# Neural bases of dyslexia in Italian: does a history of language delay matter?

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## Introduction

The literature on the cognitive bases of Developmental Dyslexia (DD) suggests that an impairment in phonological processing is frequently associated to reading deficits (Snowling, 2000). Among the neuroimaging studies, several researches found a reduced activation of the temporo-parietal area of the left hemisphere during phonological processing tasks with a possible compensatory activation in the frontal and dorsolateral prefrontal areas (Temple, 2000; Paulesu, 2001; Georgiewa, 2002). Nevertheless, these group studies do not take into account the behavioural and cognitive heterogeneity of dyslexic subjects and are mostly conducted in English, a language with an irregular orthography (Bishop, 2000; Brizzolara, 2006). The aims of this fMRI study were to compare normal readers and DD patients in Italian, a language with regular orthography, and to investigate whether the pattern of fMRI activations during phonological tasks is related to the clinical profile of the DD patients.

## Subjects and Methods

13 patients with Developmental Dyslexia (4 females, mean age 22,7 y, age range: 12-34 y) and 11 healthy normal controls matched for age (8 females, mean age 22,8 y, age range: 12-30 y) participated to the study. They were tested with behavioral tasks to measure phonological processing skills and reading skills. Patients were divided in two groups according to the anamnestic interview and to the behavioural profile: 7 DD subjects with a history of language delay (HDL) and 6 DD subjects without a history of language delay (noHDL). During the fMRI experiment, patients performed two phonological tasks previously tested on normal Italian adults (Biagi, ISMRM 2004): a rhyme generation task, in which participants had to find a word rhyming with the visually presented target (rest condition consisted in the passive observation of strings of four 'x'); a rhyme judgement task in which participants had to judge whether two pseudo-words, visually presented, rhymed (rest condition consisted in judging whether two Cyrillic strings matched). Stimuli were presented in a virtual reality sep-up (VisuaStim XGA - Resonance Technology). BOLD responses were acquired by 1.5T General Electric Signa Horizon LX System (GE, USA), equipped with Echo-speed gradient coil and amplifier hardware. Activation images were acquired using echoplanar imaging (EPI) gradient-recalled echo sequence (TR/TE/flip angle = 3 s/50ms/90°, FOV = 280x280 mm, matrix = 128 x 128, 5 mm thick slices). Time-course series of 64 volumes were collected usually in 6 epochs of 10 volumes alternating between control and active conditions. The first epoch always lasted 4 volumes more to allow the stabilisation of the signal. A volumetric set of data (3D FSPGR: TR/TE/TI/flip angle = 21.1 ms/3.8 ms/700 ms/10°; FOV = 280 x 280 mm, matrix = 256 x 256) were acquired to generate a 3-dimensional whole brain reconstruction. BOLD maps were generated by using the software package Brain Voyager QX (Brain Innovation, the Netherlands). For each subject, the two-dimensional functional data were aligned to the three.-dimensional high resolution images and transformed into Talairach space. A General Linear Model approach was used to generate statistical maps, both for the single subject analysis and for the multi-subject group analysis. Two group analysis were performed to underline the differences between controls and DD subjects and within the dyslexic group between HDL and noHDL patients. A threshold of p-value<0.05 corrected by Bonferroni, and a minimum cluster size of 30 voxels were used.

## Results and Discussion

In the rhyme generation task DD patients did not activate the temporal regions found in normal controls thus confirming that also in a language with regular orthography there is a reduced neurofunctional efficiency of areas involved in accessing the phonological lexicon (Figure 1). Control and DD subjects showed the prevalent use, both during rhyme generation and rhyme judgement tasks, of frontal and dorsolateral areas, structures involved in decoding and rehearsing the phonological input. Nevertheless, the pattern of activations of the frontal areas varied depending on the cognitive profile of DD patients: in comparison to subjects without a history of language delay, the subjects with a previous language delay, usually associated to a phonological deficit, showed a reduced activation of the left inferior frontal gyrus (Broca's area) (Figure 2). These findings would suggest a strong relation between the neural base of reading deficits and the clinical profile of dyslexic subjects.

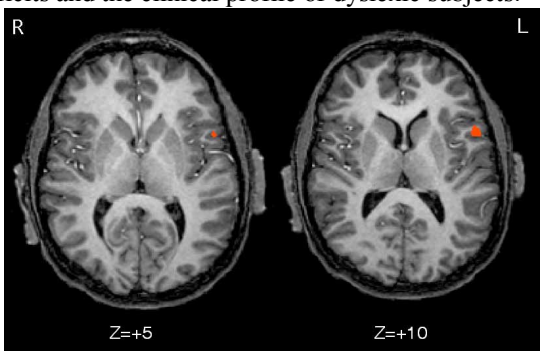


Figure 1: Controls > DD patients.

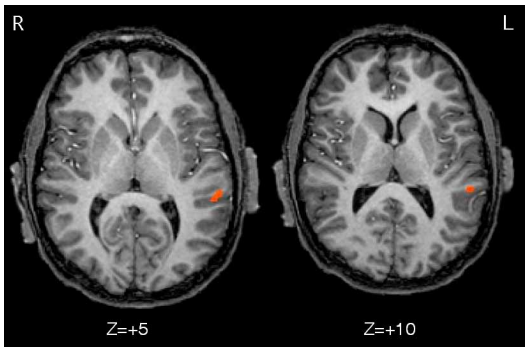


Figure 2: noHDL > HDL dyslexic patients.