Brain and behavioral indices of retrieval mode

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In recent event-related potential (ERP) studies of episodic retrieval, ERPs have been acquired in tasks where participants have been cued trial-by-trial to prepare either to make episodic or semantic retrieval judgments. ERPs elicited during this preparatory cue period and separated according to retrieval task have diverged at right frontal scalp electrodes, with a relatively greater positivity associated with preparation for episodic rather than for semantic retrieval. Importantly, this pattern of differences has been observed only on ‘stay’ trials: those trials where the participant was cued to prepare for the same retrieval task on the previous trial. These findings have provided the basis for the proposal that the ERP modulations index processes that support the adoption or configuration of retrieval mode—a tonic process that can be sustained while recovery of episodic information is required and which facilitates the retrieval process. In these studies, however, the preparatory period on each trial was no more than 2000 ms, raising the possibility that, with more time available, neural correlates of these preparatory processes would not be restricted to stay trials. In this experiment, participants were cued trial-by-trial to complete either an episodic or a semantic retrieval task, and the preparatory period was greater than 4000 ms on the majority of trials. In keeping with previous findings, the ERPs elicited by these two cue types diverged principally on stay trials at right frontal electrode locations, suggesting that time to prepare is not the primary determinant of the onset of task-specific preparatory retrieval processing. In an important addition to previous findings, moreover, the accuracy of episodic memory judgments increased with the number of successive trials of the same task that participants completed, a finding consistent with the view that adopting a retrieval mode successfully can influence the accuracy of episodic memory judgments.

Introduction

In recent years, event-related imaging methods have been employed in the study of mnemonic processes that facilitate episodic retrieval. One such class of process—retrieval mode—was introduced by Tulving (1983), who proposed that, in order to retrieve information from episodic memory successfully, it was necessary to adopt a cognitive set which ensured that cues (generated either externally or internally) would be processed primarily as probes of episodic memory (Tulving, 1983; Wheeler et al., 1997). Retrieval mode is assumed to be maintained tonically for as long as episodic retrieval is required (Buckner and Tulving, 1995; Rugg and Allan, 2000). It is also thought to remain invariant across different types of episodic memory task.

It is difficult to make inferences about retrieval mode via behavioral data alone because mode is assumed to affect all items in episodic memory tasks equivalently (Tulving, 1983; Wilding, 2001). Neuroimaging methods can be employed to circumvent this difficulty, however, as neural activity elicited during retrieval tasks can be measured while people are preparing to retrieve different kinds of information from memory. Event-related potentials (ERPs) are particularly useful in this regard as the properties of the technique mean that it is possible to separate neural activity associated with preparing to retrieve from that associated with episodic retrieval itself.

For example, in one study, participants completed two tasks, requiring either an old/new recognition memory judgment or a semantic retrieval judgment (Duzel et al., 1999, 2001). Participants completed short blocks of each task and were cued at the start of each block as to which task to complete. Neural activity elicited by the preparatory cues differed according to whether the cue directed participants to make recognition memory or semantic memory judgments. These differences were maintained for the duration of each test block and were focused over right frontal scalp sites, with ERPs associated with the recognition memory preparatory cue being more positive-going than those associated with the semantic cue. This divergence was interpreted as an electrophysiological correlate of retrieval mode, and these findings are consistent with functional neuroimaging evidence that retrieval mode is associated with activity within right prefrontal cortex (Nyberg et al., 1995; Lepage et al., 2000; Duzel et al., 2001; Grady et al., 2001).

In other studies in which ERPs have been acquired time-locked to preparatory retrieval cues, participants have been cued trial-by-trial as to which task to complete. Morcom and Rugg (2002) employed the same tasks used by Duzel et al. (1999) and again observed more positive-going ERPs at anterior scalp locations in response to the preparatory cue signaling episodic retrieval rather than the cue signaling semantic retrieval. Importantly, however, Morcom and Rugg (2002) observed cue-related differences only

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when a trial (comprising preparatory cue plus the following test word) was preceded by a single trial of the same cue type (a stay trial). Differences according to cue type were absent when a trial was preceded either by a trial of the opposite cue type (a switch trial) or when a trial was preceded by two of the same type (a stay + 1 trial). In light of this finding, Morcom and Rugg hypothesized that the preparatory cue-related differences on stay trials indexed processes involved only in the initial adoption of retrieval mode and that successful adoption of mode requires at least one trial of a given task to have been completed (for related arguments, see Herron and Wilding, 2006). This hypothesis was informed by evidence from task-switching studies that ‘task-set inertia’ (relatively slower and less accurate responses on switch than on subsequent trials) occurs predominantly on the first trial of a new task (Rogers and Monsell, 1995; Monsell et al., 2000; Monsell, 2003).

In a related study, Herron and Wilding (2004) also investigated electrophysiological correlates of preparatory processes linked to retrieval mode. In that task, participants were required to switch between a semantic retrieval task (judge whether the item denotes a moving/non-moving object) and one of two episodic retrieval tasks (retrieve encoding task or retrieve item location). Cues presented prior to each test item directed participants as to which task they were to complete, and each cue type was presented for two successive trials. There was a relatively greater positivity for both episodic cues over right frontal scalp sites than for the semantic cue. Insofar as retrieval mode should remain invariant across different episodic retrieval tasks, this finding is consistent with the view that this modulation indexes processes important for the adoption of retrieval mode. As in the Morcom and Rugg (2002) study, moreover, this effect was evident on stay trials only.

Common to both studies, however, is the fact that relatively short preparatory cue-test item delays were employed (2000 ms or less). It is possible, therefore, that correlates of these retrieval processes were not observed on switch trials simply because their onset exceeded the cue–item delay. This experiment was designed in order to test this possibility by requiring participants to switch between one episodic and one semantic retrieval task and providing a 4300 ms interval between the onset of the preparatory cue and the item to which a memory judgment was required.

This study was also designed in order to address a second issue that arose from the findings due to Morcom and Rugg (2002). In their study, the accuracy of recognition memory judgments did not improve over the course of switch, stay and stay + 1 trials, while reaction times decreased. One explanation for this finding is that adopting retrieval mode facilitates only the time course of retrieval or the efficiency with which retrieved information is processed (Wilding and Nobre, 2001; Herron and Wilding, 2004, 2006). Another possibility, however, is that the use of a recognition memory task in the study of Morcom and Rugg was not optimal for observing changes in response accuracy across trial types because, according to dual-process accounts of recognition memory, correct old judgments can be made on the basis of two independent processes: recollection and familiarity (Mandler, 1980; Jacoby and Dallas, 1981; Yonelinas, 2002).

Morcom and Rugg (2002) suggested that adopting a retrieval mode successfully may influence only the likelihood of recollection and that the trial invariant accuracy of recognition memory judgments they observed was due to the fact that familiarity was available as a basis for test judgments on the majority of trials. In order to assess this possibility, in this experiment, the episodic retrieval task required an explicit context judgment—whether the test item was presented at study on the left or right side of a display. Recovery of contextual information is considered to be the hallmark of recollection, so these task parameters should ensure that the majority of correct location judgments will be based upon this process.

To summarize, the use of the longer preparatory interval than in the study of Morcom and Rugg, as well as the use of an episodic task requiring contextual retrieval, should allow a sensitive assessment of two outstanding issues: first, the extent to which neural indices of processes indexing the adoption of retrieval mode are restricted to stay trials only; second, the question of the behavioral benefits that are conferred by successful adoption of retrieval mode.

**Method**

Eighteen undergraduates aged 18–30 participated in the experiment. All participants were right-handed native English speakers. They were paid at a rate of £5/h and gave informed consent prior to the study. Data from two participants were discarded because they failed to contribute more than 16 artefact-free ERP trials to the conditions of interest. Of the remaining 16 participants, 10 were female. The critical stimuli comprised 240 low-frequency words (MRC psycholinguistic database: frequency 1–9/million: Coltheart, 1981), which were presented in white letters on a black background. The stimuli were presented on a monitor 1.2 m from the participant and subtended maximum visual angles of 0.5° (vertical) and 2.2° (horizontal).

Each complete experiment list comprised ten study–test cycles containing all 240 words. Within each cycle, study phases contained 12 words which required animate/inanimate judgments. Half were presented on the left side of the monitor, and half were presented on the right side. Participants were asked to attend to the location of each word in addition to performing the encoding task. At the outset of each study trial, a fixation asterisk was presented for 500 ms. The monitor was then blanked for 200 ms before presentation of the word. This was presented for 300 ms, after which the monitor was blanked until a response was made. Responses were made by keypress; participants responded with one hand to words denoting animate entities, and with the other to words denoting inanimate entities. Participants were instructed that an animate object was any living thing or part of a living thing.

At the end of each study phase, participants were instructed to take a short break. They were reminded of the test response requirements by the experimenter during this time. This study–test interval lasted approximately 2 min. Each test phase contained the 12 words from the preceding study phase, together with 12 unstudied words. No words were repeated across blocks. Each word was preceded by an episodic or a semantic preparatory cue. The two cue types were denoted by the capital letters O and X, with the letter–task correspondence counterbalanced across participants. The episodic preparatory cue directed participants to prepare to indicate at which location (left or right half of the screen) the subsequent test word had been seen during study. The semantic preparatory cue directed participants to classify the subsequent word as designating a moving/non-moving object. Participants were instructed that a moving object must move in its entirety and of its own volition. These tasks are the same as those employed in our previous study of retrieval mode.
Wilding, 2004). Each task required one of three responses: episodic: left/right/new; semantic: moving/not moving/unsure. Cues (300 ms duration) were replaced by an asterisk (4000 ms) and then the test word (300 ms). The monitor was then blanked until a response was made and remained blank for a further 500 ms before the onset of the next cue. Each cue type was presented for three consecutive trials on the majority of occasions, but four additional ‘catch’ trials were also inserted into each test sequence in order to render it unpredictable. The catch trials also had a cue–word delay of only 1500 ms in order to encourage participants to prepare for each test judgment as soon as each preparatory cue was presented. Data from catch trials were not included in the subsequent analyses.

Participants were asked to balance speed and accuracy equally and to fixate centrally throughout. For each participant, responses to test words were made with one hand for new words, and with the other for old words, location responses being made on two different keys with the index and middle finger of the hand used for old responses. For each participant, the left-most of the two fingers denoted for the location judgments corresponded to the left-hand side of the screen. The old/new designation of each hand was counterbalanced across participants, as was the left/right location of study words, the old/new designation of words and the cue type/test word correspondence. The ten study–test blocks were presented in two different sequences.

EEG was recorded from 25 silver/silver chloride electrodes at midline (Fz, Cz, Pz) and left/right hemisphere locations (Fp1/Fp2, F7/F8, F5/F6, F3/F4, T7/T8, C5/C6, C3/C4, P3/P4, P5/P6, P3/P4, O1/O2) arranged according to the 10–20 system (Jasper, 1958). Additional electrodes were placed on the mastoid processes. EOG was recorded from above and below the left eye (VEOG) and from the outer canthi (HEOG). EEG (0.03–40 Hz; 8 ms/point) was acquired referenced to Cz and re-referenced off-line to linked mastoids. Trials containing large EEG artefact were rejected, as were trials containing A/D saturation or baseline drift exceeding ±80 μV. Other EOG blink artefacts were corrected using a linear regression estimate (Semlitsch et al., 1986). Data were down-sampled off-line to 56 Hz, resulting in a total epoch length of 4180 ms, including a 180-ms baseline relative to which all mean amplitudes were computed.1

Results

All analyses included the Greenhouse–Geisser correction for non-sphericity where necessary (Greenhouse and Geisser, 1959), and epsilon-corrected degrees of freedom are given in the text. The term ‘Episodic Hits’ will be used for correct location judgments to old words in the episodic task and ‘Semantic Hits’ for accurate responses to all words in the semantic task. Correctly classified new test items will be referred to as ‘Correct Rejections’. Trials where the preparatory cue on the preceding trial signaled the opposite retrieval task will be referred to as switch trials. Those where the preceding cue signaled the same task will be referred to as stay trials, and trials where cues on the two preceding trials signaled the same task will be referred to as stay + 1 trials.

Behavioral data

Table 1 shows the accuracy data and associated RTs obtained in the episodic and semantic retrieval tasks, separated according to whether responses were made on switch, stay or stay + 1 trials. For the episodic task, the likelihood of a correct old response to an old word collapsed across the accuracy of location judgment (recognition accuracy) was greater than the likelihood of an old response to a new word on switch, stay and stay + 1 trials (t > 20.00, P < 0.001 in each case). Recognition accuracy was 0.91 on switch trials (0.27 = incorrect source), 0.94 on stay trials (0.23 incorrect source) and 0.93 on stay + 1 trials (0.13 incorrect source). For the semantic task, the likelihood of a Semantic Hit was greater than an incorrect classification on all trial types (t > 2.76, P < 0.001 in each case).

ANOVA of Episodic and Semantic Hits across switch, stay and stay + 1 trials gave rise to an interaction between serial position and task, F(1.5,22.5) = 8.37, P < 0.005. This interaction was followed up by separate trend analyses for Episodic Hits, Semantic Hits, recognition accuracy and judgments to new test items. The trend analysis for Episodic Hits separated according to serial position (switch/stay/stay + 1) revealed a significant increasing linear trend only, F(1,15) = 14.83, P < 0.01, eta2 = 0.50. The trend analysis on the likelihoods of Semantic Hits revealed a quadratic trend, F(1,15) = 7.84, P < 0.25, eta2 = 0.34, in addition to a linear trend, F(1,15) = 18.33, eta2 = 0.55, likely indicating an improvement in accuracy between switch and stay trials, but no further improvement between stay and stay + 1 trials. No reliable linear or quadratic trends were observed in the trend analyses performed on correct old responses collapsed across source accuracy (i.e. recognition accuracy) or on correct new responses. The same trend analyses were completed on the RT data and revealed only reliable decreasing linear trends for the data for Episodic Hits and Semantic Hits (Episodic: F(1,15) = 7.84, P < 0.025, eta2 = 0.35; Semantic: F(1,15) = 17.41, P < 0.001, eta2 = 0.57).

ERP analyses

ERPs associated with the episodic and semantic preparatory cues were separated according to switch, stay and stay + 1 trial

<table>
<thead>
<tr>
<th>Response accuracy</th>
<th>Switch</th>
<th>Stay</th>
<th>Stay + 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Episodic Hits</td>
<td>0.64 (0.20)</td>
<td>0.71 (0.12)</td>
<td>0.78 (0.16)</td>
</tr>
<tr>
<td>Correct Rejections</td>
<td>0.90 (0.10)</td>
<td>0.87 (0.14)</td>
<td>0.91 (0.08)</td>
</tr>
<tr>
<td>Semantic Hits</td>
<td>0.64 (0.20)</td>
<td>0.75 (0.15)</td>
<td>0.75 (0.16)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RTs</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Episodic Hits</td>
<td>1656 (800)</td>
<td>1356 (586)</td>
<td>1204 (518)</td>
</tr>
<tr>
<td>Correct Rejections</td>
<td>1358 (633)</td>
<td>1320 (542)</td>
<td>1286 (641)</td>
</tr>
<tr>
<td>Semantic Hits</td>
<td>1671 (690)</td>
<td>1435 (642)</td>
<td>1360 (601)</td>
</tr>
</tbody>
</table>

1 This low pass filter reduces the likelihood of observing high-frequency changes in neural activity but was necessary due to software limitations with respect to the combination of epoch length and sample rate. Analysis of the data acquired at 8 ms/point for 1944 ms post-cue (104 ms baseline) revealed no differences additional to those reported here. This initial post-cue period is the one in which higher-frequency differences across condition are most likely to occur.
status. The mean numbers of trials (minimum and maximum in parentheses) contributing ERPs for each cue type were as follows: episodic switch: 28 (17–39), episodic stay: 27 (1639), episodic stay + 1: 29 (16–40), semantic switch: 27 (1837), semantic stay: 27 (16–40). An average of 70% of trials contributed to ERP data.

Visual inspection of the data (see Figs. 1 and 2) suggests that ERPs evoked by the episodic cue are more positive-going than those evoked by the semantic cue at right frontal and frontopolar sites from approximately 800 ms until the end of the recording epoch on stay trials (see Fig. 1). This effect is not evident to any noticeable degree on switch trials and attenuated markedly on stay + 1 trials (see Fig. 2).

The ERP analyses constituted an initial global analysis of the preparatory cue-related data from a grid of electrode sites distributed over the whole head (F7/T7/P7, F5/C5/P5, F3/C3/P3, F4/C4/P4, F6/C6/P6, F8/T8/P8). This montage was selected in order to allow for differences according to hemisphere, the anterior/posterior dimension and inferior/mid-lateral/superior site to be identified. The initial analysis incorporated data from three epochs in order to assess whether cue-related activity varied over time. The epochs selected were 800–1800 ms, 1800–2800 ms and 2800–4000 ms, respectively. Only effects involving the factor of cue type are reported here.

The initial ANOVA included the factors of epoch, cue type (episodic/semantic), serial position (switch/stay/stay + 1), hemisphere, anterior/temporal/posterior dimension and inferior/mid-lateral/superior site. It gave rise only to a cue type × serial position × hemisphere × site interaction, F(2.2,33.2) = 3.53, P < 0.05. In the absence of interactions involving epoch, subsidiary analyses were conducted on data collapsed across this factor and were implemented in order to assess the effect of cue type at each level of serial position. No effect of cue type was observed in the analysis of data from switch trials or stay + 1 trials. The analysis of data from stay trials gave rise to several interactions involving cue type, including cue type × hemisphere F(1,15) = 5.01, P < 0.05, cue type × anterior/posterior dimension × hemisphere F(1.9,29.1) = 4.10, P < P < 0.05 and cue type × hemisphere × site F(1.8,27.2) = 6.67, P < 0.005. These interaction terms reflect the fact that ERPs associated with the episodic cue are more positive-going than those associated with the semantic cue, the relative positivity being largest at inferior right frontal sites (see Fig. 1). In keeping with this claim, a subsidiary analysis restricted to right frontal sites (F4, F6, F8) revealed a main effect of cue type, F(1,15) = 6.08, P < 0.05, whereas an analysis restricted to the homotopic left-hemisphere locations did not.

Two further ANOVAs were conducted on the data from these right frontal sites, one for the ERPs elicited by the episodic preparatory cues and the other for those elicited by the semantic cues. A main effect of serial position was observed only in the analysis of the ERPs elicited by the episodic preparatory cues, F(1.9,28.4) = 7.88, P < 0.002; F < 1 for semantic cues. Pairwise comparisons of the mean amplitudes for the three serial positions for the episodic preparatory cues revealed that these were significantly more positive-going on stay trials than on switch trials, F(1,15) = 16.55, P < 0.001. There were also trends for preparatory cue-related activity on stay trials to be more positive-going than on stay + 1 trials, F(1,15) = 4.16, P = 0.06, and more positive-going for stay + 1 trials than for switch trials F(1,15) = 3.48, P = 0.08.

While these analyses have captured the differences according to task and trial type that are sustained for the majority of the recording epoch, there are also some transient differences between conditions that are evident principally on stay trials. For example, there is a somewhat different pattern of divergen-
ces across trial types than that described above at F4 from 2500 to 4000 ms (see Fig. 2). However, directed analyses at this location over this epoch and incorporating the factor of trial type (switch/stay/stay + 1) revealed no reliable effects. Similarly, although ERPs elicited by the two cue types on stay trials appear to diverge at mid-temporo-parietal sites between 800 and 2800 ms (see Fig. 1), no effect of cue type was detected in a focused analysis of these data from C3/Cz/C4/P3/Pz/P4 during this time window. Again, the ANOVA incorporated the factor of trial type. Finally, Fig. 1 shows that a frontally distributed early difference between cue types is apparent on stay trials between 300 and 600 ms post-stimulus. As for the previous directed analyses, ANOVA with factors of cue type, trial type and site (FP1/FP2/F7/F8/F5/F6/F3/F4) gave rise to no effects involving cue type.

Discussion

The initial analysis of ERPs elicited by the episodic and semantic preparatory cues revealed significant differences according to cue type on stay trials only. These differences were evident primarily at right frontal and frontopolar sites. The scalp distribution of these differences is consistent with that observed in previous electrophysiological studies of preparatory retrieval processing (Duzel et al., 1999, 2001; Morcom and Rugg, 2002; Herron and Wilding, 2004), and the fact that the differences are largest on stay trials also replicates previous work (Morcom and Rugg, 2002; Herron and Wilding, 2004). The first new finding here is that this pattern of data was obtained with a cue–word interval of 4300 ms, which is a markedly longer interval than that employed in previous studies (Morcom and Rugg, 2002; Herron and Wilding, 2004, 2006). This pattern of data is broadly consistent with the view that completion of at least one entire trial in a task is necessary for retrieval mode to be adopted fully, although the possibility that differences according to cue type would emerge given longer cue–item intervals cannot be ruled out entirely. Intuitively, however, it seems reasonable to assume that this extended time period is of sufficient length to permit identification in the electrical record of at least the onset of any cognitive reconfiguration and preparation processes that are initiated by a cue on switch trials. It is notable, furthermore, that preparation costs remain even when the cue–item interval extends beyond 5000 ms (Kimberg et al., 2000; Sohn et al., 2000).
Separate analyses of the ERP data at right frontal sites for episodic and semantic preparatory cues confirmed that neural activity associated with the episodic cue varied according to serial position, whereas the activity associated with the semantic cue was insensitive to this manipulation. This finding supports the assertion that cue-related differences observed over right frontal scalp regions can be attributed to differential neural activity elicited by the episodic cues rather than the semantic cues (Morcom and Rugg, 2002; Herron and Wilding, 2004). This is a critical finding if this differential activity is to be attributed to processes related closely to retrieval mode. This attribution, moreover, cannot be made with confidence on the basis of results in which there is only one paired contrast between neural activity elicited during an episodic and a semantic retrieval task.

The absence of differences between the cue-related activity on switch trials, however, contrasts with our findings in a recent study in which participants were required to switch between two episodic retrieval tasks having different retrieval demands (recover either location or encoding task: Herron and Wilding, 2006). In that study, cue-related activity diverged on switch trials but not on stay trials. We suggested previously that this pattern of results, alongside the data due to Morcom and Rugg (2002), indicated that switching between a semantic retrieval task and an episodic task may require a greater degree of cognitive reconfiguration than is required to switch between two episodic retrieval tasks. The findings in the present study are consistent with this account and extend it to the circumstance in which the episodic retrieval task requires explicitly the recovery of contextual information.

We also argued that the cue-related indices of retrieval orientations that were obtained reflected processes that were important for the initial adoption rather than the maintenance of a retrieval set (Herron and Wilding, 2006). The reason for this was that differences according to cue type were attenuated on stay trials in comparison to switch trials. In the present experiment, the comparable pattern of data is evident across stay and stay + 1 trials, again suggesting that these indices reflect processes that are important for adoption rather than maintenance of a tonic retrieval set. This claim is also supported by the behavioral data, where the accuracy of episodic judgments increased across switch, stay and stay + 1 trials, and the associated RTs decreased over this trial sequence. The fact, moreover, that ERP differences according to cue type were largest on stay trials, while the accuracy of task judgments increased linearly across trial sequence in the episodic task, suggests that these findings cannot be explained simply in terms of the difficulty of the task across switch, stay and stay + 1 trials.

The pattern of accurate responses on the retrieval tasks here is also important for other reasons. In keeping with the findings of Morcom and Rugg (2002), old/new recognition accuracy (correct old responses collapsed across correct/incorrect location judgments) showed no significant effect of serial position. Morcom and Rugg (2002) suggested, however, that the absence of changes in recognition accuracy in their study was due to the requirement only to make old/new recognition memory judgments. According to dual-process models (see Introduction), judgments on old/new recognition memory tasks can be based on two independent processes—familiarity and recollection (Mandler, 1980; Jacoby and Dallas, 1981). Morcom and Rugg suggested that the absence of changes in accuracy across switch, stay and stay + 1 trials might be due to the fact that adopting retrieval mode successfully influences only the availability of recollection for task judgments and that the absence of changes in accuracy according to serial position came about because of the availability of familiarity for a high proportion of old/new judgments.

The pattern of behavioral data in this study is consistent with that account since a reliable linear trend was obtained when the analysis of response accuracy was restricted to test words judged correctly to be old and assigned correctly to study location. Insofar as accurate location judgments depend upon recollection rather than familiarity, these findings support the account offered by Morcom and Rugg (2002) for the null result in their study.

An alternative interpretation of these findings, however, is that the changes in the accuracy of location judgments come about not because of the extent to which participants have adopted successfully retrieval mode but because of task-specific episodic retrieval processes—retrieval orientations. These are also tonically maintained retrieval processes, but unlike mode, they vary according to specific episodic retrieval demands. Support for the concept of orientation, and the distinction between orientation and mode, comes from analyses of cue-related and item-related ERPs in studies of episodic retrieval (for cue-related data, see Herron and Wilding, 2004, 2006; for item-related data, see Herron and Rugg, 2003; Dzulkifli and Wilding, 2005; Dzulkifli et al., 2006).

This possibility cannot be ruled out on the basis of the data described here, but our findings in a previous study are consistent with the view that the critical determinant for the changes in the accuracy of location judgments is the extent to which retrieval mode is adopted successfully. Herron and Wilding (2006) cued participants trial by trial to recover information about location or about which of two encoding tasks had been associated with an item in a prior study phase. In this design, there were no changes in the accuracy of these two kinds of episodic judgment according to serial position, and cue-related differences between ERPs were restricted to switch trials, as described earlier in this section. Insofar as changes involving retrieval mode were required in the present study but not in our previous study (where mode was constant but switches between orientations were required), the current data are consistent with the view that the reason for the changes in the accuracy of location judgments arose because of changes across trial types in the extent to which retrieval mode was engaged.

There is also another departure between the accuracy data in this study and the study of Morcom and Rugg (2002). In the semantic retrieval task, the accuracy of task judgments was superior on stay trials than on switch trials, which was not the case in the study due to Morcom and Rugg. One possibility is that these costs are a consequence of switching from the location task rather than a task requiring simply old/new recognition judgments, an account that is broadly in line with the assumption that in part the ease with which it is possible to switch between tasks having different requirements is a function of the task that is being switched from as well as the task that is being switched to. It is arguably unsurprising that the accuracy of task judgments on semantic retrieval tasks can also vary according to the opportunity to prepare, but the present data also suggest that any such task-specific preparatory processes do not elicit the same benefits on task performance as those associated with the episodic task. The reason for this claim is the different profile of errors across the two tasks: changes in the semantic retrieval task were restricted to
switch and stay trials, while extending to stay + 1 trials in the episodic task.

We now turn to the question of the mechanisms by which benefits are conferred upon performance by adopting successfully an appropriate retrieval set (mode or orientation). In our previous studies, switch costs in retrieval tasks were confined to reaction times (Herron and Wilding, 2004, 2006). On the basis of those findings, we proposed that the benefits of adopting a retrieval set were restricted to facilitating the time course of retrieval processing and that this could happen at different loci. For example, the RT benefits might be due to facilitation of the time course of retrieval or the efficiency with which processes acting on the products of retrieval operate (Herron and Wilding, 2004, 2006).

The current findings suggest that, while our previous conclusions may hold when switching between episodic retrieval tasks, and therefore different retrieval orientations, they do not extend to switches between a non-episodic task and an episodic task requiring recovery of contextual information. The pattern of behavioral data supports the claim that successful adoption of retrieval mode confers benefits on the accuracy of context judgments, as well as on the time taken to make accurate judgments. With respect to how these increments in retrieval accuracy might occur, either or both of the processing stages discussed above might be implicated in the changes in response accuracy reported in this study: switching requirements may influence the quality or amount of task-relevant information that is recovered or the likelihood that processes operating on retrieved information extract task-relevant content.

It has also been proposed that entering retrieval mode is necessary for successful episodic retrieval to occur (Wheeler et al., 1997). The data that is reported here is certainly consistent with the claim that adopting retrieval mode even partially increases the accuracy of episodic memory judgments. The presence, however, of electrophysiological correlates of retrieval mode only on stay trials in this study and in previous studies does not sit comfortably with the claim that not being in the appropriate retrieval set precludes successful episodic retrieval. This strong claim concerning retrieval mode is also broadly inconsistent with the view that preparatory states cannot be adopted spontaneously (Monsell, 2003).

A further question that follows from the findings in this study concerns whether different or at least partially overlapping brain regions are engaged during adoption/configuration and maintenance of retrieval sets. The limitations of scalp-recorded EEG with regard to unequivocal identification of the underlying neural sources mean that the data acquired using this technique might not speak directly to the question of which neural structures were involved in these types of information processing operation. This limitation notwithstanding, the use of similar paradigms to those described here, along with the acquisition of DC potentials (e.g. Duzel et al., 1999), offers a means of assessing whether the same or different brain regions are engaged during sustained and transient episodic retrieval processing. In recent fMRI studies of memory retrieval, moreover, there is evidence that some brain regions support sustained as well as transient retrieval processes, while other regions support only one of these two kinds (Donaldson et al., 2001; Velanova et al., 2003).

Conclusions

Consistent with previous findings, episodic preparatory retrieval cues elicted a sustained positivity relative to Semantic cues, a difference which was largest over right frontal sites between 800 and 4000 ms post-stimulus. As in previous studies, this effect was apparent principally on stay trials, despite the fact that a longer cue–test interval of 4300 ms was employed in this study than in previous similar studies. This finding supports the view that processes related closely to retrieval mode are engaged only when at least one trial requiring episodic retrieval has been completed.

This correlate of retrieval mode, moreover, was attenuated on stay + 1 trials, signaling that this effect reflects processes involved in the adoption and/or configuration rather than the maintenance of retrieval mode. This finding replicates the work of Morcom and Rugg (2002) and extends it to tasks having an explicit requirement to recover contextual information. In combination with findings in PET and fMRI studies of episodic retrieval processing, these data suggest that right prefrontal cortex is important for the initial adoption or configuration of retrieval mode. Whether the role of this region is restricted to this retrieval processing operation or whether it also supports tonic retrieval processing remains to be determined (for a recent approach that has some promise for addressing this issue, see Simons et al., 2005).

The findings in this study also showed for the first time that successful adoption of retrieval mode is associated with an enhancement in the accuracy with which memory judgments are made. This behavioral finding is important because there is only a limited range of circumstances in which manipulations at the time of retrieval influence the accuracy of memory judgments (Baddeley et al., 1984; Craik et al., 1998). An important question for future studies concerns the stages of episodic retrieval processing that are responsible for improvements in the accuracy of memory judgments when successive trials of the same retrieval task are completed.

References


