

# Cerebral reorganization after phonological and visuo-attentional training in dyslexic children: An fMRI study

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## Background

Developmental dyslexia is commonly associated with behavioral deficits in phonological processing [1]. This impairment is associated with a dysfunction of the neural mechanisms underlying phonological processing [2].

Specific remediation program focused, for instance, on auditory processing and oral language training (see [3]) could not only improve the reading abilities, but also ameliorate the disrupted function in brain regions associated with phonological processing.

However, recent studies showed that visuo-attentional processes are also altered in developmental dyslexia [4].

Therefore, the main aim of this fMRI study was to assess the effect of both phonological and visuo-attentional intensive training on the cerebral activity in dyslexic children.

## Protocol

Ten French dyslexic children (5 males) aged from 8 to 12 years with severe reading disorders despite a normal IQ (>85)  
 - mean chronological age = 10 years 4 months; SD = 10 months  
 - mean reading age = 7 years 2 months; SD = 4 months

The training program extended over two periods of 6 weeks devoted to one **phonological training** session and one **visuo-attentional training** session. Each dyslexic participants underwent both training sessions which were counterbalanced within subjects.

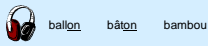
The effect of training was investigated at both the behavioural and neurobiological level. For this purpose, dyslexic participants were submitted to a battery of **fMRI experiments** and **neuropsychological tests** before training, after the first training session, and after the second training session.

## Training program

### Phonology-based training

The phonological training includes phonological awareness exercises using speech samples (AIX-Marseille team, CNRS « Paroles & Langage », Aix en Provence)

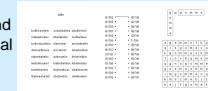
- pairing and oddity judgments based on rhyme, first phoneme and common phoneme at an intermediate location within word
- syllabic and phonemic decomposition
- acronyms...



### Visuo-attentional training

The visuo-attentional training includes exercises that have been successfully used in previous attempts to treat visuo-attentional disorders in developmental dyslexics [5]:

- visual exploring
- visual search of targets among distractors
- visual comparison of sequences
- building of mental representations of orthographic sequences...



## fMRI experiments

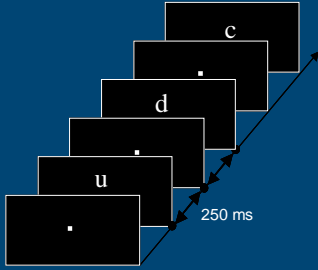
- > Event-related fMRI paradigm
- > Whole-body 3T MR scanner (Bruker MedSpec S300)
- > Whole brain volume, 41 slices, 3 mm thickness, TR = 2.5 sec
- > Data analyzed using SPM2, two-stage random effect analyses
- > Two tasks : **Rhyme detection task** and **Lateral masking task**

## Neuropsychological tests

- > Reading tasks (regular and irregular words, pseudo-words, texts)
- > Dictation tasks (irregular words, pseudo-words, text)
- > Phonological awareness tasks (deletion of the first phoneme in CV and CCV syllables and words; phonemic decomposition of heard words; acronyms)
- > Visuo-attentional tasks (global report and partial report tasks)
- > Short-term memory evaluation (WISC digit span, word span, Corsi span)

## Rhyme detection task

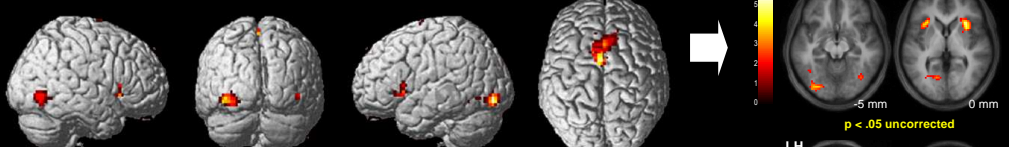
This task allow to assess the cerebral substrates related to phonological aspect of language.



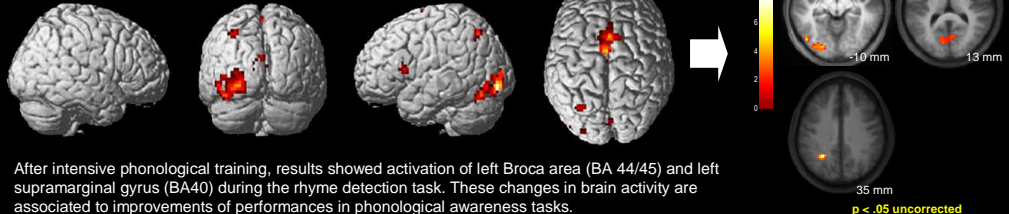
Stimuli were isolated lower-case Latin letters displayed at the centre of the screen.

Children were instructed to press a response key with the index finger of the right hand, each time and only when a letter rhymed with the phoneme /é/ (e.g. "c" yes, "u" no).

## before training program: [rhyme detection > baseline]



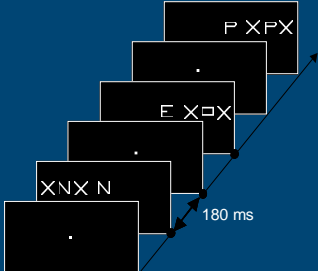
## after phonological training: [rhyme detection > baseline]



After intensive phonological training, results showed activation of left Broca area (BA 44/45) and left supramarginal gyrus (BA40) during the rhyme detection task. These changes in brain activity are associated to improvements of performances in phonological awareness tasks.

## Lateral masking task

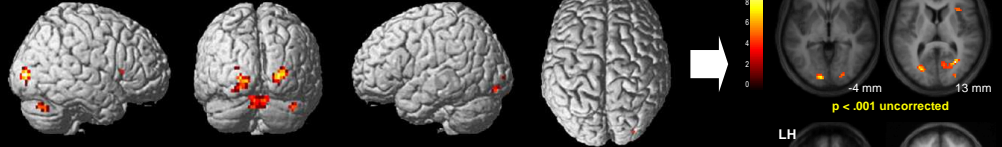
This task allow to assess the cerebral substrates related to visual attention.



The stimuli (Latin letters and geometrical figures) were displayed by pairs made up either of two letters (matched pair) of a letter and a geometrical figure (unmatched pair). For each pair, one stimulus was displayed centrally and the other peripherally at 3° of eccentricity. The letter was lateralized in either the right or left visual field, and was closely flanked by two 'X' letters.

Children had perform a categorical matching task. They were instructed to fixate the central stimulus and to press a response key with the index finger of the right hand, each time and only when they detected an unmatched stimulus pair (e.g., a centrally displayed letter and a lateralized geometrical figure, or the reverse)

## before training program: [lateral masking > baseline]



## after visuo-attentional training: [lateral masking > baseline]



After intensive visuo-attentional training, results showed activation of the superior and inferior parietal cortex (BA 7 and BA 39/40) during the lateral masking task. These changes in brain activity are associated to improvements of performances in visuo-attentional tasks.

## Conclusion

The present findings show that specific modifications in brain activation occur following the intensive rehabilitation program of visual attention processing.

References  
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