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Attention and the identification of parafoveal words in school-age children and adults

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ABSTRACT

The goal of this study was to examine whether reading parafoveal words is more attention-demanding in 7- to 10-year-old children (2^{nd} to 5^{th} grade) than in adults, and whether this increase in attention interacts with visual field. In an identification task, we presented 4-letter words in the left (LVF) or right (RVF) visual fields in single unilateral (one word in one visual field), unilateral with distractor (one word + one distractor in the opposite visual field) and bilateral (two words) conditions. We also presented object drawings. The results showed that all groups of children were more sensitive to the presence of a second stimulus (distractor or word) than adults in the block of words, but not in the block of object drawings. We interpreted this result as indicating an age-related change in the attentional demands of word identification and in attentional control when reading, thus in the interaction between the attentional control system and the language network. As well, we found the same RVF superiority for words and the same attentional bias (larger distractor effect on LVF words) in children and adults, which is not in favor of the hypothesis of an age-related change in language lateralization.

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1. Introduction

Although word reading benefits from some automaticity, spatial attention may be crucial, playing a role at a late or even at an early level of processing. For example, late attention (i.e. after identification

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takes place) may be necessary to produce a serial readout of information into the phonological code and integrate the semantics of a specific word when understanding a sentence (Mewhort, Marchetti, Gurnsey, & Campbell, 1984). Early attention may be necessary to identify a specific word, by distributing the window of processing over the entire letter string, or by focusing it on smaller units (letters) (Auclair & Siéroff, 2002; McCann, Folk, & Johnston, 1992). Whatever the exact role of attention may be, repetition is accompanied by a change in attentional demand; in addition, the improvement in reading skills with practice should lead to automaticity, and thus to some decrease in attentional demand (LaBerge & Samuels, 1974). However, few studies have evaluated the early (visuospatial) attentional demand when identifying visually presented words in children. The first goal of this study is to evaluate the development of the role of spatial attention in reading, between the ages of 7 and 10 (2^{nd} to 5^{th} grade), in comparison with adults. The attentional demand in reading may be stronger with parafoveally than with foveally presented words, and some studies have shown a different role for attention as a function of left (LVF) or right (RVF) visual fields. The second goal of this study is to evaluate the evolution of attentional demands in reading parafoveal words, as a function of visual field.

1.1. Attention in word reading

There has been considerable debate about the involvement of attention in the processing of visually presented words. Researchers have used various methods to investigate the influence of spatial attention in word processing, such as the Stroop task, semantic priming, dual tasks, visual search, the influence of distractors, or the spatial cueing paradigm (Besner & Stolz, 1999; Carr & Posner, 1995). Concerning foveal words, some suggest that spatial attention plays little or no role in word identification, especially in skilled readers, and others argue in favor of a meaningful role for spatial attention in word identification (McCann et al., 1992). An intermediary position is that word processing is attentional but benefits from some automaticity compared to the processing of an unfamiliar letter string or a nonword (Siéroff & Posner, 1988). More specifically, word processing may be accompanied by the redistribution of spatial attention over the entire spatial extent of the letter string (Auclair & Siéroff, 2002; Johnston & McClelland, 1974). This attentional mechanism may be different from the role of attention when reading a nonword, which may require one to orient and focus attention on smaller units (letters) (Siéroff & Posner, 1988). Rees, Russell, Frith, and Driver (1999) have shown, in a functional magnetic resonance imaging (fMRI) study, an obliteration of word processing by attention withdrawal, in favor of visual word recognition that depends wholly on attention (but see Ruz, Worden, Tudela, & McCandliss, 2005, for a different view).

Attentional differences may exist depending on the word's exact location in the visual field (Carrasco, Williams, & Yeshurun, 2002), and parafoveally presented words may require more attention than foveally presented words (Ducrot & Grainger, 2007). When words were displaced from the center of the visual field to a hemifield, Cohen, Dehaene, Vinckier, Jobert, and Montavont (2008) found greater activity in the bilateral posterior intra-parietal cortices and in mesial posterior parietal regions (including precuneus), which have all been involved in visual attention tasks. Thus, the relative eccentricity of the word is an important factor in revealing attention involvement in reading.

1.2. Attention in reading and visual field asymmetry

A constant finding in divided visual field studies, in which a word is parafoveally presented in the LVF or RVF, is that performance (response times, accuracy) is better in the RVF (Mishkin & Forgays, 1952), whatever the task may be (lexical decision, identification). This RVF superiority (RVFS) of words has received many explanations, of which the structuralist hypothesis, namely that RVF words benefit from direct access to the left hemisphere, which is specialized for language, may be the most influential (Kimura, 1961). However, spatial attention may also play a role in visual field asymmetries.

According to the attentional bias hypothesis (Kinsbourne, 1970), attention is not necessarily distributed symmetrically with respect to the median plane in the state of expectancy prior to presentation of each stimulus (i.e. when attending the word). A linguistic task activates the left hemisphere. Consequently, in this condition, the left hemisphere controls behavior and attention. Thus, more attentional resources are allocated to the RVF, opposite the left hemisphere, and words are better

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