LEARNING GRAPHEME - PHONEME CORRESPONDENCES – BRAIN VIEW

CIPA213 Developmental Language Related Disorders

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08/04/2019

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ADVANCING BRAIN RESEARCH IN CHILDREN'S DEVELOPMENTAL NEUROCOGNITIVE DISORDERS

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Childhood neurodevelopmental disorders ↔ *Brain development* ↔ *Brain research methods*

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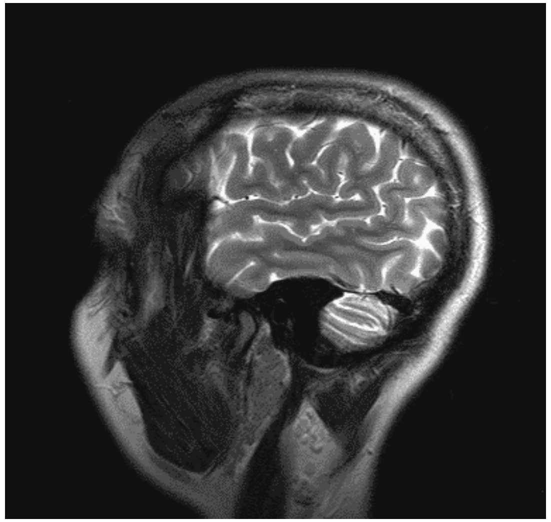
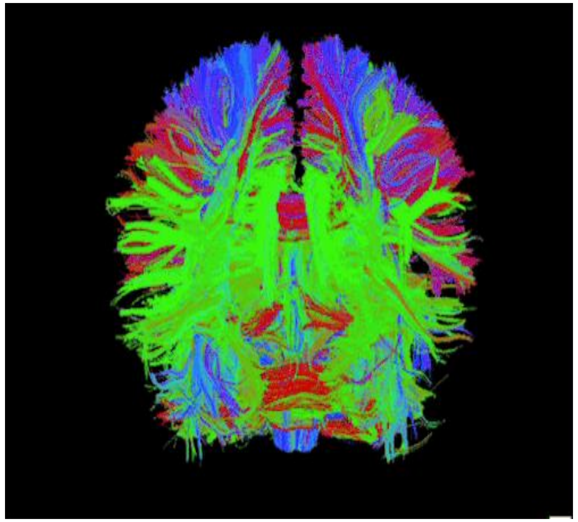
Techniques for Studying Brain Structure and Function

- **Structure**

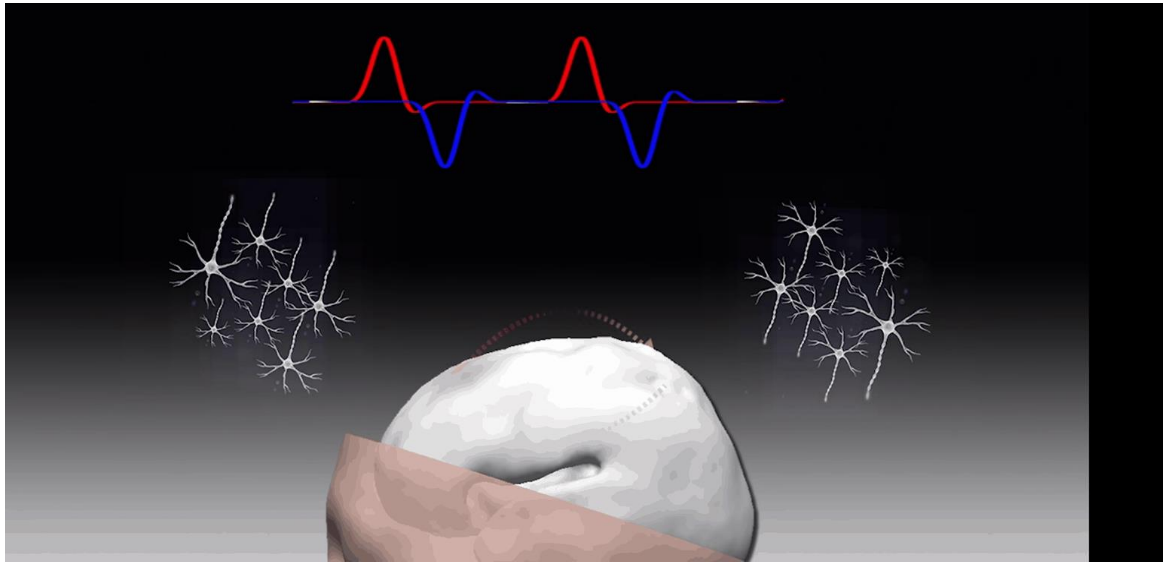
- Structural MRI
- DTI
- …





- **Function**

- EEG
- MEG
- fMRI
- PET
- …

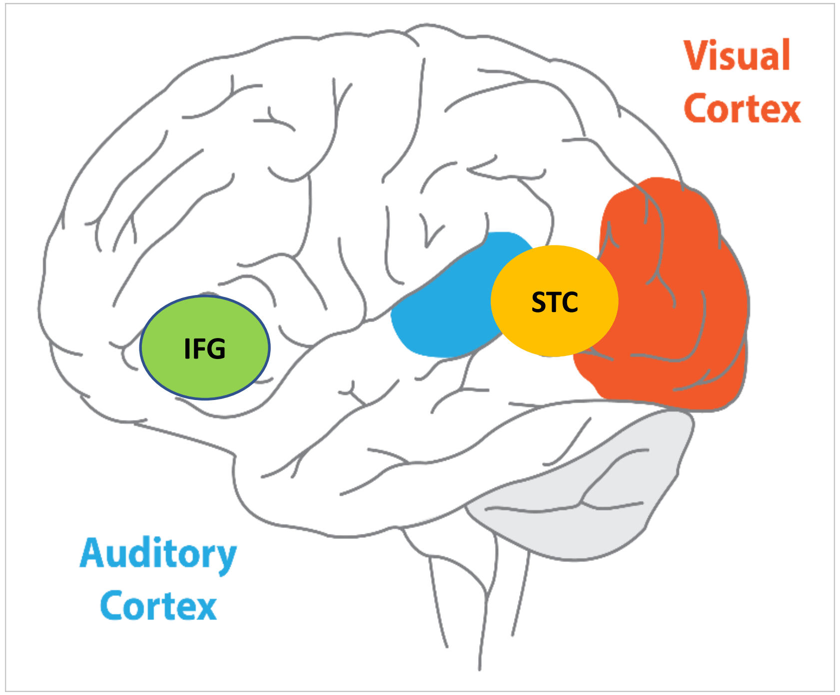


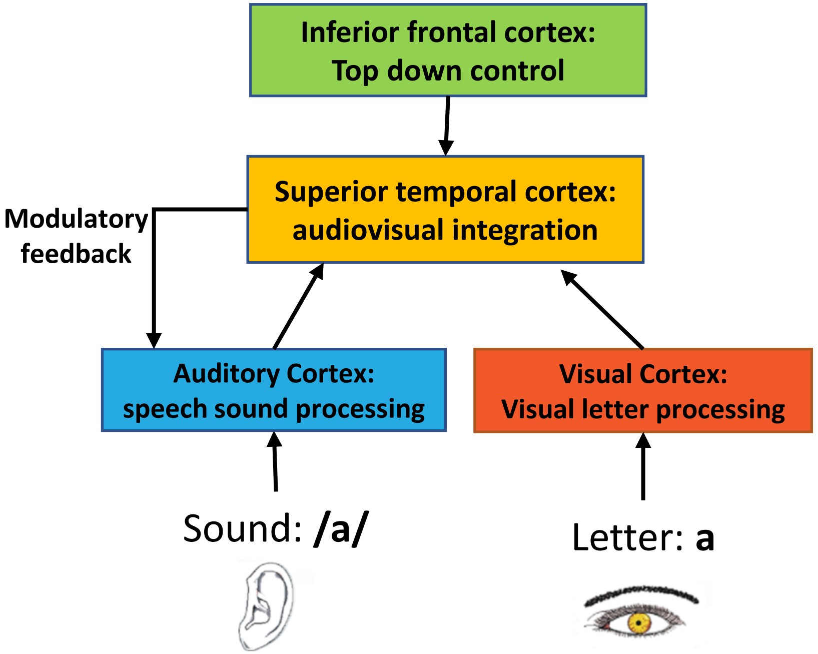
Learning grapheme - phoneme correspondences – brain view

- **Study 1:** Audiovisual integration in alphabetic language in children
- **Study 2:** Audiovisual integration in logographic language
- **Study 3:** Audiovisual learning in the brain
- Overview of MEG data analysis

Background

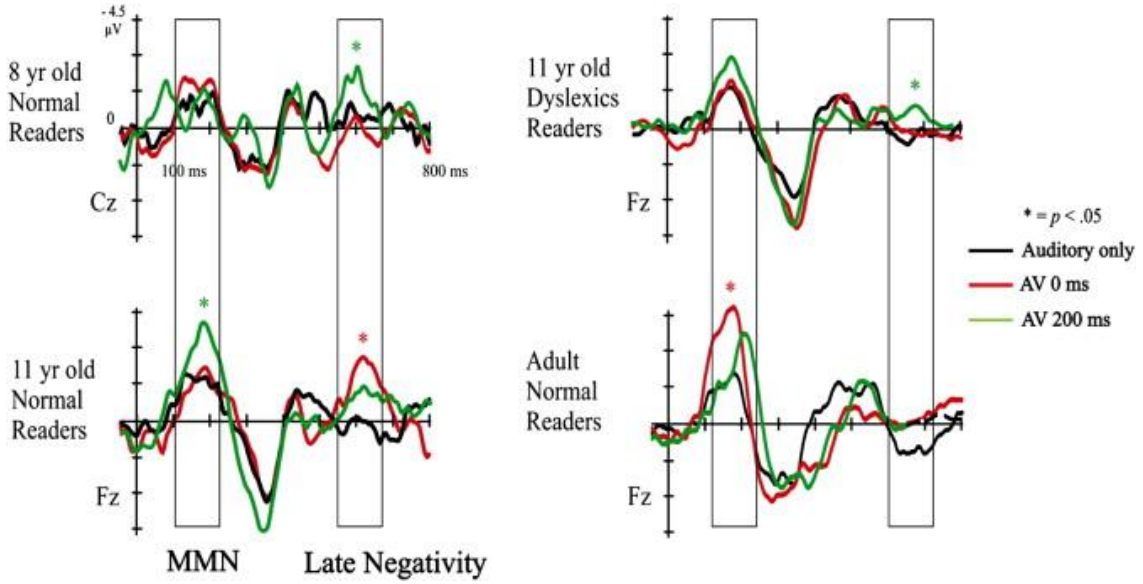
- Reading and writing are recent cultural inventions about few thousand years (Liberman, 1992)
- Learning letter-speech sound association is a crucial step in reading acquisition (van Atteveldt, 2009; Blomert, 2011)
- Studies on letter-speech sound integration in literate adults





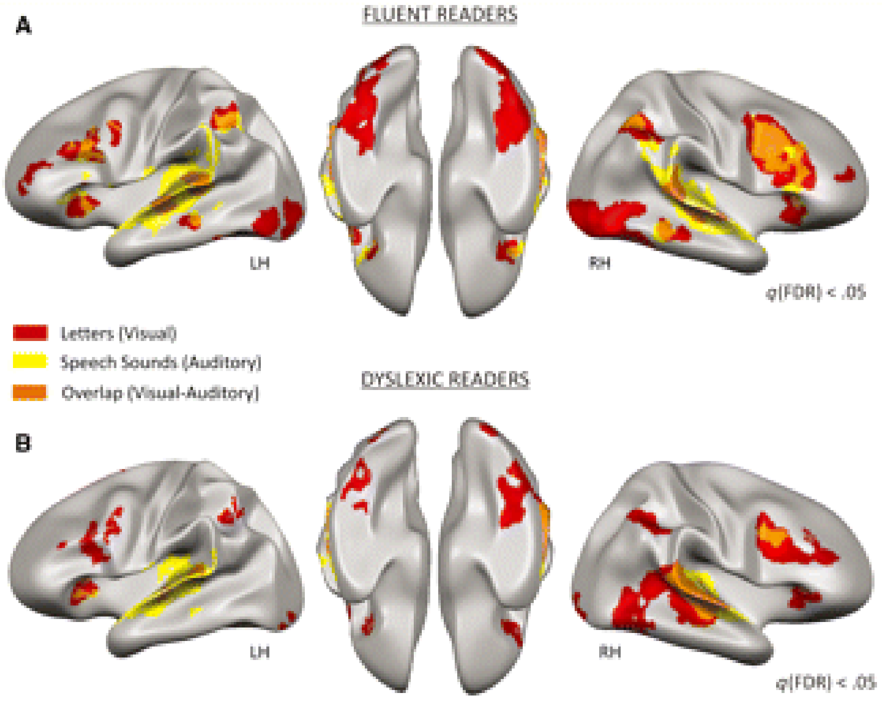
Background

- Long road to automatization at brain level (Froyen, 2008,2009; Blomert, 2011)



(Blomert, 2011)

- Related to reading disorders(Blau,2010; Richlan, 2019)



(Blau,2010)

How do we study letter-speech sound integration ?

➢Suppression effect

- Audiovisual congruent – (Auditory only +Visual only)

- Any problems?

➢Congruency effect

- Audiovisual incongruent - Audiovisual congruent

Study 1: Brain Responses to Letters and Speech Sounds and Their Correlations with Cognitive Skills Related to Reading in Children

- Brain responses to letters and speech sounds in typically developing children
- Audiovisual processing (suppression and congruency) in typically developing children
- Correlation with cognitive skills predictive of reading development

Methods

- **Participants**

29 Finnish school children

(6–11 years, mean: 8.17 years, SD: 1.05 years; 19 girls, 10 boys)

- **MEG and MRI**

Elekta Neuromag® TRIUX™ system

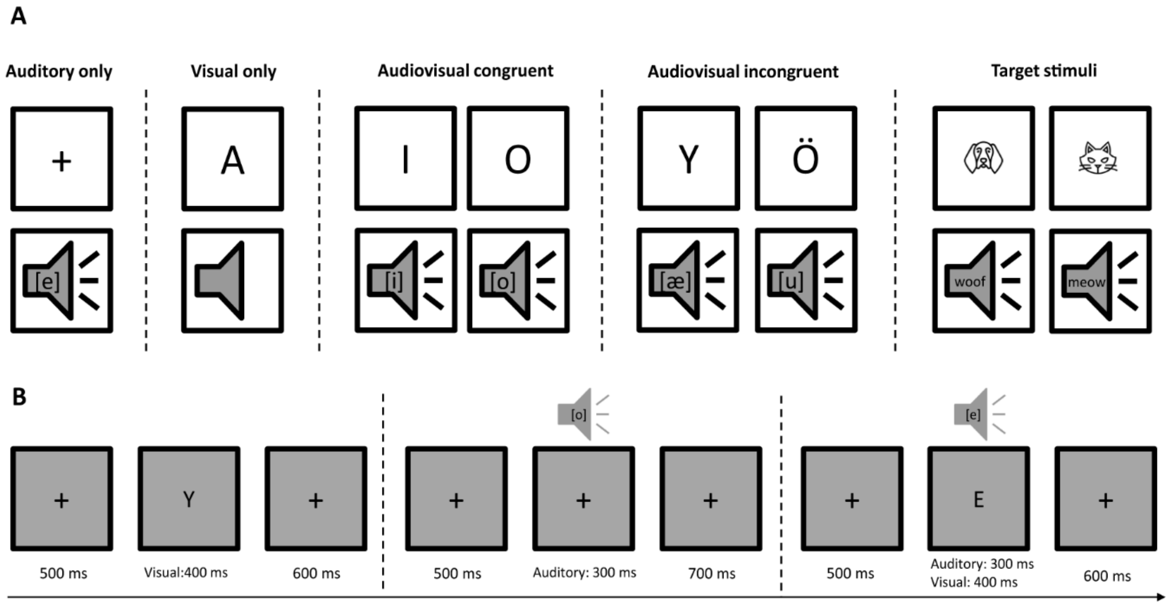
T1-weighted MRI

- **Behavioral Assessment**

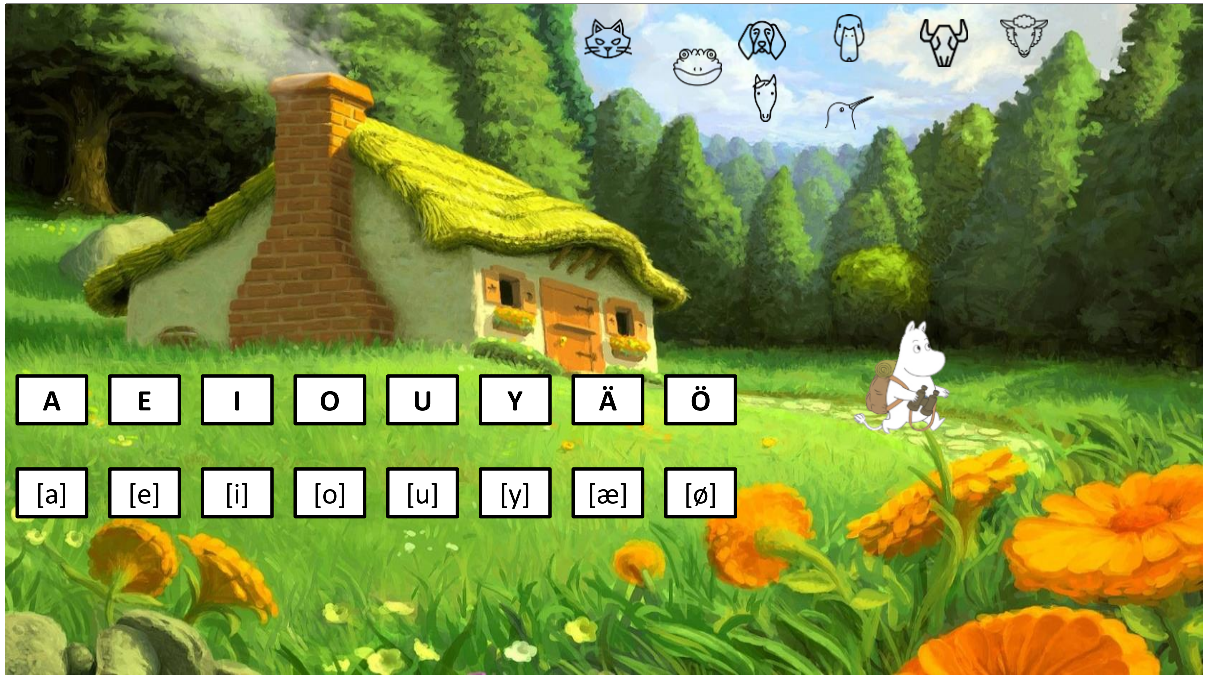
Block design, vocabulary, digit span, phonological awareness, RAN, reading and writing tests

Methods

- **Stimuli and MEG Task**



- **A child-friendly MEG task**



Results

- **Cognitive Skills and Behavioral Performance**

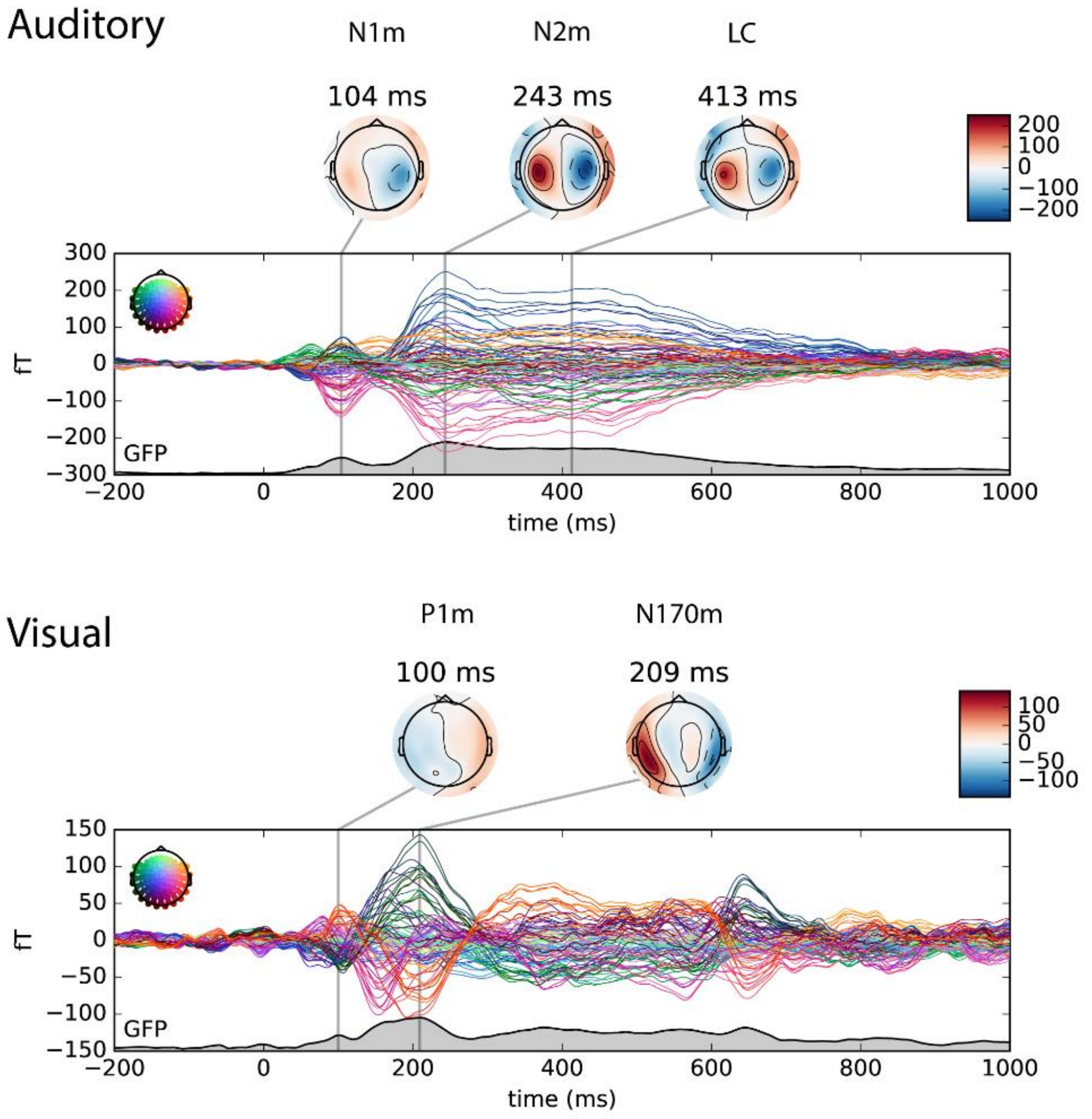
	Mean	*SD*	Range
Age (years)	8.17	1.05	6–11
Block design, raw score	25.53	9.50	10–52
Vocabulary, raw score	28.17	8.71	12–50
Digit span, raw score	11.67	1.88	8–16
NEPSY phonological processing, raw score	42.53	5.74	30–52
Rapid automatic naming(letters), time (s)	40.01	11.20	26–69
Rapid automatic naming(objects), time (s)	60.61	12.63	38–90
Word list reading, number of correct items	58.46	26.32	10–104
Non-word list reading, number of correct items	31.39	14.23	7–67
Non-word text reading, time (s)	118.32	74.74	36–390
Non-word text reading, number of correct words	29.96	5.33	16–37
Writing to dictation, number of correct words	34.07	8.14	10–40
MEG cover task, accuracy, %	96.91	3.85	81–100
MEG cover task, reaction time, ms	642	127	475–1064

Results

- **Grand Averages**

- **Auditory**
- N1
- N2
- Late Component

- **Visual**
- P1
- N170



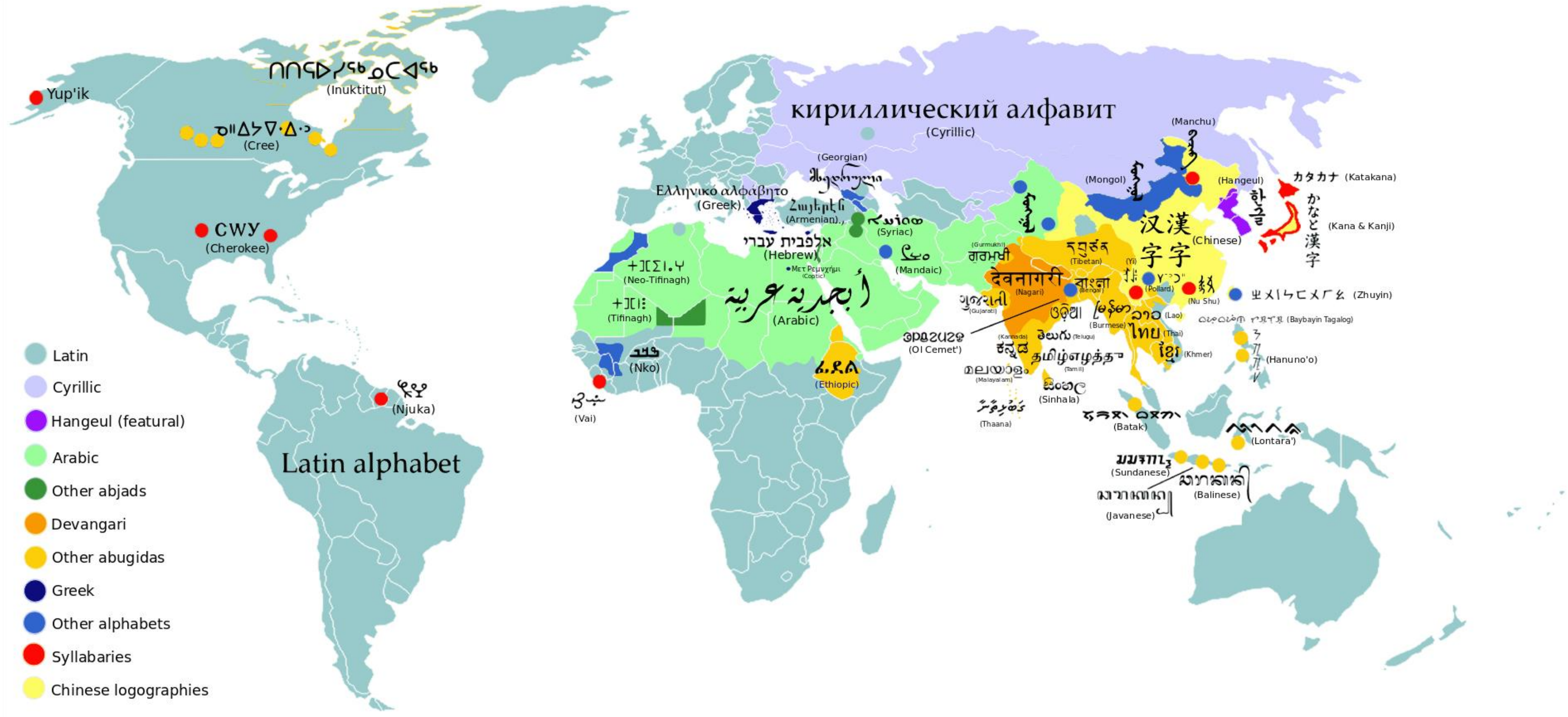
Results and Conclusion

- Brain-behavior analyses: auditory late component to be the most significant predictor of phonological skills and rapid naming.

- Audiovisual integration effect was found in left and right temporoparietal regions and several of these temporal and parietal regions showed contribution to reading and writing skills.

- Important role of **temporoparietal** regions in learning letter-speech sound associations in early reading development.

What about other writing systems?



Chinese Characters

Altogether there are over **50,000 characters**, though a comprehensive modern dictionary will rarely list over 20,000 in use. An well-educated Chinese person will know about **8,000 characters**, but you will only need about **2-3,000** to be able to read a newspaper.

The most complex Chinese character still in use may be biáng, with 58 strokes, which refers to Biang biang noodles, a type of noodle from Shaanxi province, China.

biáng

𰻝

Meanings in Chinese characters

Alphabetic letters and logographic characters

- Difference in learning the two writing systems?

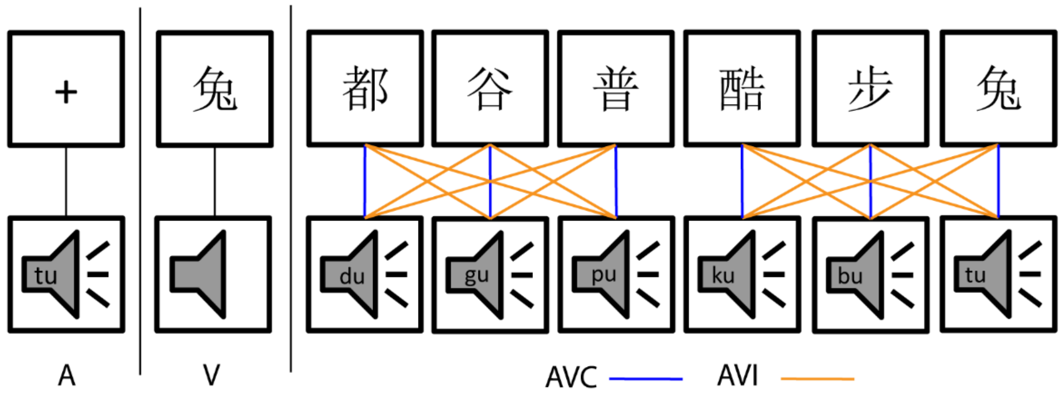
- Brain level any different processing?
  - Visual areas ?
  - meanings in Chinese?

- How do we study the difference?

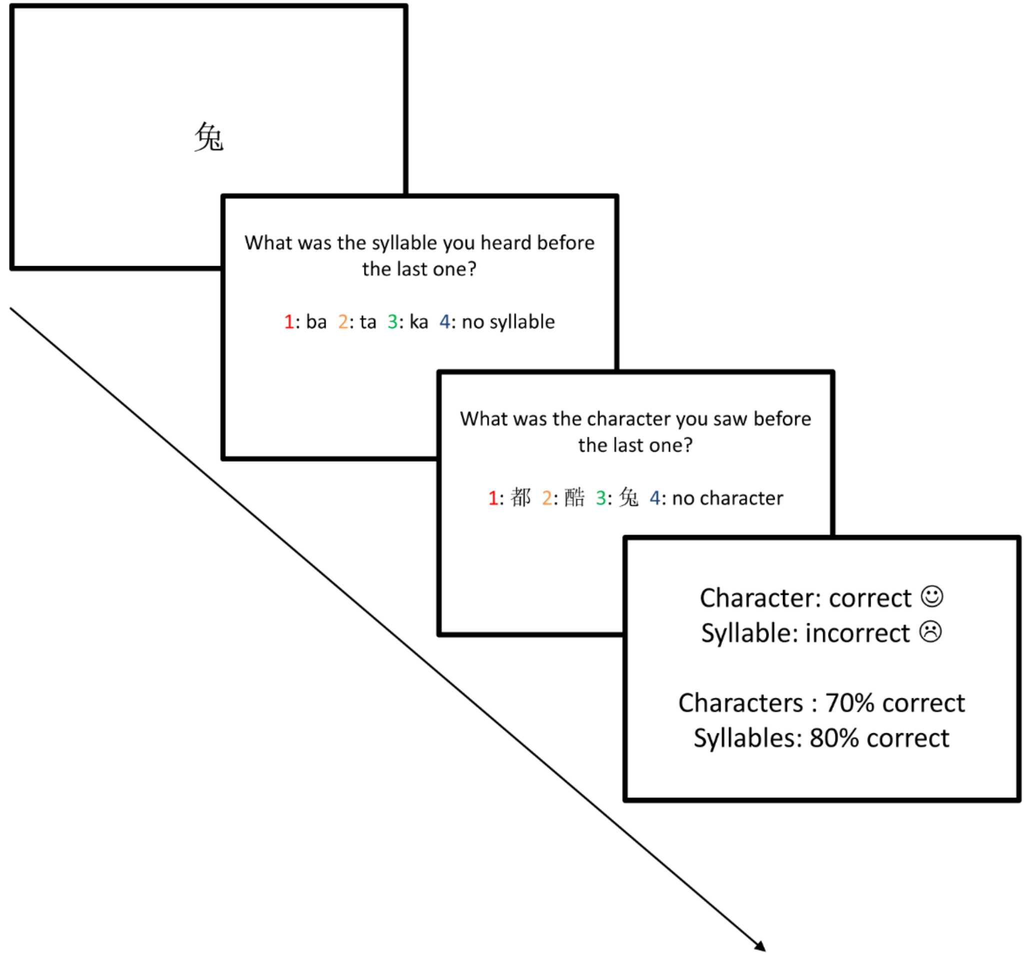
- What if we have Finnish and Chinese doing the same experiment?
  - What kind of experiment?
  - …

Study 2: Audiovisual Processing of Chinese Characters Elicits Suppression and Congruency Effects in MEG

A



B



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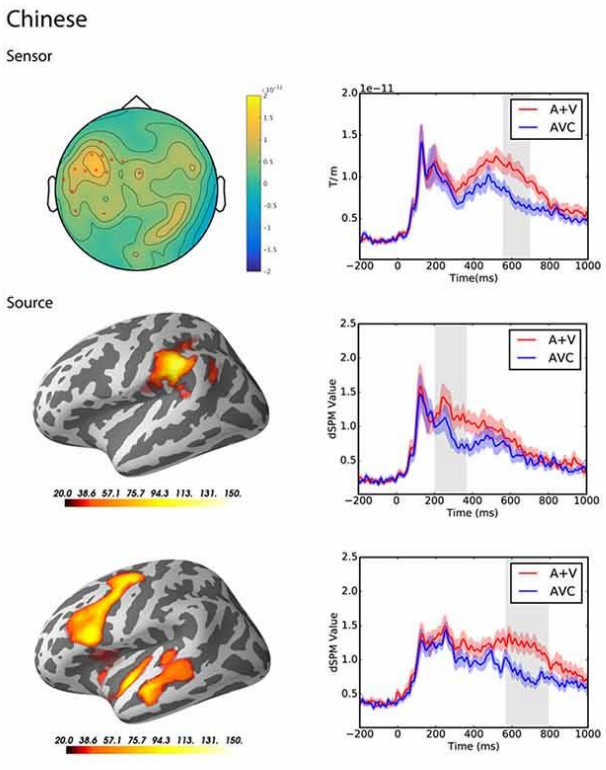
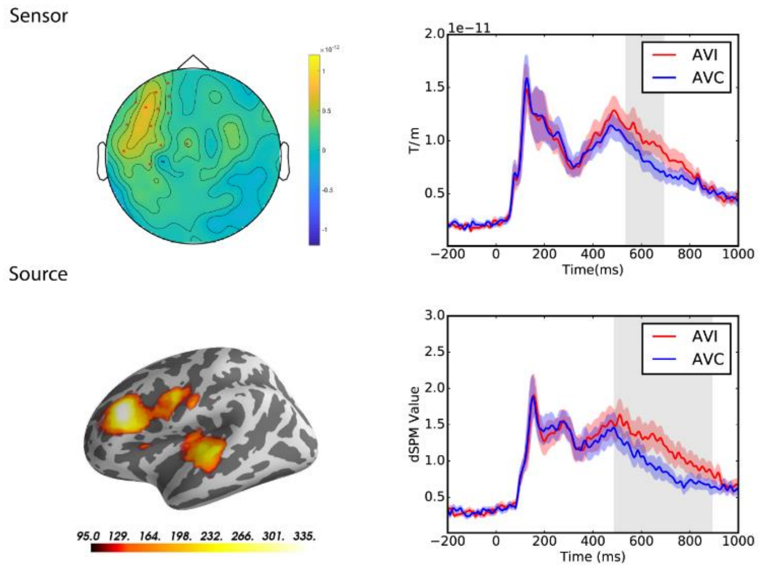
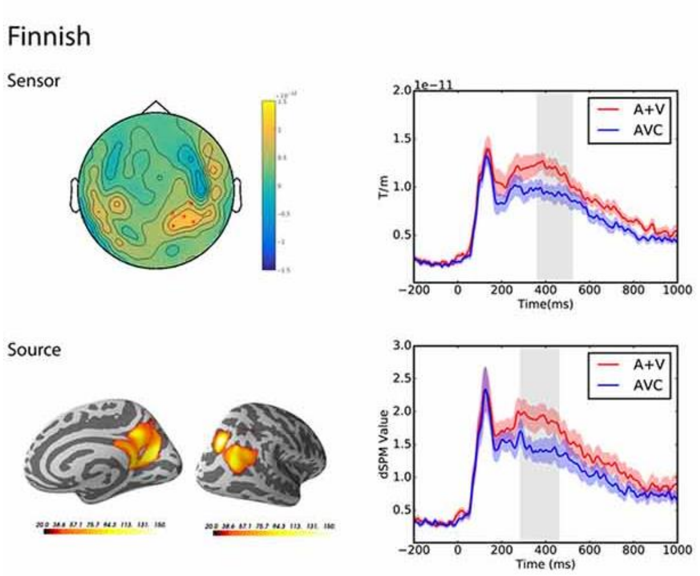






Suppression effect
[AV<(A+V)]

Congruency effect
AVI>AVC

Suppression effect
[AV<(A+V)]

Conclusion

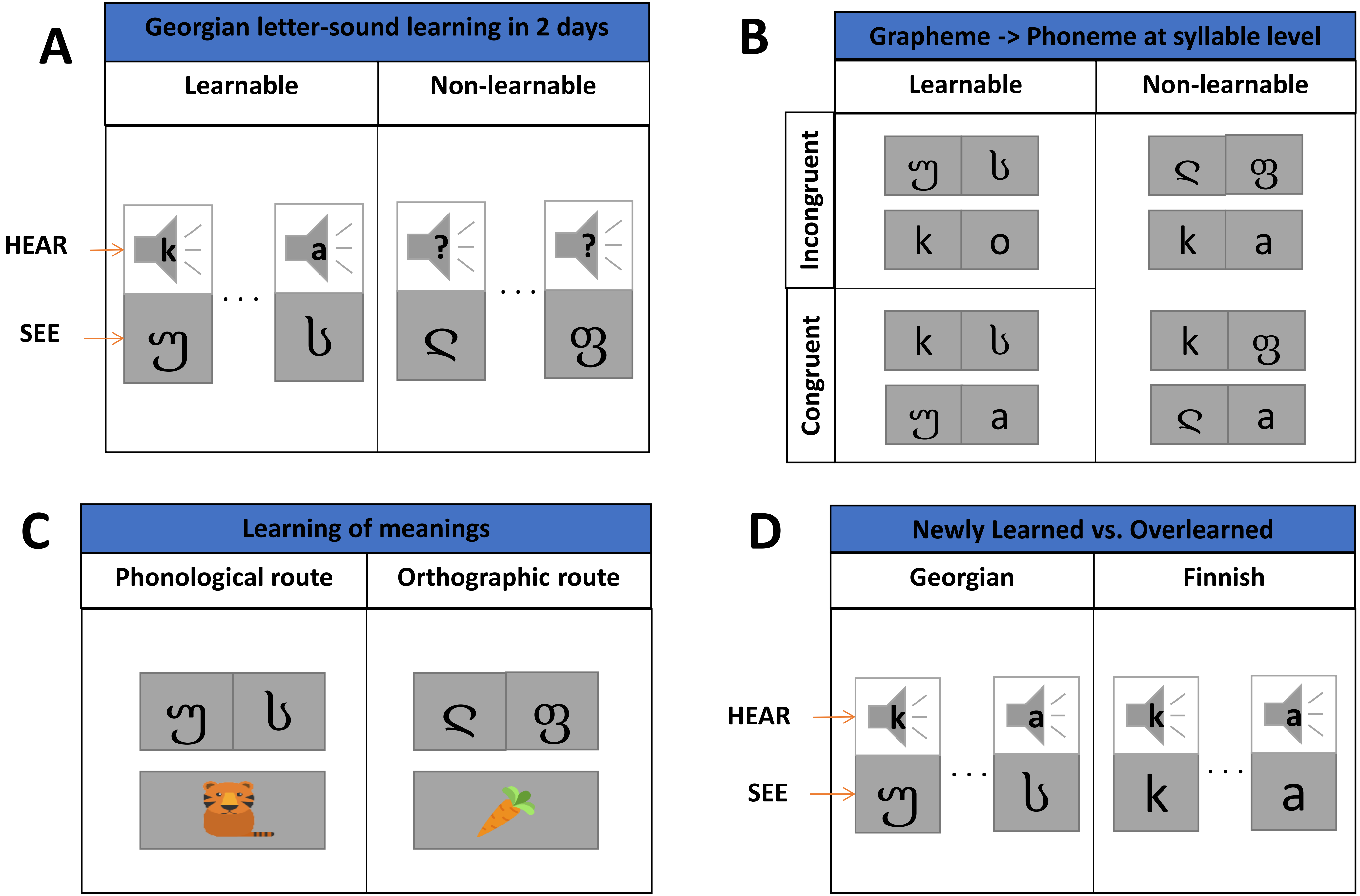
- Similar activation in left superior temporal cortex to alphabetic languages
- Language specific activation in left inferior frontal cortex
  - modulatory feedback from multi-sensory regions
  - semantic processing

Study 3: Learning Letter-Speech Sounds（LSS）

- Previous studies mainly on overlearned LSS association in adults

- Brain changes at the very beginning of learning LSS
  - How fast does the changes occur?
  - Any additional neural process support learning LSS?
  - Effect of memory consolidation during sleep?

- Audiovisual training using artificial letters and speech sounds
  - (Karipidis et al., 2017, 2018; Pleisch et al., 2019)



A
Georgian letter-sound learning in 2 days
Learnable
Non-learnable
HEAR
SEE
k
a
?
?
B
Grapheme -> Phoneme at syllable level
Learnable
Non-learnable
Incongruent
Congruent
k
o
k
a
k
k
a
a
C
Learning of meanings
Phonological route
Orthographic route
D
Newly Learned vs. Overlearned
Georgian
Finnish
HEAR
SEE
k
a
k
a
k
a

Analysis Plan

Some challenges:

Learning at different speed in each participant

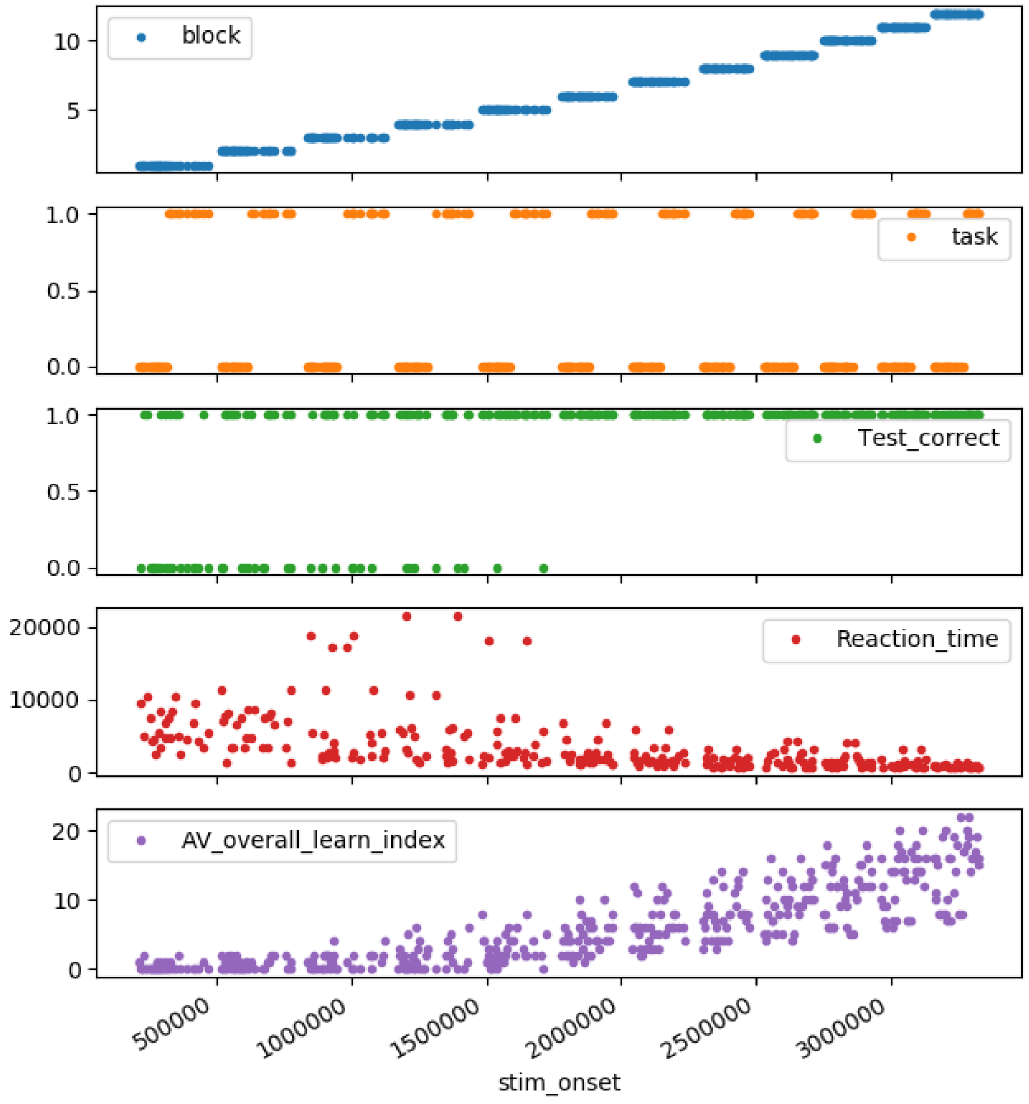
Each letter-sound pair is learned differently

Forgetting

Some ideas:

Tract the learning process trial by trial

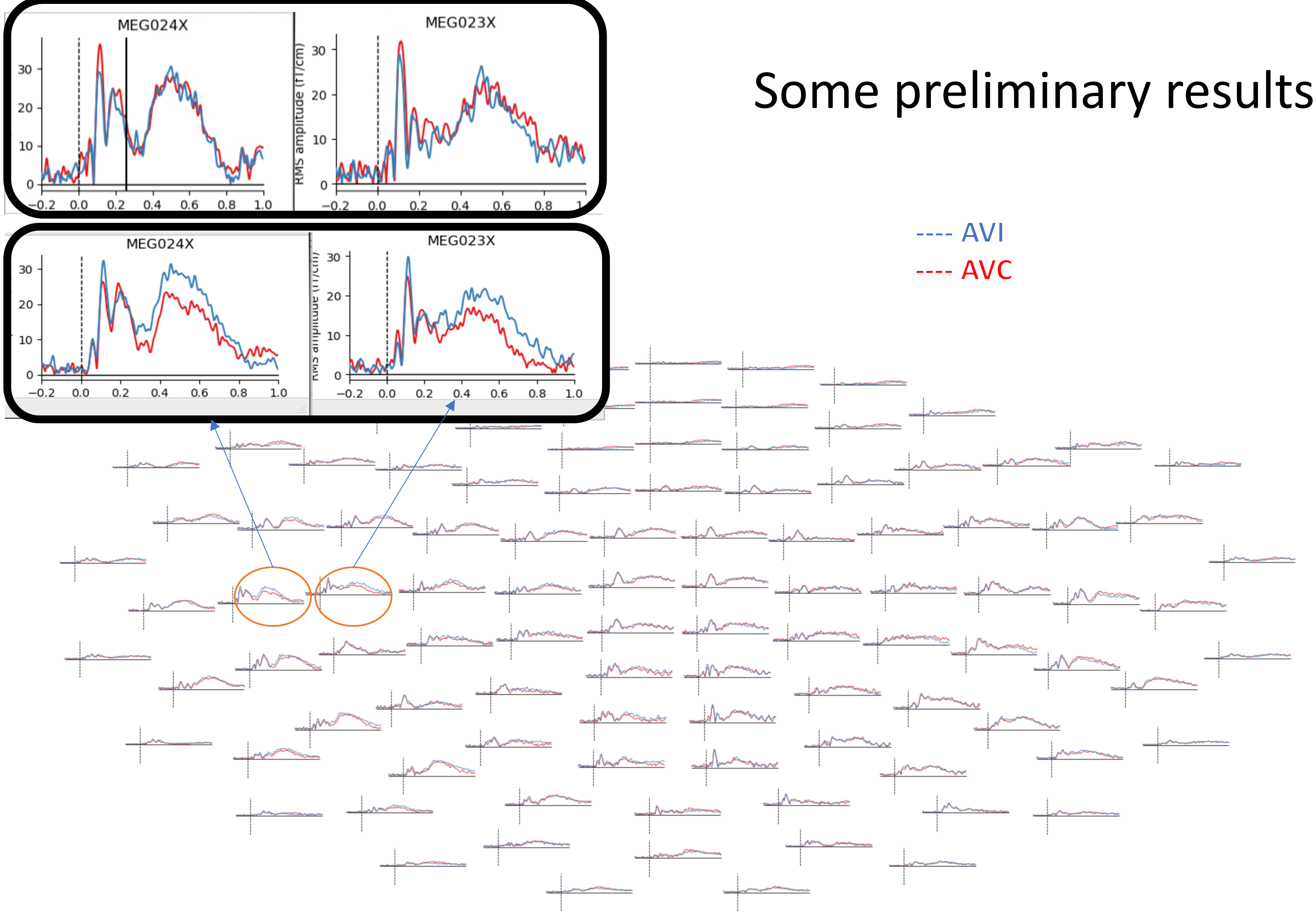
Regression-based analysis



Some preliminary results

Before Learning

After Learning

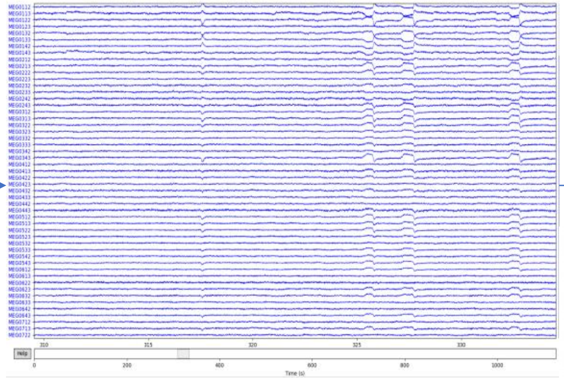


Implication

- Understanding of brain mechanism of language learning
- Education: how to teach children to read (reading instruction)
- Effective foreign language training
- ……

MEG Data Analysis

-From RAW-FIF to brain activation



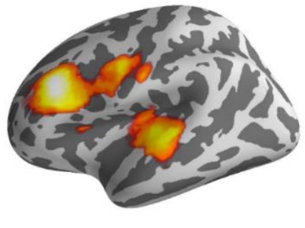
BESA

Brainstorm

FieldTrip

MNE

MEG + EEG ANALYSIS & VISUALIZATION



The typical M/EEG workflow (in MNE Python)

MEG + EEG ANALYSIS & VISUALIZATION

Speed

Multi-core CPU & GPU.

Usability

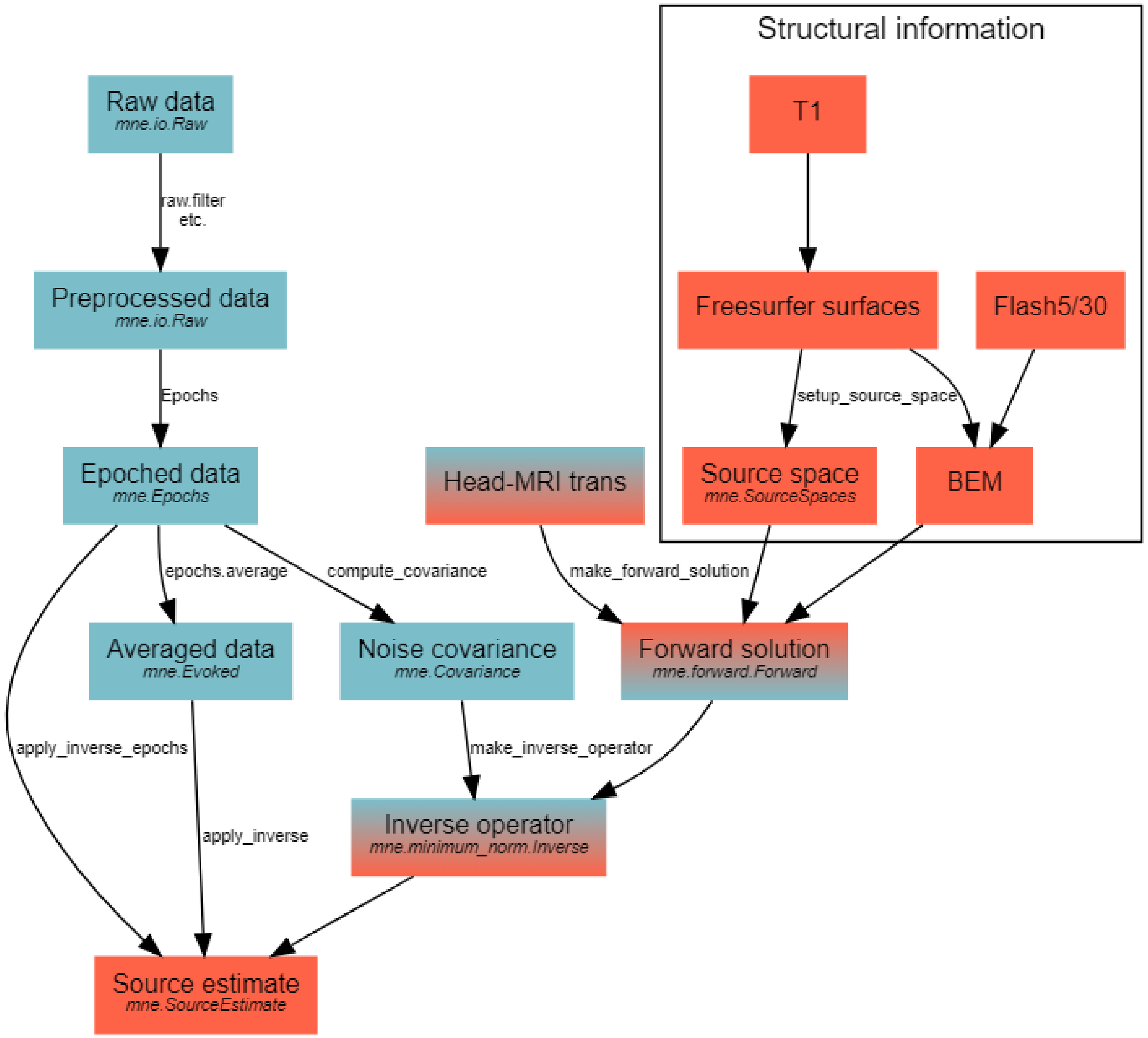
Clean scripting & visualization.

Flexibility

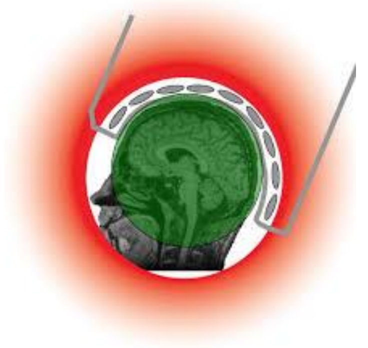
Broad data format & analysis support.

Open-source Python software for exploring, visualizing, and analyzing human neurophysiological data: MEG, EEG, sEEG, ECoG, and more.

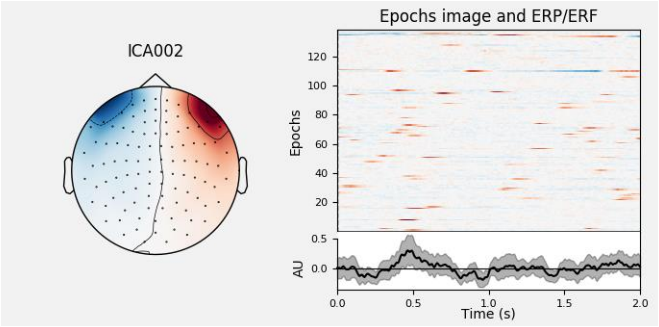
https://martinos.org/mne/stable/index.html



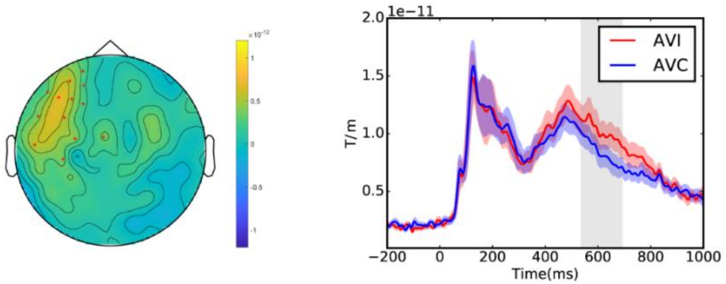
Preprocessing



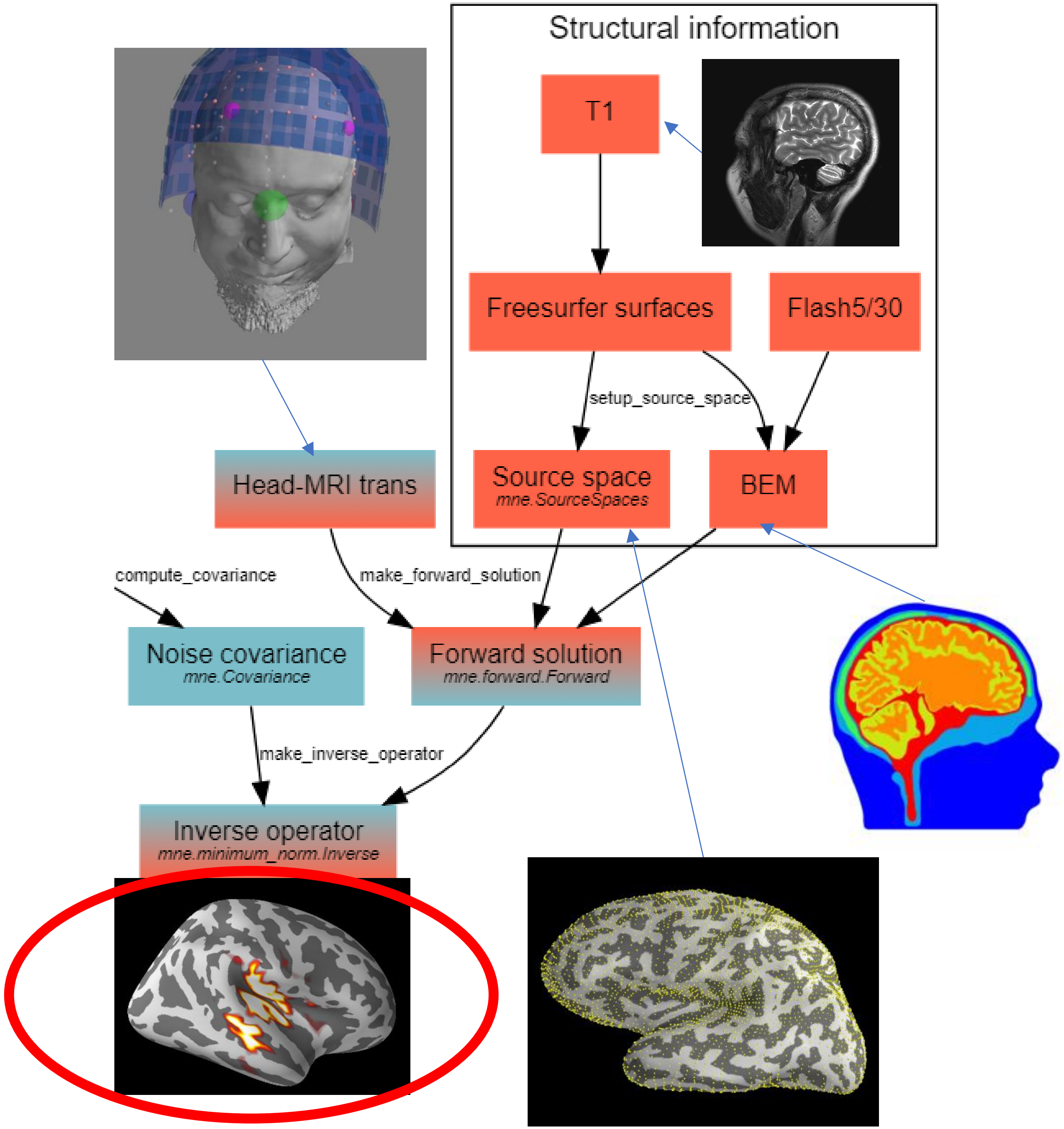
- ➢Maxfilter
- ➢Filtering
- ➢Artifacts removal
  - ➢What kind of artifacts?
  - ➢Signal-Space Projection (SSP)
  - ➢Independent Component Analysis (ICA)



- ➢Segmenting into epochs
- ➢Averaging -> Event-related fields (ERFs)



Source level analysis



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PredictAble

Understanding and Predicting Developmental Language Abilities and Disorders in Multilingual Europe

Thank you for your attention!

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