The Reactivity Effect of Judgments of Learning on False Memory

Authors: Zhao Wenbo, Cao Yuqi, Xu Muzi, 杨春亮, Luo Liang, Yang Chunliang, Luo Liang

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Abstract

Based on the DRM paradigm, the present study conducted three experiments to investigate the reactivity effects of judgments of learning (JOL) on false memory and to test the item-specific and relational processing framework. The results revealed that: (1) Compared to the no-JOL condition, item-by-item JOL facilitated true memory for studied words, while simultaneously disrupting inter-item semantic relational processing, thereby reducing false memory (Experiment 1); (2) After manipulating JOL type and list presentation format, global JOL promoted item-specific processing and intra-item semantic relational processing (Experiment 2), but disrupted inter-item semantic relational processing (Experiment 3). These findings demonstrate a double dissociation between the reactivity effects on true and false memory, support the item-specific and relational processing framework's account of reactivity effects, and reveal that the underlying mechanisms of reactivity effects differ across memory components. The results may provide scientific reference for reducing false memory.

Full Text

Reactivity Effect of Judgments of Learning on False Memory

ZHAO Wenbo[1],[2], CAO Yuqi[1], XU Muzi[1], YANG Chunliang[1], LUO Liang[1],[3]

[1]Beijing Key Laboratory of Applied Experimental Psychology, National Demonstration Center for Experimental Psychology Education (Beijing Normal University), Institute of Developmental Psychology, Beijing Normal University, Beijing 100875, China
[2]School of Sociology, Beijing Normal University, Beijing 100875, China

[3]State Key Laboratory of Cognitive Neuroscience and Learning, Faculty of Psychology, Beijing Normal University, Beijing 100875, China

Based on the DRM paradigm, this study conducted three experiments to examine the reactivity effects of judgments of learning (JOL) on false memory and to test the item-specific and relational account. The results revealed that: (1) Compared with the no-JOL condition, item-by-item JOL enhanced veridical memory for studied words while simultaneously disrupting semantic relational processing among items, thereby reducing false memory (Experiment 1); (2) After manipulating JOL type and word list presentation format, global JOL promoted processing of item-specific and intra-item semantic relations (Experiment 2) but disrupted inter-item semantic relational processing (Experiment 3). These findings demonstrate a double dissociation in the reactivity effects on veridical and false memory, supporting the item-specific and relational account's explanation of reactivity effects and revealing that different memory components exhibit distinct underlying mechanisms. The results provide a scientific reference for reducing false memory.

Abstract

Judgments of learning (JOLs) refer to learners' predictive evaluations of the likelihood that they will successfully remember a given item in a future test. Previous studies have primarily focused on examining the accuracy of JOLs and elucidating the mechanisms underlying JOL formation. However, recent studies suggest that the act of making JOLs can alter memory itself, a phenomenon known as the reactivity effect. Typically, participants made a JOL after learning each item. This metamemory monitoring process may heighten individuals' metacognitive awareness of their memory compared to conditions without JOLs, thereby triggering the reactivity effect. Zhao et al. (2023) further differentiated the reactivity effects of JOLs on item-specific memory and inter-item relational memory. They found that making JOLs can enhance item-specific memory but concurrently weaken inter-item relational memory (e.g., memory for serial order or semantic relational information). A potential explanation for this is the item-specific and relational account, which posits that making JOLs enhances encoding of item-specific details, resulting in a positive reactivity effect. However, because cognitive resources are limited, allocating more cognitive resources to processing item-specific details reduces resources available for processing inter-item relations, leading to a negative reactivity effect on inter-item relational memory. The current study employed the DRM paradigm to investigate the reactivity effect on false memory and to test the item-specific and relational account.

Experiment 1 explored the reactivity effects of JOLs on false and veridical memory. Sixty-four participants learned DRM word lists, each containing 11 DRM study words and 1 critical lure. Critical lures were withheld during the learning phase and presented only during the recognition test. Half of the DRM word lists were studied under the JOL condition, and the remaining half were learned under the no-JOL condition. Participants were instructed to learn each DRM word individually. The key distinction between the JOL and no-JOL conditions was that, in the former, participants completed item-by-item JOLs while learning each word. After the learning task, participants completed a distractor task, followed by a recognition test. The results showed that item-by-item JOLs disrupted semantic processing among DRM words and decreased false memory (i.e., false alarm rates for critical lures). Concurrently, item-by-item JOLs facilitated item-specific processing, yielding a positive reactivity effect on memory for studied words.

Experiments 2 and 3 changed the presentation format of DRM lists and asked participants to make global JOLs for a whole word list, rather than for each word, to examine the reactivity effect on both intra- and inter-item relational memory. Experiment 2 used pure DRM lists, with six words from the same thematic word lists presented together. Experiment 3 employed mixed DRM lists, with each list containing six study words from different thematic word lists but with shared thematic relationships across lists. In the no-JOL condition, DRM words were not presented individually. Instead, pure (Experiment 2) or mixed word lists (Experiment 3) were simultaneously displayed on screen for a 12 s study duration per list. Participants in both experiments provided global JOLs for each list, predicting the number of words they would remember in the subsequent test. The results showed that making global JOLs facilitated processing of intra-item semantic relations but disrupted processing of inter-item semantic relations.

In summary, the current study revealed that item-by-item JOLs disrupt semantic relational processing among individual DRM words, reducing false memory but promoting processing of item-specific information, thereby facilitating recognition of studied words. Additionally, global JOLs enhance intra-item semantic relational processing but impair inter-item semantic relational processing. The results support the item-specific and relational account and elucidate the cognitive mechanisms underlying the reactivity effect. Moreover, these findings offer valuable insights into the development of effective interventions for mitigating false memory.

Keywords: judgments of learning, reactivity effect, DRM paradigm, item-specific and relational account

Experiment 1

For critical lure false alarm rates, a paired-samples t-test revealed that the JOL condition (M = 0.67, SD = 0.24) exhibited significantly lower false alarm rates for critical lures compared to the no-JOL condition (M = 0.76, SD = 0.20), difference = -0.09, 95% CI [-0.15, -0.03], t(63) = -2.94, p = 0.005, Cohen's d = -0.37 (see Figure 2A, right panel). This result indicates that making JOLs during learning disrupted participants' encoding of semantic relations among DRM words, thereby reducing the generation of false memories for critical lures.

As shown in Figure 2B, 36 participants exhibited negative reactivity effects of JOL on false memory, while only 15 participants showed positive reactivity effects, and 13 participants showed no reactivity effect.

For the discriminability index (d') of critical lures, the JOL condition ($M = 1.62$, $SD = 1.04$) also demonstrated significantly lower discriminability compared to the no-JOL condition ($M = 1.99$, $SD = 1.04$), difference = -0.37, 95% CI [-0.63, -0.11], $t(63) = -2.88$, $p = 0.005$, Cohen's $d = -0.36$. This result further indicates that compared to the no-JOL condition, participants in the JOL condition had greater difficulty distinguishing critical lures from studied DRM words, exhibiting reduced false memory.

A 2 (learning condition: JOL vs. no-JOL) × 2 (memory type: veridical vs. false memory) repeated-measures ANOVA was conducted with memory performance (hit or false alarm rates) as the dependent variable. Results showed no significant main effect of learning condition, $F(1, 63) = 0.90$, $p = 0.347$, $p^2 = 0.01$. The main effect of memory type was significant, $F(1, 63) = 17.10$, $p < 0.001$, $p^2 = 0.21$, with false memory performance significantly lower than veridical memory. The interaction between learning condition and memory type was significant, $F(1, 63) = 49.32$, $p < 0.001$, $p^2 = 0.44$.

Experiment 1, using the DRM paradigm, found that item-by-item JOLs effectively inhibited the generation of false memory, demonstrating a negative reactivity effect on false memory. Additionally, consistent with previous findings, item-by-item JOLs promoted item-specific memory processing, thereby improving recognition hit rates for studied words. Experiment 1 replicated Zhao and Yin et al.'s (2023) findings regarding the reactivity effect on false memory, demonstrating that JOLs have a disruptive effect on semantic relations among DRM words. This disruptive effect is not limited to semantic categorical relations among studied words but also exists in the DRM false memory paradigm. These results provide further support for the item-specific and relational account, showing that making JOLs enhances item-specific memory while simultaneously disrupting inter-item relational memory.

Experiment 2: Global JOL Reactivity Effects on False Memory with Pure Lists

As previously noted, the item-specific and relational account further distinguishes between intra-item and inter-item semantic relational memory, predicting that JOLs produce different reactivity effects on these two types of memory (Mulligan & Peterson, 2015; Peterson & Mulligan, 2013). To test this theoretical prediction, Experiment 2 required participants to make global memory predictions for entire DRM pure word lists, examining the reactivity effect on intra-item semantic relational memory. All words within each DRM pure word list shared common semantic or thematic relations, indicating strong intra-list semantic relations. Different lists had no semantic relations between them, meaning no inter-list semantic relations existed. According to the item-specific and relational account, we predicted that global JOLs would promote processing of intra-item semantic relations within DRM pure lists, thereby facilitating false memory generation.

Method

Participants. Based on a statistical power analysis using pre-experiment results (Cohen's d = 0.39), at least 54 participants were required to detect a significant reactivity effect on false memory with statistical power of 0.80 (two-tailed test, $\alpha = 0.05$). Experiment 2 recruited 55 university students (12 males) with a mean age of 20.35 years (SD = 3.09), all with normal or corrected-to-normal vision. All participants completed the experiment individually in a soundproof laboratory and received compensation upon completion.

Materials. To increase the number of critical lures per learning condition, Experiment 2 made the following adjustments to the experimental materials: First, we increased the number of DRM lists for both JOL and no-JOL conditions. The 24 DRM word lists from Experiment 1 were used as the learning set (i.e., as studied words and old items in the recognition test), and 120 new words were selected from the Cai and Brysbaert (2010) Chinese word database as the control set (i.e., as new items in the recognition test). Within the control set, 48 words served as control new words for critical lures, and the remaining 72 words served as control new words for studied words. Word frequency and stroke count did not differ significantly between new words and studied words or critical lures (ps > .50). Second, unlike Experiment 1, Experiment 2 selected the first two words from each DRM list as critical lures (i.e., words ranked 1 and 2 in each DRM list), with the subsequent six words as study words (i.e., words ranked 3-8), and the final four words were excluded (i.e., words ranked 9-12 were removed). In other words, each DRM list in Experiment 2 consisted of eight words, with the first two serving as critical lures that were not presented during the learning phase and only appeared during the test phase, and the remaining six study words presented during the learning phase.

In summary, participants in Experiment 2 studied two sets of word lists under both JOL and no-JOL learning conditions, with each set containing six DRM lists and each DRM list containing six study words. During the recognition test phase, participants made old/new judgments on 240 words, including 72 studied words (i.e., words ranked 3, 5, and 7 from each DRM list), 48 critical lures from studied DRM lists (i.e., words ranked 1 and 2 from each DRM list), 48 matched control new words for critical lures, and 72 matched control new words for unstudied items.

Design. Experiment 2 employed a single-factor within-subjects design (learning condition: global JOL vs. no-JOL). The dependent variables were recognition hit rates and discriminability (d') for studied words, and false alarm rates and discriminability (d') for critical lures.

Procedure. Similar to Experiment 1, Experiment 2 consisted of a learning phase, distractor task, and old/new recognition test phase (see Figure 3 [Figure 3: see original paper]). Unlike Experiment 1, during the learning phase in Experiment 2, all words from each DRM list (i.e., six words) were presented simultaneously on the screen in a vertical arrangement. Participants studied each list for 12 s per list. The six words in each list were arranged in descending order of their associative strength to the critical lure. Additionally, unlike Experiment 1's item-by-item JOLs, Experiment 2 required participants to make global JOLs for each list. Specifically, in the global JOL condition, after studying each list for 6 s, a memory prediction slider appeared below the word list, and participants predicted how many words from that list they would successfully remember in the subsequent test (0% indicated remembering none; 100% indicated remembering all). Participants moved the mouse to the desired position and clicked to complete the prediction. If participants did not make a prediction during the final 6 s, a pop-up window appeared prompting them to complete the memory prediction for the upcoming list. If participants completed the prediction before the study time ended, the slider and word list remained on screen until the 12 s study duration elapsed. In the no-JOL condition, only the DRM word list (six words) was presented vertically on screen for 12 s, and participants did not make global JOLs. Except for these differences in the learning phase, the distractor task and old/new recognition test were identical to Experiment 1.

A pilot experiment for Experiment 2 used the same materials as Experiment 1, with each DRM list containing 11 study words and 1 critical lure. The pilot procedure was identical to Experiment 2, with the only difference being the number of study words presented on screen during the learning phase. When 11 study words were presented simultaneously, the salience of semantic relatedness cues between words was too strong, resulting in ceiling effects for critical lure false alarm rates in both JOL and no-JOL conditions. Therefore, to reduce ceiling effects for false memory, Experiment 2 decreased the number of words per DRM list and increased the number of critical lures.

Results

Veridical Memory. For recognition hit rates of studied words, a paired-samples t-test revealed that the global JOL condition (M = 0.70, SD = 0.15) produced significantly higher hit rates compared to the no-JOL condition (M = 0.64, SD = 0.21), difference = 0.06, 95% CI [0.01, 0.11], t(54) = 2.60, p = 0.012, Cohen's d = 0.35 (see Figure 4 [Figure 4: see original paper]A, left panel), indicating that global JOLs facilitated item-specific memory (i.e., a positive reactivity effect on item-specific memory). As shown in Figure 4B, 30 participants exhibited positive reactivity effects on studied word recognition, 18 showed negative effects, and 7 showed no effect.

For the discriminability index (d') of studied words, global JOLs (M = 1.87, SD = 0.63) also produced significantly higher discriminability compared to the no-JOL condition (M = 1.69, SD = 0.77), difference = 0.19, 95% CI [0.03, 0.34], t(54) = 2.41, p = 0.019, Cohen's d = 0.33. These results indicate that global

JOLs enhanced recognition performance for studied words, demonstrating a positive reactivity effect on veridical memory, consistent with Experiment 1's findings.

False Memory. Critically, for critical lure false alarm rates, a paired-samples t-test revealed that the global JOL condition ($M = 0.41$, $SD = 0.18$) exhibited significantly lower false alarm rates compared to the no-JOL condition ($M = 0.46$, $SD = 0.19$), difference = -0.05, 95% CI [-0.09, -0.01], $t(48) = -2.57$, $p = 0.013$, Cohen's $d = -0.37$ (see Figure 6A, right panel). As shown in Figure 6B, 28 participants exhibited negative reactivity effects on critical lure false alarm rates, while only 17 showed positive effects, and 4 showed no effect.

For the discriminability index (d') of critical lures, global JOLs ($M = 0.39$, $SD = 0.43$) also produced significantly lower discriminability compared to the no-JOL condition ($M = 0.53$, $SD = 0.49$), difference = -0.15, 95% CI [-0.26, -0.03], $t(48) = -2.55$, $p = 0.014$, Cohen's $d = -0.36$. The results for critical lure false alarm rates and discriminability (d') indicate that when DRM lists were presented as pure lists, global JOLs disrupted semantic relational processing among words across lists, thereby reducing false memory and again demonstrating a negative reactivity effect on false memory.

Experiment 3

A 2 (learning condition: global JOL vs. no-JOL) × 2 (memory type: veridical vs. false memory) repeated-measures ANOVA was conducted with memory performance (hit or false alarm rates) as the dependent variable. Results showed no significant main effect of learning condition, $F(1, 48) = 3.29$, $p = 0.076$, $p^2 = 0.06$. The main effect of memory type was significant, $F(1, 48) = 79.06$, $p < 0.001$, $p^2 = 0.62$, with false memory performance significantly lower than veridical memory. The interaction between learning condition and memory type was not significant, $F(1, 48) = 2.20$, $p = 0.15$, $p^2 = 0.04$.

Experiment 3 used mixed lists and found that global JOLs had a disruptive effect on false memory, consistent with Experiment 1's findings. However, unlike the previous two experiments, the processing advantage for list-specific memory disappeared (no positive reactivity effect was observed for studied words in either recognition hit rates or discriminability d'). A possible explanation for this result is that mixed lists comprised multiple unrelated sub-items (i.e., six unrelated words). The facilitative effect of global JOLs on list-specific memory may have been distributed across these sub-items, thereby diminishing the enhancement for any single sub-item and resulting in the absence of a positive reactivity effect on item-specific memory in Experiment 3.

General Discussion

This study investigated the reactivity effects of JOLs on false memory and their underlying mechanisms using the DRM paradigm, providing further support for the item-specific and relational account. Experiment 1 employed item-by-item JOLs and initially revealed that making JOLs during learning disrupted participants' processing of semantic relations among DRM words, thereby reducing false memory, while simultaneously promoting processing of DRM word features and improving item-specific veridical memory. In summary, JOLs produced a double dissociation between reactivity effects on item-specific memory (i.e., veridical memory for studied words) and inter-item relational memory (i.e., false memory for critical lures), supporting the item-specific and relational account.

To further test the theoretical predictions of the item-specific and relational account regarding intra-item and inter-item semantic relational processing, Experiments 2 and 3 manipulated DRM list presentation format (pure vs. mixed lists) and JOL type (global JOL) to successfully dissociate the reactivity effects of JOLs on item-specific memory, intra-item semantic relational memory, and inter-item semantic relational memory. Experiment 2 used global JOLs with DRM pure lists (i.e., lists with internal semantic relations) and found that global JOLs facilitated item-specific memory while enhancing intra-list semantic relational processing, thereby promoting false memory. To verify the stability of Experiment 1's results, Experiment 3 presented DRM lists in mixed format, where words within each list had no semantic associations but words in the same positions across lists shared thematic relationships. The results showed that global JOLs also had a disruptive effect on inter-item semantic relational memory (i.e., semantic relations across mixed lists), again supporting the item-specific and relational account.

Theoretical Implications

These results have been replicated in studies examining distinctiveness processing. For example, McCabe and Smith (2006), using the DRM paradigm, found that generation—作为一种独特性编码方式—enhanced veridical memory for studied words while simultaneously reducing false memory. In their study, participants in the generation condition heard words played backward (e.g., "tch-wa") and had to convert them to standard word forms (e.g., "watch"), whereas control participants simply wrote down normally pronounced words (e.g., "table"). Results showed that, compared to the control group, the generation group exhibited higher correct hit rates for studied words and lower false alarm rates for critical lures, demonstrating a mirror effect (Hunt et al., 2011; Starns et al., 2006). From a distinctiveness processing perspective, McCabe and Smith (2006) proposed that the mirror effect occurred because generative learning promoted item-specific distinctiveness processing. However, due to the limited nature of cognitive resources, this generative processing simultaneously disrupted semantic relational processing among DRM words, which is the key mechanism underlying false memory generation. Therefore, although generative learning enhanced veridical memory for studied words, it concurrently reduced false memory (Brainerd & Reyna, 2002; Roediger et al., 2001).

Extensive research has demonstrated that distinctiveness processing is a crucial mechanism for enhancing item-specific memory, which can be further divided into task distinctiveness and item distinctiveness (Hunt, 2006). Task distinctiveness refers to learning methods that promote encoding of item-specific features, such as the testing effect (testing vs. restudying), the generation effect (generation vs. complete study), and the drawing effect (drawing vs. silent reading). These learning methods enhance item-specific memory by promoting distinctiveness encoding and are therefore termed distinctiveness encoding strategies (Bodner et al., 2016; Hunt & McDaniel, 1993). Item distinctiveness refers to inherent features of items themselves, such as numbers appearing in verbal materials or pictures appearing in text materials, which can also effectively enhance item-specific memory (Icht et al., 2014).

Making JOLs during learning is another form of distinctiveness processing that may promote both task distinctiveness and item distinctiveness. On one hand, compared to not making JOLs, making JOLs requires individuals to focus attention and analyze the current item, activating more diagnostic cues about the item itself to make reasonable memory predictions (Senkova & Otani, 2021; Zhao et al., 2022). This process increases encoding of item-specific features, producing task distinctiveness. On the other hand, individuals assign different JOL values to studied items, with each value corresponding to a specific item. These JOL values increase the feature richness and discriminability among items, potentially enhancing item distinctiveness (Mitchum et al., 2016). Because making JOLs strengthens item-specific distinctive features, individuals allocate more attentional resources to items themselves; meanwhile, due to limited cognitive resources, fewer resources are available for inter-item relational processing. Consequently, making JOLs enhances item-specific memory while disrupting inter-item relational memory, leading to dissociated reactivity effects on veridical and false memory. It should be noted that distinctiveness processing is not limited to the encoding stage but also exists at retrieval (i.e., the distinctiveness heuristic). Future research could employ new paradigms that dissociate encoding and retrieval stages (e.g., inclusion tests) to further investigate how distinctiveness processing influences reactivity effects (Hege & Dodson, 2004).

Furthermore, these results are also consistent with fuzzy-trace theory's explanation of false memory (Brainerd & Reyna, 2002; Reyna & Lloyd, 1997). This theory posits that the underlying mechanism of false memory is that people primarily rely on semantic or gist representations (i.e., gist traces) rather than detailed representations (i.e., verbatim traces) during information processing. However, as individuals increase their utilization of item-specific features or details, false memory gradually decreases or disappears. Consistent with this theoretical assumption, when participants were required to make JOLs for each word in DRM lists, they needed to carefully analyze the distinctive features or specific details of each word to make accurate JOLs (Zhao et al., 2022). Because item-by-item JOLs forced participants to allocate substantial cognitive resources to item-specific feature processing, fewer resources were available for semantic relational processing among different DRM words, thereby reducing false memory.

Experiment 2 further manipulated JOL type and DRM list presentation format, finding that making global JOLs for DRM pure lists facilitated false memory. This result is consistent with Namias et al. (2021), who found that DRM list presentation format could modulate false memory generation using drawing as a distinctiveness encoding method. In their study, participants drew images representing each DRM word during learning. For one group, all DRM words from each list were presented simultaneously, and participants integrated them into a single drawing (integrated drawing group). For another group, DRM words were presented individually, and participants drew separate images for each word (single drawing group). Results showed that the integrated drawing group exhibited higher false alarm rates for critical lures than the single drawing group, demonstrating stronger false memory. Namias et al. proposed that integrated drawing, compared to single drawing, made participants more aware of the strong semantic associations among DRM words within lists, thereby enhancing intra-list semantic relational processing and leading to stronger false memory. Similarly, Experiment 2 in the current study simultaneously presented all words from DRM pure lists, which shared common semantic relations and pointed to the same critical lure. Making global JOLs during learning utilized and strengthened semantic cues among DRM words in pure lists, thereby enhancing memory for both studied words and critical lures.

Experiment 3 found that under DRM mixed list conditions, making global JOLs disrupted semantic relational processing across lists, reducing false memory—a result consistent with Experiment 1. However, unlike Experiment 1, Experiment 3 found that the facilitative effect of global JOLs on list-specific memory (recognition memory for studied words) was nearly absent. We propose that one possible explanation for this phenomenon is the difference in item quantity. Compared to item-by-item JOLs (Experiment 1), global JOLs (Experiment 3) involved multiple unrelated study words, and the processing advantage of JOLs for item-specific features was distributed across these words. Consequently, for any single word, the facilitative effect of global JOLs on item-specific memory was substantially weakened. Namias et al. (2021) reported similar results, with the single drawing group showing higher veridical memory performance than the integrated drawing group, suggesting that when distinctiveness encoding targets multiple sub-items, the memory advantage of the encoding strategy diminishes.

Another potential explanation is dual-task costs (Mitchum et al., 2016). Unlike Experiment 2's pure lists, the words within each list in Experiment 3 had no semantic associations, and the study time per list was relatively short. Therefore, requiring participants to make global JOLs while learning each list may have functioned as a secondary task that consumed encoding resources. This dual-task situation could have offset the facilitative effect of JOLs on item-specific processing, resulting in diminished or absent positive reactivity effects on item-specific memory (Zhao et al., 2022).

Limitations and Future Directions

Although previous research has partially validated the item-specific and relational account, it has neglected the theory's predictions regarding reactivity effects on intra-item semantic relational memory (Zhao, Li, et al., 2023; Zhao, Yin, et al., 2023). The current study, based on the DRM paradigm, further revealed that JOLs have facilitative effects on both item-specific memory and intra-item semantic relational memory but disruptive effects on inter-item semantic relational memory. These findings support the item-specific and relational account, demonstrating that this theory can effectively explain the underlying mechanisms of reactivity effects.

The item-specific and relational account is not mutually exclusive with other theoretical explanations of reactivity effects (e.g., cue-strengthening theory, changed-goal theory, and enhanced learning engagement theory). Rather, it effectively addresses limitations of existing theories. For example, previous theories of reactivity effects have focused primarily on item-specific memory (i.e., memory for single words or word pairs) and have difficulty explaining JOLs' effects on inter-item relational memory (Myers et al., 2020). However, the item-specific and relational account also has limitations, as it struggles to explain reactivity effects when learning materials vary in difficulty. For instance, Mitchum et al. (2016) found that in mixed lists comprising related and unrelated word pairs, JOLs significantly improved cued recall performance for related pairs but reduced performance for unrelated pairs. Mitchum et al. (2016) proposed the changed-goal theory to explain these findings, suggesting that making JOLs enhances individuals' metacognitive awareness of item difficulty—realizing they can remember easy items (e.g., related pairs) but not difficult ones (e.g., unrelated pairs). To prevent "laboring in vain" (Nelson & Leonesio, 1988), individuals actively abandon difficult items and allocate more study resources to easy items. Consequently, the performance difference between related and unrelated pairs was larger in the JOL condition than in the no-JOL condition. It should be noted, however, that changed-goal theory cannot explain why reactivity effects remain stable when learning materials do not differ in difficulty.

The different patterns of reactivity effects observed for various types of learning materials suggest that reactivity effects constitute a complex memory phenomenon comprising multiple distinct patterns, each with different underlying mechanisms (Li et al., 2022). Future research should further investigate whether the cognitive or neural mechanisms of reactivity effects differ across material types. Additionally, the item-specific and relational account and cue-strengthening theory share consistent predictions regarding positive reactivity effects of JOLs on item-specific and intra-item semantic relational memory (Maxwell & Huff, 2022; Myers et al., 2020; Rivers et al., 2021; Soderstrom et al., 2015), but cue-strengthening theory cannot predict whether JOLs produce reactivity effects on inter-item relational memory or specify the pattern of such effects.

Practical Implications

This study investigated the reactivity effects of JOLs on false memory using the DRM paradigm, providing further support for the item-specific and relational account and offering scientific insights for developing interventions to mitigate false memory. However, several limitations remain, and future research could explore the following directions:

First, the experimental materials used in this study were all word lists, which may not represent learning materials used in real educational settings, and all experiments were conducted in laboratory conditions without simulating real classroom scenarios. Students' learning processes in authentic classroom contexts are influenced by multiple factors, and the metamemory monitoring cues activated by learning environments are more diverse (Ariel et al., 2021). Future research could select more ecologically valid educational materials (e.g., anatomical structures or textbook chapters) to further examine the reactivity effects of JOLs on false memory.

Second, this study primarily used JOLs to investigate reactivity effects on false memory, requiring participants to make prospective memory predictions after learning each item. In addition to prospective metamemory monitoring, metamemory monitoring also includes retrospective monitoring (Double & Birney, 2018). Unlike prospective monitoring, retrospective metamemory monitoring occurs after memory retrieval—for example, when participants judge their confidence in the correctness of their answers after responding to a question. Future research could examine the effects of different forms of metamemory monitoring (e.g., confidence judgments, feeling-of-knowing judgments) on veridical and false memory.

Finally, this study measured reactivity effects by comparing memory performance differences between JOL and no-JOL conditions (Soderstrom et al., 2015; Zhao et al., 2022). Although study time was matched across learning conditions, like many previous studies, this study did not require participants to complete any control task in the no-JOL condition. Future research could further match JOL and no-JOL conditions to avoid interference from other irrelevant factors. For example, in the no-JOL condition, participants could be presented with the same 0-100 slider and asked to randomly select a number to increase the comparability between conditions (Senkova & Otani, 2021).

Conclusion

Item-by-item JOLs disrupt semantic relational processing among DRM words, thereby reducing false memory, while simultaneously promoting item-specific distinctiveness processing and enhancing veridical memory. Furthermore, global JOLs facilitate intra-item (or intra-list) semantic relational processing but disrupt inter-item (or inter-list) semantic relational processing. The item-specific and relational account provides a reasonable explanation for the underlying mechanisms of reactivity effects.

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Note: Figure translations are in progress. See original paper for figures.