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Top-down modulation of early selective attention processes in children

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Abstract

It has been demonstrated in adults that attention can modulate very early stages of perceptual/cognitive processing, but it has not been determined if this capacity for modulation develops with age. We investigated early attentional processes in parallel and serial visual search tasks in 40 children 7–12 years old, using event-related potentials (ERPs). Two single-feature pop-out tasks were used to assess parallel processing; a conjunction of features task was used to study serial processing. There were significant decreases in latencies with age for the peaks measured [posterior P1, N1 and anterior P2 (P2a)]. P1 and N1 latency effects also varied with trial type and were consistent with top-down modulation of processing, which differed between the parallel tasks. P2a amplitude for the hit trials decreased with increasing age for the colour and serial tasks. Increasing R > L hemispheric asymmetries with age in P2a amplitude were seen on non-target trials for the size and serial tasks only, reflecting serial processing. These data demonstrate that developmental changes in visual selective attention for early stages of processing are continuing through childhood, and that there is top-down modulation at these latencies in children. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Visual search; Event-related potential (ERP); Development; Selective attention

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1. Introduction

There are currently several competing models of visual selective attention that distinguish between parallel and serial search (e.g. Treisman, 1988; Wolfe et al., 1989), which place more or less emphasis on the differences between the automatic and intentional aspects of visual search. As behavioural data can be interpreted to fit either model, some researchers have employed event-related potentials (ERPs) in the investigation of visual search processes, as ERPs can provide fine-grained indices of cognitive processing (Picton and Hillyard, 1988). In an early study utilising a traditional visual search paradigm, Luck and Hillyard (1990) found evidence supporting Treisman's (1988) model, when only late ERP components were measured. A more recent study using pop-out stimuli (which require parallel processing) showed pop-outs to be associated with enhanced early components, suggesting automatic detection (Luck and Hillyard, 1994). They concluded that pre-attentive processes guide attention rapidly to a relevant object, but that the process was not entirely automatic, as there was evidence of top-down influence on components from P2 through to P3 and on RTs, consistent with the guided search model (Wolfe et al., 1989). Eals and Taylor (1996) recorded ERPs to parallel and serial processing tasks, with the serial task consisting of a conjunction of features. The data did not divide according to parallel and serial tasks; colour pop-out task had the shortest RT and ERP latencies, followed by the size pop-out task, and finally the serial task, suggesting that parallel and serial processing are part of a continuum, also consistent with the guided search model of visual attention (Wolfe et al., 1989).

There are numerous studies on the development of attention in children, but few have tested differing models of attention (see, however, Trick and Enns, 1998). The developmental changes in performance on attention tasks may be due to age-related increases in either attentional capacities or utilisation of strategies. In behavioural studies, there are increases in processing speed with age across a wide range of tasks (Kail, 1993). However, some investigators have not found evi-

dence of developmental differences in parallel processing between children 7–8 years of age and adults (see Plude et al., 1994, for a review). The controversy as to whether attentional processes are mature at a young age is due in part to the difficulty in measuring these processes without the contamination from other behaviours, such as motor responses, which show marked maturational changes. As ERPs assess cognitive processing independently of behavioural measures, they can determine the presence or absence of developmental changes in specifically attentional processes. Developmental studies in selective attention can also contribute to validating model(s) based exclusively on adult data; if a model can also explain developmental data, then that profers strong support for the model's validity (Enns, 1993).

Thus, the current study was designed to investigate parallel and serial processing across the age range in which parallel processing is suggested to be mature, and to determine which model of visual selective attention could best account for the developmental findings.

2. Methods

2.1. Subjects

Forty children, divided into three age groups: 7–8 years (mean 7.8 ± 0.45 years, $n = 13$), 9–10 years (mean 9.6 ± 0.48 years, $n = 14$) and 11–12 years (mean 11.4 ± 0.49 years, $n = 13$) were studied. All subjects were in the age-appropriate grade at school, had no history of neurological, behavioural or psychiatric disorder, and all had normal or corrected to normal eyesight. Thirty-seven subjects were right-handed, and one left-handed subject was in each age group. Subjects used their preferred hand for behavioural responses (button presses). There were eight males in the 7–8-year-old group, six in the 9–10-year-old group, and nine in the 11–12-year-old group. The children had been recruited via friends and colleagues within the institution and local schools.

All children were given the WRAT-R and abbreviated WISC-III (block design and vocabu-

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