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
formation coming from a specific area of the visual field (for reviews see Johnston and Dark 1986; Shiffrin 1988).

Generally defined as spatial attention, the operation that facilitates processing in a particular area of the visual field has been described as: (1) spotlight (Posner 1980; Yantis 1988), (2) filter channel (LaBerge and Brown 1989), (3) zoom lens (Eriksen and St. James 1986) and (4) distribution of processing resources (Downing and Pinker 1985; Shaw 1978). All these models imply that attentional resources can be concentrated in a small portion of space or can be diffusely distributed over the visual field. Two attentional modalities can therefore be identified: (1) diffused and (2) focused (Jonides 1983; Bergen and Julesz 1983; Duncan 1980; Schneider and Shiffrin 1977).

The M pathway which processes information about position and movement of stimuli may affect reading, hampering focalization of attention (which requires precise coding of stimulus location), and therefore maintaining a diffuse-distributed mode which in turn hampers relevant information processing and irrelevant-distracting information inhibition.

Indeed, recent studies seem to demonstrate the existence of a specific attention disorder in dyslexia (August and Garfinkel 1990; Ackerman et al. 1990). Casco et al. (1998) found that children with poor performances in visual search tasks show reduced reading speed and accuracy if compared with children with higher performances. According to the authors, this difference can be attributed to a deficit in visual selective attention. Evidence showed that dyslexics are impaired in visual search tasks in which they have to identify targets such as letters (Williams et al. 1987; Casco and Prunetti 1996) or shapes (Ruddock 1991) in a group of similar elements. Sharma et al. (1991) showed that children with specific learning disabilities were specifically impaired in tests of focused visual attention, probably owing to their difficulty in modulating the size of the focus of visual attention. Also, the effect of perceptual grouping has been shown to be greater in poor readers than in good readers (Williams and Bologna 1985). According to Brannan and Williams (1987), poor readers did not appear to make use of a peripheral cue for rapidly orienting their visual attention. Rayner et al. (1989) described a case of a developmental dyslexic who performed better than controls in reporting letters shown in parafoveal vision. This performance was attributed to a deficit of selective attention in dyslexics so that letters from words viewed parafoveally would interfere with the processing of concurrently fixated words. Also, Geiger and coworkers (Geiger and Lettvin 1987; Geiger et al. 1994) reported that dyslexics show a disability in suppressing information from the periphery of the visual field which would cause a deficit in foveal reading. Facoetti et al. (2000) collected evidence concerning dyslexic children’s difficulties in sustaining focused attention for efficient processing of visual information.

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 of 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-