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ERPs disclose the specificity of spatio-temporal patterns of brain activity during self-paced reading aloud.

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Introduction. Grapheme-to-phoneme matching is a fundamental reading strategy, and its simplest unit is represented by single-letter reading. In ecological conditions, reading is voluntarily started and overtly articulated. The aim of this work was to investigate the contribution of self-pacing and verbal-motor production to reading processes in healthy children.
Methods. Event-related potentials (ERPs) were recorded from 45 healthy children (age range 8-10 years). Stimuli consisted of single letters visually presented for 5 ms on a screen with a random inter-stimulus interval longer than 4 s. Letters appearance was controlled through button press. Each subject performed two tasks: *externally-paced letter presentation* (EPLP), i.e. passive looking at letters presented at an experimenter-determined pacing, and *self-paced letter recognition* (SPLR), i.e. active reading aloud of letters presented at a self-determined pacing. EPLP mainly involves visual perceptual processes; SPLR additionally engages attention, motor preparation to button press, verbal-motor articulation, analysis of auditory feedback. Grand averages across subjects were computed for each task and the main positive and negative peaks were manually identified according to the following labels: P1 (110 ms), N2 (180 ms), P2a (220 ms), P2b (300 ms), N3 (350 ms), P4 (460 ms), N4 (630 ms). Standardized Low Resolution Electromagnetic Tomography (sLORETA) was applied to individual ERPs and each map was normalized to global mean intensity. Paired voxel-by-voxel t-test analysis ($P < 0.01$) was performed in correspondence of the latency of the main grand average peaks in order to compare the sLORETA maps between reading conditions.
Results. The cortical regions significantly modulated by the reading task are summarized in Figure 1. During SPLR, in comparison with EPLP, we observed a significantly greater response in the left supramarginal gyrus and middle-inferior parietal lobule before 150 ms, the right angular gyrus and middle-inferior temporal lobe between 150-250 ms, the middle-inferior frontal gyrus bilaterally between 300-400 ms and the left ventral inferior temporal gyrus after 600 ms. In contrast, during EPLP the activation in the right middle-inferior temporal-occipital cortex before 150 ms, the superior frontal gyrus bilaterally between 150-200 ms, the left middle frontal gyrus between 200-250 ms and the left occipital gyrus between 300-400 ms was significantly higher than during SPLR.
Conclusions. SPLR implies a greater attentive, motor, and cognitive effort compared to EPLP. A significantly greater activation of the left supramarginal gyrus was present at short latencies during SPLR: this observation may be interpreted as a facilitatory effect produced on regions specifically related to grapheme-to-phoneme association mechanisms in order to improve reading performances. At middle latencies, the regions showing significantly greater activation during SPLR compared to EPLP gradually moved from the right angular gyrus to the right middle-inferior temporal gyrus, to bilateral inferior frontal regions. These results may suggest that self-paced reading aloud additionally engages some regions in the right hemisphere, homologous to left temporal-parietal cortices related to phonological analysis, and in the bilateral frontal regions, related to higher order cognitive processes, that are not required for looking passively at letters.

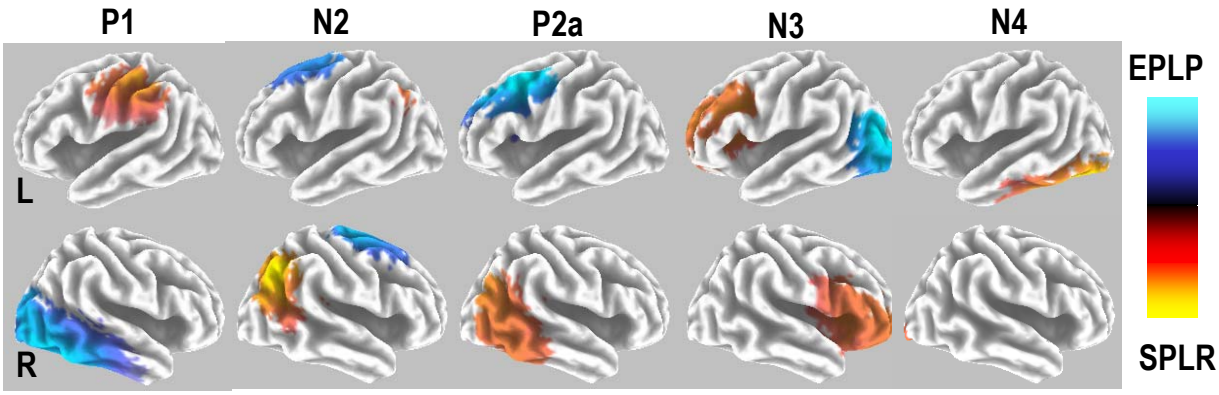

Figure 1: Significant differences in brain activation between EPLP and SPLR tasks in healthy children resulting from voxel-by-voxel paired t-test analysis of the sLORETA maps computed in correspondence of the ERP components P1, N2, P2a, N3, N4. Blue-cyan indicates that activation during EPLP is significantly greater than during SPLR; red-yellow indicates that activation during SPLR is greater than during EPLP.

Single-letter reading elicits a different spatio-temporal modulation of brain activity in dyslexic children as compared to healthy controls

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Introduction. Developmental dyslexia is a neuropsychological disorder characterized by impaired phonological awareness and visual perceptual analysis. Single-letter reading is an early predictor of later reading success and identifies adult dyslexics. This work aimed at investigating the differences between healthy and dyslexic children in the spatiotemporal modulation of brain activity occurring during single-letter reading tasks with different levels of motor and cognitive demand.
Methods. Event-related potentials (ERPs) were recorded from 45 healthy and 45 dyslexic children (age range 8-10 years). Stimuli consisted of single letters visually presented for 5 ms on a screen with a random inter-stimulus interval longer than 4 s. Letters appearance was controlled through button press. Each subject performed two tasks: *externally-paced letter presentation* (EPLP), i.e. passive looking at letters presented at an experimenter-determined pacing, and *self-paced letter recognition* (SPLR), i.e. active reading aloud letters presented at a self-determined pacing. Grand averages across subjects were computed for each task and group, and the main positive and negative peaks were manually identified according to the following labels: P1 (110 ms), N2 (180 ms), P2a (220 ms), P2b (300 ms), N3 (350 ms), P4 (460 ms), N4 (630 ms). Standardized Low Resolution Electromagnetic Tomography (sLORETA) was applied to individual ERPs and each map was normalized to global mean intensity. For each task separately, unpaired voxel-by-voxel t-test analysis ($P < 0.05$) was performed in correspondence of the latency of the main grand average peaks in order to compare the sLORETA maps between groups of subjects.
Results. Significant group differences in brain activity were observed during both reading conditions (Figure 1). During EPLP at short latencies dyslexics showed a greater response in bilateral superior parietal lobule. At middle latencies, the increased activation in the dyslexics as compared to controls moved from bilateral superior parietal lobule to the right angular gyrus. The activation in the left angular gyrus and middle parietal lobe was significantly impaired in dyslexic children at longer latencies. During SPLR at middle latencies, dyslexics were characterized by a greater activation in the right middle-inferior frontal, insular and superior temporal regions and by impaired engagement of the left middle parietal lobe as compared to the healthy controls. At middle-long latencies a significantly reduced activation in the left occipital gyrus was observed in dyslexic children compared to controls.
Conclusions. The significant group differences observed during EPLP at short latencies indicate that reading impairment begins at the stage of visual perceptual analysis of letters and likely affects the subsequent phases of information processing. Voluntary and active engagement of the subject during self-paced reading aloud likely contributes to improve efficiency of information processing, and therefore to explain the lack of significant group differences at short latencies in this task. The significantly greater involvement of right temporal-parietal regions and the significantly premature engagement of right middle-inferior frontal regions in dyslexic children as compared to controls may be related to compensatory mechanisms adopted by poor-readers in order to overcome the impaired activation of left parietal and occipital regions.

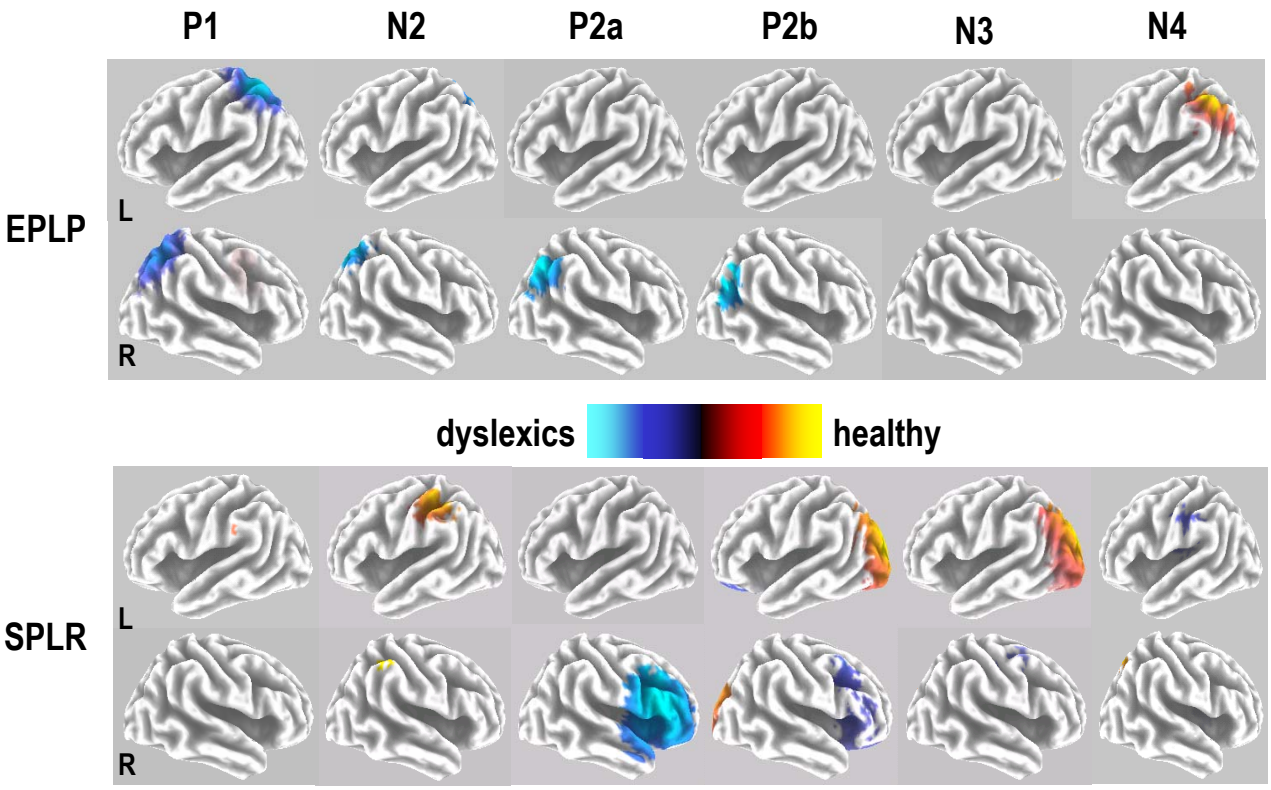

Figure 1: Significant differences in brain activation between healthy and dyslexic children during EPLP and SPLR tasks resulting from voxel-by-voxel unpaired t-test analysis of the sLORETA maps computed in correspondence to the ERP components P1, N2, P2a, P2b, N3, N4. Blue-cyan indicates that activation in dyslexic is significantly greater than in healthy children; red-yellow indicates that activation in dyslexic is reduced compared to healthy children.