

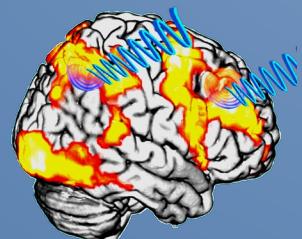


UNIVERSITY OF  
**SURREY**

# Automatic Analysis for more efficient and reproducible M/EEG pipelines

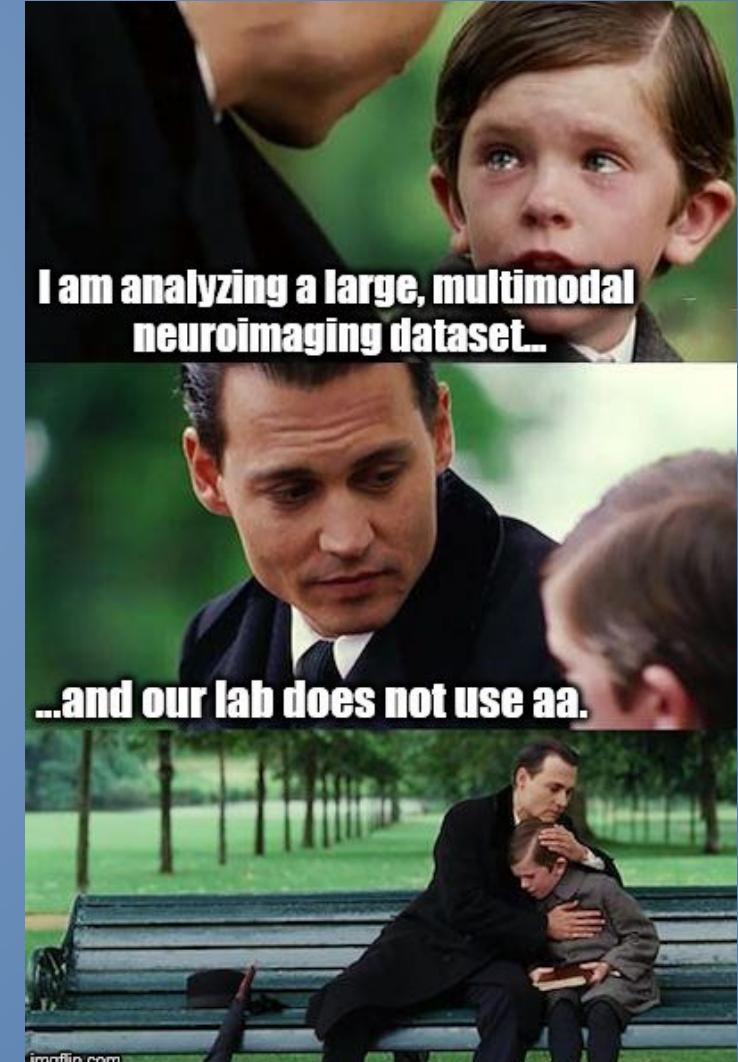
Tibor Auer

University of Surrey, School of Psychology  
NeuroModulation Lab



# Challenge

- Increasingly large cohort sizes
    - <10 (in 2005) → hundreds (in 2020)
  - Multimodality: structure, function, diffusion
    - Offers a more integrated view of the brain
    - Supported by several open research tools such as SPM, FSL, Freesurfer, EEGLAB, FieldTrip, and MNE
- ↓
- Issues
    - Requires integration of different tools → Efficiency
    - Difficult documentation → Reproducibility
    - Increased risk of human error
    - Harder to detect errors
- } Transparency



# Challenge

## Tools

- EEGLAB: more established (since 2004, ~2000 citations/year), great for pre-processing, plugins
- FieldTrip: newer (since 2011, ~900 citations/year), great for analysis and visualisation, stats tools
- MNE(-Python): newest (since 2013, ~300 citations/year), great for visualisation, Python ecosystem
- ...

## Guidelines

- [Makoto's preprocessing pipeline](#), [Makoto's code](#): more like considerations and code snippets
- [FieldTrip tutorial](#): well-structured, stand-alone, with example data and code
- [MNE tutorial](#): well-prepared, illustrated, with example data and code

# Challenge

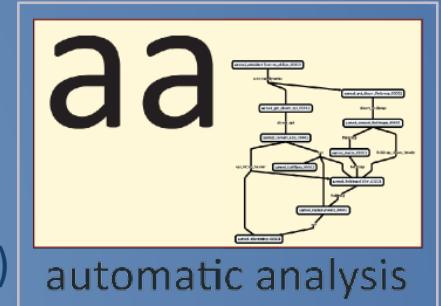
## Pipelines

- NiPype: uniform interface for pre-compiled and Python-based tools
  - Configurability, reproducibility, scalability
  - Loose integration of tools, large technical debt
- MATLAB: Script from analysis
  - EEGLAB: EEGLAB history (*eegh*): command-line back-end for GUI
  - FieldTrip: *reproducerecipe*: generates code and (intermediate) derived data
  - *Post-hoc* → Rather for documentation
  - Generalisation requires extra work
  - No interoperability
  - Parallelisation depends on user

# Solution

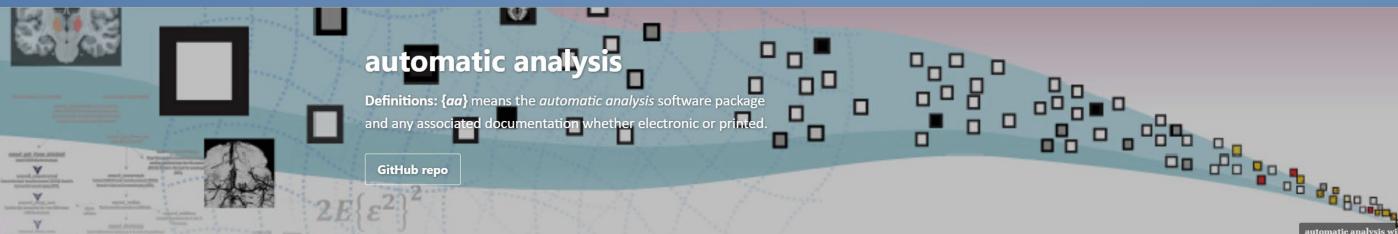
- **Description**

- A pipeline system for neuroimaging written in MATLAB
- Multimodal support: structure, function (EEG, fMRI), diffusion (DTI/DKI), ...
- Integrates major MATLAB-based tools (e.g. SPM, EEGLAB, FieldTrip, CoSMoMVPA, TDT) and some functions from FSL, Freesurfer and other toolboxes
- Disseminates code from contributors and external scientists



- **Availability**

- <https://automaticanalysis.github.io>
- <https://github.com/automaticanalysis/automaticanalysis>



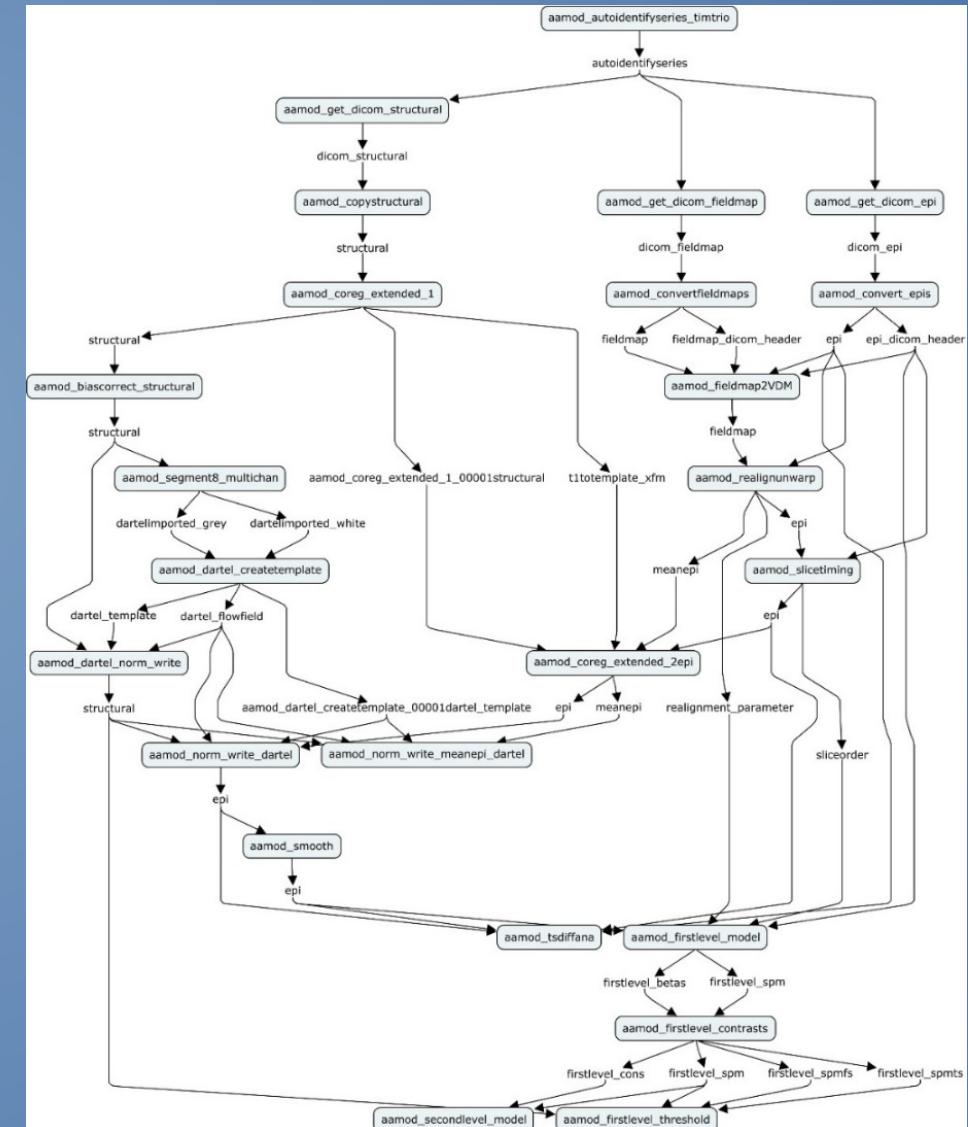
# Solution

- Configurable, automatic workflow
  - Tracks processes → Restartable
  - Notifies via e-mail
- Provides high-level workflow description
  - Replicable
  - Code recycling/sharing/publishing
- Record keeping
  - Diagnostics
  - Captures provenance

→ Efficiency

→ Reproducibility

→ Transparency



# Solution

## USPs

- Deep level of integration of tools
  - Site-/user-/study-specific definition and configuration
  - Dynamic loading → reduced ambiguity and ‘shadowing’
- Lower technical debt
  - Automatic linkage between steps
  - Information on execution → debugging
  - Workflow visualisation
  - Interlinked diagnostics for quality awareness
- Pipeline connection: takes data from a previous workflow
  - Multimodal study: separate workflow for each modality
  - Complex study: common preprocessing workflow + multiple analyses

## Development

- **Decisions**

- Which tool for what → main data format
- **Conversion ([automaticanalysis - eeglab2fieldtripER.m](#))!!!**

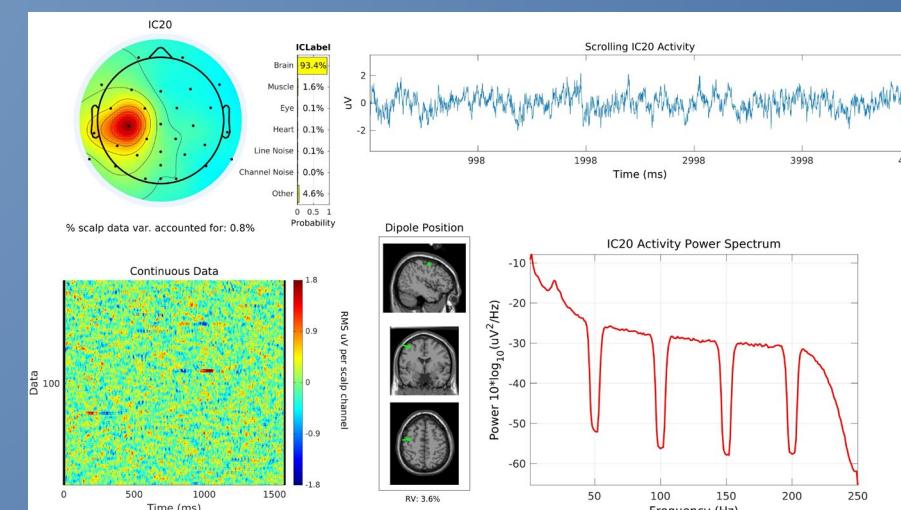
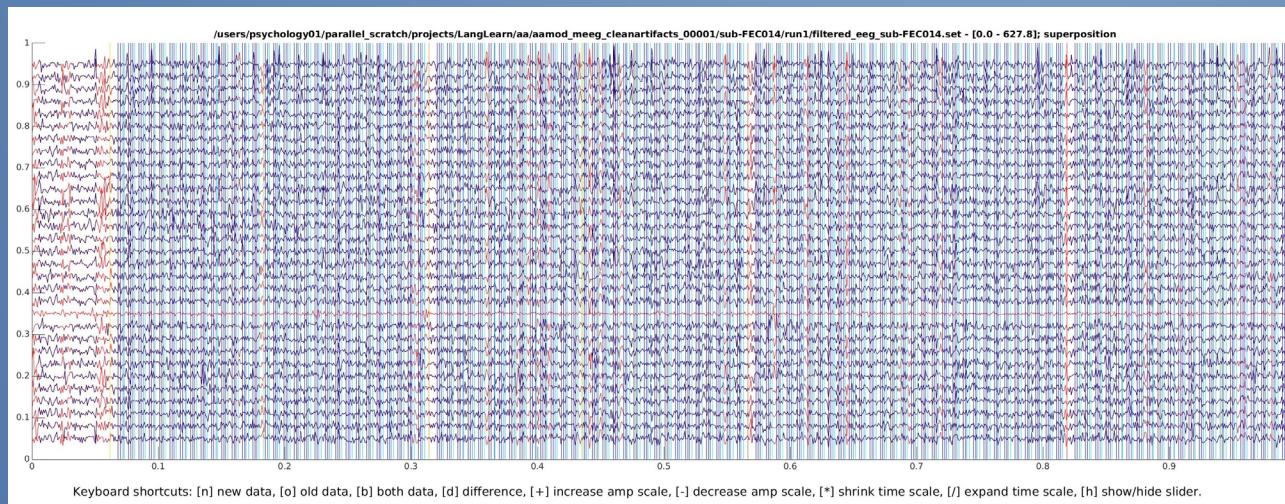
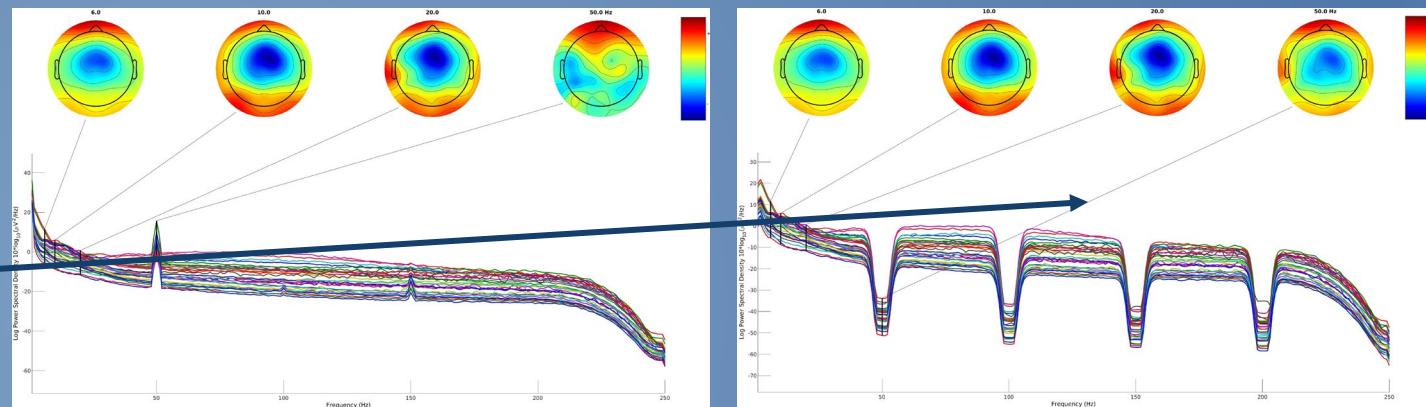
- **Options**

- Configuration options
- Intuition, convenience
- Documentation
- E.g. [aamod\\_meeg\\_cleanartifacts](#), [aamod\\_meeg\\_iclassification](#)

## Preprocessing – EEGLAB

### Makoto's pipeline

- Data format is EEGLAB's dataset
- Configurable diagnostics after each step
- Filtering is with FieldTrip

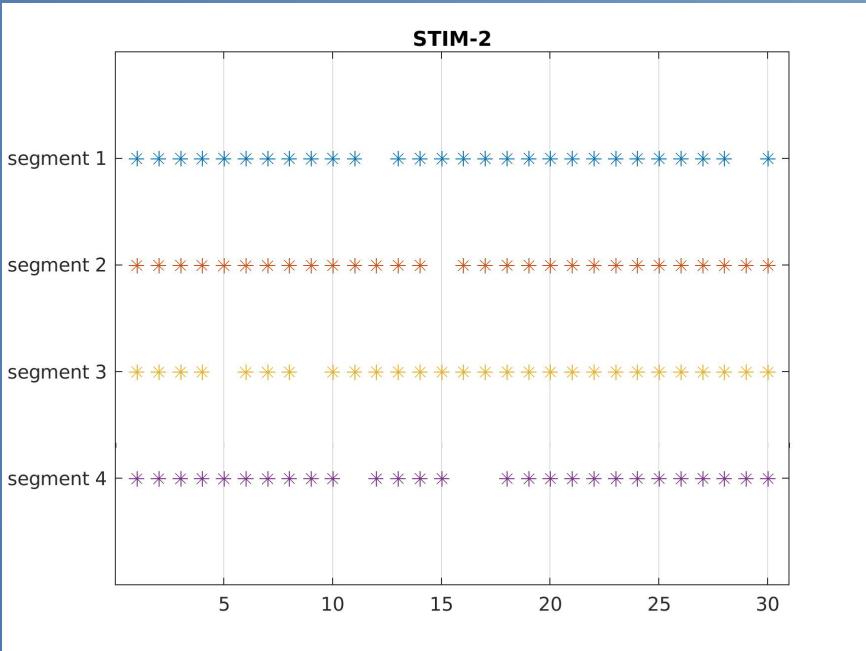


# aa for M/EEG

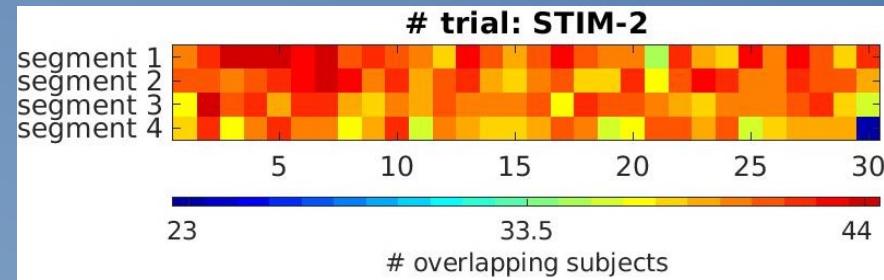
## Epoching

- Extended diagnostics

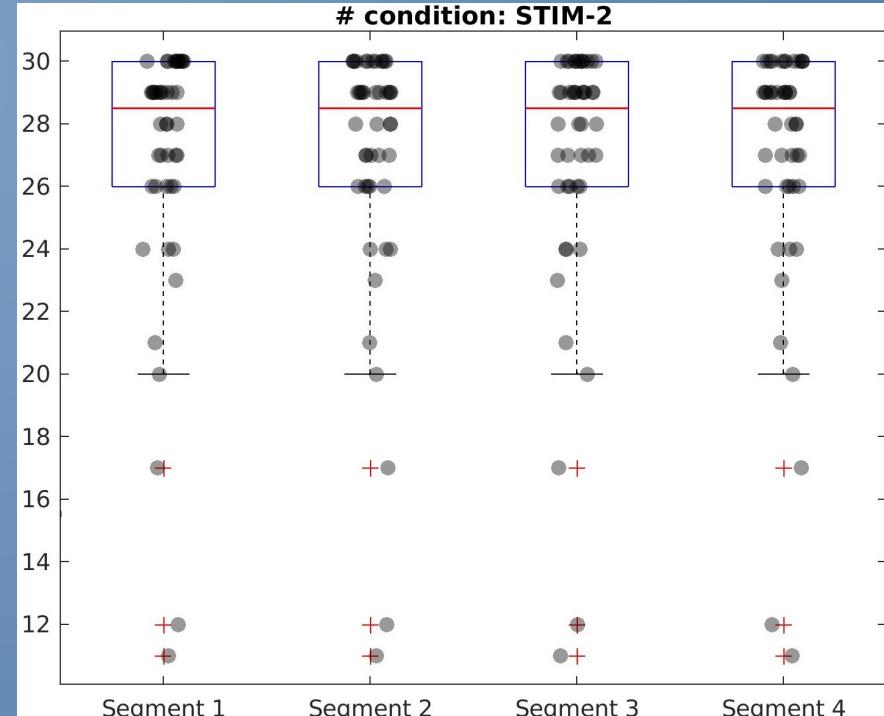
## Subject domain



## Preprocessing – EEGLAB



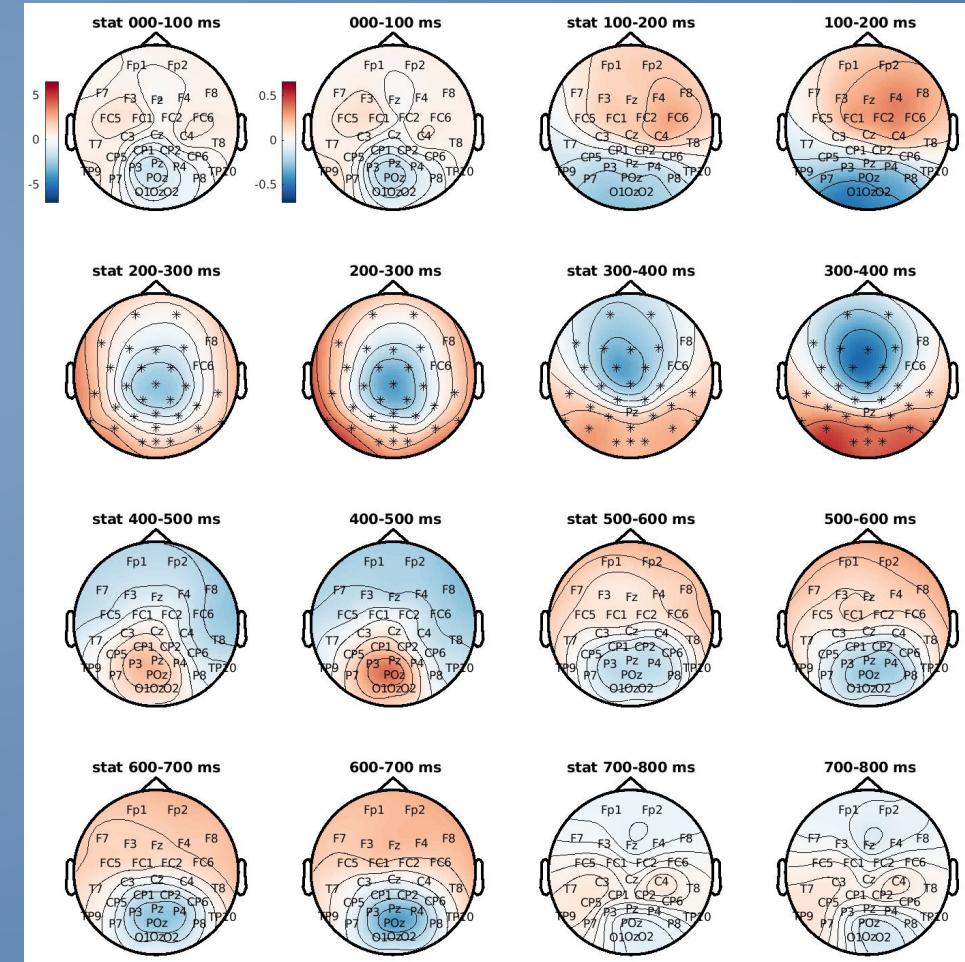
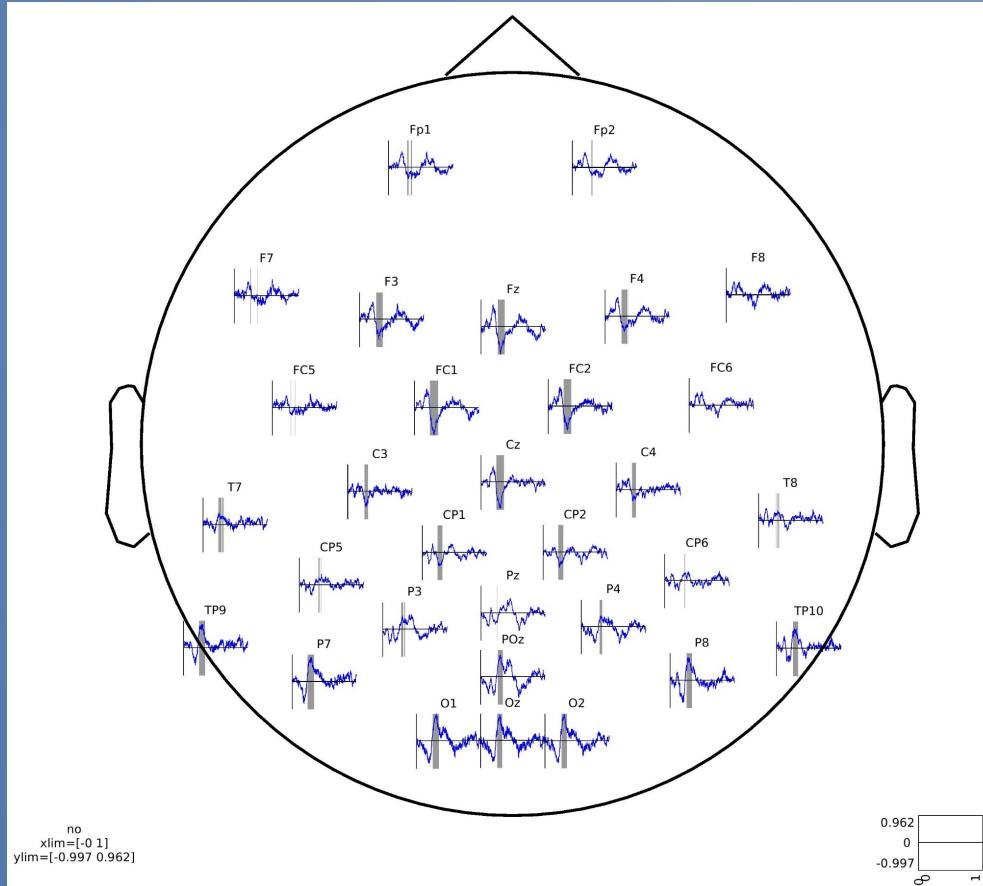
## Study domain



## Analysis – FieldTrip

- Time-locked analysis (ERPs)

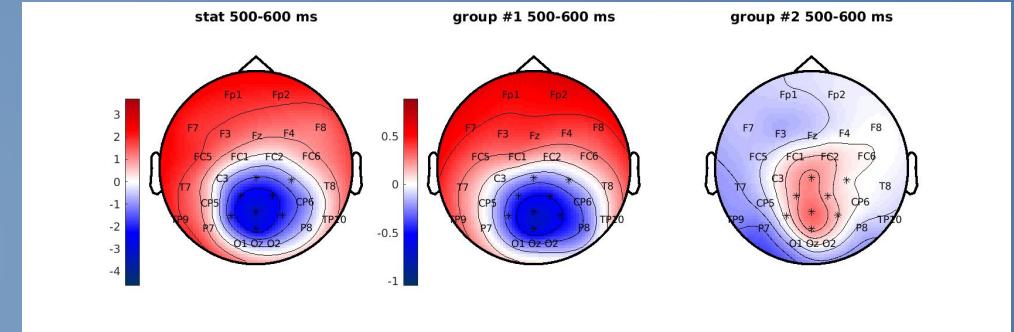
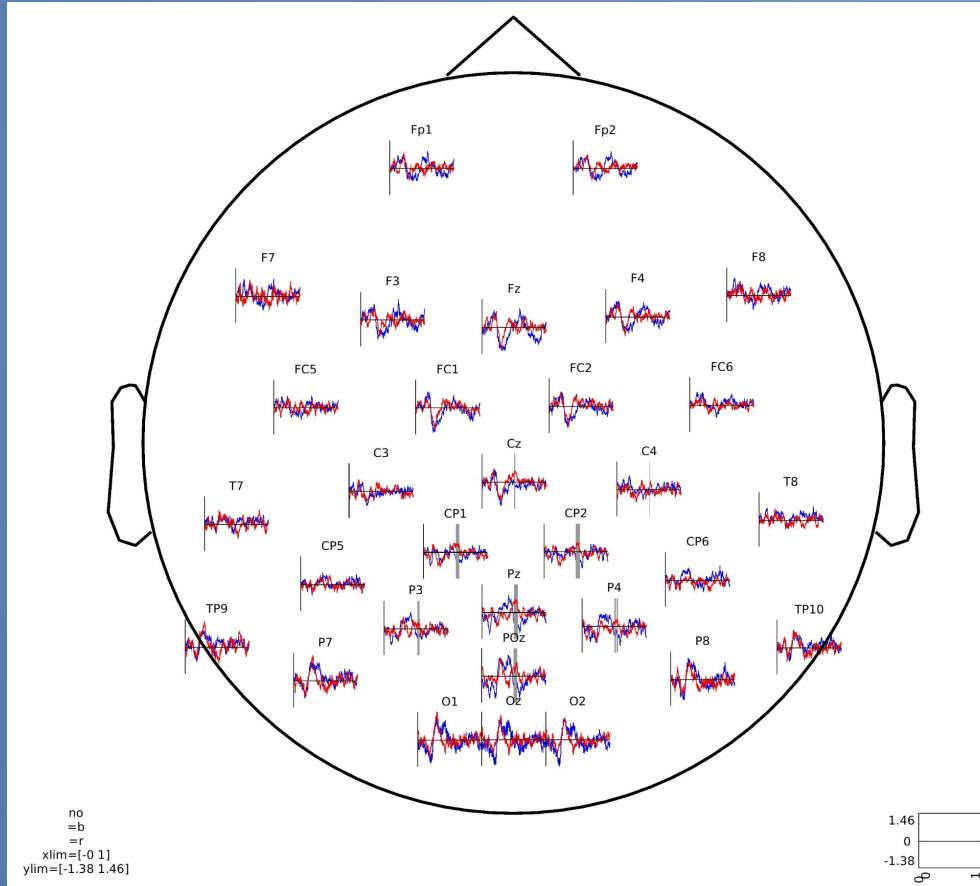
- USP: Between-trial modelling (e.g. increase)



## Analysis – FieldTrip

- Time-locked analysis (ERPs)

- Group comparison

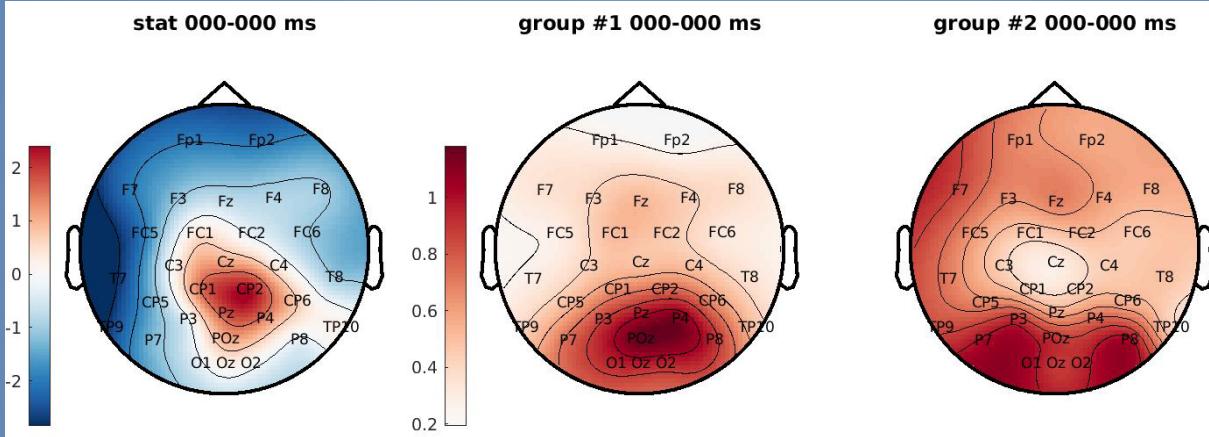


## Analysis – FieldTrip

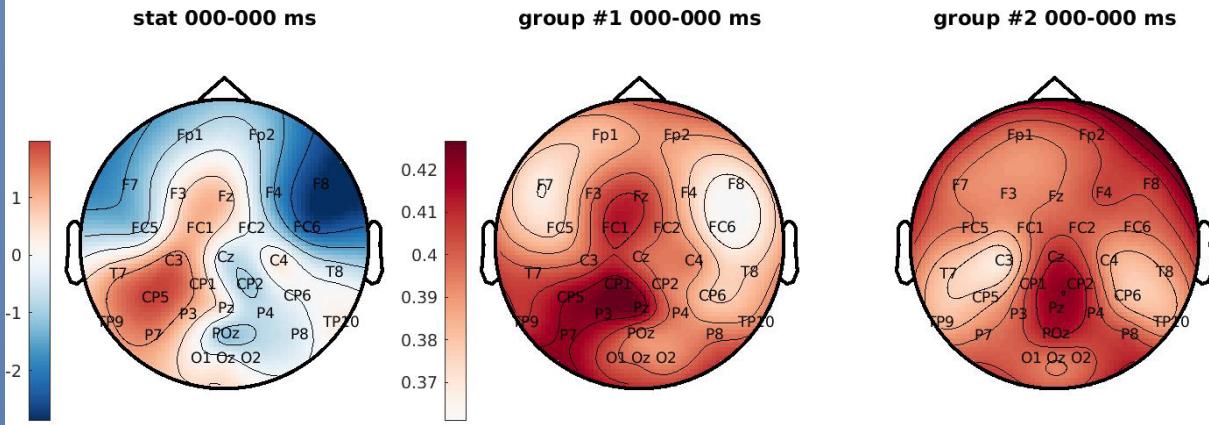
- Time-locked analysis (ERPs)

- Peak analysis (e.g. P300)

- Amplitude



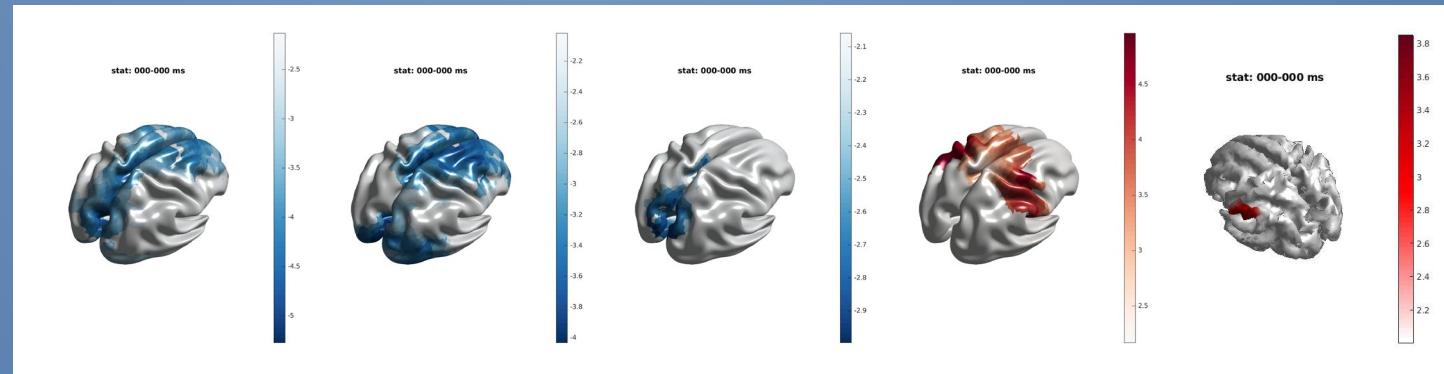
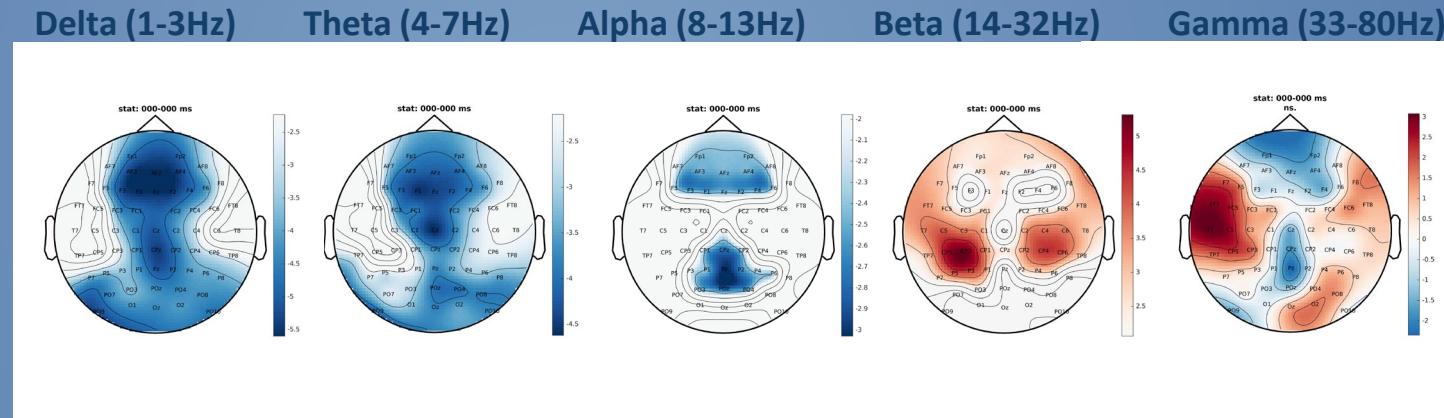
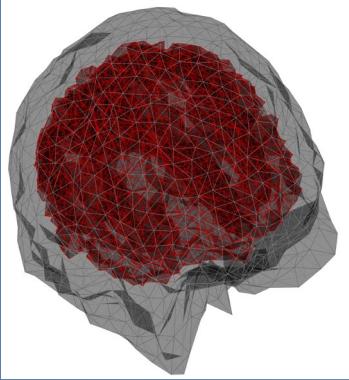
- Latency



## Analysis – FieldTrip

- Time-frequency analysis (TFRs)

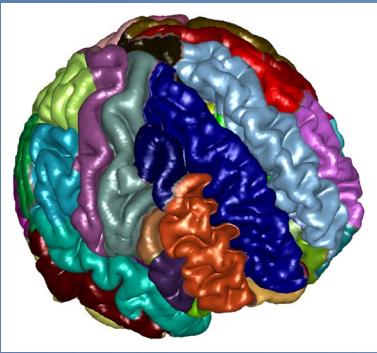
- Topoplots of band averages (configurable)
- Sensor- and source-level (grid and cortical sheet) analysis



## Analysis – FieldTrip

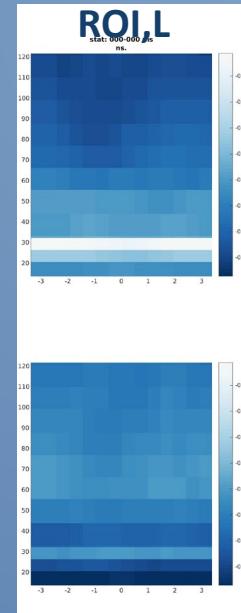
- Cross-frequency analysis (e.g. PAC)

- Source-level signal reconstruction (virtual channels)
- Atlasing e.g. according to Freesurfer's Desikan-Killiany-Tourville atlas (32 regions per hemisphere)

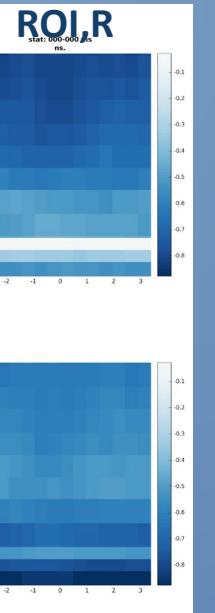


Amplitude

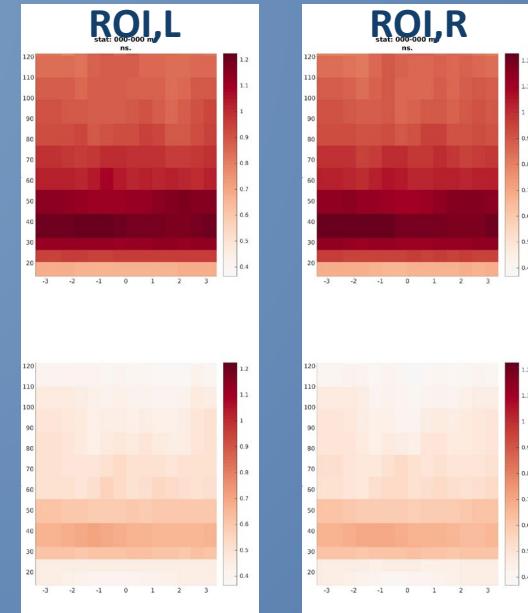
ROI, R



Group #1

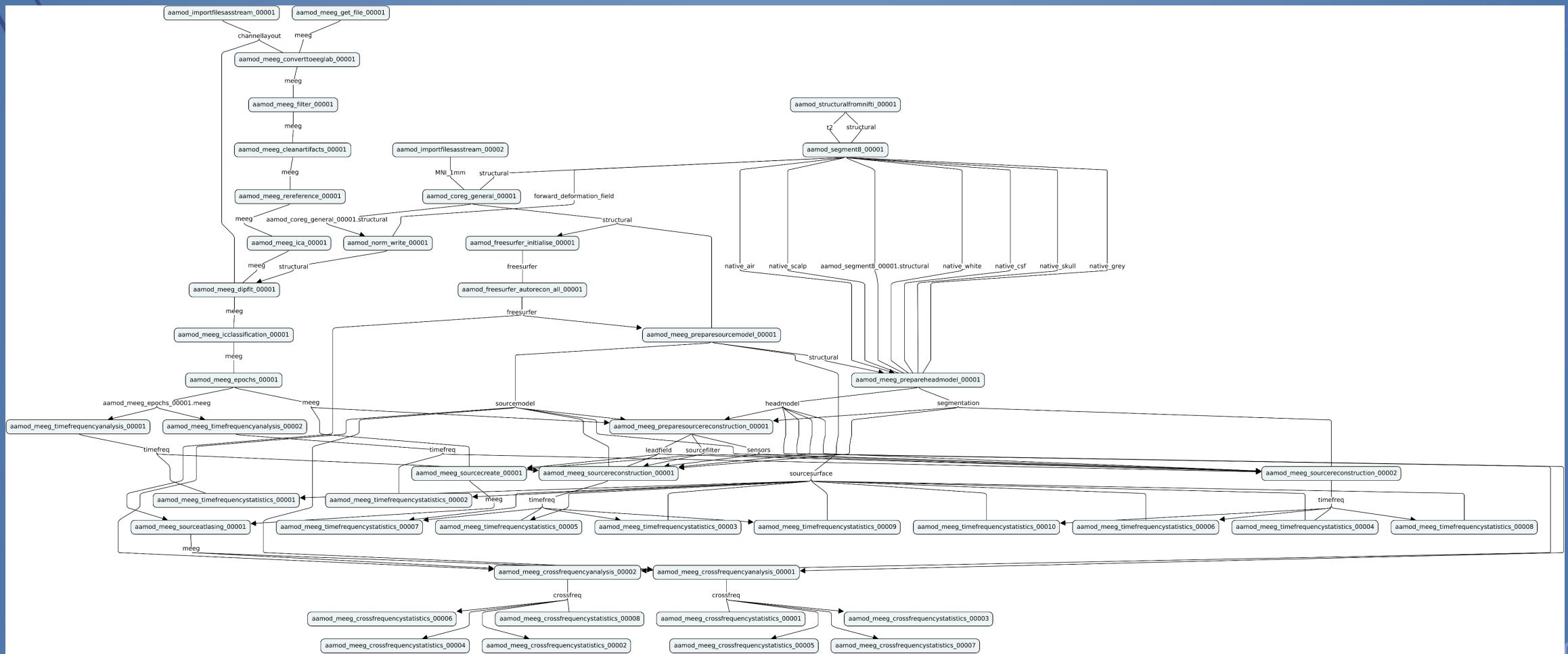


Group #2



Phase: Theta (4-7Hz)

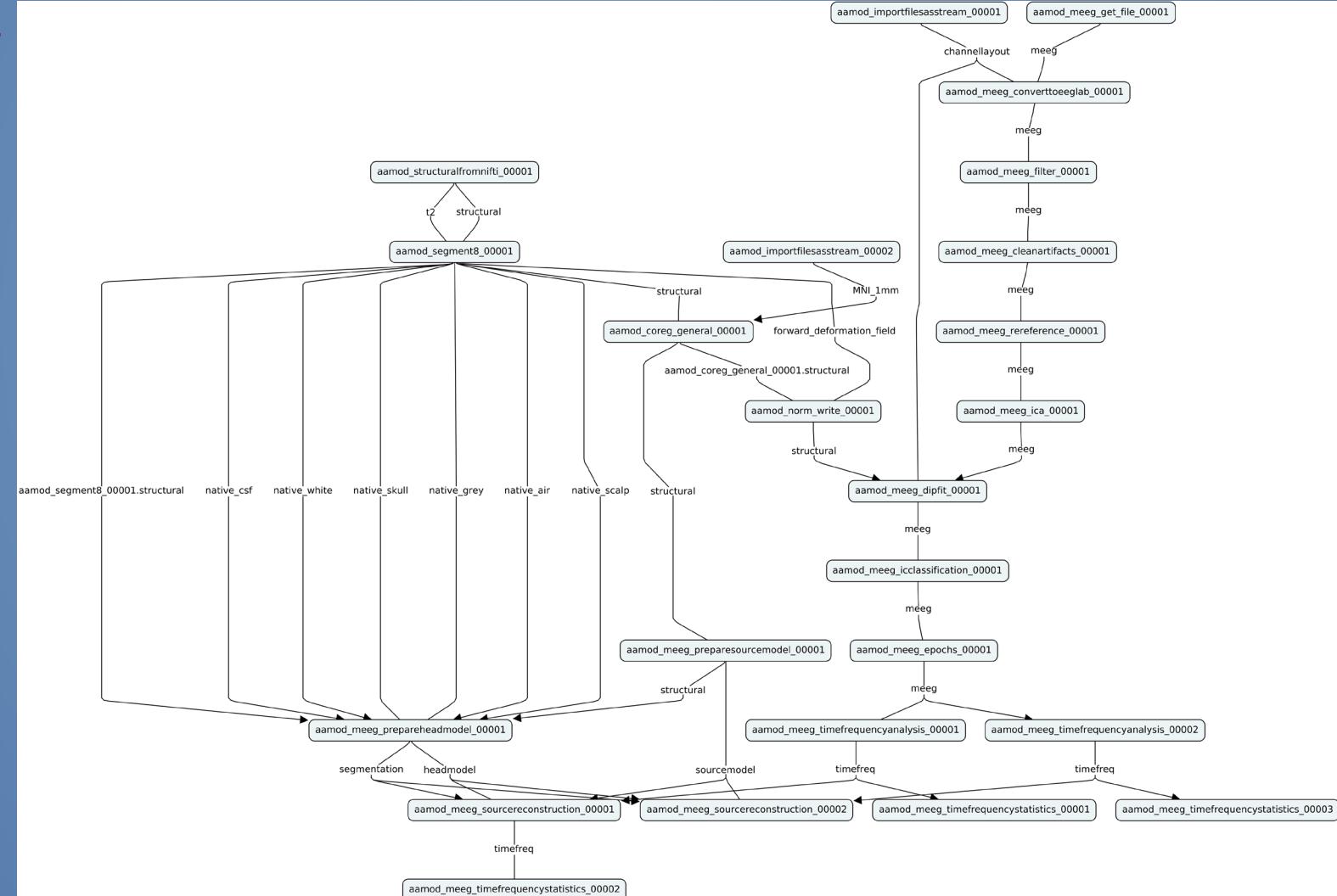
## Example



# aa for M/EEG

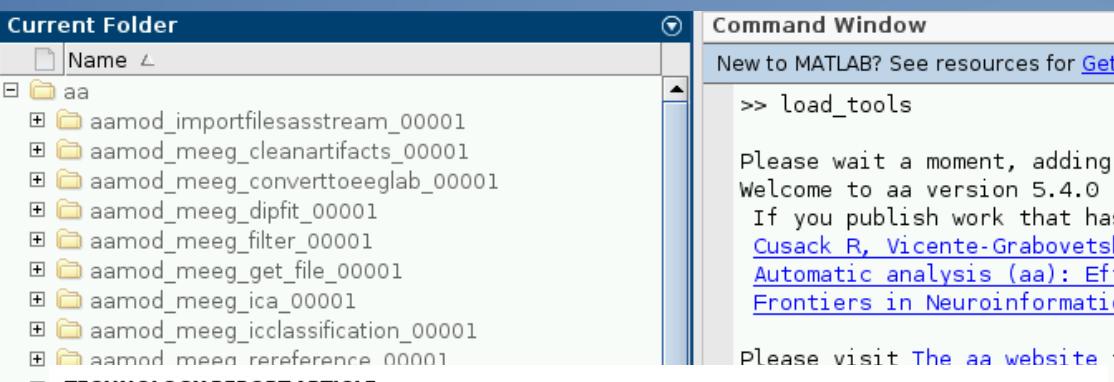
- Example tasklist
- Example UMS

## Example



# Info/Support

## Running – aa intro



```
>> load_tools

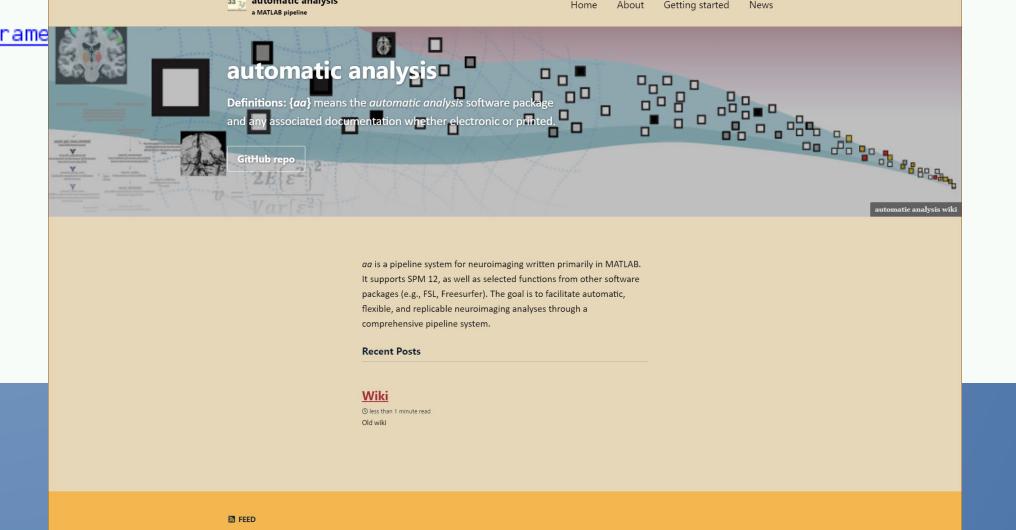
Please wait a moment, adding  to the path
Welcome to aa version 5.4.0 (7e567b2aa6668bc3e800bd7606b264f200bbbb02) Aug 2020
If you publish work that has used aa, please cite our manuscript:
Cusack R, Vicente-Grabovetsky A, Mitchell DJ, Wild CJ, Auer T, Linke AC, Peelle JE (2015)
Automatic analysis (aa): Efficient neuroimaging workflows and parallel processing using Matlab and XML
Frontiers in Neuroinformatics 8:90

Please visit The aa website for more information!
```

**Automatic analysis (aa): efficient neuroimaging workflows and parallel processing using Matlab and XML**

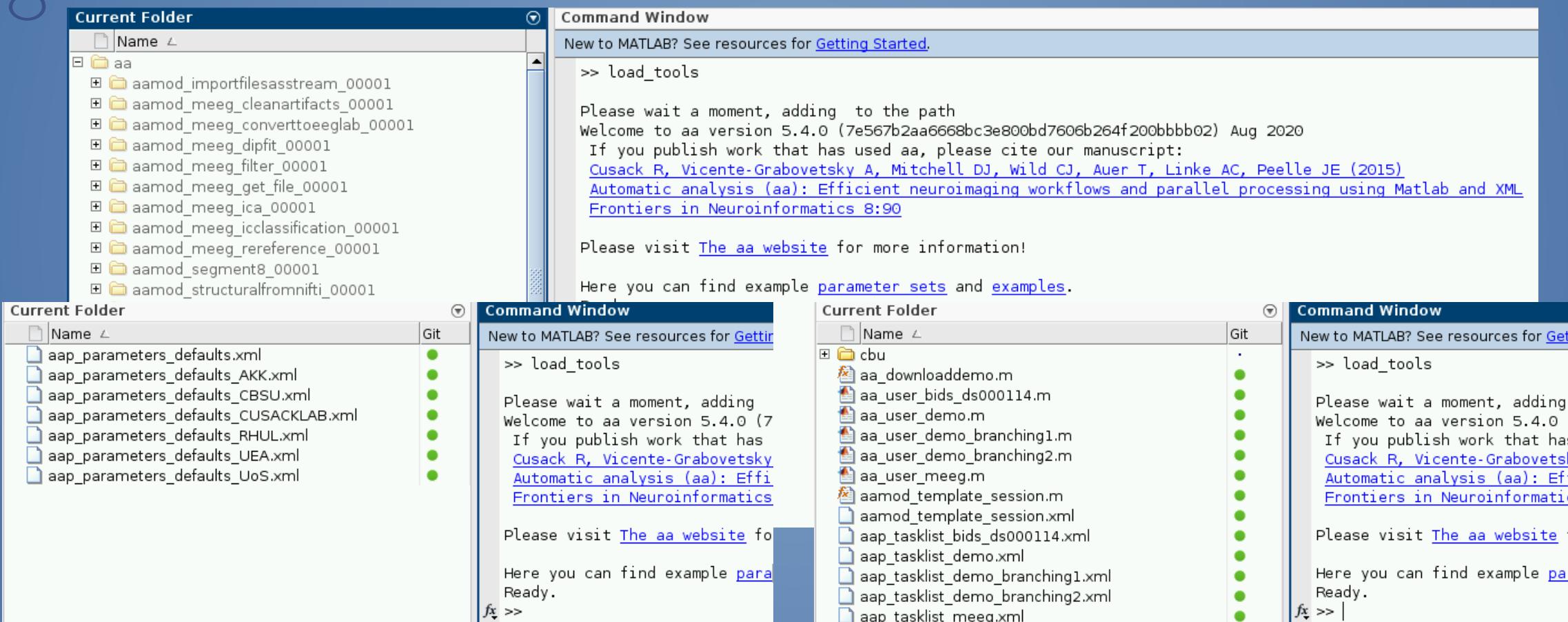
 Rhodri Cusack<sup>1\*</sup>,  Alejandro Vicente-Grabovetsky<sup>2</sup>,  Daniel J. Mitchell<sup>3</sup>,  Conor J. Wild<sup>1</sup>,  Tibor Auer<sup>3</sup>,  Annika C. Linke<sup>1</sup> and  Jonathan E. Peelle<sup>4</sup>

<sup>1</sup>Brain and Mind Institute, Western University, London, ON, Canada  
<sup>2</sup>Donders Institute for Brain, Cognition and Behaviour, Nijmegen, Netherlands  
<sup>3</sup>MRC Cognition and Brain Sciences Unit, Cambridge, UK  
<sup>4</sup>Department of Otolaryngology, Washington University in St. Louis, St. Louis, MO, USA



# Info/Support

## Running – aa intro



# Info/Support

## GitHub

The image displays two side-by-side screenshots of the GitHub interface for the repository `automaticanalysis / automaticanalysis`.

**Left Screenshot (Issues View):**

- Header:** `automaticanalysis / automaticanalysis`, Unwatched (19), Unstarred (55), Forked (32).
- Filters:** Issues (8), Pull requests (2), Discussions, Actions, Projects, Wiki, Security, Insights, Settings.
- Search Bar:** isissue isopen.
- Issue List:** 8 Open, 159 Closed.
  - #208: **aap.spm can no longer be modified in user script** (opened Nov 27 2019 by jooh)
  - #193: **Refactor CBU-specific examples to use open data** (opened Feb 25 2019 by jooh)
  - #187: **aas\_processBIDS: fmap.hdr.IntendedFor** (bug, question) (opened Feb 1 2019 by jpeelle)
  - #186: **fmap undefined in aas\_processBIDS.m** (opened Jan 27 2019 by jpeelle)
  - #179: **Incorrect documentation in aamod\_compSignal** (opened Nov 28 2018 by jooh)
  - #177: **PCA output option in aamod\_compSignal** (enhancement) (opened Nov 6 2018 by jooh)
  - #176: **Inconsistent stream outputs between segment8 and dartel\_normmni** (opened Nov 6 2018 by jooh)
  - #162: **aa user group** (good first issue, question) (opened Aug 15 2018 by jooh)

**Right Screenshot (Discussions View):**

- Header:** `automaticanalysis / automaticanalysis`, Unwatched (19), Unstarred (55), Forked (32).
- Filters:** Code, Issues (8), Pull requests (2), Discussions, Actions, Projects, Wiki, Security, Insights, Settings.
- Search Bar:** Search all discussions, New, Top: All, Answered, Unanswered, New discussion.
- Categories:** Website, General, Ideas, Q&A, Show and tell.
- Most helpful:** A note: Be sure to mark someone's comment as an answer if it helps you resolve your question — they deserve the credit! ❤️.
- List:** Various discussions including:
  - Website: tiborauer started on Jun 24 2020 in General (3 comments)
  - processBIDS for MEG: ethanknights started on Feb 25 in Ideas (1 comment)
  - FSL/Matlab: jpeelle started on Feb 15 2019 in Ideas (13 comments)
  - Welcome to automaticanalysis Discussions!: tiborauer started on Feb 12 in General (0 comments)
  - Module naming conventions: tiborauer started on Apr 14 2015 in Ideas (7 comments)
  - Hyperalignment: tiborauer started on Jul 27 2018 in Ideas (6 comments)
  - Which tools should we provide modules for in core AA?: jooh started on Jul 26 2018 in Ideas (10 comments)
  - Diagnostics: tiborauer started on Dec 11 2013 in Ideas (3 comments)
  - qsub time and memory: tiborauer started on Jul 28 2015 in Ideas (0 comments)
  - Naming of structural streams: rhorlicsack started on Jan 24 2014 in Ideas (4 comments)

## Take home message

You always wanted to use aa

