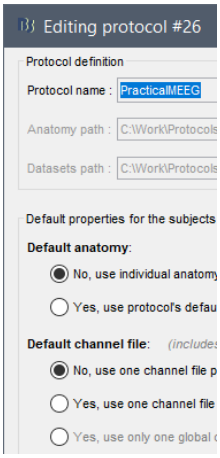
PracticalMEEG 2019
Brainstorm group

1. Tuesday am: From raw to ERP

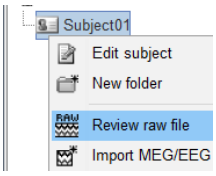


10:30-11:00 Introduction to Brainstorm (lecture)

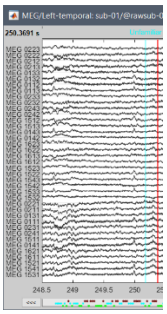
11:00-11:40 Review the recordings

- Create new protocol "PracticalMEEG"
  No, use individual anatomy
  No, use one channel file per acquisition run (MEG/EEG)
- Introduction to database explorer (list of protocols, exploration modes…)
- Right-click on protocol top node > **New subject**: sub-01

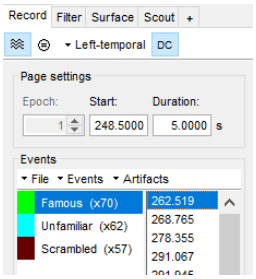
- Switch to functional view (2nd button above the database explorer)
- Create link to continuous file:
  Right-click on sub-01 > **Review raw file**
  File format: MEG/EEG: Elekta-Neuromag (*.fif)
  Select file: derivatives/meg_derivatives/sub-01/ses-meg/meg/*.fif
  Select option: Event channel > STI101



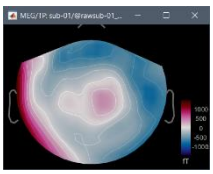
- Edit the channel types:
  Right-click on Neuromag channel file > Edit channel file
  Change the types: EEG062>EOG, EEG063>ECG, EEG061>Misc, EEG064>Misc
  Close and save



- Review MEG: Right-click on "Link to raw file" > MEG (all) > Display time series
  Display in columns + channel selection => Left Temporal
  Time: Display windows of **5s**
  Amplitude: Buttons and shortcuts, AS
  Scroll to detect the beginning of the continuous head localization (248s)
  Online filters
  Events: List, figure, time bar, display modes (dots or lines)

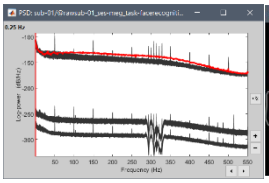
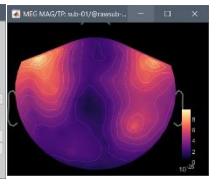


- Edit events
  Select **5+6+7**: Events > Merge groups > **Famous**
  Select **13+14+15**: Events > Merge groups > **Unfamiliar**
  Select **17+18+19**: Events > Merge groups > **Scrambled**
  Delete all the other categories of events
  Events > **Add time offset**: Faces,Unfamiliar,Scrambled **34.5ms** (delay)
- Add other views
  EEG: Right-click on "Link to raw file" > EEG > Display time series
  ECG: Right-click on Link > ECG > Display time series
  Topography: Right-click on Link > EEG > 2D Sensor Cap (or CTRL+T)
  Layout menu: Alternate between Tiled and Weighted (keep Weighted)

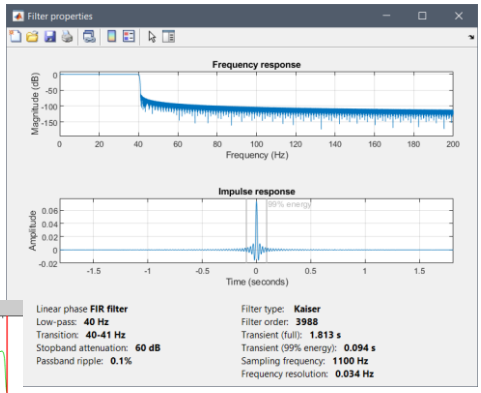


- Close all + Save modifications

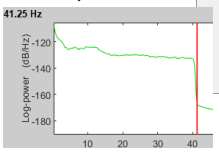
11:40-12:00 Frequency filters

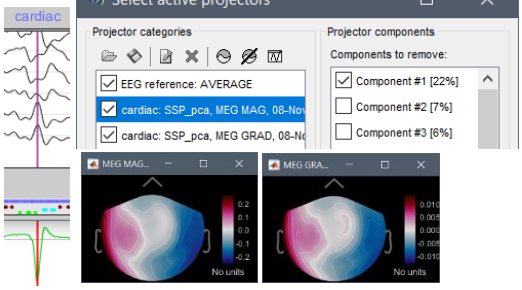
- Drag and drop the "Link to raw file" in Process1
  Explain the Process1 tab + Filter box
- Run process: "Frequency > Power spectrum density":
  [250, 300]s, win=**4s**, **MEG,EEG**
  Open the PSD file (double-click)
  Open topography: EEG > 2D Sensor cap
  Open topography: MEG (mag) > 2D Sensor cap
  Open topography: MEG (grad norm) > 2D Sensor cap
  Explain the noise sources / identify possible bad channels:
  <3Hz: eyes, 10Hz, 50Hz: power, ~300Hz: HPC, EEG016 bad



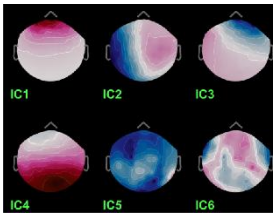
- Run process: "Pre-process > Band-pass filter": MEG, EEG
  Lower cutoff: 0 Hz (No high-pass filter)
  Upper cutoff: 40 Hz (Low-pass filter)
  Try button "View filter response"



12:00-12:30 Artifacts detection and cleaning



- Re-reference the EEG recordings
  Open the filtered file "Raw | low" > EEG
  Mark EEG016 as bad
  Record tab: Artifacts > Re-reference EEG: **AVERAGE**
- Detect artifacts
  Artifacts > Detect heartbeats > **EEG063** (ECG)
  Artifacts > Detect eye blinks > **EEG062** (EOG)
  Select all the blink events groups, menu Events > Merge groups > **blink_bad**
- Artifacts > Remove simultaneous > cardiac / blink_bad / 250ms
- Correct for heartbeat artifacts
  Artifacts > SSP: Heartbeats > MEG MAG
  Artifacts > SSP: Heartbeats > MEG GRAD
  Display 2D topography for the first spatial components
  Show the influence of the projector on the sensors Left-Temporal
  Select the artifact component (high %, good topo, removes the artifact)

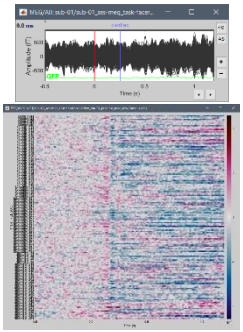


- ICA could work for removing heartbeats and blinks from EEG, but not enough time

2. Tuesday pm: Sensor level analysis

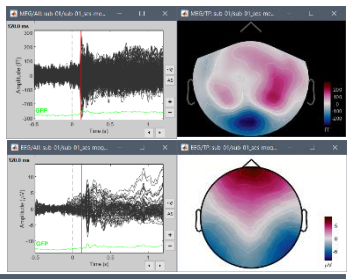
15:00-16:00 Epoching and averaging

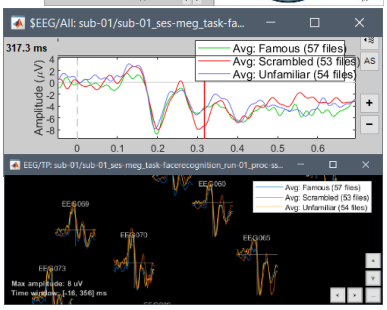
- Right-click on filtered file "Raw | low" > **Import in database**
  Use events: Famous + Unfamiliar + Scrambled, Epoch time: [-500, +1200] ms, Use SSP
  Remove DC offset [-500, 0]ms
  NO Create separate folder for each event type



- Review trials:
  Open the first trial MEG+EEG: Switch back to butterfly view, ALL sensors
  Open a 2D topography (CTRL+T) - Enable auto-scale (button [AS])
  Navigate between trials with F3 / Shift+F3
  Trials or channels can be marked as bad independently
  Raster plots: Right-click on trials > Display as image > EEG (EEG065)

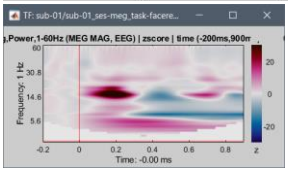
- Average trials
  - Drag and drop all the trial groups in Process1
  - Run process “Average > Average files”: By trial group (folder average)
- Review average
  - Open all averages: MEG + 2D topography view + EEG
  - Review movie of the activity (hold right/left/pgup/pgdown keys)
  - Close all and open EEG: Signals + all topography modes
  - Overlay EEG065 for 3 averages with Cluster tab (NEW IND)
  - Overlay averages with 2DLayout
  - Contact sheet topography with 2DDisc: 0ms, 500ms, 16 images
  - Movies…





16:00-17:00 Time-frequency analysis

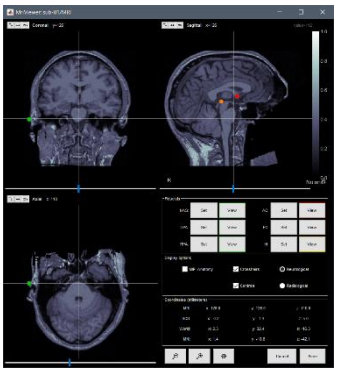
- Wavelets
  - Select all the Famous trials in Process1
  - Run process Frequency > Time-frequency (Morlet wavelets):
    EEG, Log: 1:40:60, 1Hz/3s, Save average
  - Display time-frequency average: Smooth + hide edge effects
  - Select TF average in Process1
  - Run process: Standardize > Baseline normalization > Z-score: [-200, 0]ms
  - Add process: Extract > Extract time: [-200, 900]ms, Overwrite
- Display time-frequency results
  - Display 2D Layout (maps): Select a few sensors
  - Change colormap: Maximum -10/+10, colormap type
  - Add views: time series + power spectrum + all the other options

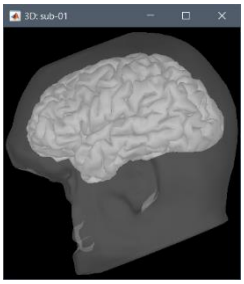


3. Wednesday am: Creating head and source models

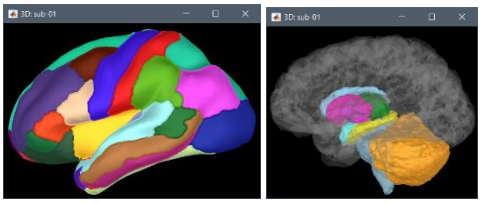
10:30-11:15 Import anatomy

- Switch to anatomy view (1st button above the database explorer)
- Right-click on sub-01 > Import anatomy folder
  - File format: FreeSurfer
  - Select folder: derivatives/**freesurfer-reconall**/sub-01/
  - Number of vertices: 10000 (lower value to make it faster)
  - Introduction to the MRI viewer:
    - Exploring the volume (click, mouse wheel, sliders)
    - Colormaps, colorbar, figure popup menu
  - Compute MNI transformation (sets all the fiducials automatically)
    - You need an internet connection to download the SPM atlas
    - Check the positions of NAS / LPA / RPA
  - Explain the coordinates (MRI, SCS, MNI)

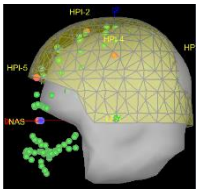


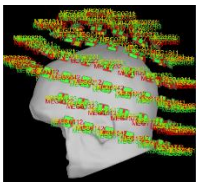


- Display the head and brain surfaces
  3D figure: rotation, zoom
  Predefined views and keyboard shortcuts
  Surface tab: smooth, sulci, edges => smooth 60%
  Scouts tab: atlases and scouts [DEMO ONLY]
  Subcortical atlas (ASEG) [DEMO ONLY]



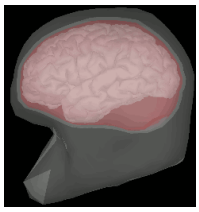
11:15-11:40 Registration MRI-sensors



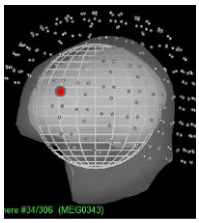


- Switch to functional view (2nd button above database explorer)
- In folder with epochs: Right-click on channel file > **MRI registration** > MEG: Check
- Channel file: Digitized head points > **Remove points points below nasion**
- Channel file: MRI registration > MEG: Edit > **Refine registration using head points**
  Save and close, Apply to EEG: Yes, Apply to other datasets: Yes
- Channel file: MRI registration > EEG: Edit > **Project electrodes on surface**
  Save and close
- Channel file > Display sensors > Vectorview306 coils (ALL)

11:40-12:10 Forward model

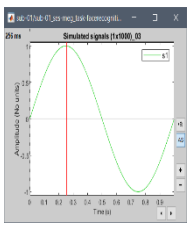


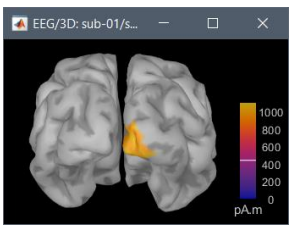
- Switch to the anatomy view
- Right-click on sub-01 > **Generate BEM surfaces** > 642 / 482 / 482 / 4mm
- Switch to functional view
- In folder with epochs: Right-click on the channel file > **Compute head model**
  MEG: Overlapping spheres
  EEG: OpenMEEG BEM (default options)
- Display locally fitted spheres

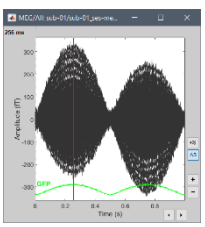


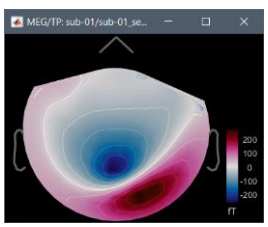
12:10-12:30 Simulation

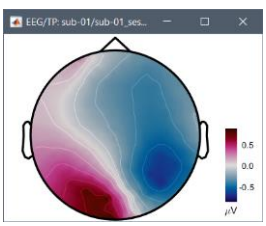
- Process1: Empty list
- Run process: Simulate > Simulate generic signals: sub-01, 1000 samples, 1000Hz, sin(2*pi*t)
- Process1: Select simulated signal
- Run process: Simulate > Simulate recordings from scouts:
  Brodmann V1R, Save full, SNR1=0.2, SNR2=0 (not possible without noise covariance)







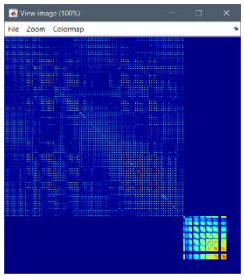




4. Wednesday pm: Single and distributed sources

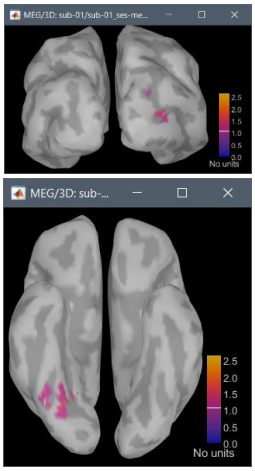
15:00-15:20 Noise covariance: MEG=empty room recordings, EEG=pre-stim baselines

- Import noise recordings:
  Right-click on sub-01 > **Review raw file**
  File format: MEG/EEG: Elekta-Neuromag (*.fif)
  Select file: derivatives/meg_derivatives/sub-emptyroom/ses-20090409/meg/*.fif
  Ignore all the questions and warnings: indeed, there is no subject in the MEG
- Filter noise recordings:
  Select it in Process1, run process Filter>Band-pass filter: 0-40Hz
- Compute noise covariance for MEG:
  Right-click on sub-emptyroom/Raw|Low > Noise cov > Compute from recordings
  Right-click on noise covariance > Copy to other folders
- Compute noise covariance for EEG:
  Select all epochs Famous+Unfamiliar+Scrambled > Noise cov > Compute from recordings
  Baseline: **[-500,0]ms**, **EEG** only, **Merge** with existing noise covariance



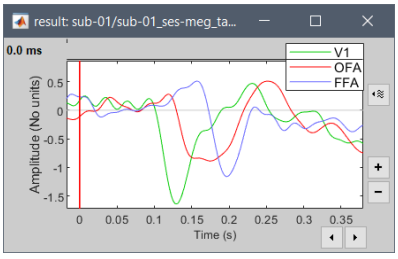
15:20-16:00 Distributed sources / minimum norm estimation

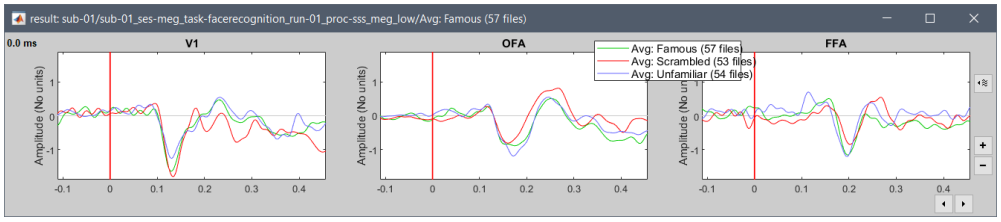
- Compute MEG sources:
  Right-click on head model > **Compute sources [2018]**:
  Minimum norm, **dSPM**, Constrained orientation, **MEG GRAD + MEG MAG**
  Explain inverse kernel / links in database
- Display Famous average:
  Average Famous: Display MEG + 2D topo + dSPM sources
  Make sure that the atlas selected is "User scouts" (in the Scout tab)
  Smooth cortex surface at 70%, show sulci, bottom+back views
  Explain amplitude threshold at largest peak: **t=85ms**
  Move to beginning: t=0ms, Amplitude threshold=**10%**
  Review movie of activity: 60ms: V1 L+R, 130ms: OFA R, 165ms: FFA R



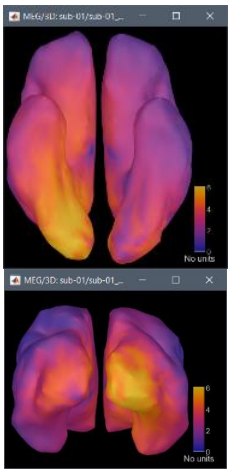
16:00-16:30 Regions of interest

- Go to t=**85ms**, amplitude threshold=**80%** (Surface tab)
- Get a close and accessible view: Right hemisphere, smooth cortex, zoom, rotate
- Create scout **V1**
  Scout tab: [Select point] (big cross in the toolbar), then point on the brain
  Grow to 20 vertices
  Rename to V1 (double-click on the scout in the list)
  (Demo atlas Brodmann)
- Review trace: Absolute values, then relative values
- Create other scouts to explore the other sources
  Decrease the threshold 40% (Surface tab)
  Go to 130ms: Create scout **OFA** => Grow to 20 vertices
  Go to 165ms: Create scout **FFA** => Grow to 20 vertices (constrained)
- Review all the traces, Absolute values / Relative values | **Overlay: Scouts**

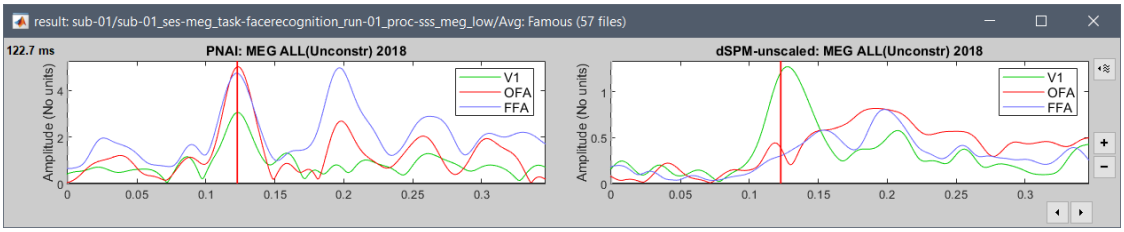




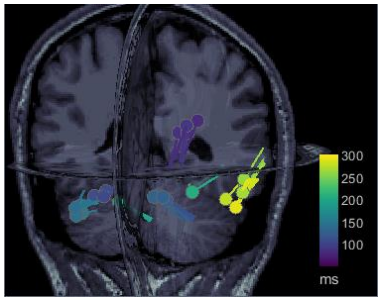
16:30-17:00 LCMV Beamformer



- Compute data covariance:
  Select all epochs > Data cov > Compute from recordings
  Baseline: **[-500,0]ms**, Data: **[30,300]ms,** All sensors
- Right-click on head model > **Compute sources [2018]**:
  LCMV beamformer, Pseudo NAI, Unconstrained, MEG GRAD + MAG
- Right-click on head model > **Compute sources [2018]**:
  Minimum norm, dSPM, Unconstrained, MEG GRAD + MAG
- Open both source maps: review in time
  Unconstrained: Smoother, nicer figures, more complicated to process
- Display scouts times series for all ROIs, compare with dSPM



16:30-17:00 Dipole scanning / Volume source models



- Right-click on channel file > **Compute head model**
  MRI volume, **MEG**: Overlapping sph, Regular grid, brain, 5mm
- Right-click on head model > **Compute sources** > **Dipole modeling**
- Demo: Display dipole maps (not a distributed source model)
- Select the dipoles map in Process1
- Run process Sources > **Dipole scanning**: **[50,300]ms**
- Demo: Dipole fitting with FieldTrip ft_dipolefitting (70-100ms, MEG MAG)

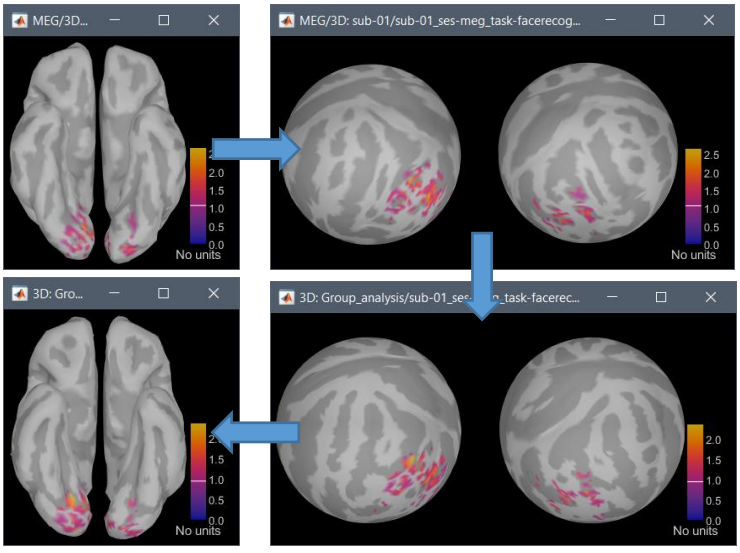
5. Thursday am: Group-level analysis

10:30-11:00 Project source maps on MNI template

- Right-click on Famous average dSPM > **Project sources** > Default anatomy > cortex_15000V
  Right-click on subject dSPM > Cortical activations > Display on cortex (t=85ms)
  Right-click on subject dSPM > Cortical activations > Display on spheres
  Right-click on projected dSPM > Cortical activations > Display on cortex
  Right-click on projected dSPM > Cortical activations > Display on spheres

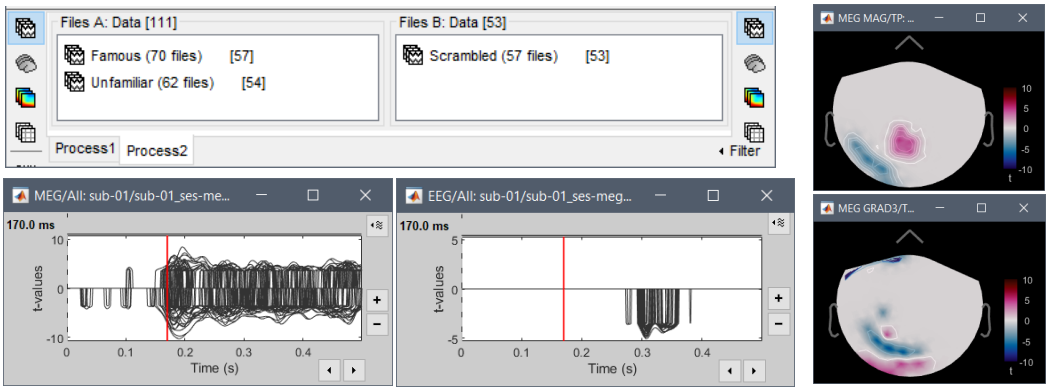
Sub-01

Default anatomy
(MNI ICBM152)

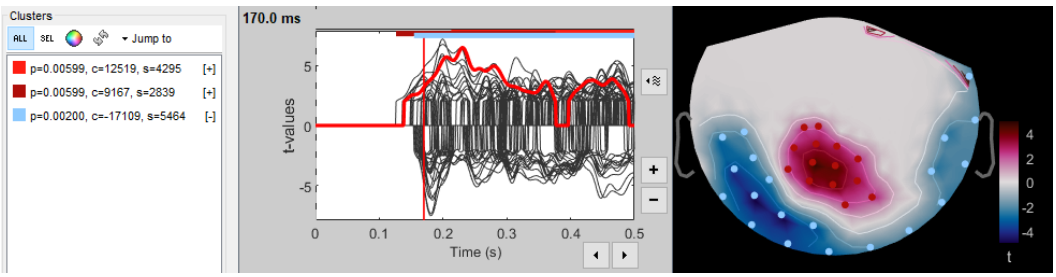


11:00-11:45 Statistical testing

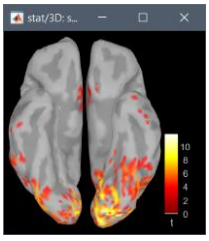
- Parametric t-test on sensors
  In Process2 tab: FilesA=Famous+Unfamiliar trials, FilesB=Scrambled
  Run process: Test > **Parametric test: Independent**
  [0,500]ms, Student's t-test (equal variance), two-tailed test
  Right-click > MEG (all) > Display time series + Press CTRL+T for 2D topographies
  Right-click > EEG > Display time series + Press CTRL+T for 2D topographies
  In Stat tab, set alpha threshold to **0.01**, **FDR** correction



- Cluster-based statistics
  Run process: Test > FieldTrip: ft_timelockstatistics
  MEG MAG, [0,300]ms, 1000 randomizations, Independent, two-tailed, cluster, alpha=0.05



- During computation: explain interactions with:
  FieldTrip: Structure conversions, direct calls
  MNE-Python: Create Python objects and call Python function (though Matlab >= 2015b)
  SPM: Export to .nii or .gii files (online tutorial)
  EEGLAB: Functions embedded in the Brainstorm distribution (runica.m)
- Permutation t-test on sources
  In Process2: Select "**Process sources**" on both sides
  + Filter to get the dSPM constrained sources
  Run process: Test > **Permutation test: Independent**
  [140,170]ms, **Average selected time window**, t-test (equal), two-tailed
  Right-click figure > Colormap > Absolute values



11:45-12:30 Scripting

- Generating Matlab scripts
- Reports viewer
- Writing plugins / Sharing code

6. Thursday pm: User requests