Mem Cogn (2013) 41:1012–1020
DOI 10.3758/s13421-013-0317-6

False memory and importance: Can we prioritize encoding without consequence?

Dung C. Bui · Michael C. Friedman ·
Ian M. McDonough · Alan D. Castel

Published online: 11 April 2013
© Psychonomic Society, Inc. 2013

Abstract Given the large amount of information that we encounter, we often must prioritize what information we attempt to remember. Although critical for everyday functioning, relatively little research has focused on how people prioritize the encoding of information. Recent research has shown that people can and do selectively remember information assigned with higher, relative to lower, importance. However, the mechanisms underlying this prioritization process and the consequences of these processes are still not well understood. In the present study, we sought to better understand these prioritization processes and whether implementing these processes comes at the cost of memory accuracy, by increasing false memories. We used a modified form of the Deese/Roediger–McDermott (DRM) paradigm, in which participants studied DRM lists, with each list paired with low, medium, or high point values. In Experiment 1, encoding higher values led to more false memories than did encoding lower values, possibly because prioritizing information enhanced relational processing among high-value words. In Experiment 2, disrupting relational processing selectively reduced false memories for high-value words. Finally, in Experiment 3, facilitating relational processing selectively increased false memories for low-value words. These findings suggest that while prioritizing information can enhance true memory, this process concomitantly increases false memories. Furthermore, the mechanism underlying these prioritization processes depends on the ability to successfully engage in relational processing. Thus, how we prioritize the encoding of incoming information can come at a cost in terms of accurate memory.

Keywords Memory · False memory · Relational processing · Value-directed remembering

D. C. Bui (✉)
Department of Psychology, Washington University in St. Louis,
St. Louis, MO 63130, USA
e-mail: dcbui@wustl.edu

M. C. Friedman · A. D. Castel (✉)
Department of Psychology, University of California, Los Angeles,
1285 Franz Hall, Box 951563, Los Angeles,
CA 90095-1563, USA
e-mail: castel@ucla.edu

I. M. McDonough
Center for Vital Longevity, School of Behavioral and Brain
Sciences, University of Texas at Dallas, Dallas, TX 75235, USA
e-mail: ian.mcdonough@gmail.com

We frequently encounter more information than we can accurately remember. Recent work has suggested that we adapt to this problem by prioritizing what we attempt to remember by using our goals and motivations as a guide (Ariel, Dunlosky, & Bailey, 2009; Castel, 2008). For example, imagine a student who is taking several classes and is heavily invested in one course but less so in another. When the student studies for both classes, prioritizing one class over another will likely influence the amount of time spent rehearsing information, but it may also change the strategies the student uses to study. How does the student choose to organize and process the information that he or she has given such high priority, and what are the consequences of that organization? Given that we selectively attend to our environment on the basis of our goals and motivations and can prioritize what we attempt to remember, the present study aimed to better understand the encoding strategies underlying this prioritization process and determine the consequences of these strategies for memory accuracy.

Prioritizing information at encoding and retrieval has been empirically demonstrated using *value-directed remembering* (VDR; e.g., Castel, Benjamin, Craik, & Watkins, 2002). In a typical VDR experiment, participants are given a list of nonrelated words to remember for a later free recall test. Each word is paired with a number or "value" (e.g., skate 7, cheek 12, fence 3), and participants are instructed prior to study to remember the words on the basis of their value. If they are able to successfully recall that word on a later test, they are awarded its associated point value. That is, certain words are more valuable to remember than others (in the example above, remembering "cheek" would be more valuable than remembering "skate" or "fence"). VDR studies have demonstrated that at a final test, participants recall or recognize more words that were paired with higher values, rather than lower values, during the study phase (e.g., Ariel et al., 2009; Castel et al., 2002; Castel, Farb, & Craik, 2007; Loftus & Wickens, 1970; Soderstrom & McCabe, 2011).

In general, VDR is thought to lead to selective recall and recognition of words via strategic encoding processes, enhanced motivation, and selective rehearsal for those words with higher values at the expense of words with lower values (Castel et al., 2002; Castel, Murayama, Friedman, McGillivray, & Link, in press; see also Tulving, 1969). However, little empirical evidence exists regarding *how* this value-directed remembering might be driven by attentional control. In other words, no research has delineated the specific encoding strategies that may be implemented for high-value words and, to a lesser extent, low-value words. For instance, during encoding, people can attend to the distinctive qualities of an event that make it unique from other events (e.g., dogs and cats are different because dogs have more teeth), referred to as *item-specific processing* (Hunt & Einstein, 1981; Hunt & McDaniel, 1993). Alternatively, people can attend to the qualities of an event shared by other events (e.g., dogs and cats are both types of four-legged animals with tails), referred to as *relational processing*. Furthermore, one can imagine making many associations among words or very few associations among words; thus, the difference in strategies between higher and lower value words may be one of degree and not of kind. Both item-specific processing and relational processing have been shown to enhance memory recall, and thus either could form the basis underlying the VDR effects. However, these processes also differentially affect memory accuracy, particularly false memories (i.e., errors of commission).

One of the most well-known examples of how false memories can be created is illustrated in the Deese/Roediger–McDermott paradigm (DRM; Deese, 1959; Roediger & McDermott, 1995). In the DRM paradigm, participants study a list of associated words and falsely report remembering a word (the critical lure) that, although semantically related to the previously studied list, was never presented in that list. The resulting false memories using this paradigm are quite robust (see Gallo, 2010, for a review), which emphasizes the reconstructive nature of memory at the time of retrieval and has significant implications in settings where memory accuracy is paramount (e.g., eyewitness testimony). One theoretical account of false remembering in the DRM paradigm, the activation/monitoring framework (e.g., Roediger, Balota, & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001), suggests that false memories result from a trade-off between activation and the efficacy of monitoring. Specifically, activation refers to a stimulus that enhances the associative activation between words, and monitoring refers to the decision processes that attempt to determine the source of the activated concept. In the context of a DRM experiment, studying a word list should induce semantic activations that can bring to mind list-related words such as the nonpresented critical lure. However, the activation of the critical lure does not mean that it will certainly be recalled (i.e., a false memory) if the monitoring process is effective in reducing this false memory effect. Simply put, activation increases false memories, while accurate monitoring decreases false memories.

Another account explaining how false memories arise is the fuzzy-trace theory (FTT; Reyna & Brainerd, 1995). This account posits that the encoding of an event is carried in two qualitatively different types of traces: a verbatim trace and a gist trace. Verbatim traces are characterized by a mental reinstatement of particular features of the target event (the surface forms of an event), whereas gist traces are thought to represent an event's semantic features (the meaning of an event). At the time of retrieval, both verbatim and gist traces are accessed, and the activation of each type of trace may vary (e.g., Reyna & Brainerd, 1995). Although both types of traces support veridical memory, they have opposite effects for false memories. Studying a list of related words in a DRM experiment increases gist traces, which in turn produce false memories (i.e., the recall of semantically related yet unstudied words) if the accompanying verbatim traces are not strong enough to suppress the false memories (i.e., recollection rejection). More specifically, FTT states that gist traces increase false memories, while verbatim traces can help decrease false memories (e.g., Brainerd & Reyna, 2002).

From the perspective of both the activation/monitoring framework and FTT, item-specific and relational processing should have different consequences for false memories. Relational processing of an item on a DRM list, as compared with item-specific processing, increases the spreading activation of related words in an activation/monitoring framework (or increases in gist from the FTT perspective), which then increases the likelihood of a false memory. Support for this explanation can be found from studies that have enhanced or disrupted relational processing, which in turn affected false memory rates. For example, McCabe, Presmanes, Robertson, and Smith, (2004) demonstrated that false memories were reduced when pleasantness ratings were made on words (item-specific processing), as compared with when the words were subjected to a sorting task (relational processing) using DRM lists (see also Smith & Hunt, 1998). Other studies have shown that presenting DRM lists in a blocked design, which is thought to increase relational processing, leads to increases in false memories, relative to interleaving the DRM lists (McDermott, 1996; Toglia, Neuschatz, & Goodwin, 1999). Together, these studies show that instructions that encourage item-specific processing lead to decreased false memories, while instructions that encourage relational processing lead to increased false memories.

In the present study, we sought to understand how prioritizing information affects the creation of false memories and to clarify the mechanisms underlying these prioritization effects. To do so, we examined true and false remembering in the DRM paradigm using a value-directed remembering approach. Across three experiments, participants viewed blocks of words that each consisted of three DRM lists, with one DRM list paired with high values, another list paired with medium values, and the last paired with low values. After the lists were presented, participants were asked to free recall the previously presented lists from that block. Combining the DRM paradigm and the VDR approach allowed us to assess the extent that processing value influences semantic-based false memories. In addition, the direction of the false memories (enhanced or reduced) can provide insight as to the type of encoding strategy used during value processing. We expected that higher value information would enhance true memory, regardless of whether relational or item-specific processing was implemented. However, we expected the false memory effects to be more sensitive to the type of processing in which participants engaged. To the extent that higher values encouraged more relational processing of an item, we predicted that this relational processing would also increase false memories. In contrast, to the extent that higher values encouraged more item-specific processing of the studied words, this process would reduce false memories.

Experiment 1

In Experiment 1, we were interested in whether prioritizing certain information could also lead to increased false memory. Because of the aforementioned theories that explain the emergence of false memories in the DRM paradigm, we reasoned that increased relational processing would enhance memory for high-value information but also lead to greater false memory. This result would suggest that selective encoding of high-value information comes at a memory cost.

Method

Participants and design

Sixty undergraduate students (36 females and 24 males; mean age=19.3 years) at Washington University, all of whom were proficient English speakers, participated for course credit. Presentation (value, no value) was manipulated between subjects, and for participants in the value condition, value (low, medium, high) was manipulated within subjects.

Materials

Twenty-four word lists were used in this experiment, all of which were the same as those used in the Roediger and McDermott study (1995, Experiment 2). Each list contained 12 words, all of which were semantically associated with a word not included on the list and, consequently, not shown to participants. The word lists were randomly partitioned into eight blocks, such that each block was composed of three word lists. Within each block, one list was assigned low values (1–12), another was given medium values (13–24), and the third was given high values (25–36), and different value lists were intermixed with a block of lists. Within each list, the distribution of values was randomized across the words such that each word was given its own unique value. Value assignment was counterbalanced across participants such that all lists were assigned at high, medium, and low values.

Following instructions, participants viewed single words, one at a time, for 1.5 s on a computer screen. For participants in the no-value condition, the words were presented alone. For those in the value conditions, each word was presented with a number next to it (e.g., candy 12). After an entire block of three lists had been presented, participants were given 1.5 min to recall as many words as possible from the just-presented block by writing down their responses on a given piece of paper, and recall for each block was on a new piece of paper. After this period was over, their response sheets were collected, and the participants began a new study–test block.

Procedure

Participants were tested individually in a private testing room. After demographic information had been collected, all participants were told that they would study eight blocks of words and that, following each block, they would be asked to free recall as many words as they could remember from that list. Participants in the value condition were additionally told that the number shown with each word represented its value and that their goal was to maximize their “recall score” by learning and recalling as many high-value words as possible but that medium-value and low-value words would also contribute to their score (see also Castel et al., 2002).

Results and discussion

Overall recall

Figure 1 displays the proportion of true and false memories recalled as a function of presentation. A 2 (presentation:

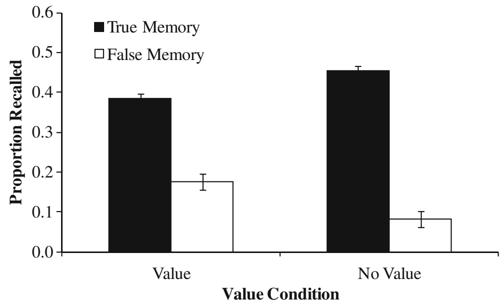

Fig. 1 Mean proportions of words recalled for true and false memory as a function of value condition in Experiment 1

value, no value) × 2 (memory type: true, false) mixed-factor analysis of variance (ANOVA) did not reveal an effect of presentation, $F(1, 58)=0.59$, $p=.45$, $\eta_p^2=.01$. Not surprisingly, recall for true memory exceeded recall for false memory, $F(1, 58)=378.83$, $p<.001$, $\eta_p^2=.87$. In addition, a presentation×memory type interaction was also found, $F(1, 58)=29.51$, $p<.001$, $\eta_p^2=.34$. Follow-up *t*-tests revealed that true memory was reduced for the value group ($M=.39$), as compared with the no-value group ($M=.46$), $t(58)=4.07$, $p<.001$. However, when false memory was examined, false recall was greater for the value group ($M=.18$) than for the no-value group, ($M=.08$), $t(58)=3.62$, $p<.001$. The pattern of results suggests that prioritizing information (i.e., value condition) decreases true memory but also increases false memory.

Value effects

The proportion of true memory and false memory words recalled as a function of value is shown in Fig. 2 for the participants assigned to the value presentation condition. A 2 (memory type: true, false) × 3 (value bins: low point values, 1–12 points; medium point values, 13–24 points; high point values, 25–36 points) repeated measures ANOVA revealed an effect of memory type, $F(1, 29)=104.25$, $p<.001$, $\eta_p^2=.78$, indicating that more words were recalled for true memory than for false memory. A main effect of value was also found, $F(2, 58)=35.65$, $p<.001$, $\eta_p^2=.55$, indicating that higher point values were associated with more words recalled. Finally, an interaction between the two factors was found, $F(2, 58)=10.26$, $p<.001$, $\eta_p^2=.26$: Follow-up tests indicated that although encoding value affected both true memory, $F(2, 58)=67.28$, $p<.001$, $\eta_p^2=.70$, and false memory, $F(2, 58)=7.92$, $p<.001$, $\eta_p^2=.21$, true memory was affected by value to a greater extent than was false memory.

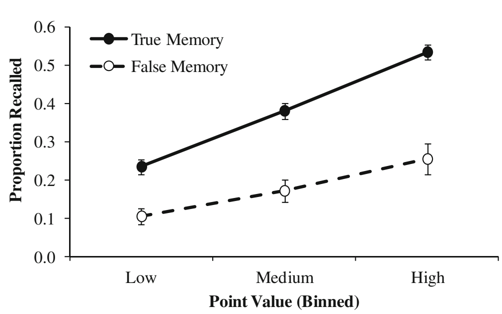

Fig. 2 Mean proportions of words recalled for true and false memory as a function of binned point values in Experiment 1

Our results replicated previous findings demonstrating VDR (e.g., Ariel et al., 2009; Castel et al., 2002; Soderstrom & McCabe, 2011); that is, people's strategic encoding operations can be guided toward information of greater relative importance, which in turn increases their memory for that information. However, our results also demonstrated that such prioritizing of information comes at a cost; false memory also increased as the associated value increased. Rhodes and Anastasi (2000) found a similar increase in both veridical and false memory when using a levels-of-processing manipulation (see also Thapar & McDermott, 2001; Toglia et al., 1999). Interestingly, in the present experiment, true memory increased more so with value, relative to false memory, indicating that the benefits of value processing for true memory may outweigh the costs of value processing for false memory.

With regards to overall recall, processing value led to lower true memory and greater false memory, as compared with not processing value. This pattern of results is similar to that found by Castel et al. (2002). One possible interpretation of this pattern is that processing value may elicit a different encoding strategy, as compared with when value is not present, which may also induce an additional cognitive load and, in turn, divide attention at the time of encoding. The idea that divided attention at encoding leads to impaired true memory has been well documented (e.g., Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996), although the effects of divided attention on false memories has been much less consistent (cf. Dodd & MacLeod, 2004; Perez-Mata, Read, & Diges, 2002). In Experiment 2, we explored how different types of encoding operations influence the value-based false memory effects.

Experiment 2

In Experiment 1, prioritizing information increased false memory. Both the activation/monitoring framework and FTT suggest that increases in false memories could be due to greater relational processing between words—in this case, selectively for higher-value words. We directly tested this idea in Experiment 2 by disrupting relational processing by encouraging item-specific processing, whereby encoding the distinctive features of an item should prevent relational encoding of similarities between all of the words on a list. To the extent that higher values facilitate relational processing, item-specific processing instructions should show reduced false recall in higher value words, with minimal effects in lower value words. Because item-specific processing also enhances true memory, we predicted that the effect of value on true memory would remain intact. The second goal of this experiment was to replicate the main results from Experiment 1 with a broader sample of participants, using a control condition similar to the value condition in Experiment 1. To achieve this goal, we used an online sample of participants recruited from Amazon Mechanical Turk.

Method

Participants and design

Eighty participants (55 females and 25 males; mean age= 33.5 years) were recruited from Amazon's Mechanical Turk Web site to take part in this study for monetary compensation. All participants reported proficiency in English and resided in the United States. Processing instructions (none, item specific) were manipulated between subjects, and value (low, medium, high) was manipulated within subjects.

Materials

The construction of the word lists was identical to that in Experiment 1.

Procedure

The procedures for this experiment were identical to those in Experiment 1, except that participants in the item-specific processing condition were given written instructions beforehand to "think of as many unique characteristics for each word that differentiate it from other words previously seen to make the words more distinctive from one another." In addition, participants typed in their responses into a text box instead of writing them down as they did in Experiment 1, and participants were given a blank text box for every study–test block.

Results and discussion

True memory

Figure 3 displays the proportion of true memories recalled as a function of value for both processing groups. A 2 (processing instructions: none, item specific) × 3 (value: low, medium, high) mixed-factor ANOVA did not reveal an effect of processing instructions, $F(1, 78)=2.27$, $p=.134$, $\eta_p^2=.03$. Consistent with our predictions, results revealed an effect of value, $F(2, 156)=94.31$, $p<.0001$, $\eta_p^2=.55$, indicating that true memory increased as value increased. No interaction between the two factors was found, $F<1$. Thus, as was predicted, value had similar effects in the control condition (standard value instructions) and in the item-specific processing condition.

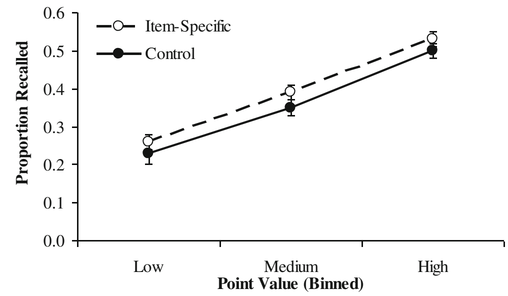

Fig. 3 Mean proportions of word recalled for true memory as a function of binned point values for both list structures in Experiment 2

False memory

Figure 4 displays the proportions of false memories recalled as a function of value for both processing groups. A 2 (processing instructions: none, item specific)×3 (value: low, medium, high) mixed-factor ANOVA did not reveal an effect of processing instructions, $F(1, 78)=2.95$, $p=.090$, $\eta_p^2=.04$. Consistent with our predictions, results revealed an effect of value, $F(2, 156)=18.08$, $p<.0001$, $\eta_p^2=.19$, indicating that false memory increased as value increased. This was qualified by a reliable processing instructions × value interaction, $F(2, 156)=5.08$, $p<.01$, $\eta_p^2=.06$: Increasing value led to more false memories for the control condition, $F(2, 78)=17.36$, $p<.001$, $\eta_p^2=.308$, but did not have an effect on the item-specific processing condition, $F(2, 78)=2.02$, $p=.140$, $\eta_p^2=.049$. Independent-samples *t*-tests indicated that the level of false memory was greater for the control group, as compared with the item-specific group, when the associated values were high, $t(78)=2.70$, $p<.01$. However, when the associated values were low, the two processing instructions conditions did not differ, $t(78)=0.28$, $p=.78$. Taken together, our results suggest that item-specific processing instructions interfered with relational processing of the high-value words only.[1]

The findings from Experiment 2 demonstrate that item-specific processing instructions eliminated VDR effects on false memory. More specifically, the item-specific processing manipulation selectively affected the level of false memories for higher values only. This provides evidence that relational

[1] It is possible that the interaction between instructions and value is due to floor effects observed in the low-value condition. To minimize these concerns, we examined the same interaction, but without the low-value condition. The 2×2 mixed-factors ANOVA yielded a significant interaction, $p<.05$: High-value false memories were more frequent than medium-value false memories for the control condition ($p<.01$), but there were no observed differences in the item-specific processing condition ($p=.75$).

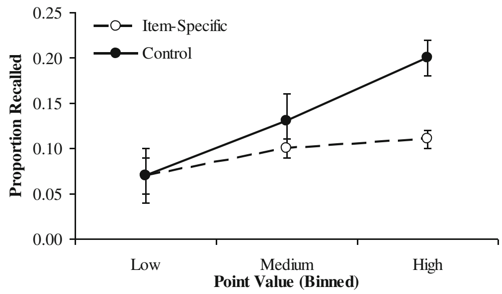

Fig. 4 Mean proportions of words falsely recalled as a function of binned point values for both instruction conditions in Experiment 2

processing mediates VDR effects on false memory and replicates the main finding from Experiment 1.

Experiment 3

In Experiment 3, the goal was to further test the relational processing hypotheses by facilitating relational processing. To do so, we presented DRM lists in a blocked fashion (i.e., present all the words from a single DRM list first before presenting the next DRM list), which contrasts with the interleaved style used in the previous two experiments. A number of studies have demonstrated that blocked list structures lead to greater false memories as compared with interleaved list structures (e.g., McDermott, 1996; Toglia et al., 1999; Tussing & Greene, 1997). One explanation for this effect is that blocked list structures may increase the likelihood of semantic activation of the common associate (or thematic relatedness of the words), which may encourage relational processing and, in turn, lead to increased false memory rates.

Parallel to the reasoning presented in Experiment 2, if higher values facilitate relational processing, as compared with lower values, then a blocked list structure should again negate the effects of VDR on false memory. Specifically, a blocked list structure may encourage more relational processing for lower-value words than they would have typically received. Thus, we expected false memory rates for low-value words to increase in conditions where word lists were blocked rather than interleaved. In contrast, to the extent that higher-value words already benefit from relational processing, we expected that encouraging relational processing using a blocked list structure would not benefit higher-value words to the same extent as lower-value words because the processing would be redundant (Hunt & Einstein, 1981).

Method

Participants and design

Fifty participants (33 females and 17 males; mean age= 31.7 years) were recruited from Amazon's Mechanical Turk Web site to take part in this study for monetary compensation. All participants reported proficiency with English and resided in the United States. Presentation structure (blocked, interleaved) was manipulated between subjects, and value (low, medium, high) was manipulated within subjects.

Materials

While the previous two experiments used eight blocks, this experiment utilized six blocks. For participants in the interleaved condition, the construction of each presentation block was identical to that in the previous two experiments. However, for those in the blocked condition, the three DRM lists within each block were clustered such that participants saw all the words from a single DRM list before being presented with the next DRM list. The distribution of value for each DRM list was random, and the order of presentation for each value category (low, medium, high) was counterbalanced across all participants.

Procedure

The procedures for this experiment were similar to those in Experiment 2, except that participants were not given instructions beforehand on how to process the words.

Results and discussion

True memory

Figure 5 displays the proportion of true memories recalled as a function of value for both processing groups. A 2 (list structure: interleaved, blocked) × 3 (value: low, medium, high) mixed-factor ANOVA did not reveal an effect of list structure, $F(1, 48)=0.99$, $p=.324$, $\eta_p^2=.02$. Consistent with our predictions, results revealed an effect of value, $F(2, 96)=59.12$, $p<.001$, $\eta_p^2=.55$, indicating that true memory increased as value increased. Interestingly, a list structure×value interaction was also found, $F(2, 96)=4.38$, $p<.05$, $\eta_p^2=.08$. Follow-up tests indicated that although encoding value had an effect when the list was either interleaved, $F(2, 48)=39.85$,

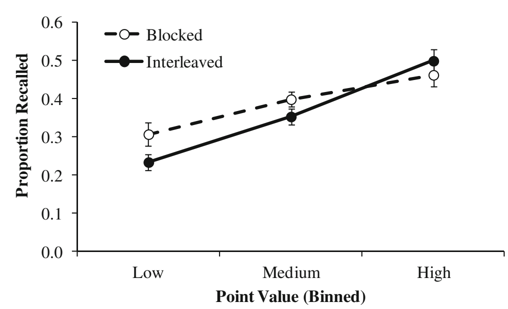

Fig. 5 Mean proportions of word recalled for true memory as a function of binned point values for both list structures in Experiment 3

$p < .001$, $\eta_p^2 = .62$, or blocked, $F(2, 48) = 19.92$, $p < .001$, $\eta_p^2 = .45$, true memory increased more across higher values with the interleaved lists, as compared with the blocked lists.

False memory

Figure 6 displays the proportions of false memories recalled as a function of value for both processing groups. A 2 (presentation structure: interleaved, blocked) × 3 (value: low, medium, high) ANOVA did not reveal an effect of presentation structure, $F(1, 48) = 2.56$, $p = .116$, $\eta_p^2 = .05$. Consistent with our predictions, results revealed an effect of value, $F(2, 96) = 3.04$, $p < .05$, $\eta_p^2 = .06$, indicating that false memory increased as value increased. These findings were qualified by a reliable presentation structure × value interaction, $F(2, 96) = 3.44$, $p < .05$, $\eta_p^2 = .07$, reflecting the fact that encoding value had an effect when the list was interleaved, $F(2, 48) = 9.32$, $p < .001$, $\eta_p^2 = .28$, but not when the list was blocked, $F(2, 48) = 0.04$, $p = .96$, $\eta_p^2 = .002$. Independent-samples *t*-tests indicated that false memory rates did not differ between the two presentation structures when the associated values were high $t(48) = 0.47$, $p = .644$. However, when the associated values were low, the blocked condition showed greater amounts of false memories, as compared with the interleaved condition, $t(48) = 2.75$, $p < .01$. This suggests that the blocked presentation structure facilitated relational processing specifically for the low-value words.

Consistent with the previous two experiments, processing higher values led to greater instances of true and false memory when the list structure was interleaved. The blocked list structure in Experiment 3 was most sensitive to words in the low-value condition and had little (or no) effect in the high-value condition, consistent with the idea that blocked list structures facilitated relational processing when minimal relational processing was implemented. This suggests that relational processing mechanisms are critical in VDR, since when the lower value words are encouraged to be processed in a relational manner (via blocked presentation), false memory rates look no different from those in the high-value condition.

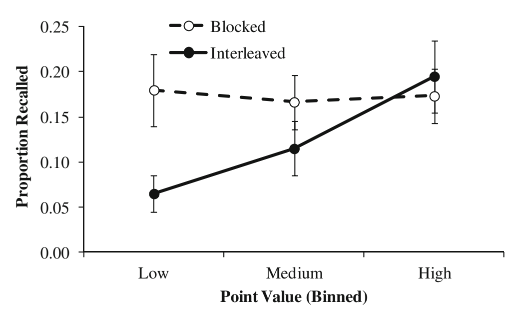

Fig. 6 Mean proportions of words falsely recalled as a function of binned value for both list structures in Experiment 3

General discussion

Three experiments provided evidence that the encoding of words paired with higher values increased true memory and, perhaps more important, false memory as well. Our finding that higher values were associated with better true memory lends further support for our ability to selectively direct our encoding strategies toward the most relevant information. However, this selectivity came at a cost: Attaching importance to information led to a greater vulnerability to false memories. Furthermore, our data suggest that the underlying mechanism of VDR is relational processing—a type of encoding that has been linked to increases in false recall (e.g., McCabe et al., 2004). Consistent with the relational processing hypothesis, reducing relational processing via item-specific processing (Experiment 2) reduced false memories in the high-value condition (where relational processing should be the greatest), and enhancing relational processing via a blocked list structure (Experiment 3) increased false memories in the low-value condition (where there should be a deficit in relational processing).

This study highlights a scenario in which increases in true memory are accompanied by increases in false memory. Although similar patterns have been obtained with manipulations of study list structure (e.g., McDermott, 1996; Toglia et al., 1999) and levels of processing (e.g., Rhodes & Anastasi, 2000; Thapar & McDermott, 2001; Toglia et al., 1999), some manipulations have also increased true memory while decreasing false memories, including instances with longer presentation times at the time of study (e.g., Gallo & Roediger, 2002) and increased study repetitions (e.g., Benjamin, 2001). In the context of the activation/monitoring framework, there are multiple ongoing processes in a DRM task that may compete, yielding different consequences for false memory. Manipulations that increase monitoring processes may lead to a reduction of false memories, whereas some manipulations may promote semantic activation without promoting monitoring processes (thereby increasing false memories). In a similar vein, FTT suggests that we encode both verbatim and gist traces in parallel and that both traces have opposing effects on false memories. False memories can be reduced under certain manipulations where verbatim traces serve as the basis for retrieval, whereas other manipulations may promote gist traces but not verbatim traces, thus increasing false memories. Regardless of the theoretical framework, we consistently found increases in false memories with higher value words, suggesting that monitoring (or recollection rejection) processes did not also increase with value to help suppress these false memories. However, these conclusions are preliminary, and study designs aimed at targeting these specific processes should be used for a stronger test of this hypothesis (cf. Gallo, 2010).

The results of Experiment 1 also demonstrate that the no-value group showed better discriminability between true and false recall, as compared with the value condition. In fact, in the no-value condition, recall for list words was as high as that for the high-value words in the value condition, and false recall was as low as that for the low-value words in the value condition. This may highlight the role of a limited attentional resources system in VDR tasks, in which VDR directs people as to how to allocate their already limited resources. Not surprisingly, people allocate cognitive resources toward encoding information through various ways (i.e., their own motivations, goals), and the results from our study suggest that VDR provides structure to that method, as well as a way to measure it. However, while selectively allocating attention is effortful and requires some level of cognitive control, it is quite possible that these attentional processes may rely less on cognitive control over time and become more automatic. Alternatively, one's goals and motivations may provide a more automatic/implicit form of control. However, more research is needed to test these ideas.

The finding of increases in both true and false memory is consistent with other memory research investigating the adaptive nature of memory (e.g., Nairne, Thompson, & Pandeirada, 2007; Otgaar & Smeets, 2010). Nairne et al. proposed that our memory systems have been shaped to help us remember information relevant to survival (i.e., securing food, water, or protection from predators). To provide evidence for this hypothesis, they showed that when people encode information by evaluating its relevance to survival, people subsequently remember more words, as compared with evaluating its relevance for moving to a new city or evaluating the pleasantness of the words (item-specific processing). In addition to enhancing subsequent true memory, survival processing also led to an increase in false memories, as measured by intrusions. Moreover, Otgaar and Smeets replicated this finding using the DRM paradigm: People increased both true and false memory with survival processing, as compared with evaluating an item's relevance for moving or making pleasantness ratings. Although speculative, the common increases in false memories as a function of processing relevance to survival and processing value may be due to shared underlying mechanisms (such as relational processing or activation of schemas/knowledge structures). What is clear is that both of these processes can be adaptive but, at the same time, come at a cost of memory accuracy.

Human memory has often been viewed as functioning in adaptive and highly effective ways. One way people maximize the efficiency of memory is to select what pieces of information are important to remember and ignore other pieces of information that are less relevant. Implicit in this efficiency is that not all memories are equally important. Because some information is simply more important to retain than other information, our memory system has adapted in such ways to be flexible in accommodating our complex and information-rich environment. However, it is important to consider that such flexibility comes at a cost and that we should be mindful of the memorial errors that are associated with prioritizing information.

Author Note We thank Roddy Roediger and Matt Rhodes for helpful comments at various stages of this work.

References

Ariel, R., Dunlosky, J., & Bailey, H. (2009). Agenda-based regulation of study-time allocation: When agendas override item-based monitoring. *Journal of Experimental Psychology. General, 138,* 432–447.

Baddeley, A., Lewis, V., Eldridge, M., & Thomson, N. (1984). Attention and retrieval from long-term memory. *Journal of Experimental Psychology, 113,* 518–540.

Benjamin, A. S. (2001). On the dual effects of repetition on false recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 941–947.

Brainerd, C. J., & Reyna, V. F. (2002). Fuzzy-trace theory and false memory. *Current Directions in Psychological Science, 11,* 164–169.

Castel, A. D. (2008). The adaptive and strategic use of memory by older adults: Evaluative processing and value-directed remembering. In A. S. Benjamin & B. H. Ross (Eds.), *The psychology of learning and motivation* (Vol. 48, pp. 225–270). London: Academic Press.

Castel, A. D., Benjamin, A. S., Craik, F. I. M., & Watkins, M. J. (2002). The effects of aging on selectivity and control in short-term recall. *Memory and Cognition, 30,* 1078–1085.

Castel, A. D., Farb, N., & Craik, F. I. M. (2007). Memory for general and specific value information in younger and older adults: Measuring the limits of strategic control. *Memory and Cognition, 35,* 689–700.

Castel, A. D., Murayama, K., Friedman, M. C., McGillivray, S., & Link, I. (2013). Selecting valuable information to remember: Age-related differences and similarities in self-regulated learning. *Psychology and Aging 28*, 232–242.

Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology. General, 125,* 159–180.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology, 58,* 17–22.

Dodd, M. D., & MacLeod, C. M. (2004). False recognition without intentional learning. *Psychonomic Bulletin and Review, 11,* 137–142.

Gallo, D. A. (2010). False memories and fantastic beliefs: 15 years of the DRM illusion. *Memory and Cognition, 37,* 831–846.

Gallo, D. A., & Roediger, H. L., III. (2002). The effects of associations and aging on illusory recollection. *Memory and Cognition, 31,* 1036–1044.

Hunt, R. R., & Einstein, G. O. (1981). Relational and item-specific information in memory. *Journal of Verbal Learning and Verbal Behavior, 19,* 497–514.

Hunt, R. R., & McDaniel, M. A. (1993). The enigma of organization and distinctiveness. *Journal of Memory and Language, 32,* 421–445.

Loftus, G. R., & Wickens, T. D. (1970). Effect of incentive on storage and retrieval processes. *Journal of Experimental Psychology, 85,* 141–147.

McCabe, D. P., Presmanes, A. G., Robertson, C. L., & Smith, A. D. (2004). Item-specific processing reduces false memory. *Psychonomic Bulletin and Review, 11,* 1074–1079.

McDermott, K. B. (1996). The persistence of false memories in list recall. *Journal of Memory and Language, 35,* 212–230.

Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33,* 263–273.

Otgarr, H., & Smeets, T. (2010). Adaptive memory: Survival processing increases both true and false memory in adults and children. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36,* 1010–1016.

Perez-Mata, M. N., Read, J. D., & Diges, M. (2002). Effects of divided attention and word concreteness on correct recall and false memory reports. *Memory, 10,* 161–177.

Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences, 7,* 1–75.

Rhodes, M. G., & Anastasi, J. S. (2000). The effect of a levels of processing manipulation on the incidence of false recall. *Psychonomic Bulletin and Review, 7,* 158–162.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 803–814.

Roediger, H. L., Balota, D. A., & Watson, J. M. (2001a). Spreading activation and the arousal of false memories. In H. L. Roediger, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 95–115). Washington, DC: American Psychological Association Press.

Roediger, H. L., Watson, J. M., McDermott, K. B., & Gallo, D. A. (2001b). Factors that determine false recall: A multiple regression analyses. *Psychonomic Bulletin and Review, 8,* 385–407.

Smith, R. E., & Hunt, R. R. (1998). Presentation modality affects false memory. *Psychonomic Bulletin and Review, 5,* 710–715.

Soderstrom, N. C., & McCabe, D. P. (2011). The interplay between value and relatedness as bases for metacognitive monitoring and control: Evidence for agenda-based monitoring. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 1236–1242.

Thapar, A., & McDermott, K. B. (2001). False recall and false recognition induced by presentation of associated words: Effects of retention interval and levels of processing. *Memory and Cognition, 29,* 424–432.

Toglia, M. P., Neuschatz, J. S., & Goodwin, K. A. (1999). Recall accuracy and illusory memories: When more is less. *Memory, 2,* 233–256.

Tulving, E. (1969). Retrograde amnesia in free recall. *Science, 164,* 88–90.

Tussing, A. A., & Greene, R. L. (1997). False recognition of associates: How robust is the effect? *Psychonomic Bulletin and Review, 4,* 572–576.