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Item-specific encoding reduces false recognition of homograph and implicit mediated critical lures

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ABSTRACT
We evaluated the effects of item-specific and relational encoding instructions on false recognition for critical lures that originated from homograph and mediated study lists. Homograph lists contained list items that were taken from two meanings of the same critical lure (e.g., autumn, trip, harvest, stumble; for fall) which disrupted thematic/gist consistency of the list. Mediated lists contained unrelated list items (e.g., slippery, spicy, vent, sleigh) that were indirectly related to a critical lure (e.g., cold), through a set of non-presented mediators (e.g., wet, hot, air, snow), and had no thematic/gist consistency. In two experiments, item-specific and relational encoding improved correct recognition relative to a read-only control task, but only item-specific encoding reduced false recognition of critical lures. Signal-detection analyses indicated that the item-specific reduction increased test-based monitoring. The item-specific reduction for homograph and mediated critical lures is consistent with the activation-monitoring framework given gist-based processes are reduced or eliminated on these list types.

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False recognition; activation monitoring; item-specific encoding; relational encoding; distinctiveness

A common goal of memory researchers is to identify methods that can improve memory output. Some approaches target encoding processes which often encourage deep or semantic-based processing within the levels-of-processing framework (Craik & Lockhart, 1972; Craik, 2002). Examples include generation (Bertsch et al., 2007; Slamecka & Graf, 1978), production (Conway & Gathercole, 1987; MacLeod & Bodner, 2017), item-specific/relational processing (Huff & Bodner, 2013; Hunt & Einstein, 1981), and more recently, the processing of survival-based features (Nairne et al., 2007; Nairne, 2015). Other approaches target retrieval-based processes such as providing a match between contextual cues and processes at encoding and retrieval (Blaxton, 1989; Tulving & Thomson, 1973) and test instructions which affect how liberal or stringent participants report information at test (Brainerd et al., 2001; Huff et al., 2011). Though these techniques are fruitful for improving memory for studied information, it is equally important to gauge their effectiveness on memory errors to assess the overall impact on memory accuracy. Our study examines the effects of item-specific and relational encoding on memory accuracy for homograph and mediated lists (Huff & Hutchinson, 2011; Hutchison & Balota, 2005), list types that have been shown to produce elevated rates of false recognition to associatively related critical lures in the absence of a consistent list theme.

Memory errors are grouped into two types: Omission errors, which include forgetting and insufficient encoding, and commission errors, which refer to remembering events differently than their original occurrence. A robust type of commission error occurs in the Deese/Roediger-McDermott (DRM; Deese, 1959; Roediger & McDermott, 1995) false memory paradigm. In this paradigm, participants are presented with lists of associates (e.g., *bed, dream, slumber*, etc.) that converge upon a non-studied critical lure (e.g., *sleep*) that is later falsely remembered. The *DRM false memory illusion* is robust. False recall can eclipse 50% (Roediger et al., 2001a), and false recognition can approximate hit rates for presented list items (e.g., Dodson & Schacter, 2001; Lampinen et al., 1999). Participants often report recollection of critical lures as appearing on studied lists via *remember* responses at test (Payne et al., 1996) suggesting that they recollect an external presentation of the critical lure from study despite its absence.

Thematic and associative processes in the DRM illusion

Although several theories have been proposed to account for the DRM illusion (see Arndt, 2015; Coane et al., 2021, for reviews), the primary accounts are Fuzzy-Trace Theory (FTT; Brainerd & Reyna, 2002; Reyna et al., 2016) and Activation-Monitoring Theory (AMT; Roediger et al., 2001a).

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FTT posits that a verbatim representation and a gist representation are derived simultaneously at encoding. The verbatim representation contains memory for the specific item and contextual details from the initial presentation. The gist representation contains the general meaning or theme of the item or listof related items in the DRM paradigm. At test, participants can rely upon either verbatim or gist representations. Because a verbatim representation is not available for critical lures as these items were not presented, the similarity between the gist trace and the critical lure produces the DRM illusion. The verbatim trace (or absence of) provides a monitoring mechanism to successfully reject critical lures. Separately, AMT posits that the DRM illusion is the result of a two-stage process. First, the critical lure is activated implicitly at encoding through automatic spreading activation of associated study items (Collins & Loftus, 1975) and this activation converges upon the critical lure. Second, a source-monitoring failure occurs at test (Johnson et al., 1993), in which the internal activation of the lure is attributed to the studied list. Thus, like FTT, AMT proposes that both encoding processes (gist representations vs. implicit spreading activation) and monitoring processes (availability of a verbatim trace vs. source monitoring), contribute to the DRM illusion.

Attempts to dissociate FTT and AMT in the DRM paradigm have proven difficult for researchers. DRM lists possess a consistent list theme which would lead to the development of a strong gist trace and are strongly associated with the critical lure via implicit activation. Consistent with AMT, Deese (1959), reported that mean backward associative strength (BAS) – which reflects the associative strength from the list items to the critical lure, was strongly correlated with false recall. This pattern was echoed by Roediger et al. (2001b) who found that BAS (measured using the Nelson et al., 1999, word-association norms) was the best predictor of false recall and the second-best predictor of false recognition. This pattern was consistent with McEvoy et al. (1999) who similarly reported that lists with higher BAS generally produced greater critical lure false recall. BAS in the norms therefore operates as a measure of associative activation from the list items to the critical lure which can be used to gauge implicit activation processes.

Researchers have also found evidence consistent with FTT. Gist traces are argued to be relatively stable or even increase across long retention intervals (Brainerd & Reyna, 2002), and indeed, the DRM illusion has been shown to persist for weeks following study (Seamon et al., 2002). Implicit activation processes however are generally short lived. For instance, semantic priming – a measure of implicit activation – can be eliminated with as few as one unrelated intervening item (Dannenbring & Briand, 1982; Masson, 1995), suggesting that long-term false memories may not be due to implicit priming from the list items to the critical lure. Although long-term priming of critical lures has been reported the following study of associatively related lists (e.g., Huff et al., 2021a; Meade et al., 2010; Tse & Neely, 2007), these "long-term" effects typically fall within a time span of 30 s or less, and not weeks or months following study (but see Meade et al., 2007, for a long-term retrieval-mode account). Additionally, Brainerd et al. (2008) reported that critical lures that were rated as high in familiarity and meaningfulness according to Toglia and Battig's (1978) semantic word norms, loaded strongly on the same factor as false recall and false recognition using a principal components analysis. The authors suggested that these loadings indicate that semantic meaning, consistent with FTT, is related to the DRM illusion. However, it is important to note that BAS is also loaded on this same factor, and since a principal components analysis cannot discern between the magnitude of different loadings, both semantic meaning and implicit activation are again related to the DRM illusion.

To circumvent the FTT/AMT confound in DRM lists, researchers have had to engineer different types of study lists designed to encourage either gist extraction or implicit activation processes. Cann et al. (2011; Experiments 3 and 4) had participants study word lists that consisted of situational features (e.g., *tractor, farmer*, *fence*, etc. for the critical lure *barn*) which were argued to be more reliant upon gist-based processes as situational features minimise BAS. Critical lure false recall and recognition were low, but reliable, which the authors interpreted as evidence for FTT. However, BAS was still present in these situational feature lists, albeit at a low rate, indicating that even when selecting study lists with thematic consistencies based on situational features, implicit activation processes could not be completely segregated from gist extraction.

Separately, studies have also assessed false recall and recognition using lists that have disrupted or eliminated the consistency of the gist representation in a list while maintaining associative properties. Hutchison and Balota (2005) compared false memories of critical lures following study of either standard DRM lists or homograph lists that converged upon two list themes (e.g., Meaning 1: *vampire, flying, night*, etc.; Meaning 2: *swing, baseball,* etc.) that were argued to produce a gist conflict for a critical lure (e.g., *bat*). Importantly, homograph and DRM lists were matched on BAS, which according to AMT, should produce equivalent levels of false memory. Across five experiments, critical lure false memories were equivalent between DRM and homograph lists, even after manipulating list item study duration, blocking or alternating homograph list item meanings, and recall and recognition test types, providing support for AMT. More recently however, Huff et al. (2015b) found false recall of homograph critical lures was greatest when study lists were both blocked by meaning and testing was completed after a delay – two factors suggested to increase the reliance upon gist-based processes. Thus, although homograph lists do contain a gist conflict that could disrupt the process of gist extraction, these lists may not consistently support either implicit activation or gist extraction.

Rather than disrupting gist consistency through the presentation of multiple themes, researchers have also used mediated lists that contain no thematic meanings and are only indirectly related to critical lures (Coane et al., 2016; Huff et al., 2021b). For example, studying list items *picnic, toilet, bar,* etc. can produce false recognition for the critical lure *chair*, through implicit activation of non-studied mediator words *table, seat, stool,* etc., which are directly related to the critical lure. This pattern is important in terms of separating FTT and AMT because mediated list items are unrelated to other list items and are unrelated to their corresponding critical lure based on associative norms (Nelson et al., 2004). Therefore, mediated lists do not have a discernable list theme. Indeed, when participants are given instructions on how mediated lists were constructed and asked to identify critical lures from mediated lists, participants are rarely able to do so successfully (Huff et al., 2012; Huff & Hutchinson, 2011), indicating that participants are unable to consciously identify a reliable gist trace. Thus, false recognition from mediated lists provides powerful evidence for AMT given the indirect associative relations between the list words and critical lure.

Item-specific reductions in the DRM illusion

In addition to determining the mechanisms that contribute to the DRM memory illusion, researchers have also been interested in methods to reduce the illusion to improve overall memory accuracy. Several methods have been identified which include study list repetitions (Benjamin, 2001), critical lure warnings before or after study (Gallo et al., 2001; McCabe & Smith, 2002), and requiring participants to indicate the source of their retrievals (Multhaup & Conner, 2002). Encoding manipulations that encourage distinctive processing have also been beneficialrelative to non-distinctive controls. Such tasks include perceptual manipulations including picture presentations (Israel & Schacter, 1997; Schacter et al., 1999; but see Smith & Hunt, 2020), studying list words in unique fonts (Arndt & Reder, 2003), and distinctive tasks that encourage processing item-specific features such as individual mental imagery (Bodner et al., 2017; Foley et al., 2006; Gunter et al., 2007; Oliver et al., 2016; Robin, 2010), pleasantness ratings (Gunter et al. 2007; Huff & Bodner, 2013) and generation of anagrams (Huff et al., 2021a; McCabe & Smith, 2006). Most of these distinctive tasks producea *mirror effect* pattern (Glanzer & Adams, 1990), which refers to an increase in correct recognition accompanied by a decrease in false recognition relative to a non-distinctive control task.

The benefits of distinctive processing have generally been ascribed to two processes – one that occurs at encoding and the other that occurs at retrieval. The *impoverished relational encoding* account (Hege & Dodson, 2004; Hockley & Cristi, 1996) posits that distinctive processing aids in disrupting either the thematic meaning of the list or the implicit activation from the list items to the critical lure. Separately, the *distinctiveness heuristic* account posits that participants employ a test-based decision strategy in which recollection of distinctive details can be diagnostic that a study item was originally studied, and the absence of distinctive details can be diagnostic that the item was not studied (Gallo, 2004, 2010).

Many methods have been utilised to determine whether encoding or retrieval processes contribute to distinctive-task benefits (see Huff et al., 2015a for a detailed discussion), though we advocate for a signal-detection approach when memory is tested via recognition (Bodner et al., 2017; Gunter et al., 2007; Huff & Bodner, 2013; Huff et al., 2021a). Signal detection aims to parse memory experiences for studied versus non-studied information (i.e., discriminability, d') from monitoring, or the tendency to false alarm to non-studied information. When estimating the contributions of encoding-based processes following distinctive study tasks in the DRM paradigm, discriminability serves as an estimate of the amount of memory information encoded for a given item type. Discriminability corresponds to the standardised difference between hits for studied items and false alarms to control list items that are taken from non-studied DRM lists. Similarly, discriminability for critical lures can be computed by treating "old" recognition responses as hits and computing the difference relative to false alarms to control lure items from non-studied lists. If impoverished relational encoding contributes to reduced false recognition, discriminability for critical lures should be lower for distinctive versus non-distinctive study tasks. When estimating monitoring contributions, a response-criterion index lambda (λ) is used. Lambda reflects the centre of the non-studied item distribution and is computed from only the false alarm rate to control distractors. Lambda is computed separately for list items and critical lures given both control items are present in the recognition test. Higher lambda values reflect more conservative responding at test due to lower false alarm rates to control distractors. We interpret more conservative responding as evidence for increased test-based monitoring given higher monitoring would be effective at reducing false alarm rates to controls. The presence of a distinctiveness heuristic would therefore be captured by the lambda index. The primary benefit of the signal-detection approach is that it yields separate indices of encoding and monitoring processes which allow for the possibility that both processes can contribute to distinctive-task benefits.

Huff and Bodner (2013) utilised the signal-detection approach across three experiments by testing between-participant groups who used different distinctive tasks at study. Specifically, item-specific instructions, pleasantness ratings, and anagram generation were compared to a read-only (non-distinctive control) group. Across experiments, distinctive tasks produced a mirror effect pattern in correct and false recognition, but an interplay between encoding and retrieval processes was found when the signal-detection analysis was applied. For correct recognition, both indices of encoded memory information and monitoring were greater following distinctive tasks relative to their read comparison groups. For critical lure false recognition, monitoring was greater across tasks, consistent with the use of a distinctiveness heuristic. However, falsely encoded memory information was lower overall when analyses were pooled across the three tasks (Huff & Bodner, 2019), consistent with impoverished relational encoding. A subsequent meta-analysis employing the signal-detection approach similarly found that distinctive tasks reduce the DRM illusion due to a combination of encoding- and monitoring-based processes (Huff et al., 2015a), indicating that both are involved in distinctive encoding.

Overview of experiments

Given the benefits of distinctive encoding at improving memory accuracy in the DRM paradigm, the purpose of the present study was to evaluate whether distinctive item-specific encoding could also improve memory accuracy using study lists that either minimised or eliminated gist-based processing. Although distinctive encoding tasks have produced consistent benefits on memory accuracy (cf. Huff et al., 2015a), these benefits have only been found using DRM lists which possess strong associative and thematic relations. It is unclear whether distinctive encoding can produce similar memory benefits if study lists produce a gist conflict (i.e., homograph lists) or do not possess a consistent gist (i.e., mediated lists).

In Experiment 1, we first evaluated the effects of distinctive encoding on correct and false recognition using homograph lists, which present list items that converge upon two separate list themes. Distinctive encoding was manipulated using an item-specific instruction task in which participants were tasked with thinking about the unique/distinctive features of each list item. Item-specific encoding was then compared to a read-only control group and a relational group, which was tasked with thinking about the consistent or related features across list items. In Experiment 2, the same three encoding tasks were again compared but with mediated lists, which do not possess a consistent list theme. The use of mediated lists provides a stronger test of whether consistent gist traces are needed to produce a memory accuracy benefit following distinctive encoding. In both experiments, we employed Huff and Bodner's (2013) signal-detection approach to determine whether potential memory accuracy benefits following item-specific encoding reflected contributions of encoding and/or monitoring processes.

Experiment 1: Homograph study lists

In Experiment 1, item-specific and relational encoding instructions were compared to a read-only control. Based on Huff and Bodner (2013), we expected that both item-specific and relational tasks would produce an increase in correct recognition as both are qualified as "deep" processing tasks. We also expected that item-specific encoding would reduce false recognition of homograph critical lures relative to both the read and relational groups, which would be equivalent. Thus, we anticipated that item-specific encoding would improve memory accuracy even with a disruption in gist consistency. Signal-detection analyses were then used to assess the contributions of encoding and monitoring processes in each of the three encoding tasks.

Method

Participants

A total of 103 undergraduates from The University of Southern Mississippi participated for partial course credit. Participants were randomly assigned to the item-specific group ($n = 32$), the relational group ($n = 35$), or the read group ($n = 36$). One item-specific participant was eliminated due to response confusion on the recognition test (flipping old/new responses), leaving 31 participants available for analysis in this group. A sensitivity analysis using G*Power (Erdfelder et al., 1996) indicated that our sample had sufficient power (.80) to detect medium-sized effects or larger. All participants reported fluency in the English language and normal or corrected-to-normal vision.

Materials

Twenty-four homograph word lists were used in the present study (see Appendix 1). Lists were based on those used by Huff et al. (2015b) and Hutchison and Balota (2005) in which list items were related to one of two meanings of a homograph critical lure. Homograph lures were initially taken from the Twilley et al. (1994) norms and were not balanced in meaning (i.e., for the homograph "bow", the meaning "arrow" is more dominant than the meaning "ribbon"). Lists were expanded to include a total of 16 items per list (vs. 12 used in Huff et al., 2015b) in which 8 items converged upon one meaning of the critical lure (e.g., *biscuit, bun, muffin*, etc.) and 8 items converged upon the other meaning (e.g., *dice, tumble, shake*, etc., for the critical lure *roll*). List size was increased to ensure sufficient rates of false recognition (cf. Robinson & Roediger, 1997) to allow for a potential reduction in false recognition following item-specific encoding. List items were generated using the Nelson et al. (2004) free-association norms by taking the associates with the highest BAS to the critical lure. For some critical lures, there were not enough available associates in the norms for 16-item lists. These remaining list items were either generated and normed by Hutchison and Balota (2005) or determined by experimenters to be related to a specific homograph meaning. All lists were constructed such that homograph meanings were presented in an alternated ordering (vs. blocked) to minimise thematic consistency of the list. Lists were also presented in descending BAS ordering within each list with the experimenter-generated list items presented last, given their absence in the norms suggests these items are low associates. The 24 lists were divided into 2 sets of 12 lists which were counterbalanced across participants. The set that was not studied was used to provide non-studied control items in the recognition test.

A 96-item recognition test was constructed which contained 36 list items (from positions 1, 8, and 10 of each studied list), 36 list-item controls from the non-studied set (from the same list positions), 12 critical lures (1 from each studied list), and 12 critical lure controls (1 from each non-studied list). Thus, all participants received the same recognition test items, but the items that were studied versus non-studied depended upon the counterbalanced set that the participant was assigned. Test items were presented in a newly randomised order for each participant.

Procedure

Participants were tested individually via a computer running SuperLab software (Cedrus, Phoenix, Arizona) with an experimenter present. Following informed consent, participants were given encoding instructions that were based on Huff and Bodner (2013). All encoding groups were instructed to read each study word aloud. The item-specific group was further instructed to "think of a unique characteristic for each word that differentiates it from the other words on the list". The relational group was instructed to "focus on what the words in the list have in common and associate them together". The read group was not presented with any explicit encoding instruction. Following the group-specific encoding instructions, participants were given an 8-item practice list of unrelated words in which participants verbalised their encoding strategy (i.e., verbally read each word aloud and state what the unique characteristic was for each word or what the list words have in common). Following the practice list, the experimenter provided feedback regarding participants' use of their encoding strategy and addressed participant questions to ensure the encoding strategy was applied correctly.

Participants then studied the 12 experimental lists, and the item-specific and relational groups were instructed to perform their encoding tasks silently. All participants still read each list word aloud. Study was participant-paced, in which participants advanced to the next study item after reading each word aloud. The words "next list" appeared on the computer screen to cue the participant of the upcoming list. Immediately following the final study list, participants completed an old/new recognition test in which participants were instructed to respond "old" to items that were studied and "new" to items that were not studied. Recognition responses were made using a labelled keyboard. An experimental session lasted approximately 30 min.

Results

A $p < .05$ level of significance was used for all comparisons. Effect size estimates were computed using partial-eta squared (η_p^2) for analyses of variance (ANOVAs) and Cohen's d for t tests. Effect size estimates were included in lieu of significant p-values. We further tested non-significant differences using a Bayesian estimate of the strength supporting the null hypothesis by computing p_{BIC} (Bayesian Information Criterion; Masson, 2011; Wagenmakers, 2007). This analysis compares two models: One which assumes an effect versus one that does not. The p_{BIC} statistic provides an estimate (via a p-value) that the null hypothesis is true. For signal-detection analyses, false alarm rates of 0 and hit rates of 1 were adjusted using a 1/2n correction (Macmillan & Creelman, 1991). Mean recognition scores and signal-detection indices for correct and false recognition as a function of encoding group are reported in Table 1.

Correct recognition

Correct recognition of studied list items was analyzed using a one-way ANOVA, which indicated a significant difference across the three encoding groups, $F(2, 99) = 12.26$, mean square error (MSE) = .01, $\eta_p^2 = .20$. Follow-up comparisons indicated that correct recognition was greater in the item-specific group than the read group (.88 vs..77), $t(65) = 4.18$, standard error of the mean (SEM) = .03, $d = 1.04$, and in the relational group compared to

Table 1. Mean (SD) proportion of "Old" responses and signal-detection indices for read, item-specific processing, and relational processing groups for Experiments 1 and 2.

Item Type/Index	Read group	Item-specific instruction group	Relational instruction group
Experiment 1: Homograph Study Lists			
N	36	31	35
List items	.77 (.12)	.88 (.09)	.87 (.09)
List item controls	.18 (.10)	.06 (.07)	.08 (.08)
List items d'	1.81 (.50)	2.99 (.64)	2.84 (.71)
List items lambda	1.00 (.48)	1.68 (.46)	1.55 (.46)
Critical lures	.54 (.23)	.42 (.22)	.56 (.23)
Critical lure controls	.25 (.16)	.08 (.11)	.06 (.09)
Critical lures d'	0.90 (.57)	1.15 (.65)	1.66 (.63)
Critical lures lambda	0.75 (.54)	1.39 (.38)	1.47 (.38)
Experiment 2: Mediated Study Lists			
N	37	34	34
List items	.79 (.11)	.88 (.10)	.84 (.10)
List item controls	.20 (.12)	.07 (.06)	.08 (.08)
List items d'	1.84 (.46)	2.90 (.77)	2.69 (.68)
List items lambda	0.95 (.49)	1.62 (.44)	1.57 (.50)
Critical lures	.27 (.20)	.14 (.14)	.20 (.16)
Critical lure controls	.23 (.18)	.09 (.10)	.09 (.10)
Critical lures d'	0.10 (.60)	0.21 (.50)	0.41 (.55)
Critical lures lambda	0.84 (.60)	1.36 (.40)	1.35 (.42)

the read group (.87 vs. .77), $t(69) = 3.93$, $SEM = .03$, $d = 0.95$, with no difference in correct recognition between the item-specific and relational groups (.88 vs. .87), $t < 1$, $p = .73$, $p_{BIC} = .88$. A one-way ANOVA was then conducted on d' to estimate the amount of encoded memory information for list items relative to controls. The d' estimates were computed as the z-score for list item hits minus the z-score for list item control false alarms (see Wickens, 2002). A significant difference was again found across encoding groups, $F(2, 99) = 37.29$, $MSE = .39$, $\eta_p^2 = .43$, indicating more list item memory information was encoded in the item-specific group than the read group (2.99 vs. 1.81), $t(65) = 8.49$, $SEM = .14$, $d = 2.11$, and in the relational group than the read group (2.84 vs. 1.81), $t(69) = 7.12$, $SEM = .15$, $d = 1.71$. There was no difference in d' between the item-specific and relational groups (2.99 vs. 2.84), $t < 1$, $p = .39$, $p_{BIC} = .85$.

We then analyzed an estimate of test-based strategic memory monitoring for list items, computed as lambda (λ). The lambda index was computed by taking the z-score of 1 minus the false alarm rate of list item controls in which greater lambda values indicate more conservative responding, which we interpret as indicative of greater monitoring (see Huff & Aschenbrenner, 2018; Wickens, 2002). Lambda differed across groups, $F(2, 99) = 20.55$, $MSE = .22$, $\eta_p^2 = .29$. Monitoring was greater in the item-specific group than the read group (1.68 vs. 1.00), $t(65) = 5.92$, $SEM = .12$, $d = 1.47$, and in the relational group than the read group (1.55 vs. 1.00), $t(69) = 4.88$, $SEM = .11$, $d = 1.17$. There was no difference in memory monitoring between the item-specific and relational groups (1.68 vs. 1.55), $t(64) = 1.18$, $SEM = .11$, $p = .24$, $p_{BIC} = .80$.

False recognition

A one-way ANOVA indicated differences in the proportions of "old" recognition responses given to critical lures across groups, $F(2, 99) = 3.58$, $MSE = .05$, $\eta_p^2 = .07$. False recognition was lower in the item-specific group than the read group (.42 vs. .54), $t(65) = 2.20$, $SEM = .06$, $d = 0.55$, but unlike correct recognition, false recognition did not differ between the relational group and the read group (.56 vs. .54), $t < 1$, $p = .78$, $p_{BIC} = .89$. False recognition was lower in the item-specific group relative to the relational group (.42 vs. .56), $t(64) = 2.50$, $SEM = .06$, $d = 0.63$. We then estimated the amount of falsely encoded memory information for critical lures by using d', computed as the standardised difference between critical lures and critical lure controls in which false alarms to critical lures were treated as hits (cf. Huff & Bodner, 2013; Huff et al., 2015a). A significant difference was found across groups, $F(2, 99) = 13.75$, $MSE = .38$, $\eta_p^2 = .22$. Follow-up tests indicated that the item-specific group encoded equivalent memory information for critical lures as the read group (1.15 vs. 0.90), $t(65) = 1.63$, $SEM = .15$, $p = .11$, $p_{BIC} = .85$, but the relational group encoded more information for critical lures than the read group (1.66 vs. 0.90), $t(69) = 5.29$, $SEM = .14$, $d = 1.27$. Additionally, the relational group encoded more information for critical lures relative to the item-specific group (1.66 vs. 1.15), $t(64) = 3.24$, $SEM = .16$, $d = 0.81$.

The memory monitoring index for critical lures was computed based on the false alarm rate to critical lure controls. Like correct recognition, greater lambda values estimate greater monitoring at test. Lambda values were found to differ across groups, $F(2, 99) = 25.09$, $MSE = .21$, $\eta_p^2 = .34$. Memory monitoring was greater in the item-specific than the read group (1.39 vs. 0.75), $t(65) = 5.15$, $SEM = .12$, $d = 1.28$, and in the relational group than the read group (1.47 vs. 0.75), $t(69) = 6.48$, $SEM = .11$, $d = 1.56$. Strategic monitoring was equivalent between the item-specific and relational groups (1.39 vs. 1.47), $t < 1$, $p = .45$, $p_{BIC} = .86$.

Discussion

As expected, both item-specific and relational encoding increased correct recognition of list items compared to the read-control task. However, only item-specific encoding reduced false recognition for homograph critical lures. Signal-detection analyses revealed that increased correct recognition in the item-specific and relational groups reflected greater encoding of list items at study and greater strategic monitoring for list items at test. Although both item-specific and relational encoding increased monitoring at test for non-presented critical lures, relational encoding increased falsely encoded memory information for those critical lures, resulting in higher rates of false recognition relative to the item-specific group. These findings indicate that increasing monitoring alone is not always sufficient for reducing associative false memories when encoded memory information for lures is high (see Huff & Bodner, 2013, for a similar pattern). Additionally, the finding that item-specific encoding reduced false recognition of homograph critical lures indicates that a single consistent list theme (i.e., gist) does not need to be present to improve overall memory accuracy.

Although homograph lists are more likely to disrupt gist-based processes due to the presence of two competing themes (vs. one in DRM lists), it is possible that participants may still identify and extract thematic information from the study lists which could contribute to false recognition of homograph critical lures at test. Huff et al. (2015b) reported that despite presenting a gist conflict, homograph lists are sensitive to factors that increase reliance on gist information, such as a delay and blocking (vs. alternating) lists by meaning. This suggests that participants can still encode and retrieve gist information from homograph lists. To address this possibility, Experiment 2 examined item-specific and relational encoding tasks relative to reading on mediated false memory lists that do not have a consistent gist representation as list items are not related to each other and are only indirectly related to a critical lure.

Experiment 2: Mediated study lists

The same procedure used in Experiment 1 was used in Experiment 2 with one exception. Specifically, Experiment 2 utilised mediated lists which contained items that are unrelated to each other and are only indirectly related to a critical lure (Coane et al., 2016; Huff et al., 2012). This list construction produces items that do not have an identifiable list theme as participants are rarely able to identify mediated critical lures when instructed to do so (e.g., approximately 5% of lures were identified when a liberal scoring criterion was used; Coane et al., 2016; Huff et al., 2012; Huff & Hutchinson, 2011). Mediated lists, therefore, provide a stronger test of whether gist is necessary to yield an item-specific reduction in false recognition as list items and critical lures are only associatively related and do not contain thematic relations. Given Experiment 1 found item-specific encoding improved memory accuracy relative to relational encoding and reading when gist was disrupted with homograph lists, we expected item-specific encoding would yield a similar pattern on mediated lists. Signal-detection analyses were again used to estimate the contributions of encoding and monitoring processes.

Method

Participants

One hundred and nine undergraduates from The University of Southern Mississippi participated for partial course credit. Data from four participants were eliminated due to excessively high "old" responses at test, leading to elevated false alarm rates to control items (>70%). Participants were randomly assigned to the item-specific group ($n = 34$), the relational group ($n = 34$), or the read group ($n = 37$). A sensitivity analysis again confirmed that our sample size provided sufficient power (.80) to detect medium or larger effect sizes. All participants were fluent in the English language and reported normal or corrected-to-normal vision.

Materials and procedure

Twenty-four mediated lists served as study materials and were taken from Huff et al. (2012) which contained 15 items each. Mediated lists were based on directly related DRM lists by taking the strongest available associate that was related to each DRM list item, but was not the critical lure, or related to the critical lure or other list items (see Appendix 2 for study lists). The Nelson et al. (2004) free-association norms were used to develop mediated lists. Thus, mediated list items were unrelated to each other and were not directly related to the critical lure according to the norms. Like Experiment 1, the 24 lists were divided into 2 sets of 12 lists in which one set was studied and the other was new. Sets were counterbalanced across participants.

A 96-item recognition test was constructed as in Experiment 1, including 36 list items (positions 1, 3, and 8), 36 list item controls (from the same test positions), 12 critical lures, and 12 critical lure controls. Although there was 1 fewer list item in each mediated list versus homograph lists used in Experiment 1, the recognition test was constructed in an identical fashion. All procedures were identical to Experiment 1 including task instructions and the practice list with experimenter feedback to ensure encoding instructions were understood.

Results

Table 1 reports mean recognition scores and signal-detection indices as a function of item type and encoding group. Analyses were conducted as in Experiment 1.

Correct recognition

Correct recognition of list items differed across groups, $F(2, 102) = 5.79$, $MSE = .01$, $\eta_p^2 = .10$, in which correct recognition was greater in the item-specific than the read group (.88 vs. .79), $t(69) = 3.38$, $SEM = .02$, $d = 0.81$, and greater in the relational than read group (.84 vs. .79), $t(69) = 1.97$, $SEM = .03$, $p = .05$ (two-tailed), $d = 0.47$. There was no difference between the item-specific and relational groups (.88 vs. .84), $t(66) = 1.34$, $SEM = .02$, $p = .18$, $p_{BIC} = .77$. Groups similarly differed on d', $F(2, 102) = 27.38$, $MSE = .42$, $\eta_p^2 = .35$. Encoded memory information was greater in the item-specific than the read group (2.90 vs. 1.84), $t(69) = 7.13$, $SEM = .14$, $d = 1.72$, and greater in the relational than the read group (2.69 vs. 1.84), $t(69) = 6.24$, $SEM = .14$, $d = 1.50$. There was no difference between the item-specific and relational groups (2.90 vs. 2.69), $t(66) = 1.21$, $SEM = .18$, $p = .23$, $p_{BIC} = .80$.

Lambda also differed across groups, $F(2, 102) = 22.05$, $MSE = .23$, $\eta_p^2 = .30$, with greater monitoring in the item-specific than the read group (1.62 vs. 0.95), $t(69) = 6.05$, $SEM = .11$, $d = 1.46$, and in the relational than the read group (1.57 vs. 0.95), $t(69) = 5.33$, $SEM = .12$, $d = 1.28$. There was no difference between the item-specific and relational groups (1.62 vs. 1.57), $t < 1$, $p = .71$, $p_{BIC} = .88$.

False recognition

False recognition of mediated critical lures was found to differ across groups, $F(2, 102) = 4.83$, $MSE = .03$, $\eta_p^2 = .09$. False recognition was lower in the item-specific group than the read group (.14 vs. .27), $t(69) = 3.00$, $SEM = .04$, $d = 0.72$, but was equivalent between the relational and read groups (.20 vs. .27), $t(69) = 1.60$, $SEM = .04$, $p = .11$, $p_{BIC} = .70$. False recognition was also equivalent between the item-specific and relational groups (.14 vs. .20), $t(66) = 1.53$, $SEM = .04$, $p = .13$, $p_{BIC} = .71$. The d' index was then compared across groups, and a marginal effect was found, $F(2, 102) = 2.79$, $MSE = .31$, $p = .07$, $\eta_p^2 = .05$. The item-specific group falsely encoded similar amounts of memory information for critical lures as the read group (.21 vs. .10), $t < 1$, $p = .42$, $p_{BIC} = .86$, but the relational group encoded more memory information than the read group (.41 vs. .10), $t(69) = 2.25$, $SEM = .14$, $d = 0.54$. There was no difference between the item-specific and relational groups (.21 vs. .41), $t(66) = 1.56$, $SEM = .13$, $p = .12$, $p_{BIC} = .71$.

Strategic monitoring (lambda) differed across groups, $F(2, 102) = 13.76$, $MSE = .24$, $\eta_p^2 = .21$. Monitoring was greater in the item-specific compared to the read group (1.36 vs. 0.84), $t(69) = 4.30$, $SEM = .12$, $d = 1.04$, and the relational group compared to the read group (1.35 vs. 0.84), $t(69) = 4.15$, $SEM = .12$, $d = 1.00$, but no difference was found between the item-specific and relational groups (1.36 vs. 1.35), $t < 1$, $p = .91$, $p_{BIC} = .91$.

Discussion

Like the homograph lists used in Experiment 1, correct recognition for mediated list items similarly benefitted from item-specific and relational encoding instructions relative to reading. Both encoding tasks increased encoded memory information and memory monitoring relative to reading. For false recognition, item-specific encoding was effective at reducing false recognition relative to reading, but not relative to relational encoding – a pattern inconsistent with our predictions. False recognition following relational encoding was also equivalent to reading. Signal-detection analyses revealed that the relational group falsely encoded more memory information for critical lures than the read group but not the item-specific group. Monitoring, however, was greater in both the item-specific and relational groups than the read group. These patterns indicate that although relational encoding increased memory information for critical lures relative to reading, this falsely encoded information was countered by greater monitoring which in turn, produced similar false recognition rates. For the item-specific group, falsely encoded memory information was equivalent to reading, but the increased monitoring was successfully able to reduce false recognition relative to reading, a pattern consistent with Experiment 1. Thus, item-specific and relational encoding tasks revealed an important interplay between encoding and retrieval processes in mediated false recognition where relational processing can facilitate encoding of critical lures that is countered by increased monitoring.

The finding that item-specific encoding produces a mirror-effect pattern on mediated lists suggests that distinctive encoding is effective at benefitting memory accuracy on lists that do not contain consistent gist information. This pattern indicates that even when critical lures are implicitly activated, item-specific processing can reduce their false recognition – a pattern that is in alignment with an activation-monitoring account given no gist information is available on mediated lists. Monitoring appears to be effective at reducing false recognition of mediated lures provided encoded memory information was not elevated as was the case in the relational encoding group.

General discussion

The present study examined the effects of item-specific and relational encoding instructions on correct and false recognition using homograph (Experiment 1) and mediated (Experiment 2) study lists. Data patterns were generally consistent across experiments. Relative to a read-only control task, a mirror-effect pattern was found in the item-specific encoding group for both list types as evidenced by increased correct recognition and decreased false recognition of critical lures relative to the read group. Correct recognition similarly benefited from relational encoding compared to reading, but relational encoding was ineffective at reducing false recognition. We then applied a signal-detection analysis to estimate contributions of encoding and monitoring processes. For correct recognition, item-specific and relational encoding increased both encoded memory information of list items and test-based monitoring relative to reading, and this pattern occurred on both homograph and mediated lists. For false recognition, encoded memory information was greater in the relational group relative to reading in both experiments, indicating that emphasising the relations across list items at study, even when those list items were ostensibly unrelated (i.e., mediated lists), can facilitate false encoding of critical lures. Estimates of encoded memory information for critical lures in the item-specific group did not differ from reading in either experiment and was only lower than the relational group on homograph lists. For memory monitoring estimates, both item-specific and relational groups were greater than the read group and equivalent to each other. This pattern indicates that the reduction in false recognition following distinctive item-specific encoding was due to enhanced monitoring, but not encoding, a pattern consistent with the use of a distinctiveness heuristic.

Although increased monitoring in the relational group did not reduce false recognition relative to reading, it likely precluded relational encoding from producing a "backfiring" pattern in which false recognition would have exceeded reading. In both experiments, falsely encoded memory information for critical lures in the relational group exceeded the read group, suggesting that memory for homograph and mediated critical lures was more likely to be available at test. Despite this increase, monitoring estimates were greater in the relational than read group, suggesting that additional monitoring (or more effective monitoring) was available to counter the increase in encoded memory information. Increased monitoring in the relational group was not as effective at reducing false recognition relative to the item-specific group, however, as the relational group showed elevated rates of falsely encoded memory information for critical lures.

Although item-specific encoding was able to reduce false recognition relative to reading through increased monitoring, it did not produce a concomitant decrease in encoded memory information. This pattern differs from Huff et al.'s (2015) meta-analysis in which distinctive encoding tasks were found to increase monitoring and decrease falsely encoded memory information for DRM lures relative to non-distinctive control tasks. We note two possibilities for this departure. First, the tasks used in Huff, Bodner, et al.'s meta-analysis were distinctive-type tasks that included generation, picture presentations, production, and unique fonts, whereas our distinctive task used item-specific encoding instructions. While the meta-analysis did not find that task type was a reliable moderator, it is possible that item-specific instructions are less effective at disrupting encoded memory information for critical lures relative to other distinctive tasks. Consistent with this possibility, Huff and Bodner (2013; Experiment 1), also found that item-specific instructions did not significantly reduce encoded memory information relative to a read-control task despite this pattern emerging with a generation task (Experiment 3). The second possibility is that relative to DRM lists, false recognition rates in the read-control group were generally lower overall on our homograph and mediated lists relative to aggregate DRM datasets that have been used in the literature (e.g., Gallo, 2006; Huff, Bodner, et al.). This is unsurprising given DRM lists used in these earlier studies typically contained the highest BAS list items, whereas BAS was lower in the homograph lists (see Appendix 1 for mean BAS values) and mediated lists, the latter of which had no associative strength between list items and critical lures. Given these lower false recognition rates, it is possible that baseline encoded memory information in the read lists may already have been quite low, making a further reduction difficult. This is particularly likely on mediated lists where mean baseline false recognition on read lists was .27 and estimated encoded memory information was at floor. Further reductions in encoded memory information for critical lures via item-specific encoding may have been difficult due to a restricted range.

The inclusion of homograph and mediated lists were used to evaluate the effects of item-specific and relational encoding on lists that were thematically disjointed due to the presentations of list items that converged upon two separate list themes (homograph lists) or did not have any thematic consistency (mediated lists). Homograph and mediated lists were designed to contrast associative-activation and gist-extraction processes in list-based false memories. Because these list types either disrupt gist consistency or present no consistent gist across list items, false recognition is likely the result of spreading-activation processes consistent with an activation-monitoring account (Roediger et al., 2001a). Similar recognition and signal-detection patterns across experiments provide evidence that item-specific and relational processing tasks operate similarly when gist extraction is minimised or eliminated. Our experiments are particularly informative regarding the processes involved in distinctive item-specific encoding which consistently produces a mirror effect pattern relative to reading (e.g., Huff et al., 2015a). Here we show that item-specific encoding can promote memory accuracy relative to a standard read group when list themes are disrupted or absent.

Our experiments indicate that item-specific and relational encoding affect implicit activation processes in false recognition, but they do not indicate that gist-extraction processes are immune to these encoding types when gist information is available. Indeed, item-specific and relational encoding may affect both gist extraction and implicit activation processes on DRM lists given both processes can contribute to the false memory illusion. To provide evidence that item-specific and relational encoding does not affect gist-based processes, one would need to show that item-specific and relational encoding are ineffective using study lists that are only thematically related to lures and do not contain associative relations. Given the reliance of associative characteristics to produce a consistent theme, developing a set of gist-only lists would be a tall order for researchers. As reviewed in the Introduction, despite efforts to minimise associative characteristics, examples such as situational feature lists developed by Cann et al. (2011) still contained BAS despite norming procedures to generate list items that were thematically but not associatively related. Similarly, Brainerd et al. (2020) created sets of four-item DRM lists that varied in their mean BAS values but normed to be either high or low in gist strength to evaluate how BAS and gist strength contribute to false recognition. They reported that gist strength predicted false recognition across all levels of BAS, but BAS only predicted false recognition when gist strength was low, indicating that gist strength may support false recognition separately from BAS. Despite this pattern, all lists still contained measurable levels of BAS, demonstrating that even in cases where gist processes may be strong, associations between list items and critical lures are still present. Generation of "association free" false memory lists may therefore be difficult if not impossible, though these lists would presumably be useful for segregating gist and associative contributions to false memory. Regardless, our experiments suggest that item-specific and relational encoding can affect false recognition when gist is either disrupted or absent but do not indicate how gist processes are affected when a list theme is available.

Our use of signal-detection indices provided useful information regarding encoding and monitoring processes, but we note that these measures are only estimates of these memorial processes and not online measures given they are computed solely using recognition responses. Despite this limitation, however, we (Huff & Aschenbrenner, 2018) reported that signal-detection estimates parallel parameter estimates using the drift-diffusion accumulation model (Ratcliff, 1978) that map onto encoding and monitoring processes. Using this model, the drift rate, which corresponds to the rate in which memory evidence accumulates towards a recognition response, paralleled patterns found in d' suggesting that both were estimating encoding processes. Relatedly, boundary separation, which corresponds to the amount of evidence needed to make a response, paralleled lambda, suggesting both were estimating monitoring processes. Importantly, the diffusion model uses both recognition responses and response latencies to generate estimates, providing convergent validity to estimates of memory processes from the signal-detection approach. Of course, both signal-detection indices and diffusion model parameters are offline quantitative estimates that provide little information on how participants encode or monitor information at test. Evaluating qualitative processes following item-specific and relational encoding is a research issue worthy of attention.

Finally, though our results present meaningful differences in recognition and signal-detection measures across encoding tasks, we are careful to acknowledge that no task is "process pure". Indeed, item-specific encoding and relational encoding likely operate on a continuum of our processing in which tasks may be more likely to promote one processing type or another. We utilised item-specific and relational encoding instructions as they have been successful at inducing these processing types in previous studies (e.g., McCabe et al., 2004). However, item-specific and relational differences have been shown while holding the task constant (e.g., generation or pleasantness ratings), while manipulating qualitative aspects of how the task is completed (Huff & Bodner, 2013; Huff et al., 2021a). Additionally, research indicates that the materials themselves can promote processing (Huff & Bodner, 2014; Hunt & Seta, 1984) based on the strength of the association of the study materials (e.g., categorised vs. weakly related ad hoc lists). This may suggest that strongly associated lists like DRM and homograph lists may be more likely to promote relational processing due to the relations of the items in each list versus mediated lists which are seemingly unrelated. Indeed, this possibility may account for why false recognition following relational encoding was greater than the item-specific group with homograph lists, but not with mediated lists. Participants may have been able to process the relations across homograph lists more fluently making relational encoding more likely to elevate false recognition. Of course, overall false recognition was greater for homograph than mediated lists, but the relative effectiveness of each task type may be related to the associative strength or the perceived associative strength of the study list. This may suggest that distinctive item-specific encoding, which has consistently improved memory accuracy, may be limited from reducing false memory on some study lists, particularly those with stronger associative/gist relations. Determining whether item-specific encoding enhances memory accuracy across lists of varying relatedness could be informative on whether accuracy benefits are global in scope.

Conclusion

The purpose of the current study was to determine if processing distinctive qualities of study list items would improve memory accuracy when gist-based processing was either minimised via homograph lists or altogether eliminated via mediated lists. In both experiments, item-specific encoding was found to produce a mirror-effect pattern on memory accuracy, and this pattern was due to enhanced monitoring versus reading. Relational encoding was found to inflate encoded memory information relative to item-specific encoding, but false recognition did not exceed the read group due to a concomitant increase in test-based monitoring. Collectively, our experiments indicate that item-specific encoding can reduce false recognition when gist-based processes are absent, and both encoding and monitoring processes can contribute to benefits on memory accuracy.

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Open practices statement

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Appendix 1

Homograph Lists Used in Experiment 1 including Mean Backward Associative Strength (BAS) from the Nelson et al. (2004) Free-Association Norms and False Recognition Proportions for each Critical Lure Collapsed Across the Read, Item-Specific, and Relational Groups.

"Roll" Mean BAS = .06; False Recognition = .49								
Theme 1	Biscuit	Bun	Muffin	Crescent	Cinnamon	Bread	Bake	Butter
BAS	.13	.11	.08	.07	.05	.03	*	*
Theme 2	Tumble	Dice	Shake	Scroll	Wheel	Bounce	Rattle	Rotate
BAS	.12	.12	.02	.02	.01	.01	.01	.00
"Class" Mean BAS = .09; False Recognition = .30								
Theme 1	Session	Course	Notes	Subject	Lecture	Lesson	Attendance	Professor
BAS	.30	.19	.16	.14	.12	.11	.10	.00
Theme 2	Stereotype	Group	Economic	Status	Prestige	Division	Fashion	Social
BAS	.20	.05	.02	.01	.01	.01	.01	.00
"Tear" Mean BAS = .09; False Recognition = .47								
Theme 1	Rip	Fray	Fold	Torn	Detach	Sew	Break	Demolish
BAS	.71	.10	.06	.04	.03	.02	.02	.02
Theme 2	Sob	Sad	Handkerchief	Rag	Toil	Eye	Salt	Upset
BAS	.05	.05	.02	.01	.01	*	*	*
"Fall" Mean BAS = .23; False Recognition = .58								
Theme 1	Stumble	Slip	Rise	Trip	Faint	Clumsy	Slide	Accident
BAS	.70	.51	.33	.29	.21	.09	.04	.01
Theme 2	Autumn	Season	Spring	Leaves	Brisk	Harvest	Pumpkin	Yellow
BAS	.52	.19	.19	.17	.00	.00	*	*
"Fly" Mean BAS = .20; False Recognition = .34								
Theme 1	Swatter	Maggot	Moth	Insect	Bug	Mosquito	Pest	Buzz
BAS	.74	.15	.10	.09	.06	.05	.03	.02
Theme 2	Kite	Soar	Airplane	Birds	Wings	Glide	Airport	Balloon
BAS	.52	.37	.32	.32	.23	.10	.06	.03
"Block" Mean BAS = .04; False Recognition = .34								
Theme 1	Impediment	Shield	Barricade	Barrier	Obstruct	Ban	Screen	Obstacle
BAS	.04	.01	.03	.09	.12	.01	.01	.06
Theme 2	Concrete	Brick	Corner	Wooden	Cube	Cement	Mason	Street
BAS	.04	.05	.04	.04	.03	.03	.02	.01
"Bow" Mean BAS = .12; False Recognition = .60								
Theme 1	Arrow	Archery	Indian	Violin	Cross	Hunter	Weapon	Rosin
BAS	.53	.24	.03	.03	.02	*	*	*
Theme 2	Ribbon	Tie	Sash	Gift	Present	Decoration	Birthday	Package
BAS	.26	.10	.01	.01	*	*	*	*
"Seal" Mean BAS = .03; False Recognition = .34								
Theme 1	Walrus	Otter	Porpoise	Flipper	Penguin	Water	Baby	Fin
BAS	.13	.10	.02	.01	.01	*	*	*
Theme 2	Envelope	Wrap	Stamp	Flap	Quality	Tape	Cover	Close
BAS	.02	.02	.01	.01	.01	.01	.01	*
"Bat" Mean BAS = .10; False Recognition = .81								
Theme 1	Baseball	Ball	Softball	Hit	Club	Glove	Catch	Plate
BAS	.31	.19	.09	.04	.02	.02	*	*
Theme 2	Vampire	Blind	Cave	Fangs	Cavern	Rabies	Bite	Night
BAS	.21	.13	.05	.01	.01	*	*	*
"Straw" Mean BAS = .05; False Recognition = .38								
Theme 1	Hut	Scarecrow	Hay	Wicker	Basket	Haystack	Horse	Bale
BAS	.13	.15	.06	.03	.02	.02	*	*
Theme 2	Sip	Slurp	Suck	Tube	Plastic	Cylinder	Cup	Drink
BAS	.06	.02	.02	.01	*	*	*	*
"Head" Mean BAS = .15; False Recognition = .49								
Theme 1	Chairperson	Chief	Leadership	Department	Boss	Principal	Coach	Commander
BAS	.13	.05	.04	.04	.03	.02	.01	.01
Theme 2	Skull	Hat	Neck	Scalp	Brain	Ache	Temple	Hair
BAS	.49	.35	.33	.32	.27	.18	.08	.04
"Horn" Mean BAS = .12; False Recognition = .81								
Theme 1	Honk	Bugle	Trumpet	Tuba	Trombone	Brass	Blow	Sound
BAS	.52	.30	.24	.08	.06	.04	.02	.01
Theme 2	Rhinoceros	Unicorn	Ram	Bull	Antler	Antelope	Tusk	Ivory
BAS	.24	.11	.11	.05	.05	.03	.01	*
"Race" Mean BAS = .08; False Recognition = .62								
Theme 1	Drag	Compete	Track	Runner	Winner	Horse	Driver	Chase
BAS	.21	.12	.10	.05	.04	.03	.01	.01
Theme 2	Ethnicity	Minority	Bias	Prejudice	Stereotype	Culture	Gander	Integrate
BAS	.48	.06	.06	.04	.04	.01	.01	.01
"Cell" Mean BAS = .10; False Recognition = .62								
Theme 1	Membrane	Nucleus	Nerve	Molecule	Bacteria	Germ	DNA	Protein
BAS	.48	.10	.10	.04	.02	.01	*	*

Theme 2	Holding	Prison	Jail	Inmate	Bars	Cage	Jumpsuit	Lockdown
BAS	.16	.10	.07	.05	.04	.01	*	*
"Organ" Mean BAS = .04; False Recognition = .40								
Theme 1	Kidney	Liver	Heart	Intestine	Lunch	Stomach	Abdomen	Transplant
BAS	.08	.07	.04	.04	.03	.02	.02	.02
Theme 2	Piano	Pipe	Keyboard	Music	Church	Blower	Damper	Bench
BAS	.09	.02	.01	*	*	*	*	*
"Hot" Mean BAS = .24; False Recognition = .58								
Theme 1	Spicy	Chili	Mild	Pepper	Cooked	Cinnamon	Radish	Potato
BAS	.55	.38	.31	.11	.04	.02	.02	.01
Theme 2	Humid	Cold	Temperature	Fever	Cool	Warm	Heat	Summer
BAS	.45	.41	.35	.34	.29	.27	.21	.15
"Match" Mean BAS = .03; False Recognition = .46								
Theme 1	Boxing	Wrestling	Chess	Contest	Tennis	Pair	Competition	Trial
BAS	.09	.08	.02	.01	.01	.01	*	*
Theme 2	Lighter	Flame	Fire	Lit	Smoke	Strike	Burn	Sulfur
BAS	.09	.03	.02	.02	.01	.01	.01	*
"Right" Mean BAS = .18; False Recognition = .58								
Theme 1	Wrong	Correct	Accurate	Proper	Exact	Answer	Okay	Ethics
BAS	.72	.23	.16	.07	.07	.04	.03	.03
Theme 2	Left	Handed	Starboard	Clockwise	Turn	Direction	Veer	Side
BAS	.93	.32	.10	.06	.06	.05	.03	.01
"Foot" Mean BAS = .20; False Recognition = .58								
Theme 1	Toe	Ankle	Shoe	Heel	Leg	Sock	Boot	Fungus
BAS	.60	.36	.32	.22	.20	.17	.14	.04
Theme 2	Inch	Yard	Mile	Meter	Measurement	Length	Space	Square
BAS	.47	.12	.02	.02	.02	.02	*	*
"Watch" Mean BAS = .11; False Recognition = .56								
Theme 1	Observe	Television	Guard	Neighborhood	Look	Patrol	Spy	Preview
BAS	.50	.12	.11	.08	.03	.03	.02	.02
Theme 2	Wrist	Digital	Time	Clock	Pocket	Swiss	Tick	Jewelry
BAS	.34	.20	.15	.08	.04	.02	.01	.01
"Check" Mean BAS = .05; False Recognition = .52								
Theme 1	Payment	Bill	Welfare	Stub	Deposit	Money	Blank	Cash
BAS	.13	.08	.05	.03	.02	.02	.01	.01
Theme 2	Inspect	Examine	Verify	Evaluate	Review	Gauge	Appraise	Overlook
BAS	.13	.10	.08	.03	.02	.02	.01	.00
"Date" Mean BAS = .05; False Recognition = .56								
Theme 1	Prom	Blind	Couple	Double	Relationship	Romantic	Fling	Swoon
BAS	.13	.07	.02	.02	.01	.01	.01	.01
Theme 2	Calendar	Appointment	Year	Birth	Event	Reservation	Current	Day
BAS	.30	.11	.07	.02	.02	.01	.01	.00
"Lot" Mean BAS = .12; False Recognition = .40								
Theme 1	Much	Many	Often	Bunch	Plenty	Numerous	Must	Mass
BAS	.37	.29	.17	.17	.15	.08	.07	.06
Theme 2	Park	Acre	Playground	Site	Parking	Asphalt	Car	Area
BAS	.24	.02	.02	.02	.01	.00	*	*
"Iron" Mean BAS = .07; False Recognition = .44								
Theme 1	Crease	Starch	Steam	Press	Wrinkle	Curtain	Appliance	Shirt
BAS	.09	.09	.09	.06	.06	.01	.01	.00
Theme 2	Ore	Steel	Metal	Rust	Copper	Element	Mineral	Smelt
BAS	.32	.22	.10	.05	.03	.02	.02	.02

Note**:** Words that were unavailable in the Nelson et al. (2004) norms are indicated by *.

Appendix 2

Mediated Critical Lures (in bold) used in Experiment 2 with non-presented mediators (i.e., DRM List Items) listed in italics.

Chair (.27)		**Foot (.25)**		**Mountain (.30)**	
Lumber	*Wood*	Sprain	*Ankle*	Pedal	*Bike*
Stand	*Sit*	Glove	*Hand*	Hitch	*Hike*
Arms	*Legs*	Pedestrian	*Walk*	Ladder	*Climb*
Toilet	*Seat*	Elbow	*Arm*	Counter	*Top*
Office	*Desk*	Tongue	*Mouth*	Ant	*Hill*
Padding	*Cushion*	Stub	*Toe*	Ordinary	*Plain*
Picnic	*Table*	Goal	*Soccer*	Waterfall	*Rocks*
Bar	*Stool*	Cobbler	*Shoe*	Domain	*Range*
Park	*Bench*	Measurement	*Inch*	Precipice	*Cliff*
Dresser	*Furniture*	Bend	*Knee*	Incline	*Steep*

Producer	*Director*
Balcony	*Patio*
Lobby	*Lounge*
Crown	*Throne*
Relax	*Recliner*

River (.20)

Jog	*Run*
Faucet	*Water*
Yacht	*Boat*
Cod	*Fish*
Pool	*Swim*
Discovery	*Channel*
London	*Bridge*
Paddle	*Canoe*
Detergent	*Tide*
Babbling	*Brook*
Pour	*Flow*
Beaver	*Creek*
Curved	*Winding*
Swan	*Lake*
Current	*Stream*

Rough (.25)

Beach	*Sand*
Horse	*Riders*
Street	*Road*
Prepare	*Ready*
Earth	*Ground*
Severe	*Harsh*
Female	*Sex*
Crooked	*Uneven*
Difficulty	*Hard*
Flat	*Smooth*
Face	*Beard*
Stone	*Gravel*
Lumpy	*Bumpy*
Guy	*Tough*
Flexible	*Rigid*

Slow (.14)

Go	*Stop*
Careful	*Cautious*
Brisk	*Fast*
Spontaneous	*Quick*
Limit	*Speed*
Slug	*Snail*
Violation	*Traffic*
Haul	*Drag*
Soothe	*Ease*
Walker	*Elderly*
Work	*Lazy*
Abnormal	*Retarded*
Stay	*Wait*
Hare	*Turtle*
Pause	*Delay*

Army (.12)

Revolution	*War*
Co-pilot	*Pilot*
Citizen	*United States*
Sailor	*Navy*
Acid	*Base*
Obstacle	*Blockade*
Bravery	*Soldier*
Parade	*March*
Gun	*Rifle*
Ahoy	*Captain*
Trophy	*Medal*
Lieutenant	*Military*
Aircraft	*Air Force*
Police	*Uniform*
Engage	*Combat*

Bread (.14)

Cafeteria	*Food*
Dine	*Eat*
Cork	*Wine*
Dairy	*Milk*
Petroleum	*Jelly*

Cowboy	*Boot*
Stick	*Yard*
Hit	*Sock*
Mule	*Kick*
Spike	*Heel*

Sweet (.20)

Bad	*Good*
Bake	*Cake*
Maple	*Syrup*
Beverage	*Soda*
Cane	*Sugar*
Bee	*Honey*
Apple	*Pie*
Beat	*Heart*
Flavor	*Taste*
Crunchy	*Candy*
Chip	*Chocolate*
Ache	*Tooth*
Lemon	*Sour*
Vinegar	*Bitter*
Friendly	*Nice*

Cold (.47)

Slippery	*Wet*
Spicy	*Hot*
Vent	*Air*
Sleigh	*Snow*
Summer	*Winter*
Cream	*Ice*
Cozy	*Warm*
Thaw	*Freeze*
Choke	*Cough*
Radiator	*Heat*
Dust	*Sneeze*
Humid	*Weather*
Mellow	*Chill*
Uptight	*Frigid*
Dew	*Frost*

Circle (.22)

Region	*Area*
Loser	*Winner*
Hula	*Hoop*
Cube	*Square*
Straight	*Line*
Wagon	*Wheel*
Core	*Centre*
Angle	*Triangle*
Ball	*Round*
Earring	*Loop*
Turn	*Around*
Mark	*Dot*
Storage	*Unit*
World	*Sphere*
Penguin	*Arctic*

Clean (.26)

Tub	*Bath*
Appliance	*Dishwasher*
Butler	*Maid*
Floor	*Mop*
Orderly	*Neat*
Hydrogen	*Peroxide*
Fingernail	*Polish*
Lather	*Rinse*
Meteor	*Shower*
Suds	*Soap*
Sloppy	*Messy*
Lint	*Dust*
Hinge	*Squeak*
Smear	*Wipe*
Genuine	*Pure*

Child (.22)

Cradle	*Baby*
Yo-yo	*Toy*
Guardian	*Parent*
Mistreat	*Abuse*
Old	*Young*

Ram	*Goat*
Gully	*Valley*
Glide	*Ski*
Zenith	*Peak*
Iceberg	*Glacier*

Window (.25)

Knob	*Door*
Clarify	*Clear*
Brick	*House*
Minded	*Open*
Crystal	*Glass*
Perception	*View*
Lace	*Curtain*
Cool	*Breeze*
Carpet	*Cleaner*
Sill	*Pane*
Lamp	*Shade*
Computer	*Screen*
Slippers	*Bedroom*
Glasses	*Frame*
Smash	*Shatter*

Party (.15)

Container	*Tupperware*
Ritual	*Ceremony*
Guest	*Host*
Fling	*Affair*
Cards	*Birthday*
Halloween	*Costume*
Ornament	*Decoration*
Amaze	*Surprise*
Meeting	*Gathering*
Situation	*Event*
Week	*Weekend*
Circumstance	*Happening*
Club	*Social*
Banner	*Celebration*
Tribute	*Celebrate*

Shirt (.22)

Wardrobe	*Clothes*
Buckle	*Belt*
Surface	*Top*
Zipper	*Pants*
Gown	*Dress*
Knot	*Tie*
Steel	*Iron*
Pouch	*Pocket*
Sheets	*Linen*
Belly	*Button*
Cuff	*Sleeve*
Boxer	*Shorts*
Cologne	*Polo*
Flea	*Collar*
Football	*Jersey*

Needle (.16)

Addict	*Drugs*
Harm	*Hurt*
Stye	*Eye*
Pitchfork	*Hay*
Fabric	*Cloth*
Razor	*Sharp*
Surgery	*Operation*
Score	*Point*
Protractor	*Compass*
Thicket	*Thorn*
Lapel	*Pin*
Weave	*Knit*
Strand	*Thread*
Desert	*Cactus*
Tree	*Pine*

Black (.03)

Meow	*Cat*
Day	*Night*
Basement	*Bottom*
Hue	*Color*
Red	*Blue*

Sub	*Sandwich*	Temper	*Tantrum*	Life	*Death*
Spread	*Butter*	Porch	*Swing*	Pale	*White*
Jar	*Jam*	Fountain	*Youth*	Shadow	*Dark*
Cinnamon	*Toast*	Responsible	*Adult*	Burial	*Funeral*
Catcher	*Rye*	Independent	*Dependent*	Pen	*Ink*
Cut	*Slice*	Joke	*Kid*	Master	*Slave*
Mill	*Flour*	Sister	*Sibling*	Tan	*Brown*
Meat	*Loaf*	Phase	*Development*	Matter	*Gray*
Cookie	*Dough*	Reckless	*Immature*	Mine	*Coal*
Pizza	*Crust*	Porcelain	*Doll*	Sorrow	*Grief*
Trash (.17)		**Cup (.07)**		**Picture (.19)**	
Opener	*Can*	Broth	*Soup*	Cinema	*Movie*
Broom	*Sweep*	Bartender	*Drink*	Noose	*Hang*
Destroy	*Ruin*	Caffeine	*Coffee*	Barrier	*Wall*
Deodorant	*Smell*	Ruler	*Measure*	Mirror	*Image*
Laundry	*Basket*	Breakable	*Glass*	Movement	*Motion*
Things	*Stuff*	Recycle	*Plastic*	Trace	*Draw*
Stack	*Pile*	Kettle	*Tea*	Flash	*Camera*
Denial	*Refuse*	Cover	*Lid*	Record	*Album*
Useless	*Worthless*	Slurp	*Sip*	Sculpture	*Painting*
Nuclear	*Waste*	Punch	*Bowl*	Landscape	*Scenery*
Dig	*Dirt*	Hut	*Straw*	Horror	*Film*
Bowling	*Alley*	Cabinet	*Cupboard*	Outline	*Sketch*
Unload	*Dump*	Beer	*Mug*	Chart	*Diagram*
Raccoon	*Garbage*	Tire	*Rim*	Skeleton	*Frame*
Scoop	*Litter*	Napkin	*Holder*	Writing	*Drawing*
Soft (.14)		**High (.24)**		**Sleep (.21)**	
Bulb	*Light*	Flight	*Airplane*	Weary	*Tired*
Noisy	*Loud*	Down	*Up*	Fantasy	*Dream*
Difficult	*Hard*	Architecture	*Building*	Truce	*Peace*
Flesh	*Skin*	Scuba	*Dive*	Alert	*Awake*
Swabs	*Cotton*	Below	*Above*	Flannel	*Pajamas*
Contact	*Touch*	Under	*Over*	Smother	*Pillow*
Mink	*Fur*	Hop	*Jump*	Stretch	*Yawn*
Mitten	*Kitten*	Short	*Tall*	Crib	*Bed*
Fragile	*Delicate*	Cloud	*Sky*	Afternoon	*Nap*
Quill	*Feather*	Edge	*Cliff*	Pendulum	*Hypnotise*
Polyester	*Silk*	Bell	*Tower*	Sunday	*Rest*
Kind	*Gentle*	After	*Noon*	Crochet	*Blanket*
Hairy	*Furry*	Eagle	*Soar*	Rise	*Wake*
Purple	*Velvet*	Shallow	*Low*	Terror	*Nightmare*
Sore	*Tender*	Wasted	*Stoned*	Reservation	*Motel*

Note: Mean False Recognition Proportions for each Critical Lure Collapsed Across Read, Item-Specific, and Relational Groups are Listed in Parentheses.