Investigating the Effects of Item-Specific and Relational Encoding on Judgment of Learning Reactivity for Categorized, Uncategorized, and DRM Lists

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Abstract

Judgments of Learning (JOLs) have been repeatedly shown to be reactive on learning. However, the specific processes underlying JOL reactivity likely differ based on the type of stimuli participants study and the method by which memory is assessed. Recently, enhanced item-specific encoding has been proposed as a mechanism explaining JOL reactivity on word list learning. The present study tests this account by comparing reactivity between item-level and global JOLs, which differentially emphasize item-specific and relational encoding. Participants studied and made item-level JOLs, global JOLs, or silently read categorized and uncategorized word lists (Experiments 1A and 1B) or DRM lists (Experiment 2). Overall, item-level JOLs produced positive reactivity on all list types but only when memory was assessed via recognition testing (Experiments 1B and 2). When free-recall testing was used, item-level JOLs were non-reactive, though global JOLs improved memory for categorized but not uncategorized lists. Separately, Experiment 2 found that while item-level JOLs improved correct recognition of studied items, global JOLs increased the DRM false memory illusion. Taken together, these results suggest that item-level JOLs encourage item-specific processing at encoding, which benefits recognition via enhanced familiarity. However, when the JOL task emphasizes relational encoding (e.g., global JOLs), memory is only modified when items contain pre-existing relations (e.g., correct memory for categorized lists, false memory for critical lists). Thus, how JOLs influence memory likely depends upon both the type of stimuli and the method of testing.

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When learning new information, it is critical to assess whether the knowledge being acquired has been sufficiently encoded. Metamemory, or the processes by which individuals monitor their learning, is crucial as it helps individuals identify which items need additional study while simultaneously letting them modify their actions accordingly (see T. O. Nelson & Narens, 1990). To investigate questions surrounding these processes, researchers commonly have participants make Judgments of Learning (JOLs), which involve studying items (commonly cue-target word pairs) and predicting the likelihood of correctly remembering them on a later test (see Rhodes, 2016; Schwartz & Metcalf, 2017, for reviews). Thus, JOLs provide researchers with a simple measure for assessing how various encoding manipulations affect the study process, including perceptual manipulations (e.g., font-size; Rhodes & Castel, 2008; Chang & Brainerd, 2022) and associations between cue-target pairs (e.g., Koriat & Bjork, 2005; Castel, McCabe, & Rhodes, 2007).

Historically, JOLs have been viewed as neutral measures with little influence on memory, particularly when participants are instructed to elicit them concurrently with or immediately following study (though see Spellman & Bjork, 1992, who argued that delayed JOLs were likely to impart a memorial benefit). However, recent studies have repeatedly demonstrated that JOLs are *reactive* on learning (e.g., Janes, Rivers, & Dunlosky, 2018; Maxwell & Huff, 2022; Soderstrom, Clark, Halamish, & Bjork, 2015; see Double, Birney, & Walker, 2018, for review). Based on these findings, making JOLs modifies participants’ memory for studied items, likely by making certain features of the stimuli more salient at encoding (Ericsson & Simon, 1993). Thus, providing JOLs at encoding could potentially produce memory benefits (i.e., *positive reactivity*) or costs (i.e., *negative reactivity*), which would be evident when comparing memory for participants making JOLs at encoding to a separate group engaging in a no-JOL control task (e.g., silent reading).

Prior research has commonly tested for JOL reactivity using cue-target word pairs (e.g., Janes et al., 2018; Maxwell & Huff, 2022; Maxwell & Huff, 2023; Mitchum, Kelly, & Fox, 2016; Myers, Rhodes, & Hausman, 2020; Soderstrom et al., 2015; though see Senkova & Otani, 2021 and Zhao et al., 2023 who had participants study word lists). Studies utilizing cue-target word pairs have revealed a consistent pattern of memory changes: When pairs are semantically related (e.g., dog – paw), JOLs generally improve memory for the target item; however, this memory benefit does not extend to unrelated pairs (e.g., dog – cup) and may even impair memory for this pair type (see Undorf, Schäfer, & Halamish, 2024). To explain positive reactivity on related pairs, Soderstrom et al. (2015) proposed that making JOLs strengthens intrinsic cues which participants use to inform the magnitude of their judgments (see Koriat, 1997) and that memory must be assessed using a method that is sensitive to the specific cues that have been strengthened. Recent studies investigating JOL reactivity with cue-target pairs has largely supported this cue-strengthening account, and later studies have explored the degree to which pre-existing cue-target relations between study items contribute to positive JOL reactivity within this context (e.g., Janes et al., 2018; Halamish & Undorf, 2023; Maxwell & Huff, 2022; Maxwell & Huff, 2023; Rivers, Dunlosky, Janes, Witherby, & Tauber, 2023). Thus, there is growing evidence that JOL reactivity on cue-target word pairs reflects JOLs encouraging participants to process pair relatedness.

However, whereas previous reactivity studies have often emphasized the link between cue-target relations and reactivity, the present study focuses instead on the potential for JOLs to also encourage *item-specific encoding* of stimuli. Based on the item-specific/relational framework (Einstein & Hunt, 1980; Hunt & Einstein, 1981), encoding tasks differ regarding their likelihood of encouraging participants to process unique properties of stimuli that differentiate between individual items (i.e., item-specific encoding) or properties which are shared between items (i.e., relational encoding). While item-specific and relational encoding tasks emphasize different aspects of studied materials, both have been shown to improve memory performance relative to silent reading. As such, the memorial benefits of JOLs could potentially reflect enhanced item-specific encoding, relational encoding, or a combination of both processing types.

Importantly, whether JOLs encourage item-specific or relational processing likely depends upon the type of stimuli that participants study. Because previous JOL reactivity studies have extensively used cue-target word pairs, which may lend themselves to relational encoding (e.g., related cue-target pairs; see Maxwell & Huff, 2022; 2024), theories of JOL reactivity have often emphasized the role of relational encoding as a factor underlying this effect. However, JOLs may also encourage item-specific encoding, particularly when they are elicited individually on words in a list rather than when they are provided for cue-target pairs. Although word lists can similarly contain pre-existing relations (i.e., words within a list can be categorized around a specific topic or theme), how individuals process these relationships when making JOLs differs from how related cue-target pairs are processed (see Koriat, 1997). Furthermore, compared to cue-target pairs, word lists are by nature more likely to encourage item-specific encoding, as JOLs are elicited individually on an item-by-item basis, rather than for items presented in pairs in which pre-existing relations are more salient. As a result, making JOLs on individual words may be more likely to encourage item-specific rather than relational encoding.

Recent studies have explored the potential for item-level JOLs to encourage item-specific encoding of individual words. For example, Senkova and Otani (2021) reported that JOLs improved free-recall of categorized word lists and, furthermore, demonstrated that the memorial benefits of JOLs approximated benefits observed when participants used other encoding tasks which similarly emphasized item-specific processing (e.g., pleasantness ratings in Experiment 1 and an imagery task in Experiment 2). Separately, Zhao et al. (2023) found that JOLs improved recognition of uncategorized lists (which relies extensively upon item-specific processing) while simultaneously impairing temporal memory for list items (which was assessed via an order reconstruction task that is inherently relational). Thus, unlike reactivity observed with cue-target word pairs, which is thought to reflect heightened relational encoding (see Halamish & Undorf, 2023; Maxwell & Huff, 2024), there is emerging evidence that JOL reactivity observed on word lists at least partially reflects item-specific encoding.

To explain why JOLs are reactive on word recognition, Zhao et al. (2023) proposed an item-order account (see McDaniel & Bugg, 2008). Per this account, word lists contain both item-specific information regarding the individual words and relational information regarding potential list-wise relations between words. Importantly, this account proposes a dissociation between item-specific and relational information, such that tasks emphasizing one aspect impair the other. Moreover, this account makes diverging predictions regarding reactivity based on test format. Specifically, the item-order account predicts that item-by-item JOLs would produce positive reactivity on word lists, particularly when the test is sensitive to item-specific and familiarity-based cues (e.g., recognition testing; see Soderstom et al., 2015, for a similar argument regarding related cue-target pairs and cued-recall testing). However, because free-recall additionally relies upon item relations (McDaniel & Bugg, 2008; Rawson & Zamary, 2019), the item-order account predicts null reactivity when participants are tested using this method. Thus, the item-order account predicts that JOL reactivity is moderated by test type, with recognition but not free-recall showing a memorial benefit.

Finally, while previous studies suggest that JOLs encourage item-specific encoding on word lists, other evidence suggests that this effect may also reflect a relational encoding process. For example, Chang and Brainerd (2024) recently assessed reactivity for two types of JOLs: traditional item-level JOLs (i.e., JOLs elicited individually for each word within a list) and global JOLs (i.e., list-wise ratings of how likely one is to remember all previously studied items within a list). Overall, only the requirement to provide item-level JOLs improved free-recall, and these effects were moderated by list type. Specifically, item-level JOLs only improved memory for randomized categorized lists (i.e., lists containing exemplars from multiple categories that are studied in a random order). For blocked categorized lists (i.e., exemplars were organized by category), no memorial benefits were observed. By fitting their free-recall data to a dual-retrieval model, the authors estimated the contributions of recollection and familiarity to reactivity (see Brainerd, Reyna, & Howe, 2009) and concluded that positive item-level reactivity on free-recall of randomized lists was primarily tied to gist processing rather than item-specific encoding. Considered alongside findings from Zhao et al. (2023), whether item-level JOLs encourage item-specific or relational encoding likely depends upon the stimuli used (e.g., blocked vs. categorized lists) and whether the method of testing is sensitive to any item-specific or relational cues which may potentially be strengthened via JOLs.

**The Present Study**

As noted above, previous research has demonstrated that although JOLs are generally reactive on word lists, the mechanisms driving this effect likely differ based on stimuli and test type. As such, the present study further examined the roles of item-specific and relational processing underlying reactivity on word lists. First, since previous studies have reported mixed findings regarding whether JOLs are reactive on free-recall of word lists, Experiment 1A sought to replicate findings from Senkova and Otani (2021) demonstrating that JOLs produce a greater memorial benefit on categorized versus uncategorized lists when free-recall testing is used. Likewise, Experiment 1B sought to replicate findings showing that JOLs are reactive on uncategorized word lists when recognition memory is assessed (e.g., Zhao et al., 2023) and tested whether this effect extends to categorized lists. In doing so, Experiments 1A/1B provided additional tests of the item-order account, as this account makes diverging predictions regarding JOL reactivity when item memory is assessed via free-recall and recognition testing.

Next, Experiment 2 used Deese-Roediger-McDermott lists (DRM; Deese; 1959; Roediger & McDermott, 1995) to test the item-order account’s central claim that JOLs specifically encourage item-specific but not relational encoding of words. Like categorized lists, DRM lists similarly center around a specific category. However, items in DRM lists are also strongly related to a non-studied critical lure (e.g., *bed*, *rest*, *dream*, *nap*, and *pillow* are each related to the non-presented word *sleep*). At test, false memory for the critical lure is generally high, regardless of whether memory is assessed via free-recall or recognition (see Gallo, 2006). However, previous studies have found that item-specific and relational encoding tasks differentially affect the DRM illusion, with item-specific, but not relational tasks reducing the DRM illusion compared to silent reading (e.g., McCabe, Presmantes, Robertson, & Smith, 2004; Huff & Bodner, 2013; Huff & Bodner, 2019). Thus, Experiment 2 provided an additional test of the item-order account while also assessing the contributions of item-specific and relational processing to JOL reactivity.

Finally, in addition to standard, item-level JOLs (i.e., JOLs elicited item-by-item for each word within a list), each experiment also included a separate group of participants who made global, list-wise JOLs following each word list (e.g., Chang & Brainerd, 2024). Unlike item-level JOLs, the global JOL task was designed to promote relational encoding by encouraging participants to process list-wise relations (i.e., processing all list items as a single unit, rather than emphasizing each individual word as is the case with item-level JOLs). As such, the inclusion of this additional control group allowed for a comparison between JOL tasks emphasizing item-specific and relational encoding.

**Experiment 1A: Categorized versus Uncategorized Lists and Free-Recall Testing**

The goal of Experiment 1A was to replicate findings initially reported by Senkova and Otani (2021) showing that JOLs produce a greater free-recall benefit on categorized lists versus uncategorized lists. In doing so, free-recall was compared between three groups: Participants who provided concurrent JOLs for each item (item-level JOLs), participants who made a single, list-wise JOL immediately following each study list (global JOLs), and a no-JOL control group in which participants silently read each item without providing JOLs. Based on Senkova and Otani’s findings, JOLs were expected to benefit free-recall of categorized lists. However, the item-order account makes diverging predictions for item-level and global JOLs. First, this account predicts that item-level JOLs would not be reactive, as this JOL type should inhibit relational processes that facilitate free-recall. However, global JOLs would be expected to improve recall, as this task encourages participants to reflect on list-wise relations which are beneficial to recall. Thus, the inclusion of item-level and global JOL encoding groups allowed for a comparison between item-specific and relational oriented JOLs. Finally, because categorized lists contain pre-exiting relations, any benefits of global JOLs on this list type were expected to be greater than uncategorized lists.

**Method**

**Participants**

One hundred twenty-nine participants were recruited from Prolific (www.prolific.co) and were compensated at a rate of $4.00 per 20-minute session. This sample was informed by an a priori power analysis conducted with *G\*Power 3.1* (Faul, Erdfelder, Buchner, & Lang, 2009), which suggested that 111 participants would be needed to detect small-to-medium main effects/interactions (*α* = .05, 1 – *β* = .80, *d* = 0.30). However, data collection was extended to account for increased variability from online testing. Data were omitted from seven participants who failed to complete the filler task (which suggested failure to adhere to task instructions) and 9 participants with extreme recall rates (above 95% which suggested cheating or below 5% which suggested failure to attend to the study lists). This resulted in a total of 113 participants included in the final dataset (item-level JOLs, *n* = 36; global JOLs, *n* = 38; no-JOL control group, *n* = 39). All participants were native English speakers and were required to have obtained at least a high school degree or equivalent.

**Materials**

Ninety-six English words were selected to serve as stimuli. These words were split into eight 12-word lists, which were based on Van Overschelde, Rawson, and Dunlosky’s (2004) categorical word norms. Of these lists, four were categorized, such that each word was an exemplar of a given category. The four remaining lists were uncategorized and, as such, all words within the list were semantically unrelated. Uncategorized lists were created by randomly selecting words from unused categories in the Van Overschelde et al. norms (see Appendix Table A1 for lexical properties of all lists).

**Procedure**

Experiment 1A was administered online using Collector, an online platform for conducting browser-based cognitive psychology experiments (Garcia & Kornell, 2015). Following informed consent, participants were told that they would be viewing a series of words and that their memory for each word would later be tested. Participants in the two JOL groups then received additional instructions regarding their respective judgments. Specifically, participants in the item-level JOL group were instructed to rate their ability to remember each word. These JOLs elicited concurrently with study, such that JOLs were provided while each word was displayed. Separately, participants in the global JOL group were informed that following the last item in each list, they would be asked to provide a single JOL representing their ability to correctly remember the previously presented set of items on a later test. For both JOL groups, JOLs were framed as the percent likelihood of correctly remembering items and were elicited via a continuous 0-100 scale (i.e., 0 = definitely will not remember, 100 = definitely will remember). To mitigate potential anchoring effects, participants were instructed to be as accurate as possible when providing their JOLs and were encouraged to use the full range of the response scale. Participants in the no-JOL group did not receive additional judgment instructions and were instead instructed to read each pair silently

After receiving their respective encoding instructions, participants were presented with the first list. For all groups, encoding was self-paced, and participants pressed the ENTER key to advance to the next word within a list. Following the first list, participants completed a short filler task in which they were presented with a random consonant and instructed to list as many words which started with this letter as they could generate in a 30 second time span (e.g., list all words starting with the letter “M”). After the time limit had been reached, participants completed a free-recall task in which they were prompted to type as many words from memory as they could correctly recall from the previous list. Following the free-recall task, participants began the second list. This process then repeated until participants had completed all four-study lists. List presentation order was randomized for all participants, and all words were additionally randomized within lists. The full experiment took approximately 20 minutes to complete.

**Experiment 1B: Categorized versus Uncategorized Lists and Recognition Testing**

Experiment 1B provided an additional test of the item-order account by assessing whether previously reported reactivity patterns observed with recognition testing on uncategorized word lists (e.g., Zhao et al., 2023) would replicate and whether this effect would extend to categorized lists. Based on an item-order account, item-level JOLs were expected to produce positive reactivity within this context. Additionally, because JOL reactivity effects are generally positive and larger on recognition memory relative to free-recall (see Zhao et al., 2023), item-level JOLs were expected to improve recognition memory for both categorized and uncategorized lists compared to the no-JOL control group. Finally, Experiment 1B similarly included a group of participants who provided global JOLs following the presentation of each study list. However, because recognition testing is less sensitive to item relations compared to recall (Hunt & Einstein, 1981), it was unclear the extent to which global JOLs would be reactive on this test type. Thus, Experiment 1B provided an additional test of the item-order account while further exploring the effects of global JOLs on word list learning.

**Method**

**Participants**

A total of 119 undergraduate students were recruited from Midwestern State University and completed Experiment 1B online in exchange for partial course credit. Participants were randomly assigned to one of the three encoding groups described in Experiment 1A. Initial sample sizes for each group were based on Experiment 1A, and the same exclusion criteria were applied. This process removed six participants from the final dataset, leading to a total of 113 participants included in the following analyses (item-level JOLs, *n* = 37; global JOLs, *n* = 40; no-JOL control group, *n* = 36). A sensitivity analysis conducted with *G\*Power* suggested that the final sample had sufficient power to detect small-to-medium main effects/interactions (*α* = .05, 1 – *β* = .80, *d* = 0.29). All participants were native English speakers.

**Materials and Procedure**

Experiment 1B used the same stimuli and materials as Experiment 1A, with the following exceptions. First, two 48-item study lists were generated using the four categorized and four uncategorized study lists presented in Experiment 1A. Lists were constructed such that each one contained items from two categorized lists and two uncategorized lists. Participants were randomly presented with one list at encoding. Second, the four free-recall tests used in Experiment 1A were replaced with a single, 96-item old/new recognition test. This test included all 48 items from the previously studied lists, as well as the 48 items from the counterbalanced lists, which served as non-presented controls. Second, participants studied items back-to-back, rather than completing filler tasks in between lists. All other materials, including the categorized lists and the three sets of encoding instructions (item-JOL, global JOL, and silent reading), were identical to Experiment 1A.

Following the final list, participants completed a 60-second filler task in which they were tasked with generating as many words as possible for a random consonant. Immediately afterwards, participants began the recognition test, which presented them with all 96 items in a randomized order. Specifically, participants were informed that they would be viewing a series of words and were instructed to indicate whether each word had been previously studied (“old”) or had not been previously studied (“new”). Test performance was self-paced; however, participants were instructed to respond as quickly as possible without compromising their accuracy. Like Experiment 1A, Experiment 1B took approximately 20 minutes to complete.

**Results**

For all reported analyses, significance was set at *p* < .05. For all significant main effects and interaction, partial eta-squared (*ηp*2)is reported, and Cohen’s *d* effect sizes are reported for significant post-hoc comparisons. Finally, all non-significant main effects and post-hoc comparisons include a Bayesian strength estimation of the evidence supporting the null hypothesis (see Masson, 2011; Wagenmakers, 2007). This analysis compares two models, which one assume a significant effect and a null effect, respectively, and allows for the computation of a probability estimate (termed *p*BIC; Bayesian Information Criterion). Thus, *p*bics provide a probability estimate of the null hypothesis being retained, such that higher values denote greater strength of evidence in favor of the null hypothesis. Importantly, *p*BICs are sensitive to sample size, providing increased confidence in reported null effects. Finally, free-recall data collected in Experiment 1A was scored in *R* using the *lrd* package (Maxwell, Huff, & Buchanan, 2022), which provides a set of tools scoring lexical data from memory studies while correcting potential spelling errors. Figure 1 depicts changes in free-recall proportions (top panel) and hit-rates/false alarms (bottom panel) as functions of encoding group and list type. For completeness, all comparisons are reported in Appendix Table A2. Additionally, Tables A3 and A4 report mean JOLs and RTs as functions of encoding group and list type.

***Experiment 1A.*** Free-recall responses were analyzed using a 3(Encoding Group: Item-Level JOL vs. Global JOL vs. No-JOL) × 2(List Type: Categorized vs. Uncategorized) mixed-measures ANOVA. Overall, the main effect of Encoding Group was non-significant, *F*(2, 110) = 2.46, *MSE* = .04, *p* = .09, *p*bic = .90. However, a significant main effect of list-type indicated that across encoding groups, recall was higher for categorized lists versus uncategorized lists (.72 vs. 54, respectively; *F*(1, 110) = 172.70, *MSE* = .01,*p* = xx, *ηp*2 = .61). Importantly, a significant Encoding Group × Pair Type interaction confirmed the presence of a JOL reactivity pattern, *F*(2, 110) = 3.94, *MSE* = .01, *p* = xx, *ηp*2 = .07. Starting with categorized lists, providing global JOLs increased free-recall relative to the no-JOL group (.86 vs. .76; *t*(75) = 2.39, *SEM* = .03, *p* = xx, *d* = 0.57). Free-recall for the item-level JOL group, however, did not statistically differ from the no-JOL control group (.71 vs. .68) or the global JOL group, *t*s ≤ 1.58, *p*s ≥ .12, *p*BICs ≥ .71. For uncategorized lists, free-recall was highest for participants in the global JOL group (.58), followed by the no-JOL control (.55) and the item-JOL group (.48). All comparisons were non-significant (*t*s ≤ 1.67, *p*s ≥ .10, *p*BICs ≥ .87) except for the comparison between the item-JOL and no-JOL groups, *t*(73) = 2.16, *SEM* = .05, *p* = xx, *d* = 0.51. Thus the memorial benefits of global JOLs on categorized lists did not extend to uncategorized lists and providing item-JOLs resulted in a memory cost to uncategorized lists.

***Experiment 1B.*** Next, hit rates were analyzed via a 3 (Encoding Group: Item-Level JOL vs. Global JOL vs. No-JOL) × 2 (List Type: Categorized vs. Uncategorized) mixed ANOVA. First, this analysis yielded a significant main effect of Encoding Group, *F*(2, 110) = 16.39, *MSE* = .03, *p* = xx, *ηp*2 = .23, as collapsed across list types, hit rates were highest for participants in the item-level JOL group (.89), followed by the no-JOL (.73) and global JOL groups (.75). Post-hoc testing confirmed that all groups significantly differed (*t*s ≥ 4.61, *ps* ≤ xx, *d*s ≥ 1.07), except for the comparison between the no-JOL and global JOL groups, which was non-significant, *t*(74) < 1, *SEM* = .03, *p* = .45, *p*BIC = .87. Next, a significant main effect of List Type was detected *F*(1, 110) = 67.72, *MSE* = .01, *p* = xx, *ηp*2 = .14, as hit rates were higher for categorized lists versus uncategorized lists (.85 vs. .73, respectively). Finally, this analysis revealed a significant Encoding Group × List Type interaction, *F*(2, 110) = 8.23, *MSE* = .01, *p* = xx, *ηp*2 = .04. Post-hoc testing revealed that hit rates for the item-level JOL group exceeded the no-JOL group for categorized lists (.91 vs. .83) and uncategorized lists (.87 vs. .68), *t*s ≥ 2.41, *ps* ≤ xx, *d*s ≥ 0.59. Hit rates for the item-level JOL group similarly exceeded hit rates for the global JOL group for both list types (categorized lists: .91 vs. .83; uncategorized lists: .87 vs. 67; *t*s ≥ 2.65, *ps* ≤ xx, *d*s ≥ 0.64). However, no differences in hit rates were detected between the global JOL and no-JOL groups for categorized (.83 vs. .81) and uncategorized lists (.68 vs. .65), *t*s ≤ 1, *p*s ≥ .51, *p*BICs ≥ .87. Thus, the requirement to provide JOLs at encoding benefited correct recognition of items from both list types, but only when JOLs were elicited individually for each item.

Regarding false alarms (i.e., false recognition of non-presented control items), a significant difference emerged between encoding groups, *F*(2, 110) = 3.91, *MSE* = .02, *p* = xx, *ηp*2 = .07. False alarms were highest for participants in the no-JOL group (.21), followed by the global JOL group (.14) and the item-level JOL group (.11). Post-hoc testing indicated that this effect was driven by differences between the item-level and no-JOL groups, *t*(71) = 2.47, *SEM* = .04, *p* = xx, *d* = 0.61. The difference between the global and no-JOL groups was marginal, *t*(74) = 1.94, *SEM* = .04, *p* = .06, *p*BIC = .78, and no difference in false alarms was detected between the item and global JOL groups, *t*(75) < 1, *SEM* = .03, *p* = .40, *p*BIC = .86.

Finally, following the designs of Myers et al. (2020) and Maxwell and Huff (2024), signal detection analyses were used to test for differences in discriminability (*d′*) and response criterion (*c*) as functions of encoding group. Signal detection indices were computed in *R* via the *psycho* package (Makowski, 2018), which accounts for extreme scores via a log-linear correction following Hautus’s (1995) guidelines. Overall, mean *d′* differed as a function of encoding group, *F*(2, 110) = 16.32, *MSE* = 0.75, *p* = xx, *ηp*2 = .23. Mean *d′* was greatest for the item-level JOL group (2.76), followed by the global JOL group (1.98), and the no-JOL control group (1.64). All comparisons differed significantly, *t*s ≥ 3.77, *p*s≤ xx, *d*s ≥ 0.85, except for the comparison between the global and no-JOL groups, which was marginal, *t*(74) = 1.83, *SEM* = 0.19, *p* = .07, *p*BIC = .62. Next, mean *c* was greatest for participants making global JOLs (.22), followed by the item-level group (.16) and no-JOL groups (.03). This effect, however, failed to reach conventional significance, *F*(1, 110) = 2.51, *MSE* = 0.14, *p* = .09, *p*BIC = .46.

**Discussion**

Previous research has reported mixed findings regarding the reactive effects of item-level JOLs on free-recall of word lists. As such, Experiment 1A first provided a further assessment of whether item-level JOLs would improve free-recall compared to a no-JOL control group. Experiment 1B then tested whether these effects would extend to recognition testing. Additionally, both experiments included a global JOL group, who provided a single judgment for each list following study, which allowed for a comparison between JOL tasks emphasizing item-specific and relational processes. Starting with Experiment 1A, item-level JOLs did not improve free-recall, regardless of list type. This finding is consistent with previous reactivity patterns reported by Zhao et al. (2023) and is likewise in line with Chang and Brainerd’s (2024) finding that item-level JOLs did not improve free-recall of blocked categorized lists. Interestingly, item-level JOLs also produced negative reactivity on free-recall of uncategorized lists. While this finding diverges from other JOL reactivity studies utilizing word lists, negative reactivity has sometimes been reported when participants provided item-level JOLs for unrelated cue-target word pairs (e.g., Mitchum et al., 2016; see Undorf et al., 2024). Finally, global JOLs produced positive reactivity on categorized lists, as correct free-recall exceeded the no-JOL group. Thus, consistent with an item-order account, JOLs only benefited free-recall when they encouraged processing of list-wise relations, rather than item-specific encoding of individual words.

Next, Experiment 1B demonstrated that item-level JOLs improved recognition memory, regardless of whether items had been studied in categorized or uncategorized lists. This replicates previous findings by Zhao et al. (2023) who similarly reported positive reactivity on uncategorized word lists while also extending these findings to include categorized lists. Global JOLs, however, were non-reactive, regardless of list type. Finally, signal detection analyses revealed that both types of JOLs improved discriminability compared to the no-JOL group, though this effect was larger for item-level JOLs. Response criterion also improved as a function of JOLs. As such, making JOLs improved participants’ ability to discriminate between studied and non-studied items, though the increased criterion levels for JOL participants suggests that these judgments led to more biased responding. Considered alongside Experiment 1A, there is converging evidence that item-level JOL reactivity is dependent upon test format, with recognition testing, but not free-recall, being particularly sensitive to reactivity from this JOL type.

Overall, the finding that item-level JOLs improved recognition but not free-recall is consistent with an item-order account of reactivity and provides further evidence that JOLs encourage item-specific processing when elicited individually for each item in a list. Additionally, the finding that global JOLs only benefitted free-recall aligns with previous studies demonstrating that JOLs improve memory for related but not unrelated cue-target pairs (e.g., Janes et al., 2018; Soderstrom et al., 2015; Maxwell & Huff, 2022), as like JOLs elicited for cue-target word pairs, global JOLs similarly encourage processing of pre-existing relations between items, benefiting later recollection. Considered alongside findings from Experiment 1A as well as previous findings reported by Zhao et al. (2023), there is converging evidence that item-level JOL reactivity on word lists is moderated by test type, likely due to this type of JOL encouraging item-specific processing of words.

While findings from Experiments 1A and 1B suggest that item-level JOLs encourage item-specific encoding, the previous set of experiments tested this by comparing different JOL types and test formats. However, a more complete test of this account would be to compare the effects of item-level and global JOLs using stimuli that are differentially affected by item-specific and relational encoding tasks. As such, Experiment 2 replaced the categorized and uncategorized lists used previously with DRM lists. Like categorized lists, items in DRM lists are associatively related. However, in addition to containing strong list-wise relations, all items are also strongly related to a non-presented critical lure (i.e., the DRM illusion; see Deese, 1959; Roediger & McDermott, 1995). The DRM illusion is highly robust, with previous research showing that false recognition of critical lures can approximate correct recognition rates (see Gallo, 2006). Importantly, previous research has demonstrated that the DRM illusion is differentially affected by item-specific and relational encoding tasks, with item-specific but not relational tasks generally leading to a strong reduction in the DRM illusion when recognition testing is used (McCabe et al., 2004; Huff & Bodner, 2013; see Huff & Bodner, 2019). Thus, Experiment 2 tested whether reactivity patterns observed with recognition testing Experiment 1B would replicate when participants studied DRM lists while testing the effects of both item-level and global JOLs on the DRM illusion.

**Experiment 2: DRM Lists and Recognition Testing**

Experiment 2 provided an additional test of the item-order account by investigating whether item-level and global JOLs would be differentially reactive on correct and false recognition in the DRM paradigm. Based on findings from Experiment 1B, item-level JOLs were expected to improve correct recognition of studied items. Global JOLs, however, were not expected to be reactive on recognition. Regarding false memory, the item-order account predicts that item-level JOLs would reduce false recognition of critical lures, as based on this account, the requirement to provide a JOL for each item should inhibit the processing of list-wise relations. This prediction is consistent with previous research showing that tasks which encourage item-specific encoding are generally effective at reducing the DRM illusion (e.g., Burns, Jenkins, & Deans, 2007; Huff & Bodner, 2013; McCabe et al., 2004). Separately, because relational encoding tasks emphasize shared connections between list items, these tasks may additionally increase false recognition of critical lures via spreading activation (see Roediger, Balota, & Watson, 2001). Thus, the DRM illusion was expected to be greater for participants making global JOLs versus item-level JOLs.

**Method**

**Participants**

One hundred and twelve undergraduate students were recruited from Midwestern State University and completed Experiment 2 online for partial course credit. This sample size was based on the previous set of experiments, and particpants were again randomly assigned to either the item-level, global, or no-JOL encoding groups. Data screening followed the same criteria as previously reported, and data from four participants were excluded. As such, the final dataset contained responses from 108 participants (item-level JOLs, *n* = 36; global JOLs, *n* = 37; no-JOL control group, *n* = 35), and a sensitivity analysis conducted using *G\*Power* suggested that the final sample was sufficient to detect a medium effect between encoding groups (*α* = .05, 1 – *β* = .80, *d* = 0.60). As with the previous experiments, all participants were native English speakers.

**Materials and Procedure**

Twenty DRM lists were taken from Roediger, Watson, McDermott, and Gallo (2001) to serve as stimuli. These lists contained 12 associates that were additionally related to a non-presented critical lure. Within each list, words were arranged in descending order of backward associative strength (BAS) based on the University of South Florida Free Association Norms (D. L. Nelson, McEvoy, & Schreiber, 2004). Lists were then divided into two equal sets to serve as counterbalances, which were matched on BAS. An 80-item old/new recognition test was generated based on these lists and consisted of 30 previously studied items (taken from positions 2, 8, and 10 from each studied list), 10 critical lures corresponding to each studied list, 30 non-presented items taken from non-studied, counterbalanced lists, and 10 critical lure controls which corresponded to the non-studied lists. The general procedure was identical to Experiment 1B, such that participants studied all 10 lists back-to-back, with the order of list presentation randomized for each participant. All JOL instructions were identical to the previous experiments, and depending on their encoding group, participants either provided their JOLs concurrent with study, made list-wise JOLs following the completion of each list, or read each word silently. Like the previous set of experiments, encoding was self-paced for all groups. Experiment 2 took approximately 30 minutes to complete.

**Results**

**Analyses of Correct and False Recognition**

Figure 2 shows mean hit rates for studied items and false recognition of critical lures for each encoding group (see Appendix Table A4 for all comparisons including false alarms for control items). First, to test for potential JOL reactivity on correct recognition of list items, hits were analyzed via a one-way between-subjects ANOVA. This analysis yielded a significant difference between encoding groups, *F*(2, 105) = 12.44, *MSE* = .01, *ηp*2 = .19, as hits were highest for participants in the item-level JOL group (.85), followed by the global JOL (.76) and no-JOL control groups (.72) Post-hoc *t*-tests confirmed that all comparisons differed significantly (*t*s ≥ 3.33, *d*s ≥ 0.75), except for the comparison between the global JOL and no-JOL groups, which was non-significant, *t*(70) = 1.56, *SEM* = .03, *p* = .12, *p*BIC = .74.

Turning to false recognition of critical lures, a separate one-way ANOVA revealed a significant difference between encoding groups, *F*(2, 105) = 3.89, *MSE* = .06, *ηp*2 = .07, such that the DRM illusion was highest for participants making global JOLs (.76), followed by the no-JOL control group (.63), and the item-level JOL group (.62). All comparisons differed significantly (*t*s ≥ 2.39, *d*s ≥ 0.55), except for the comparison between the item-level JOL and no-JOL control groups, *t*(69) < 1, *SEM* = .06, *p* = .88, *p*BIC = .89.

**Analyses of *d′* and *c***

Following the design of Experiment 1B, signal detection analyses were used to test for changes in *d′* and *c* between encoding groups for both correct and false recognition. Starting with correct recognition, discriminability was highest for item-level JOLs (2.05), followed by global JOLs (1.71), and the no-JOL group (1.65). Although this pattern failed to reach conventional significance, *F*(2, 105) = 2.74, *MSE* = 0.61, *p* = .07, *p*BIC = .40, a set of post-hoc analyses revealed a significant difference in discriminability between the item-level and no-JOL groups, *t*(69) = 2.08, *SEM* = 0.20, *d* = 0.49. The comparison between the global and no-JOL groups, however, was non-significant, *t*(70) < 1, *SEM* = 0.19, *p* = 0.73, *p*BIC = .89, and the comparison between the item-level JOL and global JOL groups was marginal, *t*(71) = 1.99, *SEM* = 0.17, *p* = .05, *p*BIC = .55. Separately, response criterion differed between encoding groups, *F*(2, 105) = 6.59, *MSE* = .15, *ηp*2 = .11. Mean *c* was greatest for participants in the no-JOL group (.23), followed by global JOLs (.11) and item-level JOLs (-.10). All comparisons differed significantly (*t*s ≥ 3.65, *d*s ≥ 0.51), except for the comparison between the global JOL and no-JOL groups, *t*(70) = 1.42, *SEM* = .09, *p* = .16, *p*BIC = .75.

Regarding false recognition, *d′* was numerically highest for the global JOL group (1.35), followed by the item-level (1.04) and no-JOL groups (1.04). Differences between encoding groups, however, were non-significant, *F*(2, 105) = 1.92, *MSE* = 0.62, *p* = .15, *p*BIC = .94. Similarly, no significant difference in *c* emerged between groups (item-level JOL = .18, global JOL = -.04, no-JOL = .16; *F*(2, 105) = 2.24, *MSE* = .26, *p* = .11, *p*BIC = .92.).

**Discussion**

Overall, findings from Experiment 2 are clear. Consistent with both Experiment 1B and the item-order account, the requirement to provide item-level but not global JOLs at study improved correct recognition compared to participants in the no-JOL control group. Furthermore, global JOLs were non-reactive on correct recognition, additionally replicating Experiment 1B. Signal detection analyses similarly revealed that discriminability was greater for particpants in the item-JOL group compared to the no-JOL control group. Regarding false recognition, making global but not item-level JOLs increased recognition of critical lures. Thus, a dissociation emerged between JOL tasks and recognition types, providing further evidence that item-level and global JOLs encourage separate types of processing. Taken together, these findings provide further evidence that JOL reactivity on word lists reflects an item-specific rather than a relational process, as only the JOL task emphasizing item-specific encoding benefited correct recognition.

**General Discussion**

The present study investigated whether JOL reactivity on word lists reflects the contributions of item-specific and relational encoding strategies. In doing so, each experiment provided additional tests of the item-order account by assessing whether JOL reactivity patterns previously reported on word lists would replicate when memory was assessed via free-recall (Experiment 1A) and recognition testing (Experiments 1B and 2) and whether recognition patterns reported on categorized/uncategorized word lists would extend to DRM lists (Experiment 2). Additionally, each experiment included a separate group of participants who made global JOLs following each list, which allowed for a comparison between JOL tasks which differentially emphasized item-specific and relational encoding of list items. As such, this allowed for a direct test of the item-order account’s claim that JOL reactivity on word lists is specifically driven by item-specific processes.

Consistent with an item-order account, Experiment 1A found no evidence that item-level JOLs are reactive when memory is assessed via free-recall testing. However, global JOLs, which emphasize relational encoding of list items, produced positive reactivity on categorized lists in which all items contained pre-existing list-wise relations. Importantly, Experiment 1B found that when recognition testing was used instead of free-recall, the inverse pattern was observed, such that item-level JOLs improved recognition for all list types while global JOLs were non-reactive. Thus, Experiments 1A and 1B demonstrated a dissociation between JOL type and test format. While the finding in Experiment 1A that JOLs were non-reactive on free-recall contrasts with previous work by Senkova and Otani (2021), this null reactivity patten is consistent with previous findings reported by Zhao et al. (2023). Similarly, studies investigating JOL reactivity with cue-target word pairs have similarly demonstrated that reactivity is moderated by test type, with item-JOLs being reactive when memory is assessed via cued-recall and recognition but not free-recall testing (Myers et al., 2020). As such, findings from Experiments 1A/1B further support the item-order account’s claim that item-level JOL reactivity reflects enhanced item-specific encoding of list items.

Next, Experiment 2 replicated reactivity patterns observed in Experiment 1B as again item-level but not global JOLs were reactive on correct recognition. Importantly, because participants in Experiment 2 studied DRM lists, this experiment also tested whether each JOL task differentially affected false recognition of critical lures. Because the DRM illusion on recognition memory is differentially affected by item-specific and relational encoding tasks (Huff & Bodner, 2013), the use of DRM lists provided an additional test of whether item-level and global JOLs encourage item-specific and relational encoding. Consistent with Experiment 1B, making item-level JOLs improved recognition of studied items and, again, this positive reactivity effect did not extend to global JOLs. However, only the requirement to provide global JOLs increased the DRM illusion. Thus, compared to item-level JOLs, the relational nature of the global JOL task facilitated activation of the critical lure (see Roediger et al. 2001), leading to increased false recognition at test relative to item-level JOLs.

Overall, the finding that item-level JOLs improved correct recognition but not free-recall is consistent with prior research suggesting that JOLs encourage item-specific encoding of word list items (e.g., Zhao et al., 2023). [EXPAND THIS OUT]

Separately, this finding is also in-line with studies showing that JOLs are similarly reactive on recognition of cue-target word pairs. For example, Maxwell and Huff (in press) recently demonstrated that while JOL reactivity is moderated by pre-existing relations when cued-recall testing was used, JOLs improved recognition of all studied word pairs, regardless of pre-existing cue-target relations. They reasoned that the requirement to provide JOLs at encoding encourages processing of both relational information and item-specific cues regarding an item’s familiarity, both of which benefit memory (i.e., cue-strengthening; Soderstrom et al., 2015; see also Koriat, 1997). However, because recognition testing is more sensitive to familiarity cues rather than relational cues (see Koriat & Goldsmith, 1996; Yonelinas, 2002), item-specific processing is more beneficial to this test type than relational encoding. Findings from the present study further support this account, as global JOLs, which place more emphasis on relational encoding, were non-reactive when recognition testing was used.

While the present study provides further evidence that item-level JOL reactivity on word lists reflects item-specific processing, it should be noted that these JOLs likely also encourage relational encoding, albeit to a lesser extent than global JOLs. For example, Chang and Brainerd (2024) recently reported that item-level JOLs were reactive on free-recall of categorized word lists, but only when items were studied in randomized lists (i.e., lists contained exemplars for multiple categories and exemplars were presented randomly). For blocked categorized lists (i.e., lists in which exemplars of a category are presented sequentially), JOLs were non-reactive on free-recall. By fitting free-recall responses to a dual-retrieval model, the authors concluded that the memorial benefits of item-level JOLs on free-recall of randomized lists reflected increased gist processing rather than item-specific processing. However, these findings are consistent with Experiment 1A, which similarly found that item-level JOLs were non-reactive on free-recall of blocked categorized lists. Separately, research investigating JOL reactivity with cue-target pairs has similarly demonstrated that reactivity reflects a relational process when recollective based-testing is used, as item-level JOLs benefit recall of related but not unrelated word pairs (e.g., Janes et al., 2018; Soderstrom et al., 2015) and that these memory benefits approximate benefits observed using other encoding tasks which encourage relational encoding (e.g., frequency of co-occurrence judgments, judgments of associative memory; Maxwell & Huff, 2022). Taken together, whether item-level JOLs ultimately encourage item-specific or relational encoding appears to be strongly dependent on both the type of stimuli participants study and the method of testing by which memory is assessed.

Moreover, although the item-level and global JOL tasks were each designed to facilitate one specific type of processing over the other, it is unlikely that either JOL task was truly process pure (see Huff & Bodner, 2019). For example, when participants are instructed to apply item-specific while studying related word lists (e.g., categorized lists, DRM lists), they are likely to also engage in some relational encoding. This is because related word lists typically encourage relational encoding of items, regardless of the specific encoding task being applied (Hunt & Seta, 1984). As such, when participants provide item-level JOLs on categorized lists, the nature of the list encourages relational encoding, in addition to item-specific encoding being afforded by JOLs. This issue may be particularly relevant in Experiment 2, as although item-level JOLs did not increase false recognition of critical lures, this JOL type also did not lead to the expected reductions in the DRM illusion compared to the no-JOL control group.

Finally, given the benefits of item-level JOLs on recognition testing that were observed in the present study and similar benefits reported with cue-target word pairs (e.g. Maxwell & Huff, in press; Myers et al., 2020), future research may wish to explore whether this effect extends to educationally relevant stimuli. Although previous research has found that JOLs are non-reactive when particpants study general knowledge facts (Schäfer & Undorf, in press) and text passages (Ariel, Karpicke, Witherby, & Tauber, 2021), these studies have assessed memory using recall testing, rather than recognition. As previously noted, recall and recognition test types differentially emphasize familiarity cues, such that recognition testing is generally more sensitive to familiarity. Thus, if item-level JOLs consistently enhance familiarity through item-specific encoding, these judgments would be expected to improve memory for educational materials, so long as memory is later assessed using recognition-based approaches. Ultimately, however, more research is needed to fully explore the extent to which item-level JOLs can improve memory within applied contexts.

**Conclusion**

In summary, the present study further evaluates JOL reactivity on word lists. By comparing between item-level and global JOLs, which differentially emphasize item-specific and relational encoding, each experiment tested recent work suggesting that JOL reactivity observed with word lists primarily reflects enhanced item-specific encoding. In doing so, the present study provides further support for an item-order account of JOL reactivity, as item-level JOLs were reactive on recognition but not free-recall testing. Thus, the present study provides further evidence that item-level JOLs encourage item-specific encoding when these judgments are provided individually for study list items. Separately, when the JOL tasks was reframed to encourage relational encoding, memory was only influenced when list items contained pre-existing relations (e.g., categorized lists, the DRM illusion). Taken together, this set of experiments demonstrates that while JOLs are likely to encourage item-specific encoding, both the potential memorial benefits of JOLs and the processes driving reactivity are likely determined by the stimuli participants study and the method of testing.

**Declarations**

**Open Practices Statement**

Study materials, data files, and *R* code used for analyses have been made available via OSF (https://osf.io/t453a/).

**Compliance with Ethical Practices**

The reported studies were approved by the Institutional Review Board at Midwestern State University (Protocol #24022005). All participants provided informed consent prior to participating in the experiments. The author reports no conflicts of interest.

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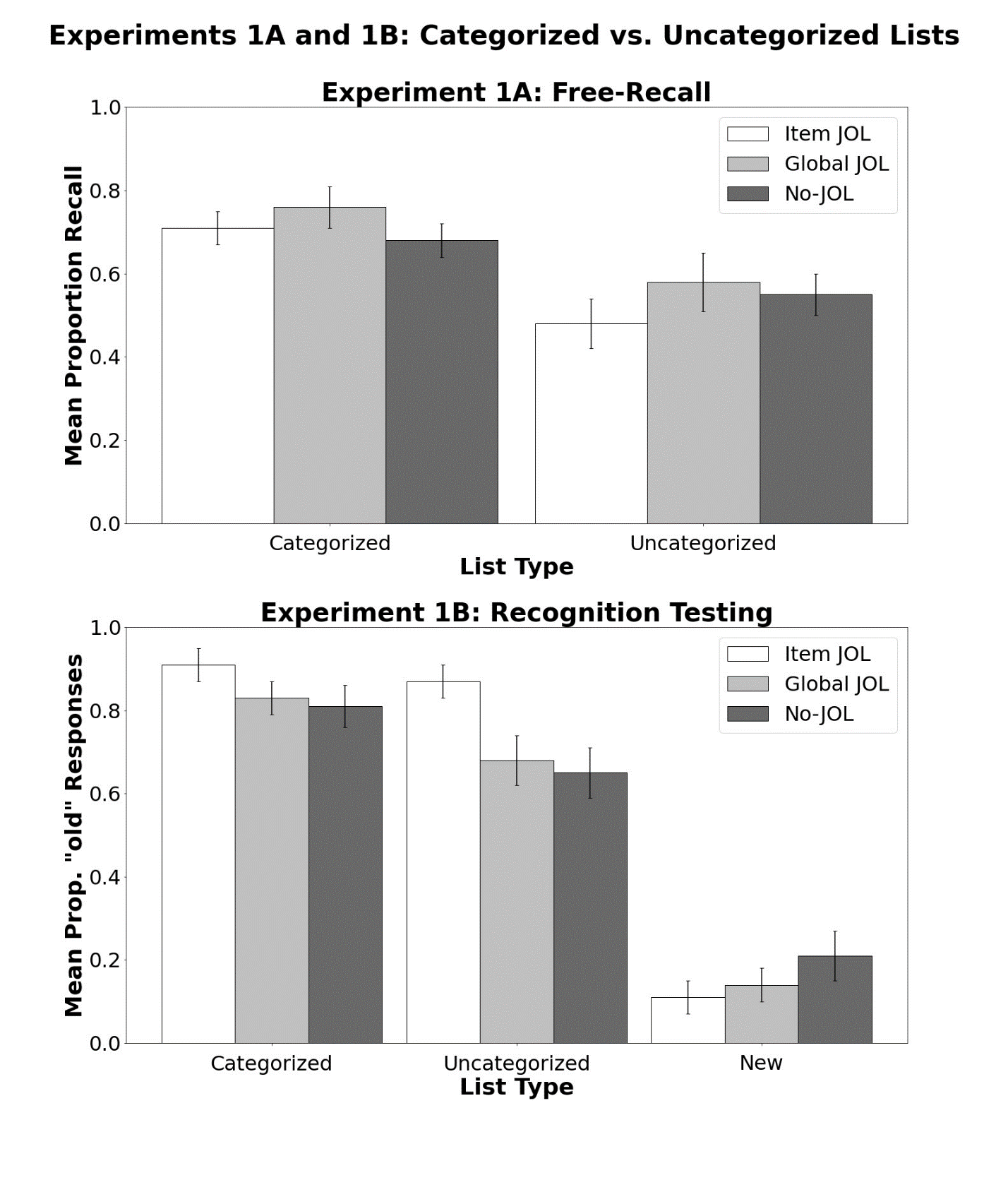
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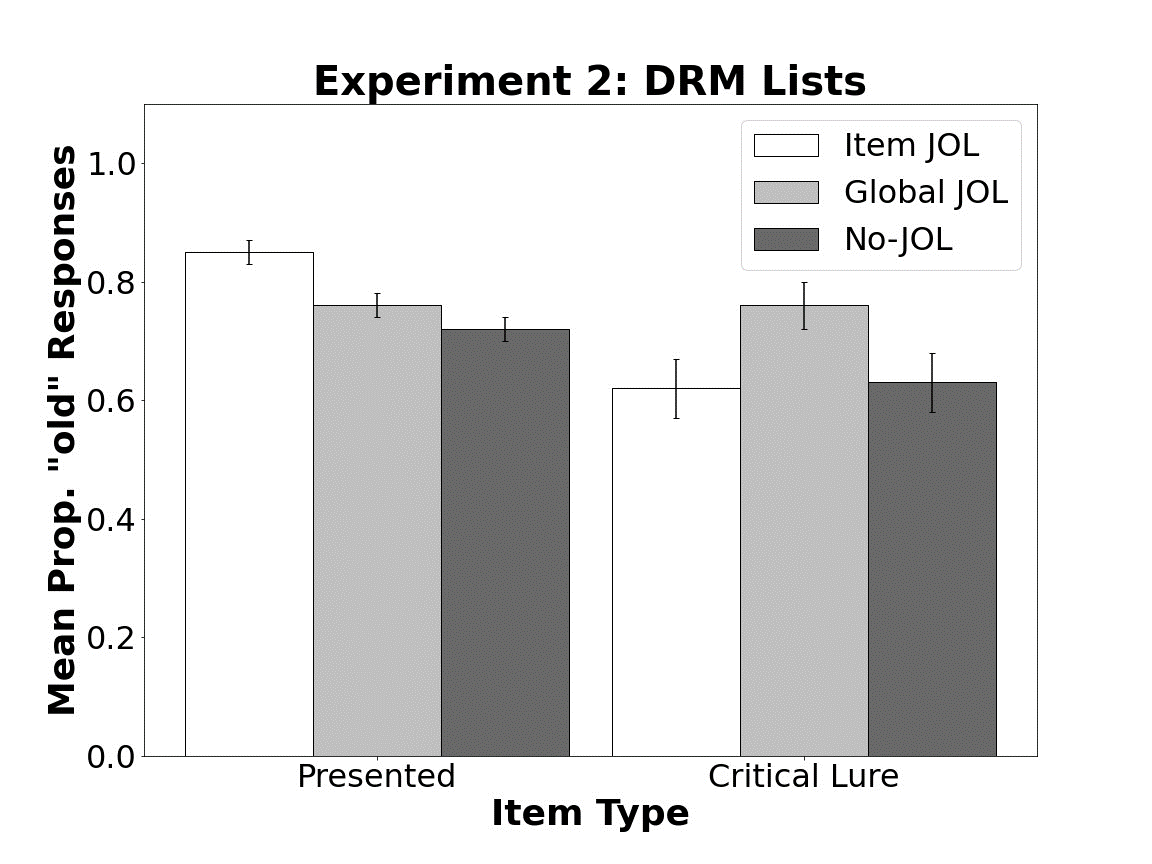
Table 1.

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[PREDICTIONS TABLE]



*Figure 1*. Mean proportion of correct free-recall in Experiment 1A (top panel) and mean proportion of “old” responses in Experiment 1B (bottom panel). “New” columns indicate “old” responses to distractor items. Bars indicate 95% *CI*s.



*Figure 2.* Mean proportion of “old” responses to presented items and critical lures in Experiment 2. Bars indicate 95% *CI*s.

**Appendix**

Table A1

*Lexical Properties of Categorized and Uncategorized Lists in Experiments 1A and 1B.*

|  |  |  |  |
| --- | --- | --- | --- |
| List Type | Variable | *M* | *SD* |
| Categorized | Concreteness | 6.17 | 0.43 |
|  | Length | 5.50 | 1.58 |
|  | Frequency | 2.97 | 0.57 |
| Uncategorized | Concreteness | 5.64 | 0.80 |
|  | Length | 4.97 | 1.27 |
|  | Frequency | 2.88 | 0.70 |

*Note*: Frequency ratings were derived from SUBLTEX (Brysbaert & New, 2009). Concreteness ratings were taken from D. L. Nelson et al. (2004). Values are collapsed across individual study lists for each list type. The full stimuli set has been made available at https://osf.io/4tgj6.

Table A2

*Comparison of Mean Recall Proportions in Experiment 1A and Hit Rates in Experiment 1B for each Encoding Group as Functions of List Type.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Experiment | Encoding Task | List Type | *M* | *± 95% CI* | U |
| Ex. 1A | Item JOL | Categorized | .71 | .04 |  |
|  |  | Uncategorized | .48 | .06 | 1.46\* |
|  | Global JOL | Categorized | .76 | .05 |  |
|  |  | Uncategorized | .58 | .07 | 0.99\* |
|  | No-JOL | Categorized | .68 | .04 |  |
|  |  | Uncategorized | .55 | .05 | 0.86\* |
| Ex 1B. | Item JOL | Categorized | .91 | .04 |  |
|  |  | Uncategorized | .87 | .04 | 0.31 |
|  | Global JOL | Categorized | .83 | .04 |  |
|  |  | Uncategorized | .68 | .06 | 0.92\* |
|  | No-JOL | Categorized | .81 | .05 |  |
|  |  | Uncategorized | .65 | .06 | 1.03\* |

*Notes*: Right-most column denotes Cohen’s *d* effect sizes for post-hoc comparisons. \* = *p* < .05. U = Uncategorized lists. Means for Experiment 1A denote proportion of correct recall. Means for Experiment 1B denote hit rates.

Table A3

[RT TABLE]

Table A4

*Comparison of Mean Hit Rates, False Alarms, and signal detection indices in Experiment 2 for each Encoding Group as Functions of Item Type.*

|  |  |  |  |
| --- | --- | --- | --- |
| Item Type | Item JOL | Global JOL | No JOL |
| List Items | .85 (.02) | .76 (.02) | .72 (.02) |
| List Item Controls | .20 (.03) | .20 (.03) | .18 (.04) |
| Critical Items | .62 (.04) | .76 (.04) | .63 (.05) |
| Critical Item Controls | .25 (.04) | .27 (.03) | .25 (.03) |

*Note*: Parentheses indicate 95% CIs.