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Faculty of Psychology and Neuroscience

Failure of letter-speech sound integration as a basis of reading dysfluency in dyslexia

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Introduction

Dyslexia is a disorder in the neural network for reading, with dysfluent reading as its most persistent symptom (Gabrieli, 2009). Individuals with dyslexia are at severe risk for adverse academic, economic, and psychosocial consequences, because of their inability to attain society's literacy demands.

A series of electrophysiological (EEG) studies employing a cross-modal oddball paradigm revealed that automatic letter-speech sound integration takes years to develop in normally reading children, despite the fact that they 'know' which letter goes with which sound (Froyen et al, 2008; 2009).

Furthermore letter-speech sound associations were shown to be less automatic in dyslexic readers (Froyen et al., 2011). And fMRI evidence showed reduced neural integration of letters and speech sounds in the Planum Temporale (PT) /Heschl Sulcus (HS) and the Superior Temporal Sulcus (STS) in 9 year old dyslexic children compared to age-matched controls (Blau et al, 2010).

Objective

To compare the effective functioning of letter-speech sound integration of typical and dyslexic readers with 2.5 years of reading instruction by means of ERP and behavioral measures, particularly reading fluency.

Methods

Participants:
36 with dyslexia; age: M(SD)=9.0(0.43)
20 normally reading; age: M(SD)=8.8(0.38)

Stimuli: Dutch phonemes /a/ and /o/
And letter "a".

Mismatch negativity (MMN) paradigm:
Standard 83%; Deviant 17% (**Fig. 1**)

3 conditions:
- Auditory (Au)
- Two audiovisual conditions with different stimulus onset asynchronies (SOA):

Audiovisual SOA 0ms (Av0)
Audiovisual SOA 200ms (Av200)

3 blocks per condition
288 trials per block
Trial onset asynchrony 1750ms

EEG recordings: 64 active channels
Biosemi system
EEG analysis:
Two time windows of interest:
100-250ms (MMN) and 600ms-750ms (Late Negativity)

Repeated measures ANOVA on mean amplitudes (across 50 ms centered on the individual peak latency) in fronto-central electrodes (Fz, Cz, FC3 and FC4).

Behavioural measures (**Fig. 2**)
1. 3DM (Blomert & Vaessen, 2009):
- Letter-speech sound identification
- Letter-speech sound discrimination
- Spelling
- Word reading (high and low frequency words and pseudowords)
- RAN

2. One minute test
3. Text reading

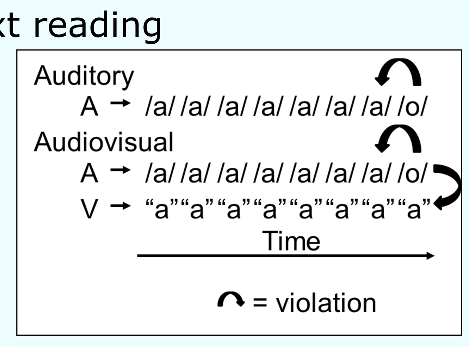

***Figure 1**: Mismatch negativity paradigm for investigating letter-speech sound integration*

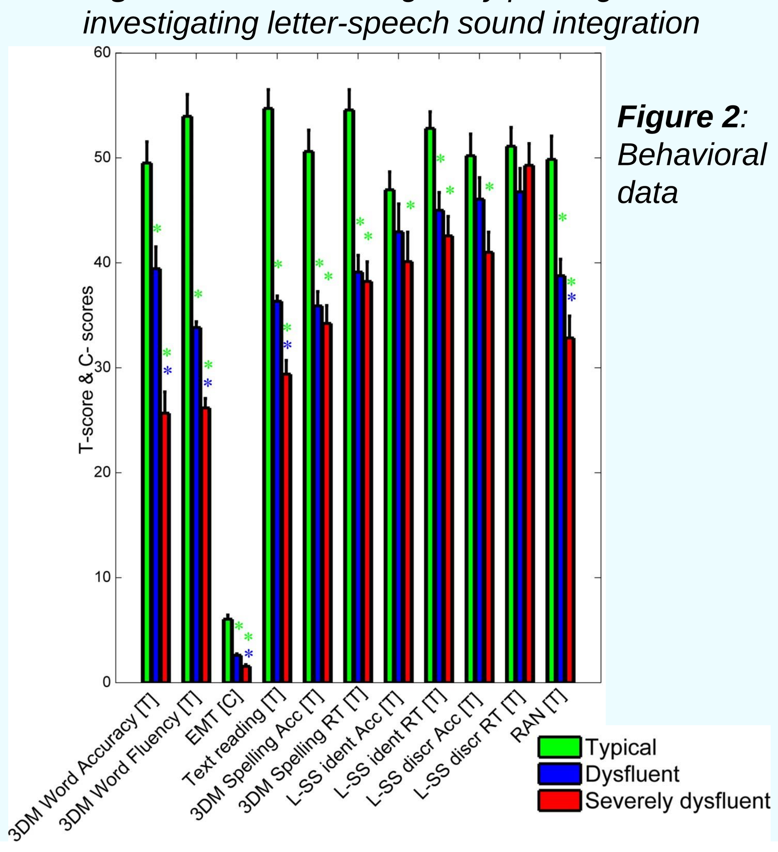

***Figure 2**: Behavioral data*

Results

Comparable auditory MMN responses around 180ms in all groups.

In the simultaneous audiovisual condition (Av0) MMN latency of dyslexic readers showed a positive correlation with the number of correctly read words (**Fig. 4**). Thus we split dyslexic group in two subgroups based on the severity of fluency impairment.

In typical readers, both cross-modal conditions led to the enhanced MMN and LN responses. Dysfluent dyslexic readers lacked the crossmodal LN enhancement while severely dysfluent lacked both LN enhancements and MMN enhancement in Av0 (**Fig. 3**).

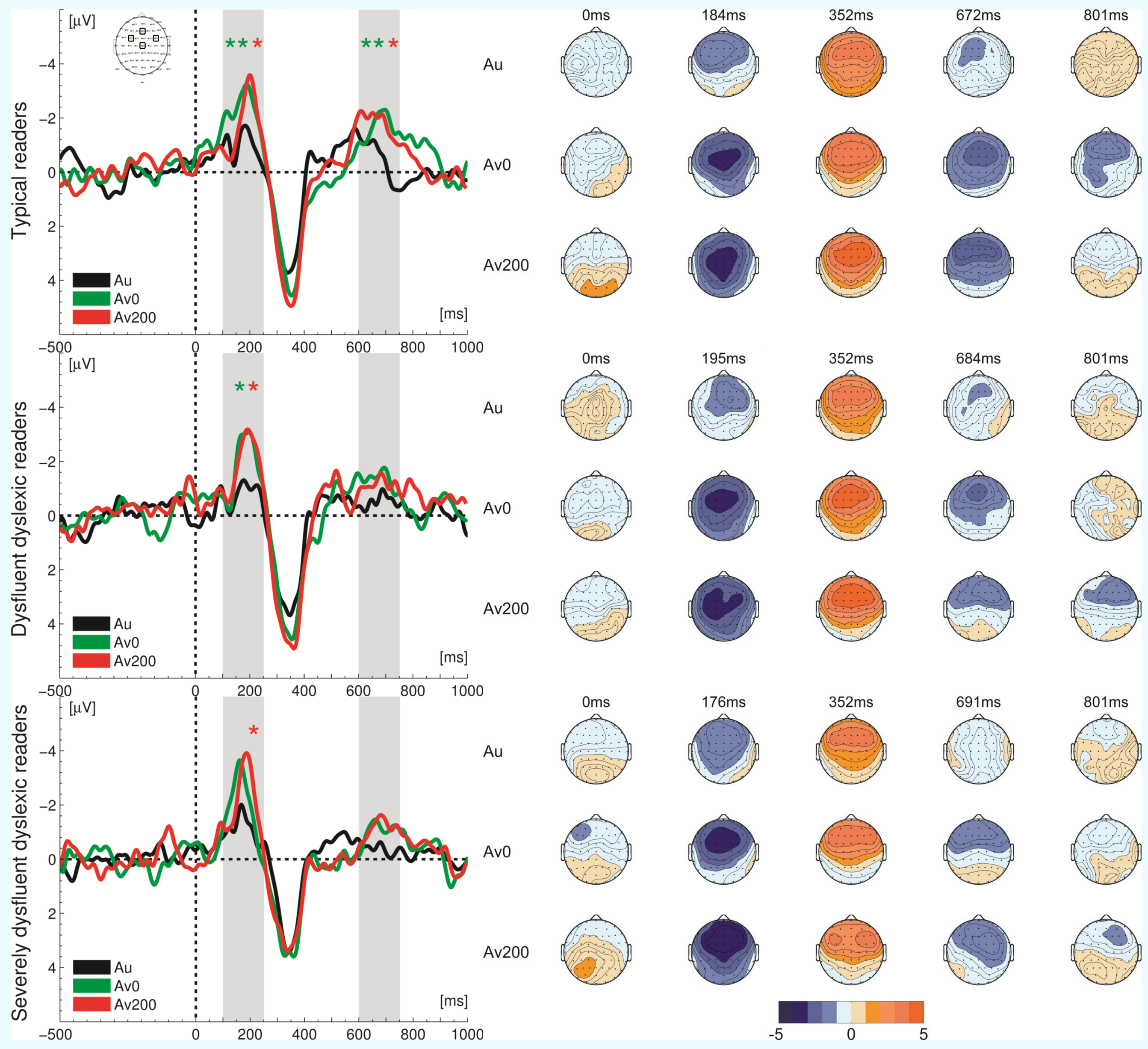

***Figure 3**: Grand average ERP difference waves averaged over 4 electrodes (left panel). Topographical distribution of difference waves in the Auditory and Audiovisual conditions (right panel).*

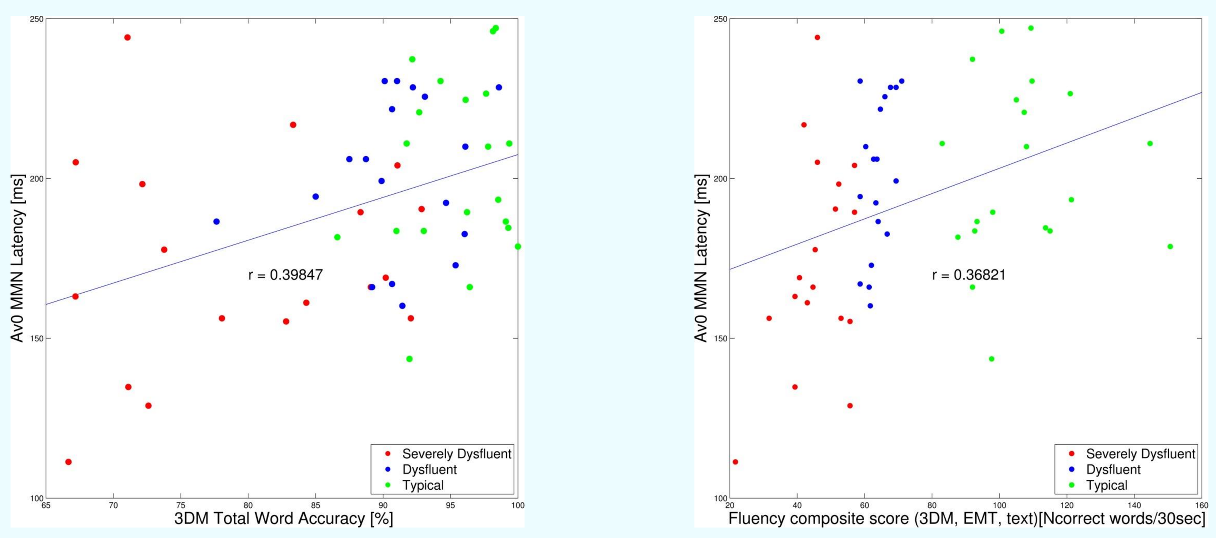

***Figure 4**: Correlations of MMN latency in the Av0 condition with the number of correctly read words (accuracy) in 3DM task and composite score of fluency (3DM, EMT, text)*

Discussion

These results indicate that after 2.5 years of reading instruction, typical readers show integration of letters and speech sounds at a different temporal window of integration in comparison with experienced readers (Froyen et al., 2008; 2009).

Our results confirm deficient letter-speech sound integration in dyslexic children, but with a different timing as compared to previous findings with 11-year old dyslexic children (Froyen et al., 2011).

Apart from indicating deficient letter-speech sound integration, the lack of cross-modal LN enhancement is consistent with recent findings suggesting this component as a neural marker of dyslexia (Neuhoff et al., 2012).

Furthermore, the latency of the MMN in the AV0 condition correlated significantly with behavioral scores of reading fluency. Analysis indicated a reduced MMN response (N1 window) in the severely dysfluent dyslectics as compared to both other groups (N1 and P2 window).

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