



Atypical Low-Frequency Neural Tracking of Natural Speech in Children with Developmental Language Disorder

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Abstract

Developmental language disorder (DLD) is characterised by persistent difficulties with language comprehension and production. Temporal Sampling theory proposes that atypical cortical tracking of slow speech-envelope fluctuations may contribute to these difficulties. MEG was recorded from 28 children (14 DLD, 14 typically developing controls) during naturalistic story listening. Children with DLD showed reduced speech-brain coherence at 0.9–2.5 Hz across bilateral auditory and speech-related regions, with right-lateralised reductions at 2.5–5 Hz. No reliable differences were observed at higher frequencies (5–9 Hz and 12–40 Hz). Stronger low-frequency coherence was associated with better language performance, while exploratory functional connectivity differences did not survive network-level correction. These findings suggest selective disruption of low-frequency neural tracking of natural speech in DLD.

Methods

Participants

- 28 children: 14 DLD and 14 typically developing controls (~9 years)
- English-speaking; normal hearing

Experimental Design

- 10-min naturalistic story listening during 306-channel MEG
- Individual structural MRI for source reconstruction

Analysis Pipeline

- Speech envelope and cortical signals filtered into four modulation ranges: 0.9–2.5, 2.5–5, 5–9, and 12–40 Hz
- Source-level lagged speech-brain coherence across bilateral auditory and speech-language ROIs
- Functional connectivity assessed using phase-locking value (PLV)

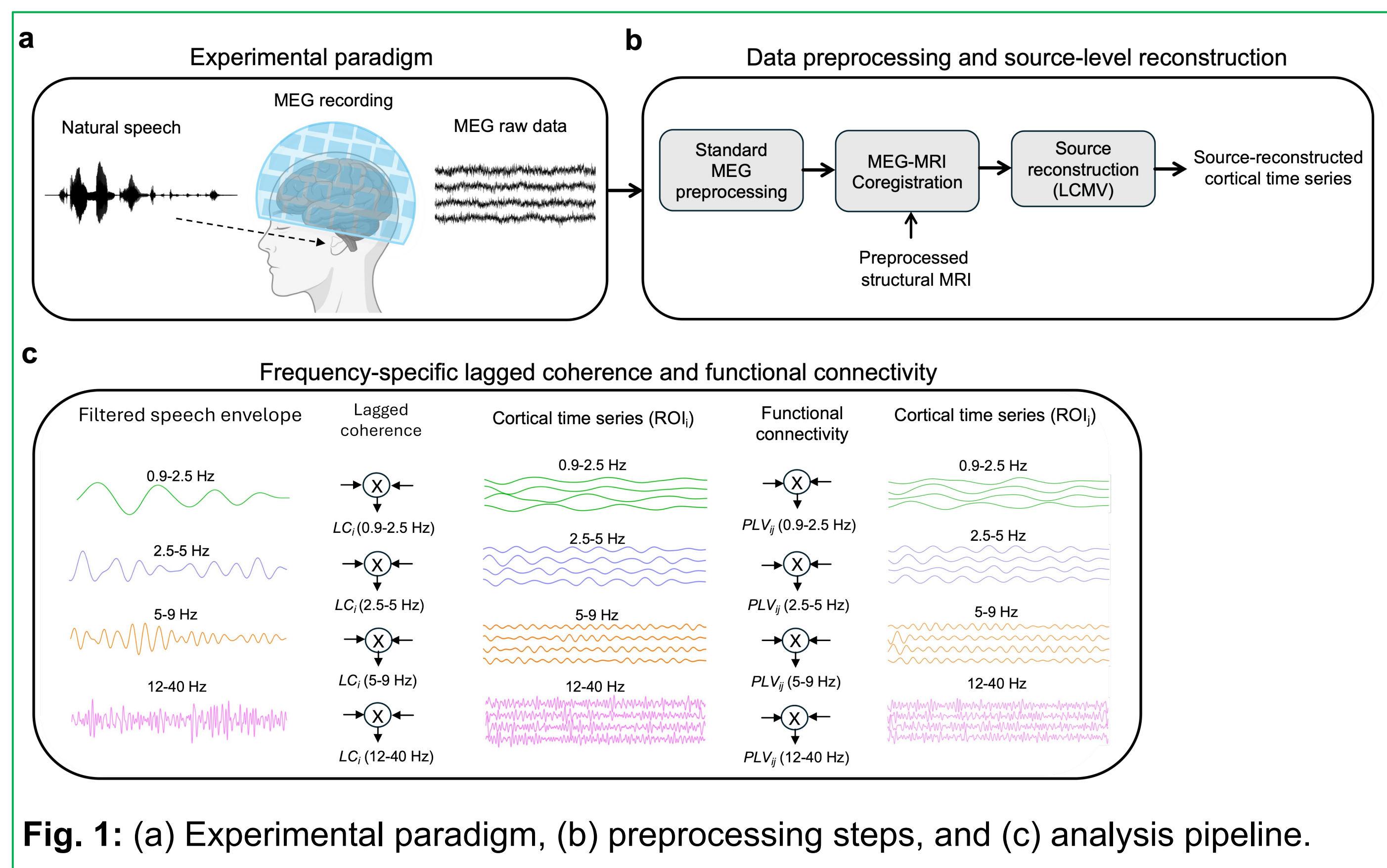


Fig. 1: (a) Experimental paradigm, (b) preprocessing steps, and (c) analysis pipeline.

Results

Prosodic-Rate Tracking (0.9–2.5 Hz)

- Reduced in DLD across bilateral network: L-HG ($p = 0.02$), L-STG ($p = 0.03$), L-PT ($p = 0.02$), L-IFGop ($p = 0.04$) and L-SMG ($p < 0.001$), R-HG ($p = 0.03$), R-STG ($p = 0.02$) and R-IFGop ($p = 0.001$).

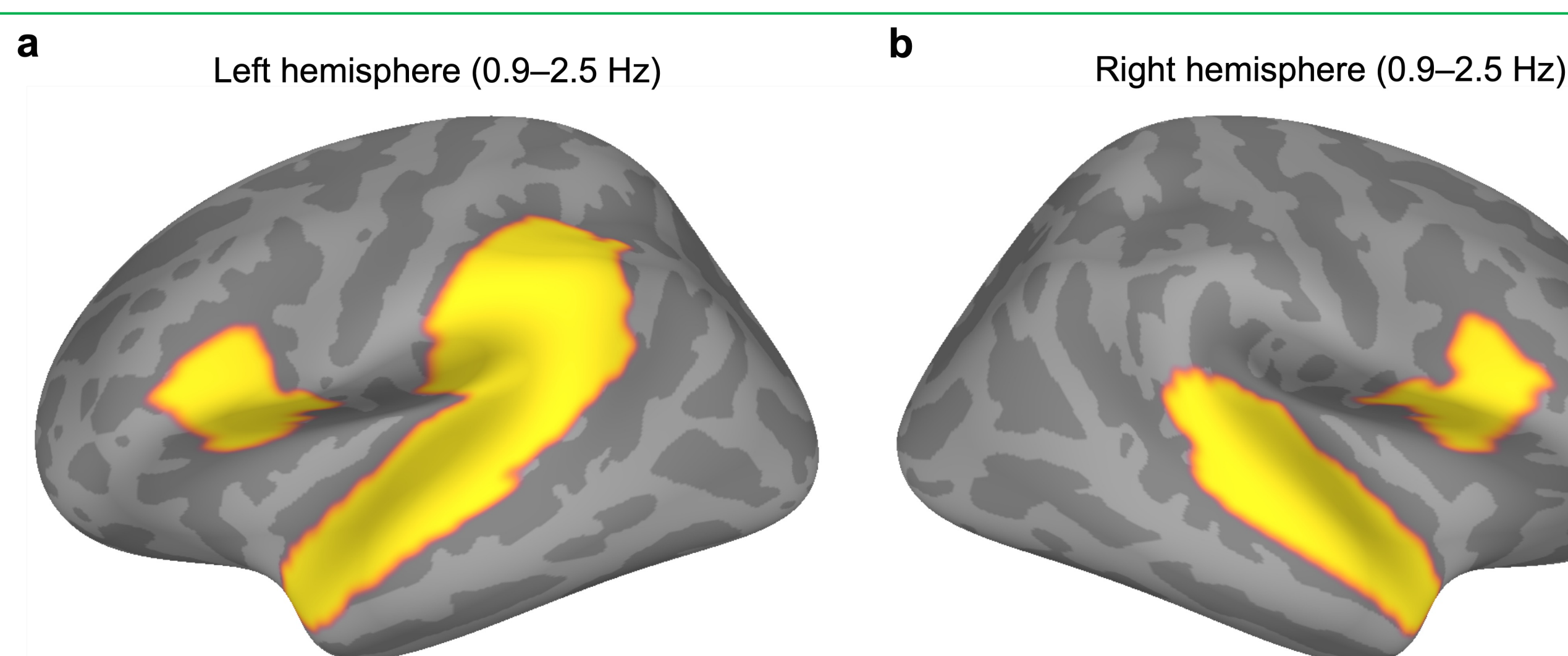


Fig. 2: Reduced prosodic-rate (0.9–2.5 Hz) speech-brain coherence in DLD

Syllabic-Rate Tracking (2.5–5 Hz)

- Right-lateralised reductions in DLD: R-STG ($p = 0.02$), R-STG ($p = 0.02$) and R-PT ($p = 0.01$).

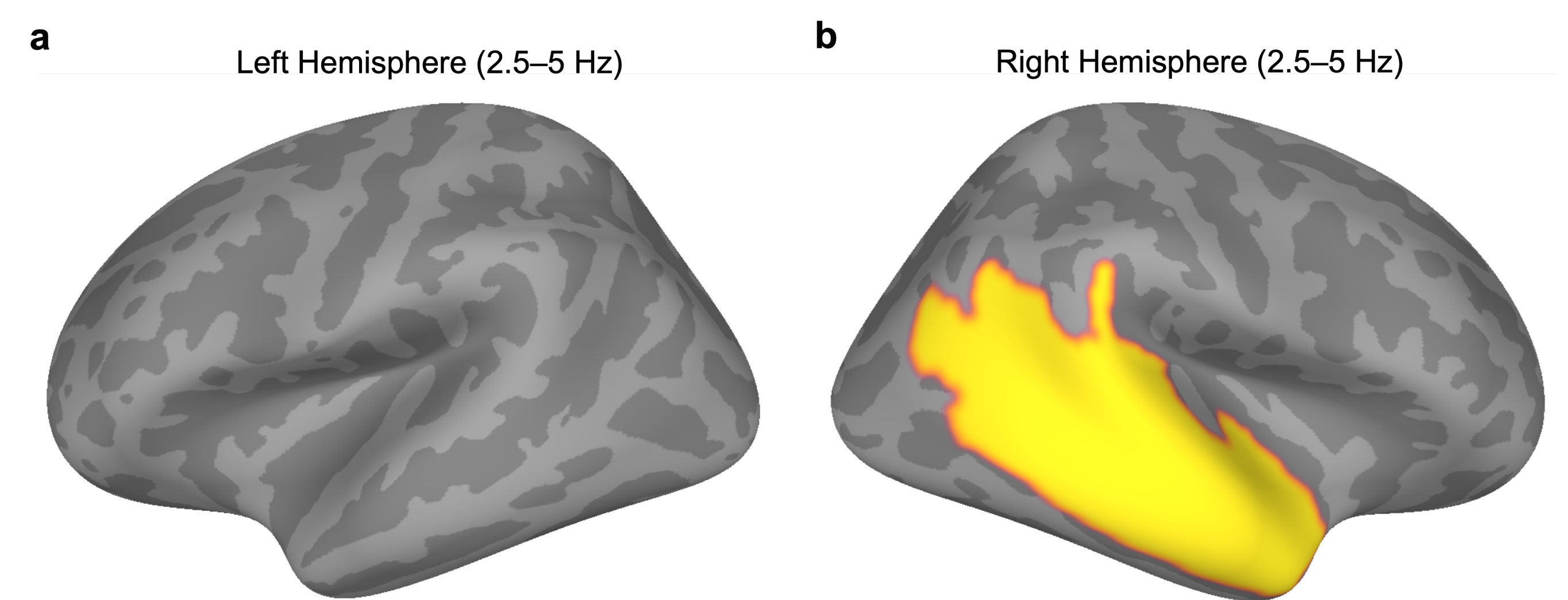


Fig. 3: Reduced syllabic-rate (2.5–5 Hz) speech-brain coherence in DLD

Faster Frequency Tracking (5–9 Hz, 12–40 Hz)

- No reliable group differences in speech-brain coherence

Functional Connectivity

- Functional connectivity differences did not survive network-level correction.

Brain–Behaviour Associations

0.9–2.5 Hz

- Recalling Sentences: FDR-significant associations in L-HG, L-STG, L-IFGop, L-SMG, R-STG and R-IFGop.
- Formulating Sentences: FDR-significant associations in L-HG, L-STG, L-PT, L-SMG, R-STG and R-IFGop.

2.5–5 Hz

- Recalling Sentences: FDR-significant association in R-PT.
- No significant associations with Formulating Sentences.

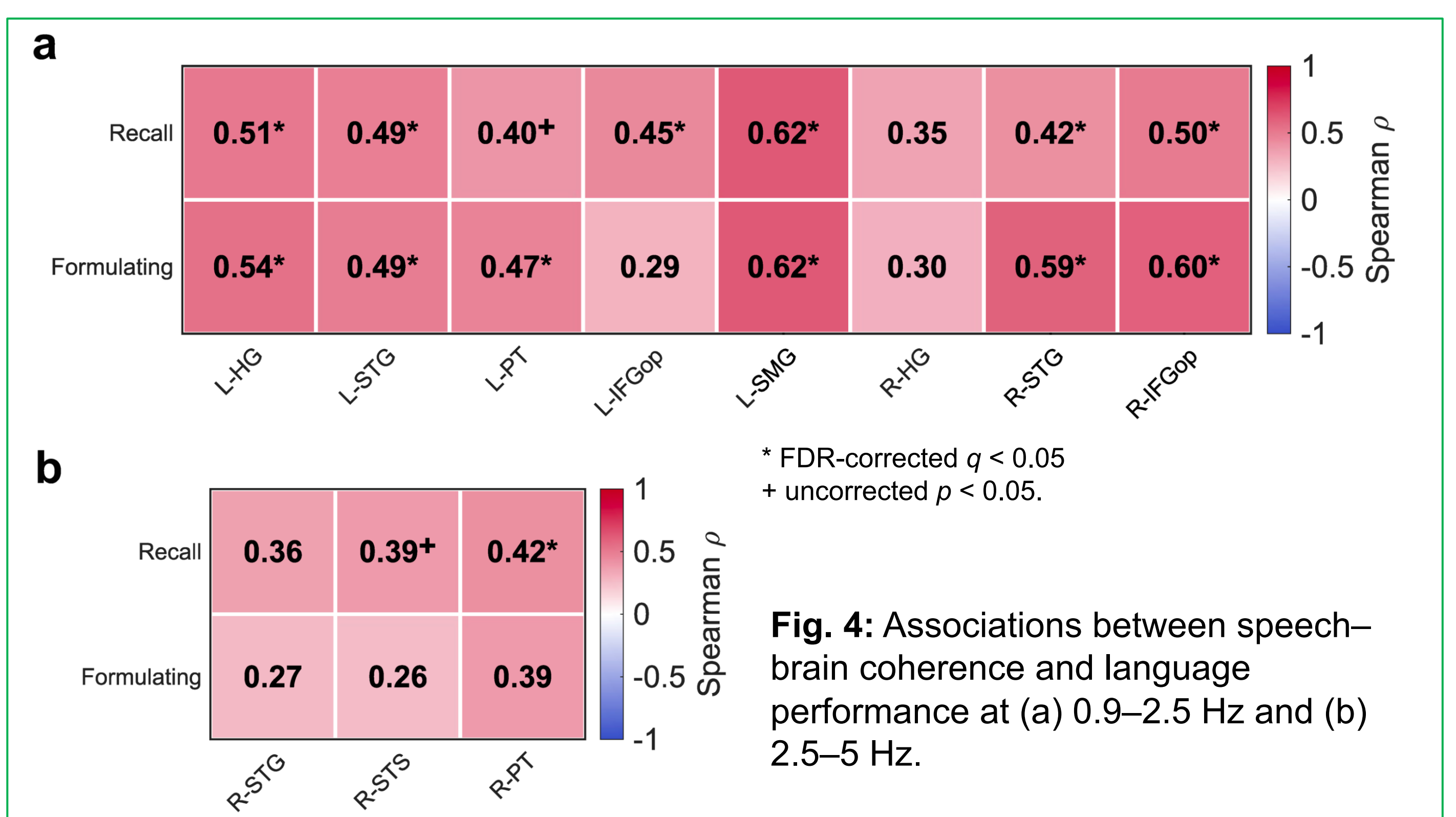


Fig. 4: Associations between speech-brain coherence and language performance at (a) 0.9–2.5 Hz and (b) 2.5–5 Hz.

Conclusions

- DLD shows selective impairment in low-frequency neural tracking of natural speech
- Widespread bilateral reductions at the prosodic rate (0.9–2.5 Hz)
- Right-lateralised reductions at the syllabic rate (2.5–5 Hz)
- No reliable differences in higher-frequency speech tracking
- Stronger low-frequency speech tracking is associated with better language performance

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Reference

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