DURATION AND WARNING WORK INDEPENDENTLY TO REDUCE FALSE MEMORIES IN DRM AND HOMOGRAPH LISTS

by

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ABSTRACT

Two experiments examined the effects of forewarning and presentation duration on false memory. Durations of 1000 ms and 3000 ms were used to present words in DRM lists containing 12 words which converged onto the same meaning of a critical nonpresented word and homograph lists containing 6 words that converged onto a different meaning of a critical nonpresented word. Associative strength from list items to critical items was equated across list types. In Experiment 1 participants were warned of the tendency of the lists to bring to mind a nonpresented critical word and were instructed to write down their guess as to the identity of that word following presentation of each list. Participants identified DRM critical words more frequently than homograph critical words. In Experiment 2 half of the participants were warned of the tendency of the lists to bring to mind a nonpresented critical word, and half were not. Following the presentation of each list all participants were instructed to recall the words for the lists. Veridical and false recall was examined. Recall of list items was greater than recall of critical items. As presentation duration increased, false memory decreased and veridical memory increased. Overall, recall was greater without a warning than with a warning, and the effects of forewarning and presentation duration were additive. False recall was greater for homograph lists than for DRM lists at short durations and under unwarned conditions. Also, warning significantly reduced false recall for homograph lists only despite the fact that Experiment 1 demonstrated DRM critical items to be easier to identify. These results suggest that separate processes drive false memory attenuation for increased presentation duration and forewarning, and that warning does not reduce false memory via critical word identification and exclusion. The effects of warning and duration are discussed in terms of a criterion shift strategy for warning an activation monitoring strategy for presentation duration.

INTRODUCTION

"There was a man named Laderecha . . . with certain details that I shall recount. I shall set them down here for what they are worth and with no further assurances as to their veracity since both forgetfulness and recollection are creative" (Borges, 1998, p. 386).

Human awareness feels seamless and true as each idea flows logically forward to the next and then just as effortlessly backward. But what seems to be true often is not, and as Borges warned, recollection can stray from truth just as forgetfulness. As such, what an unchartable landscape the mind must be with terrain that evolves according to subjectivity rather than natural law. From this perspective, the mechanisms of memory may appear incredibly perplexing. However, like many other mysteries of the mind, the most telling clues often lie not in what our minds are doing right, but in what they are doing wrong. Just as early neuroscientists determined the localization of many brain functions by observing patients with brain damage, researchers of memory have begun to assemble a picture of how memory functions correctly by studying memories that have gone awry.

Interest in false memories, either remembering events that never occurred or remembering them differently than they actually occurred (Roediger & McDermott, 1995), was generated in the 1990s as a result of a number of cases in which patients undergoing psychotherapy reported uncovering memories of abuse of which they were unaware and as it turned out, often never occurred (Loftus, 1993). This brought to light the need to understand the cognitive processes that give rise to false memories and spurred a profusion of research in the area. Earlier, Deese (1959a, 1959b) launched experimental investigations of false memory in which he provided participants with lists of items that varied in associative strength and found that lists whose items were strongly associated with a particular nonpresented item often led to the false recall of that item at test. Deese's finding eventually made a contribution to the study of false memory; however, it did not make a huge impact at the time because trends in memory research focused on veridical rather than false memory. In 1995, during a period of renewed interest in false memory, Roediger and McDermott replicated and popularized Deese's original findings as well as coined the term *DRM (Deese, Roediger, and McDermott) paradigm* to refer to experiments that present list of words which lexically converge onto a single nonpresented critical item, which is often falsely remembered as being actually presented. Currently, the DRM paradigm remains the most powerful tool for false memory induction within the laboratory.

Spreading Activation Theory versus Fuzzy Trace Theory

More than ten years have passed since Roediger and McDermott (1995) revived Deese's research. During this decade, research in the DRM paradigm has been guided by two main theories; fuzzy-trace-theory (Brainerd & Reyna, 1990, 1998, 2002) and spreading activation theory (Anderson, 1983; Roediger, Balota, & Watson, 2001; Roediger & McDermott, 1995; Roediger, Watson, McDermott, & Gallo, 2001). Both attempt to explain the cognitive processes that give rise to false memory. Roediger and McDermott (1995) argued that associative processing models (Raaijmakers & Shiffrin,

1980) can account for their false memory findings. These models hold that when a word is encountered, it activates a concept node in the brain and this activation spreads to related nodes; the stronger the relation between the two nodes, the more activation spreads between them. In the DRM paradigm all list items are highly related to a critical non-presented item so the critical item is activated every time a list item is encountered. The summing of activation over time could bring the critical item to mind consciously or activate it nonconsciously during study. In either situation, the critical item seems very familiar during recall and, as a result, false memory occurs if the participant mistakenly attributes the activation to actually viewing the list item. Further, others have argued that associative activation can occur at the lexical (word), rather than at the semantic level, and therefore does not necessitate the extraction of meaning (Balota & Paul, 1996; Hutchison & Balota, 2003). In contrast, fuzzy-trace theory of memory does (Brainerd & Reyna, 1990, 1998, 2002). This theory explains memory based on the principles of the fuzzy-to-verbatim continuum in which memory representations differ in the precision with which they specify the event. Verbatim memory is very precise and includes item specific presentation details. Gist memory is less precise, capturing the overall theme of an event rather than item specific details. “Gist memory” is thought to give rise to false memory. Fuzzy-trace-theory assumes that because list items are related in meaning to one another, an overall meaning or gist of the list is extracted which facilitates gist-based processing of the critical item because it is so similar to the overall theme of the list (Brainerd & Reyna, 2002).

Hutchison and Balota (2005) tested these theories. They were interested in how the increase from 6-item to 12-item lists affected false memory. In addition, they studied whether it mattered if the extra 6 words converged onto the same meaning of the critical item or onto a different meaning of the critical item. They presented participants with two different types of lists: DRM lists, in which all items converged onto the same meaning of a critical word and homograph lists, in which half of the items converged onto one meaning of the critical item and half of the items converged onto another meaning of the critical item. For example, the DRM list corresponding to the critical item, *sleep* included the following words: *snooze, wake, bedroom, unconscious, deep, blanket, slumber, lay, motel, trance, lazy, nightmare,* which all converged onto the same meaning of the critical item. On the other hand, the homograph list for the critical item, *fall*, included the following words: *stumble, slip, rise, trip, faint, autumn, season, spring leaves, brisk, harvest*, in which half of the words corresponded to the verb meaning (to fall) and half corresponded to the noun meaning (the season fall) of the critical item.

In this scenario, fuzzy-trace theory and spreading activation theory make contradicting predictions regarding false memory of critical items. If false memory is based on a gist-encoding process, the critical item should be recalled less frequently in the homograph lists than in the DRM lists because the dual meanings presented in the homograph lists should disrupt gist-based processing. If false memory is instead based on spreading activation for list items, there should not be a significant difference in the frequency of false memories between the two list types, despite impaired gist-encoding. The results of four recall experiments and one recognition experiment supported the spreading activation interpretation of false memory in the DRM paradigm. Equal false memory was found for DRM and homograph lists across tasks, as well as across presentation durations between 80 and 1200 ms. Also, alternating meanings for homograph lists (as opposed to blocking meanings) impaired veridical recall but did not affect false recall. However, changing the presentation order of DRM lists did not affect either veridical or false recall. Overall, this pattern provided very strong evidence in favor of spreading activation over a gist-based fuzzy trace explanation. Their investigation provides empirical evidence suggesting that false memory in the DRM paradigm is largely the result of lexical/associative activation rather than the formation of a thematic, gist-based representation. Hutchison and Balota conducted a final experiment in which the recognition decision was replaced with a relatedness decision. The DRM critical items were judged as more related to the preceding study list than homograph critical items. The final experiment confirmed that indeed the DRM critical items matched the gist of the study list better than the homograph critical items did.

The Effects of Presentation Duration and Warning on Recall of DRM Lists

Experiment 3 of Hutchison and Balota's (2005) manipulated presentation duration and found that veridical memory increased across presentation durations of 80, 200 and 1200 ms. Increasing presentation duration had the opposite effect on false memory; false memory decreased across presentation durations of 200 and 1200 ms. Like Hutchison and Balota (2005), McDermott and Watson (2001) also found that false recall decreased for semantically associated lists as presentation duration increased from

250 ms, to 5000 ms. However, they observed an increase in both veridical and false memory as durations increased from 20 ms to 250 ms. Presentation duration was also manipulated by Gallo and Roediger (2002) who constructed lists that were either highly or weakly associated to a critical non-presented item and tested recall for these lists after they were presented at three different presentation durations: 500, 1000, and 3000 ms. They also found that slower presentation durations yielded lower levels of false recall and this pattern occurred for both strongly and weakly associated lists. McCabe and Smith (2002) investigated the difference between false recognition in young and older adults, using auditory presentation of lists at two different presentation rates: 2000 and 4000 ms per word. They found that longer durations improved veridical memory but did not significantly reduce false memory, however, this effect of varied for young and older adults in which increased presentation rates benefited young adults, but not older adults.

Forewarning, or making people aware of the DRM effect has also been shown to reduce false recall and false recognition (Endo, 2005; Gallo, Roberts, & Seamon, 1997; McCabe & Smith, 2002; McDermott, 1998; Watson, Bunting, Poole, & Conway, 2005; Watson, McDermott & Balota, 2004). However, the strength and nature of this effect is more variable. Different strengths of the effect of warning have been reported based on how the warning is worded (Gallo, et al., 1997), individual differences in working memory capacity (Watson, et al., 2005), age differences (McCabe & Smith, 2002), time at which the warning is given (McCabe & Smith, 2002; Neuschatz, Payne, Lampineu, & Toglia, 2001) and whether or not critical items are sometimes actually presented in the list (McDermott & Roediger, 1998).

Interested in whether people can avoid DRM false memory if they are forewarned about it, Gallo, Roberts, and Seamon (1997) conducted a DRM recognition test under three different conditions: an unwarned condition, a condition in which participants were urged to be cautious because some nonpresented words would be similar to studied words, and a condition in which participants were explicitly warned about the false memory effect. Participants in the explicitly warned group had a lower overall hit rate (responding *old* to previously presented items) for studied items as well as a lower false alarm rate (responding *old* to items not previously presented) for critical lures than participants in the unwarned group and a similar hit rate but lower false alarm rate compared to participants in the cautious group. Their results indicate that warning can reduce, but not eliminate, DRM false recognition.

McDermott and Roediger (1998) manipulated warning in a recognition experiment in which half of the study lists actually presented the critical item and half of the study lists did not. They found that warning reduced hit rates for both nonpresented critical items as well as standard presented list items, but that it did so more for nonpresented critical items than for the standard presented list items. Although their effect of warning was significant, it was surprisingly slight. This may have been due to participants' awareness that critical items may or may not have been presented at study. In a similar experiment, Gallo, Roediger, and McDermott (2001) manipulated warning and critical item presentation in 4 different conditions. In the first three conditions, 6 DRM lists were presented with or without their critical items. In the first of these three conditions, no warning was given. The second condition warned participants before study, and the third condition warned participants after study. The final condition warned participants after study but omitted critical items in all 12 lists. They found warning before or after study reduced false recognition. However, when the warning came after study this decrease was only seen for the warned condition in which critical items were omitted from all 12 lists. In this condition, reduced false memory was observed for both veridical and false memory suggesting that if participants are aware that critical items will not appear in the study lists, they likely adopt a conservative criterion-shift strategy to reduce false recognition.

Based on experiments by McCabe and Smith (2002), and Watson et al. (2005), it appears that working memory capacity plays a role in the effectiveness of warning. Watson et al. found that warnings were only effective at reducing false recall for individuals with high working memory capacity. Those with low working memory capacity were unable to significantly reduce false recall even when they were warned of the DRM effect, shown sample DRM lists and their corresponding critical items, and explicitly asked to avoid recalling critical items. McCabe and Smith (2002) found similar differences in false recognition between young and older adults; older adults were less able to discriminate between presented items and critical lures under warned conditions than younger adults. Their findings support Watson et al. because working memory capacity tends to decline with age. However, McCabe and Smith (2002) complicated this distinction due to procedural differences in their experiment. The point in the experiment when the warning was given was not the same. The difference in the ability of older and young adults to discriminate presented items from nonpresented items was only observed when warning instructions were given after study and before the recognition test. When warning instructions were given before study, no differences were seen between age groups. This contradicts a report by Neuschatz, Payne, Lampineu, and Toglia (2001) who found that warning did not reduce false memory on either recall or recognition tests. Neuschatz et al. used introductory psychology students (presumably young adults), but the warning itself differed in their experiments from the warning that McCabe and Smith (2002) used. Neuschatz et al. warned participants of the DRM effect and encouraged them to use an explicit source monitoring strategy of subjectively identifying phenomenological differences such as sound memory, memory of list position, and memory of list item associations to guide their decisions. McCabe and Smith simply warned participants of the effect without encouraging any particular strategy.

Possible Explanations for the Effects of Duration and Warning

In a DRM situation, source monitoring involves distinguishing the source of the accumulated activation of the critical nonpresented word. Essentially, the participant must decide whether the critical item seems familiar due to its actual presentation, or if it simply comes to mind because it is related to all the other words in the list that were presented. Memory for item-specific details could aid in this task by providing a form of verification as to whether an item was actually encountered. For example, if participants could remember the font of a visually presented item, its position in the list, or a distinct combination of letters that comprised the item, they could potentially use this information to verify that the item was actually presented. On the other hand, if participants can not bring to mind any of these item specific details for a word in question, then they could use this lack of information to verify that the word was not actually presented.

Across experiments manipulating presentation duration, a fairly consistent pattern emerges. At very short presentation durations, false memory and veridical memory tend to increase although, at longer presentation durations, false memory tends to decrease while veridical memory increases. Possible explanations of the effects of manipulated presentation duration must account for how presentation duration differently affects veridical and false memory. Because of the dissociation of duration on veridical and false memory, and the U-shaped false memory function over durations, a single process theory, such as a criterion shift, cannot account for the effect (McDermott & Watson, 2001). Activation monitoring theory holds that at short durations, unregulated automatic spreading activation boosts both veridical and false memory. At longer durations a second process, consciously controlled source monitoring, is aided by increased time for processing of item-specific details during study. The notion that increased presentation duration might cause an overall increase in memory strength also seems to fit the pattern reasonably well. Following the logic that if memory strength increases with presentation duration, false memory should decrease while veridical memory increases because of memory strength’s facilitation of memory for item-specific information.

A single explanation for the effects of warning is not as easy to pin down because there appears to be more variability in the results of warning manipulations from study to study. Based on the literature, four possible explanations emerge. First, warned participants could create a guessing strategy in which they come to expect the relation of the list items to the critical item, and this strategy could then enabled them to consciously identify the critical item in order to deliberately exclude it. If this were true, then it would be expected that the frequency of false memory would decrease across warning but veridical memory would remain unchanged. However, there is also the chance that the cognitive resources required to guess the critical item could interfere with veridical recall. If this were the case, it would be expected that warning would reduce veridical and false memory, and this reduction would be quite greater for false memory than for veridical memory. Second, warning could increase item-specific encoding by leading participants to pay closer attention to these types of details. Here again, a reduction in false memory and an increase in veridical memory would be expected under warned conditions. Third, warning could lead to a criterion shift where warned participants adopt a more conservative response criterion. In this situation, there would not be a reciprocal relationship and instead, warning would reduce false and veridical memory equally. Finally, warning could encourage more careful source monitoring by causing participants to devote more concern to whether or not an item was actually presented, thereby increasing veridical memory and reducing false memory.

Of these possibilities, the first is the most intuitive. Consider the plight of the participants. In a warned DRM condition they are told that a trick is going to be played on them and then the nature of the trick is revealed. It seems obvious that their first strategy would be to use the nature of the trick to guess their way out of folly. Other mentioned possibilities, such as increased item-specific processing and careful source-monitoring could contribute to the effect, but if conscious identification of DRM critical nonpresented items is possible, it seems like deliberate exclusion of these items would be the preferred strategy. If this is the case it would be expected that warning and duration manipulations would interact, causing warnings to be more effective at longer presentation durations. However, if the retention interval is too long, or if a large number of lists are administered before test, then participants might forget that they identified the critical item during study, thereby mistaking it to have been previously presented. This alternative would predict an interaction in the opposite direction.

Past Explanations for Effects of Presentation Duration and Warning

McDermott and Watson (2001) argued in favor of activation monitoring theory, claiming that at fast presentation durations, automatic spreading activation essentially goes unchecked, resulting in high levels of false memory. As time passes the more strategically controlled process of monitoring is enabled which can oppose the tendency to recall highly activated, but nonpresented words. Both Gallo and Roediger (2002) and Hutchison and Balota (2005), interpreted their findings as support for an activation/monitoring framework that corroborated with the results of McDermott and Watson's (2001) experiment. Because they found that false memory decreased as presentation duration increased for both strongly and weakly associated lists, Gallo and

Roediger concluded that it is likely that slower presentation of list items allows greater accumulation of item-specific information which facilitates source monitoring at retrieval. Better source monitoring could improve veridical memory and also reduce false memory.

Although the effects of warning vary from one experiment to the next, one thing that remains fairly consistent is the presumed strategy causing the effects. Gallo, et al. (1997) suggested that warning instructions given prior to study reduce the likelihood of false memories by encouraging participants to identify critical items in order to exclude them from recall. They even bolstered this conclusion with post-study questionnaire responses. Participants who were forewarned generally claimed to have tried to determine and remember each list's critical lure in addition to focusing on each list's theme, whereas participants who were only told to be cautious tended to report that they used elaborative rehearsal in order to remember words.

Perhaps because of the intuitiveness of the strategy as well as participants' self-reported use, the idea caught on and has been used to explain other patterns of warning effects. Waston et al. (2004) and Watson et al. (2005) cited Gallo et al.'s suggestion as the probable explanation for false memory attenuation under warned conditions. Watson et al. (2005) conceptualized Gallo's theory as a working memory task where warning activates a task goal that must be maintained in order to effectively avoid false memory. Thus, under warned conditions individuals with high working memory capacity are able to maintain the task goal of conscious identification of the critical item whereas individuals with low working memory capacity are not. Gallo et al. (2001) reiterated the conscious identification strategy by assuming that when warned before study, participants were able to identify the critical item as well as realize that it was not studied and then use this information at retrieval to reduce false memory. Finally, McCabe and Smith (2002) also endorsed this notion, but noted that the strategy is probably only used when warnings are given prior to study. When warnings are given at retrieval, they proposed that false memory reductions occur due to a more conservative criterion shift.

Building on the findings of Hutchison and Balota (2005) and assuming critical item identification can and does occur when warned of the deceptive nature of DRM lists, two questions arise. First, does guessing depend upon duration? In other words, when warned, are critical items more identifiable at longer presentation durations? This is a possibility, given that both manipulations could potentially exert their influence by facilitating guessing of the critical item. Figure 1 displays the predicted pattern of such an interaction. Figure 2 displays the predicted pattern if warning and duration are independent. If the effects of duration and warning are additive, then it is reasonable to assume that the effects of each variable are independent of one another and involve separate cognitive processes (Sternberg, 1998). Second, does guessing depend upon list type? In their final experiment, Hutchison and Balota (2005) found that participants judged the critical items of DRM lists to be more related to their list items than they did the critical items of homograph lists. This greater sense of relatedness has the potential to give DRM lists an advantage over homograph lists when critical item guessing is engaged.

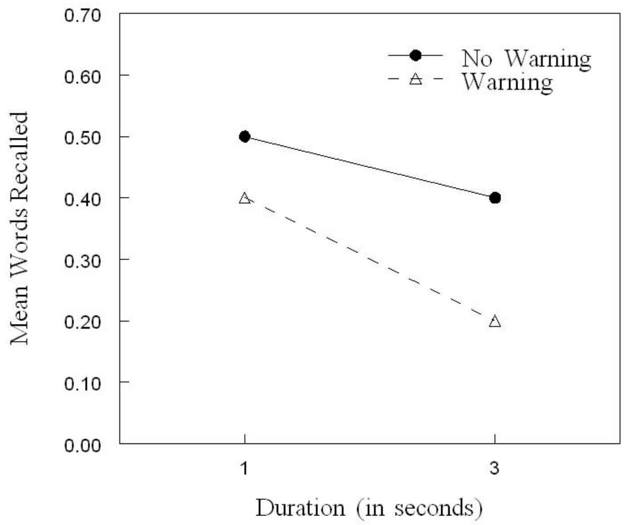

Figure 1. Hypothetical Interactive Effects of Warning and Duration on False Recall in DRM and Homograph lists.

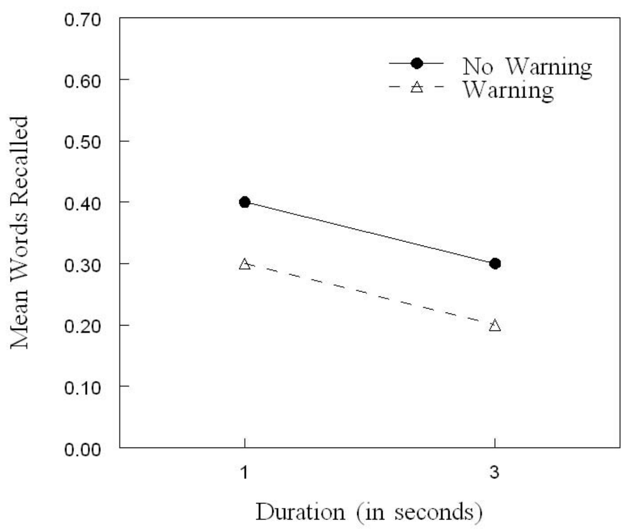

Figure 2. Hypothetical Additive Effects of Warning and Duration on False Recall in DRM and Homograph Lists

EXPERIMENT 1

Experiment 1 attempted to answer these questions by informing participants of the tendency of the lists to bring to mind a related word that was never, in fact, presented. Their single task was to view the lists with the sole purpose of guessing the nonpresented critical item. Both DRM and homograph lists were presented at either 1000 ms or 3000 ms.

Method

Participants

A total of 64 male and female undergraduate students enrolled in introductory communications and psychology courses at Montana State University participated to fulfill a research requirement of these courses. All participants were native English speakers with normal or corrected-to-normal vision. Use of human participants was approved by the Montana State University Institutional Review Board.

Materials

A subset of the lists used by Hutchison and Balota (2005) were used in this experiment. A total of 14 of their 18 lists were used for each list type (DRM and homograph lists). Lists were equated on backward association strength (BAS), the probability that the critical item would be the first word to come to mind when presented the list items in a word association test. These were obtained from the Nelson et al. (1999) word association norms. The average BAS per word was 0.12 in homograph lists and 0.11 in DRM lists t(26) < 1, $p < .163$. Study lists were structured so that for each study trial participants received either a 12-item homograph list or a 12-item DRM list. The 12-item lists were comprised of two, 6-item sublists of the same meaning (DRM) or two, 6-item sublists of different meanings (homograph). The first word presented was from sublist 1 for half of the participants. For the other half of the participants, the first word presented was from sublist 2. Two different fixed-random lists were used. Presentation of items from two, 6-item sub-lists was altered.

Each participant was given a response sheet on which to write his or her critical item guesses. Sheets were numbered according to each trial. They were also given a blank manila folder to use to keep their answers private.

Design

A 2 × 2 within subjects design was used. The independent variables were list type (DRM or homograph) and presentation duration (1000 ms or 3000 ms). Presentation duration and list type were counterbalanced across participants. List items were taken from DRM or homograph lists that contained 12 related words. The dependent variable was correct critical item guesses.

Procedure

Participants were tested in pairs or individually. After informed consent was obtained, they were lead to the experimental room and seated about 60 cm away from a computer monitor. They were then told to read the instructions on the computer screen. Instructions read, “This is a study investigating false memories, the recall of words not presented in a study list. In this study you will see 12 words shown for either 1 second or 3 seconds each. Each of the words is related to a ‘critical’ nonpresented target word. After each list, you will be asked to simply write down your best guess as to the identity of the ‘critical’ nonpresented word. Please make only 1 guess per list. Press the ‘S’ key for sample lists.” The experimenter coached participants by guessing the critical item in a sample DRM list corresponding to the critical item *army* and a homograph list corresponding to the critical item *fly*. The experimenter remained in the room throughout the experiment in order to monitor the privacy of the responses and reduce cheating problems. Each experimental session ran for approximately 30 minutes. At the end of the experiment participants were debriefed and excused.

Results and Discussion

A repeated-measures ANOVA was used to analyze the data. The within-subjects variables were presentation duration (1000 ms vs. 3000 ms) and list type (DRM vs. homograph).

A main effect of list type $F(1, 63) = 10.94$, $p = .005$, was found. Participants were able to identify the critical items of DRM lists (M =68.6%) significantly more often than they were able to identify the critical items of homograph lists (M = 61.7%), d = .26). There was no effect of presentation duration nor was there and interaction between presentation duration and list type (both F’s < 1).

Contrary to the first predication, duration had no effect, suggesting that guessing does not depend on duration. However, it was easier to guess the critical items of DRM lists than the critical items of homograph lists. The main effect of list type implies that if the decrease in false memory observed under warned conditions is attributable to conscious guessing and deliberate exclusion, then the effect of warning should be greater for DRM lists compared to homograph lists.

EXPERIMENT 2

The finding of Experiment 1 indicated the need for additional investigation to resolve two questions. Do warning and presentation duration interact in a DRM experiment such that warning depends on duration, or are the effects additive? If there is an interaction, then it can be assumed that the same mental process accounts for both effects; however, if the effects are additive there is evidence they are driven by separate processes (Sternberg, 1998). Second, do warning and increased presentation duration reduce false memory more for DRM than for homograph lists? This is predicted if warning effects are attributable to participants guessing the critical item during study. Experiment 2 attempted to resolve these two questions by manipulating duration and warning in a false memory experiment with DRM and homograph lists.

Method

Participants

A total of 128 male and female undergraduates enrolled in introductory communications and psychology courses at Montana State University participated to fulfill a research requirement of these courses. All participants were native English speakers with normal or corrected-to-normal vision. Use of human participants was approved by the Montana State University Institutional Review Board.

Materials

Materials were identical to those used in Experiment 1 except that the recall sheets contained 12 blank lines per list rather than 1.

Design

A 2 × 2 × 2 mixed model design was used. Forewarning (forewarning vs. no forewarning) represented the independent, between-subjects variable. Half of the participants were aware of the DRM false memory effect at the beginning of the experiment. There were three within-subject variables in the design: list type (DRM vs. homograph), presentation duration (1000 ms vs. 3000 ms) and study status (list item vs. critical item). Presentation duration and list type was counterbalanced across participants. List items were taken from DRM or homograph lists that contained 12 related words. Free recall performance of studied items and critical items served as the dependent variable for all participants.

Procedure

Participants were tested either individually or in pairs. After informed consent was obtained they were lead to the experimental room and seated about 60 cm from a computer monitor. They were then told to read the instructions on the computer screen. Instructions differed slightly between the two conditions. No warning condition instructions read, “In this study you will see twelve words shown for either one second or three seconds each. After each list you will be given 1 minute to recall as many words as possible by writing them down on the blank sheet in your booklet.” The forewarning condition instructions read, “This is a study about false memories, the recall of words not presented in a study list. In this study you will see twelve words shown for either one or three seconds. Each of the words is related to a ‘critical’ non-presented target word.” They were then given the same two sample lists from Experiment 1; one was a DRM list, and the other, a homograph list. Participants were told to guess the critical non-presented target word out loud. Once they had accomplished this they were instructed to, “Try to recall as many actual list items as possible, but avoid recalling the critical non-presented target.”

The experiment began and participants viewed 28 lists of 12 words centered on the monitor in uppercase letters. The words were presented for 1000 ms in half of the lists and 3000 ms for the other half. Each word was preceded by an inter-stimulus interval of 300 ms. Participants saw 1 of 2 possible randomized list orders, and lists were counterbalanced across duration. Following each list a screen appeared instructing participants to recall the list items. The experimenter timed the recall session for 60 s. At the end of the minute participants were instructed to press the “S” key for the next list. Each experimental session ran for approximately one hour. At the end of the experiment participants were fully debriefed and excused.

Results and Discussion

A repeated measures ANOVA was performed on the within subjects variables of presentation duration (1000 vs. 3000), study status (list item vs. critical item), and list type (DRM vs. homograph) and the between subjects variable of warning (unwarned vs. warned).

As predicated, there was a significant main effect of study status *F*(1, 126) = 430.04, $p < .001$ and of presentation duration *F*(1, 126) = 18.73, $p < .001$. Recall of list items (*M* = 55.1%) was higher than recall of critical items (*M* = 21.7%), *d* = 2.06. Recall was higher for presentation durations of 3000 ms (M = 39.8) than for presentation durations of 1000 ms (*M* = 37.0%), *d* = 0.12. The interaction between study status and presentation duration was also significant *F*(1, 126) = 127.97, $p < .001$. False recall of critical items was lower at the 3000 ms presentation durations (*M* = 18.8%) than at 1000 ms presentation durations (*M* = 24.6%), *d* = 0.29 while veridical recall of list items was significantly 11.4% ± 1.0% higher at 3 second presentation (*M* = 60.8%) durations than at 1 second presentation durations (*M* = 49.4%), *d* = 1.15. This replicates prior research. Figure 3 displays this interaction.

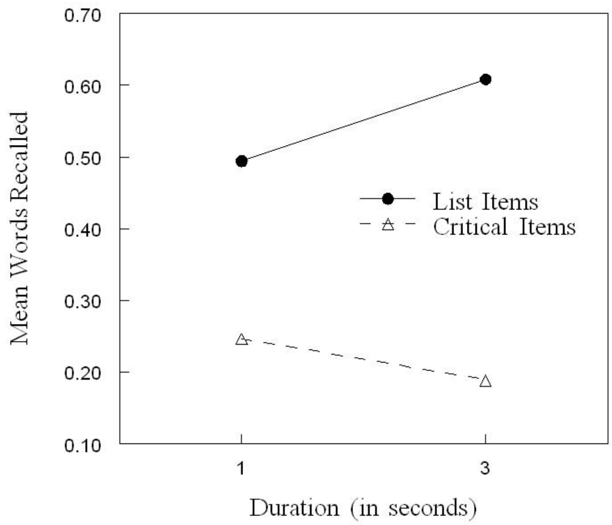

Figure 3. Interaction between presentation duration and study status on words recalled in DRM and homograph lists.

A significant main effect of warning was found *F*(1, 126) = 6.56, *p* = .012. Recall for warned participants was lower (*M* = 36.6%), than recall for unwarned participants (*M* = 40.2%), *d* = 0.15. However, there was no interaction between study status and warning *F*(1, 126) = 2.04, *p* = .115 indicating that warning reduced recall equally for list items and critical items. Figure 4 displays this relationship.

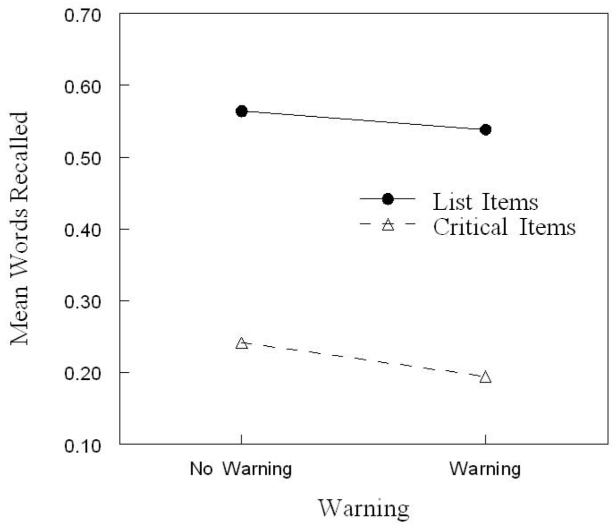

Figure 4. Additive effects of warning and study status on words recalled in DRM and homograph lists.

The effects of warning and presentation duration also did not interact, thus their effects on recall were additive

A significant main effect of list type was found *F*(1, 126) = 6.01, *p* = .016, with recall 1.7% ± 1.4% higher for homograph lists (*M* = 39.3%) than for DRM lists (*M* = 37.5%), *d* = 0.08. There was a marginally significant three-way interaction of study status, list type, and warning *F*(1, 126) = 3.81, *p* = .053. Recall of critical items in the no warning condition was higher for homograph lists (*M* = 26.4%) than for DRM lists (*M* = 21.8%), but warning diminished this difference as it had a greater effect on homograph lists than DRM lists. Recall of list items was higher for homograph lists (*M* = 54.5%)

than for DRM lists (*M* = 53.0%) under warned conditions, but no difference was seen between list types for critical item recall under unwarned conditions.

Finally, there was also a marginally significant three-way interaction of presentation duration, study status, and list type $F(1, 126) = 3.13$, $p = .079$. Recall for list items was higher at 3000 ms than at 1000 ms for both DRM and homograph lists. In contrast, false recall for critical items was lower at 3000 ms than 1000 ms for DRM and homograph lists, respectively. Thus, although, increasing the presentation duration improved veridical memory and reduced false memory for both types of lists, this pattern was enhanced for homograph lists relative to DRM lists. Homograph list items benefited from the increased presentation duration more than DRM list items. Due to these marginally significant interactions involving study status, further analysis was needed to examine the differential effects of warning and duration on list items and critical items.

<u>List Items</u>

There was a main effect of presentation duration $F(1, 126) = 485.20$, $p < .001$. Veridical memory was higher at the 3000 ms durations (*M* = 60.85) than at 1000 ms durations (*M* = 48.0%), $d = 0.29$. There was also a marginally significant main effect of warning $F(1, 126) = 3.11$, $p = 0.08$. Veridical memory was higher in the no warning (*M* = 56.4%) condition than in the warned condition (*M* = 53.8%). The interaction between presentation duration and warning was not significant $F(1, 126) = .185$, $p = .688$. Figure 3 displays this additive pattern.

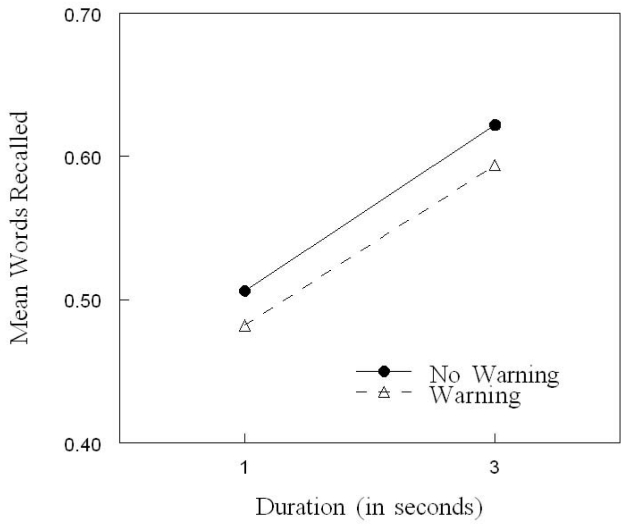

Figure 5. Veridical memory: Additive effects of warning and duration in DRM and homograph lists.

A main effect of list type *F*(1, 126) = 5.84, *p* = .017 was found. Veridical memory was significantly higher for homograph lists (*M* = 55.7%) than for DRM lists (*M* = 54.5%), *d* = 0.11. This interacted with presentation duration *F*(1, 126) = 4.86, *p* = .029. Longer presentation durations increased veridical memory for both DRM (M = 54.5%) and homograph lists (*M* = 55.7%) At 1000 ms durations veridical memory was the same for homograph lists (*M* = 49.4) and DRM lists (*M* = 49.4). However, at 3000 ms durations veridical memory for homograph lists (*M* = 62.0%) was significantly higher than veridical memory for DRM lists (*M* = 59.6%), d = 0.22. Longer presentation durations gave homograph lists an advantage over DRM lists.

<u>Critical Items</u>

There was a main effect of duration *F*(1, 126) = 19.08, *p* < .001. False memory was significantly lower at the 3000 ms duration (*M* = 18.8%) than at 1000 ms duration (*M* = 24.6%), *d* = 2.96. The effect of warning was marginally significant *F*(1, 126) = 3.14, *p* = .079. False memory was lower in the warned condition (*M* = 19.4%) than in the unwarned condition (*M* = 24.1%), *d* = 0.24. As with list items, the interaction between warning and duration was not significant *F*(1, 126) = 1.140, *p* = .288. Figure 4 displays this additive pattern for false memory.

There was a marginally significant effect of list type *F*(1, 126) = 2.95, *p* = .088. False memory was higher for homograph lists (*M* = 22.7%) than for DRM lists (*M* = 20.6%). The interaction between duration and list type was not significant *F*(1, 126) = 1.14, *p* = .288. There was also a marginally significant interaction between list type and warning *F*(1, 126) = 3.25, *p* = .074. A significant difference between false memory in DRM (*M* = 21.8%) and homograph lists (*M* = 21.8%), was only found in the no-warning condition but there was no difference between the list types in the warned condition. Also, warning significantly reduced false memory only for homograph lists (M = 19.3%) but not DRM lists (*M* = 19.4%) *d* = 0.36. This is interesting and unexpected given the results of Experiment 1 where participants found it to be easier to consciously guess DRM critical items than homographs critical items.

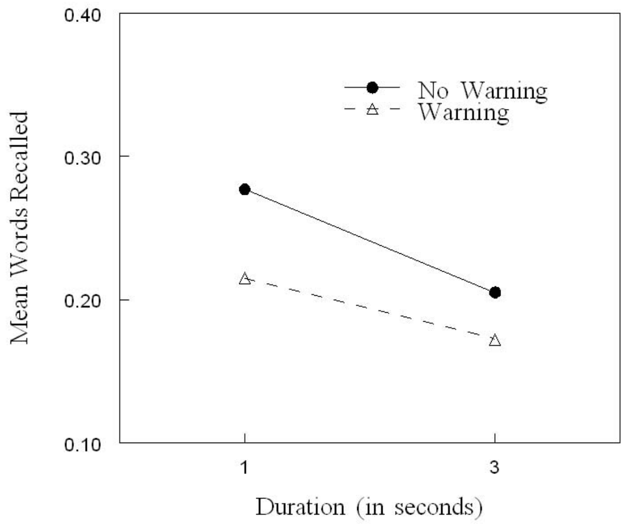

Figure 6. False memory: Additive effects of warning and duration in DRM and homograph lists.

An additional analysis was conducted in which items rather than participants were treated as a random variable in order to examine the effects of warning and duration on false memory for the critical items themselves. A repeated measures ANOVA was conducted on the within items variables of warning and presentation duration and the between items variable of list type. This analysis revealed a significant effect of duration $F(1, 26) = 15.96$, $p < .001$ and warning $F(1, 26) = 11.61$, $p = .002$, but no effect of list type $F(1, 26) = .355$, $p = .557$. Again, the interaction between warning and duration was not significant and the additive effects continued to suggest that separate processes drive false memory reduction via duration and forewarning.

An ANCOVA was conducted, treating BAS as a covariate. No difference between DRM and homograph lists was found $F(1, 25) = .098$, $p = .757$. The effect of BAS was significant $F(1, 26) = 5.26$, $p = .031$. There was a significant warning by BAS interaction $F(1, 26) = 5.43$, $p = .026$, as well as a significant duration by BAS interaction $F(1, 26) = 11.59$, $p = .002$.

Correlation analyses were also performed. Table 1 displays correlations between conditions, BAS, and identifiability. Critical item false recall significantly correlated with BAS $r(222) = .600$ at the 1000 ms duration when no warning was given. However, BAS was not correlated with false memory when presentation durations increased or when a warning was given. The difference between recall in the no warned condition and the warned condition significantly correlated with BAS, $r(110) = .573$. Furthermore, critical item identifiability based on Experiment 1 did not correlate with critical item false recall in any condition. If a conscious guessing strategy had been employed it would have been expected that identifiably would correlate negatively with critical item false recall rather than the numerical, but not significant positive correlations seen in Table 1. False recall of critical items without warning positively correlated with false recall of critical items under warned conditions $r(110) = .632$.

A second correlational analysis was performed to examine the intercorrelation between BAS and identifiability and partial correlations between each of these factors and false recall. Table 2 displays correlations between BAS, identifiability, and false memory. Overall, BAS correlated with critical items in false recall $r = (222) = 340$, whereas the correlation between critical item identifiability and critical item false recall *r*(116) = .233 was not significant. Because BAS and identifiability share a marginally significant *r*(110) = .322 correlation, we decided to examine partial correlations between each of these factors and false recall when the other variable is statistically controlled. Table 3 displays partial correlations between BAS, identifiability, and false memory in warned and unwarned conditions. As can be seen in Table 3, BAS continued to predict false memory. However, identifiability was uncorrelated with false memory in the warned and unwarned conditions. Moreover, BAS was positively correlated with false memory.

Table 1

Correlations Between Conditions, BAS, and Identifiability of Critical Items on False Memory

Condition	BAS	Identifiability
1 sec, No Warning	.600**	.251
1 sec, Warning	.234	.218
1 sec, Overall	.485**	.264
3 sec, No Warning	.344	.183
3sec, Warning	.162	.069
3 sec, Overall	.292	.147
No Warning Overall	.544**	.220
Warning Overall	.225	.224
No Warning, Warning Difference	.573**	.169

Note. * Indicates that the correlation is significant at the .05 level (2-tailed). ** Indicates that the correlation is significant at the .01 level (2-tailed).

Table 2

Correlations Between BAS, Identifiability, and False Memory of Critical Items

	BAS	Identifiability	False Memory
1. BAS	—	.322	.340**
2. Identifiability		—	.233
3. False Memory			—

Note. * Indicates that the correlation is significant at the .05 level (2-tailed). ** Indicates that the correlation is significant at the .01 level (2-tailed).

Table 3

Partial Correlations for Critical Item Recall in the No Warning Condition, Critical Item Recall Warning Condition ,Overall False Recall of Critical Items, Warning effect, and BAS of Critical Items (Controlling for Identifiability) Identifiability (Controlling for BAS)

	BAS (controlling for identifiably)	Identifiably (controlling for BAS)
1. No Warning	.437**	.118
2. Warning	.162	.121
3. Overall False Recall	.386*	.143
4. Warning Effect	.380*	.014

Note. * Indicates that the correlation is significant at the .05 level (2-tailed). ** Indicates that the correlation is significant at the .01 level (2-tailed). Note also that “warning effect” = the mean difference in recall of critical items between warned and unwarned conditions.

DISCUSSION

As predicted, longer presentation duration increased veridical memory and reduced false memory. This pattern is consistent with an activation monitoring account which predicts that as presentation duration increased, participants were able to encode more item-specific details allowing them to counteract the forces of automatic spreading activation and thus reduce false memory. However, counter to prediction, it appeared that warning only reduced false recall for homograph lists despite the fact that critical items were easier to identify in DRM lists. This suggests that warning reduces false memory in some way other than conscious guessing for deliberate exclusion. Furthermore, the effects of presentation duration and warning were additive, suggesting that warning and duration involve distinct cognitive processes (Sternberg, 1998). Because the warning was more effective for homograph lists, and warning and duration did not interact, reduced false recall under warned conditions must be due to something other than conscious identification of the critical item for deliberate exclusion.

The correlational analyses provided further support for this interpretation of the data. The likelihood that a critical item could be guessed when presented with its corresponding list items in Experiment 1 was not correlated with false recall in Experiment 2. This fits with the conclusion that warned participants were relying on something other than a conscious critical item guessing strategy in order to reduce false recall. BAS, on the other hand, correlated positively with false memory, but this correlation was only significant at short durations and under unwarned conditions. This observation suggests that both warning and increased presentation duration reduce the impact of BAS on false memory. This relationship remained the same in the partial correlation analysis between BAS and false recall when critical item identifiability was controlled for. Interestingly, short presentation durations and non-warned instructions were the very same conditions under which a difference was observed between DRM and Homograph lists. Thus, it seems that critical items of lists with high BAS are more likely to be falsely recalled at shorter presentation durations and without warning instructions. Perhaps BAS is the driving force of the differences observed between DRM and homograph lists. Even the difference in recall in unwarned and warned conditions strongly correlated with BAS suggesting that BAS plays a fairly large role in false recall. This was supported by the ANCOVA which treated BAS as a covariate. Here again no difference was found between DRM and homograph lists suggesting that the previous difference between list types must have been due to backward association strength.

In the few past experiments that manipulated both warning and duration in the DRM paradigm, most found additive effects of warning and duration (McCabe & Smith, 2002; Watson, McDermott, & Balota, 2004). In 4 experiments (including Experiment 2 of the present study) that manipulated warning and presentation duration, 3 found additive rather than interactive effects. The only exception is McCabe and Smith (2002), who found warning and duration to interact, with warning being more effective at the slow presentation rate. Because additive effects of warning and duration are the norm, it is reasonable to assume that warning and duration affect veridical and false recall through separate processes. The effects of increased presentation duration yielded an opposite pattern for veridical and false recall. Veridical recall improved at the longer presentation duration while false memory declined at the longer presentation duration. This finding fits nicely with that of other researchers (Gallo & Roediger, 2001; Hutchison & Balota, 2005; McCabe & Smith, 2002; McDermott & Watson, 2001) who found the same pattern across increasing longer durations. However, the present series of experiments did not investigate extremely short durations like those used by Hutchison and Balota (2005) and McDermott and Watson (2001). Because of this, the same activation/monitoring account used to explain the effect of duration in past studies may also be an appropriate interpretation of the present results. Longer presentation duration allows more time for item-specific encoding, thus increasing the memory strength for presented items. At time of test, these item-specific details allow for better veridical recall as well as aid in distinguishing items that had been presented from items that had not been presented resulting in lower false recall.

It is possible that a different process accounts for effects of warning. Warning reduced recall equally for both list items and critical items. In terms of the present data, the explanation for the effect of warning that best fits the results is a criterion shift that caused participants to respond more conservatively to both list and critical items, thus reducing recall for both equally. Other researchers have argued strongly against this notion primarily based on results from DRM recognition experiments which have shown that warning participants before study can reduce false memory but when warning is given after study and before retrieval it is much less effective. Gallo et al. (2001) found that warning participants before study reduced false memory. Warning them after study reduced false memory as well, but only for those participants where the critical items were never presented during study in any of the lists. In cases where critical items did sometimes occur on the lists, there were no differences in corrected recognition of list items or critical items suggesting that participants were not just guessing *new* to any item related to a list. This would constitute a conservative criterion shift. Perhaps the conservative criterion shift strategy is not used under these conditions simply because the strategy would be ineffective. However, most DRM studies do not include critical items on some lists as in the study by Gallo et al. (2001).

The possibility remains that participants do use a conservative criterion shift strategy if they know that critical items will not be presented at study. McCabe and Smith (2002) found that young adults are able to use warnings to reduce false memory regardless of whether or not the warning was given before study or before retrieval, but older adults were only able to benefit from warnings given prior to study. They argued that participants use different strategies depending on when they receive the warning. When the warning comes before study, participants rely on identifying the critical lure to be excluded at test. However, when the warning comes after study, the investigators argued, that participants were able to use a more systematic conservative decision criterion to reduce false recognition at fast presentation rates.

From these studies it is apparent that false memory reduction can occur when warnings are administered after study and before retrieval, making a decision criterion explanation viable. Albeit, if the warning is accompanied by the knowledge that critical items can sometimes occur at study, participants do not use a conservative criterion shift strategy. McCabe and Smith (2002) asserted that criterion shift strategies most likely play a role in false memory reduction if the warning is given after study, but they still held that critical item identification strategies reduce false memory if the warning is given before study. As mentioned earlier, they are not alone in this interpretation for the effects of warning on false memory. In fact, nearly every investigation of the effects of warning has concluded that the most likely strategy leading to the effect is critical item conscious identification (Gallo et al., 1997; Gallo, Roediger and et al., 2001; Watson, et al., 2005; and Watson et al., 2004).

Our data poses a problem for this interpretation. Experiment 1 demonstrated that DRM critical items can, indeed, be consciously identified and that the ease of their identification is greater than that of homograph lists, however, Experiment 2 found that warning did not reduce false memory for homograph critical items over DRM critical items. In fact, the opposite effect was seen. Warning only significantly reduced false memory for homograph critical items. This implies that even though participants are able to identify DRM critical items, it is not likely they are using that strategy to reduce false memory. This discrepancy between the effectiveness of warning on homograph and DRM list raises an important question. Why does warning have more of an impact on homograph lists than DRM lists? One possible answer draws on the functional differences between the two lists types. DRM list items converge onto one meaning of the critical non-presented word, where homograph list items diverge onto two separate meaning of the critical non-presented word. It is possible that at retrieval or encoding or both, participants divide homograph lists into their two meaning categories. Thus, instead of dealing with one large list they are faced with two smaller more manageable lists. When memory for list items is tested under warned conditions it may be easier to distinguish between presented and non-presented items when faced with two smaller lists (homograph lists) than one large list (DRM lists). This enhanced distinction would improve veridical memory while decreasing false memory.

Evidence of the effectiveness of this type of strategy comes from studies investigating clustering in recall. As early as 1953, Bousfield reported that when words corresponding to four categories are presented in a random order, participants recalled the words in clusters according to meaning. Marshall (1967) found that as measured association (the tendency of two words to elicit each other as well as common associates) increased, clustering also increased. Marshall's measured association is similar to BAS. In the present study DRM and homograph lists were equated on BAS, so it seems this measure would also be equal for list types. However, Marshall also found categorization to increase clustering of weak and moderately associated pairs. The lists used in the present study were selected in order to equate backward association strength. One drawback inherent in this technique was that standard DRM lists with particularly strong BAS had to be excluded, thus the lists used in the experiments could be considered to be moderately associated. In this situation categorization could provide and added advantage.

Mandler and Pearlstone (1966) investigated the facilitating effect of repetition on free recall and found that the effect was not direct. Repetition simply provided a greater opportunity for organization, and it was organization which directly supported improved recall. A similar explanation may account for the advantage homograph lists showed over DRM lists when participants are warned, whereby the warning caused participants to cluster words in recall according to meaning. The two meanings of homograph lists were conducive to clustering thus increasing the effectiveness of the warning, whereas the single meaning of DRM lists was not. This also could be the case for the presentation duration’s effect on veridical memory. Clustering for homograph lists during study may require longer presentation durations so that participants could reorganize the lists by meaning. This suggestion is supported by the observation that longer presentation durations increased veridical recall for homograph lists.

CONCLUSION

In conclusion, both warning and increased presentation duration reduced (but did not eliminate) false memory in the DRM paradigm. The means by which this was accomplished differed between the two variables. The additive effects of warning and duration on false memory imply that separate processes drive the false memory attenuation for warning and increased presentation duration. In the present study, increased presentation duration affected false memory following the same pattern as has been found in previous research, by increasing veridical memory and reducing false memory. This pattern maps on well to an activation/monitoring account for the phenomenon. Warning, on the other hand, reduced false memory equally for critical items as well as list items, suggestive of a conservative criterion shift. Furthermore, the present investigation poses problems for past explanations of the effect of warning in the DRM paradigm. Although the critical items of DRM lists are easier to identify than the critical items of homograph lists, it does not appear that participants strategically use this ease of identification in the experimental setting because warning only significantly reduced false memory for homographs. Ease of identification of critical items was unrelated to the effectiveness of a warning.

If the effects of warning and duration do, in fact, occur based on the activity of separate cognitive processes (as the data imply) then future research involving brain imaging techniques could provide substantial support to this assumption. Also, because working memory capacity has been implicated in DRM false memory effects, replication of Experiment 2 with the addition of a battery of attentional control measures could shed light on individual differences in false memory reduction strategies for DRM and homograph lists when participants are made aware of the phenomenon.

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