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Faculty of Psychology and Neuroscience

Reduced electrophysiological connectivity during visual word recognition in dyslexic children

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Introduction

As a complex cognitive function, reading depends on connectivity within large scale neuronal networks combining information of multiple localized processes (Engel, Fries, & Singer, 2001).

Dyslexia is a disorder in the neural network for reading, with dysfluent reading as its most persistent symptom (Gabrieli, 2009).

Dyslexic individuals may differ in their level of reading (dys)fluency, and in 9-year old dyslexic children this difference was shown to affect underlying deficits in the neural integration of letters and speech sounds (Žarić et al., 2014, 2015).

Objective

Explore the oscillatory dynamics within the reading network by means of effective (directional) electrophysiological (EEG) connectivity and its relations to different levels of reading (dys)fluency in dyslexic children.

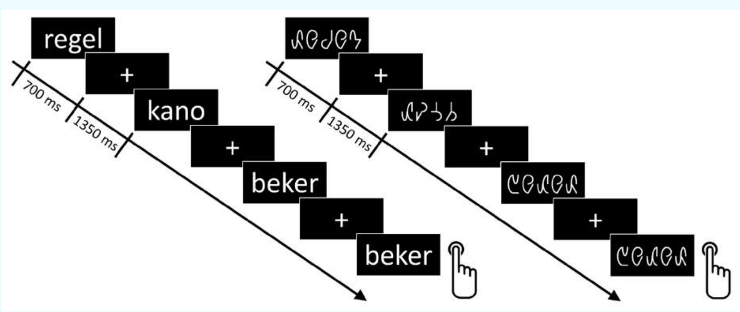
Methods

Participants: 34 9-yr old dyslexic children (divided in two groups based on their level of fluency; Žarić et al., 2014), and 20 9-yr old typically reading children

Stimuli: 80 bisyllabic (4 to 7 letter) Dutch words (AoA 6 yrs) and 80 custom made false font strings (Fraga González et al., 2014).

Block design: 8 blocks; 40 trials per block; Trial length: 700ms; Inter-trial interval (ITI): 1350ms

Task: one-back task on stimulus repetition (4 per block).



Visual Word Recognition (VWR) Paradigm (**Fig. 1**)

EEG recordings: 64 active channels Biosemi system

EEG analysis: Directed Transfer Function (DTF; Blinowska et al., 2004) based on multivariate autoregressive models and Granger causality (Granger, 1969). DTF was calculated for the epoch from 0 to 900 ms and for the 1-70 Hz frequency range per condition. Group differences were estimated with nonparametric Wilcoxon rank-sum test for two populations of independent samples

Behavioural measures: Letter-speech sound identification, and discrimination, spelling, and word reading of the 3DM (Blomert & Vaessen, 2009), the one minute word reading test and text reading.

Results

Our analysis indicated a weaker functional connectivity from occipital to inferior-temporal channels in both dyslexic groups as compared to typical readers. Conversely, dyslexics showed stronger anterior to posterior connectivity. (**Fig. 2 and Fig. 3A**).

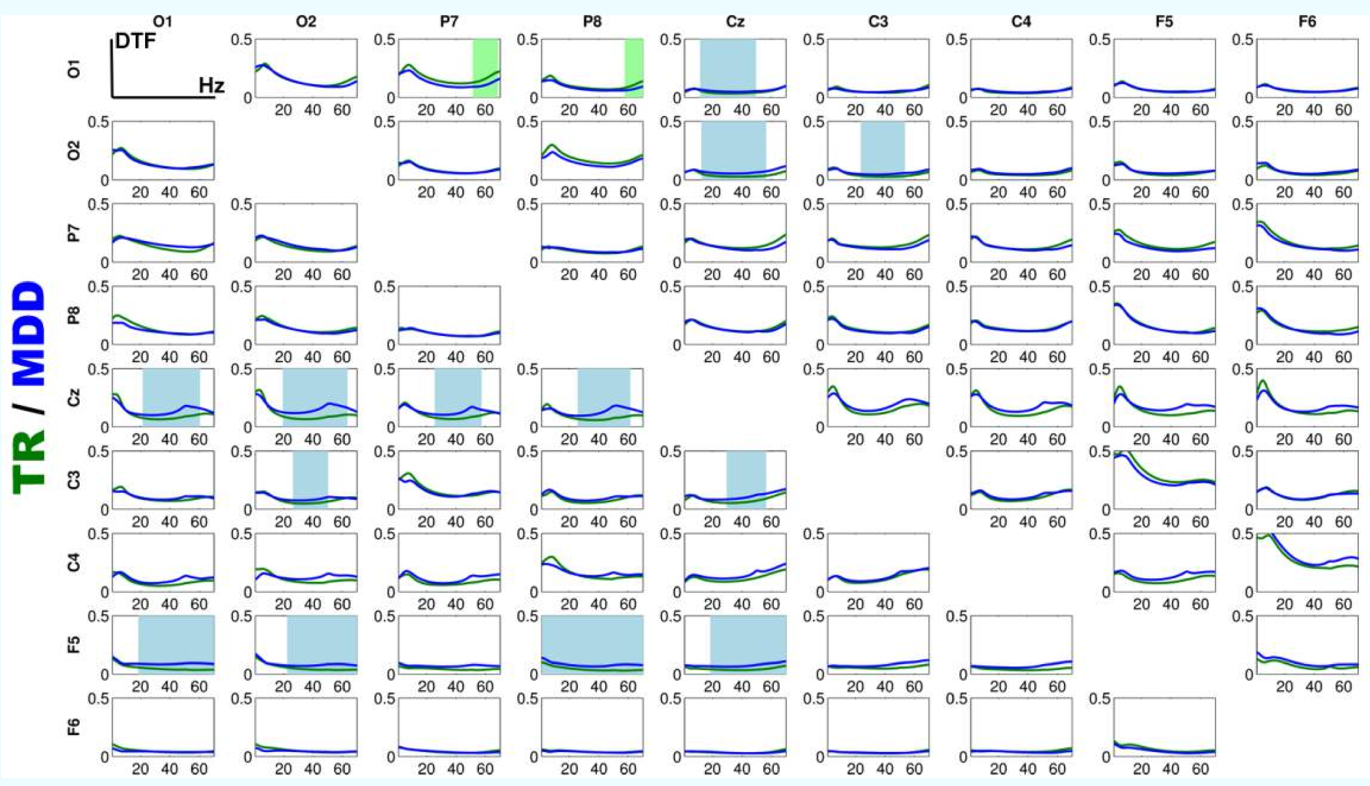


***Figure 2**: Comparison of typical (TR) and moderately dysfluent dyslexic (MDD) readers on effective connectivity for visual word recognition*

Results

Reading fluency influenced connectivity patterns with MDDs exhibiting stronger connectivity from central to bilateral inferior-temporal sites and SDDs towards the right side (**Fig. 3A**). In the false font condition, TRs and MDDs only showed small differences, whereas both groups differed substantially from SDDs (**Fig. 3B**).

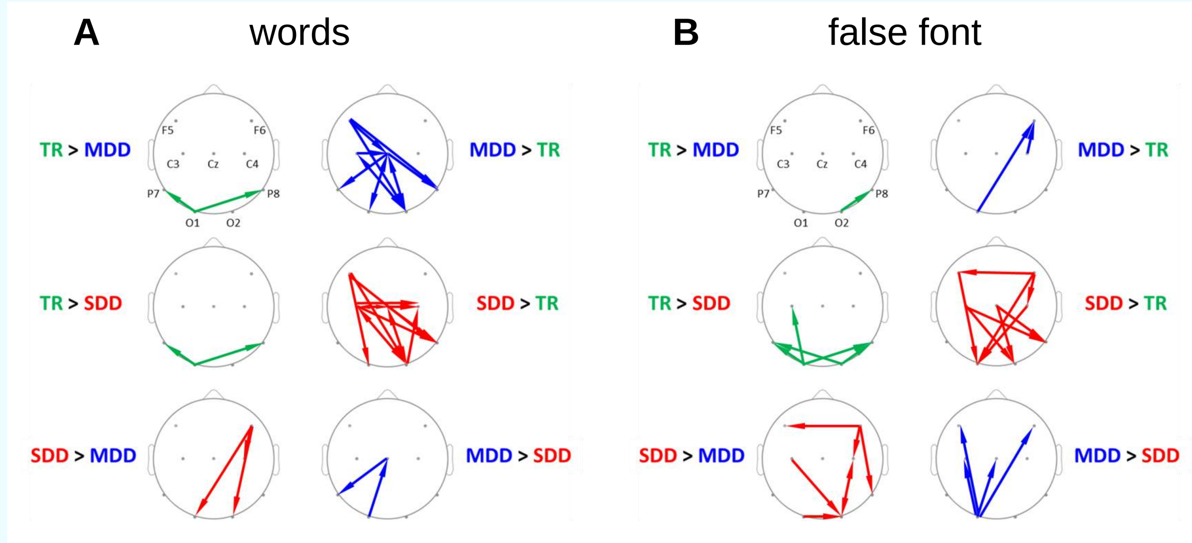


***Figure 3**: Topographical representation of differences in connectivity between three groups in visual word recognition (A) and false font (B) condition.*

TR – typical readers; MDD – moderately dysfluent dyslexic SDD – severely dysfluent dyslexic readers

Both posterior-anterior connectivity in the gamma range (**Fig. 4A**) and anterior-posterior connectivity in the higher beta and lower gamma range (**Fig. 4B**) scaled with composite behavioral measures.

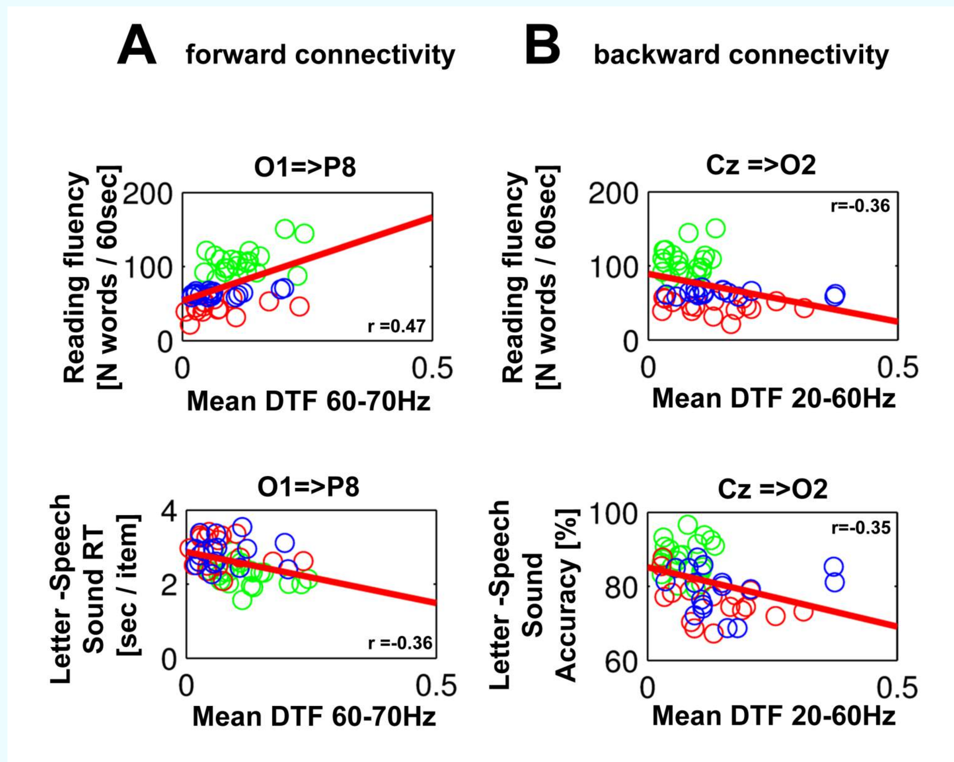


***Figure 4**: Correlations of DTF connectivity index and reading related behavioral composite scores for (A) higher gamma (60-70Hz) forward connectivity , (B) higher beta and lower gamma (20-60Hz) backward connectivity .*

Groups differed in ERP responses, with SDDs differing from TRs (and MDDs) mostly in fronto-central sites, and MDDs differing from TRs in parieto-occipital sites (**Fig. 5**) while group differences were strongly diminished in the false font string condition.

***Figure 5**: ERPs to visual words.*

Conclusion

Our results confirm dysfunctional connectivity patterns in the reading network of dyslexic children with reduced posterior-anterior and enhanced anterior- posterior connectivity in dyslexic children. Furthermore, both forward and backward connectivity correlated with reading related measures, further stressing the need to consider individual differences across the entire spectrum of reading skills in addition to group differences between typical and dyslexic readers (Žarić et al., 2014).

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