Abstract  The present study investigated the spatial distribution of visual attention in dyslexic and normally reading children. The performances of the two groups were investigated using two different paradigms. In experiment 1 we analyzed the distribution of processing resources both inside and outside the focus of visual attention by simply recording reaction times to the detection of a white dot target projected at different eccentricities from the fovea. The distribution of attentional resources differed significantly between the two groups of children. The eccentricity of the stimulus was significant only for normally reading children – who showed a normal gradient – as it influenced their detection speed, whereas it had no effect on dyslexic children, who exhibited a diffused distribution of visual processing resources inside the visual field. In experiment 2 we studied the distributed (unfocused) mode of attention in a visual search task by measuring reaction times to a target stimulus inside a large configuration with a variable number of distractors. Results show that as compared to normal children dyslexics are better able to distribute their attentional resources diffusely. Our conclusion is that reading disability may be characterized by a diffused distribution of visual processing resources. These data might be interpreted in the framework of studies on magnocellular deficits in dyslexia, whereby the anomalous distribution of visual attention might explain how transient pathway functioning influences the reading process.

Key words  Dyslexia · Spatial attention · Focusing · Visual search · Reaction time

Introduction

Developmental dyslexia or specific reading disability (SRD) is defined as a disturbance in the development of reading ability, which cannot be explained only in terms of mental age, visual acuity or inadequate schooling and can affect reading comprehension and word recognition during reading and reading aloud (ICD-10 1996).

Several recent publications (for reviews see Stein and Walsh 1997) have looked at the magnocellular (M) or transient system as the cause of both visual and phonological processing deficits in dyslexia. The M pathway is specialized in processing fast temporal information in different modalities (visual, phonological and motor). However, the mechanism by which deficits of the M pathway affect reading has not yet been fully identified. In fact, the M pathway impairments found in dyslexics are very mild and are usually found in viewing conditions which are unusual for reading. In addition, it has been assumed that a deficit in the M pathway causes reading difficulties through a failure of this pathway to suppress the activity of the parvocellular (P) pathway at the time of saccadic eye movements (e.g., Breitmeyer 1993; Lovegrove et al. 1982). However, recent studies (Burr et al. 1994) have found that it is the M pathway – and not the P pathway as postulated by the M pathway deficit theory of dyslexia – which is suppressed during saccades. The conventional theory of an M deficit acting through saccadic suppression is therefore difficult to maintain (Skottun 1997). The question is therefore in what ways could so mild a deficit of a system which is mainly sensitive to coarse patterns cause defective perception of fine details such as letters and words in small print.

During text reading the visual system is bombarded by a huge quantity of information requiring a precise selection mechanism in order to be coded, so as to make relevant information processing more efficient and to exclude irrelevant elements. Such a selection mechanism is usually defined as visual attention. For quick and precise decoding, it is very important to facilitate processing of in-
The aim of the present study was to analyze the visual spatial distribution of attentional resources in normal and dyslexic children. The hypothesis to be tested was that of a diffused distribution of processing resources in dyslexia. Diffused (or distributed) visual attention might hamper the retrieval of relevant information and inhibition of irrelevant information during the coding stage in the reading process. LaBerge and Brown (1989) claimed that, in order to identify a letter, the “filter” must be able to reduce its size so as to exclude interfering lateral information. Spatial attention might be impaired in dyslexia, thus not permitting privileged processing of a particular area of the visual field. This could theoretically determine a greater interference of lateral stimuli (other words and letters) during reading.

Two different paradigms of experimental psychology were used to test this hypothesis. The former consists of measuring simple reaction times (RTs) required for detecting a target appearing at different eccentricities from the point of fixation, thus falling either inside or outside the focus of visual attention. The latter is a visual search task in which the measured variables are Go-No Go reaction times for detecting a target within a variable number of distractors (Treisman and Souther 1985).

**Experiment 1**

This experiment investigated the attentional gradient in normal children and dyslexic children by measuring the reaction times needed to detect the target stimulus appearing at different eccentricities from the fovea, inside and outside the presumed focus of visual attention. The attentional gradient is defined as the shape of the V curve of RTs with increasing eccentricity of the target from the attentional focus (LaBerge and Brown 1989). It is assumed that the size of the cue allows to regulate the extension of the focus (Egeth 1977; Eriksen and St. James 1986; Castiello and Umiltà 1990, 1992). To study the possible temporal distribution of the gradient, two different time intervals were used to divide the onset of the focusing cue from the target onset (100 and 800 ms). The focusing cue radius being a 10° visual angle, the distribution of the gradient inside the focus was measured by comparing RTs for the first two eccentricities (8° and 4° visual angle). On the other hand, comparison of RTs for the last two eccentricities (8° and 12° visual angle) allowed to measure the distribution of the gradient just outside the focus.

**Materials and methods**

**Subjects**

We tested 21 children (15 males and 6 females). Inclusion criteria were: (1) IQ >85 as measured by the Wechsler Intelligence Scale for Children-Revised (Wechsler 1986); (2) no known gross behavioral or emotional problems; (3) normal or corrected-to-normal vision and hearing; (4) absence of drug therapy; (5) normal visual field; and (6) absence of attention deficit disorder with hyperactiv-