Independent component analysis applied to biophysical time series and EEG

Arnaud Delorme



Does removing ICA adulterate the phase of the EEG signal?



ICA Reconstruction to Remove Artifact Adulterates EEG Phase & Coherence

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Robert Thatcher Published on Nov 24, 2014

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Independent Component Analysis (ICA) Reconstruction to remove artifact Adulterates EEG phase & Coherence & invalidates any subsequent analyses

About 50 messages on EEGLABLIST https://sccn.ucsd.edu/pipermail/ eeglablist/2017/012642.html



"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)

Runica options



Option	Default	Comments
extended'	0	1 is recommended to find sub-gaussians
stop'	1e-7	final weight change \rightarrow stop
Irate' from data	determined a too large	too small → too long e → wts blow up
maxsteps'	512	more channels \rightarrow more steps
pca'	0 or EEG.nbchan	Decompose only a principal data subspace
n ICA decomposi	tion pop_runica()	Other algorithms: binica,amica,sobi,acsobire
elect)) messages) ces		runica 🗧 🔁 Դոծ նակագում,թ1809-780 . types channels

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Runica progress...



ICA weights in EEG structure

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trial	s: 1	
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srat	: 250	
xmi	1: 0	
xma	: 532.6960	
time	a: []	
dat	a: [33x133175 single]	
icaac	:: [33x133175 single]	
icawin	7: [33x33 double]	
icaspher	2: [33x33 double]	
icaweight	a: [33x33 double]	
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Plot ICA scalp maps

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	Cancel	Help		Ok						

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



Help

Ok

Cancel



Removing Artifactual Components

Reviewing component properties



IC Classification...so far















Eye blink correction

٨.		EEGLAB v6.0b				
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	Samp	Run ICA				
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Eye blink correction



Eye blink correction



Component ERPs

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A step back: Electrode-level ERP

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Traditional ERP: Time-locked activity at each channel



Definition: The data envelope



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#### **Definition: IC Envelope**



# Key: Scalp ERP peaks are often the sum of <u>multiple</u> independent source processes



#### IC contributions to ERP envelope



#### **Component contribution to the dataset ERP**



#### IC ERP difference

| M EEGLAB v7.1.7.1      | 8b                             |        |                                                                 | x |  |  |  |  |
|------------------------|--------------------------------|--------|-----------------------------------------------------------------|---|--|--|--|--|
| File Edit Tools        | Plot Study Datasets Help       |        |                                                                 |   |  |  |  |  |
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|                        | Channel data (scroll)          |        | Enter time range (in ms) to plot: -200 496                      |   |  |  |  |  |
| Filename:              | Channel spectra and maps       |        | Enter time range (in ms) to rank component contributions: 0 200 |   |  |  |  |  |
| Channels               | Channel properties             |        | Number of largest contributing components to plot (7): 6        |   |  |  |  |  |
| Frames pe              | Channel ERP image              |        | Else plot these component numbers only (Ex: 2:4,7):             |   |  |  |  |  |
| Epochs                 | Channel ERPs 🕨                 |        | Component numbers to remove from data before plotting:          |   |  |  |  |  |
| Events                 | ERP map series                 |        | Plot title: Largest ERP components of Memorizi                  |   |  |  |  |  |
| Sampling (             | Sum/Compare ERPs               |        | Optional topoplot() and envtopo() arguments: 'electrodes','off' |   |  |  |  |  |
| Epoch sta              | Component activations (scroll) |        |                                                                 |   |  |  |  |  |
| Epoch end<br>Reference | Component spectra and maps     |        | Cancel Help Ok                                                  |   |  |  |  |  |
| Channel Ic             | Component maps                 |        |                                                                 |   |  |  |  |  |
| ICA weight             | Component properties           | N N    |                                                                 |   |  |  |  |  |
| Dataset si             | Component ERP image            |        |                                                                 |   |  |  |  |  |
|                        | Component ERPs 📃 🕨             | With c | component maps                                                  |   |  |  |  |  |
|                        | Sum/Compare comp. ERPs         | With o | With comp. maps (compare)                                       |   |  |  |  |  |
| Data statistics In re  |                                |        | In rectangular array                                            |   |  |  |  |  |
|                        | Time-frequency transforms      |        |                                                                 |   |  |  |  |  |
|                        | Cluster dataset ICs            |        |                                                                 |   |  |  |  |  |

#### **IC ERP difference**



#### **Plot component power**

| ĺ                                                                                                                                                    | Component spectra and maps pop_spec                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | topo()                                                                                                                   |                                                 |           |
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|                                                                                                                                                      | Spectral and scalp map options (see to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | opoplot):                                                                                                                | 'electrodes','off'                              |           |
| A EEGLAB v7.1.7.18b                                                                                                                                  | Cancel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Help Figure 2                                                                                                            | : spectopo()                                    |           |
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#### **Plot component power**



#### **Component ERP image**



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ERP Image basics



ERP Image basics





Smoothed across 10 Trials



ERP Images: smoothing across trials



Component ERP Images



Component ERP Images



Component ERP Images



Plot IC ERSP



ICLabel website

ICLabel project: create automated EEG IC classifier (labeler)

and have an and the second and the s

https://labeling.ucsd.edu/tutorial

vast collection of datasets.









IC Label plugin (Luca Pion-Tonachini)







Component types

- Brain
- Muscle
- Eye

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- Heart
- Line Noise
 - Channel Noise
- Other



Exercise

- Start eeglab
- Load dataset stern_125.set (in EEG_data folder)
- Run ICA (already done for this dataset)
- From the GUI, plot component ERPs with maps
- Pick an interesting IC and plot an ERP image of it

- Try sorting by phase, is there any relationship to the IC activation pattern? What about power in a frequency band of choice?

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