The role of working memory capacity in the control of recollection

Rachael L. Elward*, Lisa H. Evans and Edward L. Wilding

Cardiff University Brain Research Imaging Centre (CUBRIC), School of Psychology, Cardiff University, Cardiff, Wales, UK

**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.

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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
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 informa-
tion 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 circum-
stances, 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). Par-
icipants 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 require-
ment 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 circum-
cstances. 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 informa-
tion about non-targets as well as targets when it is bene-
ficial 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 recol-
lection. 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-demand-
ing 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 recollec-
tion 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 recol-
lecting 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
contributiong to the group average. Moreover, when partici-
pants 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 diver-
gences 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
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