EEGLAB overview

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- Collection of over 300 functions (70000 lines of code)
- About 90 000 download over the past 10 years
- About 5500 users on the discussion list and 9500 on the diffusion list
- NIH funding since 2003

http://sccn.ucsd.edu/eeglab http://sccn.ucsd.edu/wiki/eeglab



EEGLAB standard processing pipeline

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Single subject

- 1. Import binary data, events and channel location
- 2. Edit, Re-reference, Resample, High pass filter data
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- 6. Perform ICA decomposition
 - Perform source localization of components
 - Analyze components contribution to ERP
 - Analyze components contribution to spectrum

Multi-subjects

- 1. Build study and STUDY design
- 2. Pre-compute measures
- 3. Cluster components
- 4. Analyze clusters

Advanced analysis using scripting and EEGLAB command line functions

The EEGLAB Matlab software

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1. Importing data

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Import/load data

File Edit Tools Plot Datasets Help							
Import data 🛛 🗅	From ASCII/float file or Matlab array						
Import epoch info D	From Biosemi .BDF file						
Import event info D	From European Data Format .EDF file						
Export D	From EGLRAW file						
Load existing dataset	From Segmented EGI .RAW files						
Save current dataset	From BCI2000 ASCII file						
Save datasets	From Snapmaster .SMA file						
Clear dataset(s)	From Neuroscan .CNT file						
Maximize memory	From Neuroscan .EEG file						
Save history	From ERPSS .RAW or .RDF file						
Quit	From Brain Vis. Anal. Matlab file						
Dataset size (Mb)	From CTF folder (MEG)						
	From ANT .CNT file						
	From ANT .AVR file						

Import events

File Edit Tools Plot	Datasets Help						
Import data D>	epochs						
Import event info	From Matlab array or ASCII file						
Export D	From data channel						
Load existing dataset	From Presentation .LOG file						
Save current dataset	75						
Save datasets	75						
Clear dataset(s)	128						
Maximize memory	1,992						
Save history 🛛 🖂	No						
Quit	Yes						
ICH Weights	Yes						
Dataset size (Mb)	14.9						



Data info

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	Dataset	t size ((МЬ)	7.9			

Scrolling data



1. Importing channel location

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Import channel location

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	Select epochs/events	75						
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	Delete dataset(s)	No						
	Channel locations	Yes						
	ICA weights	Yes						
	Dataset size (Mb)	14.9						





Edit/select data

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Ch IC Da	annel locations A weights taset size (Mb)	Yes Yes 14.9

Preprocessing data



3. Reject artifacts in continuous data by visual inspection

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Data info

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#2.	Change sampling rate	
TTZ .	Filter the data	
	Re-reference	
Filer	Reject continuous data	
Chann	Extract epochs	
Epoch	s Remove baseline	
Event	Reject data epochs	
Sampl	i Run ICA	
Epoch	Remove components	
Avera	g Reject data using ICA 🛛 🖂	
Chann	e Locate dipoles using DIPFIT ⊳	
ICA w	eights Yes	
Datas	et size (Mb) 14.9	

Reject portions of continuous data



4. Extract epochs from data & reject artifactual epochs

Preprocessing data



4. Extract epochs from data & reject artifactual epochs

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::		EE	GLAB v4.5	1	_ × _
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Ever	nts Reje	ct data	epochs		Reject data (all methods)
Epo	ch Run ch Rem	ICA ove co	mponents		Reject by inspection Reject extreme values
Ave	rag Reje	ct data	using ICA	\geq	Reject flat line data
Chai TCO	nne Loca	ate dipo	les using E	BESA >	Reject by probability
Dat	ase Loca	ate dipo	les using D	DIPFIT D	Reject by kurtosis
	Lapi	acian			Reject by spectra
L	Clus	ter com	iponent		Export marks to ICA reject
	Filte	r the da	ata (IIR)		Reject marked epochs

Different color = different rejection methods



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Plot ERP



Plot ERP map series

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Plot data spectrum and maps

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Plot channel ERPimage

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			Component ERPs	\geq	
			Sum/Compare comp. ERPs		
			Data statistics		
			Time-frequency transforms		



EEGLAB standard processing pipeline

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Single subject

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Multi-subjects

- 1. Build study
- 2. Pre-compute measures
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Advanced analysis using scripting and EEGLAB command line functions

6. Perform ICA decomposition







::	EEGLAB v4.43	_ ×
File Edit	Tools Plot Datasets Help	
Filena Channe Frames Evonts Sampli Epoch Epoch Averag	Change sampling rate Filter the data Re-reference Reject continuous data Extract epochs Remove baseline Reject data epochs Run ICA Remove components Reject data using ICA	
Channe ICA we Datase	Locate dipoles using DIPFIT (* ights Yes t size (Mb) 15,9	Autofit components Head model and settings Coarse fit (grid scan) Fine fit (iterative)
		Plot component dipoles







Component contribution to the ERP

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Component contribution to the EEG spectrum





Component time-frequency





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EEGLAB standard processing pipeline



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Advanced analysis using scripting and EEGLAB command line functions



0	$) \bigcirc$	E	EGLAB	v9.0.0.0ł)			
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(Channels	per frame	e	61				
(Channel	locations		yes				
(Clusters			1				
	Status			Pre-cl	ustered			
	Total si	ze (Mb)		8.2				

idit STUDY design

Select STUDY design		
STUDY.design 1		Add design
		Rename design
		Delete design
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	Ind. var. 1 values non-synonyms synonyms	Ind. var. 2 values
	Combine selected values	Combine selected value
Select all subjects	Unpaired statistics	Unpaired statistics
Use only specific datas	ote/triple	



2. Pre-compute measures

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\varTheta 🔿 🕥 EEGLAB	v9.0.0.0b
File Edit Tools Plot	Study Datasets Help
STUDY set:	Edit study info Select/Edit study design(s)
Study filename:s/data Study task name	Precompute channel measures Plot channel measures
Nb of subjects Nb of conditions Nb of sessions Nb of groups Epoch consistency	Precompute component measuresMeasure Product clusteringPCA clustering (original)Edit/plot clusters
Channels per frame Channel locations Clusters Status Total size (Mb)	61 yes 1 Pre-clustered 8.2

	,	v9.0.0.0k	EGLAB	E	0	0
	Datasets Help	Study	Plot	Tools	Edit	File
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Select and cor	npute component measures for later clustering pop_precomp()			
Pre-compute channel m	easures for STUDY " - 'STUDY.design 1'			
Channel list (default:all) Spherical interpolati Remove ICA artifact	on of missing channels (performed after optional ICA removal below) Ial components pre-tagged in each dataset			
List of measures to pred	compute			
Power spectrum	Spectopo parameters 'specmode', 'fft' (Test)			
ERSPs	Time/freq. parameters Cycles', [3 0.5], 'nfreqs', 100 Test			
Save single-trial measures for single-trial statistics - requires disk space Recompute even if present on disk				
Help	Cancel Ok			



3. Cluster components



4. Analyze clusters



View and edit current component clusters -- pop_clustedit()





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Advanced analysis using scripting and EEGLAB command line functions

EEG structure



3 levels of functions

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Administrative functions: handle EEG and ALLEEG structures eeglab(), eeg_checkset(), pop_delset(), ...

Pop functions: interactive functions using EEG structure pop_erpimage(), pop_topoplot(), pop_envtopo(), ...

Signal processing functions: perform signal processing erpimage(), topoplot(), envtopo(), ...



Command line tools

("eegh" Menus write both dataset and global history)

- Automated processing on groups of subjects (possibly on several processors).
- Richer options for plotting and processing functions (time-frequency decompositions, ...)
- Custom processing...



NFT: Neuroelectromagnetic Forward Head Modeling Toolbox



http://sccn.ucsd.edu/nft





BCILAB - C. Kothe





EEG database: HEAD-IT framework

Pros/Cons of Matlab based open source

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- Pros
 - Easy to program, highly modular and extendable
 - Not dependent on any platform (64-bit)
 - Large community of users (latest development in signal processing research)
 - Cannot imagine more powerful scripting capabilities
- Cons
 - Matlab required for which you have to pay
 - Large memory requirements
 - Matlab bugs, possible version differences, cross platform compatibility problems

EEGLAB WORKSHOP DAY 1 (Tuesday 21st of June, 2011)

7:30 - 8:30 Breakfast

Overview and ICA Theory/Practice

8:30 – 9:30 -- Mining event-related brain dynamics I (Scott Makeig) 9:30 – 10:00 -- EEGLAB overview (Arnaud Delorme)

-- Break--

10:30 – 11:15 -- ICA theory (Arnaud Delorme) 11:15 – 12:00 -- Data import, Artifact rejection and running ICA (Claire Braboszcz)

12:00-13:00 Lunch --

ICA, time-frequency and information flow

13:00 – 14:00 -- Evaluating ICA components (Claire Braboszcz) 14:00 – 15:00 -- Time-Frequency decompositions and practicum (Tim Mullen)

-- Break --

15:30 - 16:30 -- SIFT toolbox: Information flow and granger causality tools (Tim Mullen)
16:30 - 17:30 -- SIFT toolbox: practicum (Tim Mullen)
17:30 - 19:00 -- Data and workstation available

19:00 -- Dinner

EEGLAB WORKSHOP DAY 2 (Wednesday 22nd of June, 2011)

7:30 - 8:30 Breakfast

Source Localization

8:30 - 9:30 -- Forward and inverse models - the Dipfit plugin (Robert Oostenveld)
9:30 - 10:00 -- Why cluster independent components (Scott Makeig)

STUDY design and component Clustering

10:30 – 11:00 -- creating STUDY designs (Arnaud Delorme) 11:00 – 12:00 -- Independent Component Clustering (Romain Grandchamp)

12:00-13:00 Lunch --

Processing multiple subjects using STUDY tools

13:00 – 13:30 -- Statistical tools implemented within EEGLAB and future directions (Guillaume Rousselet)
13:30 – 14:30 -- Plotting measures and computing statistics in with studies (Arnaud Delorme)
14:30 – 15:30 -- Scripting with studies (Arnaud Delorme)

15:30-18:00-- Excursion to Saint-Bertrand-de-Comminges

19:00 -- Dinner

EEGLAB WORKSHOP DAY 3 (Thursday 23rd of June, 2011)

7:30-8:30 -- Breakfast

8:30 – 9:30 -- Mining event-related brain dynamics II (Scott Makeig) 9:30 – 10:00 -- EEGLAB plugins (Arnaud Delorme)

-- Break--

10:30 – 11:30 – Practicum, project available 11:30 – 12:00 – Participant project presentation and general discussion

12:00 -- Lunch

13:30 -- Airport/train station shuttle leaves

EEGLAB articles

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Delorme, A., Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(1), 9-21.

Makeig, S., Debener, S., Onton, J., Delorme, A. (2004) Mining event related dynamics. *Trends in cognitive Neuroscience*, 8(5), 204-210.

Delorme, A., Kothe, C., Bigdely, N., Vankov, A., Oostenveld, R., Makeig, S. Matlab Tools for BCI Research? In "human-computer interaction and braincomputer interfaces". Editors : Tan, D. and Nijholt, A. To appear in 2010. Springer Publishing.

Delorme, A., Mullen, T., Kothe, C., Bigdely-Shamlo, N., Akalin, Z., Vankov, A., Makeig, S. EEGLAB, MPT, NetSIFT, NFT, BCILAB, and ERICA: New tools for advanced EEG/MEG processing. Computational Intelligence, accepted.

Delorme, A., Makeig, S. Open Source Programming for Interpreted Language: Graphic Interface and Macro Bridging Interface. IEEE International Conference on Signal Image Technology and Internet Based Systems. In press.