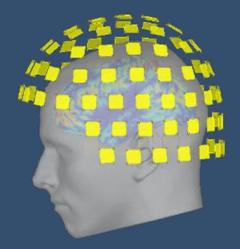
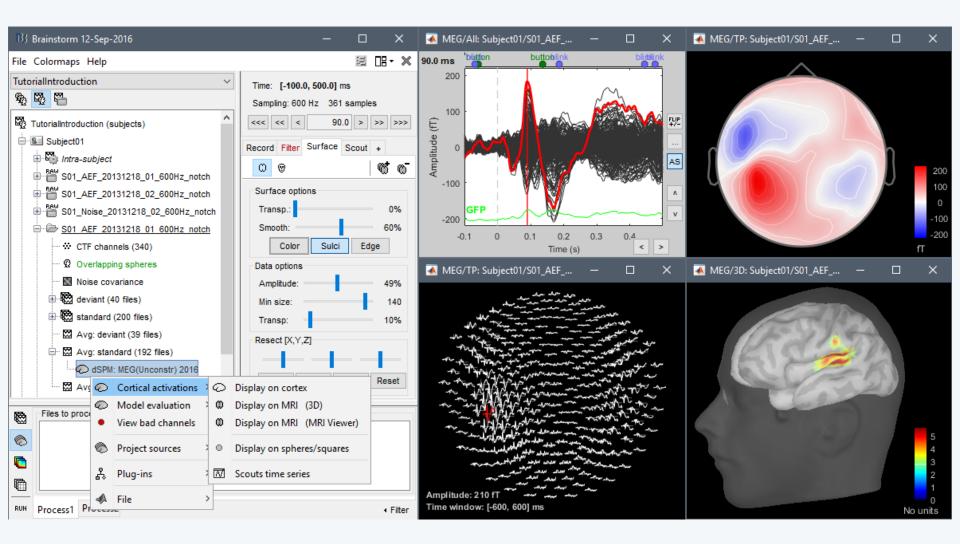
# MEG and EEG analysis using Brainstorm http://neuroimage.usc.edu/brainstorm







## Graphic interface





# Scripting environment

- Rapid selection of files and processes to apply
- Automatic generation of Matlab scripts
- Plug-in structure: easy to add custom processes

	By Pipeline editor 1 % Script generated by Brainstorm v3.1 (17-Dec-2010).
	<pre>2 - FileNamesA = {'Subject01\Left\data_average_101213_1558.mat', 3 'Subject01\Right\data_average_101213_1559.mat');</pre>
Files to process: Data [235]	
	$\odot \bullet \bullet \bullet \bullet \times$ $\pounds \bullet \bullet$
Image: Standard (200 files) [195]   Image: Standard (200 files) [195]   Image: Standard (200 files) [40]     RUH Process1   Process2	Image:
	Average: By trial group (condition average)
	5 'f1', 1,
	Process options 6 'f2', 80, 7 'overwrite', 1);
	Channel name: ECG
	Time window: 0.000 - 358.998 s 🗸 All file 0 - sFiles = bst_process(
	CallProcess', 'process_average',
	Event name: cardiac 2 sFiles, [],
	avgtype', 3,
	4 'isstd', 0);

## Brain*s*torm

- Free and open-source application
- Matlab & Java: Platform-independent
- Designed for Matlab
- Stand-alone version available
- Interface-based: click, drag, drop
- No programming experience required
- Daily updates of the software
- Supports most common file formats

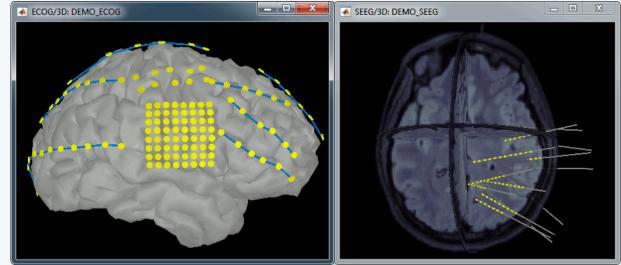




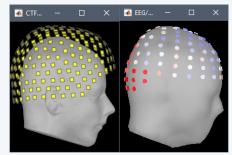
## Multi-modal imaging

**ECoG** 

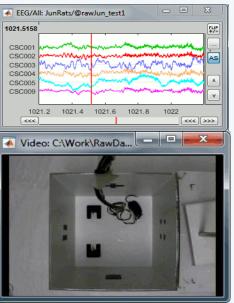
### Depth electrodes



#### **MEG/EEG**



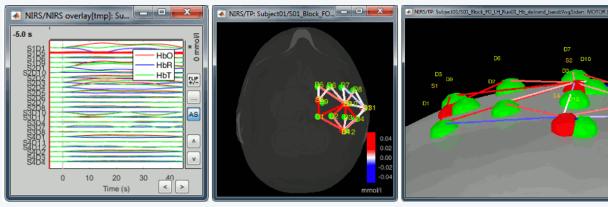
### Electrophysiology



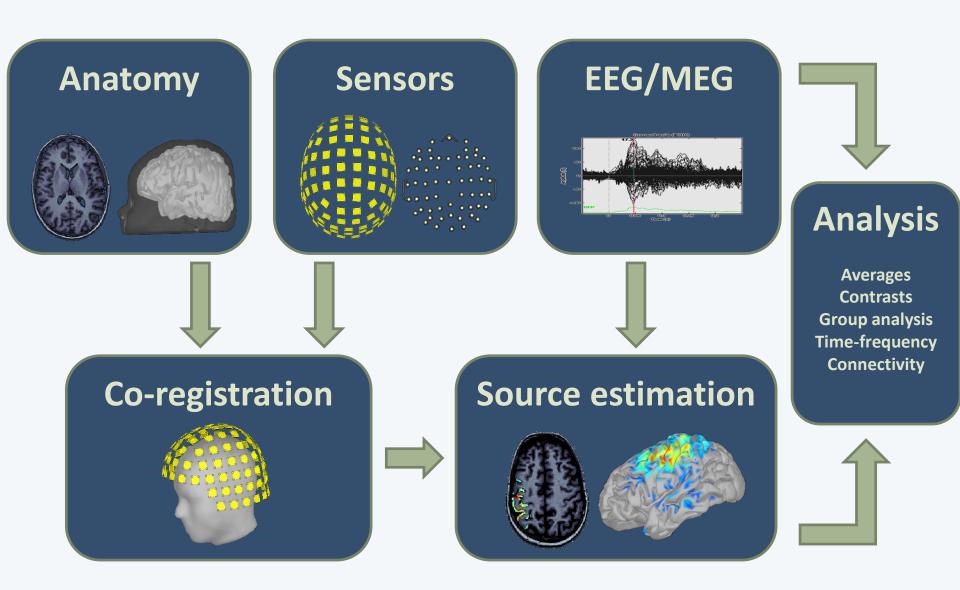
D10



**fNIRS** 



## Workflow





Anatomy Link recordings MRI registration

PSD

Filters

Bad channels Artifacts

Correction

Bad segments

Markers Epoching Averaging Sources Time-frequency Importing

**Pre-processing** 

Analysis of the experimental data

Loop: all acquisition runs all subjects



## Import

### Anatomy

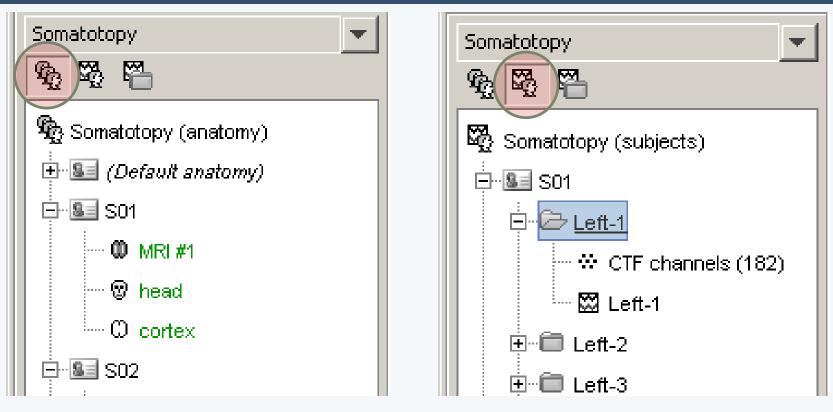
Link recordings MRI registration

PSD Filters Bad channels Artifacts Correction Bad segments

- One-click import of the T1 segmentation: FreeSurfer, BrainSuite, BrainVISA, CIVET
- Import and place fiducials in the MRI (N,L,R)



# Database



- Three levels:
  - Protocol
  - Subject
  - Condition

- Popup menus
- All files saved in Matlab .mat
- Same architecture on the disk



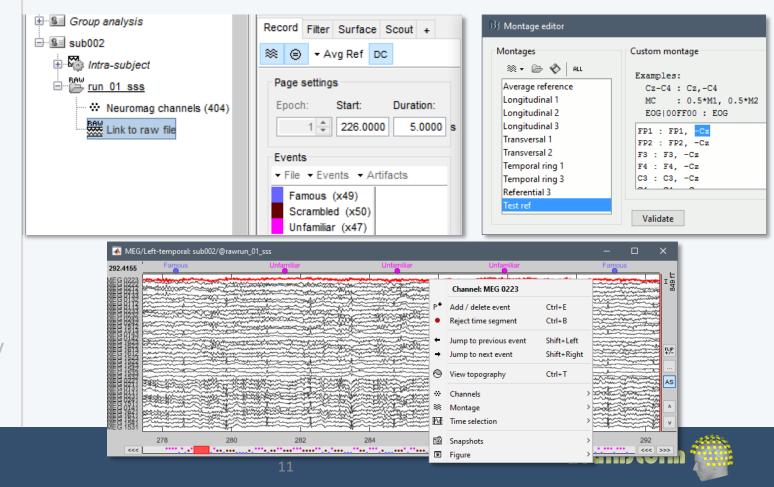
# Import

#### Anatomy Link recordings

MRI registration

- PSD
- Filters
- Bad channels
- Artifacts
- Correction
- Bad segments

- Original files linked to the database (no copy)
- Rich data viewer with flexible montage editor
- Optimized reading functions



# Co-registration MEG / MRI (1)

Anatomy Link recordings MRI registration

PSD Filters Bad channels Artifacts Correction Bad segments

- Basic estimation based on three points: Nasion (NAS), Left ear (LPA), Right ear (RPA)
- MRI: Marked in the volume with the MRI Viewer
- MEG: Obtained with a tracking system (Polhemus)



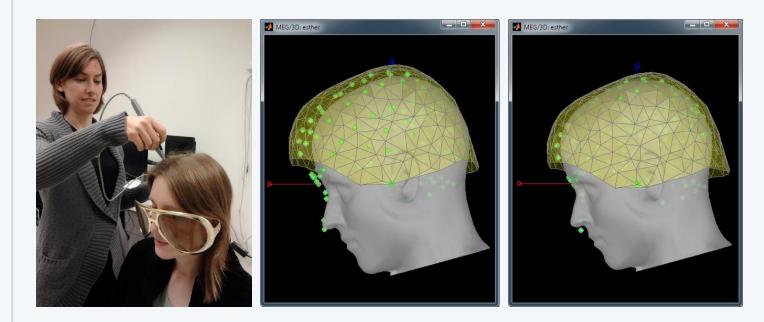


# Co-registration MEG / MRI (2)

#### Anatomy Link recordings MRI registration

PSD Filters Bad channels Artifacts Correction Bad segments

- Automatic adjustment based on head shape: Fitting Polhemus points on the MRI head surface
- Final registration must be checked manually
- Polhemus driver included in Brainstorm





# Quality control

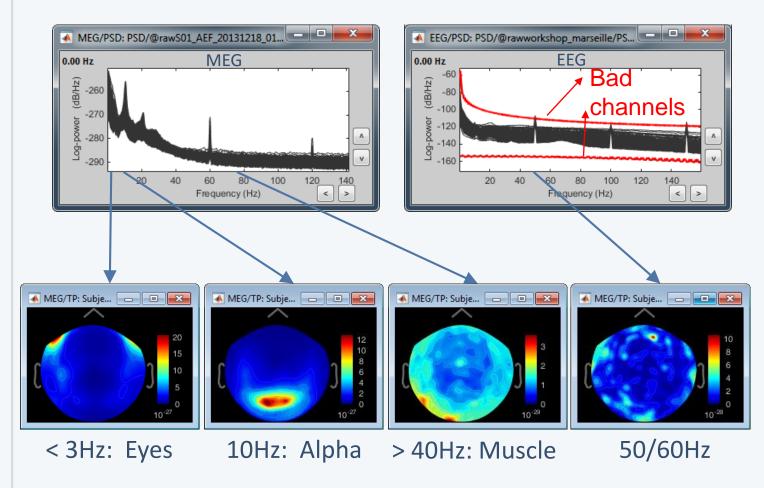
Anatomy Link recordings MRI registration

### PSD

Filters Bad channels Artifacts Correction Bad segments

Markers Epoching Averaging Sources Time-frequency

### • Power spectrum density for quality control





Anatomy Link recordings MRI registration

**PSD** 

**Filters** 

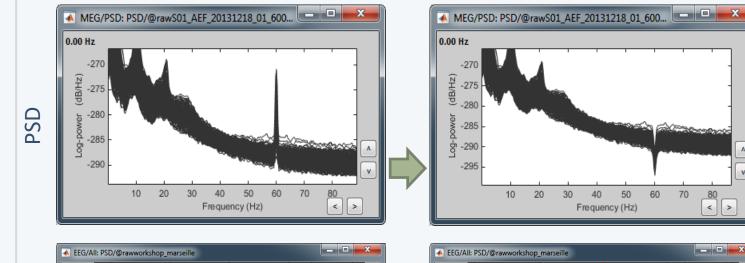
Artifacts

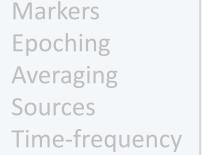
Correction

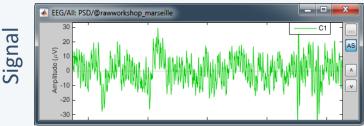
**Bad channels** 

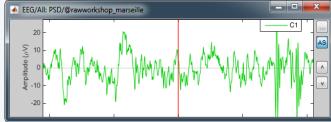
**Bad segments** 

### Notch filter: Removes 50Hz/60Hz power line noise (and harmonics)











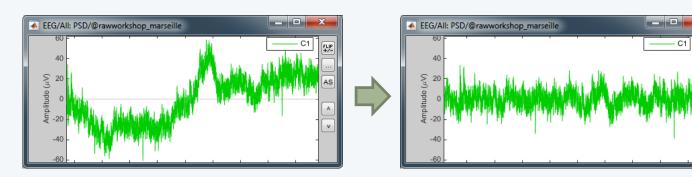
Anatomy Link recordings MRI registration

### PSD

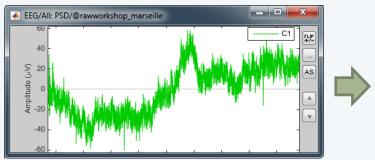
### **Filters**

Bad channels Artifacts Correction Bad segments

Markers Epoching Averaging Sources Time-frequency • High-pass filter: Removes slow components (eye movements, breathing, sensor drifts...)



Low-pass filter: Remove high-frequencies







FLIP

Anatomy Link recordings MRI registration

PSD Filters Bad channels

Artifacts Correction Bad segments

- Manual inspection of the recordings
- Interactive selection of bad channels
- Re-reference the EEG if necessary (Average ref)

EEG/AvgRef: Sub01/@rawrun_01_sss_notch			- 0 <b>X</b>			
226.0000 EE G009 EE G010 EE G010	₽ <b>*</b> ●	Add / delete event Reject time segment	Ctrl+E Ctrl+B	N 11 A 7		
EE G011 EE G012 EE G013 EE G014 EE G014	+ +	Jump to previous event Jump to next event	Shift+Left Shift+Right			
EE G015 Why the human harmonic production of the second se	Θ	View topography	Ctrl+T		View selected	Enter
EEG017 WWW MAN AND AND AND AND AND AND AND AND AND A	*	Channels		•	Mark selected as bad	Delete
EEGO18 WY W WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW	*	Montage		•	Mark non-selected as bad	Shift+Delete
EEG019 226 226.5 227 227.5	M	Time selection		•	Reset selection	Escape
<	Ô	Snapshots		•	Mark all channels as good	Shift+Escape
	*	Figure		ø	Edit good/bad channels	

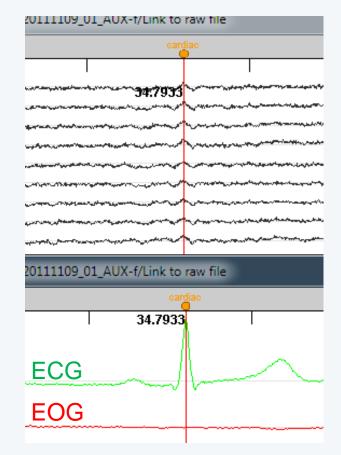


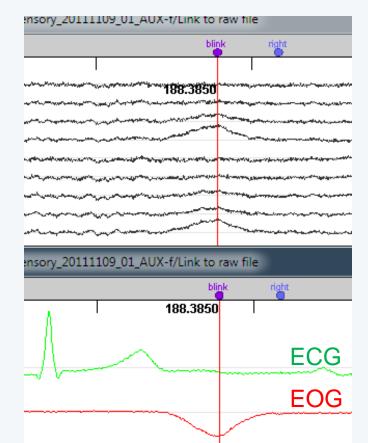
Anatomy Link recordings MRI registration

PSD Filters Bad channels Artifacts

Correction Bad segments

Markers Epoching Averaging Sources Time-frequency • Automatic detection of blinks and heartbeats (peak detection, or explicit amplitude threshold)







Anatomy Link recordings MRI registration

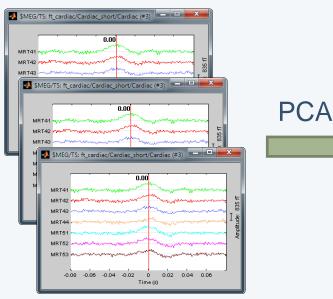
PSD Filters Bad channels Artifacts

### Correction

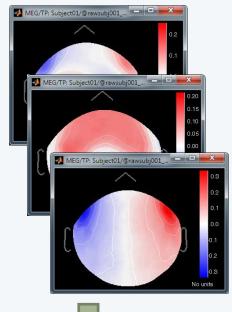
Bad segments

Markers Epoching Averaging Sources Time-frequency • Correction with Signal Space Projections (SSP)

### **Detect artifacts**



### Spatial components



Select components and compute a linear projector to remove their contribution from the recordings



Anatomy Link recordings MRI registration

### PSD

Filters

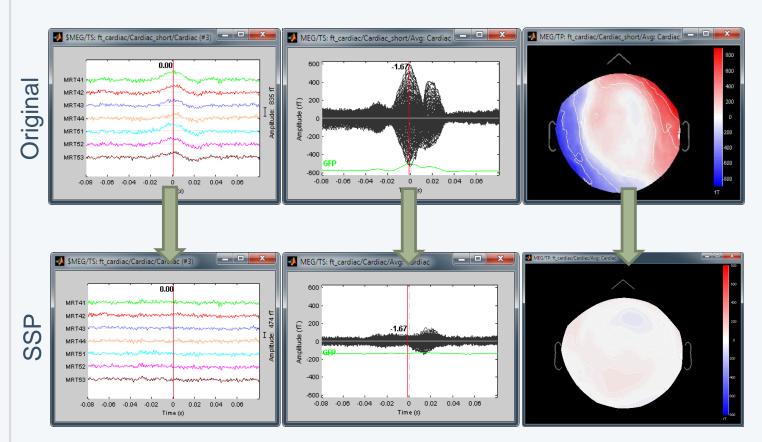
Bad channels Artifacts

### Correction

Bad segments

Markers Epoching Averaging Sources Time-frequency

### • Example: Cardiac artifact





#### Anatomy Link recordings MRI registration

#### PSD

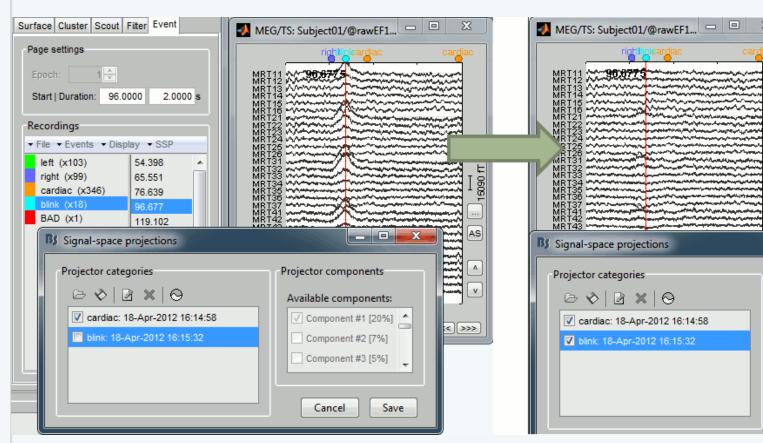
- Filters
- Bad channels Artifacts

### Correction

Bad segments

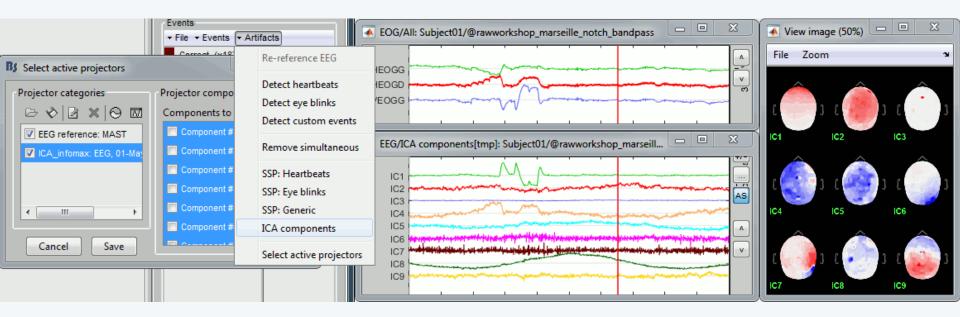
Markers Epoching Averaging Sources Time-frequency

### • Example: Blink





- Independent component analysis (ICA):
  - Popular in the EEG literature
  - Alternative to SSP for low number of sensors
  - Already implemented: Infomax and JADE (EEGLAB)





#### Anatomy Link recordings MRI registration

PSD

Filters

- **Bad channels**
- Artifacts

Correction

### **Bad segments**

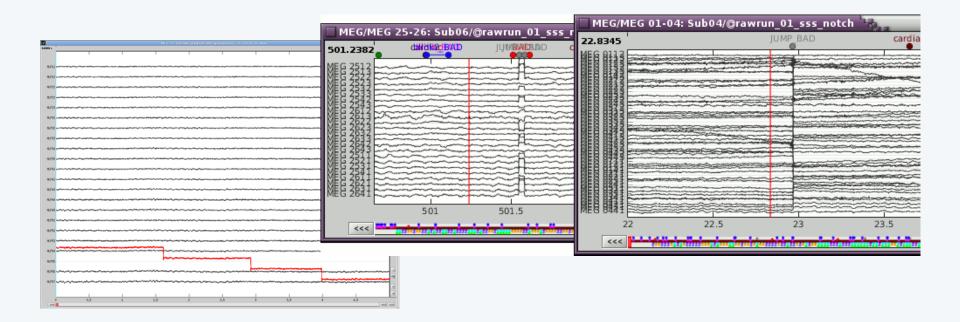
- Automatic detection of artifacts (RMS-based)
- Manual screening of all the recordings is advised (scroll all the sensors by pages of 10-20s)
  - Exclude: Blinks, movements, SQUID jumps

	599.4373	CBADac 1-740-240H2AD cardiac UnfamilBAD
B} Pipeline editor — 🛛	MEG0111	1 Martin Ma
Process selection	MEG0121	
@▼ ↑ ↓ Ж  ᠷੈ▼	MEG0131	1 mars Warmen warmen warmen and the second
Detect other artifacts	MEG0 🔺	🛦 MEG MAG/All: sub002/@rawrun_01_sss_n — 🗆 🗙 🗾
Process options Time window: 226.0000 - 716.9991 s All fil Sensor types or names (empty=all): MEG, EEG Sensitivity: 0 1 0 2 • 3 0 4 0 5 I -7 Hz: Eye movements, subject movements, dental we	le	40.9600 <sup>1</sup> act haft har and a 200 200 Hard and a 200 Hard and and a
40-240 Hz: Muscle noise, sensor artifacts      Online tutorial      Cancel      F	Run	AS A V 232 234 236 238 240 242 244
		232         234         236         236         240         242         244           <<<



## Elekta-Neuromag

- Sharps steps followed by a change of baseline value
- Mark the channels as bad before running MaxFilter
- Or mark the segments as bad in Brainstorm





SQUID jumps

Anatomy Link recordings MRI registration

PSD

- Filters
- Bad channels
- Artifacts
- Correction
- Bad segments

### Markers

Presentation Sensor Manual

### • Two types of experiments:

- Steady-state or resting-state (ongoing activity)
- Event-based (stimulus, response, spike...)
- How to get event markers in the recordings?

File      ▼ Events      ▼ A	rtifacto		MEG/Vertex: sub002/@rawrun_01_sss_notch — 🗌
File	rinacis	_	
Famous (x49)	250.207	^	275.1318 amous Scrambled Unfamiliar Famous Unfamiliar Unfamiliar Unfamiliar
Scrambled (x50)	253.247		MEG 1142
Unfamiliar (x47)	256.355		MEG 1143
	259.362		MEG 0733
	265.576		MEG 2212 Month and the second se
	275.132		MEG 0631
	281.546		MEG 0421 Manufacture and a second sec
	284.804		MEG 0431 Martin and an an and an
	287.911		MEG 0741
	297.600		MEG 1821 Manufacture and a second sec
	338,995		MEG 1111 Manual Ma Manual Manual Manu
			MEG 0721 photo with a strategy of the strategy
	342.135		MEG 0731 And
	345.276		MEG 2211 Mental and a second s
	361.079	× .	268 270 272 274 276 278 280 282 284 286



Anatomy Link recordings MRI registration

PSD

Filters

Bad channels

Artifacts

Correction

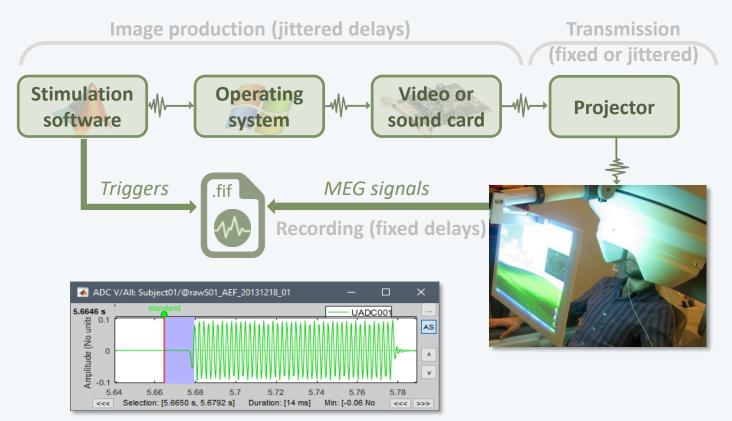
Bad segments

Markers

Presentation

Sensor Manual

### Reading the triggers saved by the presentation software (includes jittered OS delays)



• File triggers are never aligned with the real stim



Anatomy Link recordings MRI registration

PSD

Filters

Bad channels

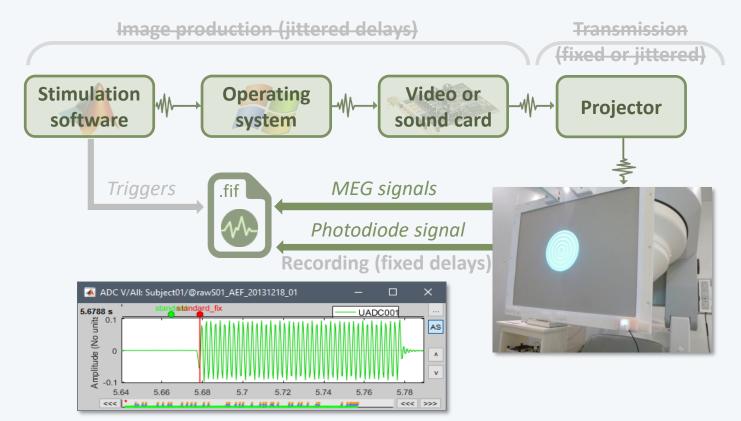
Artifacts

Correction

Bad segments

Markers Presentation

Sensor Manual  Reading information recorded on the subject side (photodiode, microphone, response box...)



• Avoids most uncontrollable jittered delays



Anatomy Link recordings MRI registration

PSD

Filters

Bad channels

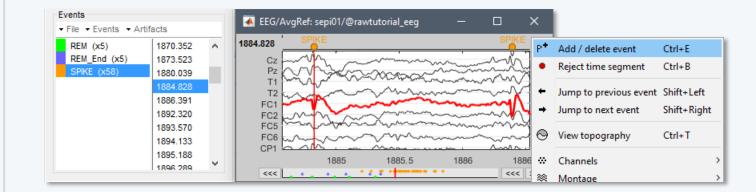
Artifacts

Correction

Bad segments

Markers Presentation Sensor Manual

- Manual or automatic marking of biological or behavioral events, post-acquisition (epileptic spikes, sleep spindles, rat position in a box...)
- Optimized workflow for clinicians (keyboard and mouse shortcuts, workspace...)



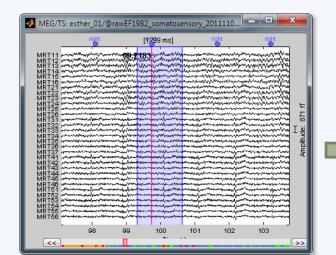


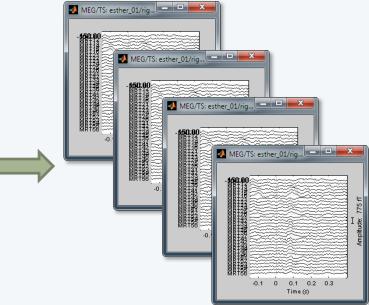
Anatomy Link recordings MRI registration

PSD Filters Bad channels Artifacts Correction Bad segments

Markers Epoching Combine **Extract** Length Process

- Epochs = Trials = Short blocks of recordings around an event of interest.
- Epoching = Extracting epochs from the continuous recordings and saving them.







Anatomy Link recordings MRI registration

PSD

Filters

Bad channels

Artifacts

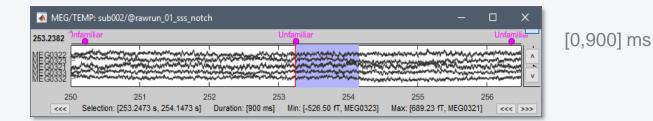
Correction

Bad segments

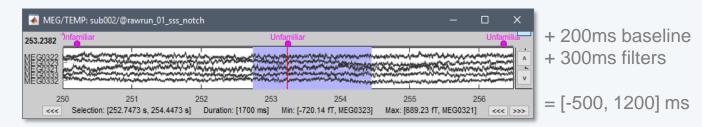
Markers Epoching Combine Extract Length

Process

- How to define the optimal epoch length ?
- Experimental design: Expected effect duration, inter-stimulus interval



Analysis: Frequency filters and amplitude normalizations may require longer epochs



• Computational limitations: Size and time



Anatomy Link recordings MRI registration

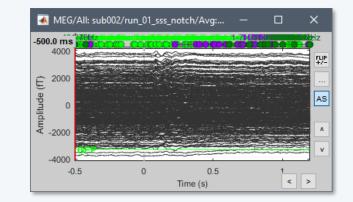
PSD

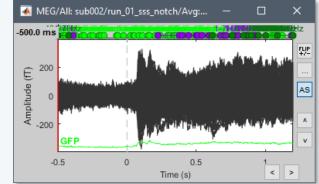
Filters

- Bad channels
- Artifacts
- Correction
- Bad segments

Markers Epoching Combine Extract Length **Process** 

- Processing steps that can be applied on epochs:
  - DC offset correction: Subtract the average estimated over a baseline period
  - Detrending: Subtract a linear trend estimated over a reference period
  - **Resampling**: Decrease the sampling rate
- This dataset: DC correction, baseline=[-500,0]ms







Anatomy Link recordings MRI registration

PSD

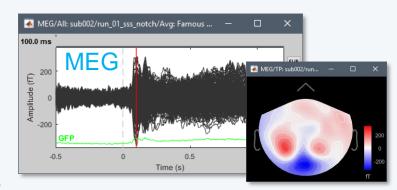
- Filters
- Bad channels
- Artifacts
- Correction
- Bad segments

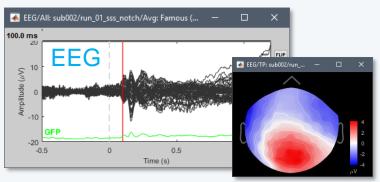
Markers Epoching **Averaging** Sources

Time-frequency

- Averaging the trials: Reveals the features of the signals that are locked in time to a given event
  - = Event-related field / potential
  - = Evoked response
  - = ERF/ERP







Brain/torm

Anatomy Link recordings MRI registration

PSD

- Filters
- Bad channels
- Artifacts
- Correction
- Bad segments

Markers Epoching **Averaging** Sources

Time-frequency

- **EEG**: Averaging data across runs and subjects OK.
  - MEG: Averaging across runs is not always accurateHead shapes differ between subjects.
    - Head positions different between runs.
    - One sensor does not record the same thing in two different runs.
    - Coregistration of runs with Elekta MaxFilter
       helps but modifies a lot the recordings.
       Never use this to average across subjects.
    - Recommended: Estimate the sources for each run separately, then average in source space.



Anatomy Link recordings MRI registration

PSD

**Filters** 

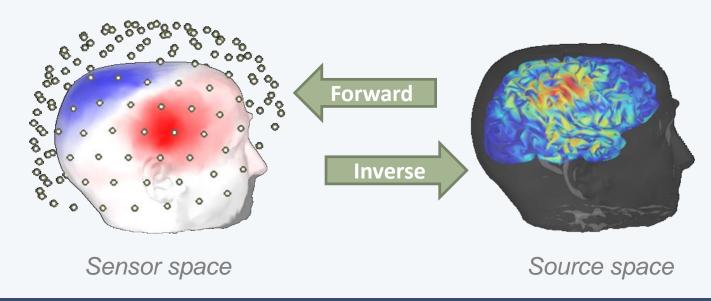
- **Bad channels**
- Artifacts
- Correction
- Bad segments

Markers Epoching Averaging **Sources** Time-frequency

- Source space:
- Forward model:
- Inverse model:

Cortex or full head volumeOverlapping spheres (MEG)OpenMEEG BEM (EEG)

Minimum norm estimates Beamformers Separately for MEG and EEG

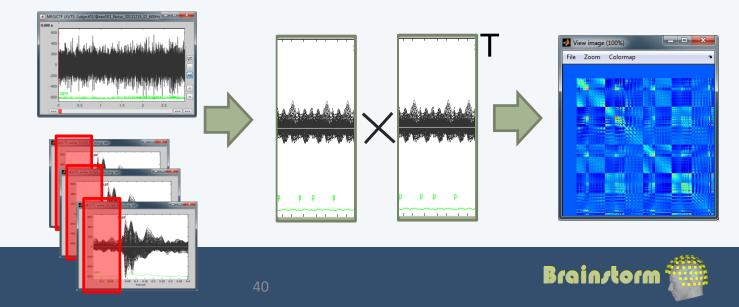




Anatomy Link recordings MRI registration

- PSD Filters Bad channels Artifacts Correction
- Bad segments

- The MNE model requires an estimation of the level of noise of the sensors
- Noise covariance matrix = covariance of segments that do not contain any "meaningful" data
- Empty room, pre-stim baseline, resting



Anatomy Link recordings MRI registration

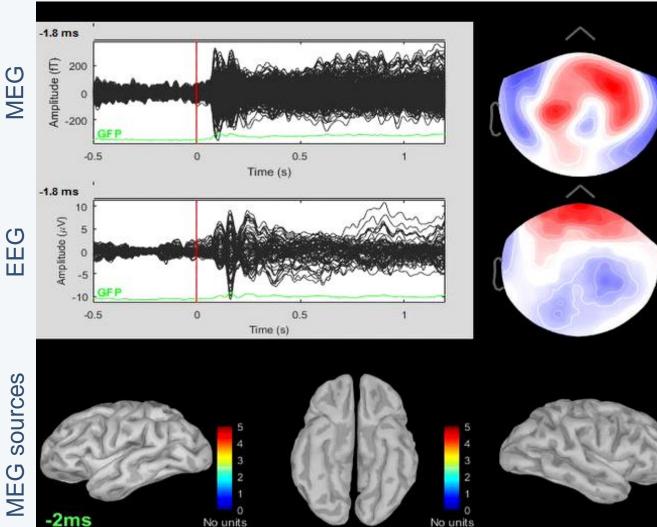
### PSD

Filters

- Bad channels
- Artifacts
- Correction
- Bad segments

Markers Epoching Averaging Sources

### Time-frequency



#### Famous faces

Brainstorm

50

fT

uV

No units

Anatomy Link recordings MRI registration

PSD

Filters

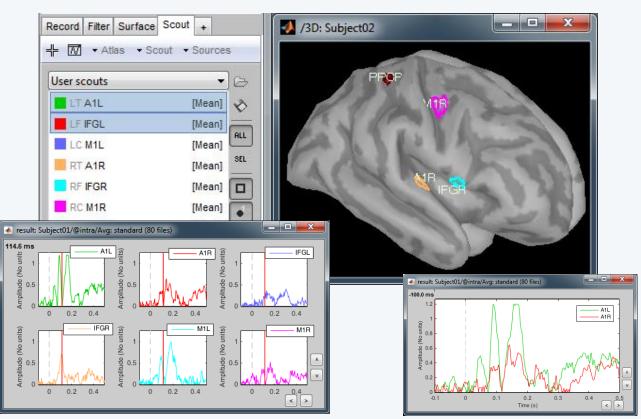
Bad channels

Artifacts

Correction

Bad segments

Markers Epoching Averaging **Sources** Time-frequency Regions of interest at cortical level (scouts)
 = Subset of a few dipoles in the brain
 = Group of vertices of the cortex surface





Anatomy Link recordings MRI registration

PSD

Filters

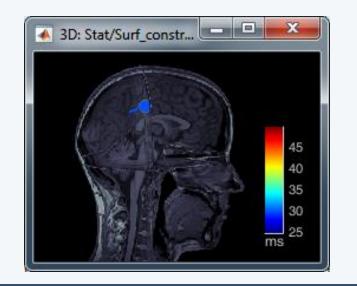
- Bad channels
- Artifacts
- Correction
- Bad segments

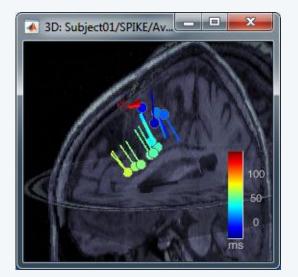
Markers Epoching Averaging **Sources** Time-frequency

#### • Dipole scanning

Compute a distributed source model, then find the most significant dipole at each time sample.

 Dipole fitting (FieldTrip)
 Non-linear search of the dipoles that minimizes the residuals (data explained - recordings)







0.2

Π4

0.6

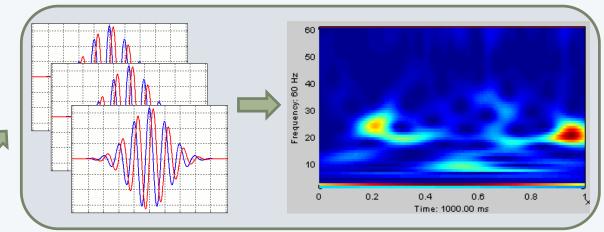
n

Anatomy Link recordings MRI registration

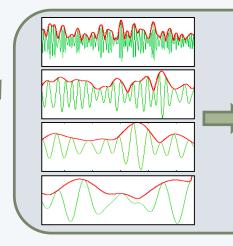
PSD Filters Bad channels Artifacts Correction Bad segments

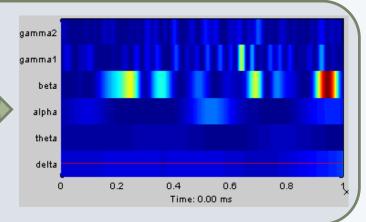
Markers Epoching Averaging Sources Time-frequency

#### Morlet wavelets



#### Hilbert transform + band-pass filter







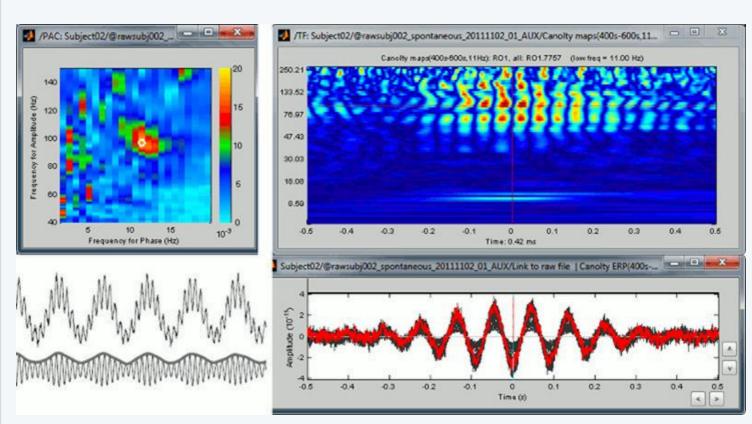
Anatomy Link recordings MRI registration

#### PSD

- Filters
- Bad channels
- Artifacts
- Correction
- Bad segments

Markers Epoching Averaging Sources Time-frequency **Other measures** 

#### Phase-amplitude coupling



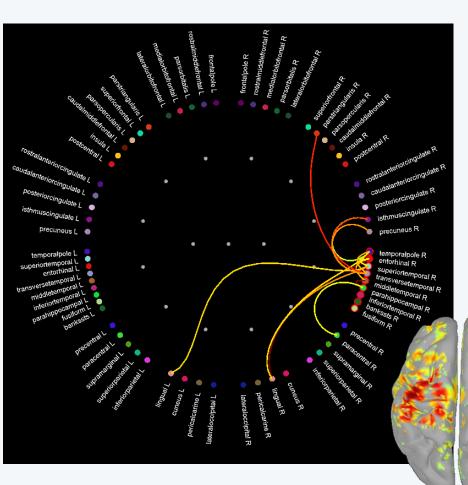


Anatomy Link recordings MRI registration

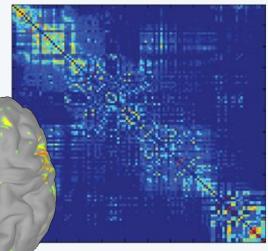
#### PSD

- Filters Bad channels
- Artifacts
- Correction Bad segments
- Markers Epoching Averaging Sources Time-frequency **Other measures**

#### • Connectivity measures



- Correlation
- Coherence
- Phase locking value
- Granger causality

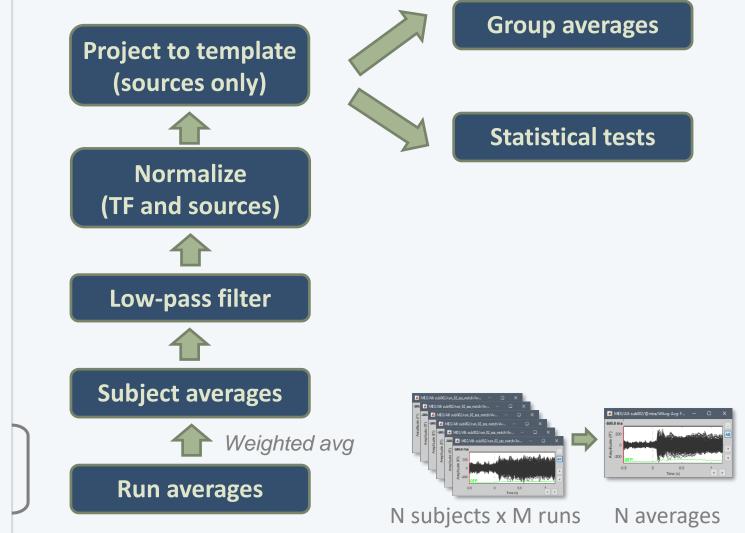




Anatomy Link recordings MRI registration

PSD Filters Bad channels Artifacts Correction Bad segments

Markers Epoching Averaging Sources Time-frequency

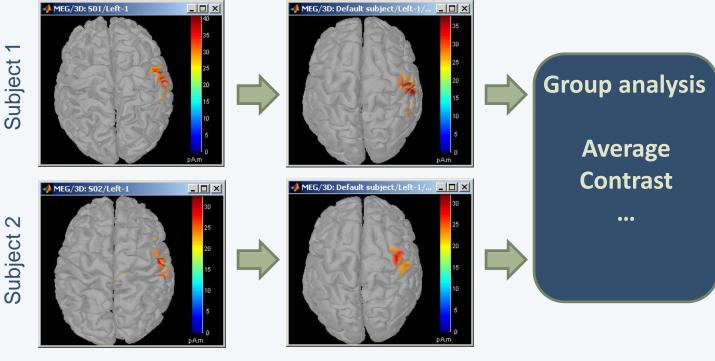




Subject averages Low-pass Normalize **Project** 

Group averages Group statistics

Quality control Workflow Registration of individual sources on a template (ICBM152, Colin27, DNI, infants...)



Individual anatomy Standard anatomy

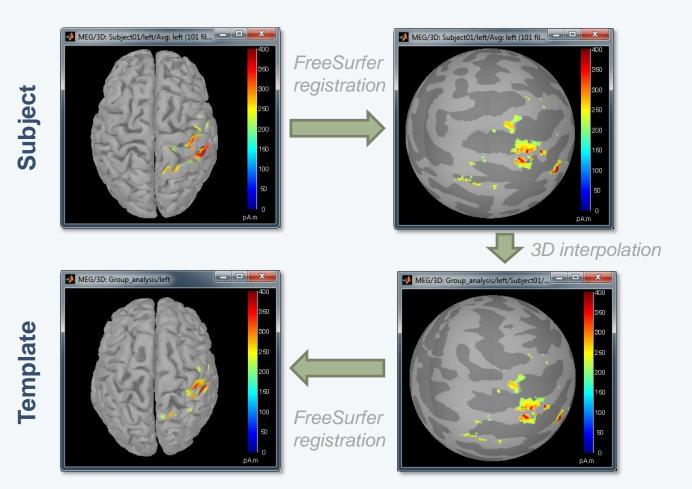


Subject averages Low-pass Normalize **Project** 

Group averages Group statistics

Quality control Workflow

#### • Using FreeSurfer registration



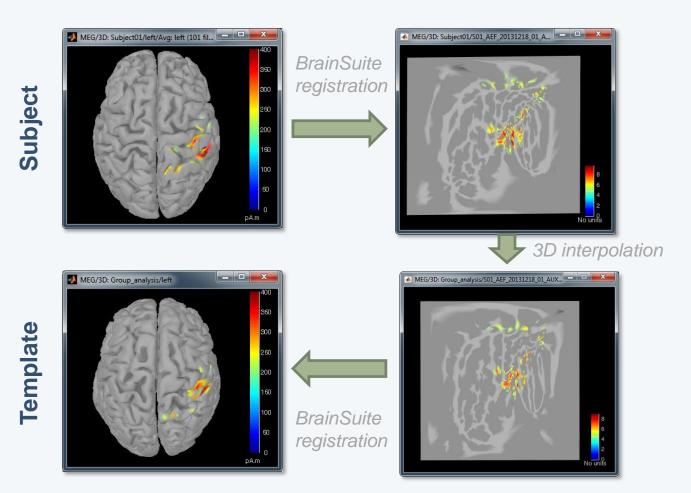


Subject averages Low-pass Normalize **Project** 

Group averages Group statistics

Quality control Workflow

#### Using BrainSuite registration



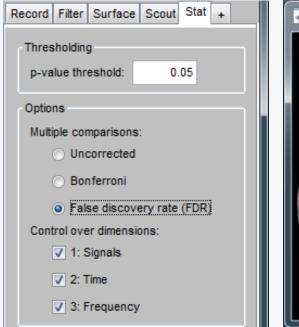


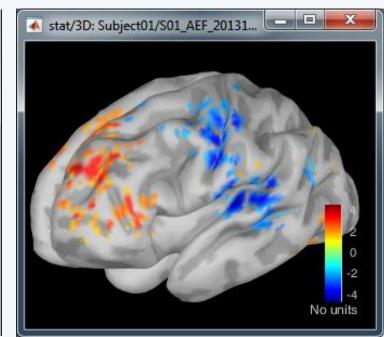
Subject averages Low-pass Normalize Project

Group averages
Group statistics

Quality control Workflow

- Contrasts between subjects or conditions
- Parametric t-test
- Cluster-based non-parametric tests
- Export to: **SPM**, R, Excel, SPSS, Matlab...





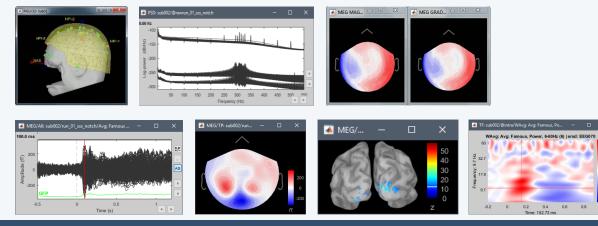


Subject averages Low-pass Normalize Project

Group averages Group statistics

#### Quality control Workflow

- When scripting the analysis, we recommend you always check visually the following items for each run separately:
  - MRI/sensors registration
  - PSD before and after filters
  - SSP and ICA component topographies
  - ERP/ERF: Sensors time series
  - ERP/ERF: Sensors topo of primary response
  - ERP/ERF: Sources of primary response
  - Any other metric of interest





Subject averages Low-pass Normalize Project

Group averages Group statistics

#### **Quality control** Workflow

TutorialGroup	~		\Users\francois\.brains
£ ₩ ₩			Jan-2013 17:25:24
TutorialGroup (subjects)	^	Starti 25-	Jan-2013 17/25/24
Group analysis		0 errors	and 3 warnings
E Common files		process_i	mport_freesurfer
□ 🖓 Intra-subject		process_i	mport_data_raw
		warnin	g [No input]
🖾 Avg: WAvg: Avg: Faces (16	files)   low(32Hz)   time		
🖤 🖾 Avg: WAvg: Avg: Famous (1	6 files)   low(32Hz)   tii		in_remove
🖾 Avg: WAvg: Avg: Scrambled	l (16 files)   low(32Hz)		g Subject01/@rawsubj evt_detect_eog
🖾 Avg: WAvg: Avg: Unfamiliar	(16 files)   low(32Hz)	info	Subject01/@rawsubj
Faces - Scrambled		process_s	isp_eog
		process_i	mport_data_event
mean( Faces-Scrambled )   N	150	info	Subject01/@rawsubj
		process_t	imeoffset
mean( Faces-Scrambled )   E	EG	process_r	
mean( Faces )-mean( Scram	bled()   MEG	process_a	average
mean( Faces )-mean( Scram	bledi) I FEG	process_s	
			neadmodel
Faces - Scrambled: Cluster t		process_i	nverse
Famous - Unfamiliar: Cluster	t-test EEG	warnin	g 2 files []
Faces - Scrambled: Paramet	ric t-test		
Faces - Scrambled: Permuta	tion t-test	Initial fi	les
Famous - Unfamiliar: Parame	tric t-test	[No input]	
Faces-Scrambled =0: Param	etric Chi2 test   MEG	Interme	ediate files
log( Faces-Scrambled )=0: P	arametric Chi2 test   ME		
Faces = Scrambled : Parame		Subject01	/@rawsubj001_somate /@rawsubj001_somate
Faces-Scrambled =0: Param		Subject01	/left/data_average_13 /left/data_left_trial00: /left/data_left_trial00:
Ing( Faces-Scrambled )=0: P		Subject01	/left/data_left_trial00 /left/data_left_trial00 /left/data_left_trial00
Faces = Scrambled : Parame		Subject01, Subject01,	/left/data_left_trial002 /left/data_left_trial002
	>	Subject01	/left/data_left_trial00: /left/data_left_trial00: /left/data_left_trial00:
¢	1		

#### • Execution reports with snapshots saved in HTML

• →   🗁   Clear history			
Start: 25-Jan-2013 17:25:24 Elapsed: 9m 56s			
0 errors and 3 warnings			
process_import_freesurfer			
process_import_data_raw			
warning [No input]		Errors detected in the events of the AUX file (markers at the beginning of a trial): Removed 1 × "left": 82.500 Removed 1 × "right": 276.000	25-Jan-2013 17:26:36
process_sin_remove			
warning Subject01/@rawsubj001_somatosensory_201	11109	Cannot overwrite native files.	25-Jan-2013 17:33:29
process_evt_detect_eog			
info Subject01/@rawsubj001_somatosensory_201	11109	EEG058: 30 events detected in 2 categories	25-Jan-2013 17:33:31
process_ssp_eog		1	
process_import_data_event		C\Users\francois\brainstorm\reports\report_TutorialScript_130125_1335.mat	-
info Subject01/@rawsubj001_somatosensory_201		Clear history	
process_baseline	anapsi		
process_baseline process_timeoffset	Subjec	:t01/right/data_average_130125_1254.mat	
process_noisecov			
process_average		Contraction of the second s	
process_snapshot			
process_snapshot			
process_headmodel			
process_inverse			
warning 2 files []			
Initial files	-104.2	101/left/dets_average_130125_1254.mat	
[No input]	60 40 E 20		
Intermediate files	Ampitude 50		
Subject01/@rawsubj001_somatosensory_20111109_01_A Subject01/@rawsubj001_somatosensory_20111109_01_A Subject01/left/data_average_130125_1734.mat		0.1 0.05 0 0.05 0.1 0.15 0.2 0.25 Time 00 e >	
Subject01/left/data_left_trial001.mat [deleted] Subject01/left/data_left_trial001_bl.mat [deleted] Subject01/left/data_left_trial001_bl_timeoffset.mat	Subjec	tt01/nght/data_average_130125_1234.mat	
Subject01/left/data_left_trial002.mat [deleted] Subject01/left/data_left_trial002_bl.mat [deleted] Subject01/left/data_left_trial002_bl_timeoffset.mat	50 E	14.	
Subject01/left/data_left_trial003.mat [deleted] Subject01/left/data_left_trial003_bl.mat [deleted]	Amplitude		
	-50		



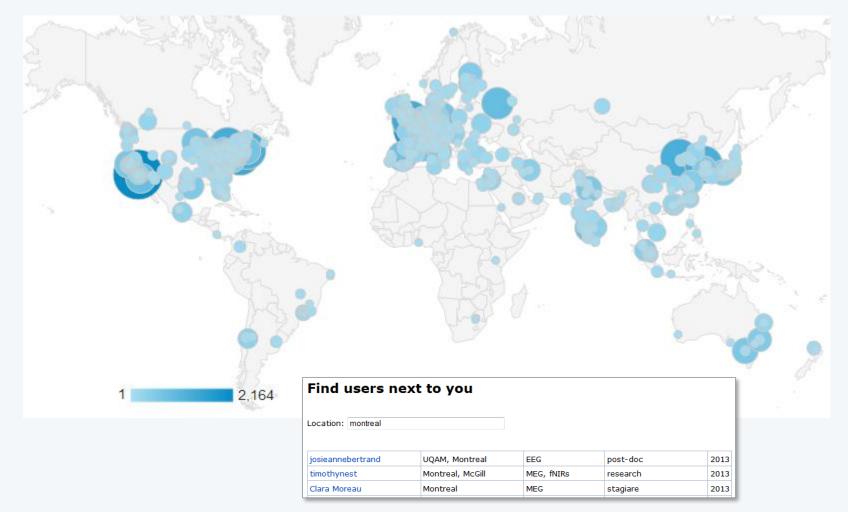
### Add your code to Brainstorm

- Direct manipulation of the files in Matlab
- Use the menu "Run Matlab command"
- Write a plugin:
  - Well documented API
  - Lots of example (170 functions written as plugins)
- Examples of recent external contributions:
  - MVPA decoding (Oliva, MIT)
  - Microstate segmentation (Cacioppo, UChicago)
  - Eyetracker/EEG synchronization (Uni Freiburg)



### User community

• 15,500 users registered on the website





#### User support

- Online tutorials:
- Active user forum: 150
- Daily updates:

- 30-hour self-training program 150 posts/month
- 750 downloads/month

🖤 Brain/torm	Edit 🖊	Search Q	15 1	age 1 of 33 1 2 3 4 5 0 16 17 18 19 20 21 22 31 32 33 ▶ Last ▶	23 24 25 26 27 28	29	
	Get started		Forum: Open discussion		Threads 1 to 20	of 648	
Software	Starting a new study	Epoching and averaging		Forum Tools▼ Administrat	ive▼ Search Forum▼ Inline	Mod 🕶	
Introduction	1. Create a new protocol [9]	15. Import epochs [9]	Title / Thread Starter	Replies / Views Last Post By -			
Gallery	2. Import the subject anatomy [8]	16. Average response [7]	Started by danibeen, Yesterday 18:57	Replies: 1 Views: 9	Francois Today, 00:11 🛄		
Download	3. Explore the anatomy [13]	17. Visual exploration [10]	Coordinates of dipoles in inverse model Started by d34905y, Yesterday 22:34	Replies: 1 Views: 8	Francois Today, 00:00 🕨		
Installation	<ul> <li>Reviewing</li> <li>4. Channel file / MRI registration [11]</li> </ul>	<ol> <li>Colormaps [5]</li> <li>Clusters of sensors [4]</li> </ol>	Noise Covariance Started by d34905y, Yesterday 21:14	Replies: 2 Views: 11	d34905y Yesterday, 22:30 🛄		
Users	<ol> <li>Continuous recordings [9]</li> <li>Multiple windows [5]</li> </ol>	Source modeling 20. Head model [9]	Import ECoG contact positions with MNI coordinates Started by mheers, May 6th, 2014 16:42	Replies: 4 Views: 69	mheers May 9th, 2014, 23:35 💴		
Tutorials	7. Event markers [10]	21. Noise/data covariance	EEG: Electrical potentials are not in right electrodes Started by danibeen, May 6th, 2014 21:50	Replies: 2 Views: 27	danibeen May 9th, 2014, 19:42 💴		
Forum	Pre-processing	22. Source estimation [28]					
Courses	8. Stimulation delays [9]	23. Scouts [17]					
Community	<ul> <li>9. Select files / Run processes [11]</li> <li>10. Power spectrum / Frequency filters [15]</li> </ul>	Advanced processing 24. Time-frequency [33]	Eine				
Publications	11. Bad channels [6]	25. Difference [13]	Find us on <b>facebook</b> .				
Development	<ul><li>12. Artifact detection [8]</li><li>13. Artifact cleaning with SSP [16]</li></ul>	<ul><li>26. Statistics [30]</li><li>27. Workflows [10]</li></ul>					
What's new	14. Additional bad segments [7]	28. Scripting [31]					



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**Rey Ramirez** UW





Jeremy Moreau





#### Oddball auditory task (Dec 2013, MNI, McGill)

- Binaural stimulation with intra-aural earphones
- 200 standard beeps (400Hz) + 40 deviant (554Hz)
- Inter-stimulus interval: Random in [0.7 1.7] s
- Subject taps the right index when a deviant is heard
- Acquisition at 2400 Hz Downsampled at 600Hz
- Recorded on CTF 275 MEG sensors
   + 2 EEG (Pz,Cz) + 26 MEG reference sensors
   + EOG + ECG + STIM + ... = 302 channels
- 6 minutes of recordings
- MRI processed with FreeSurfer 5.3

