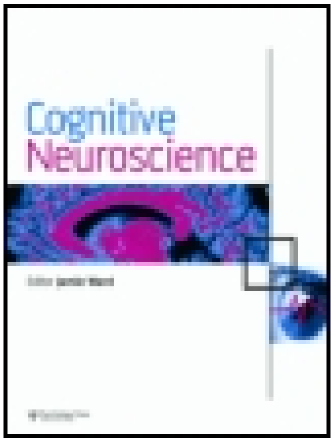

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Control over recollection varies with context-type: ERP evidence from the exclusion task

Emma K. Bridger[a], Volker Sprondel[a] & Axel Mecklinger[a]
[a] Experimental Neuropsychology Unit, Department of Psychology, Saarland University, Saarbrücken, Germany
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Control over recollection varies with context-type: ERP evidence from the exclusion task

Emma K. Bridger, Volker Sprondel, and Axel Mecklinger

Experimental Neuropsychology Unit, Department of Psychology, Saarland University, Saarbrücken, Germany

The left-parietal ERP old/new effect—an index of recollection—is often larger for classes of item to-be-endorsed as old (targets) than to-be-rejected items (nontargets), and this has been interpreted as an index of selective retrieval. The question of interest here was whether selective retrieval would be more pronounced when targets are allocated according to distinct conceptual encoding tasks than when designated according to spatial location. Participants saw words on the left/right side of fixation and made a pleasantness or function judgment to each. Across test-blocks, target designation varied according to the kind of task judgment or the study location. Robust target old/new effects were observed for both classes of target designation but the nontarget amplitude was smaller when conceptual information was targeted. The current data indicate that the class of to-be-retrieved information determines the extent to which recollection can be controlled when all other factors are held constant.

Keywords: Recollection; ERPs; Control over memory.

Many models of recollection assume that this process —the recovery of particular details associated with an event—can be controlled by prefrontally-supported cognitive control mechanisms (Burgess, 1996; Yonelinas, 2002). The possibility that the extent to which recollection can be controlled depends upon stimulus characteristics was examined here, using a robust indicator of recollection-based recognition in the electrical record. The left-parietal event-related potential (ERP) old/new effect refers to the difference between ERPs elicited by correctly responded to old and new items in recognition memory tests, between 500–800 ms post-stimulus which is usually maximal over left-parietal electrode sites (see Rugg & Curran, 2007, for a review). The amplitude of this effect has been shown to correlate with recollection-based recognition judgments in a variety of different paradigms, including with Remember rather than Know judgments (Woodruff, Hayama, & Rugg, 2006) and correct but not incorrect source judgments (Wilding & Rugg, 1996). Of particular interest here, is the finding that the effect correlates with the amount of retrieved details (Vilberg et al., 2006; Wilding, 2000).

One way to garner insight into control over retrieval is to measure the left-parietal old/new effect in a task in which, under some circumstances, it may be useful to prioritize the retrieval of one kind of information over another. One such task is a version of Jacoby's exclusion task (Jacoby, 1991), in which two classes of old items, differing on the basis of their associated study contexts, are presented at test. Participants are required to endorse only items from one of these sets as old (targets) whilst items from the other class are rejected on the same key as new items (nontargets). In one of the first reports to record ERPs

Correspondence should be addressed to: Dr. Emma Bridger, Experimental Neuropsychology Unit, Department of Psychology, Saarland University, Saarbrücken, Germany. E-mail: e.bridger@mx.uni-saarland.de

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during an exclusion task, Herron and Rugg (2003) showed that the left-parietal old/new effect was larger for targets than nontargets, a finding which has been taken to index the prioritization of recovering target over nontarget information. In a second experiment, Herron and Rugg also showed that by reducing the likelihood of retrieving target information via a shallower encoding task, this selective retrieval of targets over nontargets could be removed. Herron and Rugg took these data to indicate that the likelihood of retrieving a target determined the degree of selective retrieval: When this is high, the requirement to retrieve nontargets is reduced because the task can be completed on the basis of a target/not-a-target strategy. When this information is not as easy to recover, a more appropriate strategy is to retrieve both target and nontarget content to complete the task.

In more recent work the influence of other factors on the likelihood of selective retrieval has been investigated. The first of these factors is working memory capacity (WMC), following work from Elward, Evans, and Wilding (2013, 2010) who showed that individuals with higher WMC show more pronounced ERP correlates of selective retrieval in the exclusion task, even when the likelihood of retrieving a target did not vary between WMC groups. These data points can be reconciled with Herron and Rugg's (2003) findings if one notes that in both paradigms, selective retrieval was more pronounced under conditions in which more resources were available (either because of high WMC or because target retrieval was easier). According to this view then, it is the degree to which cognitive resources are available which determine whether control over recollection in the form of selective retrieval will be exerted or not.

In further work, Evans, Wilding, Hibbs, and Herron (2010) investigated the possibility that selective retrieval is more difficult when there is greater content overlap between targets and nontargets. The encoding task associated with targets was kept constant (determining whether items were easy to draw) but two classes of nontargets were employed: Those associated with a size-judgment task thought to contain perceptual information overlapping with that of targets (similar-nontargets), and those associated with a pleasantness task assumed to be associated with information that was more distinct from target information (dissimilar-nontargets). The left-parietal old/new effect was present only for targets and there was no evidence of recollection for either kind of nontarget. Although these data indicate that selective retrieval can take place even when there is content overlap between targets and nontargets, they do not provide any strong indication that information content affects control over recollection, because nontarget retrieval was not evident in either condition. An arguably more powerful approach to determining the limits of controlling recollection would be to start from the assumption that deep encoding tasks of this kind generally allow controlled retrieval because the associated contextual features which they provide are, on average, more distinct and multifaceted than for other kinds of source contexts, such as physically-constrained characteristics like color or spatial location. If this is the case, then selective retrieval should be more likely to occur when targets are designated according to associated conceptual information than when derived from perceptual dimensions, when all other factors are held constant.

This was tested in the current study. Single words were encoded along both a conceptual (one of two tasks employing distinct cognitive operations) and perceptual (presented in one hemi-field of the screen) dimension. Across test-blocks, different classes of contextual information (e.g., items presented on the left at study) were randomly allocated as targets. This ensured that participants were naive to the target designation during each encoding phase and that, although both conceptual and perceptual context was available for each old item, only one particular class of context could signal target/nontarget status. The critical contrasts were thus ERP old/new effects to targets and nontargets separated according to whether conceptual or perceptual information was targeted. At the same time, it was necessary to ensure that the accuracy with which participants could discriminate targets from nontargets was comparable across these two designations to ensure that the context-type manipulation did not reduce target accuracy differences.

METHODS

Participants

Twenty-five native German speakers were recruited from the student population of Saarland University. All were right-handed and had no known neurological problems. Informed consent was required, payment was provided at a rate of 8€/hour or course credit, and participants were debriefed after the experiment. They were also informed that the three participants with the best behavioral performance would receive an additional 10€. Three participants were excluded from the final analysis: Two because we were unable to extract sufficient ($n = 16$) artifact-free trials per critical condition and the final participant was excluded because target-nontarget discrimination was at zero in the conceptual condition. The mean age of the remaining participants (10 male) was 22 years (range = 19–26 years). The experiment was approved by the local ethics committee at Saarland University.

Stimuli and design

Stimuli were 432 low-to-middle frequency concrete German nouns taken from the WebCelex database (Baayen, Piepenbrock, & Gulikers, 1995) between four and eight characters in length. Twelve lists each containing 36 words were created, each of which operated as stimuli for one study-test block. Each set of 36 words was split into six lists of six items, matched for word length and frequency. The matched lists allowed words to be counterbalanced across encoding condition. Twenty-four items were learned in each study-phase. Of these items, six were presented to the left in the pleasantness task, six to the right in the pleasantness task, six to the left in the function task, and six to the right in the function task. The allocation of items to left and right was pseudo-randomized such that words were never presented to the same side more than three times in a row. The order of conceptual tasks, however, was blocked within each study-phase to minimize task switching requirements, and the order in which tasks were encountered was counterbalanced across study-phases. Words presented centrally at a viewing distance of 70 cm subtended maximum visual angles of 1.06° (vertical) and 5.89° (horizontal). Midpoints of stimuli presented peripherally were 7.76° to the left/right of the screen center.

Procedure

Participants completed four study-test blocks in a 15-minute practice block (using an additional 120 concrete German words) to acquaint them with the study requirements and each of the four different target designations. Once all questions had been answered, the participant was allowed to begin the experiment proper, which comprised 12 study-test blocks. Participants could take breaks between blocks and a 3–5 minute break was enforced between the sixth and seventh study-test block.

Trials in the study-phase began with an asterisk (500 ms) which cued the side of the screen on which the word would be presented and was immediately followed by the word presented for 500 ms. Participants were to respond with the keyboard button *w* if the item was presented on the left and *p* if it was presented on the right. This response was prompted with the cue “LINKS oder RECHTS?” which remained on-screen until a response was made. After this response, either the cue “ANGENEHM?” or “FUNKTION?” prompted a yes/no answer using the same keys (*w* and *p*) for the pleasantness (is this item pleasant?) and function task (is it easy to think of a function for this item?) respectively. The task cue remained on-screen until a response was given. The allocation of yes/no responses to *w* and *p* was counterbalanced across participants.

After each study-phase, participants were informed of the target designation for the upcoming test-block, which could be one of four context-types: Items presented to the left, items presented to the right, items encoded in the pleasantness task, or function task. For each target designation, there were three blocks and the order of blocks was randomized so that participants could not guess which would be the targeted information in the upcoming test phase. Participants could not begin a test phase until they had correctly explained to the experimenter what the target designation was. There were 36 words in each test phase: 12 targets, 12 nontargets, and 12 new items. A test trial began with a 500 ms fixation cross, immediately after which the test item appeared for 300 ms. Participants had another 3500 ms to respond with buttons *c* and *m*. The allocation of responses to target and nontarget/new was counterbalanced across participants for the conceptual-task target designations. This was not the case for the perceptual tasks because piloting showed that asking participants to respond to targets presented on the left with a button on the right was too difficult. Thus, all participants responded *c* to targets when left-presented items were targets and the reverse for the right-presented target designation.

EEG parameters

Continuous EEG was recorded from 32 scalp locations based on the international 10–20 system (Jasper, 1958). EEG was acquired referenced to the left mastoid and re-referenced offline to the average of the mastoids. EEG signals were band-pass filtered from 0.016–70 Hz and digitized at a sampling rate of 500 Hz. Electrooculographic activity (EOG) was assessed using signals recorded from four additional electrodes above and below the right eye (vertical EOG) and on the outer canthi (horizontal EOG). Electrode impedances were kept below 5 kΩ. Offline, a digital band-pass filter (0.03–30 Hz) was applied and epochs were created beginning 100 ms prior to and ending 1000 ms after the onset of stimulus presentation. Waveforms were corrected relative to the 100 ms pre-stimulus baseline period. EOG blink and movement artifacts were corrected using a modified linear regression algorithm (Gratton, Coles, & Donchin, 1983) embedded in the eeprobe software package (ANT Software: www.ant-neuro.com/products). Probability values for follow-up analyses were adjusted applying Holm's sequential Bonferroni correction (Holm, 1979), and corrected p-values are reported. The significance level was set to $\alpha = .05$. Analysis of variance (ANOVAs) included the Greenhouse–Geisser correction for non-sphericity where necessary and epsilon-corrected degrees of freedom are given when this was applied.

RESULTS

Behavior

Table 1 shows the mean proportion of correct responses for each item-type separated according to the four levels of target designation. Initial ANOVAs were conducted separately for each target-type with factors of target-level (2: Pleasant/function; left/right), X item-type (3: Target/nontarget/new) and revealed only main effects of item-type (both $F(2, 42) > 20.024$, $p < .001$), indicating no target-level differences in each target-type. Subsequent analyses were conducted on data collapsed across target-level (see Table 3) and began with an ANOVA with factors of target-type (2: Conceptual/perceptual) and item-type (3: Target/nontarget/new) which again revealed only a main effect of item-type, $F(2, 42) = 41.707$, $p < .001$. This main effect reflects the fact that correct responses were more likely to new items than targets, $t(21) = 6.981$, $p < .001$, and nontargets, $t(21) = 8.916$, $p < .001$, and nontarget correct responses were more likely than target correct responses, $t(21) = 3.645$, $p = .006$. Critically, the likelihood of a correct response did not vary with target-level or type.

TABLE 1
Mean proportions of correct responses to targets, nontargets, and new words separated according to target-type and level; numbers in parenthesis represent +/-1 standard deviation

	Word status		
	Target	*Nontarget*	*New*
Conceptual			
Pleasantness	0.74 (0.17)	0.84 (0.11)	0.98 (0.03)
Function	0.74 (0.17)	0.84 (0.09)	0.96 (0.04)
Perceptual			
Left	0.76 (0.17)	0.82 (0.10)	0.93 (0.12)
Right	0.73 (0.18)	0.81 (0.11)	0.94 (0.09)

TABLE 2
Mean reaction times to correct responses to targets, nontargets, and new words separated according to target-type and level; numbers in parenthesis represent +/-1 standard deviation

	Word status		
	Target	*Nontarget*	*New*
Conceptual			
Pleasantness	1164 (271)	1238 (307)	888 (190)
Function	1210 (300)	1221 (281)	936 (213)
Perceptual			
Left	978 (216)	995 (249)	840 (166)
Right	987 (237)	992 (246)	857 (166)

Table 2 shows mean reaction times to correct responses separated according to the four levels of target designation. Initial ANOVAs separated for each target-type and with factors of target-level and item-type revealed main effects of item-type only (both $F(2, 42) > 17.867$, $p < .001$). The data were thus collapsed across target-level and an ANOVA with factors of target-type and item-type, revealed main effects of target-type, $F(1, 21) = 23.710$, $p < .001$, and item-type, $F(2, 42) = 43.241$, $p < .001$, alongside an interaction between target-type and item-type, $F(2, 42) = 16.256$, $p < .001$, were observed. Follow-up contrasts revealed that, for both target-types, responses to targets and nontargets were slower than responses to new items, $t(21) > 4.509$, $p < .001$, whereas there was no difference in response times to targets and nontargets, $t(21) < 1.422$, $p > .169$. The interaction came about because responses were faster to both classes of old items in the perceptual compared to the conceptual-task, $t(21) > 4.870$, $p < .001$, but there was no significant difference in responding to new items across retrieval condition, $t(21) = 2.55$, $p = .133$. The absence of interactions including the factor target-level (pleasant/function; left/right) for both accuracy and speed of responding, licensed collapsing across this factor for the critical ERP analyses. Table 3 shows the mean proportion of correct responses and RTs to these responses collapsed across this factor but separated for target-type (conceptual/perceptual).

TABLE 3
Mean proportions of correct responses and reaction times to correct responses to targets, nontargets, and new words separated according to target-type; numbers in parenthesis represent +/-1 standard deviation

	Word status		
	Target	*Nontarget*	*New*
Conceptual			
p(correct)	0.74 (0.16)	0.84 (0.09)	0.97 (0.03)
RT (ms)	1187 (276)	1230 (281)	912 (196)
Perceptual			
p(correct)	0.75 (0.16)	0.81 (0.09)	0.93 (0.07)
RT (ms)	982 (215)	993 (239)	849 (161)

ERPs

Figure 1 shows the ERPs elicited by correct responses to targets, nontargets, and new items at a left and right parietal electrode. Old/new effects for both targets and nontargets are evident for both target-types from approximately 300 ms onwards. From 500 ms, old/new effects are larger for targets than nontargets in both conditions. Whereas the ERP elicited by nontargets in the perceptual condition is close to that for targets, nontarget ERPs in the conceptual condition are approximately half the size of targets.

The mean amplitudes between 500 and 800 ms from the two electrodes shown in Figure 1, were subjected to an ANOVA with factors of target-type (conceptual/perceptual), item-type (target/nontarget/new) and laterality (left = 3/right = 4). This elicited a main effect of item-type, $F(1.27, 26.59) = 36.11$, $p < .001$, an interaction between target-type and item-type, $F(1.94, 40.77) = 3.61$, $p = .037$, and a marginally significant interaction between item-type and laterality, $F(1.62, 33.92) = 3.15$, $p = .065$. To ascertain the presence of old/new effects, follow-up pairwise comparisons (target vs. new; nontarget vs. new) were conducted on data collapsed across hemisphere and confirmed significant target and nontarget old/new effects for both perceptual and conceptual target-types (conceptual target vs. new: $t(21) = 6.31$, $p < .001$, $d = .54$, conceptual nontarget vs. new: $t(21) = 2.80$, $p = .044$, $d = .22$, perceptual target vs. new: $t(21) = 5.90$, $p < .001$, $d = .62$, perceptual nontarget vs. new: $t(21) = 4.94$, $p < .001$, $d = .44$). The corresponding effect sizes indicate that the amplitude of the perceptual nontarget old/new

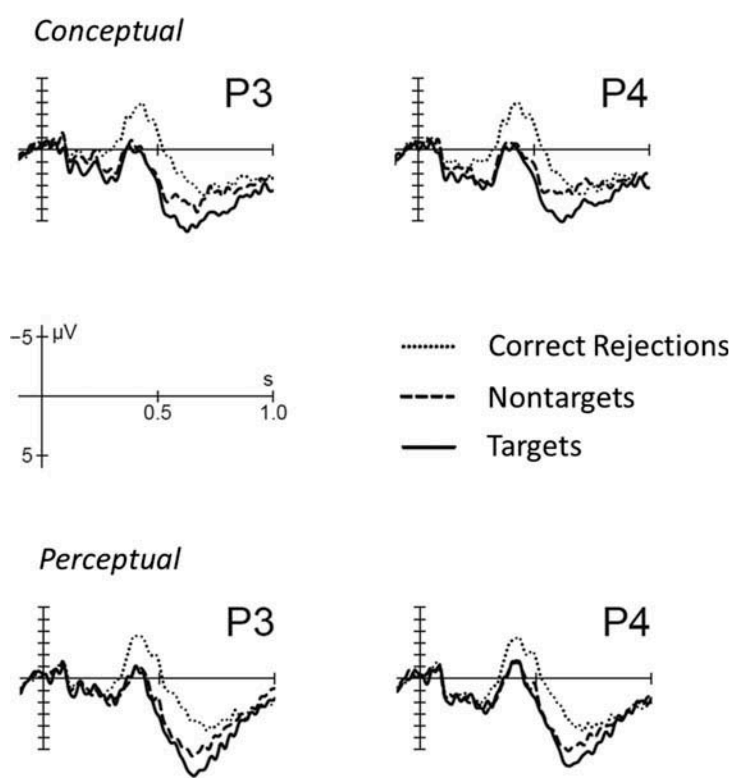

Figure 1. Grand average ERPs elicited by targets, nontargets, and correct rejections separated according to target-type. Data are shown for the parietal electrode locations (P3, P4) used in the principal analyses.

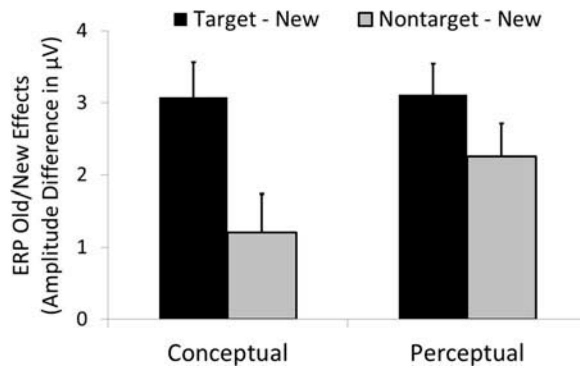

Figure 2. Mean target and nontarget old/new effects shown separately for the conceptual and perceptual target-type. Old/new effects (target minus new, nontarget minus new) are collapsed across left and right parietal electrodes and taken from the 500–800 ms time window. Error bars show +1 standard error.

effect was twice as large as that for the conceptual condition. To confirm this, target and nontarget old/new effects (target-new, nontarget-new; see Figure 2) were submitted to a 2 x 2 ANOVA with factors of target-type and item-type. A main effect of item-type, $F(1, 21) = 44.54$, $p < .001$, was qualified by an interaction, $F(1, 21) = 5.17$, $p = .034$. Pairwise contrasts showed that, whereas target old/new effects were comparable across target-type ($p = .923$), the nontarget old/new effect was marginally significantly larger in the perceptual condition, $t(21) = 2.21$, $p = .076$.

DISCUSSION

Late parietal old/new effects of comparable amplitude were observed for targets both when conceptual and perceptual information designated targets, but the amplitude of the corresponding old/new effect for nontargets was larger when perceptual content was targeted. Differences in the amplitude of nontarget old/new effects in the absence of evidence for corresponding changes for target effects lead us to infer that it is principally control over nontarget retrieval which varied with target designation rather than the amount of recollection per se. It is important to note that differences in selective retrieval across target designation are difficult to attribute to changes in target accuracy, as this was comparable across the two retrieval conditions. Variations in the amount of selective retrieval are thus likely to arise from differences in the kind of information that was retrieved in the two cases.

Why might it be easier to exercise control over retrieval when conceptual information is targeted? One possibility is that the two conceptual tasks provided classes of source details which were sufficiently distinct from one another to support successful targeted retrieval in the corresponding test phases. A related possibility is that the way in which location and conceptual information is bound to study items differs to some degree, and that this has an impact on the extent to which the retrieval of this information can be controlled. In some reports on the impact of different kinds of associations on recognition memory processes, the distinction between intrinsic (e.g., item-color) and extrinsic item features (e.g., background-color) has been made, and recollection has been shown to vary with differences in extrinsic features (Ecker, Zimmer, & Groh-Bordin, 2007). When viewed along this extrinsic-intrinsic dichotomy, spatial location is typically thought of as an extrinsic feature; however, one recent report indicates that familiarity-based recognition processes can also discriminate spatial location (Mollison & Curran, 2012). Such data suggest that spatial location can be unitized or embedded within an item during encoding and thus, that such item-location bindings might be more automatically retrieved at test. Applied to the current findings then, such strong item-location bindings may make it more difficult to prioritize the retrieval of specific locations over others, compared to the selective retrieval of contexts which can be specified by self-generated associated features.

Another explanation arises from the fact that whereas perceptual information was pseudo-randomized at study, the two conceptual tasks were blocked sequentially allowing for the possibility that an additional contextual cue in the form of a temporal tag may have been available to participants in the conceptual but not the perceptual target designation.[1] This aspect of the current design reduces the strength of claims that can be made about how strategic recollection might vary with the extent to which associated information is conceptual as opposed to perceptual. Further research will be required to fully delineate which aspects of associated contextual information most powerfully determine changes in control. What is novel about the current data despite this limitation, however, is that they strongly indicate that features of associated details determine control over recollection when target accuracy and task difficulty are controlled.

Although target accuracy was comparable across conceptual and perceptual retrieval blocks, reaction times were nearly 200 ms quicker when participants allocated responses according to the side of the screen on which items had been learned. This RT difference may denote differences in the accessibility of spatial location compared to the retrieval of associated cognitive operations. It is also possible, however, that this difference came about because responding was easier in the perceptual tasks, as participants always responded to items presented on the left during study with their left hand (and vice versa for items studied on the right). Although it is not possible to exclude this possibility here, it is worth noting that a similar source memory paradigm using comparable classes of source information also reported quicker RTs for location than conceptual information when left/right responses did not correspond with the side of the screen (Bridger & Wilding, 2010). Insofar as RT differences might indicate that more resources are available in one class of retrieval block, either because the corresponding source information is easier or quicker to retrieve, or because response requirements are easier to implement, the current data nonetheless do not correspond with previous reports in which resource-availability has been proposed to account for changes in selective retrieval (Elward et al., 2013). Such an account would expect selective retrieval to be greater in the easier perceptual condition, but the current data instead indicate more selective retrieval for conceptual information. By this, the current data suggest that resource availability is not the only factor which bears influence over selective retrieval and that the kind of to-be-retrieved information may also determine the extent to which recollection can be controlled.

[1]We are grateful to an anonymous reviewer for suggesting this account.

In the current experiment, all items were associated with both conceptual and perceptual information, but greater control over recollection was observed in the task in which conceptual information was required to make these decisions. These data indicate that a factor other than the availability of processing resources can influence selective recollection in the exclusion task: The type of contextual information that is to be retrieved to make a target/nontarget decision.

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