Published in final edited form as:

J Mem Lang. 2014 August 1; 75: 45–57. doi:10.1016/j.jml.2014.04.007.

How Distinctive Processing Enhances Hits and Reduces False Alarms

R. Reed Hunt and Rebekah E. Smith

University of Texas at San Antonio

Abstract

Distinctive processing is a concept designed to account for precision in memory, both correct responses and avoidance of errors. The principal question addressed in two experiments is how distinctive processing of studied material reduces false alarms to familiar distractors. Jacoby (Jacoby, Kelley, & McElree, 1999) has used the metaphors early selection and late correction to describe two different types of control processes. Early selection refers to limitations on access whereas late correction describes controlled monitoring of accessed information. The two types of processes are not mutually exclusive, and previous research has provided evidence for the operation of both. The data reported here extend previous work to a criterial recollection paradigm and to a recognition memory test. The results of both experiments show that variables that reduce false memory for highly familiar distractors continue to exert their effect under conditions of minimal post-access monitoring. Level of monitoring was reduced in the first experiment through test instructions and in the second experiment through speeded test responding. The results were consistent with the conclusion that both early selection and late correction operate to control accuracy in memory.

The ability to discriminate between correct and incorrect responses in memory is a difficult challenge when the incorrect response is plausible and familiar in the context of the cue. Such situations are common in day-to-day memory. Examples include: In which of those three journals did I encounter that paper?; Which type of mustard was I to buy?; Was Pat at last week's meeting or the one the week before or both?. In this paper, we report experiments based on a laboratory model of these examples. The experiments were designed to investigate the roles of target encoding and test strategy on memory accuracy. The research was premised on a particular view of distinctive processing developed to account for precision in memory both in terms of correct memory for target items and correct rejection of incorrect items.

© 2014 Elsevier Inc. All rights reserved.

Address correspondence to: Reed Hunt, Department of Psychology, University of Texas at San Antonio, 1 UTSA Circle, San Antonio, TX 78249, reed.hunt@utsa.edu, Phone: 210-458-6642, Fax: 210-458-5728.

R. Reed Hunt and Rebekah E. Smith, Department of Psychology, The University of Texas at San Antonio.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Distinctive Processing

Distinctive processing is defined here as the processing of difference in the context of similarity (Gentner, & Markman, 1994; Hunt, 2006). Similarity refers to the spatio-temporal, semantic context of the items comprising an event (Klein, Shiffrin, & Criss, 2007). Difference refers to attributes of an item not shared by other items in the event. A common laboratory implementation of this definition requires the subject to perform an item-specific processing task, e.g. pleasantness rating, on a categorized list. The pleasantness rating task encourages processing of item-specific meaning in the context of the spatio-temporal and categorical similarity among the items. The combination of item-specific meaning encouraged by the processing task and relational categorical meaning shared by the items is highly diagnostic of a particular item and theoretically is the basis for precise memory. In this laboratory model, each word is a theoretical item and each list is a theoretical event. Prior studies have shown much better memory for target items processed distinctively in accord with this definition than for items processed only for similarity (see Hunt & McDaniel, 1993; Hunt, 2012 for reviews).

As described here, distinctive processing is initiated at study, which begs the question of how distinctive processing could directly affect performance on incorrect items that are not part of the study event. Hunt (2003) proposed that distinctive processing occurs at various grain sizes of memory. Memory for items within an event benefit from processing the differences among the items in the context of their similarity, termed item-based distinctive processing. Likewise, differences in the processing of lists that are similar on one or more dimensions also is distinctive processing, which in the context of proper cues at test will reduce confusion between the events. Building on the work of Dobbins, Kroll, Yonelinas, and Liu (1998) and Gruppiso, Lindsay, and Kelley (1997), Hunt had participants study two categorized lists, each containing instances from the same categories. Either a category judgment or a pleasantness rating task was performed on the lists. Some participants performed the same task on both lists while others performed different tasks on each list. The test required participants to recognize items from List 2 in the presence of List 1 distracters. False alarms to first list items were reduced by performing different orienting tasks on the two lists (see also Dobbins et al. and Gruppiso et al. for this finding using unrelated word lists). Hit rates for second list items were higher following pleasantness rating than following category judgment on the second list items. Thus item-based distinctive processing of the second list items facilitated hit rates while event-based distinctive processing of the separate lists reduced false alarms to familiar items. The purpose of the research presented here is to investigate how event-based distinctive processing enhances regulatory control over memory errors as well as to replicate the effects of item-based distinctive processing on hit rates. Three candidate explanations for the effect of event-based distinctive processing are considered.

Post-Access Monitoring

Accuracy can be controlled by monitoring retrieved memories for evidence of an item's presence in the target list. The monitoring hypothesis originates with Johnson's seminal work on memory for the source of items (e. g., Johnson, Hashtroudi, & Lindsay, 1993).

Monitoring can take the form of general source monitoring as in the activation-monitoring theory of false memory (Roediger, Watson, McDermott, & Gallo, 2001) or more specific monitoring as in the distinctiveness heuristic (Schacter, Israel, & Racine, 1999). The distinctiveness heuristic describes the case in which some aspect of the original experience is judged to be highly memorable (distinctive), and a strategy is adopted at test to examine each accessed item for the presence of that distinctive information. Absence of the distinctive property is evidence that the item is incorrect. For example, Schacter and his colleagues have shown repeatedly that false memories are less likely when the material is presented as pictures versus words and have argued that pictures yield more distinctive recollection than words (see Schacter & Wiseman, 2006, for a review). Gallo (2010, 2013) developed a more general version of the same monitoring principle, which stipulates that retrieval expectations, regardless of memorability, influence monitoring accuracy. Applied to event-based distinctive processing, the idea is that subjects expect more accurate discrimination between two similar lists if the lists were processed differently than if the same process were applied to both lists. For example, if the topic of conversation between you and me on two different occasions is the same, identifying a particular element of the conversation with one of the conversations will be more difficult than if the two conversations were about two different topics. As applied to Hunt (2003), monitoring accuracy of items from the second list was better when the orienting tasks differed for the two lists because recollection of performing the List 2 task was highly diagnostic of target items.

Retrieval Constraint

Retrieval accuracy also can be enhanced by constraining access to the target items. This restraint can be imposed in two different ways. The first is by reducing processing at study that would encourage potential false responses at test. As applied to false memory in the DRM paradigm, the argument is that any variable that focuses processing on item-specific information at study also limits relational processing among the studied items. Because the critical item is related to the studied items, the reduction in relational processing limits access to the critical item at study and hence the probability of it later being falsely remembered (Arndt & Reder, 2003; Hege & Dodson, 2004; Huff & Bodner, 2013). Although this version of the constraint hypothesis provides a plausible explanation of the effect of certain variables on false memory in the DRM paradigm, it is less applicable to the data from Hunt (2003) on event-based distinctive processing. The manipulation that reduced false alarms in the Hunt study, which was the orienting task on the second study list, cannot cause a reduction in the activation of the incorrect items at study because those items were presented prior to the critical manipulation.

More relevant is a different version of the constraint hypothesis. Rather than assume that some aspect of processing is deficient, the argument is that precise processing of targets at study can be reinstated at retrieval to the exclusion of incorrect items. Jacoby's research on memory for foils introduced this idea (Halamish, Goldsmith, & Jacoby, 2012; Jacoby, Shimizu, Daniels, & Rhodes, 2005; Shimizu & Jacoby, 2005), which subsequently has been supported by additional research (Alban & Kelley, 2012; Danckert, MacLeod, & Fernandes, 2011; Marsh, Meeks, Cook, et al., 2009). In essence, the combined effect of precise

encoding with appropriate cuing restricts access to the targeted information. Item-based distinctive processing provides the precision of target encoding that could serve this purpose

Constraint + Monitoring

That constraint and monitoring are not mutually exclusive is explicit in Koriatic and Goldsmith's (1996) model of control processes as well as in generate-recognize models of retrieval (e.g., Jacoby & Hollingshead, 1990). The idea is that within the constraints on retrieval resulting from the coaction of encoding and cuing conditions, at least some if not all of the information that is accessed is subjected to monitoring.

Reasonable evidence exists for the joint operation of retrieval constraint and post-access monitoring. Hege and Dodson (2004) analyzed the effect of presenting pictures at study on memory for DRM lists under two different test conditions. In the standard test condition, participants were encouraged to report the study items as accurately as possible. In the inclusion test condition, participants were told to try to remember the studied items but if other items came to mind, also report those items. The purpose of the inclusion condition was to reduce or eliminate post-access monitoring. If monitoring is sufficient to account for the reduction in false memory for pictured items, then that reduction should be eliminated under inclusion instructions. To the contrary, Hege and Dodson found that the reduction in false memory associated with picture presentation persisted under inclusion instructions. At the same time, both true and false memory increased under inclusion instructions suggesting that those instructions effectively stopped the monitoring that otherwise did occur in the standard condition. Thus, both constrained access and monitoring appear to be at work in this case.

Hunt, Smith and Dunlap (2011) found the same pattern of results in their examination of the effects of study modality and study task on recall in the DRM paradigm. Relative to auditory presentation of study items, visual presentation is known to reduce false memory for critical items (e.g. Smith & Hunt, 1998; Smith, Hunt, & Gallagher, 2008). Likewise, pleasantness rating of study items leads to fewer false memories than intentional study (Smith & Hunt, 1998). Hunt et al. used Hege and Dodson's (2004) technique to examine the output processes mediating the effect of visual presentation and pleasantness rating. Hunt et al.'s data showed that false recall of the critical DRM item increased under inclusions instructions relative to standard instructions, a result suggesting that monitoring does occur under standard instructions. Importantly however, false recall was reduced by the modality and study task manipulations in the inclusion test as well as in the standard test condition. Thus the results suggest that visual presentation and pleasantness rating reduce false memory in the DRM paradigm by enhancing the sensitivity of monitoring and through some other factor, which Hunt et al. (2011) assumed was retrieval constraint.

The Current Experiments

The experiments reported here move beyond the DRM paradigm to a situation requiring recognition of target items from among highly familiar distractors. The paradigm is the same as that used by Hunt (2003), which as described below has the advantage of being a criterial recollection task. In general, criterial recollection tests confound properties of targets and

distractors and in so doing put a premium on recollective monitoring for studied information (Gallo, 2013; Gallo, Weiss, & Schacter, 2004; Scimeca, McDonough, & Gallo, 2011). For example, Scimeca et al. (2011) presented a study list consisting of words in black font, words in red font, and pictures. Half of the words in red font and half of the pictures also appeared as black font words. Two different recognition tests followed study. In the red font test, the test items were words studied in red font, black font, or both at study. All test items were in black font. Subjects were to identify the items studied in red font, including those presented in both red and black font. For the picture tests, the items were words studied as pictures, black font words, or both. Items studied as pictures were to be identified, including those presented as both pictures and black font words. The critical data were false alarm rates to words presented only in black font. On the self-paced recognition tests, fewer false alarms to words studied only in black font occurred on the picture test than on the red word test. These results were predicted on grounds that pictorial presentation is more memorable than font color and hence would be used for recollective monitoring.

The current experiments build upon Hunt's (2003) variation of the criterial recollection paradigm. Test manipulations were used to investigate whether item-based and event-based distinctive processing work through increasing monitoring, constraining access, or some combination of the two. In both experiments, subjects study two lists of words and are then tested on the second list in the context of first list distractors. Half of the words in the second list also appeared at study in the first list, which confounds list membership and test status. Thus strategies such as recalling that an item was in the first list are not a reliable basis for rejecting that item. To equate the familiarity of items in the two lists, half of the items appearing only in the first list are repeated. The lists are categorized words and are studied through various combinations of orienting tasks in order to manipulate item-based and list-based processing. More details and specific predictions are provided in the introduction to each experiment

Experiment 1

In the first experiment, participants studied two categorized lists of words. The words for the two lists were drawn from the same categories. Item-based and list-based distinctive processing were manipulated by varying the orienting tasks on the two lists. The same orienting tasks were used on each list in two of the conditions. In one case, category judgments (CJ) were performed on the words in both lists and in the second case, pleasantness rating (PR) judgments were performed on both lists. Different orienting tasks were used on the two lists in the other two conditions: CJ on first list followed by PR on second or PR followed by CJ. On the subsequent recognition test, second list items were the targets, with first list items and novel items used as lures. Previous research using this paradigm (Hunt, 2003; Hunt & Rawson, 2011) has shown that false alarm rates for first list items are lower after performing different tasks (CJ-PR, PR-CJ) on the two lists than after performing the same task on both lists (CJ-CJ or PR-PR). We expect the same result, which will provide evidence for list-based distinctive processing. That same previous research has shown that hit rates are higher when PR is performed on the target list, in this case the second list. We expect to replicate this finding, which will provide evidence for item-based

distinctive processing. These predictions for the criterial recollection test are summarized in Table 1.

The critical question is what happens to the effects of the orienting conditions when monitoring is minimal? To address the question, test instructions were manipulated such that half of the individuals in each orienting condition received criterial recognition test instructions and half were given inclusion test instructions as used by Hege et al. (2004) and Hunt et al. (2011). If the benefit of list-based distinctive processing is due solely to post-access monitoring, the beneficial effect of different orienting tasks under recollective test instructions will be eliminated or significantly reduced under inclusion instructions. If different orienting tasks continue to reduce false alarms in the inclusion condition, either inclusion instructions failed to eliminate post-access monitoring or post-access monitoring has no role in controlling the accuracy of output. The latter two explanations, however, will be ruled out if the inclusion instructions lead to more false alarms than criterial recollection instructions. An increase in false alarms under inclusion instructions is attributable to suspension of monitoring which served to lower the false alarm rate under recollective instructions. The combination of higher false alarm rates with no reduction in the effect of the different orienting task conditions in the inclusion condition would extend the findings of Hege and Dodson (2004) and Hunt et al. (2011) beyond the DRM paradigm and recall to criterial recognition. Such an outcome would indicate that post-access monitoring does facilitate performance but is complemented by an additional control process.

Our speculation is that this additional factor is retrieval constraint resulting from precision of target list encoding, which leads to an untested prediction. According to our view of distinctive processing, the two conditions supporting precise target encoding are the PR-PR and CJ-PR, where item-based distinctive processing occurs for the second list. Higher hit rates in these two conditions relative to the PR-CJ and CJ-CJ positions will support this assumption. In the PR-PR condition, however, there is no basis for discriminating first and second list items, all of which are from the same categories, have equal familiarity, and are distinctively processed. Thus while this condition should have hit rates comparable to CJ-PR, false alarms to List 1 items in the PR-PR condition will be at the same level as CJ-CJ for both recollection and inclusion test instructions.

In contrast, the different orienting tasks in the CJ-PR and PR-CJ conditions support list-based distinctive processing, allowing for discrimination between List 1 and List 2. The difference in orienting tasks can be used for recollective monitoring, which should reduce false alarms to List 1 items under recollection instructions. We also predict that under inclusion test instructions, false alarms will be reduced in the CJ-PR condition relative to the PR-PR and CJ-CJ conditions. This is so because the precision of target processing enabled by the PR task on the second list entails constraint of search to the target items, and this constraint in combination with the list discriminability enabled by list-based distinctive processing will reduce false alarms to List 1 even when monitoring is suspended. This prediction does not hold for the other condition performing different orienting tasks, PR-CJ. The PR-CJ condition benefits from list-based distinctive processing under recollective instructions because the difference in list processing is useful for monitoring. Under inclusion instructions, however, the level of false alarms to List 1 items is predicted to be

equivalent in the PR-CJ condition and the CJ-CJ and PR-PR conditions. In the absence of monitoring, the PR-CJ condition does not have the additional advantage of precise target encoding that characterizes the CJ-PR condition and consequently will not benefit from retrieval constraint. The predictions for performance under inclusion instructions are shown in Table 1.

To summarize the predictions, false alarm rates to List 1 distractors should be lower in conditions CJ-PR and PR-CJ than in conditions CJ-CJ and PR-PR under recollection test instructions. Hit rates to second list items should be higher for PR-PR and CJ-PR than for CJ-CJ and PR-CJ. Critically, the false alarms rates to first list items under inclusion instructions should be lower for CJ-PR than the other three conditions, which should be approximately equal.

Method

Participants and design—Participants were 250 volunteers from the introductory psychology course at the University of Texas at San Antonio who received credit toward a course assignment for their participation. Participants were randomly assigned to one of eight conditions based upon the orthogonal manipulation of two between-subject variables: study condition and test type. The study conditions were defined by the orienting tasks performed on the two lists shown at study. In one condition (CJ-CJ), category judgments were performed on all of the items in both lists. In a second condition (PR-PR), pleasantness ratings were made to each word in both of the lists. The third condition (CJ-PR) entailed category judgment on the first list and pleasantness rating on the second list. The fourth condition (PR-CJ) performed pleasantness rating on the first list and category judgment on the second list. Participants received either criterial recognition instructions or inclusion instructions.

The design also included three types of items on the recognition test, correct items from the second study list, familiar distracters from the first study list, and novel distracters not present at study. Finally, half of the correct List 2 items also appeared in List 1. To avoid an imbalance of familiarity for correct items and first list distracters, half of the List 1 items were repeated. Thus, half of the correct List 2 and half of the List 1 distracters items were seen twice prior to test. The remaining items in each list were seen once.

Materials—A pool of 120 words was selected from the category norm of van Overschelde, Rawson, and Dunlosky (2004), with 12 instances taken from each of 10 categories. The 10 normative categories were selected such that each category could be combined with one other category as follows: nonalcoholic beverage and alcoholic beverage collapsed to *beverage*; fruit and vegetable collapsed to *food*; female names and male names collapsed to *names*; flower and tree collapsed to *plant*; bird and four-legged animal collapsed to *animal*. The reason for combining the normative categories into superordinate categories was to provide enough items in the categories without using low frequency, atypical category instances.

The categories *beverage*, *food*, *names*, *plants*, and *animals* were each represented by 24 instances. These instances were distributed across five different item types: List 1 distracters

shown one time; List 1 distracters shown 2 times; items appearing in Lists 1 and 2; items appearing only in List 2; and novel distracters. Each of the first four item types contained 4 items from each of the five categories. The novel distracters were 8 instances from each of the 5 categories that were not present in either List 1 or 2. The novel distracters remained constant across all lists whereas the remaining items were counterbalanced such that each of those items appeared equally often in the four item types. The counterbalancing yielded four different study lists, each of which was experienced by an approximately equal number of participants.

Sixty items comprised List 1, 20 items shown once, 20 items shown twice, and 20 items appearing once on List 1 and once again on List 2. List 2 contained 40 items: 20 items seen on List 1, which were shown again on List 2, plus 20 additional items not shown on List 1. The items were presented in a random order in both Lists 1 and 2. The recognition test consisted of 120 items, which included all of the items shown in Lists 1 and 2 plus the 40 novel distracters. Note again that all categories were represented equally across all item types.

Procedure—On entering the laboratory, participants were seated at individual computer stations, given an overview of the procedure, and then gave their consent for participation. At that point, instructions were administered for the first-list orienting task. The category judgment instructions were to examine each word as it appeared and assign the word to its proper category. The five category labels appeared below each study word, with a number (1 to 5) above each category. The judgment was registered by pressing the number key of the selected category. The instructions for the pleasantness rating task were to judge each word for its pleasantness on a 5-point scale. The scale appeared below each word, and the judgment was made by pressing the corresponding number key. Participants were warned that some items would be repeated in the list and to make their judgment on all items. For both orienting tasks, instructions were followed by practice on six items. The practice items were from categories not represented in the study lists. Following the practice items, the first study list was shown at a rate of 3 sec./word.

After all List 1 words were presented, a two-minute distracter task was administered. A randomly selected letter (excluding z) appeared on the monitor and the task was to press the next letter in the alphabet as quickly as possible. The task was continuous in that a key-press not only recorded the response to the letter but also initiated presentation of the next letter. After two minutes of this task, participants were told that they would see a second list of words on which they would perform an orienting task. For the CJ-CJ and the PR-PR conditions, the instructions were to perform the same task as was done on the first list, and they were reminded of the instructions for that task. The CJ-PR condition was given new instructions for the pleasantness rating task and the PR-CJ condition received new instructions for the CJ condition. The second list words were then shown for three seconds each.

Following the second study list, instructions were given for the recognition test. Instructions for the recollection test were:

In a moment you will complete a recognition test. You will be shown words one at a time. Some of these words were on the lists that you saw earlier and some of them were not on the lists. For each word on the recognition test, you should try to identify the words from the second list. If the word was on the second list, you should press the Y key for “yes, this word was on the second list”. You should only press the Y key for words that were on the second list. Do not press the Y key for words from the first list, unless you are sure that the words also appeared in the second list. Press the N key for words that were not on the second list.

Instructions for the inclusion test were:

In a moment you will complete a recognition memory test for the words you judged. You will be shown words one at a time. Some of these words were on the lists you saw earlier and some of them were not on the lists. For each word on the recognition test, you should try to identify the words from the second list. If the word was on the second list, you should press the Y key for “yes, this word was on the second list”. If you are not completely sure but it seems like the word could have been on the second list, go ahead and press the “Y” key. If you are convinced that the word was not on the second list, press the “N” key.

The test items were shown individually on the monitor and remained available until a yes/no response had been made. On completion of the test, the participant was debriefed and thanked for their assistance.

Results

The detailed analyses of hits and false alarms are reported separately. Given that the principal theoretical concern is with the false alarm rates as a function of conditions, those data will be presented first.¹

False alarms—The mean proportion of false alarms is presented in Table 2 as a function of study condition and test type. Two types of lures are represented in Table 2. Novel lures were not seen prior to the test whereas List 1 lures are the items that appeared only in the first list. Only List 1 lures were repeated, confounding type of lure with repetition, and consequently the two types of lures were analyzed separately. In order to equate for possible effects of orienting tasks on familiarity of List 1 items, direct comparisons were performed between study conditions that had the same orienting task on the first list, CJ-PR with CJ-CJ and PR-CJ with PR-PR. These analyses allowed the important contrasts between conditions with same versus different orienting tasks to be drawn while controlling for first list orienting task.

¹As described in the methods, the experiment included repetition of both List 1 and List 2 words in order to create a criterial recollection paradigm. Means for List 1 false alarms and List 2 hits as a function of repetition can be found in the Appendix. Given that repetition was not relevant to the central conceptual issue, detailed analyses of repetition will not be included in the results. Generally those analyses conformed to expectation, with increased hits and false alarms for twice presented items. More correct old responses were given to List 2 items than were incorrect old responses to List 1 items at each level of repetition. The correct old responses to List 2 items were reliably higher than were false alarms for once presented List 1 items, $F(1, 248) = 132.30$, $MSE = .02$, $p < .001$, $\eta_p^2 = .29$, and correct responses to List 2 items were also higher than were false alarms for twice presented List 1 items, $F(1, 248) = 264.10$, $MSE = .04$, $p < .001$, $\eta_p^2 = .34$.

CJ-CJ and CJ-PR: As can be seen in Table 2, false alarms to List 1 lures were higher in the CJ-CJ study condition relative to the CJ-PR condition, $F(1, 127) = 23.99$, $MSE = .03$, $p < .001$, $\eta_p^2 = .16$. Inclusion instructions also increased List 1 false alarms reliably over recollection instructions, $F(1, 127) = 8.27$, $MSE = .03$, $p = .005$, $\eta_p^2 = .06$. Test instructions did not interact reliably with study condition to affect false alarms, $F(1, 127) = .02$, $p = .88$. Thus, false alarms to familiar lures were lower for CJ-PR study than for CJ-CJ study in both the recollection and the inclusion tests.

False alarms to novel lures also were lower in the CJ-PR than in the CJ-CJ condition, $F(1, 27) = 8.89$, $MSE = .01$, $p = .003$, $\eta_p^2 = .06$. The effect of test type was marginal for novel lures, $F(1, 127) = 3.10$, $MSE = .01$, $p = .08$, $\eta_p^2 = .02$. Study condition and test type did not interact, $F(1, 127) = 2.07$, $MSE = .01$, $p = .15$.

PR-PR and PR-CJ: The comparison between the PR-CJ and PR-PR conditions yielded a reliable effect of study condition, $F(1, 115) = 8.51$, $MSE = .03$, $p = .004$, $\eta_p^2 = .07$, as well as a reliable effect of test type, $F(1, 115) = 9.51$, $MSE = .03$, $p = .003$, $\eta_p^2 = .08$. Although the interaction only approached significance, $F(1, 115) = 2.49$, $MSE = .03$, $p = .11$, $\eta_p^2 = .02$, our *a priori* predictions led to individual comparisons of study condition for each type of test. In the recollection test, false alarms to List 1 lures were reliably lower in the PR-CJ condition than in the PR-PR condition, $t(56) = 3.51$, $p = .001$. For the inclusion test however, the difference between the study conditions was not reliable, $t(59) = .88$, $p = .38$. Thus the PR-CJ study condition reduced false alarms to familiar distractors relative to the PR-PR condition on the recollection test but not on the inclusion test.

For novel distractors, the false alarms rates did not differ for the PR-CJ and PR-PR conditions, $F(1, 115) = 2.29$, $MSE = .01$, $p = .13$. Neither the effect of test type, $F(1, 115) = .48$, $MSE = .01$, $p = .49$, or the interaction of test type and study condition, $F(1, 115) = .46$, $MSE = .01$, $p = .50$, were reliable for false alarms to novel lures.

Hits—Table 2 also contains the mean hit rate to List 2 items as a function of study condition and test type. As predicted, the data in Table 2 show higher hit rates for the conditions in which pleasantness rating was performed on List 2 (CJ-PR and PR-PR) relative to conditions in which category sorting was completed for List 2 encoding (CJ-CJ and PR-CJ), which was confirmed by a reliable effect of study condition, $F(3, 242) = 15.22$, $MSE = .01$, $p < .001$, $\eta_p^2 = .05$. Individual comparisons among the study conditions via Tukey's HSD showed that both CJ-PR and PR-PR differed reliably from both CJ-CJ and PR-CJ. The conditions with category sorting on the second list, CJ-CJ and PR-CJ, did not differ reliably nor did the conditions with pleasantness ratings on the second list, PR-PR and CJ-PR. Test instructions also reliably affected hit rates, $F(1, 242) = 13.04$, $MSE = .01$, $p < .001$, $\eta_p^2 = .05$, with more hits following inclusion instructions than recollection instructions. The interaction between study condition and test instructions was not reliable, $F(3, 242) = .54$, $p = .65$. In summary, more correct List 2 responses occurred following pleasantness rating on the second list as well as following inclusion instructions.

Discussion

Under recollection test instructions, false alarms to familiar distracters were reduced when the orienting tasks on the two lists were different compared to when the same task was performed on the lists. This finding replicates results from previous work (e.g. Dobbins et al, 1998; Gruppuso et. al, 1997; Hunt, 2003; Hunt & Rawson, 2011). Hit rates were higher for conditions in which a pleasantness rating was performed on the second list, regardless of the orienting task on the first list. These data also replicate previous findings following recollection test instructions.

The new data from the inclusion test followed a different pattern. More false alarms and more hits occurred with inclusion instructions than with recollection instructions. The increase is what one expects if the test instructions succeeded in reducing the post-access monitoring that occurred with recollection instructions. Post-access monitoring can protect against false alarms but also carries the risk of mistakenly rejecting correct items, and thus a reduction in monitoring would increase both hits and false alarms. Importantly, the CJ-PR condition continued to show reduced false alarms to familiar items under inclusion instructions relative to PR-PR. In contrast PR-CJ, which yielded fewer false alarms under recollection instructions than CJ-CJ, did not differ from CJ-CJ under inclusion instructions. We should note, as is clearly implied by this discussion, that from the perspective of continuous signal detection theory the inclusion instructions would encourage a more liberal response bias. Although the concepts of post-access monitoring and response criterion can be seen as functionally analogous in relation to the inclusion instructions, other important differences distinguish the two concepts theoretically (e.g., see Gallo et al., 2004).

The pattern of results is consistent with predictions derived from the distinctive processing framework. Different orienting tasks on the two lists provide a basis for differentiating the lists and information corresponding to that difference can be used effectively for diagnostic monitoring. Under inclusion instructions however, monitoring appears to be reduced, as indicated by increased false alarm rates. Consistent with the reduction in monitoring, the PR-CJ condition no longer effectively controls false alarms, suggesting that the reduction in false alarms under recollection instructions in the PR-CJ condition is due entirely to monitoring. In contrast, the CJ-PR condition continues to produce a reliable reduction in false alarms under inclusion instructions, suggesting that some mechanism in addition to monitoring controls output quality. Our speculation is that precise encoding of targets constrains access to the target list.

One subtle but potentially important discordant finding was that the difference between CJ-PR and CJ-CJ was equivalent on the recollection and inclusion tests. If monitoring is reduced by inclusion instructions, the difference between CJ-PR and CJ-CJ should be smaller following the inclusion test because one of the two forms of control is no longer operating for CJ-PR². If however our speculation about the effect of distinctive processing on retrieval constraint is valid, monitoring may have played little role in the CJ-PR condition

²We thank Jason Arndt for noting this discrepancy.

on the recollection test. Rather the beneficial effects of distinctive processing may have been due primarily to retrieval constraint³.

According to the distinctive processing framework such precision emerges from PR on the second list in the form of item-based distinctive processing, an assumption that is supported by higher hit rates for those conditions performing PR on the second list. Thus, the CJ-PR condition continues to show reduced false alarms in the absence of monitoring. The effect of precise target encoding on false alarms is neutralized in the PR-PR condition because there is no basis for discriminating the lists.

Experiment 2

Our predictions and interpretations of the data in the first experiment are based on the assumption that monitoring is severely reduced if not eliminated by inclusion instructions. Although the data conformed to the predicted pattern, we unfortunately have no independent index of monitoring. Consequently the second experiment was designed to provide converging evidence by using a different method for eliminating monitoring. Previous research has shown that rapid response deadlines affect recollective processes (e.g., Arndt, 2012; Benjamin, 2001; Dodson & Hege, 2005; Yonelinas, 2002), and thus should reduce monitoring. Consistent with this reasoning, Scimeca et al. (2011) found that the prophylactic effect of picture presentation of targets was reduced in a criterial test pitting picture-word discrimination against discrimination of font colors. A more detailed description of this study was given under the heading Current Experiments in the Introduction.

Following the rationale of Scimeca et al. (2011), the second experiment compared self-paced and speeded responding in the two lists, criterial recognition design. The same four combinations of orienting tasks were used as in the first experiment and were orthogonally combined with test timing. The tests were either self-paced or speeded by a response deadline. Our predictions were that the study conditions performing different orienting tasks on the two lists, PR-CJ and CJ-PR, would yield lower false alarm rates to familiar List 1 items on the self-paced test than the conditions performing the same task on each list. The focal question concerns the effect of orienting conditions on speeded test performance. Based on the results of Experiment 1 and on predictions derived from distinctive processing, the condition supporting distinctive processing of the second list, CJ-PR, should continue to show reduced false alarms on the speeded test whereas the other condition showing reduced false alarms on self-paced tests, PR-CJ, should lose that benefit on the speeded tests. This is so because monitoring has been minimized and the target list has not been processed distinctively.

Method

Participants and design—The two independent variables, four levels of study conditions and two levels of test timing, were orthogonally combined to form 8 independent groups. The 287 participants were randomly assigned in approximately equal numbers to

³Thanks to David Gallo for noting this nuance of our approach.

these groups. The participants were volunteers who received course credit for their participation.

Materials and procedure—The study and test materials were the same as those used in Experiment 1. The procedure for the groups undergoing self-paced recognition testing was the same as used in Experiment 1 with recollection test instructions. For the speeded test condition, the response deadline was 800 ms. following onset of the test item. To familiarize subjects with the timing, a series of practice trials was given prior to testing. The practice began with an animation of a white rectangle outlined in black that filled with gray from left to right over 800 msecs. This animation was shown twice. Then the subjects were given four trials in which the word PRACTICE appeared in the center of the monitor with “In the second study List? Y or N” beneath it. Subjects pressed the “y” or “n” key in response and saw the feedback “Good timing” if their response was less than 800 msecs. or “Too slow” if it was greater than 800 msecs. The feedback remained on the monitor for two seconds, after which the subject pressed the space bar to initiate the next test trial. Following practice, the actual recognition test was administered with feedback about response time provided on each trial.

Results⁴

False alarms—False alarms to familiar List 1 distractors are presented in Table 3 as a function of study condition and test timing. As in Experiment 1, direct comparisons were performed between the two conditions sharing the same List 1 task, CJ-CJ vs. CJ-PR and PR-PR vs. PR-CJ. False alarms to novel lures were analyzed separately from false alarms to familiar List 1 lures.

CJ-CJ and CJ-PR: The comparison of List 1 false alarms by conditions CJ-PR and CJ-CJ yielded a reliable effect of study condition, $F(1, 128) = 37.02$, $MSE = .04$, $p < .001$, $\eta_p^2 = .22$, as well as a reliable interaction between study condition and test timing, $F(1, 128) = 6.54$, $MSE = .04$, $p = .01$, $\eta_p^2 = .05$. Inspection of Table 3 suggests that false alarms were lower in CJ-PR than in CJ-CJ for both self-paced and speeded tests, which was confirmed by individual comparisons of the study conditions in each test. For the self-paced test, $t(66) = 5.74$, $p < .001$, and for the speeded test, $t(62) = 2.70$, $p = .009$. The interaction between study condition and test timing resulted from increased false alarms in the speeded test relative to the self-paced test for the CJ-PR condition but fewer false alarms in the speeded test than in the self-paced test for CJ-CJ. We have no explanation for this reversal in the CJ-CJ condition.

False alarms to novel distractors were lower in the CJ-PR condition than in CJ-CJ, $F(1, 128) = 7.98$, $MSE = .02$, $p = .005$, $\eta_p^2 = .06$. Novel distractors drew more false alarms in the speeded test than in the self-paced test, $F(1, 128) = 20.02$, $MSE = .02$, $p < .001$, $\eta_p^2 = .13$.

⁴As with Experiment 1, the mean List 1 false alarms and List 2 hits for the different levels of repetition can be found in the Appendix. The effect of repetition was as expected with more hits and false alarms with two presentations than with one. The percentage of List 2 item hits was greater than that of false alarms for List 1 items presented once, $F(1, 248) = 212.64$, $MSE = .02$, $p < .001$, $\eta_p^2 = .46$, and for List 1 repeated items, $F(1, 248) = 206.28$, $MSE = .02$, $p < .001$, $\eta_p^2 = .45$. The analyses of false alarms and hits reported in the text collapses over repetition.

The interaction between study condition and test timing did not affect false alarms to novel distractors, $F(1, 128) = 1.46$, $MSE = .02$, $p = .23$.

PR-PR and PR-CJ: Comparison of false alarms to familiar distractors between the PR-CJ and PR-PR conditions showed a reliably higher false alarm rate in the PR-PR condition, $F(1, 120) = 5.83$, $MSE = .03$, $p = .017$, $\eta_p^2 = .05$. The effect of test timing was not reliable, $F(1, 120) = .52$, $MSE = .03$, $p = .47$, nor was the predicted interaction between study condition and test timing, $F(1, 120) = 2.10$, $MSE = .03$, $p = .15$. Given the pattern depicted in Table 3 along with the *a priori* predictions, individual comparisons between study conditions were performed for each of the tests. For the self-paced test, PR-CJ produced fewer List 1 false alarms than CJ-CJ, $t(66) = 3.08$, $p = .003$, but the difference between the conditions was not reliable in the speeded test, $t(54) = .61$, $p = .54$.

Although slightly fewer false alarms to novel distractors occurred for the PR-CJ condition than the PR-PR condition, the difference was not reliable, $F(1, 120) = .84$, $MSE = .02$, $p = .36$. Novel false alarms were significantly higher in the speeded test than in the self-paced test, $F(1, 120) = 17.11$, $MSE = .02$, $p < .001$, $\eta_p^2 = .12$, and test timing did not interact reliably on novel false alarms, $F(1, 120) = .20$, $MSE = .02$, $p = .65$.

In summary of the analyses of false alarms, study conditions with different tasks on the lists committed fewer false alarms to familiar distractors than study conditions with the same tasks on the two lists when the test was self-paced. With speeded recognition, however, PR-CJ did not differ from PR-PR while CJ-PR continued to produce fewer List 1 false alarms than CJ-CJ. Different task study conditions also had fewer false alarms to novel distractors than conditions with the same task, although the difference between PR-CJ and PR-PR was not reliable. Considerably more novel false alarms occurred with speeded tests than self-paced tests.

Hits—Mean hit rates are shown in Table 3 as a function of study condition and test timing. Correct responses to List 2 items were affected reliably by study condition, $F(3, 248) = 5.64$, $MSE = .03$, $p = .001$, $\eta_p^2 = .06$. Hit rates also were considerably higher with subject paced responding relative to speeded responding, $F(3, 248) = 36.22$, $MSE = .03$, $p < .001$, $\eta_p^2 = .12$. Inspection of Table 3 suggests that the effect of study condition was limited to subject paced responding, a suspicion heightened by a marginally reliable interaction between study condition and response timing, $F(3, 248) = 2.50$, $MSE = .03$, $p = .06$, $\eta_p^2 = .03$. Separate analysis of the self-paced responses showed a reliable effect of study condition, $F(3, 132) = 11.30$, $MSE = .01$, $p < .001$, $\eta_p^2 = .20$. Individual comparisons among the conditions using Tukey's HSD replicated previous research in showing higher hit rates for conditions in which the PR task occurred on the second list. Hits in the CJ-PR condition were reliably higher than in the CJ-CJ ($p = .02$) and the PR-CJ ($p < .001$) conditions, but no difference was found between CJ-PR and PR-PR ($p = .88$). The PR-PR condition produced more hits than the PR-CJ condition ($p < .001$) and marginally more hits than the CJ-CJ ($p = .09$) condition. The CJ-CJ and PR-CJ conditions did not differ reliably ($p = .20$). In contrast, the speeded test led to a different pattern. Hit rates with speeded responding were not affected reliably by study condition, $F(3, 116) = .58$, $MSE = .02$, $p = .63$, $\eta_p^2 = .01$.

Discussion

Output monitoring is a controlled process and speeded recognition is known to negatively affect controlled processes (e.g., Benjamin, 2001; Hege & Dodson, 2005; Scimeca et al., 2011; Yonelinas 2002). Thus if the reduction in false alarms in subject-paced recognition following distinctive processing is due solely to monitoring, that benefit should be eliminated under speeded response requirements. Importantly, the large reduction in hits and increase in novel false alarms in the speeded response condition indicate that speeded responding did affect performance. With that established, we can move to discussion of the principal results.

Under subject paced responding, the conditions that encouraged event-based distinctive processing, CJ-PR and PR-CJ, committed fewer false alarms to familiar distractors than the conditions that did not promote event-based distinctive processing. We assume that event-based distinctive processing contributes to the monitoring process. When monitoring was dampened by a response deadline, the CJ-PR condition still yielded reliably fewer false alarms than conditions CJ-CJ. In contrast, the PR-CJ condition lost its advantage over CJ-CJ under speeded responding. The pattern of the results is quite consistent with the idea that monitoring is supplemented by constrained access. Item-based distinctive processing in CJ-PR condition yields a precision of encoding that includes restriction of access favoring the target list. The other condition supporting item-based distinctive processing, PR-PR has no basis for discriminating the two lists, and consequently the effect of precise encoding of the target does not extend to constraint of access to the target list.

Unlike the comparison of test types in the first experiment, the difference in false alarms between CJ-PR and CJ-CJ was half as large in the speeded test as in the self-paced test. Consistent with our interpretation of the comparison between these conditions in the first experiment, we assume that item-based distinctive processing restrains retrieval in CJ-PR, perhaps such that little monitoring occurs in this condition. The effects of item-based distinctive processing have been shown to result from controlled processing (Hunt, 2003; Toth, Reingold, & Jacoby, 1994). Consequently speeded responding undermines some of the advantage of constrained retrieval that was available in CJ-PR following recollection instructions³.

Correct responding to target items with subject-paced responding replicated previous findings (Hunt, 2003; Hunt & Rawson, 2011) showing an advantage to the PR task on the second (target) list. This effect on hits has been attributed theoretically to item-based distinctive processing on the assumption that PR encourages encoding of distinct meanings among otherwise similar items, thus allowing for item differentiation at retrieval (e.g. Hunt, 2013). Importantly, item-based distinctive processing has been shown to be a recollective process (Hunt, 2003; Toth et al., 1994), and consequently it is not surprising that the effects of the PR task on hits were eliminated under speeded responding. Note however that the reduction of hits under speeded responding has nothing to do with monitoring. Theoretically monitoring can only reduce hits. This is so because monitoring is post-access, and the only influence of monitoring on hit rate would be failure to correctly recognize an accessed item as a target. Thus, eliminating monitoring could only have a positive effect on hits, which

was the result in Experiment 1 where the inclusion instructions eliminated monitoring but did not affect other recollective processes.

General Discussion

In two experiments false alarms to familiar distractors were reduced on criterial recollection tests of recognition when similar lists were subjected to different orienting tasks. That benefit was eliminated, however, when post-access monitoring was minimized by inclusion test instructions or speeded responding, except in the case where the different processing conditions entailed distinctive processing of the target list. These results refine our knowledge of both the nature of output processes and how distinctive processing enhances memory accuracy.

Distinctive processing is the processing of difference in the context of similarity (e.g., Hunt, 2006; 2012). Distinctive processing can occur at the level of both items and events, where events are sets of items sharing spatio-temporal as well as other dimensions of similarity. Much previous research has shown that item-based distinctive processing facilitates performance on target items (Hunt & McDaniel, 1993). More recent work reported reductions in false alarms to familiar distractors following event-based distinctive processing of different lists (Hunt, 2003; Hunt & Rawson, 2011). The current results clearly show that the effect of event-based distinctive processing is due in part to monitoring. In the absence of monitoring, one of the two conditions affording event-based distinctive processing (PR-CJ) lost its advantage on false alarms over conditions that did not foster event-based distinctive processing. The other condition designed to support event-based distinctive processing (CJ-PR) maintained its advantage on false alarms even under conditions of reduced monitoring. The difference between the two conditions is that the latter case encourages item-based distinctive processing, as evidenced by higher hit rates for the PR task on the target list under criterial recollection testing conditions.

How does item-based distinctive processing at study affect responses to non-studied items? Encoding the differences between a particular item and the other studied items in the context of the similarity among these items yields a precise record of processing of that item. In the case of the categorized words used here, a pleasantness rating task encourages processing of item-specific meaning, which when combined with the spatio-temporal and semantic similarity among the list items provides highly diagnostic information. Note, however, item-based distinctive processing will constrain retrieval effectively only if event-based distinctive processing also has occurred. This is so because a minimal requirement for an effective cue is that the cue references the target event from which specific items are to be drawn. If the cued event is defined by processing that differs from similar events, the probability of confusion with similar events is reduced. Item-based distinctive processing in the PR-PR condition does nothing to reduce false alarms to familiar items because the List 1 distractors are not constrained by event-based distinctive processing. Notice that the contribution of event-based distinctive processing to cuing of targeted items is through cuing of the event, not the particular items. In theory, the processing that defines event-based distinctive processing is shared by all of the items of the list, and as such cannot directly facilitate correct item memory.

The distinctiveness account is in effect the important principle of differentiation that is embedded in certain formal models. As Criss and her colleagues have stressed (e.g., Criss, 2006; 2010), the Subjective Likelihood Model (McClelland & Chappell, 1998) and the Retrieving Effectively from Memory model (REM, Shiffrin & Steyvers, 1997) explain phenomena such as the strength-based mirror effect by appealing to a principle of differentiation. The idea is that variables increasing the strength of a memory trace (e.g., repetition) exert their effect by adding item and context features to the trace. Thus, a strong trace represents more of the item and context features of a particular study item than does a weak trace. There is a direct parallel between strength and distinctiveness, although the former rests on a quantitative metaphor and the latter a qualitative metaphor, an extremely important difference that can translate to very different predictions (see Scimeca et al., 2011, for an example). At the time of test, the context cue accesses the appropriate episode, much the same as our assumption that similarity based processing defines the target event at retrieval. The match between item features of the test probe and the encoded trace inform the recognition decision and, given that strong traces contain more item features, hit rates will be a direct function of strength.

In the strength-based mirror effect, not only are hit rates high for strong items, the false alarm rates are relatively low for those items. Just as in the criterial recollection paradigm used here, the study manipulation yielding high hits also produces lower false alarms (our CJ-PR condition). On the differentiation principle, the reduction in false alarms with increasing item strength is an encoding process whereby increases in item strength (adding more features to the trace) render the trace less like the distractors (but again see Scimeca et al. for conflicting evidence). The idea is identical to the notion that distinctive processing is diagnostic of a particular item. In that regard, the idea that item-based distinctive processing constrains access to the target list is another of many suggestions that precise encoding of targets limits competition from distractors. Application of REM to our paradigm probably will require additional assumptions to the model because in our paradigm study variables influence not only the target items but also the List 1 lures and their relationship to the target items, but one might expect such an application ultimately to succeed given the shared principle of differentiation.

Conflicting Conclusions

The two previous studies arguing for the necessity of a process in addition to monitoring based their conclusions on an inclusion test of recall (Hege & Dodson, 2004; Hunt et al., 2011). Experiment 1 extends that conclusion to recognition, which we view as important because one can easily imagine that reduced false alarms would not occur on an inclusion recognition test. For one reason, given that List 1 lures are presented on the recognition test, familiarity could lead to many more false alarms in recognition than in recall, particularly under inclusion instructions. In fact, previous research has reported that a variant of inclusion instructions in recognition does indeed eliminate the effect of variables which reduce false memory in standard tests. For example, Schacter, Cendan, Dodson, and Clifford (2001, Experiment 2) compared picture versus word presentation of DRM lists at study followed by either standard or inclusion instructions on a recognition test. Under standard instructions, mean false recognition for pictures and words was .28 and .65 respectively.

With inclusion instructions, the difference was reduced substantially, pictures = .75 and words = .87. Moreover, Pierce, Gallo, Weiss and Schacter (2005) reported that the beneficial effect of visual study of words compared to auditory study on false memory in the DRM paradigm was completely eliminated under test conditions designed to discourage the use of monitoring. In contrast to the recall studies of Hege and Dodson (2004) and Hunt et al. (2011) as well as Experiment 1 here, the Schacter et al. and Pierce et al. studies concluded that late correction monitoring is sufficient to explain output control in recognition.

Importantly, the inclusion instructions across these studies differed in a subtle but potentially crucial way. Schacter et al. (2001) and Pierce et al. (2005) used the instructions first reported by Brainerd and Reyna (1998). Brainerd and Reyna's goal was to demonstrate that the gist of an associated list is extracted and remembered. To do so, they instructed subjects to recognize any items that were consistent with themes of the associative categories represented by the study list. That is, the instructions explicitly required a positive response to any item that instantiated the categories present on the study list without regard to whether the particular item had been on the study list. In effect, the test required recognizing categories, not individual items. In contrast, the instructions used by Hege and Dodson (2004) and Hunt et al. (2011) as well as in Experiment 1 here encouraged the subject to be accurate but also to say yes to words that could have been on this list, even if not recollected as being on the list. The critical difference is that Brainerd and Reyna's instructions explicitly require positive responses to non-studied items whereas the instructions first used by Hege and Dodson encourage accurate memory with the proviso to report other items that come mind when accessing studied items. These latter instructions are more appropriate for testing the sufficiency of monitoring.

Even if the inclusion instructions reduced monitoring, definitive conclusions about the sufficiency of monitoring are not sustainable from those data alone because we have no independent index of monitoring. To strengthen the argument, we provided converging evidence in Experiment 2 with speeded recognition. We followed the precedent of Scimeca et al. (2011) who argued that speeded responding would disrupt monitoring in a criterial task. The criterial task requires recollective monitoring, and recollective processes are known to be disrupted by speeded responding. The pattern of the results from Scimeca et al. is quite similar to those we obtained. When initial processing was not distinctive, speeded responding had little effect on false alarms to familiar lures but with distinctive processing, speeded responding dramatically increased false alarms to familiar lures. Nonetheless, and this is the important point, false alarms to familiar lures in Scimeca et al. were still 13% lower in the distinctive processing condition than in the non-distinctive condition. No statistical comparison of these conditions was reported given that this was beside the point of that paper, but the parallel between this outcome and our data is notable.

Likewise, the Schacter et al.'s (2001, Experiment 2) study yielded data consistent with the notion that monitoring is not sufficient to account for the beneficial effects of picture presentation. Under their version of inclusion instructions, false recognition increased disproportionately following picture plus word presentation compared to words alone. Nonetheless, the picture plus word condition produced 12% fewer false memories than the word alone condition, a difference that reached the .053 level of reliability. Thus, the

literature contains hints that monitoring alone is insufficient to account for output control even in studies arguing for the sufficiency of monitoring.

Summary

Two experiments tested predictions from a distinctive processing framework of precise memory about hits and false alarms in a difficult recognition task, where the distractors were highly familiar. As in previous research, the hits were controlled by the type of processing of target items whereas false alarms were reduced when the processing of the two study lists was different. Distinctive processing of the target items differentiates each of those items from each other and provides highly diagnostic information about the individual targets at test. That same distinctive processing indirectly reduces false alarms to the familiar distractors by restricting access to members of the target event. However, the benefit of distinctive target processing on false alarms also requires that the target event and highly similar events were distinctively processed. Thus, the concepts of event-based and item-based distinctive processing taken together nicely account for both correct acceptance of target items and correct rejection of familiar distractors.

Acknowledgments

Support for this project was provided in part by Grant AG034965 from the National Institute on Aging to RES. The authors thank Marisa Aragon, Ryan Brigante, Andrew Bolisay, Ross DeForrest, Nadia Khoja, Sheila Meldrum, Bridget Miller, Florence Mizutani, Brittany Murray, Julie Niziuski, Eric Olguin, Brandon Oscarson, Katrina Presswood, Gabriel Tellez, Harvir Virk, Verlinda Wilkerson, and Manuel Zepeda for assistance with data collection. Joe Tidwell assisted with programming as well as data collection. Jason Arndt, David Gallo, and two anonymous reviewers provided valuable comments on an earlier version of the manuscript.

References

- Alban MW, Kelley CM. Variations in constrained retrieval. *Memory & Cognition*. 2012; 40:681–690. [PubMed: 22297425]
- Arndt J. The influence of forward and backward associative strength on false recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2012; 38:747–756.
- Arndt J, Reder LM. The effect of distinctive visual information on false memory. *Journal of Memory and Language*. 2003; 48:1–15.
- Benjamin AS. On the dual effects of repetition on false recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2001; 27:941–947.
- Brainerd CJ, Reyna VF. When things that were never experienced are easier to remember than things that were. *Psychological Science*. 1998; 9:484–489.
- Brainerd, CJ.; Reyna, VF. *The science of false memory*. New York: Oxford University Press; 2005.
- Criss AH. The consequences of differentiation in episodic memory: Similarity and the strength-based mirror effect. *Journal of Memory and Language*. 2006; 55:461–478.
- Criss AH. Differentiation and response bias in episodic memory: Evidence from reaction time distributions. *Journal of Experimental Psychology: Learning, Memory, And Cognition*. 2010; 36:484–499.
- Danckert SL, Macleod CM, Fernandes MA. Source constrained retrieval influences encoding of new information. *Memory & Cognition*. 2011; 39:1374–1386. [PubMed: 21647810]
- Dobbins IG, Kroll NEA, Yonelinas AP, Liu Q. Distinctiveness in recognition and free recall: The role of recollection in rejection of the familiar. *Journal of Memory and Language*. 1998; 38:381–400.
- Dodson CS, Hege ACG. Speeded retrieval abolishes the false memory suppression effect: Evidence for the distinctiveness heuristic. *Psychonomic Bulletin & Review*. 2005; 12:726–731. [PubMed: 16447388]

- Gallo, DA. Associative illusions of memory: False memory research in DRM and related tasks. New York: Psychology Press; 2006.
- Gallo DA, Weiss JA, Schacter DL. Reducing false recollection with criteria recollection tests: Distinctiveness heuristic versus criterion shifts. *Journal of Memory and Language*. 2004; 51:473–493.
- Gentner D, Markman AB. Structural alignment in comparison: No difference without similarity. *Psychological Science*. 1994; 5:152–158.
- Gruppuso V, Lindsay DS, Kelley CM. The process-dissociation procedure and similarity: Defining and estimating recollection and familiarity in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1997; 23:259–278.
- Halamish V, Goldsmith M, Jacoby LL. Source constrained recall: Front end and back end control of retrieval quality. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2012; 38:1–15.
- Hege ACG, Dodson CS. Why distinctive information reduces false memories: Evidence for both reduced relational processing and the distinctiveness heuristic. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2004; 30:787–795.
- Huff MJ, Bodner GE. When does memory monitoring succeed versus fail? Comparing item-specific and relational encoding in the DRM paradigm. *Journal of Experimental Psychology: Learning, Memory and Cognition*. 2013; 39:1246–1256.
- Hunt RR. Two contributions of distinctive processing to accurate memory. *Journal of Memory and Language*. 2003; 48:811–825.
- Hunt, RR. The concept of distinctiveness in memory research. In: Hunt, RR.; Worthen, JB., editors. *Distinctiveness and memory*. New York: Oxford University Press; 2006. p. 1-25.
- Hunt, RR. Distinctive processing: The co-action of similarity and difference in memory. In: Ross, BH., editor. *The psychology of learning and motivation*. Vol. 56. New York: Academic Press; 2012. p. 1-46.
- Hunt RR, McDaniel MA. The enigma of organization and distinctiveness. *Journal of Memory and Language*. 1993; 32:421–445.
- Hunt RR, Rawson KA. Knowledge affords distinctive processing in memory. *Journal of Memory and Language*. 2011; 65:390–405.
- Hunt RR, Smith RE, Dunlap Kathryn R. How does distinctive processing reduce false memory? *Journal of Memory and Language*. 2011; 65:378–389. [PubMed: 22003267]
- Jacoby LL. Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1999; 25:3–22.
- Jacoby LL, Hollingshead A. Toward a generate/recognize model of performance on direct and indirect tests of memory. *Journal of Memory and Language*. 1990; 29:433–454.
- Jacoby, LL.; Kelley, CM.; McElree, BD. The role of cognitive control: Early selection versus late correction. In: Chaiken, S.; Trope, Y., editors. *Dual-process theories in social psychology*. New York: The Guildford Press; 1999. p. 383-400.
- Jacoby LL, Shimizu Y. Similarity guided depth of retrieval: Constraining at the front end. *Canadian Journal of Experimental Psychology*. 2005; 59:17–21. [PubMed: 15832628]
- Jacoby LL, Shimizu Y, Daniels KA, Rhodes MG. Modes of cognitive control in recognition and source memory: Depth of retrieval. *Psychonomic Bulletin & Review*. 2005; 12:852–857. [PubMed: 16524001]
- Johnson MK, Hastroudi S, Lindsay DS. Source monitoring. *Psychological Bulletin*. 1993; 114:3–28. [PubMed: 8346328]
- Klein, KA.; Shiffrin, RM.; Criss, AH. Putting context in context. In: Nairne, JS., editor. *The foundations of remembering: Essays in honor of Henry L. Roediger, III*. New York: Psychology Press; 2007. p. 171-190.
- Koriat A, Goldsmith M. Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review*. 1996; 103:490–517. [PubMed: 8759045]
- Marsh RL, Meeks JT, Cook GI, Clark-Foos A, Hicks JL, Brewer GA. Retrieval constraints on the front end create differences in recollection on a subsequent test. *Journal of Memory and Language*. 2009; 61:470–479.

- McClelland JL, Chappell M. Familiarity breeds differentiation: A subjective-likelihood approach to the effects of experience in recognition memory. *Psychological Review*. 1998; 105:734–760.
- Pierce BH, Gallo DA, Weiss JA, Schacter DL. The modality effect in false recognition: Evidence for test-based monitoring. *Memory & Cognition*. 2005; 33:1407–1413. [PubMed: 16615388]
- Roediger HL III, Watson JB, McDermott KB, Gallo DA. Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review*. 2001; 8:385–407. [PubMed: 11700893]
- Schacter DL, Cendan DL, Dodson CS, Clifford ER. Retrieval conditions and false recognition: Testing the distinctiveness heuristic. *Psychonomic Bulletin & Review*. 2001; 8:827–833. [PubMed: 11848606]
- Schacter DL, Israel L, Racine C. Suppressing false recognition in younger and older adults: The distinctiveness heuristic. *Journal of Memory and language*. 1999; 40(1):1–24.
- Scimeca AM, McDonough IM, Gallo DA. Quality trumps quantity at reducing memory errors: Implications for retrieval monitoring and mirror effects. *Journal of Memory and Language*. 2011; 65:373–377.
- Shiffrin RM, Steyvers M. A model for recognition memory: REM-retrieving effectively from memory. *Psychonomic Bulletin & Review*. 1997; 4:145–166. [PubMed: 21331823]
- Smith, RE. Adult age differences in episodic encoding: Item-specific, relational, and distinctive processing. In: Hunt, RR.; Worthen, JB., editors. *Distinctiveness and memory*. New York: Oxford University Press; 2006. p. 259-287.
- Smith RE, Hunt RR, Gallagher MP. The effect of study modality on false recognition. *Memory and Cognition*. 2008; 36:1439–1449. [PubMed: 19015503]
- Smith RE, Hunt RR. Presentation modality affects false memory. *Psychonomic Bulletin & Review*. 1998; 5:710–715.
- Toth JP, Reingold EM, Jacoby LL. Toward a redefinition of implicit memory: Process dissociations following elaborative processing and self-generation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1994; 20(2):290–303.
- van Overschelde JP, Rawson KA, Dunlosky J. Category norms: An updated and expanded version of the Battig and Montague (1969) norms. *Journal of Memory and Language*. 2004; 50:289–335.

Appendix: List 1 False Alarms and List 2 Hits as a Function of Repetition

Table A1

Experiment 1: Mean proportion of false alarms to List 1 items and mean proportion of hits to List 2 items a function of study condition, test type, and repetition. Numbers in parentheses are standard errors.

Test Type	Study Condition	List 1 Item False Alarms		List 2 Item Hits	
		Repetitions in List 1		Repetitions during study	
		1	2	1	2
Recollection	CJ-CJ	.57 (.03)	.72 (.03)	.68 (.03)	.83 (.02)
	CJ-PR	.40 (.03)	.61 (.03)	.81 (.02)	.89 (.02)
	PR-PR	.62 (.03)	.74 (.03)	.77 (.02)	.87 (.02)
	PR-CJ	.51 (.03)	.60 (.03)	.62 (.03)	.78 (.02)
	CJ-CJ	.65 (.03)	.80 (.03)	.78 (.02)	.86 (.02)
	CJ-PR	.49 (.03)	.70 (.03)	.87 (.02)	.88 (.02)
Inclusion	PR-PR	.62 (.03)	.74 (.03)	.77 (.02)	.91 (.03)
	PR-CJ	.65 (.03)	.72 (.03)	.68 (.03)	.85 (.03)

Note: For List 1 false alarm items, repetitions occurred in List 1. For List 2 hit items, repetition of 1 indicates that the item appeared on List 2 only, while repetition of 2 indicates that the item appeared once on List 1 and once on List 2.

Table A2

Experiment 2: Mean proportion of false alarms to List 1 items and mean proportion of hits to List 2 items a function of study condition, test type, and repetition. Numbers in parentheses are standard errors.

Test Type	Study Condition	List 1 Item False Alarms		List 2 Item Hits	
		Repetitions in List 1		Repetitions during study	
		1	2	1	2
Self-Paced	CJ-CJ	.68 (.03)	.77 (.03)	.74 (.03)	.87 (.03)
	CJ-PR	.40 (.03)	.61 (.03)	.88 (.02)	.90 (.02)
	PR-PR	.68 (.03)	.75 (.02)	.86 (.02)	.89 (.02)
	PR-CJ	.58 (.03)	.60 (.04)	.69 (.03)	.83 (.02)
	CJ-CJ	.58 (.03)	.73 (.03)	.66 (.02)	.80 (.03)
	CJ-PR	.48 (.03)	.60 (.04)	.69 (.02)	.77 (.02)
Speeded	PR-PR	.63(.03)	.66 (.03)	.70 (.02)	.76 (.03)
	PR-CJ	.57 (.03)	.66 (.04)	.68 (.03)	.85 (.03)

Note: For List 1 false alarm items, repetitions occurred in List 1. For List 2 hit items, repetition of 1 indicates that the item appeared on List 2 only, while repetition of 2 indicates that the item appeared once on List 1 and once on List 2.

Highlights

- Early selection and late correction control processes in memory
- Post-access monitoring and retrieval constraint reduce false memory
- Retrieval constraint in criterial recollection paradigm

Table 1

a. Predicted relative effects of study conditions under criterial recollection test instructions for Experiment 1.

<u>STUDY CONDITION</u>		<u>PREDICTED PERFORMANCE</u>	
<u>List 1</u>	<u>List 2</u>	<u>Hits</u>	<u>False Alarms to List 1</u>
CJ	CJ	low	high
PR	PR	high	high
PR	CJ	low	low
CJ	PR	high	low

b. Predicted relative effects of study conditions under inclusion tests instructions.

<u>STUDY CONDITION</u>		<u>PREDICTED PERFORMANCE</u>	
<u>List 1</u>	<u>List 2</u>	<u>Hits</u>	<u>False Alarms to List 1</u>
CJ	CJ	low	high
PR	PR	high	high
PR	CJ	low	high
CJ	PR	high	low

Table 2

Experiment 1: Mean proportion of false alarms to List 1 and novel lures and mean proportion of correct hits to List 2 items, as a function of study condition and test type. Numbers in parentheses are standard errors.

Test Type	Study Condition	List 1 Lures	Novel Lures	List 2 Hits
	CJ-CJ	.65 (.03)	.13 (.02)	.75 (.02)
	CJ-PR	.50 (.03)	.12 (.02)	.84 (.03)
Recollection				
	PR-PR	.68 (.03)	.08 (.02)	.80 (.03)
	PR-CJ	.55 (.03)	.11 (.02)	.70 (.02)
	CJ-CJ	.72 (.03)	.19 (.02)	.83 (.03)
	CJ-PR	.58 (.03)	.11 (.02)	.88 (.03)
Inclusion				
	PR-PR	.68 (.03)	.11 (.02)	.84 (.03)
	PR-CJ	.68 (.03)	.12(.02)	.71 (.02)

Table 3

Experiment 2: Mean proportion of false alarms to List 1 and novel lures and mean proportion of correct hits to List 2 items, as a function of study condition and test type. Numbers in parentheses are standard errors.

Test Type	Study Condition	List 1 Lures	Novel Lures	List 2 Hits
Self-Paced	CJ-CJ	.72 (.02)	.21 (.03)	.80 (.02)
	CJ-PR	.50 (.03)	.11 (.02)	.89 (.03)
	PR-PR	.71 (.03)	.14 (.02)	.87 (.02)
	PR-CJ	.59 (.03)	.10 (.02)	.76 (.02)
	CJ-CJ	.65 (.02)	.28 (.03)	.73 (.03)
	CJ-PR	.54 (.04)	.24 (.02)	.73 (.02)
	PR-PR	.64 (.03)	.23 (.02)	.73 (.03)
	PR-CJ	.61 (.04)	.22(.02)	.71 (.02)
Speeded				
Speeded	PR-PR	.64 (.03)	.23 (.02)	.73 (.03)
	PR-CJ	.61 (.04)	.22(.02)	.71 (.02)