CORTEX 49 (2013) 1452–1462

Available online at www.sciencedirect.com

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Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

The role of working memory capacity in the control of recollection

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ARTICLE INFO

Article history:
Received 31 August 2011
Reviewed 19 March 2012
Revised 12 June 2012
Accepted 25 July 2012
Published online 27 August 2012

Keywords:
Recollection
Episodic memory
Cognitive control
Event-related potentials (ERPs)
Working memory capacity

ABSTRACT

The links between control over recollection and working memory capacity (WMC) were investigated using event-related potentials (ERPs) and behavioural assays. Electrophysiological evidence for a relationship between greater control over recollection and higher scores on a measure of WMC was obtained. In addition, people with high WMC who first completed a task requiring cognitive control showed no electrophysiological evidence for control over recollection on a subsequent task. This outcome suggests a causal link between control over recollection and the availability of WMC, in so far as the consequence of completing the first task was a reduction in WMC that impacted on completion of the subsequent task. All participants also completed a final recall task, on which they were asked to remember the stimuli they had encountered during the task in which ERPs were acquired. Only those participants who showed electrophysiological evidence for the exertion of control over recollection showed differences between the likelihoods of recalling stimuli over which control either had or had not been exerted. In combination, the findings provide insights into the conditions under which control over recollection occurs, and make a strong argument for including individual difference measures of resource availability when assessing how and when people exert control over what they remember.

1. Introduction

Recollection is a retrieval process associated with the recovery of qualitative information about studied events. The process is widely assumed to be under some degree of voluntary control (e.g., Burgess and Shallice, 1996; Johnson, 1992; Schacter et al., 1998; Yonelinas, 2002). In this paper, we describe findings in a study where event-related potential (ERP) data were acquired, alongside behavioural assessments, to understand: (i) how control over recollection is exerted when people must adjudicate between contexts in which events were encountered, and (ii) pre-requisites for exerting control over recollection.

The study described here was motivated by findings in a series of ERP studies in which systematic changes in the magnitude of an electrophysiological index of recollection – the left-parietal ERP old/new effect – have been used to infer that some form of control over recollection has taken place. ERP old/new effects are measured by comparing neural activities that are elicited in response to old (previously studied) and new (unstudied) stimuli that attract correct judgements during a retrieval task (Rugg, 1994). The left-parietal ERP

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http://dx.doi.org/10.1016/j.cortex.2012.07.003

old/new effect comprises a greater relative positivity for old than for new stimuli, which is largest at left-posterior/parietal scalp locations between approximately 500 and 800 msec post-stimulus (Wilding and Sharpe, 2003). The evidence linking this effect to the process of recollection is substantial, and is not re-reviewed here (see Donaldson et al., 2003; Friedman and Johnson, 2000; Rugg and Curran, 2007). The key finding to emphasise is that the left-parietal effect is sensitive to either the amount or quality of contextual information that is recovered from memory (Vilberg et al., 2006; Vilberg and Rugg, 2009a, 2009b; Wilding, 2000). Consequently, changes in the magnitude of the effect have been argued to index the extent to which recollection has occurred (Paller et al., 1995; Wilding and Herron, 2006). In some circumstances, moreover, changes in the magnitude of this ERP effect across certain experimental conditions have been used to make inferences about when control has been exerted over recollection (Evans et al., 2010; Herron and Rugg, 2003; Wilding and Herron, 2006).

The critical ERP data for this latter inference were acquired in exclusion tasks, where participants are commonly exposed to study items in two separate contexts (Jacoby, 1991). Participants make a binary response on an ensuing memory test, during which they are exposed to study items from both contexts, as well as new (unstudied) items. The test requirement is to use one response option for items from one of the two study contexts (hereafter *targets*), and the other response option for new items, as well as those from the other study context (hereafter *non-targets*).

Comparisons between the left-parietal ERP old/new effects elicited by targets and non-targets have formed the basis for inferences about control over recollection. In a number of studies, it has been shown that the likelihood of recollecting information about targets influences the magnitude of the effect for non-targets: the old/new effect for targets is larger than that for non-targets when the likelihood of recollection is relatively high, but more similar to the effect for non-targets as the likelihood of recollecting information about targets decreases (Dzulkifli et al., 2006; Dzulkifli and Wilding, 2005; Herron and Rugg, 2003). This finding has been interpreted as evidence for the selective control of recollection, in so far as the ERP data indicates that some kinds of recollected content are being prioritised over other kinds (Fraser et al., 2007; Herron and Rugg, 2003).

One explanation offered for this pattern of findings is that using the presence or absence of recollected content about targets to make the binary judgement in an exclusion task (an A/not A strategy) is a good approach when recollection of target content is likely, hence the larger parietal old/new effects for targets than for non-targets under those circumstances. The utility of this strategy, however, diminishes as the likelihood of recollecting target content diminishes. Thus, the explanation for the circumstances under which target and non-target old/new effects are comparable is that this reflects a strategy of relying on an assessment of recollected information about non-targets as well as targets when it is beneficial to do so (Herron and Rugg, 2003).

An important development of this account has been offered recently, which is that another determinant of when control over recollection can be exerted is the availability of sufficient cognitive resources. Elward and Wilding (2010) demonstrated that people with increased working memory capacity (WMC) showed greater evidence of selective recollection. That is, they had larger target than non-target ERP old/new effects than people with lower WMC. This outcome did not vary with levels of response accuracy in the exclusion tasks they used.

Elward and Wilding (2010) interpreted WMC as a measure of the availability of cognitive resources, and suggested that, as the likelihood of recollecting information in a task decreases, the demands upon cognitive resources increase. For example, retrieval itself may be more resource-demanding if the quality of recovered information is not high, and this in turn might place additional load on processes involved in monitoring the (degraded) outputs of retrieval. Elward and Wilding (2010) proposed that selective control over recollection would be implemented only when there was sufficient cognitive resource available to do so. Hence individual differences in WMC, and not solely the likelihood of recollecting task-relevant information, determine when control over recollection can be exerted.

In so far as exerting control over recollection is resource-demanding, the findings of Elward and Wilding (2010) might not be regarded as surprising, but there are two related points that are worth making. First, for high WMC participants, response accuracy did not predict when recollection of target content would be prioritised over recollection of non-target content. This raises the possibility that the availability of resource results in a processing style that is not always optimal. Second, WMC is an individual difference variable that is rarely controlled for in functional imaging studies of memory, but the ERP findings described above comprise marked changes in neural activity despite little evidence of behaviour change. In so far as the findings reported by Elward and Wilding (2010) are not peculiar to the exclusion task, the outcome they obtained raises the possibility that group-averaged functional imaging data might not reflect accurately the activity (hence the processes engaged) for all participants contributing to the group average. Moreover, when participants are selected without recourse to WMC scores, it may be that differing WMC profiles across cohorts are the primary driver for differences between measures of neural activity, rather than other task characteristics to which the divergences might be (and most commonly are) assigned.

These possibilities motivated in part the study described here, in a paradigm that is immune to some of the objections that might be raised on the basis of Elward and Wilding's initial findings and interpretations. Elward and Wilding (2010) employed a version of the exclusion task in which items were encountered in one context at study (Jennings and Jacoby, 1997). These were re-presented at test and designated as targets. A proportion of new test items were repeated, and participants were asked to treat the repetitions as non-targets. One potential problem with this design is that the targets and non-targets differ with respect to the time between first and second presentations. This is not typically the case in studies depending upon memory for contextual details (with the exception of studies of temporal context), and it may be that participants relied upon factors such as the relative strengths of memories to make decisions in the test phase. If this was