Mean-field modeling of brain-scale dynamics for the evaluation of EEG source-space networks

Sahar Allouch[1,2], Maxime Yochum[1], Aya Kabbara[1], Joan Duprez[1], Mohamad Khalil[2,4], Fabrice Wendling[1], Mahmoud Hassan[3], Julien Modolo[1]

[1]Univ Rennes, LTSI - INSERM U1099, F-35000 Rennes, France
[2]Azm Center for Research in Biotechnology and its Applications, EDST, Tripoli, Lebanon
[3]NeuroKyma, F-35000 Rennes, France
[4]CRSI research center, Faculty of Engineering, Lebanese University, Beirut, Lebanon

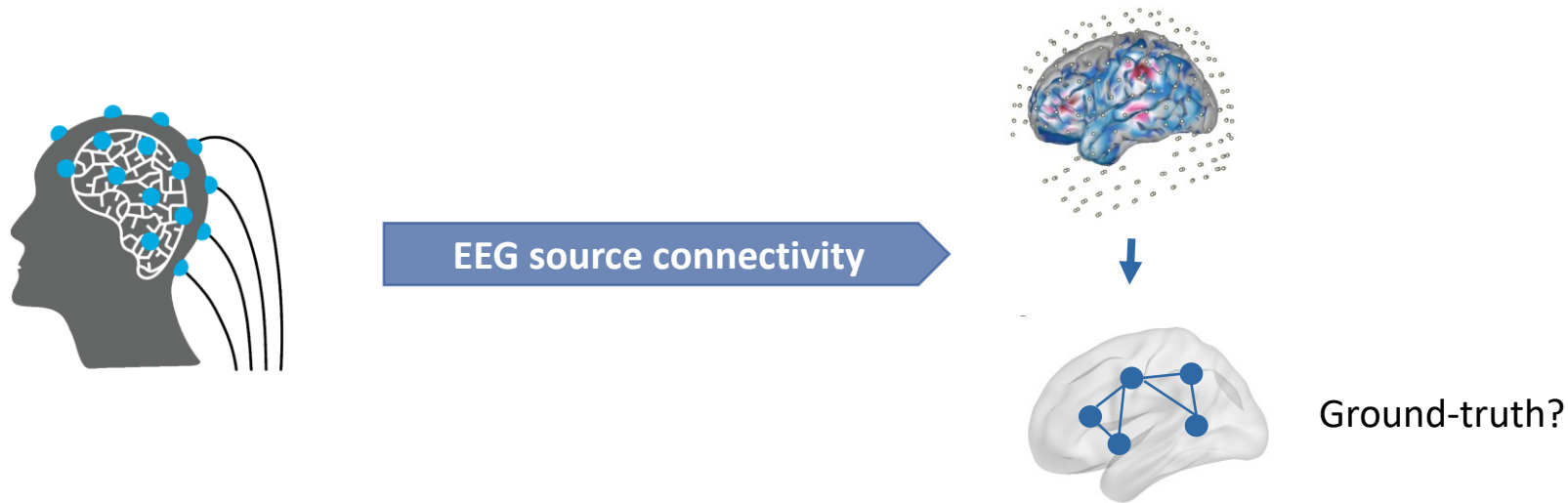Ecole Doctorale en Sciences et Technologie

Universite Libanaise

UNIVERSITÉ DE RENNES 1

AUF

CNRS
National Council for Scientific Research

Problematic:

- The absence of a '**ground truth**' when applying EEG-source connectivity on real EEG data represents a challenge for comparative studies
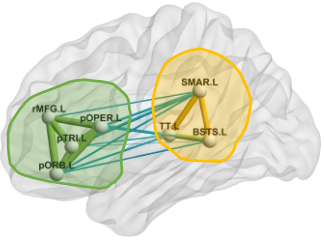
EEG source connectivity
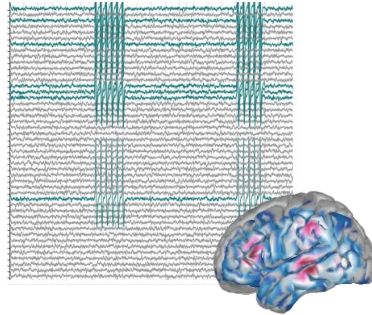
Ground-truth?

Objective:

- Use **COALIA**, a physiologically-inspired model to generate epileptiform, cortical activity and evaluate the effect of:

  1 five different electrode densities

  2 two inverse solution algorithms

  3 two functional connectivity measures

Methods and Materials
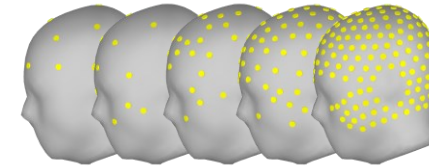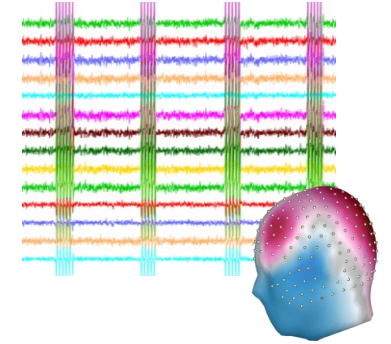

1. Reference network

2. Simulated cortical activity
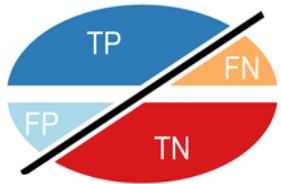
COALIA computational model

3. Forward model

19/32/64/128/256 channels

4. Scalp EEG

8. Accuracy assessment
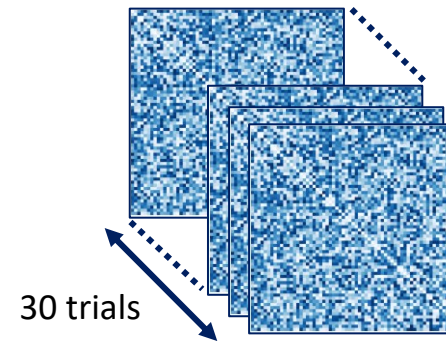
TP FN FP TN

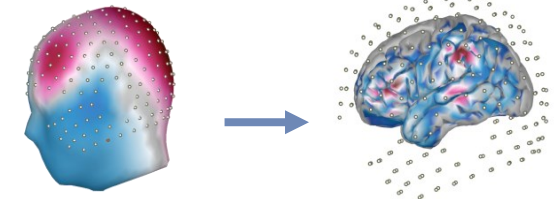**7. Estimated networks**
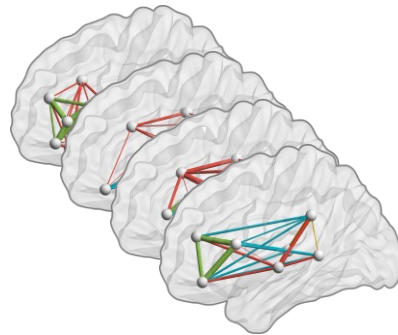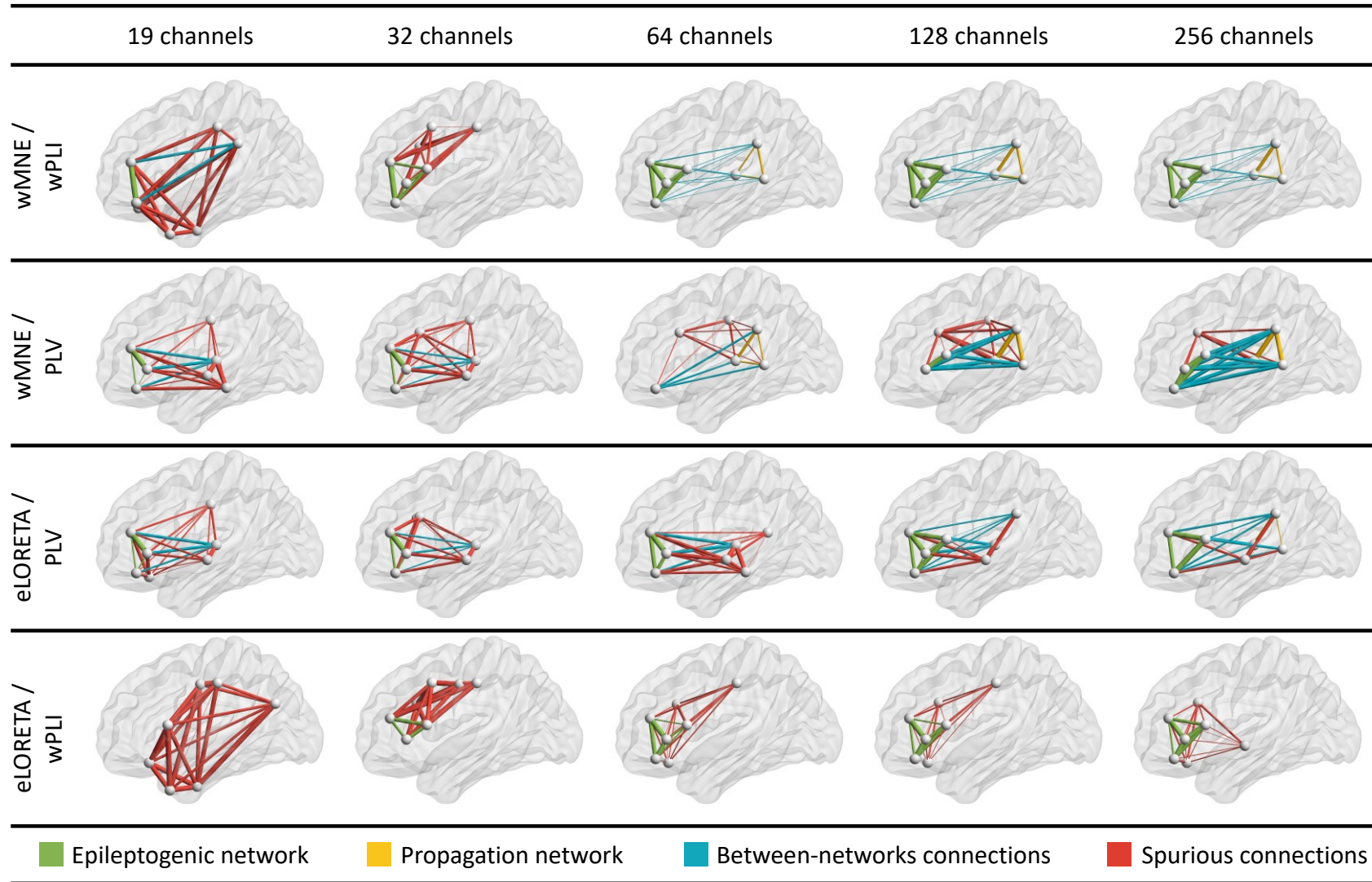
6. Functional connectivity

30 trials

PLV
wPLI

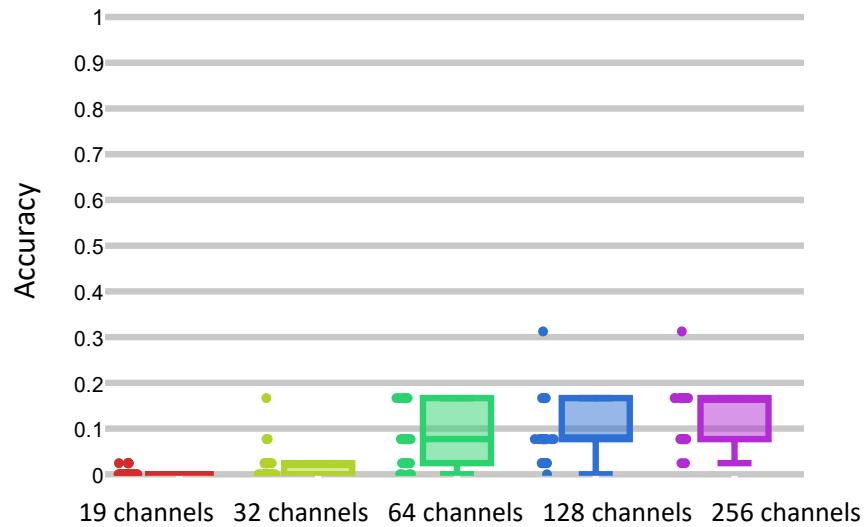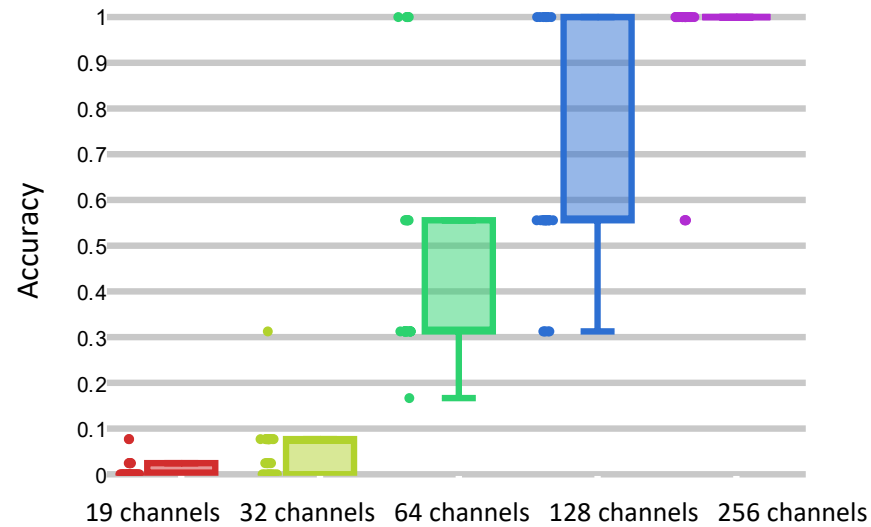**5. Source reconstruction**

wMNE
eLORETA

Results

Qualitative results:
- Higher sensor density
  → Better performance

- wMNE/wPLI
  → Best Performance
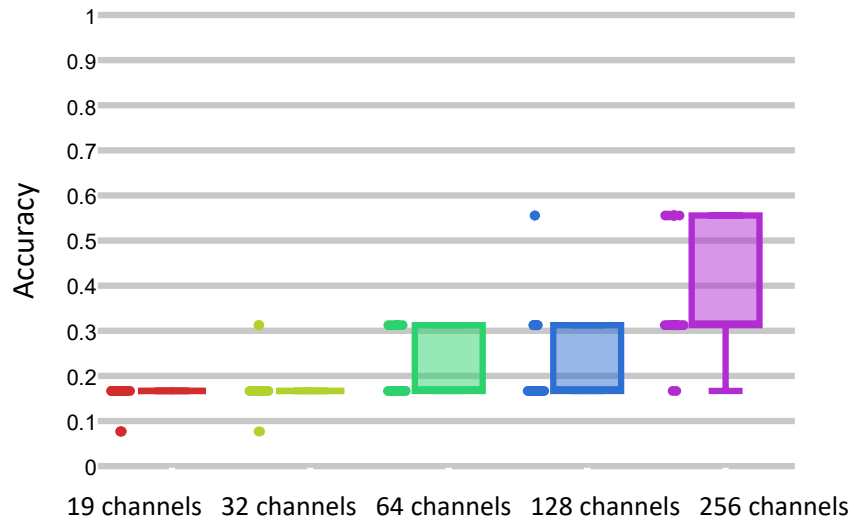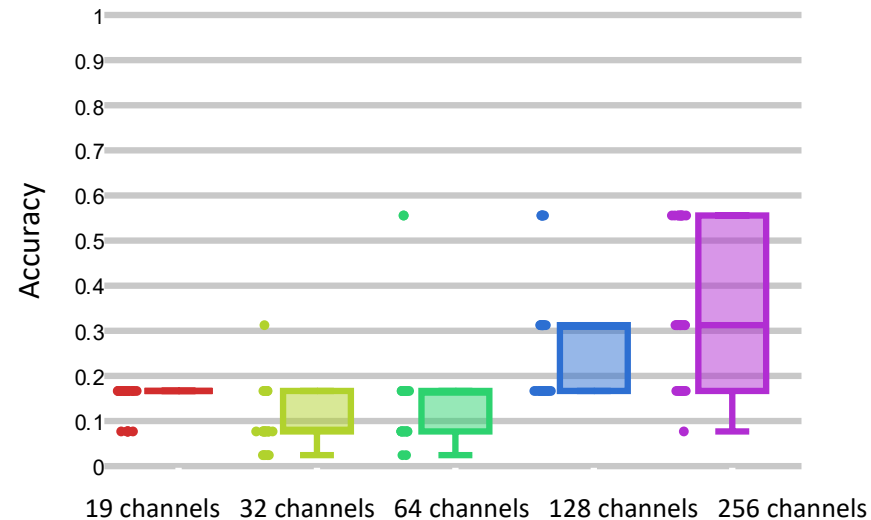
- eLORETA/wPLI
  → Worst performance

Results

- Significant effect of the inverse solution and connectivity measure combination as well as the number of electrodes

- Significant difference between 256 channels and 64, 32 and 19 electrodes

Results

- Mean accuracy and standard error of each inverse solution/connectivity measure combination plotted against different levels noise for the case of 256 electrodes
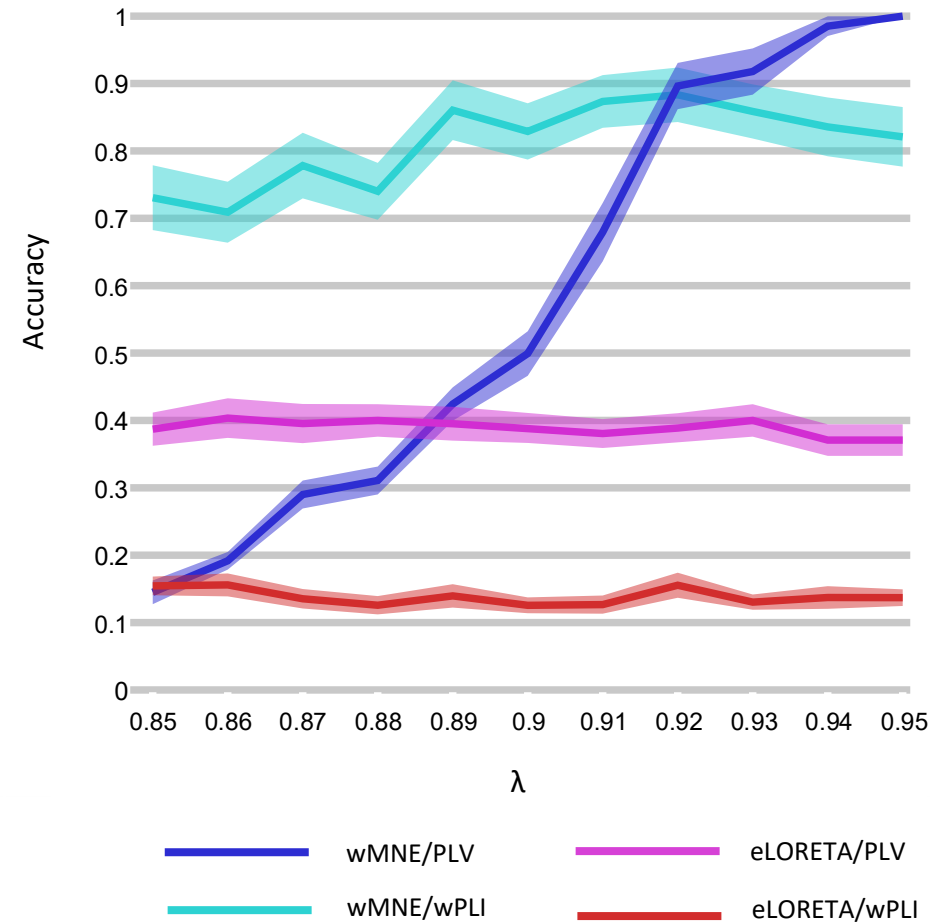
- wMNE/PLV
  → Most affected by noise

Conclusions

- Proof of concept that COALIA can provide a ground-truth for comparative studies aiming at optimizing the EEG-source connectivity pipeline.

- A higher network estimation accuracy requires a high number of EEG electrodes

- A careful choice of an inverse solution/connectivity measure combination is necessary.

Citation:
Allouch, S., Yochum, M., Kabbara, A., Duprez, J., Khalil, M., Wendling, F., Hassan, M., Modolo, J. (2020). Mean-field modeling of brain-scale dynamics for the evaluation of EEG source-space networks. Brain Topography (minor revision). BioRxiv. https://doi.org/10.1101/2020.09.16.299305

Thank You!