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Investigating Long-Term Context of Language Models on Brain Activity during Narrative Listening in fMRI

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Introduction

- 1 Sequence-based and pretrained language models have been found to be successful for text-driven prediction of brain activations.
- 2 However, these models still lack long-term memory plausibility (i.e. how they deal with long-term dependencies and contextual information)

Can current language models deal with long-term dependencies?

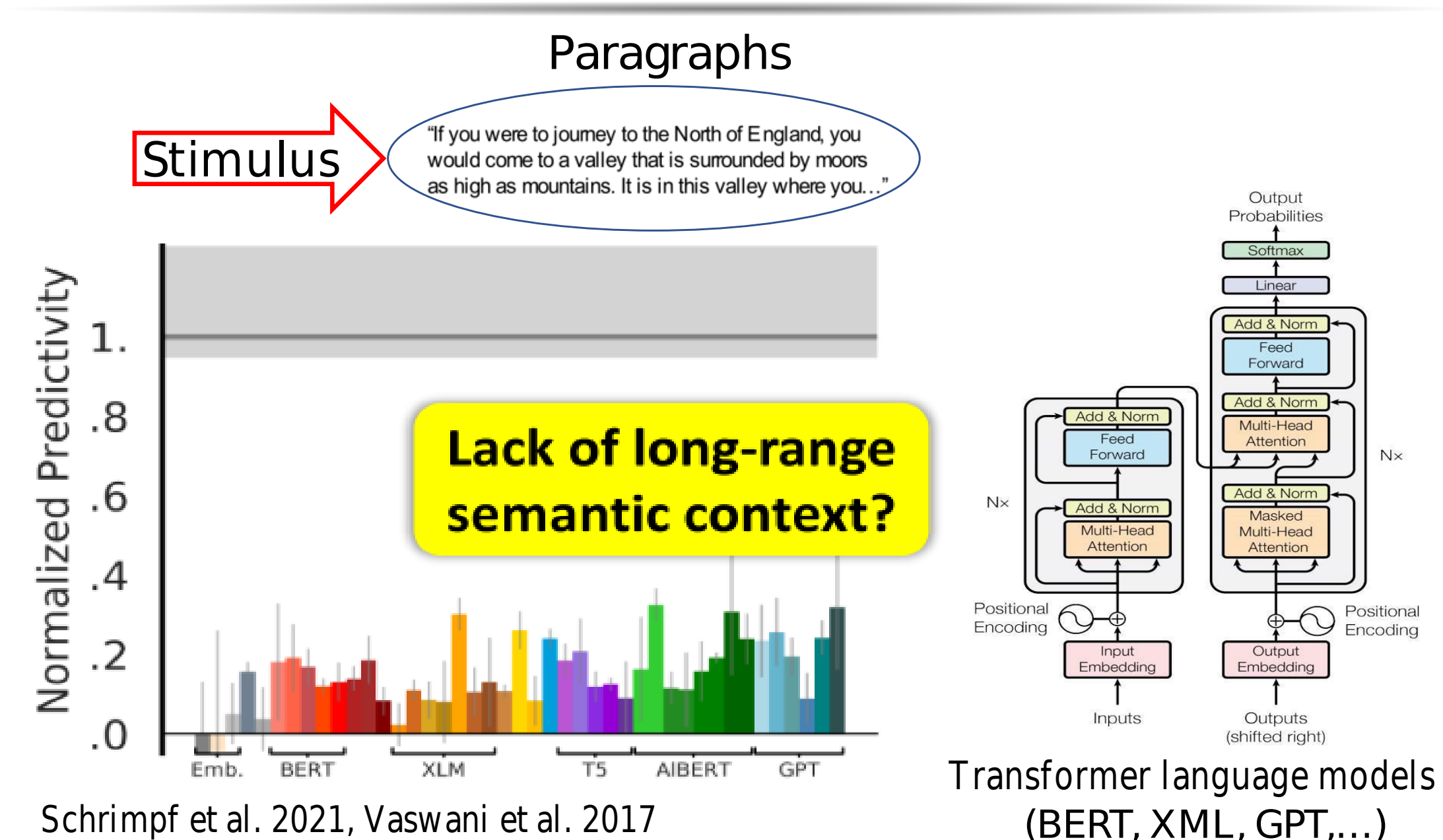


Figure 1: Sequence length is fixed to 512 words in Transformers.

Questions

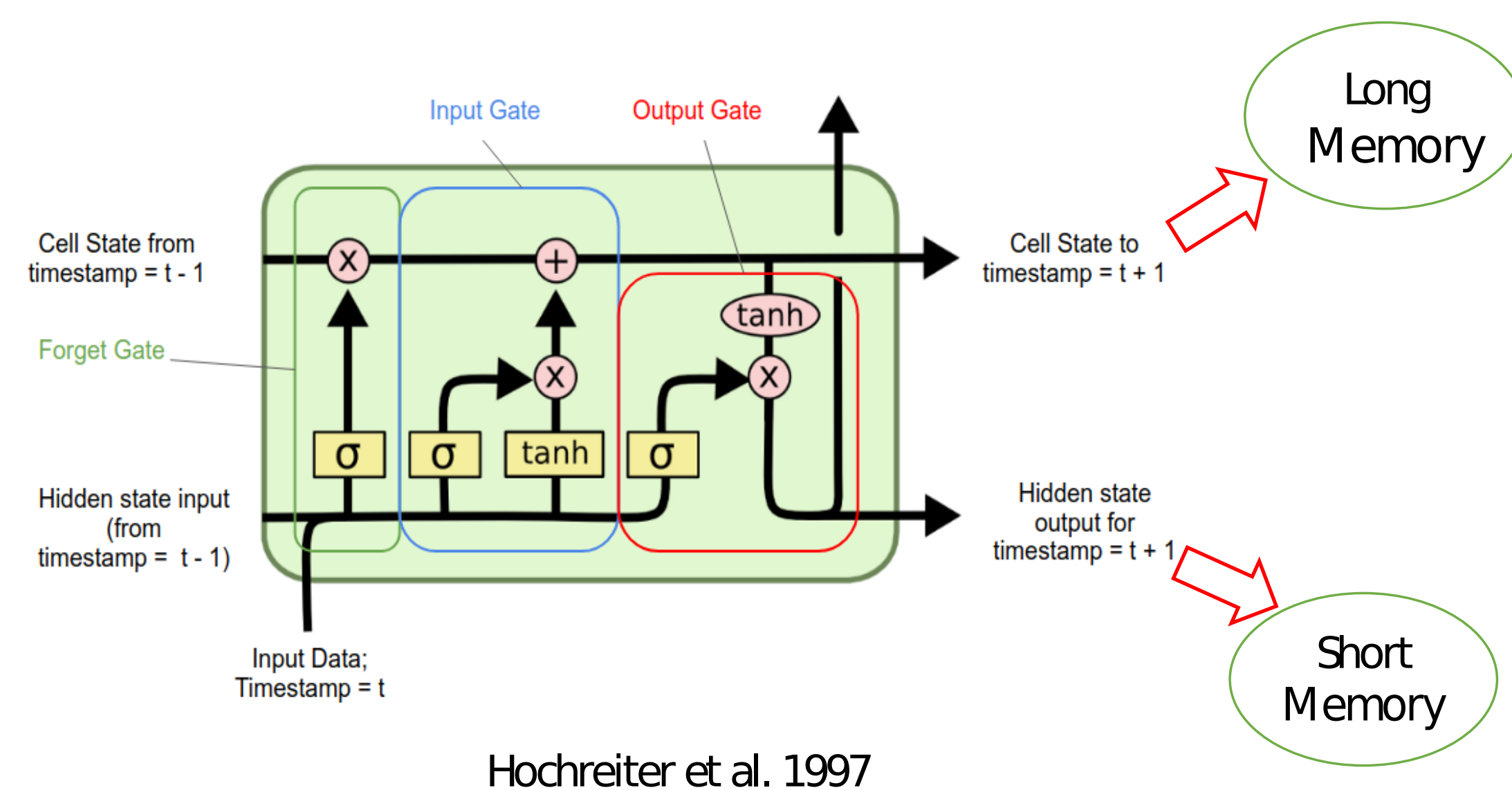
- 1 What kind of language models can represent long-term dependencies?
- 2 Could these language models also predict better brain activity while subjects are engaged in longer stories?

Main Contributions

- 1 We propose the problem of finding which type of language models are the most predictive of fMRI brain activity for listening tasks.

Models Considered

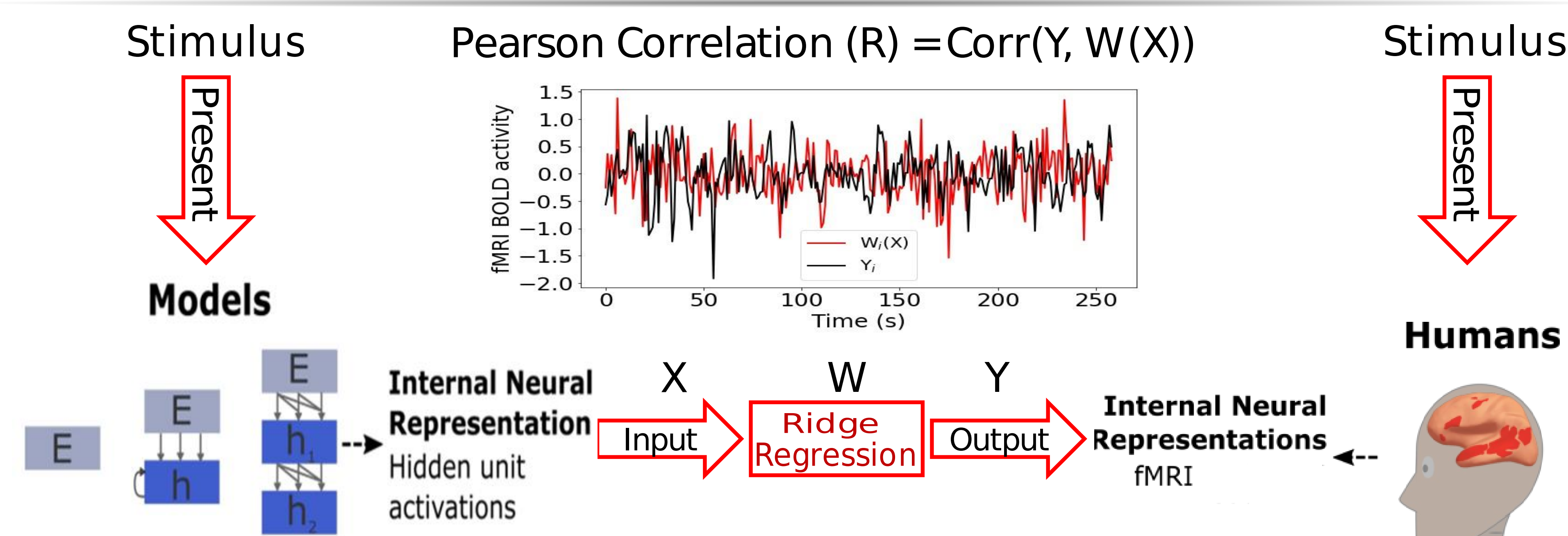
- 1 GloVe, Long Short-Term Memory Networks (LSTM)
- 2 ELMo, Longformer



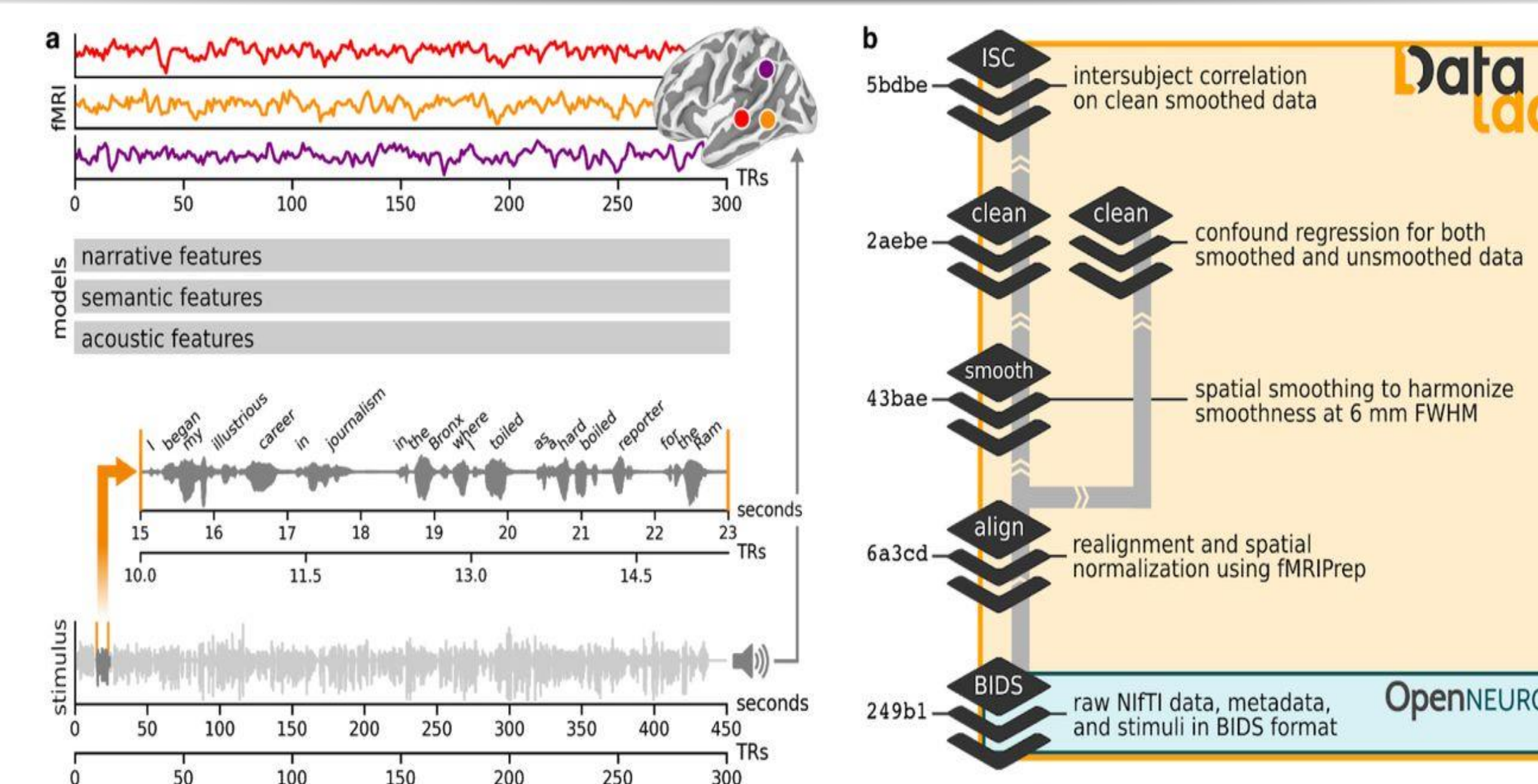
Evaluation Metrics

- 1 2V2 Accuracy
- 2 Pearson Correlation (R)

Brain Encoding



Narrative Listening (Pieman dataset from Nastase et al. 2021)



Brain Maps (Pearson Correlation)

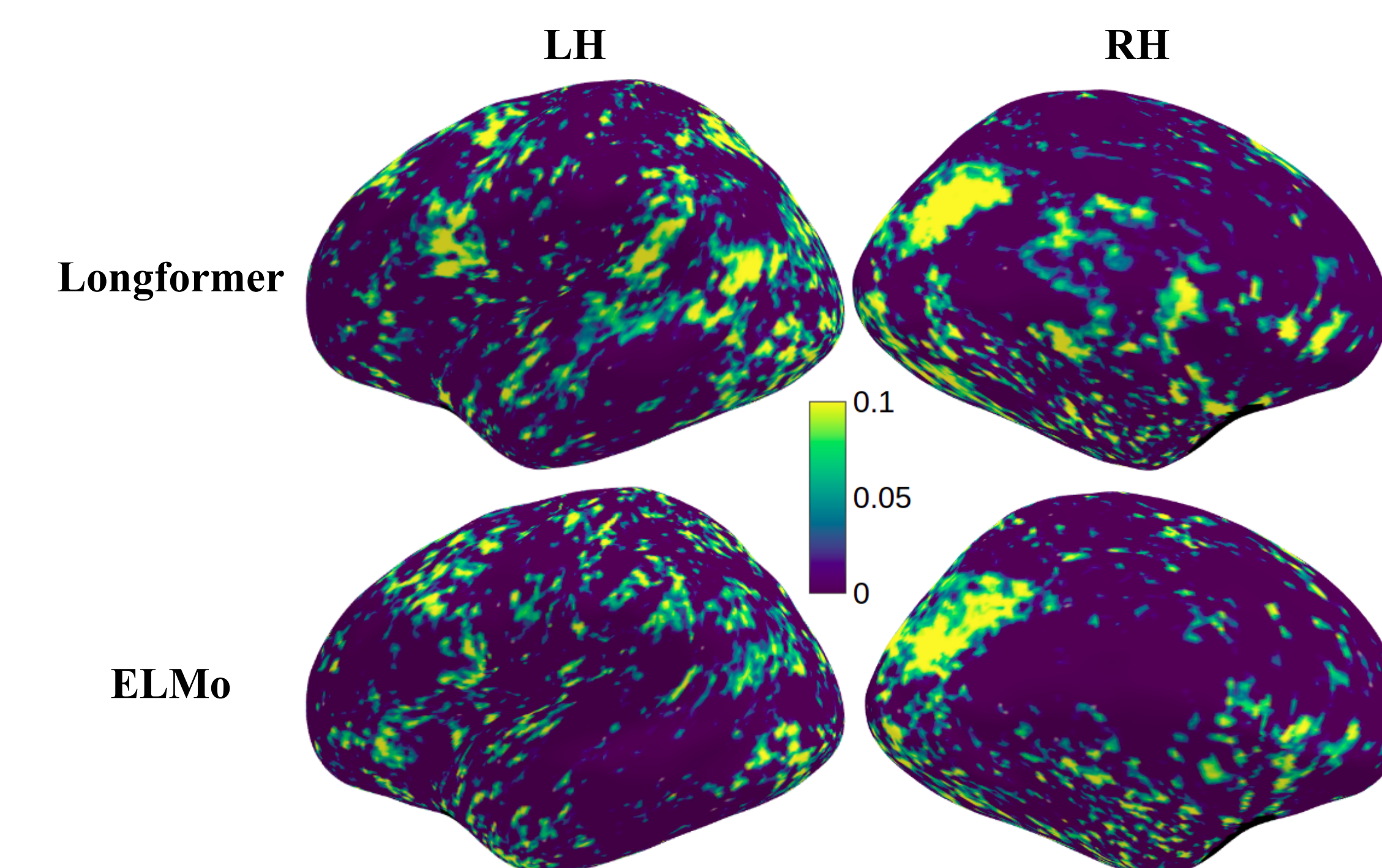


Figure 2: Whole Brain

Cognitive Insights

- 1 In LSTM, the cell state representations (long term memory vector) yield better encoding performance than hidden state representations.
- 2 We used different layers of ELMo and Longformer, where higher layers display better correlation for ELMo while intermediate layers show superior performance for Longformer.

Conclusion

- Language models with longer context (e.g. Longformer) better predict brain activity while subjects listening to stories.
- Future Directions: (i) Use more plausible language models than Transformers. (ii) Make hierarchical language models.

References

- [1] Martin Schrimpf et al. 2021. The neural architecture of language: Integrative modeling converges on predictive processing.
- [2] Ashish Vaswani et al. 2017. Attention is all you need.
- [3] Samuel A Nastase et al. 2021. The “narratives” fMRI dataset for evaluating models of naturalistic language comprehension.

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Encoding Performance of Language Models

