Summary and Q&A

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IMC
INTERACTING MINDS CENTRE

Contents

1) MVPA analysis of intertrial phase …
2) Exam
   - Formalities
   - Paper outline
3) Q & A

eNeuro

New Research

Sensory and Motor Systems

MVPA Analysis of Intertrial Phase Coherence of Neuromagnetic Responses to Words Reliably Classifies Multiple Levels of Language Processing in the Brain

Mads Jensen,[1] Rasha Hyder,[1] and Yury Shtyrov[1,2]

https://doi.org/10.1523/ENEURO.0444-18.2019

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Background

Main question:

Can we assess language functioning in patients suffering from Parkinson disease in a task free way?

1. Test the paradigm in young healthy controls
2. Test the paradigm in elderly healthy controls
3. Test the paradigm in Parkinson patients

Background

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Can we assess language functioning in patients suffering from Parkinson disease in a task free way?

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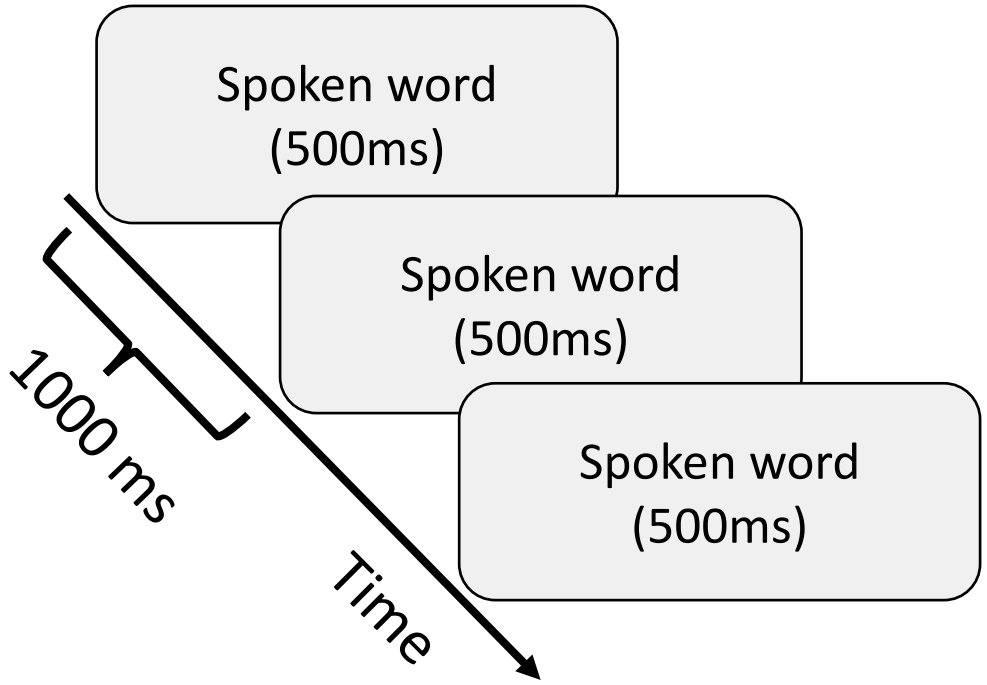
Background

Task-free language paradigm.



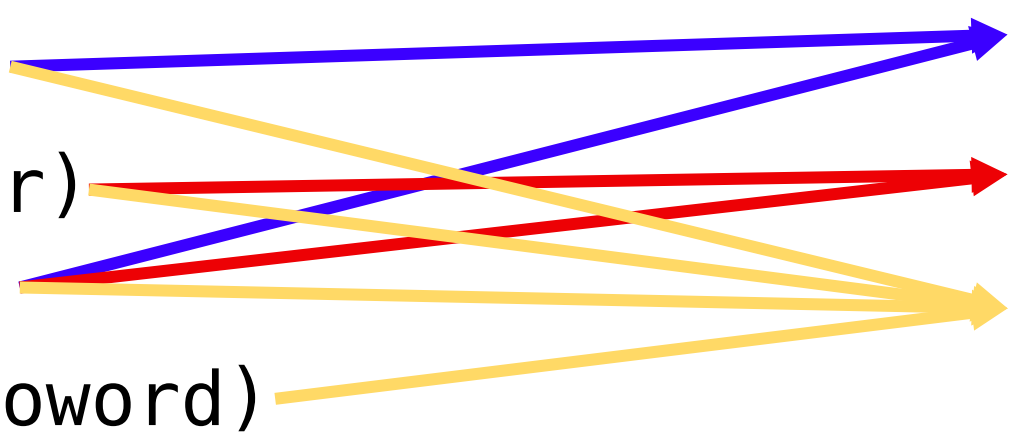
Naatanen, Paavilainen, Rinne, & Alho (2007). The mismatch negativity (MMN) in basic research of central auditory processing: a review. *Clin Neurophysiol, 118*(12), 2544-2590. doi:10.1016/j.clinph.2007.04.026

Pulvermuller & Shtyrov (2006). Language outside the focus of attention. *Prog Neurobiol, 79*(1), 49-71 doi:10.1016/j.pneurobio.2006.04.004

Background

Single words in *Danish* were played in ear tube while participants were watching a silent film in the MEG.

- Bide (bite)
- Gide (bother)
- Mide (mite)
- Nide (pseudoword)



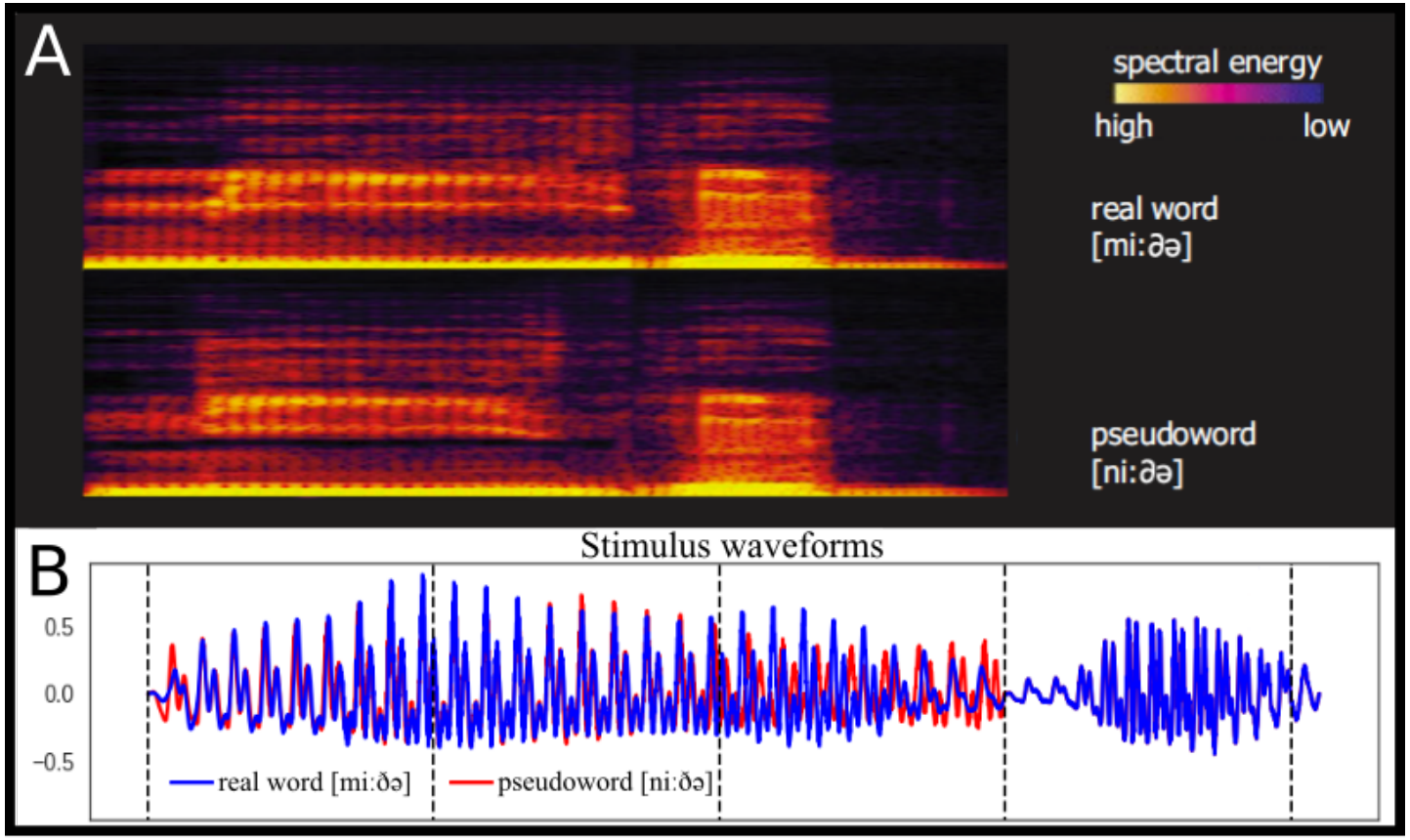
Semantic contrast

Syntactic contrast

Lexical contrast

(Hyder et al., 2020)

Sound waveform



(Fig A adapted from Gansonre et al. 2018)

What to with the data?

- Preprocessing
  - Filtering
  - Artefacts handling
  - ERFs vs oscillations
- Sensor vs source space
  - Less data vs location precision
  - Sensor types
  - Source reconstruction
- Statistical analysis
  - ROIs vs full dataset
  - Descriptive vs predictive

Can we *assess language function* in Parkinson patients in a task free way?

What does “assess” and “language function” *actually* mean?

What to with the data?

- Preprocessing
  - Filtering
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  - ERFs vs **oscillations**
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  - Less data vs **location precision**
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  - **Source reconstruction**
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  - ROIs vs **full dataset**
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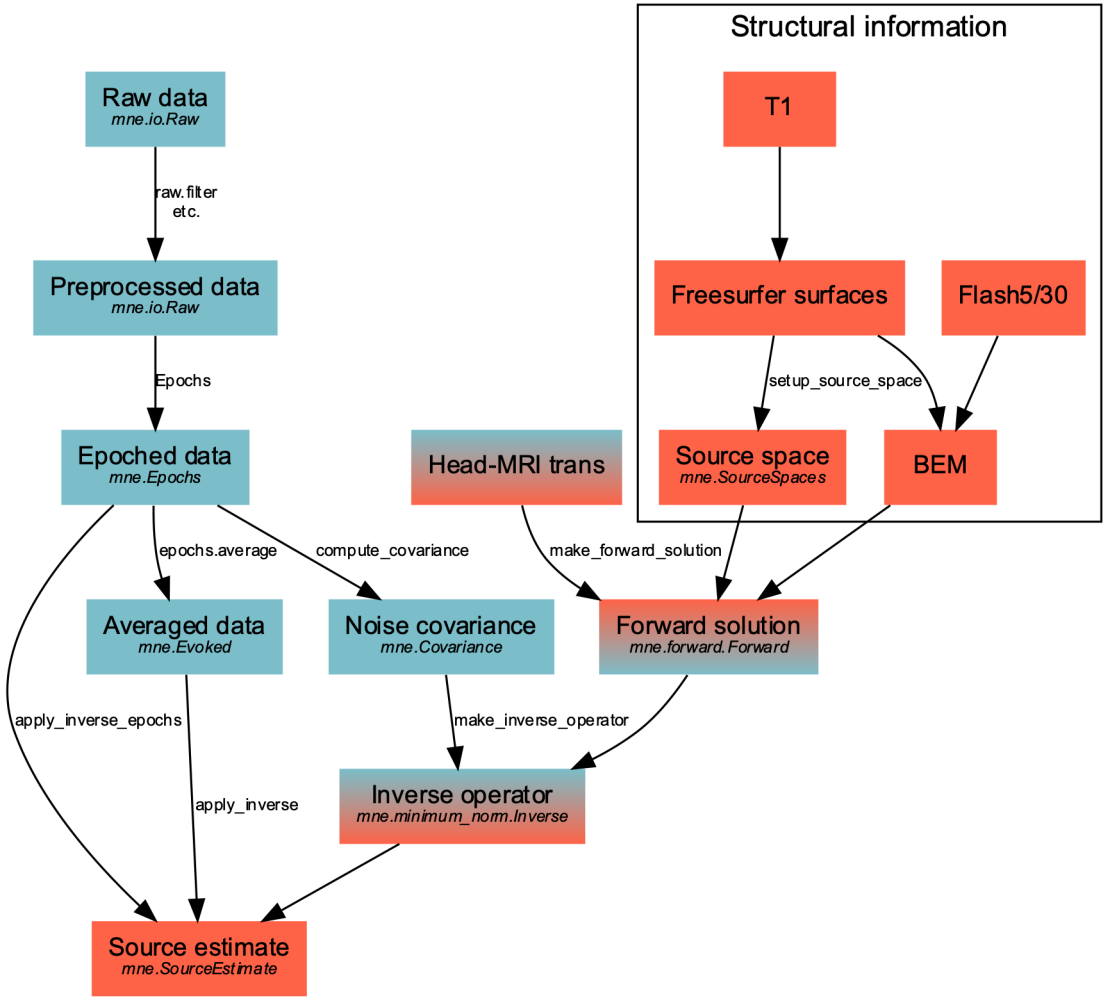
Can we *assess language function* in Parkinson patients in a task free way?

What does “assess” and “language function” *actually* mean?

MNE example



(Figure from http://martinos.org/mne/dev/manual/cookbook.html?highlight=flow)

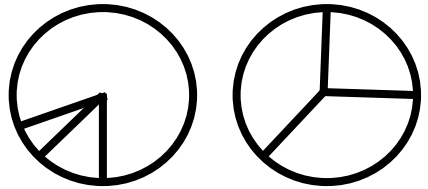
Data pipeline

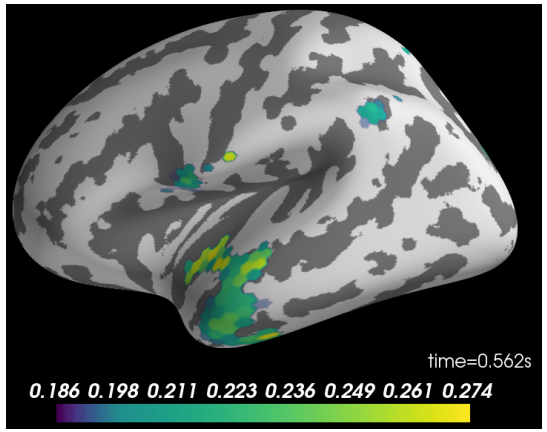
→ Bandpass filter

α: 8 – 12 Hz
β: 13 – 30 Hz
γ-low: 30 – 45 Hz
γ-med: 55 – 75 Hz
γ-high: 70 – 90 Hz

→ LCMV Beamformer

→ Intertrial phase coherence

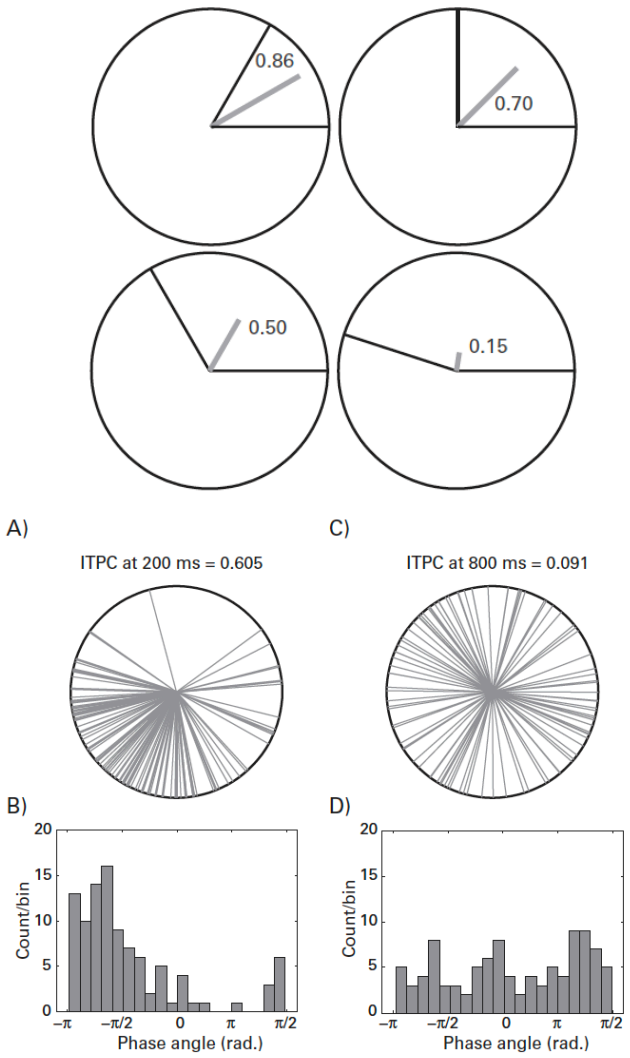




← **MVPA pipeline**

Hilbert beamforming: Westner, B. U., & Dalal, S. S. (2017). Faster than the brain's speed of light […]
BioRxiv. https://doi.org/10.1101/153551
Google summer of code: https://brittas-summerofcode.blogspot.com/2017/08/google-summer-of-code-2017-final-report.htmlz

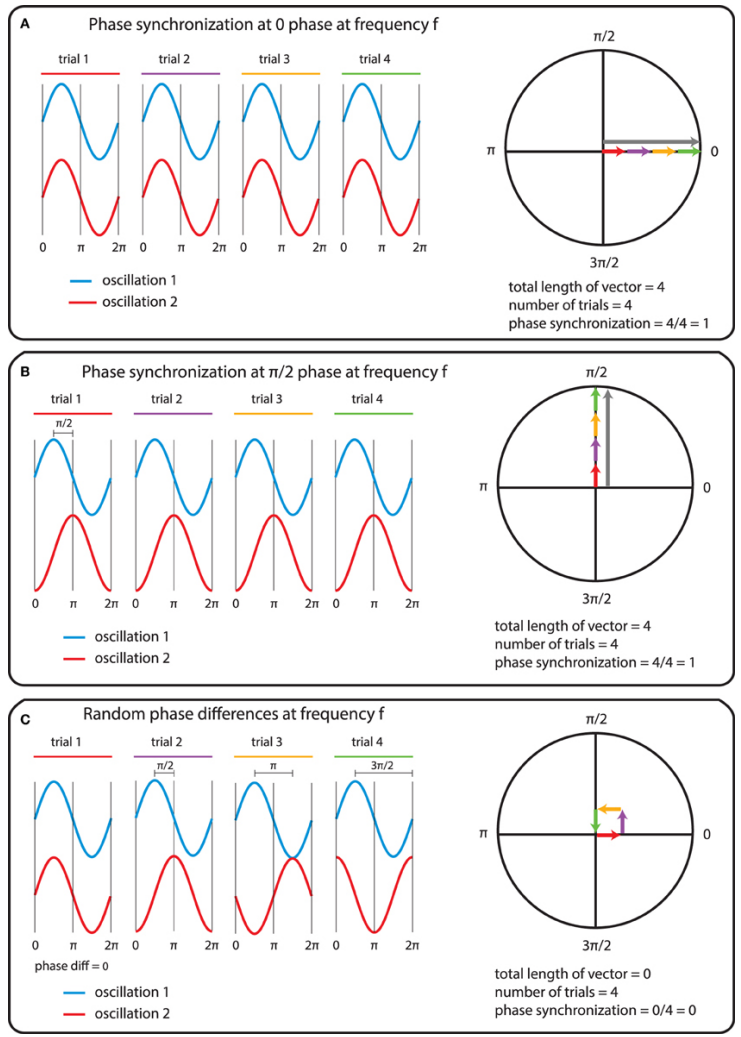
Intertrial phase coherence



(Figures from Cohen, 2014)

$$ITPC_{tf} = \left| n^{-1} \sum_{r=1}^{n} e^{ik_{tfr}} \right|$$

- n is the number of trials
- n^{-1} is shorthand for $1/n$ and combined with the summation operator indicates an average;
- e^{ik} is from Euler's formula and provide complex polar representation of phase angle k on trial r at time–frequency point tf.



(Figure from Bastos & Schoffelen, 2016)

MVPA pipeline

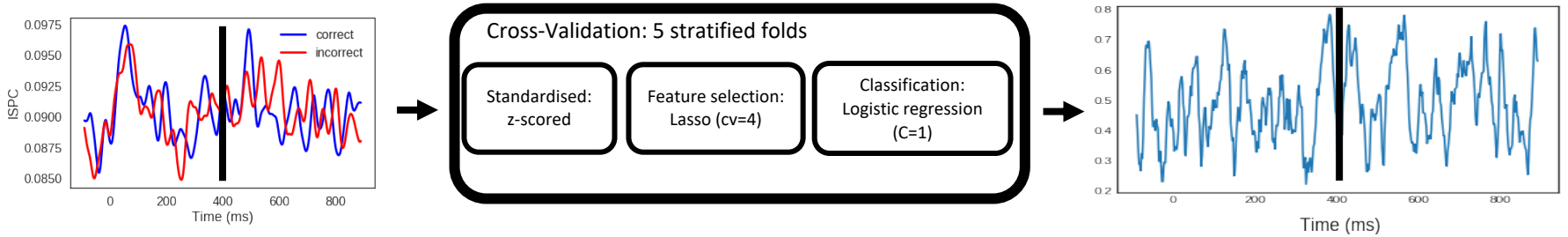
What data do we have

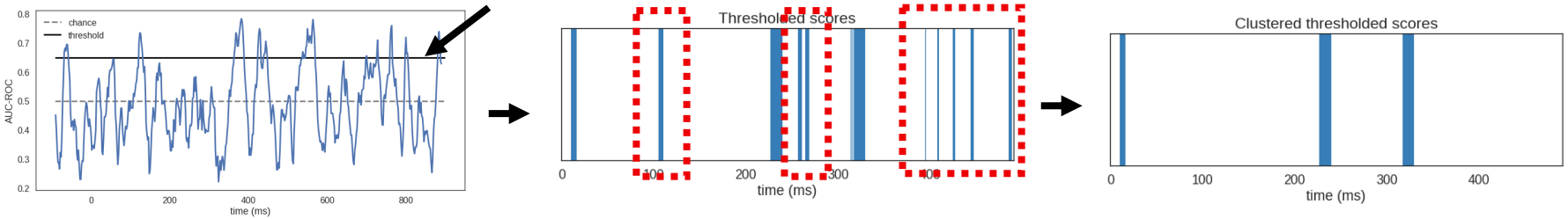
- Time series of phase coherence for each word
- Source space (5124 vertices)
- 5 frequency bands

MVPA

https://xkcd.com/1838/

MVPA pipeline



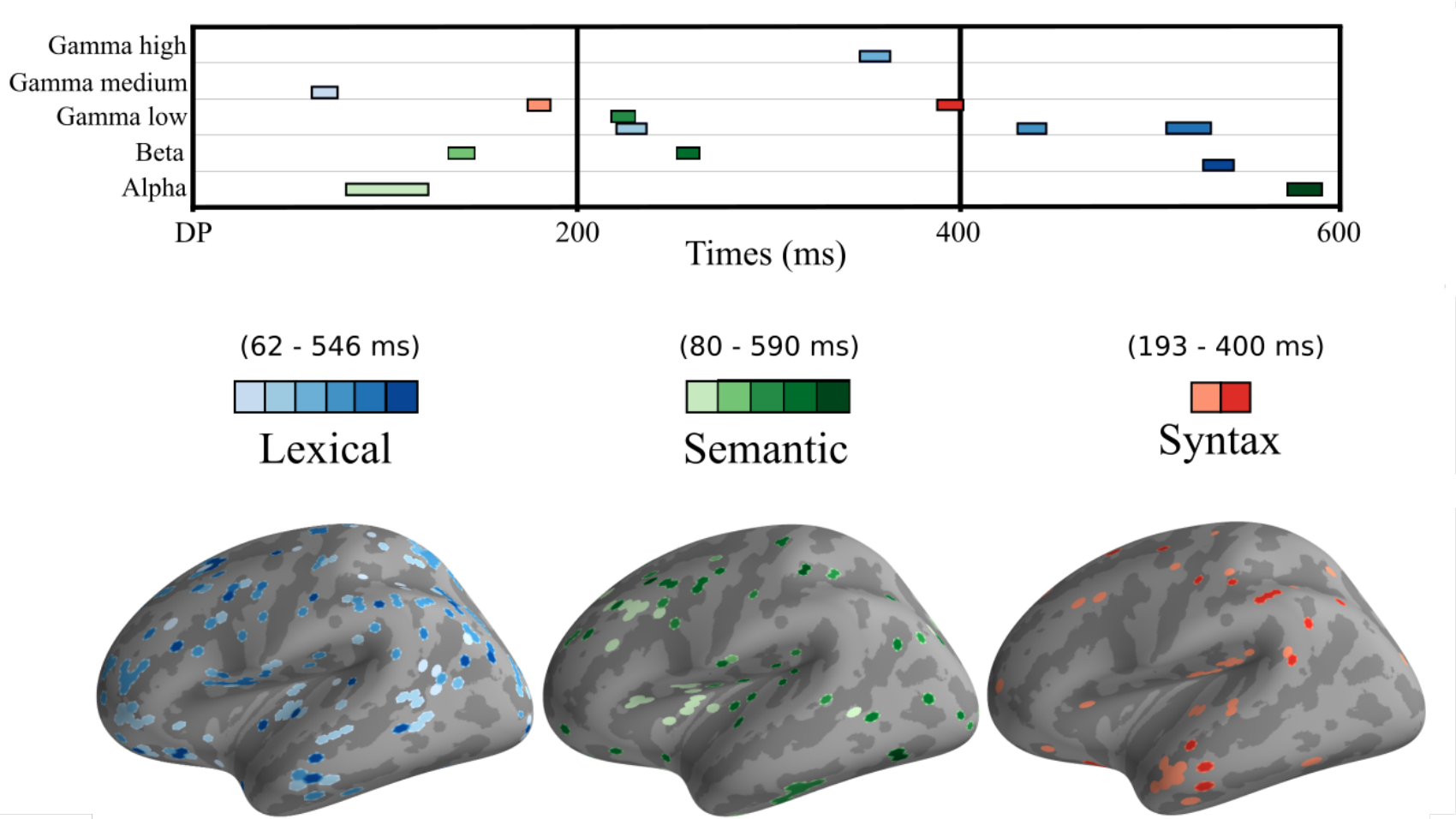


What did we find?

- What are the results?
- How to present them?

Can we *assess language function* in Parkinson patients in a task free way?

Results:



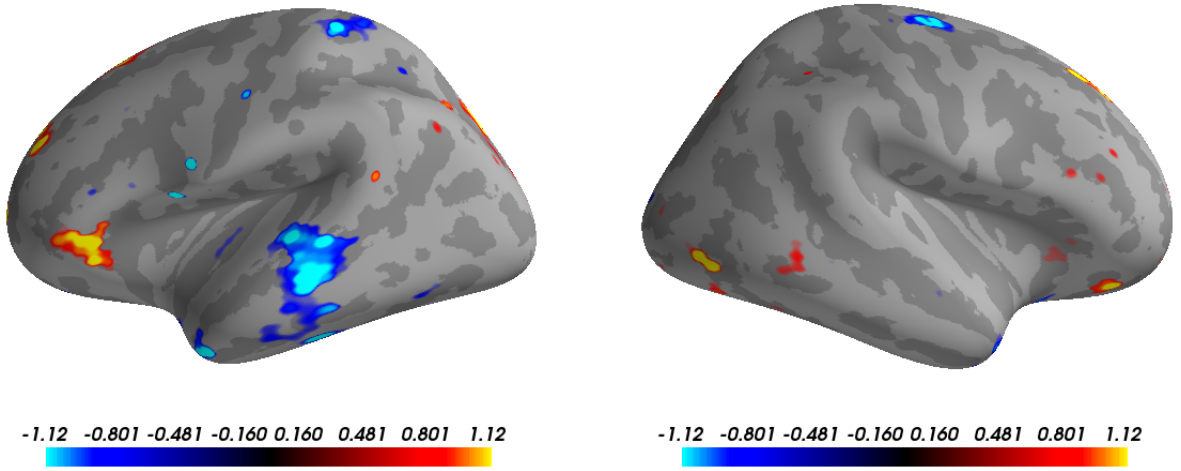
(Figure from Jensen, Hyder, & Shtyrov, 2019)

Results: lexicality

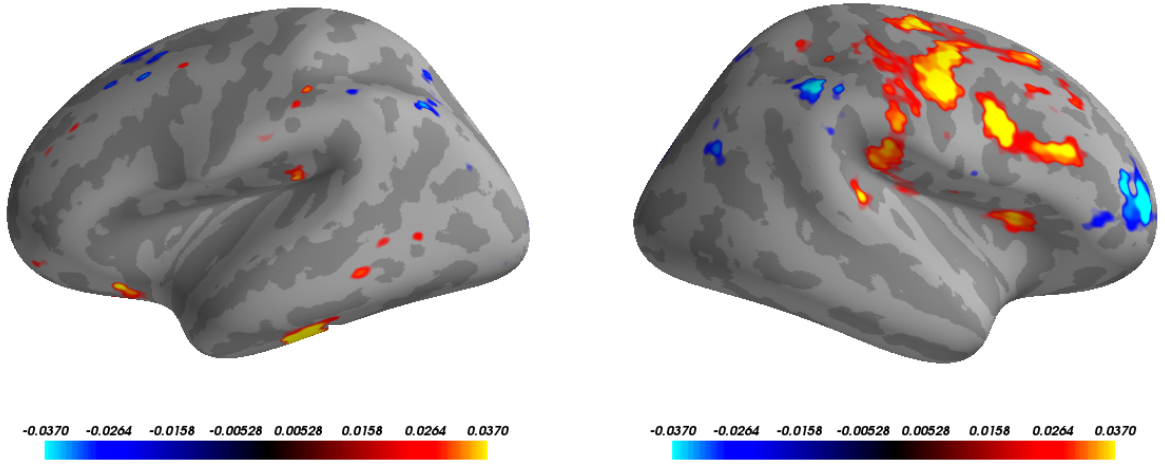
Lexical

band	peak (%)	peak std (%)	Peak time	Cluster start	Cluster end	Cluster length	Cluster mean	Cluster std (%)
Gamma meduim	88,53	6,43	66	62	76	14	83,20	4,57
Gamma low	94,35	4,50	224	222	238	16	85,02	9,68
Gamma high	87,88	9,29	358	350	366	16	80,19	4,95
Gamma low	87,65	11,08	440	432	448	16	81,34	4,99
Gamma low	87,71	8,83	516	510	534	24	81,34	4,36
Beta	85,97	14,95	538	530	546	16	80,25	4,32

Average pattern

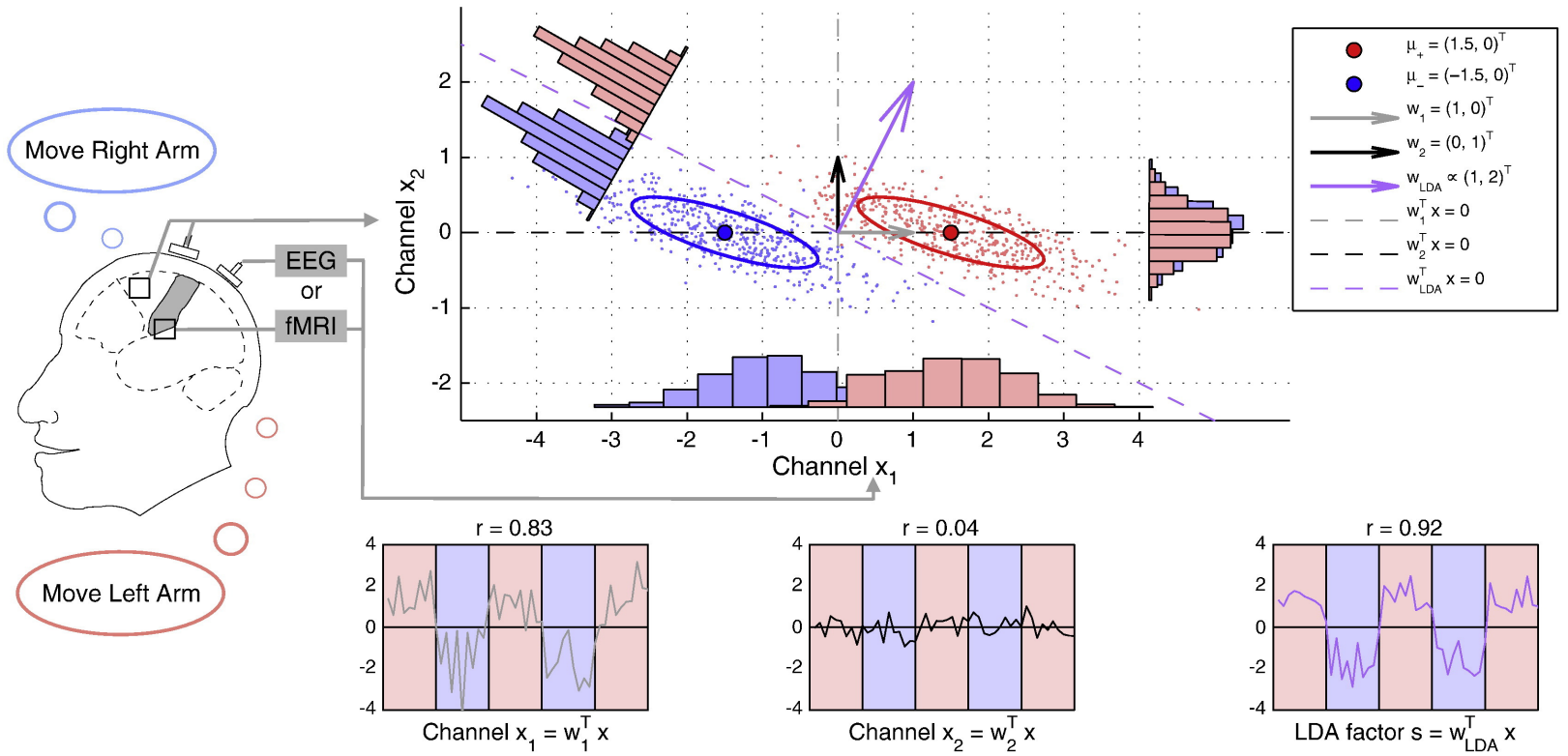


Average ITPC



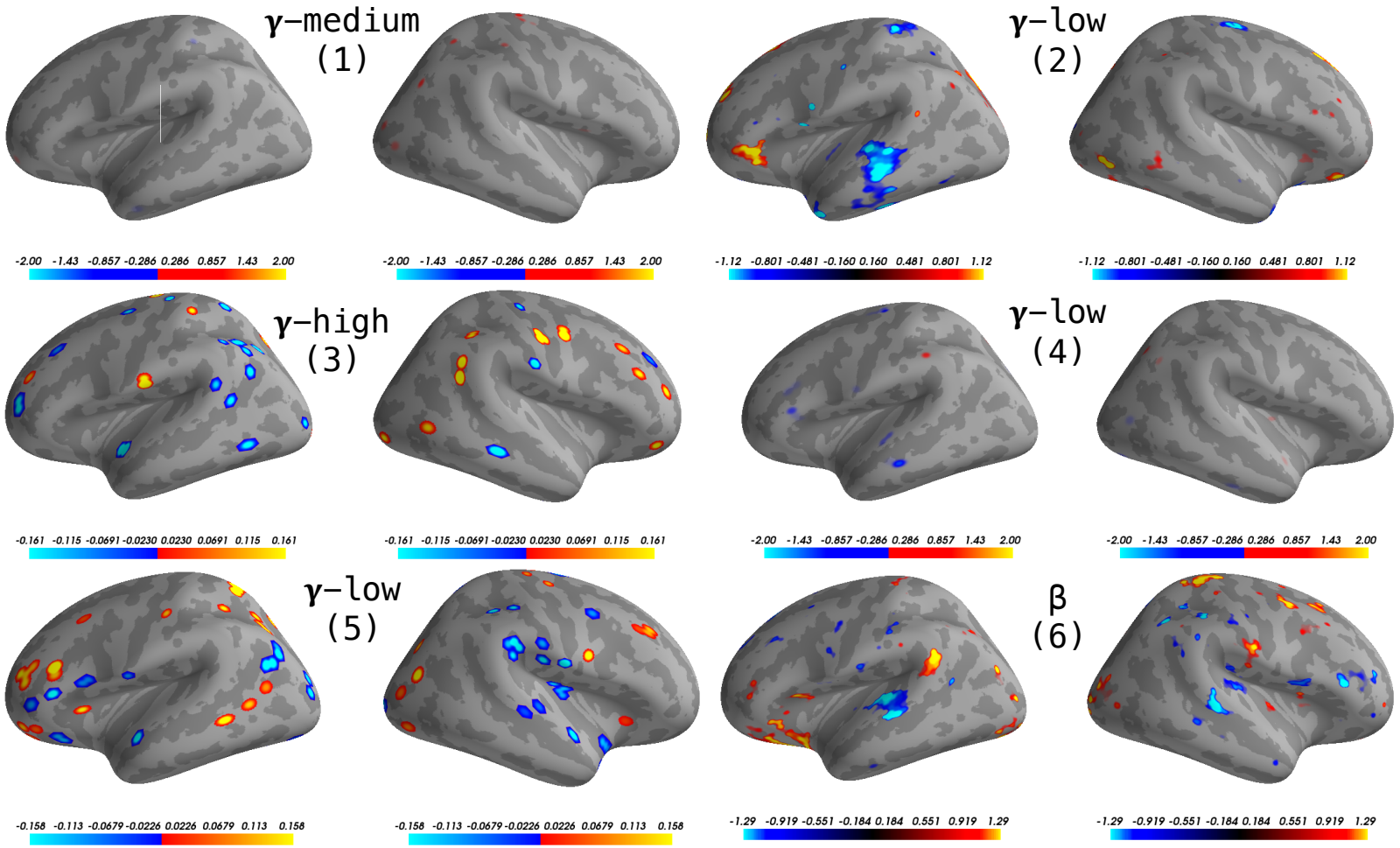
Re patterns see: Haufe et al (2014). On the interpretation of weight vectors of linear models […] *Neuroimage*, *87*, 96–110.

Patterns

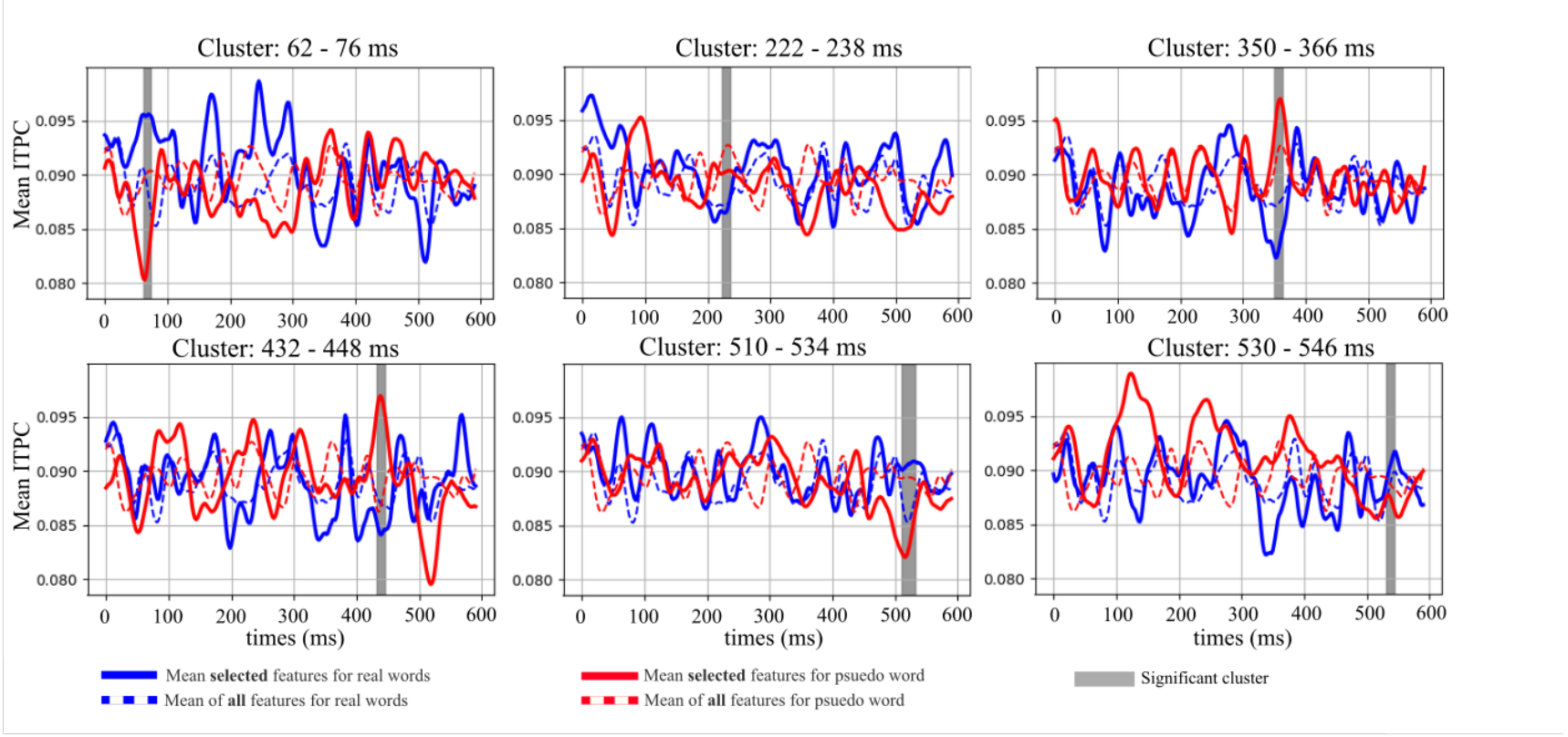


(Figure from Haufe et al., 2014)

Results: lexicality



Results: lexicality

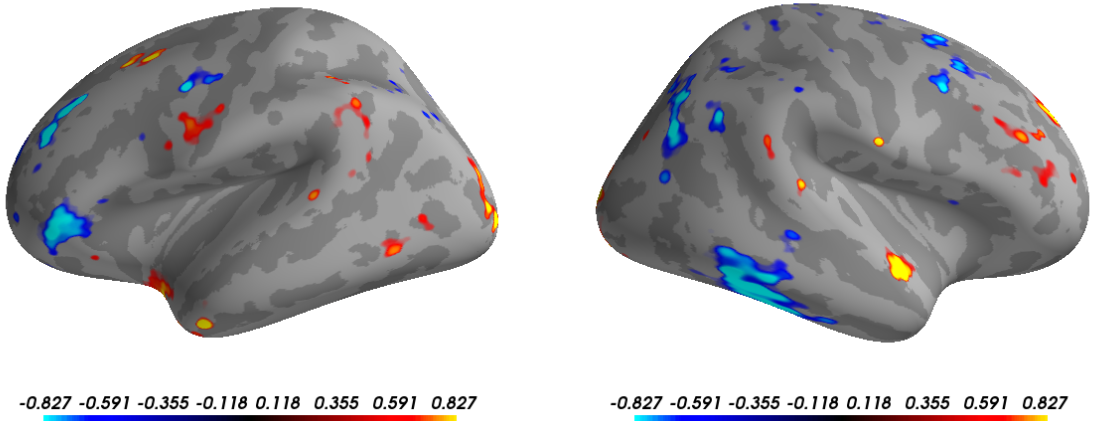


Results: semantic

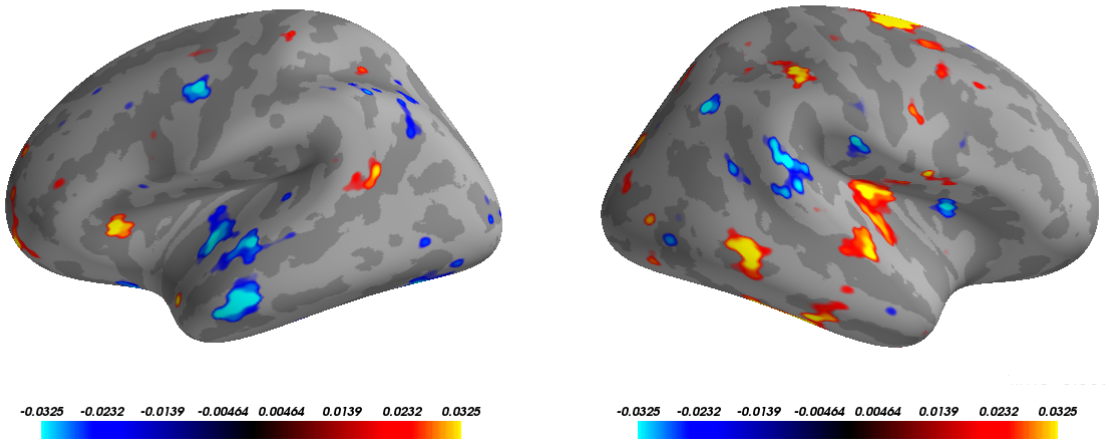
Semantics

band	peak (%)	peak std (%)	Peak time (ms)	Cluster start (ms)	Cluster end (ms)	Cluster length (ms)	Cluster mean (%)	Cluster std (%)
Alpha	91,11	12,96	106	80	122	42	68,21	9,77
Beta	75,00	19,08	138	134	146	12	69,62	5,25
Gamma low	84,58	9,01	224	220	230	10	71,85	7,06
Beta	70,00	13,43	256	254	264	10	66,53	3,37
Alpha	85,83	3,74	584	574	590	16	71,71	7,62

Average pattern

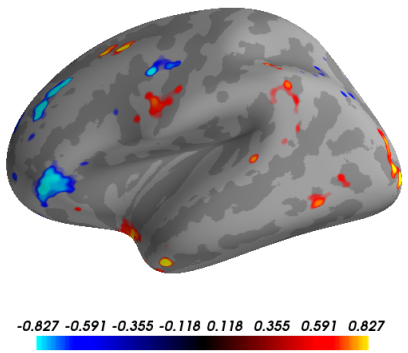


Average ITPC

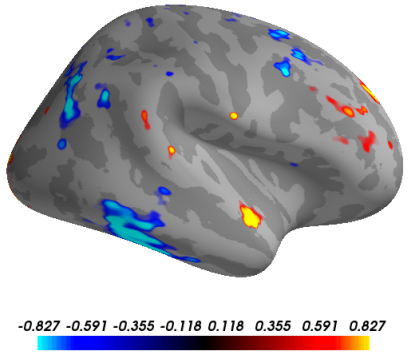


Results: semantic

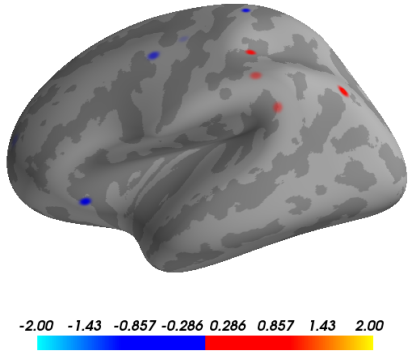
α (1)



-0.827 -0.591 -0.355 -0.118 0.118 0.355 0.591 0.827

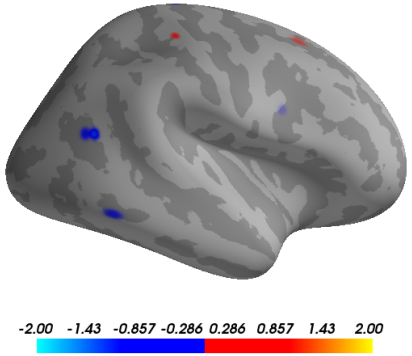


-0.827 -0.591 -0.355 -0.118 0.118 0.355 0.591 0.827



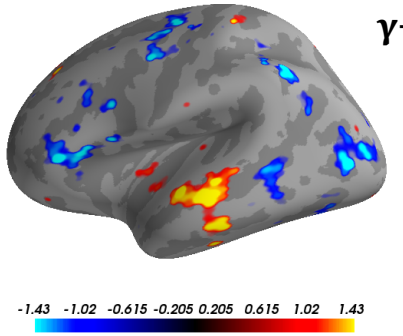
-2.00 -1.43 -0.857 -0.286 0.286 0.857 1.43 2.00

β (2)

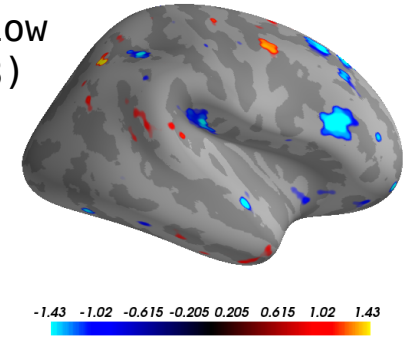


-2.00 -1.43 -0.857 -0.286 0.286 0.857 1.43 2.00

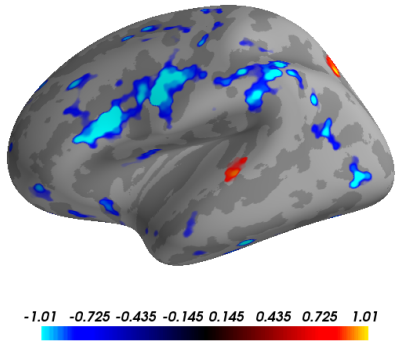
γ−low (3)



-1.43 -1.02 -0.615 -0.205 0.205 0.615 1.02 1.43

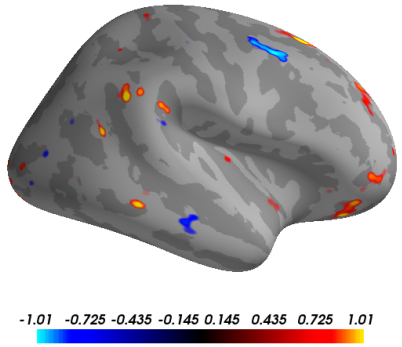


-1.43 -1.02 -0.615 -0.205 0.205 0.615 1.02 1.43



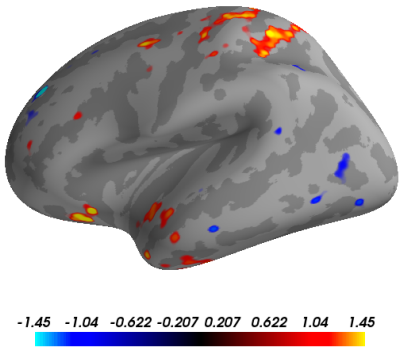
-1.01 -0.725 -0.435 -0.145 0.145 0.435 0.725 1.01

β (4)

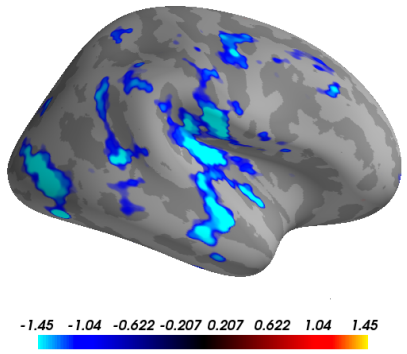


-1.01 -0.725 -0.435 -0.145 0.145 0.435 0.725 1.01

α (5)

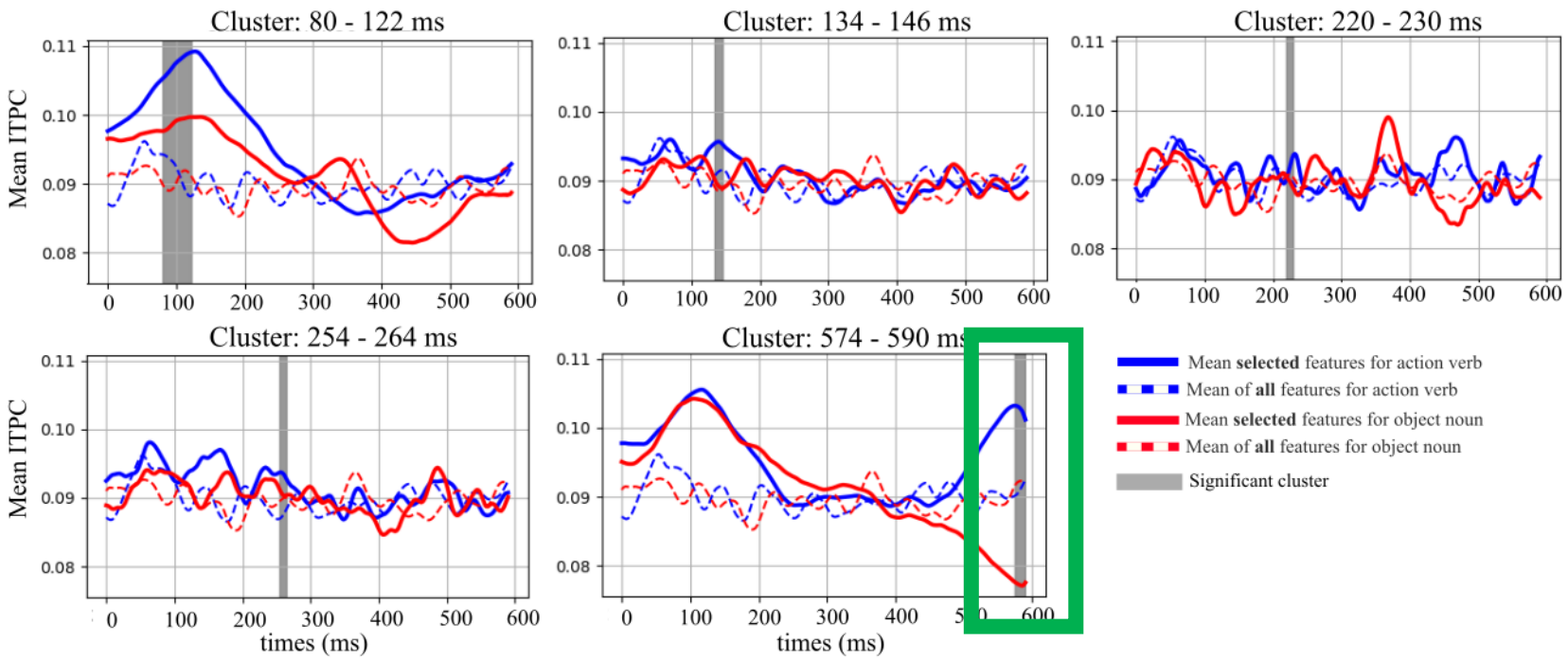


-1.45 -1.04 -0.622 -0.207 0.207 0.622 1.04 1.45



-1.45 -1.04 -0.622 -0.207 0.207 0.622 1.04 1.45

Results: semantic

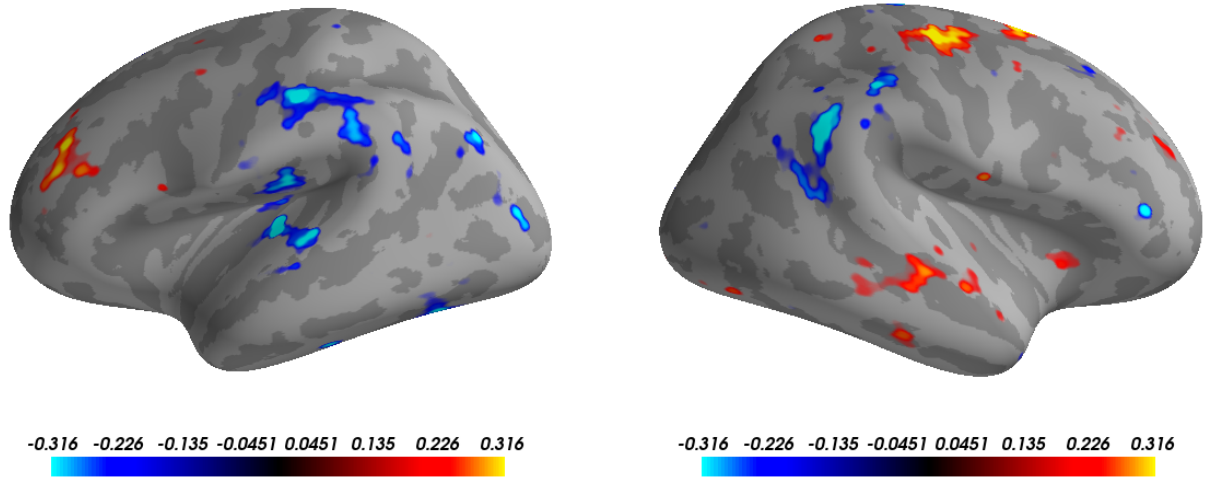


Results: syntax

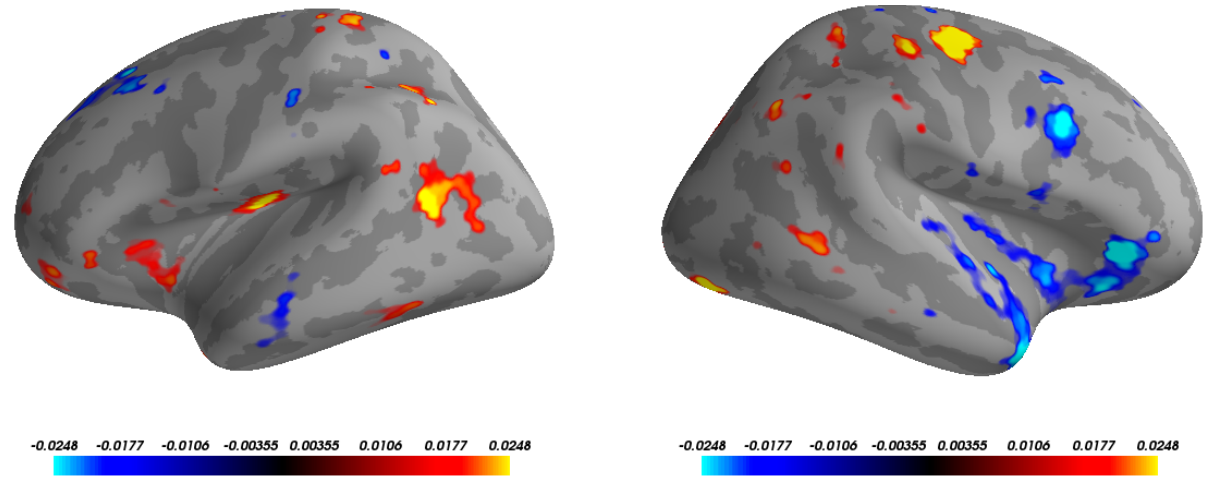
Syntax

band	peak (%)	peak std (%)	Peak time (ms)	Cluster start (ms)	Cluster end (ms)	Cluster length (ms)	Cluster mean (%)	Cluster std (%)
Gamma low	69,22	13,05	90	85	98	12	62,57	9,16
Gamma low	68,36	11,57	302	300	314	14	64,04	5,10

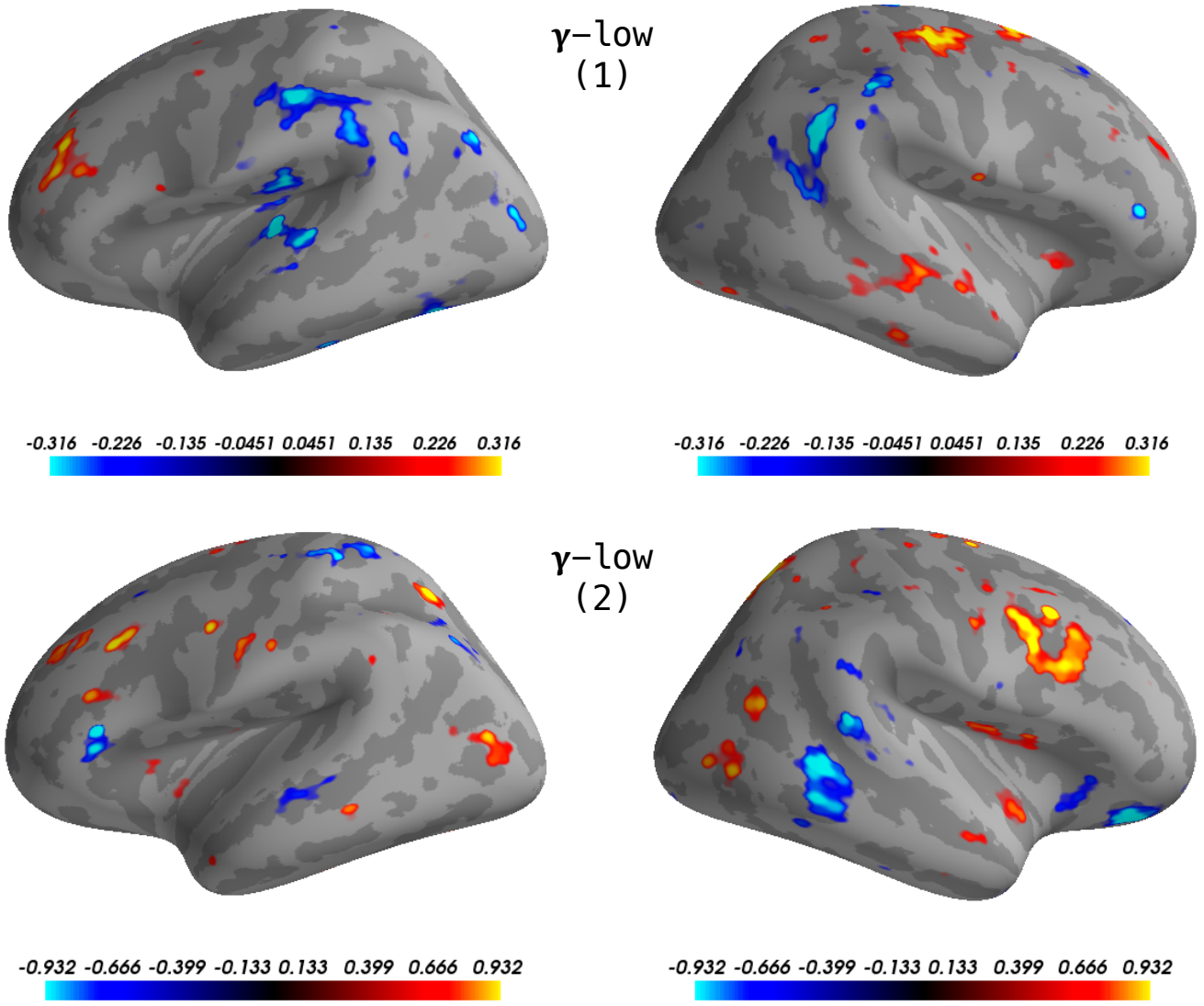
Average pattern



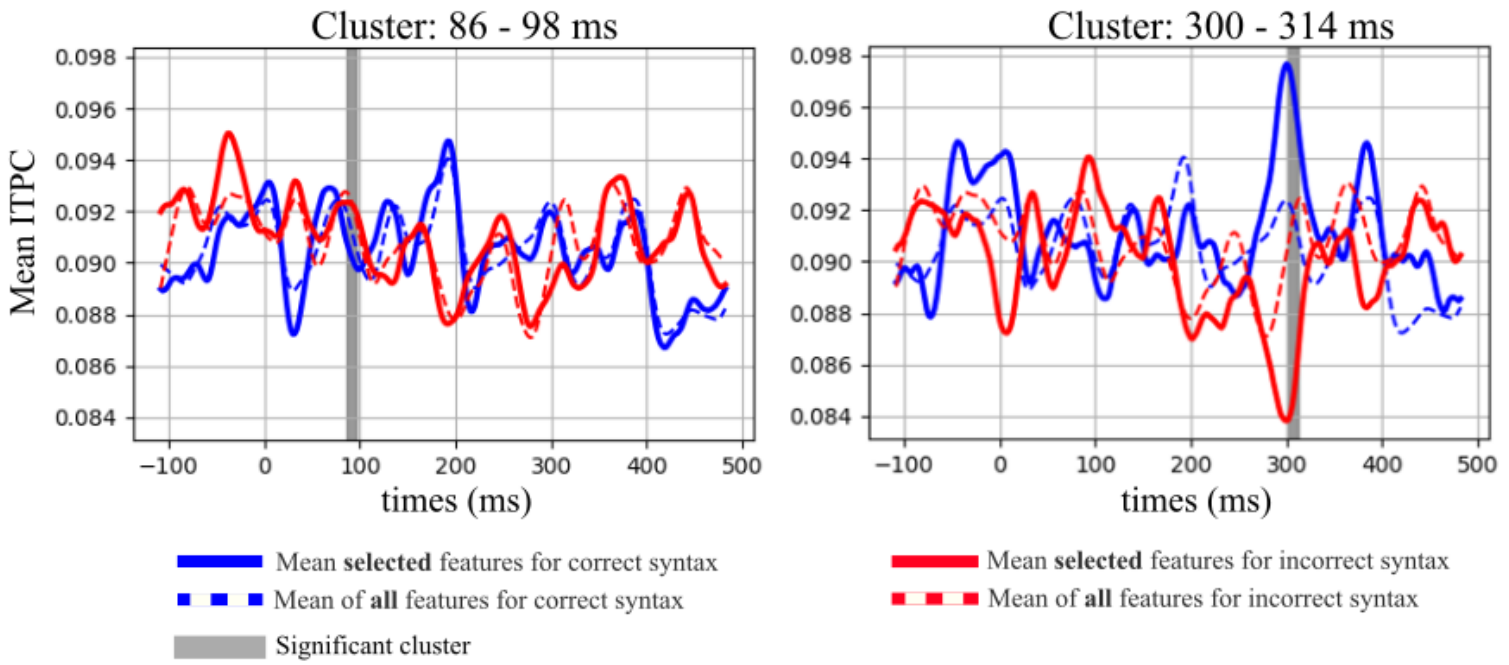
Average ITPC



Results: syntax



Results: syntax



Summary

- We can decode all three types of language features
- They have different time course and topological distributions
- Right hemisphere activity:
  - Lexical: mostly related to pseudo word
  - Syntax: mostly related to the incorrect syntax

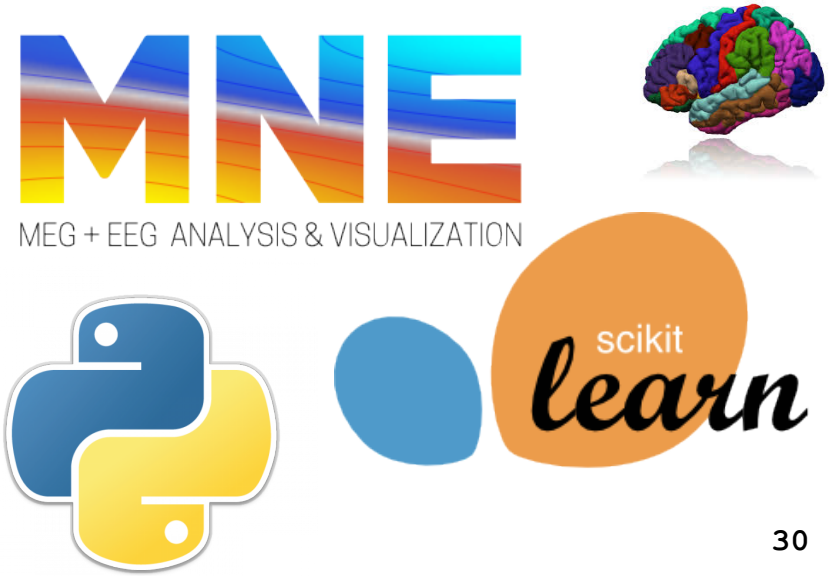
Thanks to:

Collaborators:

Yury Shtyrov, Prof
Rasha Hyder, PhD
Andreas Højlund, PhD
Karen Østergaard, MD, Prof

Britta Westner
The M/EEG group at CFIN

DANMARKS FRIE FORSKNINGSFOND
INDEPENDENT RESEARCH FUND DENMARK



Exam: formalities

Portfolio exam

Deadline: 21th of December

The exam consists of a portfolio containing 3–7 assignments, which the student submits to the teacher during the course. Their form (individual and/or group-based, written, product and/or oral, set and/or on a topic of the student's choice), length and deadline for submission will be announced on Blackboard by the teacher at the start of the semester.

The complete portfolio must be handed in for assessment in the Digital Exam system by a specified date. The portfolio can be written individually or in groups of up to 3 students. **Group assignments must be written in such a way that the contribution of each student can form the basis of individual assessment.** The portfolio should clearly state which sections the individual students are responsible for.

Portfolio papers

- A selection of three paper with an introduction and discussion/conclusion is to be handed in as one joint submission.
- A paper can be maximum 7 normal pages
  - code goes in an appendix
  - Figures does not count
  - Abstract etc count towards the 7 normal pages
- Introduction and discussion/conclusion is combined maximum of 7 normal pages.
- A normal page is 2400 characters including spaces and in-text references.
- The reference list does not count for the pages limits.
- Citation style is APA7

Imaginary paper outline

Part of papers

- Introduction
  - Introduction to the overall topic
  - What is the research question(s) to be addressed
  - What will happen in the paper
- Method
  - Methods to approach the question(s) above
  - E.g. experiments
- Results
  - What the did experiment(s) show
- Discussion
  - How does this help clarifying the research question(s)
  - Relate results to the research question(s)
- General discussion
  - Related the results and discussion to the overall topic
  - Inverse of the introduction

Link oscillations to a cognitive function

- **Method:** Compare a known cognitive function to changes in oscillatory activity
- Use a **case** to answer the question

Link oscillations to a cognitive function

1. What is **question** the authors want to answer?
2. How does **oscillations** help answering the question?

   Why oscillations
3. What **type** of oscillations?
4. What are the **results**?
5. What have we **learnt** about the cognitive function?

Link oscillations to a cognitive function

Introduction

1. What is **question** the authors want to answer?
2. How does **oscillations** help answering the question?

Introduction

- Introduce oscillations and cognitive functions, and link the them.
  1. Assessing language function
  2. Look at the phase part of the oscillation across several bands to compare the decoding ability – as measure of brain activity.

Link oscillations to a cognitive function

Method

3. What **type** of oscillations?

Method

- How to quantify oscillations?
- Why does it matter?

3. What did the authors do and what can they say with their method of choice?

Link oscillations to a cognitive function

Discussion

4. What are the **results**?
5. What have we **learnt** about the cognitive function?

Discussion

- Summarise the results
- Comment on what was found and what is new.

General advise

- If possible do not cite a textbook
- Explain your quotes, figures etc.

- It is just an exam!

Semester overview

1. Overview
2. The brain & brain data
3. Electrophysiology
3. Oscillations
4. Oscillations cont.
5. Connectivity
6. Machine learning
7. Machine learning cont.
8. Machine learning as signal processing
9. Artificial neural networks
10. Artificial neural networks cont.

11. Summery and Q & A

Questions?

1. Overview
2. The brain & brain data
3. Electrophysiology
3. Oscillations
4. Oscillations cont.
5. Connectivity
6. Machine learning
7. Machine learning cont.
8. Machine learning as signal processing
9. Artificial neural networks
10. Artificial neural networks cont.

11. Summery and Q & A

References

Bastos, A. M., & Schoffelen, J.-M. (2016). A Tutorial Review of Functional Connectivity Analysis Methods and Their Interpretational Pitfalls. *Frontiers in Systems Neuroscience*, *9*. https://doi.org/10.3389/fnsys.2015.00175

Cohen, M. X. (2014). *Analyzing neural time series data: Theory and practice*. The MIT Press.

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