Lexical and Phonological Frequency Effects in Developmental Dyslexia

Evidence from Auditory MEG Data

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I Introduction

- Most individuals with diagnosed dyslexia have a phonological processing deficit[1], which has led to the **Phonological Representation Hypothesis of Dyslexia**: Individuals with dyslexia have poorly specified phonological representations and/or difficulties in accessing these representations.[2]
- Assuming weaker phonological representations in dyslexia, **atypical neural encoding of phonological neighbourhood (NP)** during auditory word access is expected. However, it is unclear how a deficit in learning phonological associations affects **processing at the lexical level (word form frequency; WF)**.
- Research on NP and WF effects in dyslexia has concentrated on visual processing and found conflicting evidence, ranging from virtually no processing differences[3] to differences in localization[4], atypical word repetition effects[5], and differences in evoked power.[6]
- **The link between behavioural phonological deficits and the neural basis of phonological-lexical access in dyslexia remains unclear.**

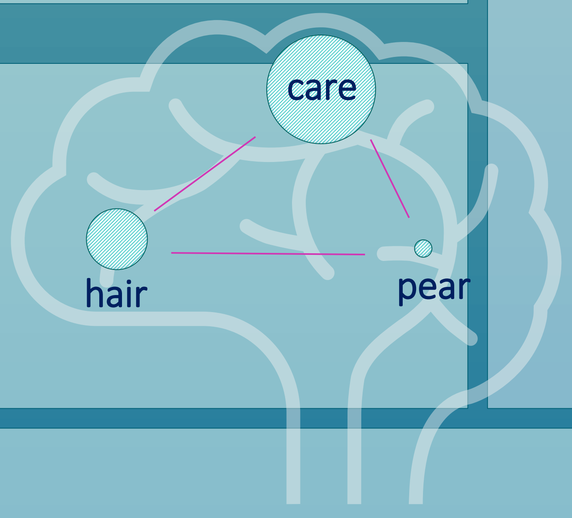
Research Question

Does the phonological deficit in dyslexia modulate how phonological-statistical information is encoded during auditory word access?

At what level?

(1) at the *Phonological Level*:
— Phonological Neighbours

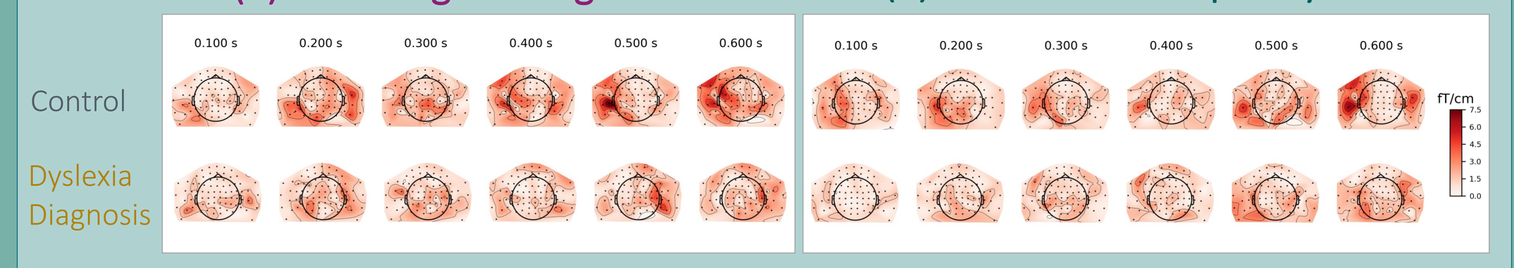
(2) at the *Whole Word Level*:
Word Form Frequency



III Results

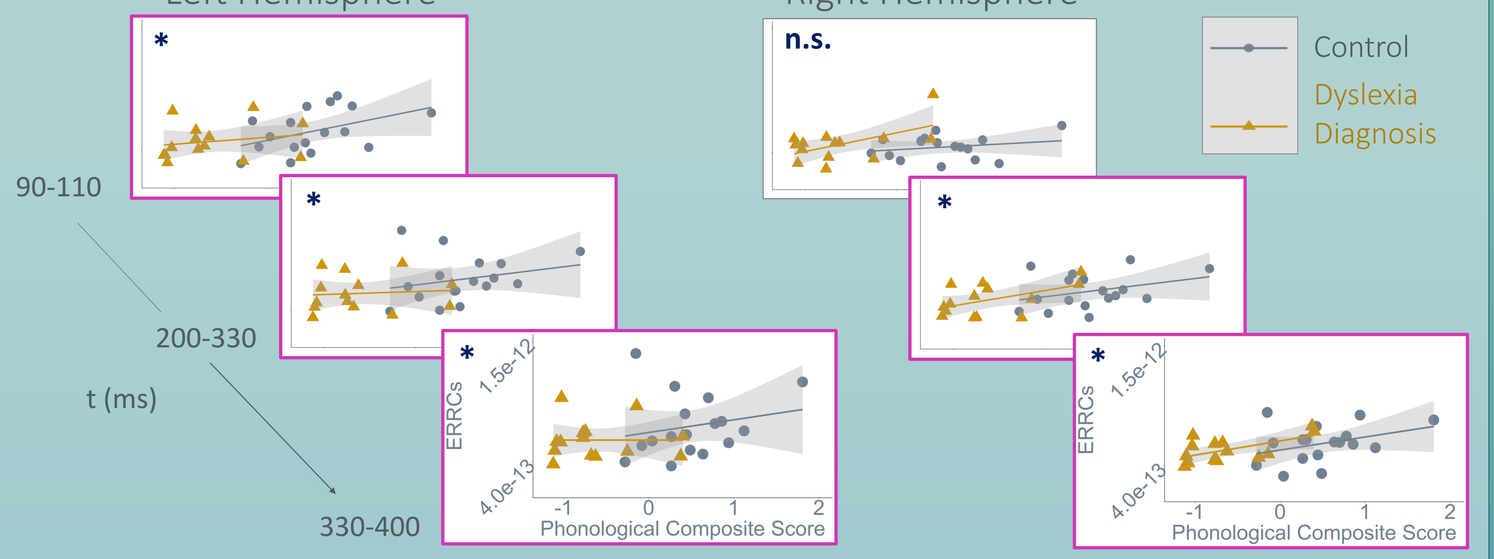
1. Single Regression of the Epoched Data[10]

(1) Phonological Neighbours (2) Word Form Frequency



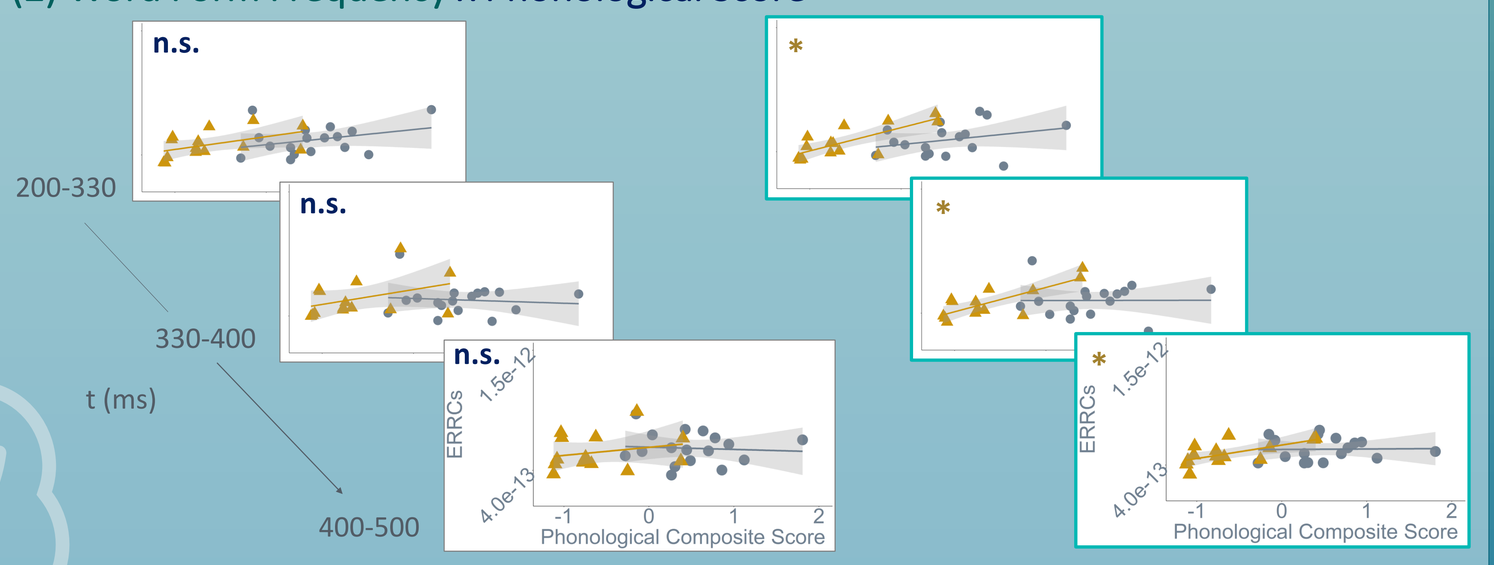
2.&3. Correlation of Averaged ERRCs and Phonological Composite Score

(1) Phonological Neighbours x Phonological Score



→ Correlation between NP and **Phonological Score** in the left and right hemispheres 90-400ms post stimulus-onset

(2) Word Form Frequency x Phonological Score



→ Correlation between WF and **Phonological Score** in the right hemisphere 200-500ms post stimulus-onset, but only for subjects with diagnosed dyslexia

II Methods

Participants

17 without reading problems, 14 diagnosed with dyslexia, matched in age (12-44, *M*=26.1) and general IQ (*M*=119.5)

Behavioural Tests of Phonological Skill

(a) **Phonological awareness test** (PECO: N out of 40)
(b) **Nonword reading test** (accuracy/time*100)

→ Combined into **Phonological Composite Score:** z(a) + z(b) / 2

Procedure

- MEG recordings
- Participants listened to Spanish nouns (N=120)
- Occasional decision as to whether word was animate or inanimate

Analysis

1. Single-subject regression of the epoched data (-100–700ms):
   (1) Phonological Neighbourhood *(Phonological Level)*
   (2) Written Word Form Frequency (*Whole Word Level*)
2. Averaging of Event-Related Regression Coefficients (ERRCs)[7] within pre-defined time-windows (90-650ms)[8]
3. Correlation of ERRCs and **Phonological Composite Score**[9]

IV Discussion

(1) At the *Phonological Level*

- **Better phonological skills are correlated with stronger encoding of phonological neighbourhood** in the brain throughout the time course of word processing, especially in the left hemisphere.
- This correlation holds regardless of dyslexia diagnosis, but dyslexics tend to have lower phonological skills (lower Phonological Composite Score) and as such weaker encoding overall.

(2) At the *Whole Word Level*

- Better phonological skills are associated with stronger encoding of word frequency in the right hemisphere in mid-late time-windows, but only for people with diagnosed dyslexia.
- **Stronger encoding of word form frequency in the right hemisphere could be a dyslexia-specific mechanism**, compensating weaker phonological form encoding in the left hemisphere.[11]

Phonological deficits are linked to weaker neural encoding of phonological information and compensatory encoding of word form frequency during auditory word access

→ **in line with the Phonological Representation Hypothesis of Dyslexia**.

Acknowledgements: Many thanks to Mikel Lizarazu and Nicola Molinaro for their help with this project. References: 1) Lyon et al., 2003; Shaywitz et al., 2006; Metsala, 1997; Vellutino, 2004; Boets et al., 2013; Ramus, 2014; Ramus & Szenkovits, 2008; Brady, 1997; Fowler, 1991; Hulme & Snowling, 1992; Wagner & Torgeson, 1987; 2) Swan & Goswami, 1997; Griffiths & Snowling, 2001; 3) Araújo, Huettig & Meyer, 2020; Rüsseler et al., 2003; 4) Heim et al., 2013; 5) Johannes et al., 1995; 6) Paul et al., 2006; 7) Hauk et al., 2006, 2009; 8) Dufour, Brunelliere & Frauenfelder, 2013; 9) Fdr correction applied; 10) Topomaps based on matched samples (14 subjects/group); 11) Klimovich-Gray et al. (in prep.)