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Letter-speech sounds intervention for children with dyslexia: reading fluency gains and neural changes in visual word processing

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Introduction

Dyslexia refers to a disorder in the neural network for reading, with dys**fluent reading** as its most persistent symptom (Gabrieli, 2009).

Recent accounts of dyslexia assume that a failure to develop automated **letter-speech sound integration** results in reading failure (Blau et al.,2010)

Neuroimaging studies suggest a Visual Word Form Area (**VWFA**) in **left occipito-temporal** regions specialized for print reading (McCandliss, Cohen, & Dehaene, 2003). Electrophysiological data suggest that early **N1 responses** at around 200 ms are sensitive to word-likeness of stimuli and reading expertise (Maurer et al.,2003).

In a previous study we found that N1 responses for words were larger at left relative to right hemisphere sites in dyslexics but not in typical readers (Fraga González et al., 2014). The **N1 word response related to reading fluency** in dyslexics but not in typical readers.

The current report presents preliminary findings of the effects on N1 responses of an **intervention** program with an explicit focus on letter-speech mapping.

Goals

- **Evaluate** gains on reading fluency after explicitly training letter-speech sound associations in dyslexics
- Explore **changes** in visual **ERP**s to words in dyslexics after reading intervention
- Find **correlations** between neural responses to words and gains in reading fluency measurements.

Methods

Participants
44 dyslexics
(age 8.86 ± 0.43).Grade 3
Randomly assigned to:
- Training (N=23; N_{ERP}=18)
- Control (N=21)

21 typical readers:
(age 8.77 ± 0.41). Grade 3.

Intervention
Systematic and explicit.
Letter-Speech sound mapping
One to one 45 min sessions
34 sessions, twice a week

ERP experiment
Block design:
8 blocks
(2 x 2 string types x 2 lengths)
40 trials per block
Trial length: 700ms
Inter-trial interval (ITI): 1350ms
Stimuli:
Words (CELEX database) and *symbol strings* (letter-like).
Either short (4-5 characters) or long (6-7 characters).
Task:
Button press when stimuli immediate repetitions are detected (4 per block).

ERP analysis
Biosemi ActiveTwo system
64 scalp electrodes
Epoch:(-500 to1550 ms)
Artifact rejection:
Manual and ICA
Reference: average.
Filter: 1-30 Hz
Statistics:
Repeated Measures ANOVA
Electrodes in analysis:
P9,P7,P5,P10,P8,P6,PO7
PO3,PO8,PO4,O1,O2

Behavioral analysis
ANCOVA (Pretest as covariate)
Multilevel Model (random intercept)

Behavioral measurements
Letter-Speech sound mapping
Word reading (HF,LF,Pseudo)
Spelling
One Minute Test
Text reading

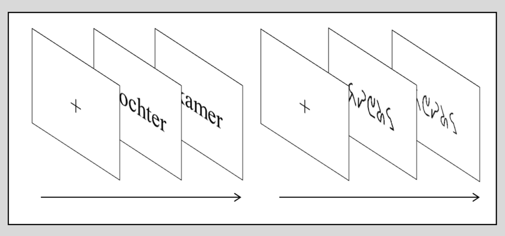

Figure 1. Word and symbol string stimuli (examples) visually presented in blocks

Results

Impairments in dyslexics referred primarily to **fluency** rather than accuracy measures. Importantly, trained dyslexics showed **substantial fluency gains** for the main word reading and spelling measures after the letter-speech sound intervention. The rate of change in reading fluency was faster in trained dyslexics compare to dyslexics without training and typical readers.

N1 amplitudes discriminated between words and symbol strings in both groups. Dyslexics at the pretest showed N1 word enhancement at left relative to right hemisphere sites. This effect was only found in interaction with electrode at the posttest. **N1 responses to word** at left hemisphere sites tended to be **reduced after intervention**. N1 responses to words showed no lateralization effects in typical readers.

Gains in reading fluency moderately **related to changes in N1** responses after the intervention,

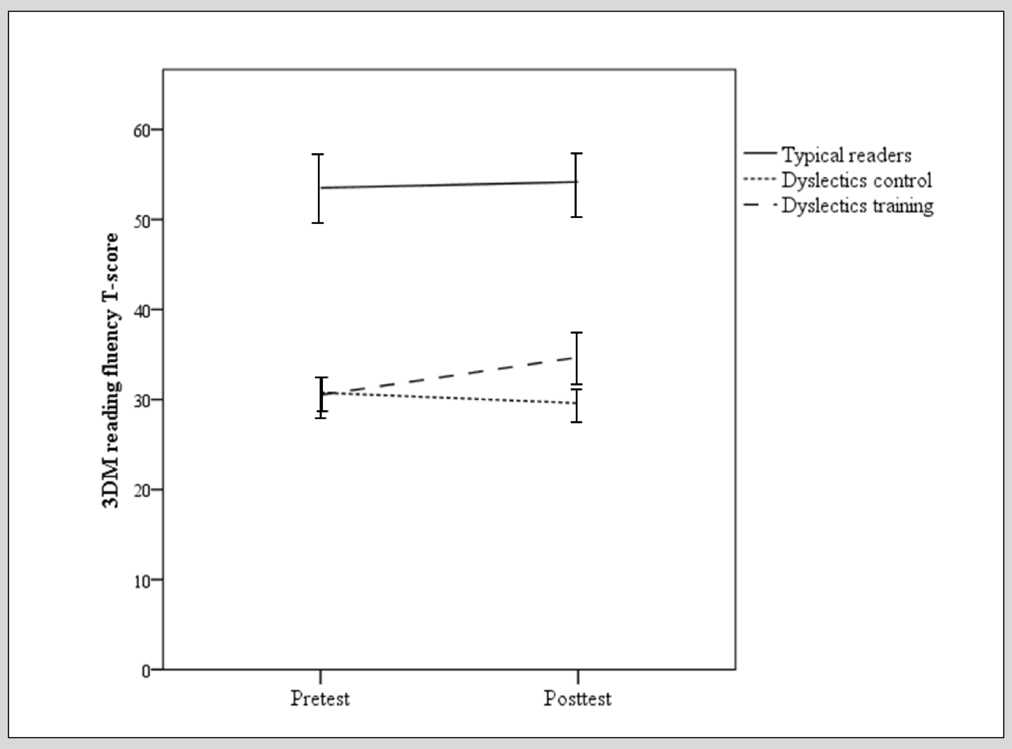

Figure 2. Differences in reading fluency overall score between pretest and posttest. The analysis using a multilevel model with random intercept indicated significant differences in slope (rate of change) between trained dyslexics and typical readers but not between untrained dyslexics and typical readers.

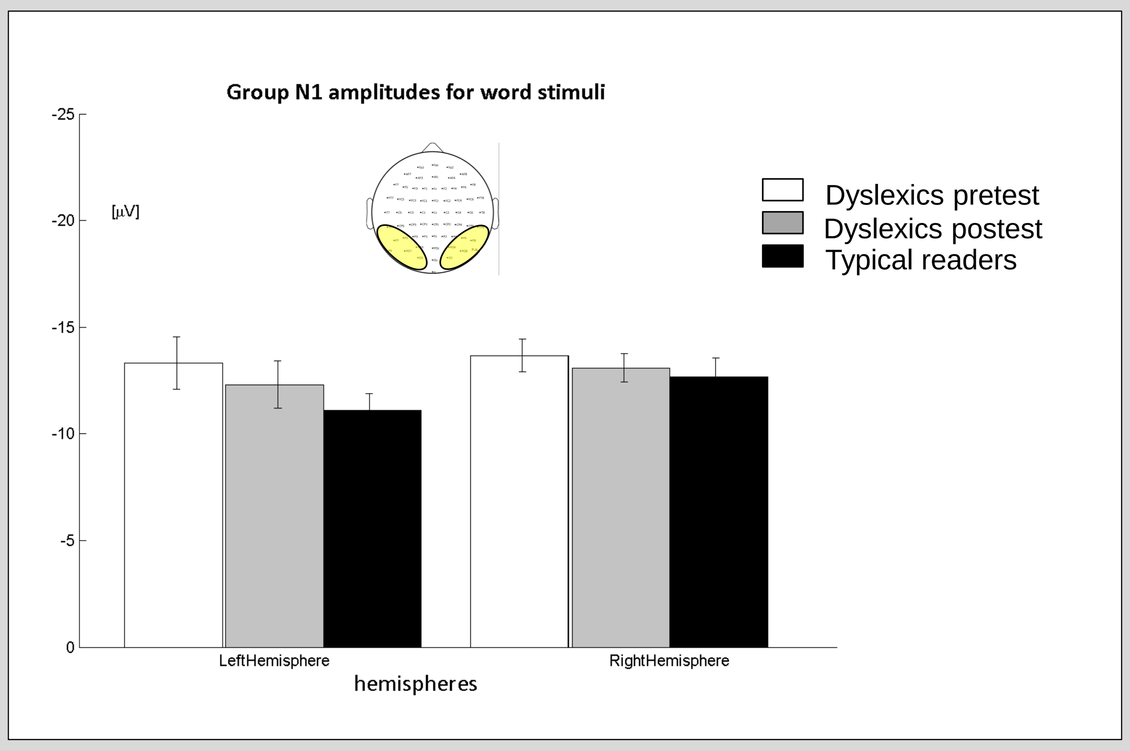

Figure 4 Mean N1 amplitude for words at left and right hemisphere sites for dyslexics in the pretest and posttest, and typical readers. Left hemisphere amplitudes are averaged across TP7, P9, P7, P5, PO7, PO3 and O1 sites, and right hemisphere across their homologue pairs. Error bars show standard errors of the sample.

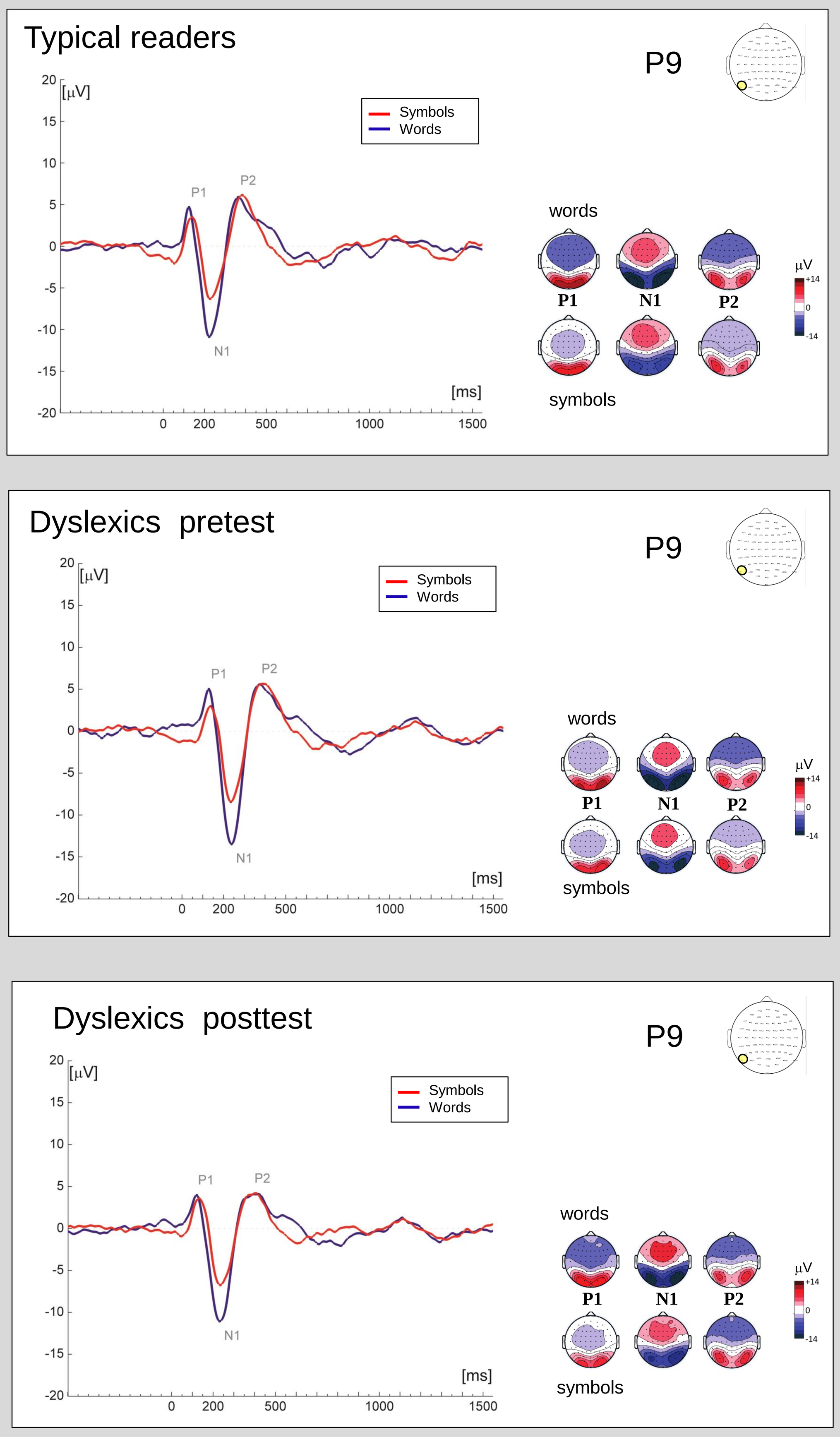

Figure 3. Group ERPs for word and symbol stimuli at P9. Topographical maps showing the course of neural activity following stimulus presentation. Posterior activations and polarity are visible at peak latencies.

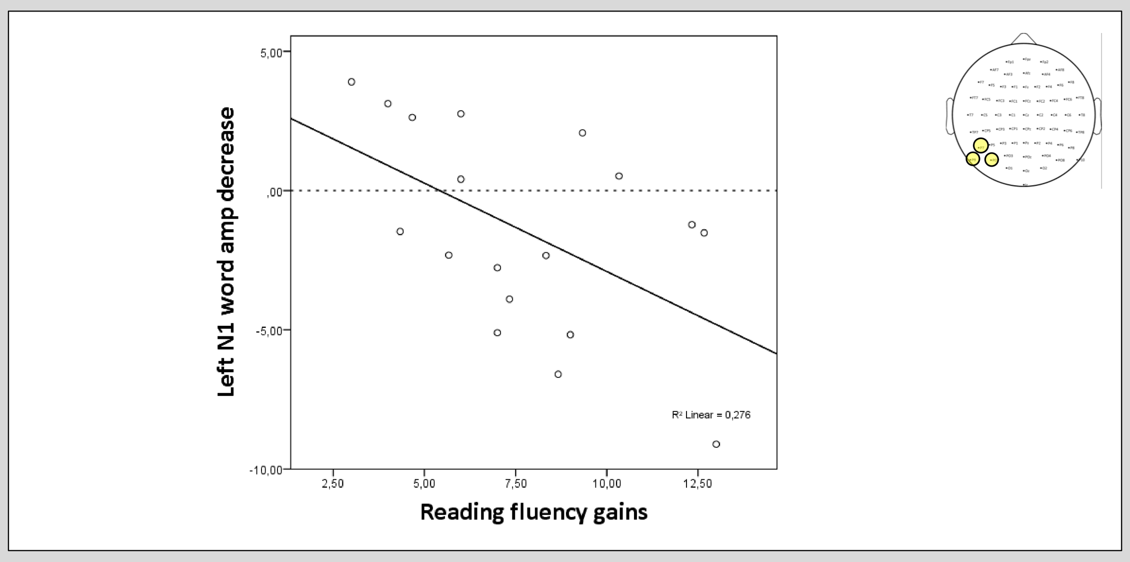

Figure 5. Linear regression between posttest-prestest difference in N1 amplitudes for words at the left posterior electrodes (average of P9,P7 and PO7) and gains in reading fluency (average of 3DM high and low frequency word reading, and One minute test).

Discussion

Intensive and explicit training of letter-speech sound mapping can improve reading fluency in severely impaired readers.

The multisensory integration deficit account of dyslexia offers a better framework to interpret current results than accounts based on the phonological deficit as a main cause for dyslexia.

Larger N1 responses in dyslexics might indicate a stronger reliance on visual encoding that becomes more efficient and more similar to typical readers when higher fluency levels are attained after intervention.

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