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Interpolated Task Effects on Direct and Mediated False Recognition: Effects of Initial Recall, Recognition, and the Ironic Effect of Guessing

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In two experiments, participants studied two types of word lists. Direct lists were taken from the Deese–Roediger–McDermott (DRM) paradigm (e.g., *water, bridge, run*) and contained words directly related to a nonpresented critical item (CI; e.g., *river*, Roediger & McDermott, 1995). Mediated lists (e.g., *faucet, London, jog*) contained words related to the CI through a nonpresented mediator. After each study list, participants completed either a recall test, a recall test with a warning about the CI, arithmetic problems, or a recognition test, or they guessed the CI. On a final recognition test, both warning and guessing decreased direct false recognition but increased mediated false recognition, an ironic effect of guessing. An initial recognition test also increased final mediated false recognition. We argue that warning and guessing tasks strengthened associative pathways to the CI, increased the accessibility of associated mediators, and increased monitoring for the CI at test. Increased monitoring was able to reduce CIs from direct, but not mediated, lists.

Keywords: testing effect, false memory, recognition, guessing, warning, semantic priming

The role of associative or semantic relations between items in a study set has been well documented within cognitive psychology. Evidence that relatedness between study items can facilitate memory includes findings such as better remembering of related than unrelated word lists (Huff, Meade, & Hutchison, 2011; Rabinowitz, Craik, & Ackerman, 1982), participants' tendency to group related items into categorizable "chunks" at study (Bousfield, 1953; Miller, 1956), and improved performance when using elaborative encoding tasks that induce relational processing (Einstein & Hunt, 1980). Although relations between items play a role in increasing veridical (i.e., correct) episodic memory, they can also produce errors in episodic memory. For example, in the Deese–Roediger–McDermott (DRM) paradigm, participants study lists of associatively related items (e.g., *valley, climb, top*) that all converge upon a single, nonpresented critical item (e.g., *mountain*; Deese, 1959; Roediger & McDermott, 1995). These lists were generated from word association norms such that the list items are the most common responses generated when the critical item (CI) is given as a cue. Thus, these lists consist of items that are associatively and thematically related to one another and to the CI. At test, false memories for the CI are robust and often match levels found for studied items (Lampinen, Neuschatz, & Payne, 1999; Roediger & McDermott, 1995).

The influence of association has also been demonstrated in experiments that measure lexical processing, such as the semantic priming paradigm. The *semantic priming effect* describes the finding that participants are faster to respond to a target word (e.g., *dog*) when it is preceded by a related prime (e.g., *cat*) than an unrelated prime (e.g., *pencil*; Meyer & Schvaneveldt, 1971; Neely, 1977; see McNamara, 2005, for a recent review). It is important to note that this effect also occurs when prime-target pairs are not directly related, but only indirectly related through a nonpresented mediator. That is, participants show facilitation to a target word (e.g., *box*) that is preceded by a prime (e.g., *beach*) related only indirectly through a nonpresented mediator (e.g., *sand*), relative to unrelated prime-target pairs (Balota & Lorch, 1986; Chwilla & Kolk, 2002; Jones, 2010; McNamara & Altarriba, 1988). Interesting, the magnitude of the priming effect from a mediated prime is approximately half that of the direct priming effect (Balota & Lorch, 1986), consistent with a two-step spread of activation. In fact, mediated priming effects are typically explained in terms of spreading activation (Anderson, 1983; Collins & Loftus, 1975; Hutchison, 2003) in which activation from a primed concept spreads prospectively to both directly and indirectly related concepts, facilitating responding. Recently, however, Jones (2010, 2012; see also Chwilla, Kolk, & Mulder, 2000; Hill, Strube, Roesch-Ely, & Weisbrod, 2002) proposed that a retrospective semantic matching account could accommodate some mediated priming effects, namely those observed when the associations between prime and mediator and between mediator and target are weak or when strategic processes are likely to be operating.

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Associative and Thematic Contributions to False Memory

Since the publication of Roediger and McDermott's (1995) paper, researchers have explored whether the DRM false memory illusion is due to *associative activation* or a *gist extraction* process. Associative activation is assumed by the two-process activation monitoring theory (AMT; Roediger, Balota, & Watson, 2001) in which the illusion is due to automatic lexical activation spreading from studied items to the CI. According to AMT, false recall and recognition reflect a source-monitoring error in which participants fail to successfully monitor the source of the CI activation and endorse it as studied (Meade, Watson, Balota, & Roediger, 2007; Roediger, Balota, & Watson, 2001). Evidence for the role of association in the DRM illusion has been well documented. Using backward associative strength (BAS), a measurement of association from the list items to the CI, Deese (1959) reported that BAS was strongly related to the probability that a participant would falsely recall the CI, a finding verified by Roediger, Watson, McDermott, and Gallo (2001) using a regression analysis. Additionally, increasing study list length has been shown to increase the DRM illusion, likely due to an increase in BAS (e.g., Coane, McBride, Raulerson, & Jordan, 2007; Robinson & Roediger, 1997).

Gist extraction is a mechanism postulated in fuzzy-trace theory (FTT) to account for list-based false memories (Brainerd & Reyna, 1990). FTT posits that when studying a related word list, participants store both a *verbatim* and *gist* representation. Verbatim representations consist of specific details, including the item itself, as well as any perceptual details such as sound, font, and color, and contextual details such as test position. In contrast, gist is a stored representation of the overall meaning of a word or list; thus, gist extraction is particularly sensitive to the theme or coherence of the list. Further, verbatim representations are suggested to fade at a faster rate relative to gist representations. In the DRM paradigm, the presentation of many items related to a similar theme strengthens a gist representation and is therefore considered responsible for CI false memories (Brainerd & Reyna, 2002; Reyna, 1998). Because the CI cannot possess a verbatim representation, the DRM illusion presumably occurs due to a stored gist representation.

In support of gist extraction processes, there is evidence that the DRM illusion can persist after a delay, with false recall and recognition occurring weeks and months after study (Seamon et al., 2002). After a delay, veridical memory typically decreases while the DRM illusion remains, due to differences in the persistence of verbatim and gist representations (but see Colbert & McBride, 2007). In contrast, associative activation tends to dissipate quickly when a target is primed with a single item or several related items such as a DRM list (Meade et al., 2007; Neely, 1977; Zeelenberg & Pecher, 2002; but see Meade, Hutchison, & Rand, 2010; Tse & Neely, 2005 for exceptions). Persisting implicit associative activation from studied items therefore cannot account for DRM effects after a delay. To account for this difference, Meade et al. (2007) suggested that participants might engage in a retrieval-mode process (Tulving, 1983). That is, when participants attempt to retrieve a studied list, the associative network formed during encoding is subsequently reactivated at retrieval, resulting in falsely remembering the CI (see Hutchison & Balota, 2005, for a similar explanation).

Attempts to isolate the influences of associative activation and thematic similarity have been difficult because BAS and thematic similarity are highly confounded in DRM lists. Hutchison (2003) noted that this confound exists in both association and typicality norms, arguing that associated words contain a variety of semantic relations and that words more typical for a category are also more strongly associated with the category label. In addition, Brainerd, Yang, Reyna, Howe, and Mills (2008) demonstrated that BAS effects across DRM lists are confounded with differences in the semantic characteristics of the CIs themselves. Specifically, CIs from high BAS lists were rated as more familiar and meaningful in Toglia and Battig's (1978) semantic word norms. Such characteristics could cause these CIs to elicit higher false memory independently from any associative relation to study items. Taken together, these findings suggest the positive relation of BAS to false memories is insufficient to distinguish between AMT and FTT.

In order to circumvent the association/theme confound we have described, Hutchison and Balota (2005) examined thematic and association-based influences on false memories using both standard DRM lists and newly constructed homograph lists that were equated in BAS to the standard DRM lists. For the homograph lists, all list items were related to a CI (e.g., *fall*), but half of the list items were related to one meaning (e.g., *autumn*), while the other half were related to a second meaning (e.g., *stumble*). False memories were equal across the standard DRM and homograph lists, even though participants in a subsequent experiment rated the standard DRM CIs to be more strongly related to the meaning of the list, suggesting that BAS, rather than thematic convergence, is critical for associative false memories.

More recently, Huff and Hutchison (2011) developed a novel method for dissociating association from thematic coherence. Huff and Hutchison examined list-based false memories using lists that appeared, on the surface, to be completely unrelated and lacking an overall theme, but were actually indirectly associated to a CI. Participants studied lists of unrelated items (e.g., *slope, reindeer, corn*) that were all related to nonpresented mediators (e.g., *ski, sleigh, flake*) and that all converged upon a nonpresented CI (e.g., *snow*). As with mediated triads used in semantic priming experiments (e.g., Balota & Lorch, 1986), the studied list items lacked any direct association to either themselves or the CI, but were indirectly related to the CI through a mediator (e.g., *slope*–[ski]–snow). Mediated word lists were used because they allowed for associative activation of the CI without presenting a list theme, two factors that are confounded in the DRM paradigm.

In Huff and Hutchison (2011), participants studied mediated lists immediately followed by either a recall test or arithmetic problems. Following a series of study–test/arithmetic trials, a final recognition test was completed. CIs were not falsely recalled initially; however, they were falsely recognized at a greater rate than nonpresented control items. Interestingly, this mediated false memory effect tended to be stronger after the completion of an initial recall test relative to the completion of arithmetic problems.

In an additional experiment to test whether participants were consciously aware of the mediated relations, participants were instructed to guess the CI instead of doing recall or math problems. Participants failed to successfully guess the CI, but a mediated false memory effect was still found on the final recognition test. In fact, this false recognition effect was numerically greater following a guessing task than following the initial arithmetic or recall task used in other experiments.

Several conclusions were made from these experiments. First, false recognition found in the absence of a list theme is consistent with the associative activation account. Second, completing an initial recall test may strengthen the associations formed between list items and the CI, which, in turn, may have increased false recognition. Finally, attempting to guess the CI produced a false recognition effect at least as large as that found following an initial recall test. Thus, attempting to relate list items during presentation in order to guess the CI may mimic, or even enhance, the relational processing that occurs during recall. If this is the case, then any task that increases such relational processing between the seemingly unrelated items from mediated lists may produce a mediated false memory effect, possibly by providing additional opportunities for activation of the relevant networks, thereby increasing the accessibility of the CI (cf. Meade et al., 2007).

The mediated false memory effect found using a guessing task is also interesting given that attempting to guess the CI may act as an implied warning. That is, in explaining the guessing task, participants are told about the nature of the lists and asked to guess the critical nonpresented word. This procedure is similar to typical warning instructions that have been shown to effectively reduce false memories in the DRM paradigm (Gallo, Roberts, & Seamon, 1997). During the final recognition test, having attempted to guess the CI during study may increase monitoring for a nonpresented distractor associated to the studied list on the final recognition test. Although increased monitoring should occur during recognition when participants are asked to guess the CI, the mediated false memory effect actually showed a significant increase over initial arithmetic and a nonsignificant numerical increase over initial recall. This potentially *ironic effect of guessing* was likely due to the more indirect nature of association in mediated lists. In other words, if participants are not able to correctly guess the CI, the warning is not likely to be effective (see Neuschatz, Benoit, & Payne, 2003) and may actually boost mediated false memory through the implicit or explicit generation of mediators during relational processing (e.g., Carpenter, 2011). In contrast, for directly associated lists, such as DRM lists, the opposite pattern should occur with a guessing task. Guessing should decrease false recognition of the CI because participants may accurately identify the CI and therefore reject that item during the recognition test (e.g., Gallo, Roediger, & McDermott, 2001; McCabe & Smith, 2002; Neuschatz et al., 2003; Neuschatz, Payne, Lampinen, & Toglia, 2001).

Overview of Experiments

In the current study, we extended the experiments reported by Huff and Hutchison (2011) by more closely examining the influence of various interpolated tasks on a final recognition test. Specifically, in Experiment 1, we compared initial arithmetic, recall, recall + warning, and guessing tasks for their influence on veridical and false recognition within a single experiment. The arithmetic, recall, and guessing tasks were the same as in Huff and Hutchison (2011). In the recall + warning condition, participants were also warned about the nature of the DRM task prior to study and instructed not to recall the CI.

Additionally, we compared directly associated DRM lists and indirectly associated mediated lists. In Huff and Hutchison (2011), mediated false recognition effects were numerically smaller than effects typically reported in DRM experiments. However, the different effects could not be directly compared because the mediated lists lacked direct lists for comparison. In the current study, new materials were developed, and the mediated word lists used here were extrapolated from directly associated DRM word lists (hereafter, direct lists). That is, we formed mediated lists by taking the highest associated word to each direct list item that was not directly associated to either the CI or other list items using the Nelson, McEvoy, and Schreiber (1999) word association norms. Therefore, mediated word lists could be directly compared with direct lists because each list type shared the same CI.

On the initial recall test, it was expected that participants would not falsely recall CIs from mediated lists (see Huff and Hutchison, 2011), but would falsely recall CIs from direct lists. The recall + warning condition was expected to reduce CI intrusions from direct lists relative to the recall condition (cf. Gallo et al., 2001).

On the final recognition test, direct lists were expected to produce a greater level of false recognition relative to mediated lists due to stronger associative strength (or due to stronger gist, according to FTT). For direct lists, we expected that completing an initial recall test would inflate CI false alarms relative to the arithmetic condition, similar to the findings of Roediger and McDermott (1995; see also Gallo, 2006, 2010). Further, warning participants about the false memory illusion was expected to reduce CI false alarms compared with recall without warning. Thus, the warning should have offset the increase in false alarms normally observed after completing an initial recall test. We also expected that guessing would act as an effective warning by providing a strategy to reduce false recognition (Gallo et al., 1997). Because participants were required to generate CIs after study, they could use this information to reject CIs at test. Given that participants are expected to be successful in guessing the CI from direct lists, this condition should reduce false recognition.

For mediated lists, the type of interpolated task completed was expected to yield different outcomes than direct lists. This is largely because participants should be unsuccessful in consciously identifying mediated CIs. We predicted that we would find no mediated false recognition following arithmetic tasks, replicating the finding of Huff and Hutchison (2011). However, the remaining conditions were all expected to produce mediated false recognition, due to strengthening of the associative networks during the interpolated task. Thus, as with direct lists, we predicted an increase in mediated false recognition following an initial recall test, relative to initial arithmetic test. In contrast to direct lists, however, warning participants about CIs was not expected to reduce mediated CI false alarms due to the indirect nature of the lists. Further, we predicted an ironic effect of guessing such that the guessing condition should produce the greatest mediated false recognition. This is because guessing should induce associative processing during study as participants attempt to find the nonpresented CI, strengthening the associative network and increasing the chance of activating mediators and also the CI. Unlike the condition with the direct lists, the impact of this strengthened associative network should not be countered by success in guessing, and therefore rejecting, the CI.

In Experiment 2, we further explored initial task differences on later false recognition. Huff and Hutchison (2011) demonstrated that mediated false memory occurred only in final recognition and not in initial recall tasks. These testing differences suggest that processing differences involved in recognition compared with recall may be critical in producing mediated false memories. However, in Huff and Hutchison, a series of study–test/arithmetic trials always preceded the recognition test, confounding task type with retention interval. We separated the influence of delay and task by having participants complete an initial recognition test or arithmetic problems prior to a final recognition test. If a recognition task alone is sufficient for mediated false memories, then a mediated false memory effect will be found in the initial recognition task. If, however, mediated false memories are contingent upon a delay, then they may occur only on the final recognition test.

Experiment 1

Method

Participants. A total of 160 male and female undergraduate students participated for partial course credit or $10 compensation. Forty-eight participants were tested at Colby College, 64 at Montana State University, and 48 at the University of Calgary. At all three testing sites, equal numbers of participants were tested in all four conditions. All participants were native English speakers with normal or corrected-to-normal vision.

Materials. To develop new lists of directly associated and indirectly associated mediated lists, we selected 24 CIs. The criterion for CI selection was that false recall probability was at least .24 (based on norming data) to ensure a sufficiently strong direct false memory effect to allow detection of mediated false memory. An additional constraint in the selection of CIs was that each directly associated item had to have a relatively strong associate that was neither directly related to the CI nor presented in another direct list. Due to clerical error, six items were used twice in different lists.[1] Of the 24 CIs, 19 were selected from the Stadler, Roediger, and McDermott (1999) norms and the other five were from a norming study by Coane and Cutting (2004). Based on the norms for the original (i.e., unmodified) lists, the average false recall rate of the lists from the Stadler et al. norms was .44 (SD = .12) and the average false recall of the lists from Coane and Cutting was .26 (SD = .02). The higher false recall rates for the Stadler et al. lists is possibly due to methodological differences between the two studies: Stadler et al. used auditory presentation and an immediate free recall task, whereas Coane and Cutting used visual presentation and a 30-sec filled delay prior to recall. It is important to note, however, that the lists were fully counterbalanced across conditions in the present study.

Two lists of 15 items each were developed for each of the 24 CIs. The direct list consisted of list items that were directly related to the CI, and the mediated list included words that were directly related to the direct associates but not to the CI itself (see Table 1 for a sample of direct and mediated lists). The mediated lists were developed using the Nelson et al. (1999) free association norms. For each direct associate, the strongest associate that was not presented on another list and unrelated to the CI was selected. The mean BAS was .16 (SD = .18) and the average forward association from the CI to the list items was .04 (SD = .10). The average strength of association from the mediated list items to the direct list items (i.e., mediated BAS) was .21 (SD = .21), and forward associative strength was .08 (SD = .14; see Table 2 for other lexical characteristics of direct and mediated list items).[2] It should be noted that the items were not matched on these lexical characteristics, but we report them for sake of completeness.

Table 1
Sample Direct and Mediated Lists for the Critical Item "Cold"

Direct list	Mediated list
wet	slippery
hot	spicy
air	vent
snow	sleigh
winter	summer
ice	cream
warm	cozy
freeze	thaw
cough	choke
heat	radiator
sneeze	dust
weather	humid
chill	mellow
frigid	uptight
frost	dew

For counterbalancing purposes, the 24 CIs were divided into four sets of six that were matched on average direct BAS and mediated BAS. Within each study set, three lists were direct and three were mediated. Two sets were assigned to the studied condition, and two sets served as nonstudied controls. Each CI was tested in each condition (direct or mediated, studied or control) an equal number of times across participants.

Two 36-item recognition tests were created. The first test was based on the first set of six study lists while the second test was based on the second set of study lists. Each recognition test included 12 list items (from Positions 7 and 10 of each study list), 12 list item controls (from the same list positions of the nonstudied lists), six CIs (one per study list), and six CI controls (one per nonstudied list).

Procedure. Participants were tested individually on computers using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) with all responses made using a keyboard. Additionally, participants were given a booklet containing recall, guess, or arithmetic sheets, depending on the condition being tested.

Prior to study, all participants were informed that 15 words would be presented on the computer screen. Additionally, participants were presented with instructions specific to the experimental condition. In the recall condition, participants were instructed to

[1] None of the repeated items were ever included in the final recognition tests and only in two cases did participants study both items (once within the same block, once across blocks). In all other cases, participants did not study the two lists where the repeated items occurred. Thus, it is unlikely this repetition affected the observed results in any significant way.

[2] We note that in the priming literature, BAS typically refers to the association from the target to the prime and forward-association strength refers to association from the prime to the target. To be consistent with the terminology used in the false memory literature, we adopted the standard usage of BAS to refer to the association from list items to the CI.

Table 2
Lexical Characteristics of Direct and Mediated List Items

	Length		Frequency		Contextual diversity		Orthographic neighborhood		RT		Accuracy	
List type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Direct	5.20	1.65	9.29	1.50	2.81	0.56	6.35	6.30	623.70	60.64	.97	.03
Mediated	5.84	1.86	8.54	1.80	2.48	0.66	5.05	6.41	648.39	69.53	.96	.07

Note. All estimates are from the English Lexicon Project (Balota et al., 2007; www.elexicon.wustl.edu). Frequency counts refer to the Hyperspace Analogue to Language (HAL) log frequency; contextual diversity is from the SUBTLEX norms (Brysbaert & New, 2009); orthographic neighborhood is from Coltheart, Davelaar, Jonasson, & Besner, 1977); RT = mean lexical decision reaction time; accuracy = mean lexical decision accuracy.

recall as many list items as possible after each presented list by writing them in the booklet provided. In the recall + warning condition, participants were informed that they were participating in a false memory study and that study list words were related to a "critical" nonpresented target word. They were instructed to recall as many list items as possible but not to accidentally recall the nonpresented target word. In the guess condition, participants were informed that all list items converged upon a nonpresented target word and that they were required to guess the CI for each list. In the arithmetic condition, participants were instructed to complete math problems following the presentation of each list. List items were each presented for 1,500 ms with a 500-ms interstimulus interval. Following each list presentation, participants in each condition were given 60 s to complete the interpolated task. Instructions in each condition were given to participants prior to presentation of the word lists.

Following the completion of six study–recall/guess/arithmetic trials (three direct lists, three mediated lists presented in random order), participants completed a 36-item old/new recognition test on the computer. Participants were instructed to respond quickly but without sacrificing accuracy. After completing the recognition test, participants repeated the same procedure with six new study lists (three direct, three mediated) followed by a second recognition test. At the end of the second recognition test, all participants were debriefed and awarded credit or compensation for their participation. A typical experimental session was approximately 30 min.

Results and Discussion

For all results reported, statistical significance is set at $p < .05$ unless otherwise noted.

Initial guessing performance. The proportion of correctly guessed critical items for participants in the initial guessing condition are presented in Table 3 and were calculated by taking the number of correctly guessed CIs divided by the total number of possible CIs. Not surprisingly, participants were more accurate at guessing CIs from direct lists than from mediated lists, $t(39) = 7.43$, standard error of the mean (*SEM*) = 0.04. However, correct guessing for both types of lists was greater than zero—single sample $t(39) = 8.59$, *SEM* = 0.04 and $t(39) = 2.91$, *SEM* = 0.02 for direct and mediated lists, respectively.

Initial recall performance. The proportion of correctly recalled list items along with the proportion of critical intrusions recalled for participants who completed immediate recall tests under warning and no-warning conditions are presented in the two middle columns of Table 3. We performed two separate 2 (list type) × 2 (initial task) mixed analyses of variance (ANOVAs) on veridical recall of list items and false recall of critical items. Both analyses revealed only a main effect of list type—$F(1, 78) = 168.25$, mean square error (*MSE*) = 28, and $F(1, 78) = 99.49$, *MSE* = 178, for veridical and false recall, respectively—such that both veridical and false recall were greater for items from direct lists than from mediated lists. No other effects reached significance. Follow-up single sample *t* tests revealed that false recall was greater than zero for direct critical items following both initial recall and initial recall + warning conditions—$t(39) = 8.71$, *SEM* = 0.03, and $t(39) = 6.33$, *SEM* = 0.03, for initial recall and initial recall + warning, respectively—but was not significant for mediated critical items following either initial recall or initial recall + warning conditions—$t(39) = 1.00$, *SEM* = 0.00, and $t(39) = 1.43$, *SEM* = 0.01, for initial recall and initial recall + warning, respectively.

Recognition. The proportions of studied list items and nonstudied critical items from direct and mediated lists that were given an "old" response are presented in Table 4. These means are presented separately for the four initial tasks (math, recall, recall + warning, and guessing). In addition, corrected recognition measures are reported for both list items (hit rates to studied list items minus false alarm rates to nonstudied controls) and critical items (false alarm rates to CIs from studied lists minus control CIs from nonstudied lists).[3]

A 4 (initial task) × 2 (list type) mixed factorial ANOVA was used to examine effects of initial task and list type on corrected recognition rates of list items. As was found for recall, recognition was greater for items from direct lists than mediated lists, $F(1, 172) = 41.75$, *MSE* = 561. In addition, recognition accuracy was influenced by initial task, $F(3, 172) = 9.73$, *MSE* = 726, such that recognition was highest in the initial guess condition and lowest in the initial math condition. Pairwise comparisons revealed that those in the initial math condition were significantly less accurate than each of the other three conditions. This demonstrates the

[3] In addition to the corrected proportions of list items and CIs, we also conducted a signal detection analysis (Snodgrass & Corwin, 1988; Wickens, 2002) on d' values for list items and CIs. All statistical patterns for list item and CI-corrected recognition in Experiments 1 and 2 were identical to the d' analysis. Therefore, to eliminate redundancy, we report only those analyses completed on corrected recognition.

Table 3
Experiment 1 Initial Recall Proportions for Studied Items and Recall or Guessing of Critical Items of Direct and Mediated Lists

	Math		Recall		Recall + warning		Guessing	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
List items								
Direct items	—	—	.57	.02	.53	.02	—	—
Mediated items	—	—	.44	.01	.41	.02	—	—
Critical items								
Direct items	—	—	.26	.04	.24	.04	.40	.06
Mediated items	—	—	.00	.00	.01	.01	.05	.02

Note. $N = 40$ in each of the initial task conditions.

testing effect – an initial memory test often improves later memory for studied material (see Roediger & Karpicke, 2006). In addition, those in the guessing condition were significantly more accurate than those in the initial recall + warning condition. The interaction between initial test and list type was not significant, $F < 1$.

A 4 (initial task) × 2 (list type) mixed factorial ANOVA was also used to examine effects of initial task and list type on corrected false recognition rates for CIs. As was found for hit rates, there were main effects of initial testing and list type, $F(3, 172) = 2.95$, $MSE = 937$, and $F(1, 172) = 315.12$, $MSE = 528$, respectively, such that false recognition was greater for direct than mediated CIs and false recognition was lowest overall for those in the initial math condition. Pairwise comparisons revealed that similar to correct recognition, false recognition was lower for the initial math group than for the other three groups, which did not differ from each other. Of most importance, there was a significant Initial Test × List Type interaction, $F(3, 172) = 4.74$, $MSE = 528$, demonstrating that the effect of initial task differed for the direct and mediated lists. As can be seen in Table 4, false recognition of direct CIs showed the predicted quadratic pattern across conditions, increasing from the initial math to the initial recall condition, and then decreasing from initial recall to initial recall + warning and initial guessing conditions. Pairwise comparisons confirmed this observation. Namely, false recognition was significantly higher in the initial recall condition than in all three other conditions, which did not differ from each other. In contrast, and also consistent with predictions, false recognition for mediated CIs increased linearly across initial test conditions, with lowest false recognition in the initial math condition and highest false recognition in the initial guessing condition. Pairwise comparisons confirmed that false recognition was higher in the initial guessing condition than in the initial recall or initial math conditions. False recognition was not significant following initial math performance ($p = .12$), but was significant following the other three tasks. This replicates Huff and Hutchison (2011) who found significant false recognition following initial recall or guessing tasks, but not following the initial math task.

We suggest that the reduction of direct and mediated CI recognition in the guessing condition is contingent upon correctly guessing the CI. To examine this possibility, we conditionalized CI false recognition on performance in the previous guessing task. For direct lists, five participants never correctly guessed any direct CIs and one participant correctly guessed all six direct CIs. For the 39 participants who did not correctly guess all CIs, when direct CI false recognition was conditionalized on incorrect prior guessing, false alarms to direct CIs was .86. Similarly, the five participants who never correctly guessed any direct CIs had false alarms of .90. In contrast, participants had false alarms of .55 on previously guessed CIs and the one participant who never guessed wrong had a false alarm rate of .50. Thus, relative to false alarm rates of .82 and .70 in the recall and recall + warning conditions, respectively, previously guessed direct CIs had lower rates of false alarms—.55 versus .82, $t(73) = 3.38$, $SEM = 0.07$, for guessing and recall; .55 versus .70, $t(73) = 1.94$, $SEM = 0.07$, $p = .06$, for guessing and recall + warning—and previously unguessed CIs had more false alarms than those in the recall + warning condition—.86 versus .70, $t(77) = 3.12$, $SEM = 0.04$—and numerically but nonsignificantly more false alarms than those in the recall only condition, .86 versus .82, $t < 1$].[4] For mediated CIs, conditionalizing was difficult because only 11 of the 240 possible CIs were correctly guessed (three of which were later falsely recognized). The false alarm rate for the remaining 95.4% of mediated CIs that were unguessed was .43, which was unsurprisingly very similar to the unconditionalized false alarm rate of .41.

To summarize the results of Experiment 1, veridical and false recall and recognition were greater for items from direct lists than mediated lists. As predicted, participants were very successful in guessing the CIs from direct lists, but were largely unsuccessful in guessing the CIs from mediated lists. In addition, all three types of initial testing increased veridical memory over the initial math condition. Of most importance, we obtained the predicted Initial Task × List Type interaction on false recognition. False recognition for direct items increased with an initial recall test, relative to initial math, but then decreased in the recall + warning and guessing conditions. This is presumably because participants could utilize the warning to identify and reject the critical lures from these lists. Also as predicted, false memory for mediated CIs showed a linear increase across testing conditions, with significantly greater false memory in the recall + warning and guessing conditions than in the math condition and greater false memory in the guessing condition than in the recall condition. This demon-

[4] There was likely a ceiling effect in the comparison of direct item false alarms following recall (.82) versus false alarms for previously unguessed items (.86). Specifically, 25 out of 39 subjects in the guessing condition had 100% false alarms on previously unguessed items and 18 out of 40 subjects in the recall condition had 100% false alarms.

Table 4
Experiment 1 Final Recognition Proportions for Studied Items and Critical Items of Direct and Mediated Lists as a Function of Initial Testing Conditions

	Math		Recall		Recall + warning		Guessing	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
List items								
Direct items	.77	.03	.86	.02	.81	.02	.90	.01
Control direct	.23	.03	.14	.02	.15	.03	.15	.02
Mediated items	.60	.04	.59	.05	.56	.04	.72	.04
Control mediated	.17	.02	.05	.01	.10	.02	.10	.01
Corrected recognition								
Direct items	**.54**		**.72**		**.66**		**.75**	
Mediated items	**.43**		**.54**		**.46**		**.62**	
Critical items								
Direct items	.78	.03	.82	.04	.70	.04	.72	.04
Control direct	.31	.04	.13	.02	.15	.03	.18	.03
Mediated items	.36	.04	.22	.04	.26	.04	.41	.04
Control mediated	.31	.04	.13	.02	.11	.03	.19	.03
Corrected recognition								
Direct items	**.47**		**.69**		**.55**		**.54**	
Mediated items	**.05**		**.09**		**.15**		**.22**	

Note. $N = 40$ in each of the initial task conditions. Boldface indicates data used in the statistical analyses.

strates an ironic effect of warnings and guessing tasks on mediated false memory, in which attempting to guess the CI strengthens the associative network (including both the mediators and the CI) without a concurrent ability to identify, and therefore reject, the CI itself.

Experiment 2

The purpose of Experiment 2 was to further examine the influence of an initial test on false recognition by having participants complete an initial recognition test rather than free recall. This modification was made to address the possibility that the delay, as opposed to the retrieval task, is responsible for the mediated false memory effect. In both Huff and Hutchison (2011) and Experiment 1, an initial arithmetic, recall, or guessing task always preceded a final recognition test. Therefore, we examined whether mediated false recognition could occur without an interpolated task by having participants complete an initial recognition test or arithmetic problems after each list presentation. As in Experiment 1, both direct and mediated word lists were studied, and a final recognition test was completed.

Method

Participants. A total of 80 male and female undergraduate students participated for partial completion of course credit or $5 compensation. Twenty-eight participants were tested at Colby College, 36 at Montana State University, and 16 at the University of Calgary. At all testing sites, equal numbers of participants were tested in both conditions. All participants were native English speakers with normal or corrected-to-normal vision.

Procedure and stimuli. All procedures and stimulus lists used in Experiment 2 were the same as Experiment 1 with one exception. Immediately after studying each word list, half of the participants completed a six-item recognition test while the other half completed arithmetic problems for 60 s, identical to Experiment 1. The six-item recognition test consisted of two list items (from Positions 7 and 10), two list item controls (from the same positions from nonstudied lists), one CI (from the studied list), and one CI control (from a nonstudied list). After six study–recognition/arithmetic trials, participants completed the same final recognition test as in Experiment 1, and again, this procedure was repeated for a second block of six study–recognition/arithmetic trials and a final recognition test. All items on the initial recognition test were repeated on the final recognition test to allow for direct comparisons between initial recognition in Experiment 2 and final recognition following initial math in Experiment 2 or final recognition following other conditions in Experiment 1. Repeating unrelated items from initial to final recognition also controlled for increases in CI familiarity and pure test-induced priming of tested list items and CIs from initial to final recognition (Kimball, Muntean, & Smith, 2010).

Results and Discussion

Initial recognition performance. The proportions of studied list items and nonstudied CIs from direct and mediated lists that were given an "old" response on the initial recognition test are presented in the left column of Table 5. Corrected recognition measures are again reported for both list items and CIs. Both accurate recognition for list items and false recognition of CIs were higher for direct lists than mediated lists, $t(39) = 3.57$, $SEM = 0.06$, and $t(39) = 9.56$, $SEM = 0.05$, for direct versus mediated recognition for list items and CIs, respectively. Interestingly, however, initial false recognition was significantly greater than zero for both direct lists, $t(39) = 17.24$, $SEM = 0.04$, and mediated lists, $t(39) = 4.70$, $SEM = 0.04$. Significant immediate false recognition for mediated CIs demonstrates that mediated false recognition does not require a delay between study and test.

Final recognition performance. The proportions of studied list items and nonstudied CIs from direct and mediated lists that were given an "old" response on the final recognition task are

Table 5
Experiment 2 Initial Recognition and Final Recognition Proportions for Studied Items and Critical Items of Direct and Mediated Lists as a Function of Prior Testing Conditions

Variable	Initial recognition		Final recognition interpolated task: Math		Final recognition interpolated task: Recognition	
	M	*SE*	*M*	*SE*	*M*	*SE*
List items						
Direct items	.84	.02	.74	.02	.73	.03
Control direct	.05	.01	.30	.03	.36	.04
Mediated items	.65	.05	.49	.04	.58	.04
Control mediated	.06	.02	.24	.03	.29	.03
Corrected recognition						
Direct items	**.80**		**.44**		**.38**	
Mediated items	**.59**		**.25**		**.29**	
Critical items						
Direct items	.75	.04	.68	.03	.75	.04
Control direct	.09	.02	.30	.03	.37	.05
Mediated items	.25	.04	.37	.04	.48	.05
Control mediated	.07	.02	.30	.03	.28	.04
Corrected recognition						
Direct items	**.66**		**.38**		**.40**	
Mediated items	**.18**		**.07**		**.20**	

Note. $N = 40$ in both the initial math and initial recognition conditions. Boldface indicates data used in the statistical analysis.

presented in the two right columns of Table 5. Two separate 2 (initial task) × 2 (list type) mixed factorial ANOVAs were used to examine effects of initial task and list type on corrected veridical and false recognition rates. For veridical recognition, there was only a main effect of list type, $F(1, 78) = 12.08$, $MSE = 598$, with greater recognition for items from direct lists. False recognition was also greater for direct CIs than mediated CIs, $F(1, 78) = 29.67$, $MSE = 801$. A priori comparisons revealed that mediated false recognition was greater following the initial recognition task than following initial math. In contrast, and contrary to the pattern found for initial recall tasks in Experiment 1, there was no effect of initial task on direct items. Despite the different patterns, however, the Initial Task × Item Type interaction failed to reach significance ($p = .15$).

The results of Experiment 2 revealed that mediated false recognition can be obtained immediately following a studied list. Therefore, the differential false memory across recall and recognition tasks found in Experiment 1 (and in Huff and Hutchison, 2011) were due to task differences, rather than retention interval. This suggests the lack of immediate false recall is due to inaccessibility of the CI, rather than to a heightened response criterion during initial testing. For instance, one might predict that participants consciously think of the mediated CI during the initial recall test, but then monitor against its production due to its lack of episodic study details. However, there are two reasons to reject this idea. First, we have provided evidence that participants are largely unable to identify the CI even when instructed to do so (see also Huff & Hutchison, 2011). Second, if this account were true, then there should have been no immediate false recognition, since such contextual study details would have still been available in memory.

In general, corrected veridical and false recognition decreased from initial to final recognition. This is likely due to a source monitoring error in which participants mistake having *seen* the control items on the previous initial recognition test for having *studied* them. Interestingly, however, though veridical recognition for both list types and false recognition for direct CIs decreases during final recognition, false recognition for mediated CIs does not (see Table 5). A 2 (delay) × 2 (list type) ANOVA on corrected false recognition indeed revealed a significant interaction, $F(1, 39) = 13.75$, $MSE = 623$, in which false recognition decreased across delay for direct CIs, but not for mediated CIs.

General Discussion

The present experiments provide a thorough examination of the influences of initial task type on associated-list based false memories. As expected, direct list CIs were falsely recognized at a greater rate than mediated CIs, presumably due to stronger associations to the CI. More important, novel dissociative false recognition effects between directly related and mediated word lists were demonstrated as a function of the initial task completed. Direct CI false recognition was greatest following an initial recall test, but decreased when participants were either explicitly warned about the CIs or asked to guess the identity of the CI. In contrast, mediated false recognition was not reliable after an initial math task, but increased linearly in the recall, recall + warning, and initial guessing conditions. Attempting to guess the CI produced opposite effects for direct and mediated CIs, decreasing false recognition for direct CIs, but increasing false recognition for mediated CIs, an ironic effect of guessing.

In Experiment 2, we further examined interpolated task differences by comparing an initial math task with an initial recognition test. On the initial test, both direct and mediated CIs were falsely recognized, demonstrating that a delay is not necessary for mediated false memory. On the final recognition test, false recognition of direct CIs occurred for both initial task conditions equally, but mediated CIs were only falsely recognized following initial recognition. Finding mediated false memory in the initial recognition test but not the delayed recognition test that followed initial math suggests that a recognition test alone is insufficient to produce mediated false memory. Instead, the recognition test must either (a) occur soon enough that the relatively weak mediated activation has not decayed or (b) be proceeded by an interpolated task that presumably strengthens the associative pathways between items.

Across both experiments, interpolated tasks that required participants to retrieve one or more list items through guessing, recall, or recognition all produced a significant mediated false memory effect, whereas an interpolated math task did not. We suggest that the interpolated task differences provide evidence for the strengthening encoded associative networks due to the retrieval of studied items (e.g., Meade et al., 2007). That is, the initial associative network formed at encoding is strengthened, relative to the math condition, when participants attempt to retrieve list items during guessing, recall, or recognition and is sufficient to produce a mediated false memory effect. Whereas false recognition of CIs from direct lists was found after an initial math condition, this was likely due to stronger associations from the list items to the CI relative to mediated lists, which can cause the direct CI to be included within the original associative network created during encoding. However, a retrieval-mode process can also boost false memory for direct lists: Completing an initial recall test increased direct CI false recognition relative to the initial math condition. Thus, strengthening the associative network through an interpolated task produces greater false recognition, unless participants are able to detect and reject the CI due to guessing or warning instructions (as they often can for direct CIs).

Additional evidence for the importance of initial retrieval in mediated false memory can be found within the mediator effectiveness hypothesis (Carpenter, 2011; Pyc & Rawson, 2010). This hypothesis has been used to account for the testing effect (i.e., better long-term retention following initial study–test trials compared with repeated study trials; Roediger & Karpicke, 2006). According to this hypothesis, initial testing results in the generation of associated mediators, which, in turn, provide additional retrieval cues to assist performance on subsequent tests. Experiments that have tested the mediator effectiveness hypothesis have typically used memory tests in which participants were required to recall studied items from memory. It is possible that in addition to tests of recall or recognition, any task that requires a participant to retrieve studied information may also result in the generation of associated mediators. Guessing tasks may also activate mediators as participants retrieve studied items in order to generate a guess.

An alternative explanation for why retrieval increases CI false memory is that the type of interpolated task may also increase relational processing of list items (Hunt & Einstein, 1981). Relational, as opposed to item-specific, processing has been demonstrated to increase CI false alarms from DRM lists when a study tasks requires participants to think about shared attributes of the list items (i.e., relational processing) rather than their unique attributes (i.e., item-specific processing; McCabe, Presmanes, Robertson, & Smith, 2004). Although our experiments did not manipulate the processing at encoding, the type of interpolated task may have increased relational processing of list items. In particular, the guessing instructions likely resulted in relating the list items together to generate a guess. In the recall + warning condition, participants were instructed not to recall the nonpresented CI and therefore may have related list items in order to detect and then reject the CI. Recall testing has also been demonstrated to increase clustering scores, a measure of relational processing (Burns, 1993; Zaromb & Roediger, 2010), which should also increase subsequent CI false recognition.

One way of testing the processing that was completed during the guessing task is to directly compare the guessing procedure on mediated and direct lists with relational processing at encoding. If the ironic effect of guessing is due to an increase in relational processing, participants who attempt to relate the words at study would be expected to demonstrate a similar pattern with an increase in mediated CI false alarms. We are currently testing item-specific and relational processing encoding differences on mediated and direct study lists to compare these interpolated task-based differences.

It is important to note that although we infer that associative activation results in false memories through the use of word association norms for direct lists and the conceptual similarities between mediated lists and mediated priming experiments, we are unable to directly measure this activation process. A similar issue exists for the retrieval-mode process in associative activation. According to AMT, false recognition for both direct and mediated CIs is enhanced by participants engaging in a retrieval-mode process that reactivates the semantic network that was established at study. This reactivated network results in CI false recognition.

One possible way to test for a stronger retrieval-mode process as a function of interpolated task type is to examine the relationship between list item recognition and CI recognition. If retrieval mode is used at initial test, the proportion of list items recognized from a given list should be related to the probability with which the CI from that list is falsely recognized. This relationship should also be stronger if the interpolated task strengthens the semantic network such as the recall and guessing conditions. To examine this possibility, we calculated gamma correlations between correctly recognized list items and falsely recognized CIs from direct and mediated lists. No significant relationships were found between correct and CI recognition for any of the test conditions or list types with the exception that for mediated lists in the recall condition, list item and CI recognition were significantly correlated ($r = .44$, $p < .01$). Therefore, it is difficult to ascertain whether a retrieval-mode process actually occurs at initial test or whether this process underlies recall or guessing performance.

Consistent with Huff and Hutchison (2011), we argue that the mere existence of mediated false memory is more consistent with associative activation as opposed to a gist-extraction process. Mediated lists were constructed so that studied items were not associated to each other or the nonpresented CI. Therefore, these lists were seemingly unrelated and did not possess thematic consistency that would produce a gist representation of the CI. Although gist extraction, like associative activation, adequately accounts for direct list false memory, FTT in its current form is not a fully viable account for mediated false memory. However, it may be possible to modify FTT to account for the present results. Specifically, it is possible that participants may derive a weak gist trace that is not specific enough to generate a correct guess or recall the CI, but is sufficient enough to produce an "old" response in recognition. Future studies could perhaps explore this more thoroughly by asking participants to give more detailed reports about possible themes detected from each list, rather than simply trying to guess the critical linking word as was done in the present study.

The data reported herein also provide support for retrospective accounts of mediated priming effects. Because of the relatively small mediated priming effects observed in the literature (e.g., Balota & Lorch, 1986; Jones, 2010, 2012) and the rapidly decaying nature of activation processes, it seems likely that a strategic or retrieval-based mechanism was operating to increase the accessibility of the mediated CI during recognition. The systematic increase in false recognition for mediated CIs as a function of the strategic demands of the encoding task also suggests that a search for mediators is potentially driving some of the observed effects.

In sum, given the empirical interest in the influence of testing and retrieval on subsequent memory, it is important to examine how interpolated retrieval tasks impact false and veridical memory. We suggest that some retrieval tasks improve memory performance by strengthening associative networks, increasing mediator accessibility, or inducing relational processing, we also argue that some tasks may be more effective at these processes than others. Because associative-based false memories are well documented in both applied and laboratory-based settings, retrieval task type may be critical to maximizing veridical memory while simultaneously minimizing errors for direct and mediated lists.

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