

Encoding and Retrieval Processes Involved in the Access of Source Information in the Absence of Item Memory

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The current study sought to examine the relative contributions of encoding and retrieval processes in accessing contextual information in the absence of item memory using an extralist cuing procedure in which the retrieval cues used to query memory for contextual information were *related* to the target item but never actually studied. In Experiments 1 and 2, participants studied 1 category member (e.g., *onion*) from a variety of different categories and at test were presented with an unstudied category label (e.g., *vegetable*) to probe memory for item and source information. In Experiments 3 and 4, 1 member of unidirectional (e.g., *credit* or *card*) or bidirectional (e.g., *salt* or *pepper*) associates was studied, whereas the other unstudied member served as a test probe. When recall failed, source information was accessible only when items were processed deeply during encoding (Experiments 1 and 2) and when there was strong forward associative strength between the retrieval cue and target (Experiments 3 and 4). These findings suggest that a retrieval probe diagnostic of semantically related item information reinstates information bound in memory during encoding that results in reactivation of associated contextual information, contingent upon sufficient learning of the item itself and the association between the item and its context information.

Keywords: source memory, partial information, spreading activation, reactivation, binding

Source monitoring concerns the cognitive processes involved in determining the origin of a memory. The majority of research on the processes involved in source monitoring has examined performance when participants are able to access the target event from encoding (but see Chalfonte & Johnson, 1996; Cook, Marsh, & Hicks, 2006; Starns & Hicks, 2008; Starns, Hicks, Brown, & Martin, 2008). However, in everyday life, we often fail to remember the exact content of learned information yet are still able to recall details associated with the target event. For example, a friend may be picking up beverages for a social gathering and ask you what you were drinking over the weekend that was so delicious. Upon trying to recall which beverage you had, you may not be able to retrieve the exact drink, although you could effectively remember where you had the drink (i.e., it was had at a restaurant and not at a pub). In such instances, although item information (i.e., beverage) is not directly accessible during retrieval, contex-

tual details (i.e., location) are nevertheless recovered that allow for accurate decisions concerning the origin of the memory. In the current study, we sought to better understand the encoding and retrieval mechanisms thought to underlie the ability to retrieve source information¹ in the absence of item memory.

The source-monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993) posits that during the source attribution process, individuals inspect memory for characteristics associated with the original encoding event. Assuming that memory traces are bundles of features and that these features can be activated to varying degrees by a retrieval cue (Bower, 1967), source-monitoring decision processes can be based on a variety of the features that were present at encoding. Decision processes are based on weighting the quality and quantity of retrieved details associated with an event against an otherwise expected amount, and a positive source attribution is given when the retrieved details of an event are more diagnostic of originating from one source over another (Mitchell & Johnson, 2000, 2009). Even if the features activated by a particular cue during retrieval are insufficient to recognize or recall an item, associated features may nevertheless be reactivated and recovered in order to arrive at an accurate source attribution. Accordingly, previous research has demonstrated that source information can be recovered in the absence of item memory (e.g., Cook et al., 2006; Kurilla & Westerman, 2010; Starns, Hicks, Brown, & Martin, 2008).

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¹ We use the terms *context* and *source* interchangeably throughout the article.

Associative and semantic binding processes between item and context have been considered an integral part in the ability to retrieve source information in the absence of item memory. Previous research using the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) has demonstrated that after studying a list of semantically related words (e.g., *bed*, *rest*, *tired*), people will often erroneously make a source attribution for a unstudied lure (e.g., *sleep*) that is consistent with the source in which the related items were studied (Hicks & Hancock, 2002). Thus, even though there are no memorial item details associated with the lure, per se, contextual information from semantically related items influences source memory. Hicks and Hancock suggested that this type of source-monitoring error is due to the studied items eliciting activation of the lure representation at encoding that results in the source characteristics becoming additionally bound to the unstudied, activated lure. Similarly, binding processes that occur during encoding may mediate the recovery of veridical source information in the absence of item memory. Cook et al. (2006) had participants learn paired associates during study in which the cue was always presented visually, and the target was spoken in either a male or a female voice. At test, cued recall failed participants, they were asked to determine whether the target was originally presented in a male or female voice. The results showed that when participants failed to recall the target item source, memory was only above chance when the cue–target and target–context associations were simultaneously strengthened by multiple study presentations and intentional encoding, but not when either association was strengthened in isolation. The authors suggested that multiple presentations of cue–target pairs during encoding create a direct association between the cue and source of the target item, and intentional encoding allows for the contextual information to be bound to the cue deliberately. Thus, associative-binding processes that occur between the cue and context during encoding may allow for source information to be directly accessed even when target recall fails.

More recently, it has been suggested that associative and semantic processes during retrieval may serve to reactivate related information from the study episode and influence source decisions. In a study by Ball et al. (Ball, Marsh, Meeks, & Hicks, 2011), participants studied forward and backward members of associative word pairs (e.g., *credit* and *card*) in either the same (e.g., both seen) or different (e.g., seen vs. heard) sources during encoding. For example, the word *credit* may have been studied visually, and later during the encoding episode, *card* could have been studied visually or auditorily (for a similar procedure, see Hicks & Starns, 2006). In this example, the word *credit* (which we refer to as the *forward* member) has a strong forward association to and produces the word *card* (which we refer to as the *backward* member) in the Florida word association norms (Nelson, McEvoy, & Schreiber, 1998). However, the word *card* does not produce the word *credit*. When the two members were studied in the same source, performance was better for the forward member (e.g., *credit*) than for the backward member (e.g., *card*). We suggested that when a test item is used to probe memory, related information from encoding may be inadvertently reactivated and affect the source-monitoring decision (see also Henkel & Franklin, 1998; Lyle & Johnson, 2006, 2007). Thus, when *credit* was presented during test source information from the associated item, *card* was also automatically reactivated, resulting in an increase in performance for the forward

member when the two items were presented in the same source. Furthermore, semantically related pairs (e.g., *motor* and *engine*) encoded in the same source benefitted performance, suggesting that semantically related items may serve to reactivate study information during retrieval in a similar manner as do direct preexperimental associations. These findings implicate an important role in retrieval processes in the recovery of source information and suggest that even if a target item is not remembered, items used to probe memory that are associatively or semantically related to the target may activate related information from encoding that influences source decisions.

The Current Study

In all of the studies examining the recovery of source information in the absence of (veridical) item memory, the retrieval cue used to probe source memory was always paired with source information during encoding (e.g., Cook et al., 2006; Kurilla & Westerman, 2010; Starns et al., 2008; but see Starns & Hicks, 2008). In such instances, it is likely the case that the retrieval cue itself contains contextual details associated with the target regardless of whether or not the actual target is recognized or recalled. For example, Cook et al. suggested that multiple and intentional encoding opportunities allowed for an association between the cue and target's context information to be formed more automatically. However, we believe that there may be other important processes involved in retrieval of contextual information in the absence of item memory that have not previously been explicitly addressed.

As depicted in Figure 1, we suggest that the encoding of item information results in automatic spreading activation of conceptual representations within a semantic network (Anderson, 1983; Collins & Loftus, 1975; Roediger, Balota, & Watson, 2001). That is, during encoding of both cue and target items (represented in the solid circles in Figure 1), features that are associatively and/or semantically² related to the item are simultaneously activated (represented in the dashed circles in Figure 1), and these features become bound to one another during formation of the memory trace (Anisfeld & Knapp, 1968). The solid arrows reflect direct cue-to-target and target-to-context associations, whereas the dashed arrows reflect indirect associations among items and related features as a result of cotemporaneous activation during encoding via spreading activation. Importantly, contextual information associated with the target may additionally be bound to both the cue (Cook et al., 2006) as well as the associatively and semantically related information that is implicitly activated during encoding (Hicks & Hancock, 2002).

During retrieval, presentation of the cue and search of the target also results in spreading activation within a semantic network, which may involve reactivation of related features from encoding that were bound together during the formation of the memory trace. When cued recall is successful, the full “encoding model” is reinstated and contextual information is accessible via both direct paths (as indicated by the solid arrows from the cue and

² We do not assume that other important information (e.g., orthographic features) is not activated during encoding of item information. However, for the purpose of the current study, we are primarily concerned with associative and semantic features related to item information that are activated during encoding and retrieval.

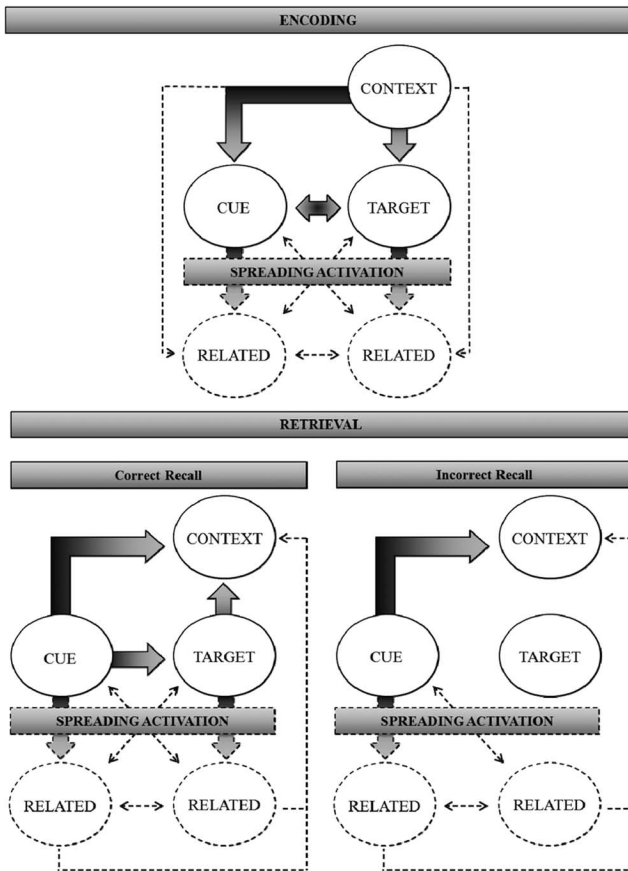


Figure 1. General conceptual model depicting the encoding and retrieval processes involved in accessing source information during a cued recall test in which contextual information is paired with the target during encoding. **(Encoding)** During encoding of both cues and targets, features related to the items are automatically activated via spreading activation and become bound together in memory as a result of cotemporaneous activation. Consequently, contextual information is bound not only to the cue and target but also to the activated related features. **(Retrieval)** Presentation of the cue results in spreading activation that involves reactivation of related features from encoding that were bound together during the formation of the memory trace. **(Correct Recall)** Contextual information is accessible directly from the cue and target, or indirectly from the activated related features. **(Incorrect Retrieval)** Contextual information is accessible directly from the cue, or indirectly from the activated related features. Solid circles represent items and context present at encoding. Dashed circles reflect information that is implicitly activated via spreading activation. Solid thick arrows reflect direct item-to-item or item-to-context associations present at encoding. Dashed thick arrows reflect direct associations from item-to-implicitly activated information. Thin dashed lines reflect indirect associations of information bound in memory as a result of cotemporaneous activation via spreading during encoding.

target to the context in Figure 1) and any of the indirect pathways (as indicated by the dashed arrows from the related items to the context in Figure 1). When cued recall fails, contextual information is no longer accessible via the target item but still may be accessible via the direct pathway from the cue or indirect pathways that are activated by the cue during memory search.

Although Figure 1 provides a useful model to represent the processes involved in retrieval of contextual information, it is

admittedly difficult to parse the relative contributions of encoding and retrieval processes in accessing source information when item memory fails because the cue and context are paired during study. Thus, in the current study, we used an extralist cuing procedure (e.g., Nelson, McEvoy, & Friedrich, 1982; Nelson et al., 1998) in which the retrieval cues used to query memory for contextual information were *related* to the target item but never actually studied (see Table 1 for an example of the stimuli used across experiments). Therefore, any access of source information in the absence of item memory cannot be due to cue-context and/or cue-target binding during encoding. The extralist cuing procedure allows for a more nuanced understanding of the encoding and retrieval processes involved in accessing source information in the absence of any direct associations formed between the cue and context during encoding.

Experiment 1

Experiment 1 served as an initial investigation to determine whether contextual information can be accessed in the absence of item memory when the retrieval cue used to query memory for item and context is not present during encoding. Participants studied one category member (e.g., *onion*) from a variety of different categories (e.g., *vegetable*) and incidentally learned item and source information by performing either of two orienting tasks on each category member. At test, category labels (e.g., *a vegetable*) were used to probe item and source memory for category members and their associated contextual details. Because Cook et al. (2006) found that source information was accessible when learning was good (i.e., multiple study trials), but not when learning was poor (i.e., single-study trial), we additionally manipulated level of processing (LOP; Craik & Lockhart, 1972) during encoding to provide a conceptual replication of that finding. In the shallow-processing condition, the orienting tasks focused processing on lexical aspects of the items (number of letters vs. syllables in the item). In the deep-processing condition, the orienting tasks focused processing on the semantic meaning of the items (pleasantness vs. frequency of prior encounters of the item).

Figure 2 depicts a particular instantiation of the general conceptual model (i.e., Figure 1) used in the current experiment in which only the target item and source information are presented during encoding. In this model, during encoding of the category member, associatively (e.g., *cry*) and semantically (e.g., *potato*) related information is activated via spreading activation that may be additionally bound with both the target and its associated contextual information. During retrieval, a related cue (e.g., *vegetable*) is used to probe memory for the target (e.g., *onion*) and its associated contextual information. Upon searching memory for information semantically related to the cue, spreading activation occurs that activates information directly related to the cue, which may include reactivation of information that was originally bound to the context during encoding (e.g., *potato*). It is important to note that the major distinction between the retrieval model in Figure 2 and the general retrieval model in Figure 1 is that because the cue is never presented during encoding, there is no direct pathway from the cue to the context or indirect pathway from the cue to the related features activated by the target during encoding.

Cook et al. (2006) found that only after simultaneously strengthening both target–context and cue–target associations through

Table 1
Examples of the Stimuli and Procedure Used for Each Experiment

| Experiment | Study | Study stimuli | Test Phase 1 cue | Test Phase 2 cue |
|--------------|-----------------------------------|------------------------------|----------------------------|------------------|
| Experiment 1 | Deep and Shallow | ONION | A VEGATABLE | ONION |
| Experiment 2 | Deep and Shallow cue No cue | (A VEGETABLE) ONION ONION | A VEGETABLE A VEGETABLE | ONION ONION |
| Experiment 3 | Forward member Backward member | CREDIT ALIEN | CARD ABDUCT | CREDIT ALIEN |
| Experiment 4 | Bidirectional Backward member | PEPPER ALIEN | SALT ABDUCT | PEPPER ALIEN |

multiple study trials was source information accessible in the absence of item memory, presumably by promoting more direct binding of the context with the cue. In the current study, the strength of target–context associations was varied by manipulating the LOP during encoding while holding cue–target strength constant by using retrieval cues (e.g., *a vegetable*) that have preexperimental associations with the targets (e.g., *onion*). Importantly, however, because the cue is never presented during encoding, it cannot be bound in memory with the source information. Consequently, if cue–context binding during encoding is the primary determinant in accessing source information when target recall fails, source accuracy should not be above chance in either encoding condition. Alternatively, if processes at retrieval automatically reactivate contextual information from study, then source discrimination should be above chance in the absence of item memory regardless of LOP. However, if reactivation of contextual information is partially dependent on the strength of target–context binding at encoding, source information should only be accessible when recall fails in the deep-processing condition.

Method

Participants. Undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a course research requirement. Each participant was individually tested in sessions that lasted approximately 25 min. Thirty participants were randomly assigned to one of the two between-subjects depth-of-processing encoding conditions.

Materials and procedure. The experimental materials consisted of 40 unrelated superordinate category labels (e.g., *a vegetable*) and one member from each category (e.g., *onion*) taken from the Overschelde category norms (Van Overschelde, Rawson, & Dunlosky, 2004). There was no clear relation between any of the 40 members. Each of the 40 category members served as studied items in the first phase of the experiment, whereas the category labels served as test cues during the second phase of the experiment. Category members that served as studied items were weakly associated with the superordinate categories in the normative database. On the basis of the norms, the member for each category on average was output less than 50% of the time ($M = .21$), low in the output ranking (mean output position = 8.05), and rarely output first ($M = < .1$; see Overschelde et al., 2004, for analytic details). Such criteria ensured that, given a particular category label, it would be unlikely for participants to guess the correct member without explicit knowledge of the originally studied item.

The experiments consisted of three separate phases (study phase, Test Phase 1, and Test Phase 2). During the study phase,

participants studied items in one of two sources. Participants in the deep-processing condition were asked to rate 20 of the items for how pleasant the word was and rate 20 items for how frequently it was encountered within the last month, both on a scale ranging from 1 (*being very unpleasant/infrequent*) to 5 (*being very pleasant/frequent*). Participants in the shallow-processing condition were asked to indicate the number of syllables in each word for half the items and indicate the number of letters for the other 20 items. In both conditions, each item was presented in the center of the computer screen with a cue below it indicating which rating task to perform and remained on the screen until participants completed the rating for that item. The order of presentation and the rating task for specific items were determined randomly anew for each participant. Upon conclusion of the study phase, a 2-min distractor phase consisting of a series of maze tasks was administered. Following the distractor phase, instructions for the first test phase were given.

During the first test phase, participants were told that category labels for each of the studied items would be presented individually on the screen. Upon seeing the category label, participants were asked to try to think of the studied item from that category and to indicate the rating task performed on the item. Participants were informed that even if they were unable to remember the studied item, or were unsure that the item they remembered was correct, they should still make their best effort to try to remember the rating task performed for the item that was studied from the given category label. After making a source decision, participants were asked to make a confidence rating on a scale ranging from 1 to 6 on how sure they were that the response they chose was correct, where 1 = *being very unsure* and 6 = *being very sure*. Subsequently, participants were to recall the specific studied member from the presented category by typing the word. If absolutely unsure of the member, participants were to type in “XXX” to continue to the next trial. Upon completion of all 40 trials, participants were given instructions for Test Phase 2. During the second test phase, participants were presented with each of the original 40 studied items (e.g., ONION) and asked to indicate which rating task was originally performed on the item during the study phase. No confidence judgments were made during the second test phase.

Results

For Experiment 1, and all subsequent experiments, the descriptive statistics are parsed by condition and presented in two separate

tables. Table 2 summarizes the overall recall performance as well as source memory performance for both test phases. Table 3 presents source memory performance conditional on whether or not recall was correct during the first test phase.³ Table 3 also includes confidence ratings for source performance during the first test phase conditional on whether or not recall was correct.

Source memory. We first consider source memory performance for Test Phases 1 and 2 when cued recall was *successful* (see the Correct recall column of Table 3). The proportion of

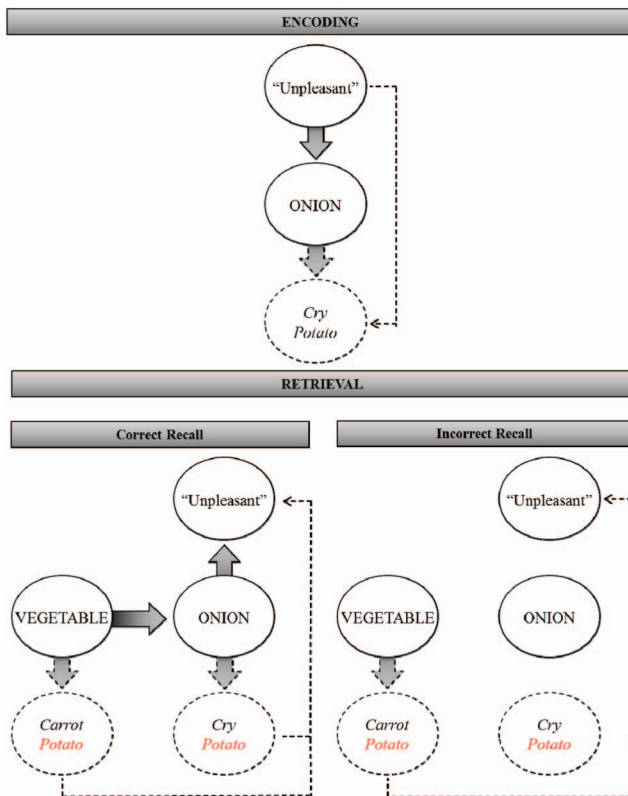


Figure 2. Example conceptual model for Experiment 1 when only the target item and contextual information are presented during encoding. (**Encoding**) During encoding, features related to the target are automatically activated via spreading activation and become bound with both the target and context as a result of cotemporaneous activation. (**Retrieval**) Presentation of the cue results in spreading activation that activates information directly related to the cue, which may include reactivation of information that was originally bound to the context during encoding (presented as *Potato*, which is in red in the online version of the article, under Correct Recall and Incorrect Recall). (**Correct Recall**) Contextual information is accessible directly target, or indirectly from the activated related features. (**Incorrect Retrieval**) Contextual information is only accessible indirectly from the activated related features. Solid circles represent items and context present at encoding or retrieval. Dashed circles reflect information that is implicitly activated via spreading activation. Solid thick arrows reflect direct item-to-item or item-to-context associations present at encoding. Dashed thick arrows reflect direct associations from item-to-implicitly activated information. Thin dashed lines reflect indirect associations of information bound in memory as a result of cotemporaneous activation via spreading during encoding. Information presented in italics under Correct Recall and Incorrect Recall reflects similar information that is implicitly activated during encoding and retrieval. See the online article for a color version of this figure.

Table 2

Overall Recall and Source Memory Performance During Test Phase 1 (Related Cue), and Source Memory (and Standard Errors) for Test Phase 2 (Copy Cue) for Each Experiment

| Experiment | Study | Related cue | | Copy cue: Source |
|--------------|---------------|-------------|-----------|---------------------|
| | | Recall | Source | |
| Experiment 1 | Deep | .55 (.03) | .71 (.03) | .80 (.03) |
| | Shallow | .16 (.02) | .55 (.02) | .64 (.02) |
| Experiment 2 | Deep | Cue | .74 (.02) | .82 (.02) |
| | | No cue | .65 (.03) | .78 (.02) |
| | Shallow | Cue | .20 (.02) | .55 (.02) |
| | | No cue | .15 (.02) | .54 (.02) |
| Experiment 3 | Forward | .60 (.03) | .74 (.02) | .80 (.02) |
| | Backward | .76 (.02) | .80 (.02) | .79 (.02) |
| Experiment 4 | Bidirectional | .64 (.03) | .71 (.02) | .71 (.02) |
| | Backward | .74 (.02) | .74 (.02) | .75 (.02) |

accurate source attributions when recall was accurate was submitted to a 2 (test phase: first vs. second) \times 2 (processing: deep vs. shallow) mixed-factorial analysis of variance (ANOVA). This analysis revealed an effect of test phase and an effect of processing, $F(1, 58) = 6.27, p < .05, \eta_p^2 = .098$; and $F(1, 58) = 6.08, p < .05, \eta_p^2 = .095$, respectively, indicating better source memory during the first test phase and following deep processing. However, these effects were qualified by a significant interaction of test phase and processing, $F(1, 58) = 4.71, p < .05, \eta_p^2 = .075$. This interaction reflects that when given a category cue during the first test phase, source memory was not affected by the depth-of-processing manipulation, $t(58) = 1.41, p = .16, d = .364$. However, when cued with the original item (copy cue) during the second test phase, source memory was superior following deep processing compared with shallow processing, $t(58) = 3.08, p < .01, d = .795$. The difference in performance across processing conditions during the second test phase is primarily due to a significant decrease in performance across test phases for the shallow- but not deep-processing condition, $t(29) = 2.79, p < .01, d = .512$; and, $t(29) < 1$, respectively. Thus, when participants were able to accurately retrieve the member when presented with the category label, source performance was generally high, but source performance benefited from deep processing when the original item was presented as a test cue.

³ To examine performance for both source memory test phases, source accuracy was conditionalized on whether or not the target item was successfully recalled when presented with the category label (or related associate in Experiments 3 and 4) during the first test phase. Conditionalized source accuracy for correct recall is simply the proportion of successful source attributions given that recall was correct, divided by the proportion of items successfully recalled. For incorrect recall, conditionalized source accuracy is the proportion of successful source attributions given that recall was incorrect, divided by the proportion of items that were not successfully recalled. It should be noted that the source memory performance during the second test phase that is reported in Table 3 and the subsequent analyses is *also* conditional upon whether or not the item was originally recalled during the first test phase. The reason for computing conditional source accuracy for the second test phase was to compare performance for items that were initially recallable versus those that were not after reinstating the exact copy cue in the second test phase.

Table 3

Conditional Source Memory Performance and Confidence Judgments (and Standard Errors) During Test Phase 1 (Related Cue) and Conditional Source Memory Performance During Test Phase 2 (Copy Cue) for Each Experiment

| Experiment | Study | Correct recall | | | Incorrect recall | | |
|--------------|-----------------|----------------|-----------|---------------------|------------------|------------|---------------------|
| | | Related cue | | Copy cue: Source | Related cue | | Copy cue: Source |
| | | Confidence | Source | | Confidence | Source | |
| Experiment 1 | Deep | 5.03 (.11) | .79 (.03) | .79 (.03) | 2.71 (.15) | .60 (.03) | .81 (.03) |
| | Shallow | 4.80 (.19) | .72 (.04) | .62 (.04) | 2.24 (.13) | .53* (.02) | .64 (.02) |
| Experiment 2 | Deep | | | | | | |
| | Cue | 5.14 (.10) | .88 (.02) | .84 (.02) | 3.57 (.23) | .65 (.05) | .78 (.03) |
| | No cue | 5.21 (.09) | .87 (.02) | .84 (.02) | 2.52 (.23) | .61 (.04) | .83 (.04) |
| | Shallow | | | | | | |
| | Cue | 4.46 (.18) | .78 (.04) | .66 (.05) | 1.98 (.12) | .50* (.02) | .60 (.02) |
| | No cue | 4.32 (.30) | .64 (.07) | .69 (.06) | 1.83 (.13) | .51* (.03) | .64 (.03) |
| Experiment 3 | Forward member | 5.01 (.10) | .88 (.01) | .81 (.02) | 2.67 (.14) | .52* (.03) | .78 (.03) |
| | Backward member | 4.97 (.10) | .87 (.02) | .81 (.02) | 2.73 (.21) | .59 (.03) | .71 (.04) |
| Experiment 4 | Bidirectional | 4.63 (.14) | .79 (.02) | .74 (.02) | 2.57 (.16) | .57 (.03) | .68 (.03) |
| | Backward member | 4.87 (.13) | .80 (.02) | .76 (.02) | 2.70 (.17) | .57 (.03) | .70 (.03) |

Note. Values with an asterisk indicate that performance was *not* significantly above chance.

To examine source accuracy when recall was *unsuccessful* (see the Incorrect recall column of Table 3), we submitted the proportion of accurate source attributions with incorrect recall to a 2 (test phase: first vs. second) \times 2 (processing: deep vs. shallow) mixed-factorial ANOVA. This analysis revealed an effect of test phase and an effect of processing, $F(1, 58) = 62.05, p < .001, \eta_p^2 = .517$; and, $F(1, 58) = 24.95, p < .001, \eta_p^2 = .301$, respectively, indicating that performance was better after deep processing and when the copy cue was presented during the second test phase. However, these effects were qualified by a significant interaction of test phase and processing, $F(1, 58) = 4.81, p < .05, \eta_p^2 = .077$, indicating that although performance was better in the deep-processing condition in the first test phase, $t(58) = 2.44, p < .05, d = .63$, the difference between the two conditions was substantially larger in the second test phase, $t(58) = 5.04, p < .001, d = 1.301$. That is, reinstating the copy cue during the second test phase increased source memory in both conditions, but this benefit was much more substantial in the deep- than the shallow-processing condition. Critically, however, source performance during first test phase was significantly above chance when recall failed for the deep- but not shallow-processing condition, $t(29) = 3.83, p < .01, d = .699$; and, $t(29) < 1.57, p > .12$, respectively. These results indicate that contextual information was still accessible in the absence of item memory, but only when items were processed deeply.

Confidence. During the first test phase, participants made confidence ratings on the accuracy of their source judgment prior to recalling the item (see the Confidence column of Table 3). To examine confidence for accurate source judgments, we submitted mean confidence ratings to a 2 (recall: correct vs. incorrect) \times 2 (processing: deep vs. shallow) mixed-factorial ANOVA. This analysis revealed an effect of recall accuracy and an effect of processing, $F(1, 58) = 301.7, p < .001, \eta_p^2 = .839$; and, $F(1, 58) = 4.64, p < .05, \eta_p^2 = .074$, respectively, indicating greater confidence when subsequent recall was correct and following deep processing. The interaction of recall and processing was not significant, $F(1, 58) < 1$. However, planned comparisons revealed that deep processing led to higher confidence ratings than shallow

processing when recall was incorrect, $t(58) = 2.34, p < .05, d = .604$, but not when recall was correct, $t(58) = 1.1$. Thus, participants were more confident in their source decisions in the absence of item information when items were processed deeply.

Discussion

The results from Experiment 1 demonstrated that when recall was correct, source memory was generally high regardless of whether probed with a related or copy cue (although performance in the shallow condition decreased across test phases). Furthermore, participants were more confident in their source decisions when they were able to access the target item. When participants were *unable* to retrieve the target item, they were only able to access source information above chance levels and were more confident in their decisions when items were processed deeply. Finally, when the original study item was reinstated during the second test phase, performance increased and was above chance across all encoding conditions. This latter finding suggests that contextual information was indeed bound to the target in the shallow-processing condition. However, previous research has suggested that during incidental encoding of similar sources, contextual information in the shallow-processing condition may lose its distinctiveness and only be weakly bound to the appropriate item due to interference from processing other items with similar cognitive operations (Mammarella & Fairfield, 2008). Thus, given that performance decreased across test phases following correct recall in the shallow-processing condition and that source memory was generally better following deep processing, it is likely the case that target–context binding was weaker in the shallow condition. Importantly, the finding that contextual information was accessible even in the absence of item memory suggests that cue–context or cue–target binding processes at encoding are not necessary to retrieve source information following deep processing. Nevertheless, to test the influence of binding processes more directly, in Experiment 2 the category cue was presented with half of the category members during encoding to strengthen cue–context and cue–target associations.

Experiment 2

Experiment 1 revealed that source information was only accessible in the absence of item memory following deep processing. However, by presenting the category label at study, source information may be directly bound to the retrieval probe and eliminate the necessity of item information to retrieve context. Consequently, presenting the category label at study may allow for weakly bound target–context information in the shallowly processed item to actually be accessible for shallowly processed items when target recall fails, and improve performance for deeply processed items over and above what was found in Experiment 1 when the category members were studied in isolation. Thus, in Experiment 2, the category label was presented with the context information of its category member during encoding of half of the items to more directly assess the influence of cue–context binding processes at encoding.

The left- and right-hand portions of Figure 3 depict a conceptual model of the encoding and retrieval processes involved in accessing source information in the absence and presence, respectively, of the category cue during encoding. It is important to note that the left half of the model is identical to Figure 2 used in Experiment 1 (when recall fails), whereas the right half of the model is identical to the model in Figure 1 (when recall fails). The major distinction between the two models is that when the category cue is presented during encoding, contextual information should still be accessible when target recall fails via the direct pathway from the cue to the context. Thus, the two models make clear predictions involving the accessibility of contextual information in the absence of item memory. If cue–context and/or cue–target binding processes at encoding are the primary determinant of accessing source information in the absence of item memory, source accuracy should only be above chance only when the cue is presented at encoding. Alternatively, if processes at retrieval automatically reactivate contextual information from study, then performance should be above chance regardless of whether or not the cue is processed at encoding. Finally, if binding processes at encoding and associative reactivation retrieval processes jointly interact to facilitate retrieval of contextual information in the absence of item memory, source accuracy should be greatest for items that were originally paired with the category label during encoding.

Method

Participants. Undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a course research requirement. Each participant was individually tested in sessions that lasted approximately 25 min. Thirty new participants were randomly assigned to one of the two between-subjects depth-of-processing encoding conditions.

Materials and procedure. The only difference between Experiments 1 and 2 was that in Experiment 2, participants were informed that sometimes a label would appear above the category member (in parentheses) during the study phase. However, participants were not explicitly instructed to attend to the label and were to perform the rating task as instructed. Thus, for half (10) of the items in each source, during study, the category label was presented above the category member (in both between-subjects encoding conditions). The instructions and procedure for the first and second test phases were identical to those in Experiment 1.

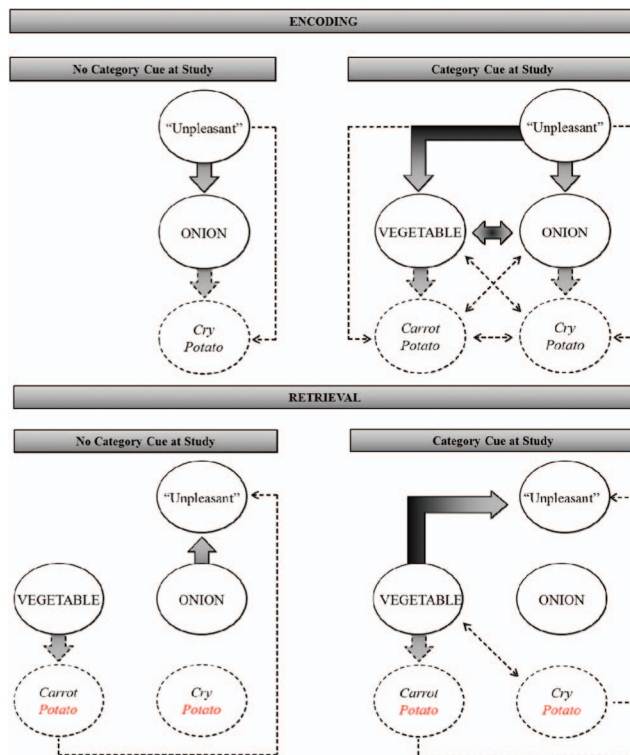


Figure 3. Example of conceptual model for Experiment 2 when the target item and contextual information are presented with and without the category cue during encoding. (**Encoding: No Category Cue at Study**) During encoding, features related to the target are automatically activated via spreading activation and become bound with both the target and context as a result of cotemporaneous activation. (**Encoding: Category Cue at Study**) During encoding of both cues and targets, features related to the items are automatically activated via spreading activation and become bound together in memory as a result of cotemporaneous activation. Consequently, contextual information is bound not only to the cue and target but also to the activated related features. (**Retrieval: No Category Cue at Study**) Presentation of the cue results in spreading activation that activates information directly related to the cue, which may include reactivation of information that was originally bound to the context during encoding (presented as *Potato*, which is in red in the online version of the article, under No Category Cue at Study and Category Cue at Study). Retrieval reflects only when recall is *incorrect*. (**Retrieval: No Category Cue at Study**) Contextual information is only accessible indirectly from the activated related features. (**Retrieval: Category Cue at Study**) Contextual information is accessible directly from the cue, or indirectly from the activated related features. Solid circles represent items and context present at encoding or retrieval. Dashed circles reflect information that is implicitly activated via spreading activation. Solid thick arrows reflect direct item-to-item or item-to-context associations present at encoding. Dashed thick arrows reflect direct associations from item-to-implicitly activated information. Thin dashed lines reflect indirect associations of information bound in memory as a result of cotemporaneous activation via spreading during encoding. Information presented as *Potato* under No Category Cue at Study and Category Cue at Study reflects similar information that is implicitly activated during encoding and retrieval. See the online article for a color version of this figure.

Results

Source memory. We separately analyzed accurate source attributions when recall was correct and incorrect (see Table 3) by

submitting correct source attributions to a 2 (study cue: cue vs. no cue) \times 2 (test phase: first vs. second) \times 2 (processing: deep vs. shallow) mixed-factorial ANOVA. When recall was correct, this analysis revealed only an effect of processing, $F(1, 58) = 20.71$, $p < .001$, $\eta_p^2 = .263$, indicating that source accuracy was better following deep than shallow processing. There was no effect of study cue or test phase, nor any higher order interactions, $F_s(1, 58) < 1.41$, $ps > .23$. Thus, presenting a cue at study did not affect source memory performance when participants were able to retrieve the studied member.

When recall was incorrect, this analysis revealed an effect of test phase and an effect of processing, $F(1, 58) = 37.85$, $p < .001$, $\eta_p^2 = .395$; and, $F(1, 58) = 36.32$, $p < .001$, $\eta_p^2 = .381$, respectively, indicating that performance was better after deep processing and when the copy cue was presented during the second test phase. However, there was no effect of study cue, nor any interactions between any of the variables, $F_s(1, 58) < 1$. Critically, source memory for participants in the deep-processing condition was above chance when recall failed during the first test phase both with and without a study cue, $t(29) = 3.05$, $p < .01$, $d = .557$; and, $t(29) = 2.75$, $p < .05$, $d = .502$, respectively, and discrimination did not differ between the two, $t(29) < 1$. However, when items were processed shallowly, performance was not above chance regardless of study cue presence, $t_s(29) < 1$. This indicates that participants had access to source information only when items were processed deeply and that adding a study cue did not appear to influence performance.

Confidence. To examine confidence for accurate source judgments (see Table 3), we submitted mean confidence ratings to a 2 (study cue: cue vs. no cue) \times 2 (recall: correct vs. incorrect) \times 2 (processing: deep vs. shallow) mixed-factorial ANOVA. This analysis revealed an effect of processing, $F(1, 51) = 28.2$, $p < .001$, $\eta_p^2 = .356$, with greater confidence in the deep-processing condition. There was also an effect of recall accuracy and cue presence, $F(1, 51) = 341.07$, $p < .001$, $\eta_p^2 = .87$; and, $F(1, 51) = 9.21$, $p < .01$, $\eta_p^2 = .153$, respectively, indicating greater confidence when subsequent recall was correct as well as when a cue was presented at study. These effects were qualified by a significant two-way interaction of recall and study cue, $F(1, 51) = 4.44$, $p < .05$, $\eta_p^2 = .08$, and a significant three-way interaction with processing, $F(1, 51) = 7.76$, $p < .01$, $\eta_p^2 = .132$.

Follow-up comparisons revealed that this three-way interaction primarily reflects that in the deep-processing condition, presenting a cue at study did not affect confidence when recall was correct, $t(29) = .94$, $p = .33$, $d = .181$, but resulted in increased confidence when recall was incorrect, $t(28) = 3.3$, $p < .01$, $d = .614$. In the shallow condition, study cues did not affect confidence regardless of whether recall was correct or incorrect, $t_s(23) < 1.5$, $ps > .13$. Perhaps of most importance is that deep processing led to higher confidence ratings than shallow processing when recall was incorrect both with and without a cue, $t(29) = 6.15$, $p < .001$, $d = 1.602$; and, $t(29) = 2.61$, $p < .05$, $d = .68$, respectively.

Discussion

The results from Experiment 2 are entirely consistent with those of Experiment 1. When recall was correct, source memory and confidence were generally high. However, when target recall

failed, source memory was only above chance levels when items were processed deeply, and reinstating the copy cue during the second phase increased performance across all encoding conditions for items that were initially not recalled. Additionally, deep processing resulted in greater confidence when recall failed, and confidence increased when the category label was presented at study. However, presenting the category cue with the target during encoding did not increase performance, suggesting that cue–context and cue–target binding did not influence performance.⁴ Although it is possible that deep processing resulted in implicit activation of categorical information, thereby strengthening the association between the category and context for *all* items, higher confidence in source judgments for items that were originally studied with the category label during Experiment 2 suggest this might not be the case. Rather, the finding that source accuracy was statistically equivalent with or without the category cue appearing at encoding suggests that studying the category label may have increased cue familiarity that increased confidence ratings, but this familiarity did not necessarily aid in determining the source of the item information.

It is important to note that there was a substantial difference in recall performance between deep and shallow conditions in both Experiments 1 and 2. The chance source performance in the shallow condition during the first test phase may be due to an inefficient retrieval cue. However, even if the retrieval cue was sufficient to retrieve the target, the cue may not necessarily activate the structural details encoded with the target event in the shallow condition. That is, searching memory for targets that are semantically related to the category label may automatically activate associated contextual details for deeply (semantically) processed but not shallowly (structurally) processed items. Thus, benefit in memory performance following deep processing may simply reflect a type of transfer-appropriate processing (TAP; Morris, Bransford, & Franks, 1977) due to the overlap in processing between study and test for the deep, but not shallow, condition. Therefore, Experiments 3 and 4 were designed to manipulate associative strength at encoding and retrieval while holding semantic processing constant.

Experiment 3

Previous research has suggested that associative processes during encoding may allow contextual information to become additionally bound to related information that is automatically activated during an encoding event (Hicks & Hancock, 2002), whereas associative processes at retrieval may serve to reactivate information from related encoding events that inadvertently influences source-monitoring decisions (Ball et al., 2011). Therefore, Experiment 3 was designed to examine how associative activation during encoding and retrieval influences the recovery of source information in the absence of item memory. Participants studied one

⁴ Although it could be argued that participants simply did not attend to the category label during encoding, overall recall performance (see Table 2) was better for items that were originally studied with their respective category label. Furthermore, in the deep-processing condition, when recall was incorrect, participants gave higher confidence ratings for items that were studied with their category label. These findings suggest that participants indeed attended to the category labels despite no explicit instructions to do so.

member of associative word pairs (e.g., *credit*), whereas the unstudied pair member (e.g., *card*) served as a test probe during the first test phase. To control for LOPs (Craik & Lockhart, 1972) and TAP (Morris et al., 1977), participants only processed items deeply during encoding.

Associative activation during encoding and retrieval was manipulated by presenting either the forward (e.g., *credit*, *abduct*) or backward (e.g., *card*, *alien*) member during study and test (see Table 1). That is, for half of the items, the forward member (e.g., *credit*) was studied, and the (unstudied) backward member (e.g., *card*) served as a test probe, whereas for the other half, the backward member (e.g., *alien*) was studied, and the (unstudied) forward member (e.g., *abduct*) served as a test probe. Together, manipulating forward associative activation strength at study or test allows for clear predictions for the underlying processes involved in accessing source memory in the absence of item memory (see Figure 4).

During encoding, studying the forward member (e.g., *credit*) and its source should result in automatic activation of the backward member (e.g., *card*), thereby resulting in additional binding of the source information to the backward member (which will later be used as a test cue). Thus, studying the forward member should implicitly strengthen both cue–target (e.g., *credit* – *card*) and cue–context (e.g., *card* – “pleasant”) associations during encoding. However, studying the backward member (e.g., *alien*) should not activate the related forward member (e.g., *abduct*) during encoding, and therefore source information should not be implicitly bound to cue. Consequently, according to an associative-binding process during encoding account (left-hand portion of Figure 4), during test only, the backward member (e.g., *card*) should contain contextual details from study that may be directly retrieved from the cue to influence performance in the absence of item memory. In contrast, according to a reactivation retrieval account (right-hand portion of Figure 4), source information should only be accessible in the absence of item memory when the forward member (e.g., *abduct*) is used as a test probe because it should automatically activate the studied backward member and the associated contextual information bound to the item during encoding (e.g., *alien* – “pleasant”).

Method

Participants. A total of 30 undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a course research requirement. Participants were individually tested in sessions that lasted approximately 45 min.

Materials and procedure. The experimental materials consisted of 80 word pairs from the Florida word association norms (Nelson et al., 1998). Word pairs were selected such that one member had a high-forward associative strength to the other member (e.g., *credit* produces the word *card*), but there was no associative strength in the opposite direction (e.g., *card* does not produce *credit*). For clarity, we refer to *credit* as the forward associate because it produces *card* (which we label the backward associate) in the Florida word association norms; obviously, this terminology is arbitrary. The average associative strength from the forward member to the backward member was .80, whereas the strength in the opposite direction was .05. Criti-

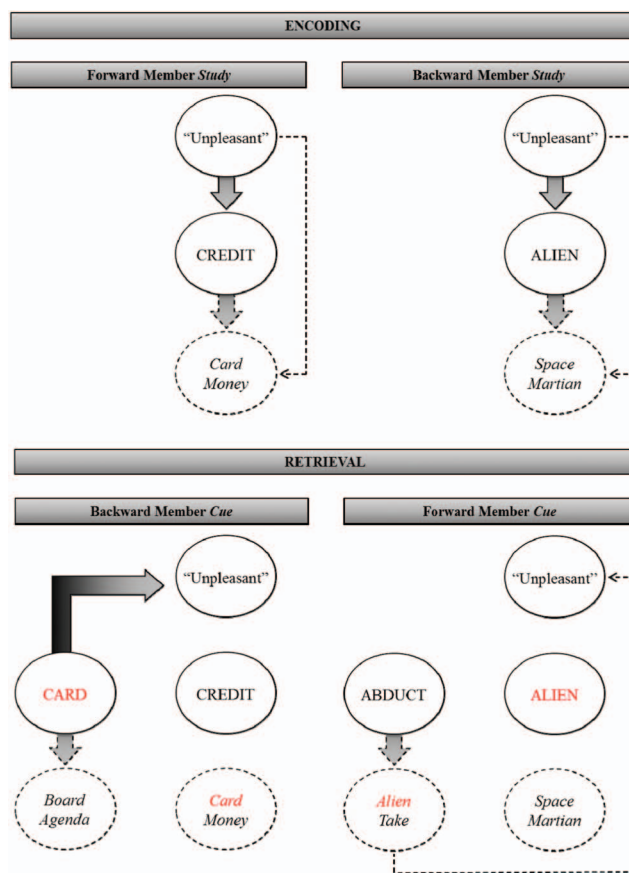


Figure 4. Example of conceptual model for Experiment 3 when only the target item and contextual information are presented during encoding. (**Encoding**) During encoding, features related to the target are automatically activated via spreading activation and become bound with both the target and context as a result of cotemporaneous activation. (**Retrieval**) Presentation of the cue results in spreading activation that activates information directly related to the cue, which may include reactivation of information that was originally bound to the context during encoding (presented as CARD, ALIEN, *Card*, and *Alien*, which are all in red in the online version of the article, under Backward Member Cue and Forward Member Cue). Retrieval reflects only when recall is *incorrect*. (**Retrieval: Backward Member Cue**) Contextual information is accessible directly from the cue as a result of its implicit activation during encoding. (**Retrieval: Forward Member Cue**) Contextual information is only accessible indirectly from the activated related features. Solid circles represent items and context present at encoding or retrieval. Dashed circles reflect information that is implicitly activated via spreading activation. Solid thick arrows reflect direct item-to-item or item-to-context associations present at encoding. Dashed thick arrows reflect direct associations from item-to-implicitly activated information. Thin dashed lines reflect indirect associations of information bound in memory as a result of cotemporaneous activation via spreading during encoding. Information presented as CARD, ALIEN, *Card*, and *Alien* under Backward Member Cue and Forward Member Cue reflects similar information that is implicitly activated during encoding and retrieval. See the online article for a color version of this figure.

cally, only one of the members was studied during the encoding episode, whereas the other (unstudied) member was used as a test probe during retrieval (see Table 1 for an example of the study and test stimuli).

The experimental procedure consisted of three separate phases (study phase, Test Phase 1, and Test Phase 2) and was identical to Experiment 1 except that participants only performed the deep-processing tasks (i.e., pleasantness or frequency rating) during the study phase. The critical within-subjects manipulation in each experiment consisted of which member of the pair was presented at study. The computer software randomly determined which pair member would be presented during study, such that for half the items only the forward member (e.g., *credit*) was studied, whereas for the other half of the items, only the backward member (e.g., *alien*) was studied. During test, the other (unstudied) pair member (e.g., *card*, *abduct*) was used to probe memory for its related member that was presented at study. Study items and the corresponding rating task were randomly presented and counterbalanced such that each item was rated for pleasantness or frequency an equal number of times across participants. Upon conclusion of the study phase, a 2-min distractor phase was administered, followed by the instructions for Test Phase 1.

During the first test phase, participants were told that a word that was not studied (e.g., *card*, *abduct*) was going to appear on the computer monitor and that this word would be related to an item that was actually studied previously (e.g., *credit*, *alien*). Upon seeing the test probe, participants were asked to try to think of the related studied item and to indicate the rating task performed on the item. Participants were informed that even if they were unable to remember the related studied item, or were unsure that the item they remembered was correct, they should still make their best effort to try to remember the rating task performed for the item that was related to test probe. Participants then rated their confidence on the accuracy of their source judgment and then were to type in the retrieved item. Upon completion of all 80 trials, participants were given instructions for Test Phase 2 in which all of the original studied items (e.g., *credit*, *alien*) were presented, and participants were to indicate which rating task was originally performed on the item during the study phase.

Results

Source memory. We separately analyzed accurate source attributions when recall was correct and incorrect (see Table 3) by submitting correct source attributions to a 2 (study member: forward vs. backward) \times 2 (test phase: first vs. second) within-subjects ANOVA. When recall was correct, this analysis revealed an effect of test phase, $F(1, 29) = 23.27, p < .001, \eta_p^2 = .445$, with better performance during the first test phase than the second. However, there was neither an effect of study member nor an interaction of study member and test phase, $F_s(1, 29) < 1$.

When recall was incorrect, this analysis revealed an effect of test phase, $F(1, 29) = 23.34, p < .001, \eta_p^2 = .446$, with better performance during the second phase, but no effect of study member, $F(1, 29) < 1$. However, the interaction of study member and test phase was significant, $F(1, 29) = 4.59, p < .05, \eta_p^2 = .137$. This interaction reflects that although performance in the first phase tended to be better when the backward member was studied (i.e., the forward member was the test cue), $t(29) = 1.7, p = .1, d = .314$, performance during the second phase tended to be better when the forward member was studied, $t(29) = 1.58, p = .13, d = .294$. Critically, source accuracy during the first test phase was above chance when the backward member was studied, $t(29) =$

$2.76, p < .05, d = .504$, but not when the forward member was studied, $t(29) < 1$.

Confidence. To examine confidence for accurate source judgments (see Table 3), we submitted mean confidence ratings to a 2 (study member: forward vs. backward) \times 2 (recall: correct vs. incorrect) within-subjects ANOVA. There was an effect of recall, $F(1, 29) = 408.5, p < .001, \eta_p^2 = .934$, with greater confidence when recall was correct. However, there was neither an effect of study member nor an interaction of cue member and recall, $F_s(1, 29) < 1$. Thus, even though partial source information was accessible with incorrect recall when the backward member was studied, participants were no more confident in those source decisions than when the forward member was studied, $t(29) < 1$.

Discussion

The results from Experiment 3 are generally consistent with the findings from the deep-processing conditions of Experiments 1 and 2. When the target item was successfully recalled, both source performance and decision confidence was high and dropped considerably when target recall failed. However, reinstating the copy cue during the second test phase substantially benefitted performance. Importantly, when target recall failed, participants were only able to retrieve source information during the first test phase above chance when the backward pair member was studied (i.e., when cued at test with the forward member). These findings suggest that associative processes at retrieval play an important role in accessing source information in the absence of item information. To better understand whether the *interaction* between encoding and retrieval processes additionally benefits performance, Experiment 4 was designed to examine source memory after strengthening both cue–context associations during encoding and cue–target associations during retrieval.

Experiment 4

Experiment 4 was similar to Experiment 3 except that we additionally included bidirectional associates (e.g., *salt* and *pepper*) for study and test items. For bidirectional associates, either member of the pair has a forward association to the other member. For example, *salt* produces the word *pepper* in the Florida association norms (Nelson et al., 1998), just as *pepper* produces the word *salt*. Essentially, both items could be considered “forward members.” Although we assigned one item as the forward and one as the backward member, this distinction is arbitrary. That is, regardless of which member is studied, it should automatically activate its associate during encoding, and regardless of which member is used to probe memory at test, it should automatically activate its associate during retrieval. In contrast, the word pairs used in Experiment 3 are considered unidirectional associates in the sense that the associative strength only works in one direction (e.g., *credit* produces *card*, but *card* does not produce *credit*), and therefore the effect of associative activation differs depending on which member of the pair is studied or used as a test probe.

In Experiment 4, we compared source memory performance for unidirectional with bidirectional associates (left- and right-hand portions of Figure 5, respectively). For both unidirectional and bidirectional associates, the backward member was always studied, and its related (unstudied) forward member was always pre-

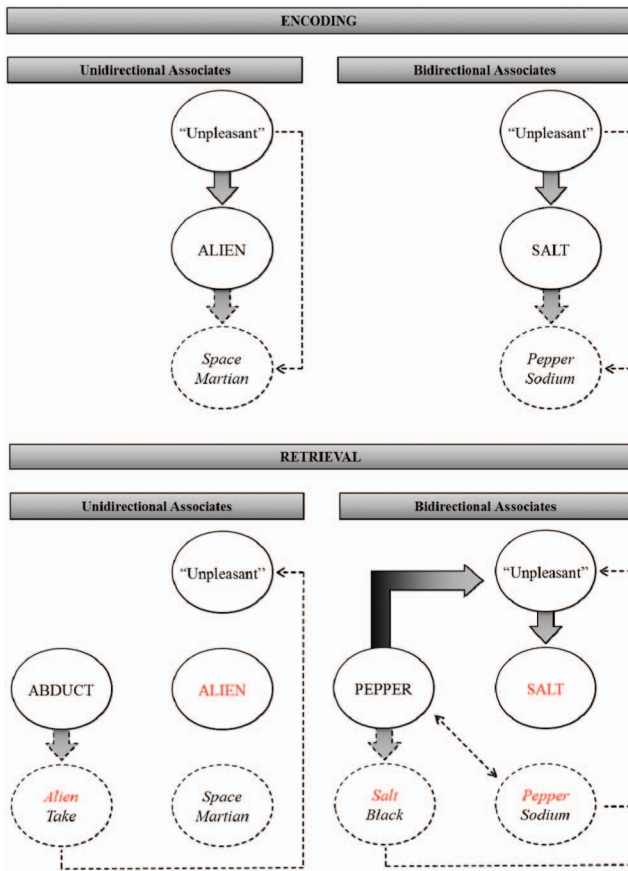


Figure 5. Example of conceptual model for Experiment 4 when only the target item and contextual information are presented during encoding. (**Encoding**) During encoding, features related to the target are automatically activated via spreading activation and become bound with both the target and context as a result of cotemporaneous activation. (**Retrieval**) Presentation of the cue results in spreading activation that activates information directly related to the cue, which may include reactivation of information that was originally bound to the context during encoding (presented as ALIEN, SALT, *Alien*, *Salt*, and *Pepper*, which are all in red in the online version of the article, in the two Retrieval panels). Retrieval reflects only when recall is *incorrect*. (**Retrieval: Unidirectional Associates**) Contextual information is only accessible indirectly from the activated related features. (**Retrieval: Bidirectional Associates**) Contextual information is accessible directly from the cue as a result of its implicit activation during encoding and indirectly from the activated related features. Solid circles represent items and context present at encoding or retrieval. Dashed circles reflect information that is implicitly activated via spreading activation. Solid thick arrows reflect direct item-to-item or item-to-context associations present at encoding. Dashed thick arrows reflect direct associations from item-to-implicitly activated information. Thin dashed lines reflect indirect associations of information bound in memory as a result of cotemporaneous activation via spreading during encoding. Information presented as ALIEN, SALT, *Alien*, *Salt*, and *Pepper* in the two Retrieval panels reflects similar information that is implicitly activated during encoding and retrieval. See the online article for a color version of this figure.

sented at test to probe memory for the related studied item. Thus, the only difference between the two stimulus types is the forward-associative activation that should theoretically occur during encoding for bidirectional but not unidirectional associates. Consistent

with a reactivation retrieval process and the results from Experiment 3, source performance should be above chance when the backward members of both unidirectional and bidirectional associates are studied because the forward member used as a test probe should activate the associated contextual information. However, if strengthening cue–context and/or cue–target associations at encoding partially facilitates retrieval of contextual details, there should be a benefit to performance for the bidirectional relative to the unidirectional pairs because the backward member of unidirectional associates should not activate the forward member during encoding.

Method

Participants. A total of 31 undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a course research requirement. Participants were individually tested in sessions that lasted approximately 45 min.

Materials and procedure. The materials in Experiment 4 were nearly identical to those used in Experiment 3 and consisted of 80 word pairs from the Florida word association norms (Nelson et al., 1998). Forty of the word pairs were identical to the unidirectional associates (e.g., *credit* and *card*) that were used in Experiment 3. The average forward-association value was .70, whereas the backward-association value was .05. The other 40 word pairs had strong bidirectional associations with one another (e.g., *salt* and *pepper*). That is, when either member of the pair is given as a cue, it produces the other as an associate in the norms. Thus, essentially both words serve as “forward associates” to one another. For the bidirectional associates, we arbitrarily assigned one member of the pair as the “forward” and the other as the “backward” associate. The bidirectional pairs had average association values from forward-to-backward and backward-to-forward members of .70 and .69, respectively. Critically, the forward member for both unidirectional and bidirectional associates were always presented as cues during the test phase to probe memory for the studied (backward) member. The procedure used in Experiment 4 was identical to that of Experiment 3.

Results

Source memory. We separately analyzed accurate source attributions when recall was correct and incorrect (see Table 3) by submitting correct source attributions to a 2 (study member: backward vs. bidirectional) \times 2 (test phase: first vs. second) within-subjects ANOVA. When recall was correct, this analysis revealed an effect of test phase, $F(1, 30) = 9.17, p < .01, \eta_p^2 = .234$, with better performance during the first test phase than the second. However, there was no effect of study member and no interaction between the two variables, $F_s(1, 30) < 1$.

When recall was incorrect, this analysis revealed an effect of test phase, $F(1, 30) = 27.99, p < .001, \eta_p^2 = .483$, with better performance during the second test phase. There was no effect of study member and no interaction between the two variables, $F_s(1, 30) < 1$. Critically, source accuracy was above chance when both the backward and bidirectional members were studied, $t(30) = 2.47, p < .05, d = .444$; and, $t(30) = 2.38, p < .05, d = .428$, respectively, and there was no difference in performance between the two, $t(30) < 1$.

Confidence. To examine confidence for accurate source judgments (see Table 3), we submitted mean confidence ratings to a 2 (study member: backward vs. bidirectional) \times 2 (recall: correct vs. incorrect) within-subjects ANOVA. There was an effect of recall, $F(1, 30) = 185.8, p < .001, \eta_p^2 = .861$, with greater confidence when recall was correct. However, there was no effect of study members and no interaction between the two variables, $F_s(1, 30) < 1.35, p_s > .25$. Thus, participants were equally confident in source decisions regardless of study member and were more confident when able to access the target.

Discussion

The results from Experiment 4 are consistent with the findings from the deep-processing conditions of Experiments 1 and 2 and the results of Experiment 3 when the backward member was studied (i.e., the forward member was used as a test probe). Importantly, source memory during the first test phase was above chance when target recall failed for both unidirectional and bidirectional associates, and there were no differences in source memory performance across all analyses between the two item types. This latter finding suggests that the strengthening of cue–context and cue–target associations via implicit activation of the backward member for bidirectional associates at encoding provided no additional benefit to performance when target recall failed. Together, these findings suggest that influence of associative processes at encoding may be relatively minimal in recovering source information when recall fails and that associative processes at retrieval are particularly important in accessing source information in the absence of item information.

General Discussion

Previous research has implicated an important role of binding processes during encoding in the ability to recover source information in the absence of item memory (e.g., Cook et al., 2006). The results from the current study suggest that beyond cue–target and cue–context binding at encoding, other important factors in accessing contextual information are associative and semantic processes that occur during retrieval. Across all experiments, when recall was correct, source memory was generally high regardless of whether probed with a related or copy cue. However, when recall failed, source information was accessible only when items were processed deeply during encoding (Experiments 1 and 2) and when there was high forward associative strength between the retrieval cue and target (Experiments 3 and 4). Reinstating the copy cue during the second test phase increased source memory across all experiments, suggesting that source information from encoding was indeed available, but differentially accessible, across conditions. Together, these findings suggest that contextual information that is strongly bound to item information through deep processing during encoding can nevertheless be reactivated at retrieval by associatively or semantically related (unstudied) information even if the original event is not actually remembered.

In general, these results are consistent with those of Cook et al. (2006) in that only the strongest encoding conditions resulted in recovery of source details when target recall failed. However, in the current study, source information was accurately retrieved with incidental encoding and no prior exposure of the retrieval cue

during encoding. Furthermore, efforts to try to increase cue–context and cue–target binding either explicitly by presenting the retrieval cue during study (Experiment 2) or implicitly by presenting forward members of associative word pairs during encoding that likely activate the (subsequent) retrieval cue (Experiments 3 and 4) failed to benefit performance. These results suggest that the role of cue–context and/or cue–target binding processes during encoding in the retrieval of source information in the absence of item may be relatively minimal. It is likely the case that multiple study presentations and intentional encoding used by Cook et al. allowed for source information to be more strongly bound to the target and increased cue–target retrieval strength in a similar manner as did the deep-processing and preexperimental semantic/associative relationships, respectively, used in the current study. Consequently, with stronger target–context binding and retrieval cues that more automatically activate the target during retrieval, participants in the Cook et al. study may have been better able to reactivate source details even when the target item could not be recalled. We suspect that had Cook et al. used semantically or associatively related cue–target pairs instead of unrelated pairs, participants would have been able to accurately recover source details in the absence of item memory regardless of the number of study episodes or type of encoding. The subtle distinction between the interpretations of the two studies is that we are proposing that the onus of the effect is based on retrieval processes without invoking the idea that the cue was automatically bound with the context information of the target during encoding. A similar account has been proposed to explain why participants confidently attribute source attributes to critical lures in the DRM paradigm, such that when the critical lure is processed at retrieval, source information from related associates is inadvertently reactivated and imputed to the critical lure that affects source decisions (Mather, Henkel, & Johnson, 1997). Likewise, Lyle and Johnson (2006, 2007) suggested that participants falsely claim to have seen something that was only imagined because during the decision process, features from perceptually or conceptually similar experienced items are inadvertently reactivated and imported to the imagined event.

Although we prefer a retrieval explanation for the current findings, we are not suggesting that binding processes during encoding play no role in retrieving source information in the absence of item memory. Across Experiments 1 and 2, contextual information was not accessible when target recall failed for shallowly processed items, presumably due to weak target–context binding due to interference from processing other items with similar cognitive operations (Mammarella & Fairfield, 2008). However, elaborative processes during deep-processing conditions should produce greater differentiation among study items and context, thereby establishing a more distinctive memory trace that allows for contextual information to be more strongly bound to its appropriate target (Craik & Rose, 2012). Thus, the strength of the target–context binding appears to play an important role in retrieving contextual information in the absence of item memory. Furthermore, it is possible that because participants were not explicitly instructed to attend to the category label or to form associations during encoding, binding processes may have been weak and insufficient to produce an increase in performance. Thus, had we presented items multiple times and explicitly told participants to associate the cue and target together during encoding, source

discrimination may have been better for the targets that were presented simultaneously with the categorical information in Experiment 2. Additionally, as depicted in the general conceptual model of Figure 1, it is likely the case that encoding of an item results in the activation of a set of features, including that of related items (Anisfeld & Knapp, 1968). Encoding *onion* may also activate associatively (e.g., *cry*), semantically (e.g., *potato*), or orthographically (e.g., *ion*) similar information that additionally becomes bound with the context information (Hicks & Hancock, 2002). However, we believe that if encoding processes were the primary contributor to retrieval of source information when item recall fails source memory, performance should have been greatest when forward and bidirectional members of associative word pairs were studied in Experiments 3 and 4, which was not the case.

Rather, we suggest that categorical cues and strong forward associations from the retrieval cue to the target item may delimit the search set by reducing the number of unrelated alternatives sampled (Nelson, Bennett, Gee, Schreiber, & McKinney, 1993; Nelson, Dyrdal, & Goodmon, 2005; Nelson, Goodmon, & Akirmak, 2007). For example, the word *credit* has only eight backward associates according to the Florida word association norms, whereas *card* has 21 (Nelson et al., 1998). Furthermore, of the eight associates for *credit*, six are related to money in some sense or another (e.g., *card*, *union*, *money*, *cash*, *limit*, *shopping*). Because cued recall in the current study required searching memory for semantically related information, retrieval of related (but incorrect) information may nevertheless serve to activate semantically related item or contextual details from the study episode. For example, mistakenly recalling *potato* instead of *onion* may still reinstantiate the cognitive operations enacted during encoding, allowing for the participant to determine that they rated the item unpleasant because they do not like vegetables. However, for shallowly processed items, mistakenly recalling *potato* would not necessarily be diagnostic of source information as it differs from *onion* in both number of letters and syllables. Although differences in performance between deep- and shallow-processing conditions could be explained by a TAP mechanism (Morris et al., 1977), the results from Experiments 3 and 4 suggest that TAP cannot fully account for the differences in performance because all items were processed deeply. To fully account for the current findings, we posit that a retrieval probe diagnostic of semantically related item information results in activation of related contextual information contingent upon sufficient learning of the item itself and the association between the item and its context information.

It should be noted that although in the current study source information is arguably considered to be an intrinsic item feature (i.e., cognitive operation enacted upon the item), other research has examined source information that is considered an extrinsic feature (e.g., background color) of the item (e.g., Ecker, Zimmer, & Groh-Bordin, 2007a, 2007b; Zimmer & Ecker, 2010). Although we do not distinguish between the two types of source information in the current study, future research should examine the recovery of contextual information in the absence of item memory for intrinsic versus extrinsic source details, as they likely differ in their relative contribution of encoding and retrieval processes needed for information to be bound into or reactivated from memory (e.g., Boywitt & Meiser, 2012). For example, it has been suggested that whereas intrinsic source features are bound relatively automatically to item information and promote familiarity-based retrieval

processes, extrinsic source details require more effortful processing to form an associative link between the item and source and promote recollective retrieval processes (Ecker et al., 2007b). We suspect that within the context of the current study, extrinsic source features easily bound (or “unitized”) to the target item on the basis of semantic properties of the item (e.g., the word *pepper* on a black background; Diana et al., 2008) during encoding may be automatically reactivated when using associatively or semantically related retrieval cues (e.g., the word *salt*) even in the absence of item memory. However, this may not be the case with extrinsic source features not easily bound to item (e.g., the word *pepper* on a green background) during encoding. Demonstration of such an empirical dissociation would allow for a better understanding of the mechanisms that underlie retrieval of contextual information in the absence of item memory, and provide important limitations of the general conceptual model (see Figure 1) proposed in the current study.

Although not of primary interest to the aims of the current study, these data are also informative in regard to the types of information that feed into tip-of-the-tongue (TOT) states and feelings-of-knowing (FOK) judgments. Previous research has demonstrated that participants in TOT states are often able to accurately retrieve the number of letters or syllables of an item that currently cannot be retrieved (Koriat, Levy-Sadot, Edry, & de Marcas, 2003; for a review, see Schwartz, 2002). Furthermore, the amount of partially recollected information is positively correlated with FOKs (Brewer, Marsh, Clark-Foos, & Meeks, 2010), metacognitive predictions of future recognition (Koriat, 1993), and future states of awareness (i.e., “remember” vs. “know”; Hicks & Marsh, 2002). The results from the current study suggest that contextual information recovered from study in the absence of item information may be another piece of partial information that contributes to FOK judgments and TOT states. Interestingly, however, there was a dissociation between source memory and confidence ratings for source decisions when recall failed in Experiments 2 and 3. In Experiment 2, although providing the category label at encoding did not influence source memory, it did result in higher confidence for source decisions when recall failed. Alternatively, in Experiment 3, source memory was only above chance when the forward member was used to probe memory, yet there were no differences in confidence for either type of test cues. This dissociation may reflect different types of information that feed into source decisions versus confidence judgments. That is, accurate source memory is generally considered to require recollective details from study (Wixted & Stretch, 2004; Yonelinas, 2002; but see Hicks, Marsh, & Ritschel, 2002; Wais, Mickes, & Wixted, 2008), whereas confidence judgments can be based on both familiarity and recollective processes (Koriat & Levy-Sadot, 2001). Thus, presenting the category label at encoding in Experiment 2 may have increased cue familiarity and consequently increased confidence ratings. However, increased familiarity should not necessarily aid in determining the source of this activated information. In Experiment 3, the backward member presented at test may have engendered greater cue familiarity due to it being implicitly activated during encoding (when its forward-member counterpart was studied) that contributed to confidence judgments, but not source decisions. Alternatively, the forward member at test should not have been activated during encoding but nevertheless may have engendered greater recollective source details that contributed to

both source decisions and confidence. Therefore, the overall amount of information that fed into the confidence judgments (whether it be familiarity or recollection) may have been equivalent between the two test member types, but only recollective processes resulted in improved source memory performance. Regardless of the exact mechanisms, these findings are consistent with previous research that suggests that the amount and quality of episodic details can influence metacognitive assessments of performance (e.g., Koriat, 1993).

The results from the current study are also consistent with the growing body of literature that suggests that accurate source decisions can be based on partial recollection processes or familiarity with sparse or incomplete contextual details (e.g., Diana, Yonelinas, & Ranganath, 2008; Dodson, Holland, Shimamura, 1998; Hicks et al., 2002; Simons, Dodson, Bell, & Schacter, 2004; Wais et al., 2008; Wixted & Mickes, 2010). Recent studies using functional magnetic resonance imaging (fMRI) have shown that accurate source attributions are associated with enhanced perirhinal cortex (PRc) activity, a region thought to support familiarity (e.g., Diana, Yonelinas, & Ranganath, 2007; Staesina & Davachi, 2006). Other studies examining event-related potentials (ERPs) have revealed that source memory can be indexed by the FN400, an ERP correlate thought to reflect familiarity (e.g., Diana, Van den Boom, Yonelinas, & Ranganath, 2011; Ecker et al., 2007a; Mecklinger, 2006; Mollison & Curran, 2012). Of particular relevance to the current study, a recent ERP study examining item recognition and subsequent source decisions revealed a late-negative component for items recognized with low confidence (i.e., no item recollection) but with accurate source attributions that was different from the traditional components thought to reflect recollection or familiarity (Addante, Ranganath, & Yonelinas, 2012). The authors suggested that the peculiar effect might reflect a type of “contextual familiarity,” whereby even in the absence of recollective item memory, the test probe may have elicited weak activation of contextual information allowing for accurate source discrimination. The “contextual familiarity” hypothesis is consistent with recent theories from fMRI studies that suggest that item, context, and item–context associations may be represented in distinct regions within the medial temporal lobe. The Convergence, Recollection, and Familiarity Theory (Montaldi & Mayes, 2010) and Binding of Item in Context (BIC) view (Diana et al., 2007; Diana, Yonelinas, & Ranganath, 2010; Eichenbaum et al., 2007) posit that item information and contextual information are encoded and represented in the PRc and the parahippocampal cortex (PHc), respectively, whereas item–context associations are represented in the hippocampus. During retrieval, the BIC model proposes that processing of an item results in input to the hippocampus that may trigger reinstantiation of the neural pattern from encoding, which in turn reactivates the associated contextual information represented in the PHc. Consequently, contextual information may nevertheless be accurately recovered even when recollection fails. Similarly, we suggest that when searching memory for information semantically related to the retrieval probe in the current study, information bound in memory during encoding is reinstantiated, which in turn reactivates the associated contextual information even in the absence of item memory.

More generally, the results from the current study are consistent with memory models that suggest retrieval processes may involve access to more and less specific information that jointly contribute

to recognition and source decisions (e.g., Johnson et al., 1993; Onyper, Zhang, & Howard, 2010; Slotnick & Dodson, 2005; Wixted, 2007; Wixted & Mickes, 2010). Assuming that memory traces are bundles of features (e.g., Bower, 1967), processes during retrieval may serve to reactivate and recover features bound together during the study episode. The source-monitoring framework readily predicts that even if the specific candidate item cannot be recalled, bits and pieces of information can be retrieved and evaluated to accurately determine the origin of a memory on the basis of partial information. The current study highlights the importance of target–context binding during encoding and the strength of the retrieval cue to sufficiently activate contextual details within the stored memory trace. However, it is still possible that even weakly encoded source dimensions may still be accessible given the appropriate retrieval cue. Thus, perhaps a fruitful avenue for future research would be to investigate the overlap in the type of processing at encoding (e.g., phonological vs. semantic) and search at retrieval (e.g., rhyme vs. related words) to better understand the interaction of encoding and retrieval processes involved in accessing contextual information in the absence of item memory.

In the current study, we have carefully examined the reactivation of contextual details associated with episodes that cannot be fully recovered. Across four experiments, the results consistently supported a conceptual model specifying source-characteristic binding at encoding and subsequent reactivation at retrieval (see Figure 1). This model makes testable claims about the underlying processes involved in the recovery of contextual details in both the presence and absence of item information. This model also dovetails with recent metacognitive and neuroscience investigations of partial information effects in memory. We hope this model encourages researchers to think carefully about additional mechanisms that may support memory retrieval and more carefully test the processes proposed herein.

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