Title Here: SOMETHING ABOUT DRM AND RELATIONAL ENCODING

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Abstract

[ABSTRACT WILL GO HERE]

Word Count: XXX

*Keywords*: Judgments of Learning; Reactivity; Single Item Lists; DRM Paradigm; Recognition

[TITLE HERE]

When learning new information, it is helpful to assess whether the knowledge one is acquiring is being sufficiently encoded. Metamemory, or the processes by which individuals regulate their learning, is a crucial component of learning, as it helps individuals decide whether items need additional study or if they have been sufficiently learned (see Nelson & Narens, 1990). To investigate questions surrounding metamemory, researchers commonly use Judgments of Learning (JOL) tasks, where participants study a set of items and predict their likelihood of correctly remembering them on a later test (see Rhodes, 2016; Schwartz & Metcalf, 2017, for reviews). Thus, JOLs provide a simple measure for assessing how various manipulations affect the study process, including perceptual manipulations (e.g., font; Rhodes & Castel, 2008; Maxwell, Perry, & Huff, 2022) and the presence of associations between items in cue-target pairs (e.g., Koriat & Bjork, 2005; Castel, McCabe, & Rhodes, 2007).

Historically, research involving JOLs has considered these ratings to be neutral measures with no effect on memory, particularly when participants make them concurrently with or immediately following study (though see Spellman & Bjork, 1992, who posited that JOLs made following a delay improved memory for judged items). As such, early JOL studies often focused on factors influencing their accuracy, rather than their potential effects on memory. However, over the last decade, a growing body of research has 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 accounts, the act of making JOLs modifies participants memory for studied items, likely by making certain features of the stimuli more salient at encoding (Ericsson & Simon, 1993). Thus, eliciting JOLs at encoding could potentially produce memorial benefits (i.e., *positive reactivity*) or costs (i.e., *negative reactivity*), which would be evident when comparing memory performance between participants making JOLs at encoding and a separate group of participants completing a no-JOL control task (e.g., silent reading).

Studies investigating the mechanisms behind JOL reactivity have commonly used cue-target word pairs. These studies have revealed a consistent pattern of reactivity: When pairs are semantically related (e.g., mouse – cheese), making JOLs improves memory for the target item (Janes et al., 2018; Halamish & Undorf, 2023; Maxwell & Huff, 2022; Soderstrom et al., 2015). However, this memorial benefit does not extend to unrelated pairs (e.g., mouse – cup), particularly when memory is assessed via cued-recall testing (but see Mitchum, Kelley, & Fox, 2016, who showed no reactivity on related pairs and *negative* reactivity on unrelated pairs). To explain why relatedness moderates JOL reactivity patterns, Soderstrom et al. proposed that two conditions must be met for reactivity to occur on cue-target pairs. First, studied items must contain intrinsic cues which participants use to inform their JOLs (see Koriat, 1997). Second, participants must be tested using a method that is sensitive to any cues that are strengthened due to making JOLs. Based on this *cue-strengthening account*, when participants are tested via cued-recall, the cue-strengthening account predicts a memory benefit on related pairs, given that cued-recall testing is highly sensitive to pair relatedness. For unrelated pairs, however, JOLs do not produce a memorial benefit, as intrinsic cue-target relations are not available for this pair type.

While the cue-strengthening account makes no specific claims regarding the particular cues that JOLs strengthen, it is likely JOLs primarily strengthen pre-existing cue-target relations, as pair relatedness is a highly salient cue for later remembering (Mueller, Tauber, & Dunlosky, 2013). Given this possibility, recent studies have explored the degree to which relatedness contributes to reactivity. For example, Maxwell and Huff (2022) compared recall for participants making JOLs to three additional encoding groups: A no-JOL control group, a group of participants completing a shallow vowel-counting task instead of providing JOLs, and, importantly, a group of participants who engaged in a deep relational encoding task. Compared to both the no-JOL and shallow encoding groups, JOL participants showed positive reactivity for all related pair types. Critically, participants in the relational encoding group also demonstrated this pattern, even though they were not required to provide JOLs at encoding. Thus, Maxwell and Huff concluded that providing JOLs at encoding encouraged participants process cue-target relations, which led to the implicit adoption of a relational encoding strategy.

Additionally, Halamish and Undorf (2023) recently investigated relatedness effects on JOL reactivity using related, unrelated, and identical cue-target pairs. In addition to testing differences in cued-recall across pair types, participants also made relatedness judgments at test, in which participants indicated whether cue items had been previously paired with a related, unrelated, or identical target word. Overall, JOLs produced positive reactivity on related but not unrelated pairs, a finding consistent with previous reactivity studies (e.g., Janes et al., 2018; Soderstrom et al., 2015, etc.). Positive reactivity also extended to identical cue-target pairs, further suggesting that perceived relatedness is necessary for reactivity to occur. Importantly, making JOLs also improved the accuracy of relatedness judgments, but only on related pairs. Taken together, these findings suggest that JOLs encourage participants to process relatedness but only for pairs with pre-existing relations.

**JOL Reactivity and List Relatedness**

As noted above, most work investigating JOL reactivity has tested for potential memory changes using various types of cue-target word pairs. This is likely because factors influencing JOLs are often studied within the context of related versus unrelated cue-target pairs, rather than via list-wise manipulations of relatedness (see Chang & Brainard, in press). However, like cue-target relatedness, list relatedness has similarly been shown to affect the magnitude of JOLs. For example, Matvey, Dunlosky, & Schwartz (2006) had participants make item-level JOLs for words presented in either categorized (i.e., related) or uncategorized (i.e., unrelated) single word lists. Overall, a classic relatedness effect emerged, such that JOLs were higher for categorized lists relative to uncategorized lists. More recently, Chang and Brainard replicated this general pattern for JOLs while also demonstrating that items in categorized lists were consistently recalled at a greater rate relative to uncategorized lists. Thus, relatedness effects that are observed on JOLs with cue-target pairs extend to categorized and uncategorized single item lists.

While relatedness has been shown to affect the magnitude of JOLs regardless of whether it is manipulated inter-item (i.e., related and unrelated cue-target pairs) or when using categorized and uncategorized single-item lists, the mechanisms driving these effects likely differ based on the type of stimuli. According to Koriat’s (1997) cue-utilization account, making JOLs for cue-target pairs promotes the use of intrinsic cues (i.e., inherent item properties) which participants use to inform the magnitude of their JOLs. Pre-existing cue-target relations reflect a primary example of intrinsic cues, given that the relation between items is inherent to the pair and easily processed at encoding. However, by nature, single-item lists display study items to participants one item at a time. Thus, any relatedness cues would reflect *extrinsic cues*, given that participants must assess how the item relates back to previously presented items within the list. Thus, extrinsic cues reflect the specific characteristics in which encoding occurs, rather than inherent properties of the stimuli.

Regarding JOL reactivity, few studies have directly assessed the effects of making JOLs on memory for single-item lists. As a result, current theories of JOL reactivity primarily focus on explaining the role intrinsic cues as an underlying factor for reactivity to occur on cue-target pairs (e.g., Soderstrom et al.’s, 2015 cue-strengthening account). Thus, it remains unclear whether the relatedness effects driving JOL reactivity with cue-target pairs would similarly affect categorized word lists. In a notable exception, however, Senkova and Otani (2021) assessed the effect of list relatedness on JOL reactivity by testing for reactivity on categorized and uncategorized word lists for participants making JOLs, pleasantness ratings, or a control task in which participants simply assigned a random number to each item (Experiment 1) and participants making JOLs, completing an imagery task, or the control task (Experiment 2). Across experiments, participants making JOLs had greater free-recall relative to participants in the control group. Importantly, recall benefits were greater for categorized lists, suggesting that the presence of list-wise relatedness facilitated reactivity. Additionally, both deep encoding comparison groups also improved free-recall relative to participants in the no-JOL control group. Because both pleasantness ratings and imagery tasks are classic item-specific tasks based on the item-specific/relational framework (Einstein & Hunt, 1980; Hunt & Einstein, 1981), Senkova and Otani argued that positive JOL reactivity reported on categorized wordlists reflected an item-specific process rather than a relational encoding process. Considered alongside findings investigating the effects of relatedness on reactivity with cue-target pairs (e.g., Halamish & Undorf, 2023; Maxwell & Huff, 2022), it is likely that JOL reactivity reflects different underlying processes based on the type of stimuli that participants study.

**The Present Study**

Although it is evident that making JOLs benefits recall of related versus unrelated cue-target pairs, less is known about the effects of making these judgments on categorized and uncategorized lists. As such, the present study sought to first replicate findings from Senkova and Otani (2021) demonstrating that categorized lists show a greater memorial benefit versus uncategorized lists using both free-recall (Experiment 1A) and recognition testing (Experiment 1B). Next, Experiment 2 used the Deese-Roediger-McDermott paradigm (Deese; 1959; Roediger & McDermott, 1995), which allowed for an assessment of the effects of item-specific and relational processes on JOL reactivity. To preview, across experiments [RELATED VS UNRELATED FINDINGS FOR FREE-RECALL] [RECOGNITION FINDINGS?] Finally, [ITEM-SPECIFIC VS. RELATIONAL FOR DRM]

**Experiment 1A: Related versus Unrelated Lists and Free-Recall Testing**

The goal of Experiment 1A was to replicate findings reported by Senkova and Otani (2021) showing that JOLs improve free-recall of categorized but not uncategorized single-item lists. As such, free-recall was compared between three groups: Participants who provided concurrent, item-level JOLs, participants who made global JOLs immediately following presentation of each study list, and a no-JOL control group in which participants silently read each item. Based on previous research, it was expected that making JOLs would [PREDICTIONS]

**Method**

**Participants**

XX participant were recruited from XX University and completed the study in exchange for partial course credit. Next, an additional XX participants were recruited from Prolific (www.prolic.co) and participated at a rate of $3.00 per 20-minute session. The final sample contained XX participants and was informed by an a priori power analysis conducted with *G\*Power 3.1* (Faul, Erdfelder, Buchner, & Lang, 2009), which suggested that xx participants would be needed to detect medium main effects and interactions (STATS). All participants were native English speakers, and Prolific participants were additionally required to have obtained at least a high school degree or equivalent.

**Materials**

[CATEGORIZED AND UNCATEGORIZED LISTS]

**Procedure**

[WORDS HERE]

**Results**

For all analyses, significance was set at the *p* < .05 level. For all significant main effects and interaction, partial eta-squared (*ηp*2)is reported, and Cohen’s *d* effect sizes are reported for all significant post-hoc comparisons. Additionally, for all non-significant main effects and post-hoc comparisons, a Bayesian estimate of the strength of the evidence supporting the null hypothesis is reported (Masson, 2011; Wagenmakers, 2007). This analysis compares two models, one of which assumes a significant effect with the other assuming a null effect and allows for the computation of a probability estimate (a *p*-value termed *p*BIC; Bayesian Information Criterion). This value estimates the probability of the null hypothesis being retained and is sensitive to the sample size, providing increased confidence in null effects reported. Finally, for completeness, all comparisons are reported in the Appendix (Table AX).

Figure X (top panel) depicts changes in free-recall as functions of encoding group and list construction. To test for reactivity effects, the data was analyzed using a 3(Encoding Group: Item-JOL vs. List-JOL vs. No-JOL) × 2(List Type: Categorized vs. Uncategorized) mixed-measures ANOVA. Overall, [MAIN EFFECT OF ENCODING GROUP?] [PATTERN]. Next, [MAIN EFFECT OF LIST-TYPE] [PATTERN]. Importantly, [INTERACTION] Starting with categorized lists, [PATTERN]. However, for uncategorized lists, [PATTERN]. Thus, [SUMMARY]

**Experiment 1B: Related versus Unrelated Lists and Recognition Testing**

Experiment 1B tested [MAIN GOAL – FREE RECALL]. Based on [WHAT DO WE PREDICT?]

**Method**

**Participants**

An additional XX participants were recruited from Midwestern State University who completed Experiment 1B in exchange for partial course credit. Participants were randomly assigned to one of the three encoding groups used in Experiment 1A. Initial sample sizes for each group were based on the previous experiment, and the same exclusion criteria were applied. This process removed XX participants from the final dataset, leading to a total of XX participants in the final sample (Item-wise JOLs, *n* = XX; List-wise JOLs, *n* = xx; No-JOL control group, *n* = xx). A sensitivity analysis conducted with *G\*Power 3.1* suggested that this sample had sufficient power to detect [SIZE OF EFFECT] [STATS]. All participants were native English speakers.

**Materials and Procedure**

Experiment 1B used the same stimuli and materials as Experiment 1A, with the exception that the free-recall tests used in Experiment 1A were replaced with a single, 80-item old/new recognition test, which was presented following the final study list. This test consisted of 30 previously studied items (taken from positions 2, 8, and 10 from each list), 10 critical lures from each studied list, 30 non-presented items taken from counterbalanced lists, and 10 critical lure controls which were taken from the non-studied set of lists. Participants studied all 10 lists back-to-back, with the order of list presentation randomized across participants. All JOL instructions were identical to Experiment 1A, and depending on their encoding group, participants either made JOLs concurrent with study, made list-wise JOLs following the completion of each list, or read each word silently. Consistent with the previous experiment, all encoding was self-paced.

Following the presentation of the final list, participants completed a 60-second filler task in which they were given a random consonant and were tasked with generating as many words as possible which started with this letter. Immediately after this task, [DESCRIBE THE RECOGNITION TEST]

**Results**

Figure X (bottom panel) [REFERENCE FIGURE AND APPENDIX] [INTRODUCE MODEL]

**Discussion**

[WORDS HERE]

**Experiment 2A: DRM Lists and Free-Recall Testing**

[WORDS HERE]

**Method**

**Participants**

[WORDS HERE] [PROBABLY PROLIFIC]

**Materials**

[WORDS HERE]

**Procedure**

[WORDS HERE]

**Results**

[WORDS HERE]

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

[WORDS HERE]

**Method**

**Participants**

[WORDS HERE] [MSU TEXAS]

**Materials**

[WORDS HERE]

**Procedure**

[WORDS HERE]

**Results**

[WORDS HERE]

**Discussion**

[WORDS HERE]

**General Discussion**

[WORDS HERE]

**Conclusion**

[WORDS HERE]

**Open Practices Statement**

[WORDS HERE]

**Compliance with Ethical Practices**

[WORDS HERE]

**References**

[FIRST REF HERE]

[FIGURE 1]

[FIGURE 2]

**Appendix**

Table AX