Development of Dynamic Functional Connectivity and Cross-Frequency Coupling Tools for Task-Based MEG Data

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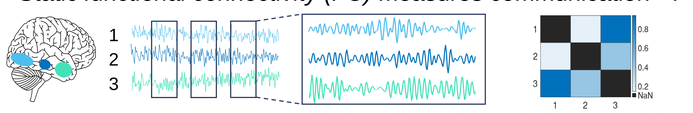
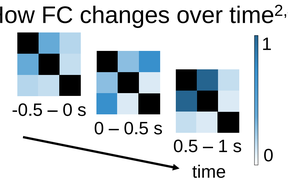
#34 References & Digital Poster

Background

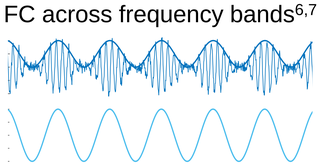
- Neural communication underlies ability to complete tasks[1,2]
- Static *functional connectivity (FC)* measures communication[3,4]:



Dynamic FC (dFC)
How FC changes over time[2,4,5]



Cross-Frequency Coupling (CFC)
FC across frequency bands[6,7]



Objectives

(1) Develop accessible dFC and CFC tools
(2) Apply on selective attention data

Pipeline & Validation Results

Built with:

MATLAB

FieldTrip[8]

Source localized data

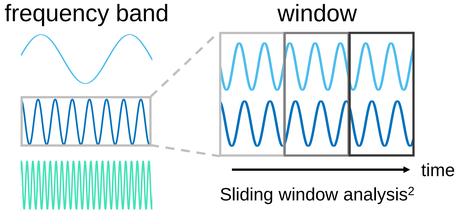
Sub-select data by condition

dFC

For each frequency band

For each time window

Calculate debiased weighed phase lag index (d-wPLI)

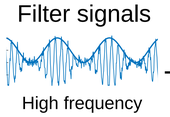


Sliding window analysis[2]

0 ≤ d-wPLI ≤ 1, where 1 is perfect phase locking[9]

CFC

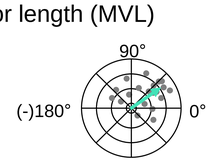
Filter signals



Extract amplitude

Extract phase

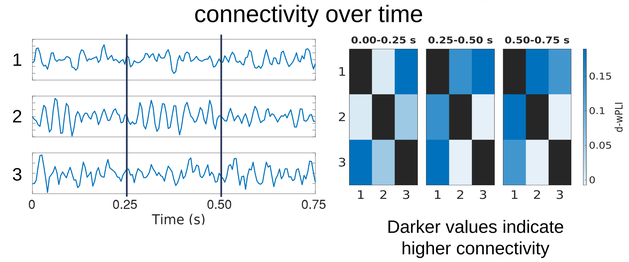
Calculate mean vector length (MVL)



Construct vectors and average

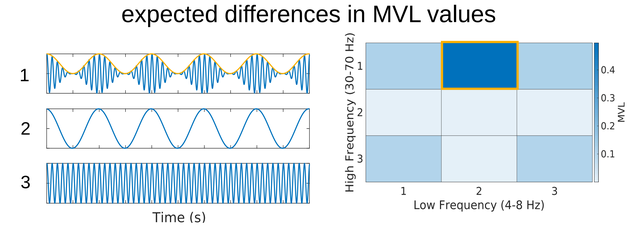
Longer vectors = more coupling[10]

Simulated signals demonstrated changes in connectivity over time



Darker values indicate higher connectivity

Simulated signals with known CFC showed expected differences in MVL values

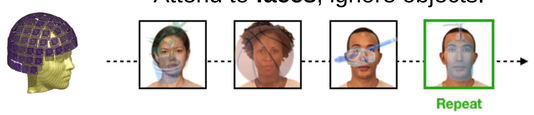


Proof of Concept: Application on Selective Attention Dataset

Subsample
n=3 (healthy controls) , *n*=3 (children treated for brain tumor), 14-17 years, 2 male, 1 female

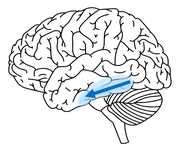
Task Paradigm
Modified *n*-back task[11] in MEG (600 Hz, CTF Systems Inc., Coquitlam, BC, Canada)

Attend to **faces**, ignore objects.



250 trials → exclude trials with repeats or button presses → average 148 trials/participant

Analysis
Calculate metrics between regions in the ventral visual stream including:



- *Fusiform face area (FFA):* involved in face recognition[12]
- *Lateral occipital cortex (LOC):* involved in object recognition[13]

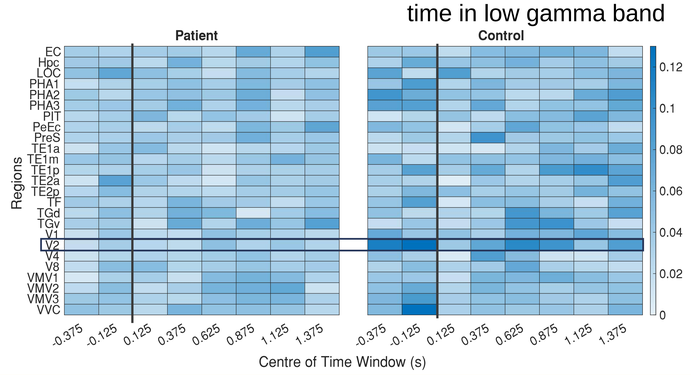
Frequency Bands

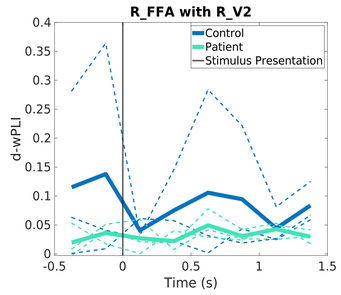
Alpha (8-12 Hz)
Suppression of distractors[14,15]

Low Gamma (30-70 Hz)
Associated with attention modulation in visual processing[16,17]

dFC

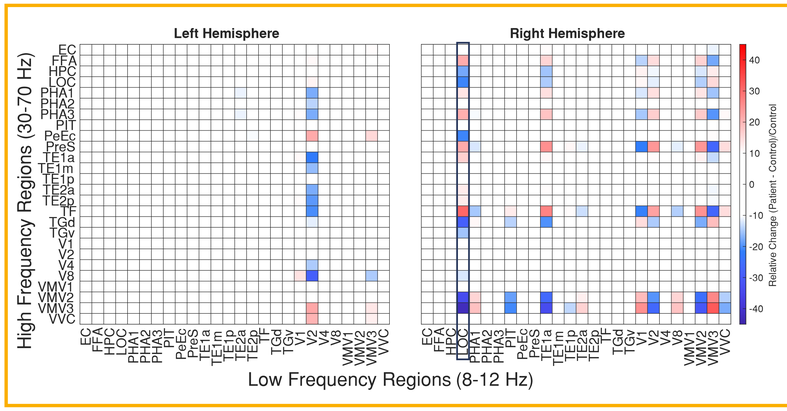
Group connectivity averages between R_FFA and remaining regions have different patterns over time in low gamma band



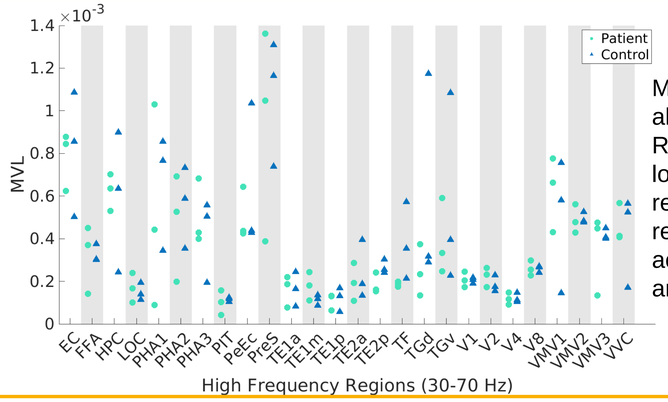


Dashed lines represent individual participants, solid lines indicate group averages.

CFC



Relative change in alpha-low gamma MVL between patients and controls differ between hemispheres



MVL between alpha band in R_LOC and low-gamma in remaining regions varies across patients and controls.

Conclusions

- Developed tools were successfully applied to simulated and empirically collected data
- Proof of concept results show the potential to demonstrate differences in brain communication that may not be seen with traditional methods
- dFC and CFC tools may be used to assess neural communication in other areas, including working memory and sleep, and to identify population differences
- Integrate functions into in-house MEG processing pipeline
- Apply tools to larger dataset to examine differences in brain communication in task-based data
- Investigate other FC metrics for dFC and for CFC