td>
</tr>
<tr>
<td>Electrode(s)</td>
<td>1:31</td>
</tr>
<tr>
<td>Calculate</td>
<td></td>
</tr>
<tr>
<td>All channels limit (std. dev.)</td>
<td></td>
</tr>
<tr>
<td>Currently marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Find abnormal spectra (slow)</td>
<td></td>
</tr>
<tr>
<td>Upper limit(s) (dB)</td>
<td>25</td>
</tr>
<tr>
<td>Low frequency(s) (Hz)</td>
<td>0</td>
</tr>
<tr>
<td>Electrode(s)</td>
<td>1:31</td>
</tr>
<tr>
<td>Calc / Plot</td>
<td></td>
</tr>
<tr>
<td>Lower limit(s) (dB)</td>
<td>-25</td>
</tr>
<tr>
<td>High frequency(s) (Hz)</td>
<td>50</td>
</tr>
<tr>
<td>Currently marked trials</td>
<td>0</td>
</tr>
<tr>
<td>Help</td>
<td></td>
</tr>
<tr>
<td>Plot</td>
<td></td>
</tr>
<tr>
<td>Find abnormal activity</td>
<td></td>
</tr>
<tr>
<td>Abnormal appearance</td>
<td></td>
</tr>
<tr>
<td>Abnormal values</td>
<td></td>
</tr>
<tr>
<td>Abnormal distributions</td>
<td></td>
</tr>
<tr>
<td>Abnormal trends</td>
<td></td>
</tr>
<tr>
<td>Abnormal spectra</td>
<td></td>
</tr>
<tr>
<td>Plot</td>
<td></td>
</tr>
<tr>
<td>Plotting options</td>
<td></td>
</tr>
<tr>
<td>Show all trials marked for rejection by the measure selected above</td>
<td></td>
</tr>
<tr>
<td>Abnormal appearance</td>
<td></td>
</tr>
<tr>
<td>Abnormal values</td>
<td></td>
</tr>
<tr>
<td>Abnormal distributions</td>
<td></td>
</tr>
<tr>
<td>Abnormal trends</td>
<td></td>
</tr>
<tr>
<td>Abnormal spectra</td>
<td></td>
</tr>
<tr>
<td>Close (keep marks)</td>
<td></td>
</tr>
<tr>
<td>Clear all marks</td>
<td></td>
</tr>
<tr>
<td>Reject marked trials</td>
<td></td>
</tr>
</tbody>
</table>
Reject data epochs

Trials

Channel

Noisy epoch
Reject data epochs

Exceeds channel standard dev. max
Reject data epochs

```matlab
>> EEG = pop_jointprob(EEG,1,[1:31],5,5,0,0);
>> EEG = pop_rejepoch(EEG,find(EEG.reject.rejglobal),0);
```
Reject data epochs (automatic)

>> EEG = pop_autorej(EEG, 'nogui', 'on', 'eegplot', 'on');
Reject data epochs (automatic)

Iterative rejection based on probability

‘eegplot’, ‘on’ shows rejected epochs
Artifact rejection and running ICA

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Exercise...
Independent Component Analysis

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

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

\[ u = \text{sources} \]

\[ W^*x = u \]

ICA

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

\[ W^{-1} \text{ (scalp projections)} \]
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/nFinding 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 spheric matrix ... 
Starting weights are the identity matrix ...
Sphering the data ...
Beginning ICA training ... first training step may be slow ...
step 1 - lrate 0,000001, wchange 16,85061324, angledelta 0,0 deg
step 2 - lrate 0,000001, wchange 0,26760405, angledelta 0,0 deg
step 3 - lrate 0,000001, wchange 0,73058533, angledelta 104,0 deg
step 4 - lrate 0,000980, wchange 0,66700001, angledelta 147,2 deg
step 5 - lrate 0,000980, wchange 0,62849071, angledelta 146,5 deg
step 6 - lrate 0,000941, wchange 0,73967959, angledelta 150,7 deg
step 7 - lrate 0,000922, wchange 0,73727229, angledelta 151,6 deg
step 8 - lrate 0,000904, wchange 0,74051387, angledelta 137,9 deg
step 9 - lrate 0,000886, wchange 0,74536137, angledelta 156,0 deg
step 10 - lrate 0,000000, wchange 0,72101402, angledelta 143,7 deg
step 11 - lrate 0,000000, wchange 0,14690114, angledelta 102,5 deg
step 12 - lrate 0,000000, wchange 0,11822100, angledelta 114,3 deg
step 13 - lrate 0,000000, wchange 0,75552966, angledelta 106,6 deg
step 14 - lrate 0,000000, wchange 0,26739700, angledelta 109,1 deg
step 15 - lrate 0,000000, wchange 0,12123521, angledelta 94,2 deg
step 16 - lrate 0,000759, wchange 0,10285606, angledelta 110,7 deg
step 17 - lrate 0,000754, wchange 0,09770499, angledelta 118,6 deg
step 18 - lrate 0,000739, wchange 0,09544428, angledelta 117,1 deg

Sorting components in descending order of mean projected variance ... 
Permuting the activation wave forms ...
Artifact rejection and running ICA

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Exercise...
Plot ICA scalp maps

[Image of a computer screen showing a EEGLAB software interface, with a focus on plotting ICA scalp maps.]
help topoplot

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 val plotrad or grid, xmesh, ymesh]= ...
   topoplot(datavector, chan_locs, 'Input1','Valuel', ...);

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:

'maplimits' - 'abmax' -> 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: 'abmax')

'style' - 'map' -> 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','ptsnumbers'. 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

Time periods that are not independent across ICs should be removed and ICA run again for better decomposition.
Plot ICA component properties

Trial 1
Trial 2
Trial 3
Trial 4

ERP Image
Reviewing component properties
Component scalp maps/properties
Eye blink component

Component 4 map
Component 4 activity (global offset 0.036)
Sorted Trials
Activity power spectrum

Magnitude (dB)
Frequency (Hz)
Muscle
Bad channels
Brain ICs

EEGLAB Workshop VII, Apr. 20-22, 2009, Bloomington, IN: Julie Onton – Artifact rejection and running ICA
ICA weights in EEG structure

```
>> EEG
EEG =

    setname: 'faces_4 continuous'
    filename: 'faces_4.dat'
    filepath: '/home/julie/workshop09/
    subject: '
    group: '
    condition: '
    session: []
    comments: ['1x48 char']
    nbchan: 33
    trials: 1
    pts: 133175
    rate: 250
    xmin: u
    xres: 532.6960
    tixes: []
    data: [33x133175 single]
    icancpt: [33x133175 single]
    icancelv: [33x23 double]
    icasphere: [33x33 double]
    icaseweights: [33x33 double]
    chanlocs: [1x33 struct]
    urchanlocs: []
    chaninfo: [1x1 struct]
    ref: 'common'
    event: [1x731 struct]
    urevent: [1x731 struct]
    eventdescription: [] []
    epoch: []
    epochdescription: []
    reject: [1x1 struct]
    states: [1x1 struct]
    specdata: []
    specificsct: []
    splinesfile: '
    iicasplinesfile: '
    dilpct: [1x1 struct]
    history: [1x1633 char]
    saved: 'no'
    etc: []
```
Exercise

- ALL
  - Load faces_3.set or faces_4.set
  - Epoch the data on faces and objects
  - From Reject data epochs->All methods menu
  - Scroll the data and perform visual rejection
  - Try other rejection protocols and compare
  - Explore channel probability and abnormal distribution plots
  - Find and identify artifact ICs
  - How can you be sure that an IC is artifact?