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Timing matters: Age-related changes in episodic retrieval control as revealed by event-related potentials

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ABSTRACT

The retrieval of information from episodic memory involves the engagement of pre-retrieval control processes that facilitate the recovery of task-relevant information. The development of these processes was investigated here by comparing neural correlates of retrieval orientation between 13–14-year-old adolescents and young adults. In each age group, event-related potentials (ERPs) elicited by new test pictures were contrasted across two recognition memory tasks (specific vs. general retrieval tasks), which were designed to place greater demands on the recovery of perceptual information associated with each picture in the specific than in the general task. Memory accuracy was higher in the general than in the specific task but did not differ between age groups. In adults, new item ERPs at anterior sites were more positive going in the specific than in the general task from 400 to 1200 ms. In adolescents, the onset latency of this effect was delayed by 300 ms relative to adults, even though no age differences in response speed were obtained in either task. The magnitude of the ERP new item effect in adults correlated with response accuracy, consistent with the view that pre-retrieval processes facilitate the recovery of task-relevant information. For adolescents, this relationship was only obtained for a subset of participants with early onsetting ERP effects, supporting the claim that the influence of pre-retrieval processes depends upon their temporal onset. Together, the findings suggest age-related changes in the efficiency of using control processes to facilitate successful retrieval while highlighting the role of onset latency in mediating these changes.

1. Introduction

Recent accounts of episodic memory development have emphasized the view that the development of cognitive control processes plays a fundamental role in episodic remembering throughout childhood and adolescence (Ghetti et al., 2012; Ofen, 2012; Shing et al., 2010). These control processes enable the increasing use of memory strategies with age, such as children's more frequent and efficient use of semantic organization during the formation of episodic memories. Equally important, however, is the influence of control processes on the development of strategies engaged during retrieval.

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Several models of episodic memory retrieval assume that there are functionally distinct processing stages at which cognitive control can support the implementation of different kinds of retrieval strategies (e.g., Moscovitch and Winocur, 2002; Schacter et al, 1998). A critical assumption of these models is that the specific contributions of retrieval control processes differ depending on whether they occur before or after the recovery of information. In the present report, the focus will be on the development of processes engaged before retrieval, because these processes have been conceived as one of the key determinants of the degree to which retrieval is successful (Burgess and Shallice, 1996; Mecklinger, 2010). In particular, pre-retrieval processes are assumed to be responsible for constraining and maintaining task-dependent representations of the retrieval cue, in order to specify which parts of the memory trace that is related to the cue should be accessed. These constraints in retrieval cue processing have also been described in terms of retrieval orientations, which are cognitive sets that are maintained according to the specific demands of the retrieval task and can be initiated before a memory judgment is made (Rugg and Wilding, 2000).

Evidence from neuropsychological and functional neuroimaging research indicates that retrieval control processes depend on an ensemble of prefrontal cortex (PFC) regions and their interactions with the medial temporal lobe (MTL) memory system (Simons and Spiers, 2003). Structural brain maturation within the PFC, in turn, has been shown to follow a protracted developmental course, with the evidence suggesting that critical changes occur through adolescence in the form of synaptic pruning and myelination (O'Hare and Sowell, 2008). This is consistent with neuroimaging findings showing that the functional development of the networks that underlie cognitive control continues through adolescence (Luna et al., 2010). As there is no evidence about developmental changes in pre-retrieval processing during adolescence available to date, in the present study we addressed these changes by means of event-related potentials (ERPs).

Evidence about the development of controlled retrieval processing is scarce, yet there are a few studies in which ERPs were used to make inferences about the development of processes that occur at retrieval and post-retrieval stages of episodic recollection (for reviews see: Mecklinger et al., in press; Friedman, 2012). The critical ERP data for these inferences were acquired in memory exclusion paradigms, in which participants were required to discriminate between target and non-target items depending on the study context in which the items were learned (see Jacoby, 1991, for details). This paradigm has been employed, for example, in studies in which an ERP index of recollection – the parietal old/new effect – was compared across groups of 8–11-year-old children and young adults (Czernochowski et al., 2009; Czernochowski et al., 2005; Sprondel et al., 2011). A key observation from these studies was that ERP old/new effects elicited by non-targets were present in adults but virtually absent in the children groups, which has been taken to suggest that the processes that underlie the strategic control of recollection are still immature in late childhood and develop during adolescence.

Evidence consistent with the role of adolescent development comes from a recent exclusion paradigm, in which young adults and 13-year-old adolescents made target/non-target judgments depending on the color of previously studied words (Sprondel et al., 2012). A critical aspect in which that paradigm differed from the aforementioned exclusion tasks was the emphasis on only one class of diagnostic information distinguishing between targets and non-targets, because this can be assumed to increase the degree to which it is useful to rely on a selective retrieval strategy by which recollection of target information is prioritized over non-target recollection. In line with this was the finding that the adults showed reliable parietal ERP old/new effects for targets only, whereas for adolescents, these effects were reliable for targets and non-targets. Alongside the observation that the adults showed higher levels of target/non-target discrimination than adolescents, this pattern of results was interpreted as evidence for age-related changes in the selective control of recollection, in so far as the absence of non-target ERP old/new effects in adults suggested greater success in prioritizing target content (Sprondel et al., 2012). Of additional interest to those data are findings from studies in which ERP correlates of post-retrieval control processes were reported to be absent in adolescents or less refined compared to those observed in adults (de Chastelaine et al., 2007; Sprondel et al., 2011, 2012). Findings such as these were taken to indicate that control processes that operate downstream from the recovery of information also develop over the adolescent years.

The evidence reviewed here argues for a critical role of adolescence in the development of controlled retrieval processing. However, because these changes have only been demonstrated for processes that operate in parallel to or after successful recollection, one question that arises from this data is whether maturation also affects processes that are set in train at pre-retrieval stages of episodic retrieval. The experiment described here, therefore, was designed to determine whether comparable evidence would be obtained by investigating age-related changes in the neural correlates of retrieval orientation.

ERP correlates of retrieval orientation have typically been investigated in paradigms in which contrasts were limited to new (unstudied) items from tasks with distinct retrieval requirements (Rugg and Wilding, 2000; for reviews see: Mecklinger, 2010; Wilding and Ranganath, 2011). It is typically assumed that, because new item ERPs bear no relation to studied items, they provide an uncontaminated index of retrieval cue processes engaged before retrieval success occurs. Consistent with this assumption is the finding that differences between new item ERPs often emerge as early as 200–300 ms post-stimulus, suggesting that these differences reflect processes engaged prior to item recognition (Hornberger et al., 2006; Robb and Rugg, 2002). It should be noted, however, that there is considerable variability in the timing of ERP new item effects across studies, and that more extended time courses of these effects may index periods during which cue processing continues in the face of retrieval failure (Hornberger et al., 2004).

An important related finding is that ERP indices of pre-retrieval processing predict response accuracy, consistent with the assumption that these processes facilitate the recovery of task-relevant information (Bridger et al., 2009; Bridger and Mecklinger, 2012). For example, Bridger and Mecklinger (2012) contrasted the differences between new item ERPs in distinct retrieval tasks and observed that the magnitudes of these differences – reflecting the degree to