Retrieval Orientation and the Control of Recollection

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Abstract

■ Event-related potentials (ERPs) were employed to investigate whether recognition test items are processed differently according to whether they are used to probe memory for previously studied words or pictures. In each of two study-test blocks, subjects encoded a mixed list of words and pictures, and then performed a recognition memory task with words as the test items. In one block, the requirement was to respond positively to test items corresponding to studied words, and to reject both new items and items corresponding to the studied pictures. In the other block, positive responses were made to test items corresponding to pictures, and items corresponding to words were classified along with the new items. ERPs elicited during the test phase by correctly classified new items differed according to whether words or pictures were the sought-for modality. This finding was interpreted as a neural correlate of the different retrieval orientations adopted when searching memory for words versus pictures. Relative to new items, correctly classified items studied in both target modalities elicited robust, positive-going "old/new" effects. When pictures were targets, test items corresponding to studied words also elicited large effects. By contrast, when words were targets, old/new effects were absent for the items corresponding to studied pictures. These findings were interpreted as evidence that, in some circumstances, adoption of an appropriate retrieval orientation permits retrieval cues to be employed with a high degree of specificity. ■

INTRODUCTION

The idea that memory retrieval depends upon an appropriate interaction between a retrieval cue and a stored memory representation is embodied in several important approaches to understanding the relationship between memory encoding and retrieval (Morris, Bransford & Franks, 1977; Tulving & Thomson, 1973; Semon, 1923). Central to these approaches is the notion that the way a retrieval cue is processed during a retrieval attempt, in particular, the extent to which the processing recapitulates that engaged during encoding, has a significant bearing on whether the attempt will be successful. This idea has received extensive empirical support (e.g., Roediger, Weldon, & Challis, 1989). In short, other things being equal, a retrieval cue will be more or less effective depending on how it is processed.

Robb and Rugg (2002) suggested that rememberers are sensitive to the importance of optimizing the relation between cue processing and stored memory representations (see also Rugg & Wilding, 2000). According to this suggestion, given the knowledge about the information being probed for, rememberers can adopt a "retrieval orientation" which biases how retrieval cues are processed so as to maximize the likelihood of retrieval success. If this suggestion is correct, it follows that cue processing can be manipulated by varying the nature of the memory representations that must be probed for. Consequent differences in cue processing should be reflected in the neural activity elicited by the cues employed to probe for the different kinds of representation.

Robb and Rugg (2002) reviewed the existing evidence that lent support to the above proposal (Rugg, Allan, & Birch, 2000; Wilding, 1999; Johnson, Kounios, & Nolde, 1997) and attempted directly to test it. In separate study-test cycles, subjects first studied lists of pictures or words, and they then undertook a yes/no recognition memory test with words as the test items. The authors reasoned that subjects would vary their processing of the test items depending on whether they were attempting to retrieve words or pictures. Consistent with this assumption, the event-related potentials (ERPs) elicited by test words corresponding to unstudied items—words associated with unsuccessful retrieval—differed markedly according to whether the study materials were words or pictures. This ERP difference onset approximately 250 msec poststimulus, and it took the form of a topographically widespread, temporally sustained negativity in the waveforms elicited during the picture condition relative to the word condition. This effect was unaffected by the manipulation of task difficulty, which was crossed with the factor of study material to allow material effects to be disambiguated from those due to retrieval "effort" (see Rugg & Wilding, 2000 for a discussion of this notion). Robb and Rugg interpreted their findings as indicating that retrieval cues are indeed processed differently according to the nature of the sought-for representations.

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The aims of the present experiment were twofold. First, we wanted to determine whether subjects can maintain a consistent orientation when relevant and irrelevant memory representations have been encoded in the same study context, and retrieval cues corresponding to the nontarget information are available. To investigate this question we employed a mixed study list and a test task that resembled the ''exclusion'' procedure developed by Jacoby and associates (e.g., Jacoby, 1991; Jacoby & Kelley, 1992). At test, an ''old'' response was required only to retrieval cues corresponding to studied items presented in the sought-for material (targets); a ''new'' response was required for both unstudied items, and retrieval cues corresponding to items studied in the alternative material (nontargets). The finding of an ERP retrieval orientation effect in this task would suggest that one consequence of the adoption of a specific retrieval orientation is the ability to focus retrieval attempts on only a subset of the memories encoded in a given spatio-temporal context.

The second aim of the study was to investigate whether the test instructions (retrieve pictures versus retrieve words) were reflected in the specificity with which the test words were employed to probe memory. That is, given the instruction to retrieve, say, studied words, would test items corresponding to studied pictures also elicit evidence of successful retrieval? To the extent that the adoption of a retrieval orientation permits rememberers to focus cue processing on a ''target'' class of memory representations, cues corresponding to ''nontarget'' representations should be ineffective, and thus fail to elicit nontarget memories. We addressed this question by taking advantage of the well-established finding that, in tests of recognition memory, ERPs elicited by correctly classified old items differ in a characteristic fashion from the ERPs elicited by new items (see Friedman & Johnson, 2000; Rugg & Allan, 2000 for reviews). These so-called ''old/new effects'' onset around 300 msec poststimulus and take the form of greater positivity in the ERPs to old items. It has been proposed (Rugg & Allan, 2000) that the effects reflect the contributions of at least three sets of neural generators, the activity of which can be dissociated on topographic, temporal, and functional grounds. For present purposes, the key point is that, regardless of its exact characteristics, an old/new effect in the ERPs elicited by cues corresponding to nontarget study items would indicate that cue processing was not so specific as to preclude retrieval of nontarget information.

RESULTS

Performance

Behavioral performance is summarized in Table 1. ANOVA of the accuracy data [factors of target material (picture vs. word) and item (target, nontarget, new)] gave rise to significant effects for item, $F(1.5,25.0) = 16.48$, $p < .001$,[1] and for the Material × Item interaction, $F(1.8,30.0) = 12.58$, $p < .001$. Pairwise tests revealed that target accuracy was lower when pictures were targets rather than words, $F(1,17) = 9.19$, $p < .01$, but that there were no differences in either nontarget or new item accuracy according to material. ANOVA of the reaction time (RT) data gave rise to analogous findings [item: $F(1.8,30.5) = 4.68$, $p < .025$; Material × Item: $F(1.9,31.6) = 4.05$, $p < .05$]. Pairwise tests demonstrated that target RTs were slower when pictures were targets, $F(1,17) = 5.14$, $p < .05$, but that neither nontarget nor new item RTs differed according to material (F's < 2).

Table 1. Percent Accuracy and Reaction Time (msec) for Correctly Classified Targets, Nontargets, and New Items

Target Material	*Item Type*	*% Correct (SD)*	*RT (SD)*
Pictures	Targets	74 (13)	1214 (179)
	Nontargets	90 (10)	1234 (206)
	New	93 (7)	1275 (295)
Words	Targets	84 (10)	1104 (178)
	Nontargets	86 (8)	1236 (172)
	New	91 (6)	1182 (228)

Additional planned ANOVAs were conducted to determine whether accuracy or RT differed between correct rejections as a function of item type (nontarget vs. new) or target material (picture vs. word). ANOVA of the accuracy data gave rise to a main effect of item type, $F(1,17) = 6.53$, $p < .025$, but to no effects for material, $F(1,17) = 1.18$, or for the interaction between these two factors ($F < 1$). The effect reflects the tendency for nontarget responses to be slightly less accurate (3.8% collapsed over task) than responses to new items. ANOVA of the RT data gave rise to no main effects (F's < 1) but revealed a reliable interaction, $F(1,17) = 5.36$, $p < .05$. The interaction reflects the fact that whereas responses were somewhat quicker for nontargets in the picture condition, there was a trend in the opposite direction when words were the targets. Pairwise comparisons failed however to reveal significant effects for either the within-tasks contrasts between nontarget and new responses, or the between-tasks contrasts for each item type.

Event-Related Potentials

Grand average ERPs elicited by correctly classified new items are illustrated in Figure 1, whereas ERPs for correct responses to all three classes of item are shown in Figure 2. The mean number of trials (range in brackets) comprising the ERPs in the picture condition were 25 (16–38), 29 (19–37), and 31 (21–38) for targets, nontargets, and new items, respectively; trial numbers in

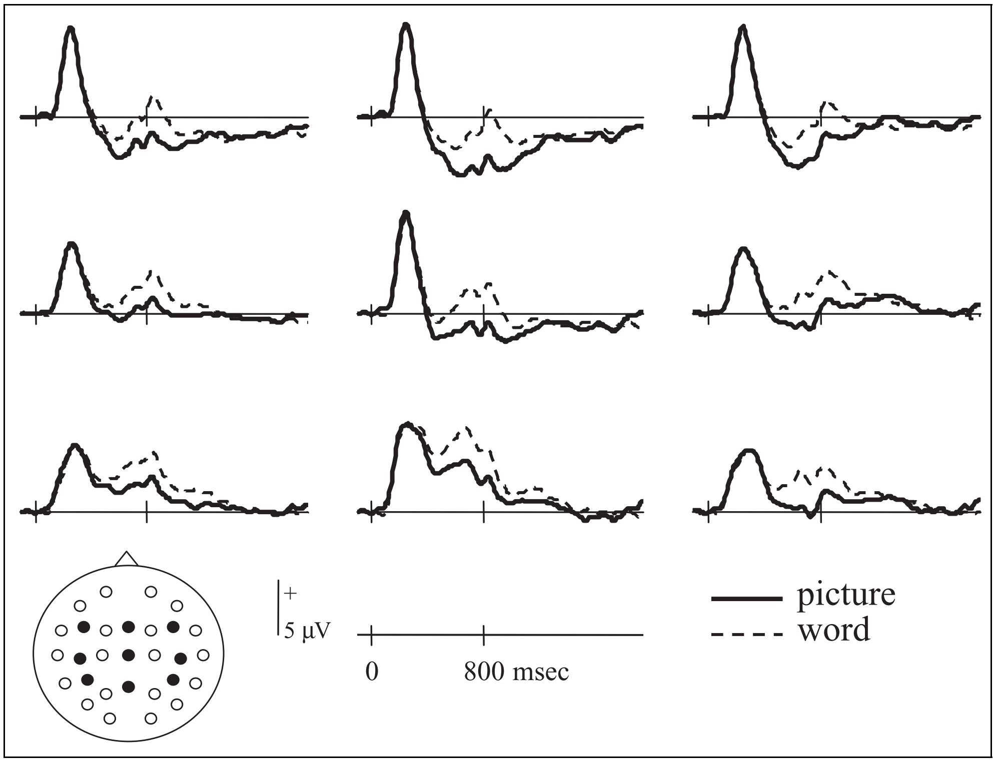


Figure 1. Grand average waveforms elicited in the picture and word conditions by new words at frontal, temporal, and parietal sites. The locations of depicted sites are indicated on the insert.

the word condition were 28 (19–39), 29 (21–36), and 28 (23–35), respectively.

Inspection of Figure 1 reveals that the ERPs elicited by new items appear to differ markedly according to the target material, the ERPs elicited in the picture condition exhibiting more negative amplitudes approximately between 300 and 1000 msec poststimulus. As can be seen in Figure 1, the "old/new" effects elicited by target and nontarget items also appear to differ according to material. In the picture condition, both targets and nontargets elicit more positive ERPs than do new items; this effect onsets around 300 msec, lasts for around 1000 msec, and is widespread over the scalp, appearing to be somewhat more sustained for targets than nontargets. By contrast, when words are the sought-for material, old/new effects appear confined to target items only, the ERPs to nontargets resembling those to new items.

The ERPs were quantified by measurement of the mean amplitude of three consecutive latency ranges—300–600, 600–900, and 900–1200 msec—which roughly correspond to the initial, peak, and late phases of the aforementioned effects. To investigate effects on ERP amplitude, ANOVAs were conducted on data from each latency range obtained from the electrode sites illustrated in Figure 4. Electrodes were factored according to anterior/posterior chain (frontal, central/temporal, parietal), hemisphere, and site (inferior, middle, superior). Effects are reported only if they involve the factor of material or item type. Differences in the scalp topography of ERP effects were investigated on data from all electrodes by ANOVA of difference scores representing the effects of interest. These scores were rescaled prior to analysis to remove the potentially confounding effects of global amplitude differences (McCarthy & Wood, 1985).

ERPs to New Items

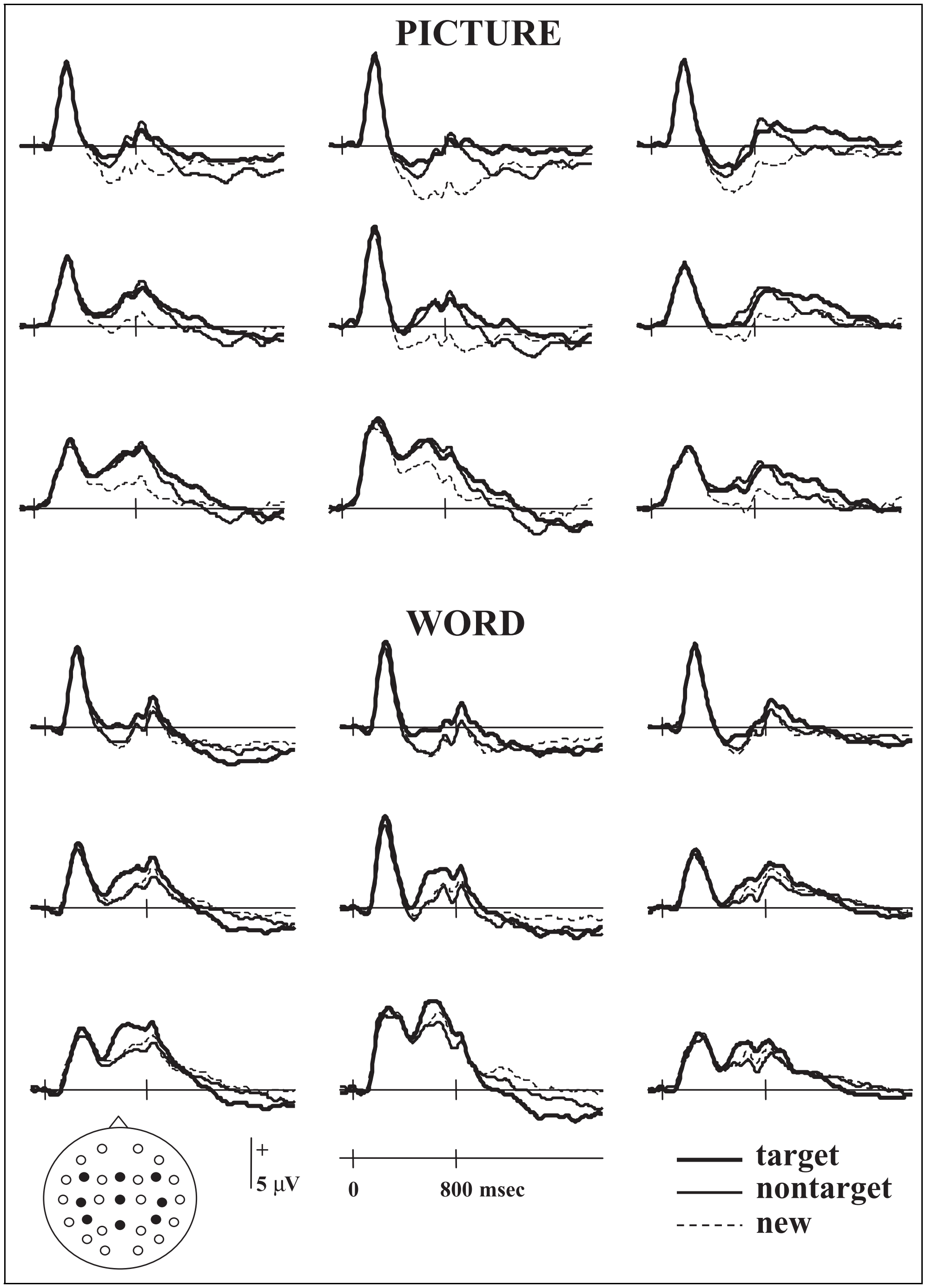
Consistent with the impression given in Figure 1, ANOVAs for the three latency ranges each gave rise to significant effects of material, $F(1,17) = 16.86$, $p < .001$, $F(1,17) = 27.86$, $p < .001$, and $F(1,17) = 5.75$ $p < .05$, for the 300–600, 600–900, and 900–1200 msec latency ranges, respectively, reflecting the more negative ERPs when pictures were the target material. In the case of the last of these ranges, the main effect of material was unmodified by any interactions. For the 300–600 msec range, material interacted with electrode site, $F(1.3,21.4) = 9.61$, $p < 0.005$, and for the 600–900 msec range, it interacted both with site, $F(1.3,21.9) = 11.99$, $p < 0.001$, and with Site × Chain, $F(2.5,42.4) = 5.19$, $p < 0.01$.

The foregoing analyses indicate that the ERP differences evident in Figure 1 are highly reliable, and they suggest also that their scalp topography may vary with time. However, ANOVA of the topography of these differences according to latency range revealed no evidence of a Range × Electrode Site interaction ($F < 1$).

ERP Old/New Effects

Analysis of old/new effects proceeded in two stages. First, the effects were evaluated separately for the picture and word conditions to assess the reliability of

Figure 2. Grand average waveforms elicited in the picture and word conditions by targets, nontargets, and new words. Sites as depicted on the insert.



effects elicited by the target and nontarget items. These analyses employed ANOVAs with factors of item type (target, nontarget, new) and the site variables described previously. The results of these ANOVAs, and associated subsidiary contrasts, are given in Table 2. Second, target and nontarget effects elicited in the picture and word conditions were compared directly by ANOVA of difference scores representing the effects (i.e., target–new, nontarget–new). The results of these analyses are given in Table 3. Finally, the scalp topographies of the old/new effects were contrasted using the same approach as that described in the preceding paragraph.

As is evident from Table 2, ANOVA of the data from the picture condition revealed significant old/new effects for both targets and nontargets in all three latency ranges. By contrast, old/new effects in the word condition were found for targets only, the nontarget ERPs failing to differ from ERPs to new items in any latency range.

For the 300–600 msec latency range, ANOVA contrasting the old/new effects across conditions revealed no significant differences. In the two subsequent latency ranges (see Table 3), both target and nontarget old/new effects were reliably smaller in the word condition; reliable interactions between material and item type indicated that these differences between the conditions were greater for nontargets than targets.

In summary, when pictures were the sought-for material, both target and nontarget items elicited old/new effects in all three latency ranges. In the word condition, however, only targets elicited such effects. Direct contrasts revealed that, with the exception of the 300–600 msec latency range, target and nontarget old/new effects were both greater in magnitude in the picture condition.

The aforementioned differences among old/new effects were manifested in a mixture of main effects

Table 2. ANOVA Results of Within-Condition ERP Analyses for Each Latency Range

Target	*Comparison*	*Effect*	*300–600 msec*	*600–900 msec*	*900–1200 msec*
Pictures	Targets/nontargets/new	CC	$F(1.5,26.0) = 4.44$, $p < .05$	$F(2.0,33.2) = 19.57$, $p < .001$	$F(1.9,32.2) = 11.69$, $p < .001$
		CC/HM/ST	–	$F(2.6,43.7) = 3.41$, $p < .05$	–
		CC/HM/AP	–	–	$F(3.0,51.7) = 3.26$, $p < .05$
		CC/AP/ST	–	$F(4.1,70.3) = 5.67$, $p < .001$	$F(4.0,68.7) = 2.90$, $p < .05$
	Targets/new	CC	$F(1,17) = 15.76$, $p < .001$	$F(1,17) = 28.88$, $p < .001$	$F(1,17) = 30.56$, $p < .001$
		CC/ST	$F(1.2,21.0) = 4.64$, $p < .05$	$F(1.2,19.8) = 22.30$, $p < .001$	$F(1.1,18.8) = 7.24$, $p < .025$
		CC/HM/AP	–	$F(2.0,33.8) = 4.89$, $p < .025$	–
		CC/HM/ST	–	$F(1.4,23.6) = 4.54$, $p < .05$	–
		CC/AP/ST	–	$F(2.5,41.9) = 7.65$, $p < .001$	$F(2.4,40.7) = 3.91$, $p < .025$
	Nontargets/new	CC	$F(1,17) = 5.17$, $p < .05$	$F(1,17) = 30.59$, $p < .001$	$F(1,17) = 6.28$, $p < .025$
		CC/HM/AP	–	$F(1.4,23.5) = 4.14$, $p < .05$	$F(1.7,28.9) = 6.92$, $p < .005$
		CC/HM/ST	–	$F(1.5,24.7) = 4.40$, $p < .05$	–
		CC/AP/ST	–	$F(2.7,46.5) = 7.40$, $p < .001$	–
	Targets/nontargets	CC/ST	–	$F(1.5,25.1) = 7.26$, $p < .01$	$F(1.2,20.8) = 17.58$, $p < .001$
Words	Targets/nontargets/new	CC	–	$F(2,34) = 5.98$, $p < .01$	–
		CC/ST	$F(2.4,40.4) = 3.36$, $p < .05$	–	–
		CC/AP/ST	–	$F(3.7,62.3) = 2.84$, $p < .05$	$F(3.3,56.8) = 4.49$, $p < .005$
	Targets/new	CC	$F(1,17) = 7.17$, $p < .025$	$F(1,17) = 12.71$, $p < .005$	–
		CC/AP/ST	–	–	$F(2.1,36.0) = 5.03$, $p < .011$
	Nontargets/new	no sig. effect			
	Targets/nontargets	CC	–	$F(1,17) = 8.54$, $p < .01$	–
		CC/HM	$F(1,17) = 4.58$, $p < .05$	–	–
		CC/ST	$F(1.4,23.2) = 4.33$, $p < .05$	–	–
		CC/AP/ST	–	$F(2.0,33.3) = 3.38$, $p < .05$	$F(1.6,27.9) = 5.39$, $p < .025$

CC = condition (target/nontarget/new), HM = hemisphere, ST = site, AP = anterior/posterior chain.

Table 3. ANOVA Results of Between-Conditions ERP Analyses

	600–900 msec	*900–1200 msec*
PW	–	$F(1,17) = 41.58$, $p < .001$
PW/TN	$F(1,17) = 6.10$, $p < .025$	–
PW/ST	$F(1.2,20.9) = 11.41$, $p < .005$	–
PW/TN/ST	–	$F(1.1,18.2) = 12.98$, $p < .005$
TN/AP/ST	$F(2.5,43.1) = 4.57$, $p < .01$	$F(2.3,39.1) = 5.66$, $p < .005$
Targets: Picture vs. Word		
PW	$F(1,17) = 5.49$, $p < .05$	$F(1,17) = 11.26$, $p < .005$
PW/ST	$F(1.2,19.6) = 9.32$, $p < .005$	$F(1.1,19.5) = 9.72$, $p < .005$
Nontargets: Picture vs. Word		
PW	$F(1,17) = 30.97$, $p < .001$	$F(1,17) = 6.50$, $p < .025$
PW/ST	$F(1.2,21.2) = 7.51$, $p < .01$	–
PW/AP/ST	$F(2.4,40.0) = 3.19$, $p < .05$	–
PW/HM/AP	–	$F(1.8,30.8) = 6.23$, $p < .01$

PW = picture versus word, TN = target versus nontarget, HM = hemisphere, ST = site, AP = anterior/posterior chain.

and a variety of interactions with topographical variables, raising the possibility that the different effects might vary in scalp topography according to latency range, item type, or condition. This possibility was explored in two topographical analyses. In the first analysis, the topographies of the target old/new effects from each condition and latency range were contrasted. In the second, target and nontarget effects from the picture condition were compared. The relevant scalp distributions are illustrated in Figure 3. In neither case did the topographies vary according to target material, item type, or latency range, as evidenced by the failure to find significant interactions between any of these variables and the factor of site.

DISCUSSION

Behavior

Correct classification of words corresponding to targets was slower and less accurate in the picture condition. This result represents an exception to the ''picture superiority effect,'' the finding that recall and recognition are generally better for pictures than for words (Madigan, 1983). As was noted also by Robb and Rugg (2002), however, the picture superiority effect in recognition memory is diminished or reversed when, as in the present study, words are employed as retrieval cues (Mintzer & Snodgrass, 1999; Stenberg, Radeborg, & Hedman, 1995). Presumably, whether a superiority effect is observed under such circumstances will depend on whether it is offset by the reduction in transfer appropriate processing that obtains when study and test items are presented in different modalities.

Subjects made slightly more false alarm to nontargets than to new test items, but this tendency did not vary according to whether words or pictures were the sought for information. Furthermore, in neither condition did RTs to nontargets and new items differ significantly (the seemingly sizeable difference in RTs to these items in the word condition evident in Table 1 was some way from significance, $F(1,17) = 3.11$, $p < 0.1$, and was carried by only 12 of the 18 subjects). Together, these findings suggest that subjects were able to reject nontarget memories with a high level of efficiency. They offer scant evidence that different mechanisms or strategies might have been employed in the two conditions to accomplish this, and thus stand in constrast to the evidence provided by the ERP data discussed below.

ERPs Elicited by New Items

The differences found for new item ERPs represent both a replication and a significant extension of the findings of Robb and Rugg (2002). As in that study, new items elicited more negative ERPs when pictures rather than words were probed for. This effect emerged around 300 msec poststimulus, continued for about 1000 msec, and did not change in its scalp distribution over time. Because no differences were found between the picture and word conditions with respect to new item RT or accuracy, the effect is unlikely to reflect factors such as difficulty or ''effort.'' We assume that the effect is a neural correlate of differences in cue processing engendered by the different test instructions, in other words, that the effect reflects the adoption of different retrieval orientations.

The present findings extend those of Robb and Rugg (2002) in two ways. First, they demonstrate that ERP retrieval orientation effects can be found when both relevant and irrelevant items are encoded in a common study context. They further show that the effects are obtained even when the test list contains retrieval cues corresponding to both classes of study item. These findings suggest that the adoption of a retrieval orientation may not only help to maximize the probability of retrieving targeted memories, but may also reduce the likelihood of retrieving irrelevant memories (see below). One interesting question for future research is whether retrieval orientation, as manifested by the present ERP effects, can be maintained solely on the basis of an instructional set, or whether it must be "reinforced" in some sense by successful retrieval attempts involving the sought-for information. By analogy with findings from studies investigating the neural correlates of retrieval "mode"—a construct closely related to orientation, and referring to a state that biases subjects to treat environmental events as episodic retrieval cues (Wheeler, Stuss, & Tulving, 1997; Tulving, 1983)—it might be expected that instructional set is not sufficient for the maintenance of a specific retrieval orientation (Morcom & Rugg, 2002; Duzel et al. 1999).

A second important question is whether the new item ERP effects observed in the present study and in Robb and Rugg (2002) depend upon the employment of a "copy cue" condition. In both studies, the critical comparison was between a condition where study and test items were in the same physical format, and a condition where format (and, indeed, material) changed. It remains to be determined whether ERP retrieval orientation effects can be obtained when the degree of physical

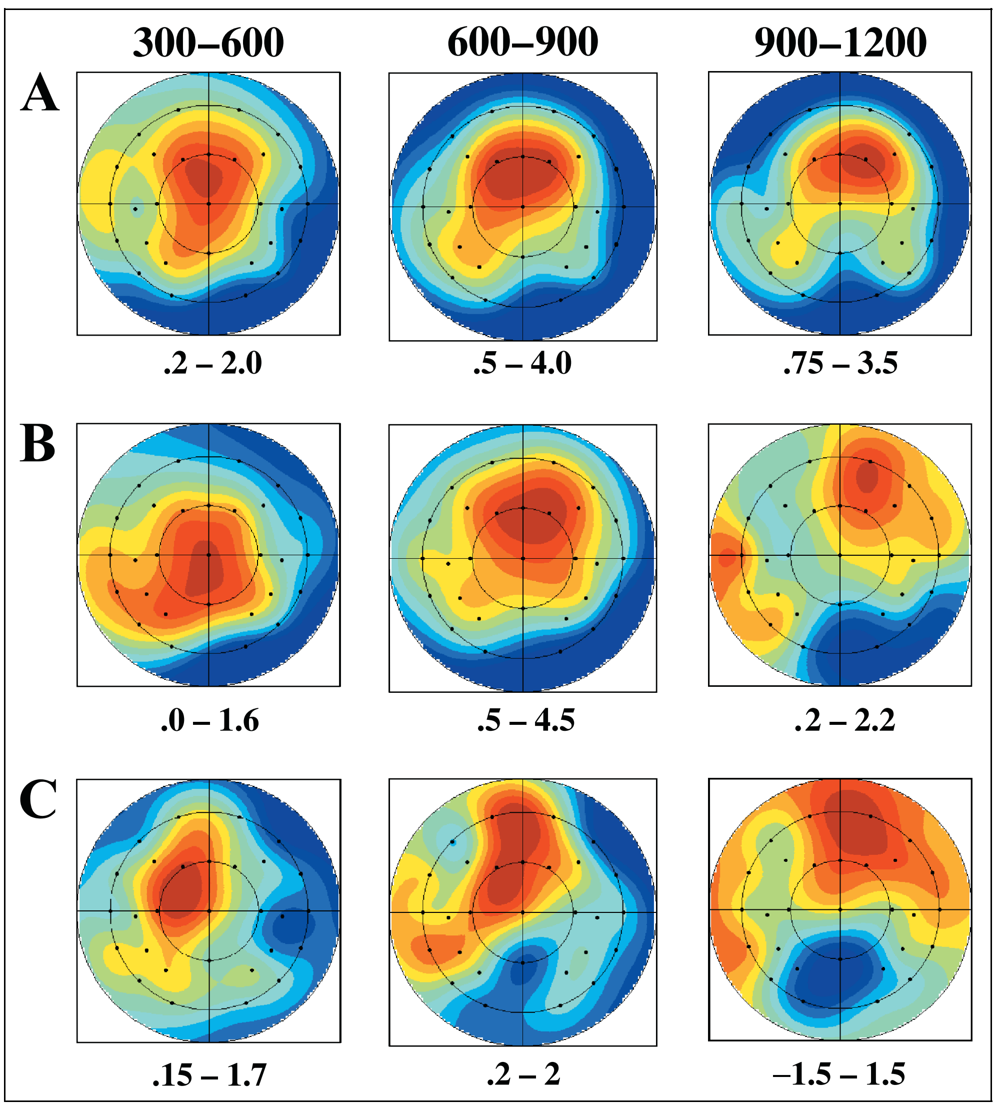


Figure 3. Spherical spline voltage maps showing scalp distributions in the 300–600, 600–900, and 900–1200 msec latency ranges for: (A) target old/new effects in the word condition; (B) target old/new effects in the picture condition; and (C) nontarget old/new effects in the picture condition. Each map is proportionately scaled between the maxima (red) and minima (blue) of the depicted effect (values below in microvolts).

overlap between the different categories of study item and their retrieval cues is held constant.

Old/New Effects

Correctly classified targets elicited robust old/new effects in both conditions. Although the effects were greater in magnitude when pictures were targeted, the scalp distributions of the effects for each type of material were statistically equivalent. These distributions (Figure 3) indicate that the effects included a contribution from the so-called ''left parietal'' old/new effect, a phasic positivity over the left posterior scalp that has been interpreted as a neural correlate of successful episodic retrieval (''recollection''; Curran, 2000; Rugg & Allan, 2000). The left parietal effect is, however, by no means the only contributor to the observed old/new effects; as is evident from the figure, the effects demonstrate a frontal maximum in all three of the latency ranges analyzed and, as in some previous studies (e.g., Curran, Schacter, Johnson, & Spinks, 2001; Wilding & Rugg, 1996), relatively late in the recording epoch the frontal effect demonstrates a trend (albeit nonsignificant in the present case) towards a right-sided distribution.

The results of the topographical analyses of the old/new effects suggest that, at least as can be ascertained from the scalp, a common set of neural populations were engaged regardless of whether it was words or pictures that were successfully retrieved. The interpretation of this finding is unclear. On the one hand, it may indicate that, despite the marked differences in surface format and encoding task, memories retrieved about pictures and words were similar in content. This interpretation rests on the assumption that the scalp distribution of ERP old/new effects should vary according to the content of the retrieved information, as was reported by Senkfor, Van Petten, and Kutas (2002). Alternatively, the similar distributions of the old/new effects in the present study might be construed as further evidence that ERP old/new effects primarily reflect content-insensitive, ''generic'' retrieval processes (Allen, Robb, & Rugg, 2000; Schloerscheidt & Rugg, 1997). It will not be possible to decide between these alternative explanations until more data are available regarding the sensitivity of old/new effects to the content of retrieved information.

A striking dissociation was observed between the two conditions in the old/new effects for nontargets. In the picture condition, these effects were of roughly the same magnitude as those elicited by targets, whereas in the word condition, they failed to achieve statistical significance. These findings point to a difference in the specificity with which the test words were employed as retrieval cues in the two conditions: When searching for studied words, test items corresponding to studied pictures failed to elicit any sign of successful retrieval. When searching for pictures, by contrast, test words corresponding to nontargets appear to have been as effective at eliciting retrieval as were those corresponding to targets. This pattern suggests that subjects were able to adopt a specific retrieval orientation only when probing memory for words. On the contrary, using the test items to probe memory for pictures was accomplished only at the ''cost'' of the retrieval of nontarget memories.

How might this asymmetry be explained? One possibility is that it is a consequence of a reliance on qualitatively different forms of memory in the two conditions. By this argument,[2] in the word condition, subjects were able identify targets on the basis of an acontextual sense of familiarity (Mandler, 1980; Yonelinas, 2002), without the need to recollect information about the items' study episodes. This was possible because familiarity was low not only for new items (because of their unstudied status), but for nontargets also (by virtue of the format change between study and test). Thus, test items were not processed as episodic retrieval cues, and, consequently, there was no recollection of nontarget items. Because of low target familiarity, however, this strategy could not be employed in the picture condition, and, hence, discrimination between targets and nontargets was possible only on the basis of recollection. In the picture condition, therefore, both target and nontarget ERPs demonstrated old/new effects characteristic of episodic retrieval. There are two principal difficulties with this account. First, the assumption that familiarity would be lower when items were studied as pictures than when they were studied as words receives little support from the literature. Whether estimated by the Process Dissociation Procedure (Wagner, Gabrieli, & Verfaellie, 1997, Experiment 1), or the Remember/Know procedure[3] (Wagner et al., 1997, Experiment 4; Dewhurst & Conway, 1994; Rajaram, 1993, Experiment 2), there is little evidence that, when words are the test items, studying pictures leads to lower levels of familiarity than does studying words. Second, it is unclear why targets in the word condition elicited a robust left parietal effect, the ERP signature of successful recollection (Rugg & Allan, 2000). If test items in this condition were not processed as episodic retrieval cues, the effect should have been absent in both nontarget and target ERPs.

An alternative way of accounting for the disparate nontarget old/new effects in the two conditions is to assume that test items were processed as episodic retrieval cues in both cases, but that the items were employed with more specificity when searching for words. By this account, the high level of cue-target compatibility in the word condition permitted retrieval attempts to be focused on the targeted material. For example, subjects may have avoided imaginal or semantic processing of the test items, confining processing to orthographic or lexical levels, that is, to word-specific attributes. By contrast, the more elaborative processing needed for successful picture retrieval may have led unavoidably to the generation of cue representations that shared features with both classes of the encoded study items. Thus, whereas target classification in the word condition could, to a large extent, be based upon the mere detection of a successful retrieval attempt (because retrieval of nontarget information rarely occurred), discrimination between targets and nontargets in the picture condition required evaluation of the content of retrieved information. These differing strategies may underlie the shorter target RTs that were observed in the word condition, as well as the finding that both nontarget and target ERP old/new effects were greater in magnitude in the picture condition. According to the account just given, this finding is a consequence of the retrieval of more episodic information in the picture than the word condition, and a concomitant increase in the magnitude of the associated ERP old/new effects.

The foregoing account implies an alternative explanation for the ''retrieval orientation'' effects observed in the ERPs elicited by new items. According to this explanation, the differences in cue processing represented by these effects do not reflect the adoption of different retrieval orientations, but instead, the requirement to retrieve more information in the picture than in the word condition. This alternative explanation does not, however, offer a satisfactory account of the new item effects also observed by Robb and Rugg (2002). In that experiment, study lists were blocked, test items corresponded to target and unstudied items only, and the old/new effects elicited in the picture and word conditions, while robust, did not differ in magnitude (this latter result is not reported in the article). In light of these findings, we prefer to interpret the ERP effects for new items observed in the present experiment as being due to differences in cue processing consequent upon the adoption of different retrieval orientations.

The present findings are of interest in relation to a recent study in which ERPs were used to investigate episodic retrieval in a different kind of exclusion task (Herron and Rugg, in press). Subjects encoded words in two temporally segregated study lists, and were required subsequently to endorse as ''old'' items from the second study list (targets), rejecting both new items and items belonging to the first list (nontargets). The crucial manipulation was the memorability of target items; in one condition these were encoded in an elaborative study task that led to good subsequent memory, in another condition the task was relatively shallow, and gave rise to much poorer subsequent recognition. Herron and Rugg (in press) hypothesized that both target and nontarget items would elicit a ''left parietal'' old/new ERP effect when target memory was relatively poor. When it was good, however, a left parietal effect was expected for targets only, reflecting the fact that nontargets could be successfully excluded on the basis of their failure to elicit episodic information diagnostic of the target source. These expectations were upheld, leading Herron and Rugg to conclude that subjects are able to adjust retrieval strategies in the exclusion task in order to control whether or not nontarget items elicit recollection, a conclusion similar to that reached here. They suggested that the failure of nontarget items to elicit the ERP correlate of recollection could have arisen either because of a ''cue bias'' (in the terminology of Anderson & Bjork, 1994)—that is, the adoption of a retrieval orientation that focused retrieval attempts on items encoded in list 2—or because of an ''attentional bias,'' a failure to allocate attentional resources to information once retrieved. Herron and Rugg opted for the latter of these alternative accounts as the more likely. On the grounds of parsimony, however, the former account is arguably to be preferred, because it more easily accounts for both the previous and present findings.

In summary, the present findings replicate and extend those of Robb and Rugg (2002), supporting the proposal of those authors that physically identical retrieval cues receive differential processing depending upon the nature of the sought-for information. The findings also point to an asymmetry in the ability to use recognition memory test items to probe for specific kinds of information: A word can be used to selectively retrieve information about a previous episode involving that word rather than its pictorial equivalent, but not vice versa. Together, the findings add weight to the view that investigation of the factors that lead to variations in retrieval orientation, and their consequences for the control of memory retrieval, is likely to be of value in the understanding of episodic retrieval processing.

METHODS

Subjects

Twenty-five subjects participated in the experiment. All subjects were right-handed, had English as their first language, and were aged 18–30 years (mean 22 years). Data from seven subjects were rejected because there were fewer than 16 artefact-free trials in at least one of the critical conditions. Eight of the remaining 18 subjects were men. All subjects gave informed consent before participation in the study, which was approved by an Institutional Ethics Committee.

Stimuli

The experimental stimuli consisted of pools of 240 color pictures of objects and 240 words (ranging in length between four and nine letters), each of which corresponded to one of the pictures (correspondence was operationalized as name agreement between at least five out of six pilot subjects for each picture). These were divided into six pairs of corresponding lists. Eighty-item study lists were formed by randomly

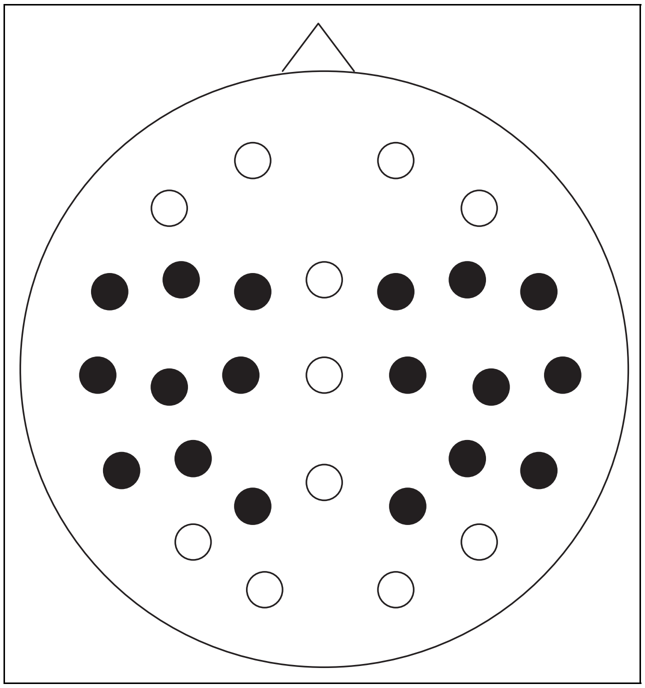


Figure 4. Recording montage and the sites from which data were employed in the analyses of mean amplitude effects (black infills).

intermixing members of one picture list with items from a noncorresponding word list. The accompanying test list was composed of 40 words corresponding to the studied pictures, 40 words corresponding to studied words, and 40 words that referred to items unstudied either as pictures or words. Six study-test blocks were constructed, with objects rotated across study and test lists such that they served equally often as studied pictures, studied words, and new items. The blocks were administered to subjects in a counterbalanced fashion to ensure that every studied item also served equally often as a ''target'' and a ''nontarget'' (see below).

Procedure

Subjects were fitted with an electrode cap prior to the experiment (see below). They were then seated in a sound-attenuated recording booth facing a display monitor with the index fingers of each hand resting on response keys. Two study-test blocks were administered. An interval of approximately 1 min separated the study and test phases in each block, during which time a counting task was undertaken. A short rest was given between the end of the test phase of the first block and the beginning of the study phase of the second block. The target material (words or pictures) in the test phase of the first block alternated across subjects, as did the hand employed for ''old'' and ''new'' responses. At both study and test, the experimental stimuli and the fixation character ''*'' were presented in central vision. Stimuli were presented within a white frame that subtended a visual angle of 3.7° × 3.7°. Words were presented in white upper case letters on a black background. Pictures were presented against a gray background.

The two study-test blocks were identical other than for the designated target material in the test phase. Prior to the appearance of the first item in a list the phrase ''GET READY'' was centrally presented. Study trials consisted of the presentation of the fixation character for 500 msec, followed by presentation of the stimulus for 1500 msec. The screen was then blanked for 500 msec. At test, each trial began with the presentation of the fixation character for 1200 msec. Stimuli were presented 100 msec after fixation offset for a duration of 500 msec. The stimulus was replaced by the fixation character for another 2444 msec, after which the screen was blanked for 200 msec.

During the study phases, subjects performed one of two tasks according to whether the stimulus presented was a picture or a word. If it was a picture, subjects were required to respond on one key if the object depicted would fit inside a shoebox, and to press another key if it would not. If the stimulus was a word, a pleasant/unpleasant judgment was required.[4] The test requirement was to press one key if a word had been presented in the immediately preceding study phase in the target material (i.e., as a picture or word depending on the run), and to press another key if the word was either new or had been studied in the nontarget material. Instructions were to respond as quickly as possible without sacrificing accuracy.

ERP Recording and Analysis

EEG was recorded from 31 silver/silver chloride electrodes, 29 of which were embedded in an elastic cap (these 29 sites were a subset of the ''montage 10'' provided by the supplier of the electrode cap http://www.easycap.de/easycap/english/schemae.htm; see Figure 4). The remaining two electrodes were placed on the right and left mastoid processes. Vertical and horizontal EOG were recorded from electrode pairs situated above and below the right eye and on the outer canthus of each eye, respectively. Recordings were made with respect to the midfrontal electrode (Fz) and were re-referenced offline to linked mastoids. EEG and EOG were amplified with a bandwidth of 0.03–35 Hz (3 dB points) and digitized at 125 Hz. Trials containing horizontal or vertical eye movements other than blinks were rejected, as were trials with A/D saturation or baseline drift exceeding ±55 μV. Contamination of ERPs from EOG artefact was corrected using a method described previously (Maratos & Rugg, 2001).

ERPs (epoch length 2048 msec, 128 msec prestimulus baseline) were formed separately for correctly classified target, nontarget, and new words according to whether pictures or words were the target material.

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Notes

1. Fractional degrees of freedom for these and other *F* ratios arise from the application of the Geisser–Greenhouse correction to compensate for the violation of the sphericity assumption in repeated-measures ANOVA (Winer, 1971).
2. We thank an anonymous referee for suggesting this possibility.
3. Data in the cited studies were rescored to conform to the assumption of independence between familiarity and recollection (Yonelinas and Jacoby, 1995; Yonelinas, 2002).
4. In employing different encoding tasks with pictures and words, the intention was to emphasize differences between the memory representations formed for the two types of item, so as to increase the likelihood that subjects would adopt different retrieval orientations when attempting to retrieve each type. Thus, the relative contributions of task and material to the retrieval orientation effects observed in the present study cannot be determined. This and related questions would be an interesting avenue for future research.

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