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The effect of divided attention on false memory depends on how memory is tested

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In three experiments, we investigated the effects of divided attention on false memory, using the Deese/Roediger–McDermott (DRM) paradigm. In Experiments 1 and 2, participants studied six DRM lists with full attention and six in one of two divided-attention conditions (random number generation or digit monitoring). Both divided-attention conditions increased false recall of related words (Experiment 1) but reduced false recognition (Experiment 2). These results were confirmed in Experiment 3, in which the type of secondary task was manipulated within groups. We argue that the increase in false recall with divided attention reflects a change in participants' response criterion, whereas the decrease in false recognition occurs because the secondary tasks prevent participants from generating associates of the words presented at study.

The Deese/Roediger–McDermott (DRM) procedure (Deese, 1959; Roediger & McDermott, 1995) has been widely used to investigate false memories and memory distortions under controlled laboratory conditions. The procedure involves the presentation of lists of semantic associates of a word that is not itself presented (the critical lure). For example, participants hear words such as *bed*, *rest*, *awake*, *tired*, and *dream*, which are all associates of the critical lure *sleep*. Roediger and McDermott found that participants falsely recalled the critical lures with a probability that was the same as or higher than the probability with which they correctly recalled the words that were presented in the middle of the lists. They also found that the critical lures were as likely as studied items to be judged as *old* in subsequent recognition tests. Moreover, the critical lures were recognized with high levels of confidence and were frequently categorized as *remember* (R) responses, on the basis of conscious recollection (Gardiner, 1988; Tulving, 1985), suggesting that the participants had detailed (although illusory) recollections of encountering those items at study. These observations have been confirmed in many subsequent studies (see Roediger & Gallo, 2004, for a review).

Roediger and McDermott (1995) developed an activation-monitoring account to explain their findings. The activation component is based on the *implicit associative responses* account of false recognition proposed by Underwood (1965). Underwood suggested that participants spontaneously generate associates to words presented by the experimenter at study. For example, participants presented with the word *cold* spontaneously generate the antonym *hot*. In the DRM procedure, participants generate the critical lures in response to the study lists. In subsequent tests of recall or recognition, participants make source-monitoring errors and erroneously believe that the generated items were included in the study lists. The monitoring component is based on the source-monitoring framework developed by Johnson and colleagues (e.g., Johnson, Hashtroudi, & Lindsay, 1993).

The DRM illusion has proved to be a particularly robust phenomenon and persists (although in an attenuated form) even when participants are forewarned about the effects observed in previous studies (McDermott & Roediger, 1998). However, a number of encoding manipulations have been found to reduce the magnitude of the DRM illusion. For example, levels of false recall and false recognition are reduced when the DRM stimuli are presented in short, rather than long, lists (Robinson & Roediger, 1997), when presented in random, rather than blocked, sequences (McDermott, 1996; Toglia, Neuschatz, & Goodwin, 1999), or when accompanied by a corresponding picture (Israel & Schacter, 1997). These findings suggest that the DRM illusion is reduced when encoding conditions restrict participants' opportunity to generate semantic associates of the study items.

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The aim of the present study was to investigate the effects of divided attention on the DRM illusion. If levels of false recall and false recognition are attenuated when the opportunity to generate associates is restricted, preventing such generation processes by asking participants to perform a demanding secondary task at study should significantly reduce the DRM effect. However, previous investigations into the effects of divided attention on false memory have produced conflicting results. For example, Pérez-Mata, Read, and Diges (2002) found that divided attention at study *increased* false recall, whereas Dewhurst, Barry, and Holmes (2005) found that divided attention at study *reduced* false recognition. Pérez-Mata et al. presented their participants with DRM lists either under full-attention conditions or while they were performing one of two concurrent tasks. In their first experiment, the participants heard the DRM lists while monitoring a video clip for changes in perspective. In their second experiment, the DRM lists were presented visually, and the secondary task required the participants to distinguish between letters and digits presented on an audiotape by pressing one of two response keys. Both secondary tasks increased false recall, relative to the full-attention condition. Pérez-Mata et al. argued that dividing attention at study prevented the participants from monitoring the status of the studied items and the associates generated in response to them and, thus, reduced their ability to distinguish between studied items and critical lures at recall.

In contrast to the increase in false recall reported by Pérez-Mata et al. (2002), Dewhurst et al. (2005) found that divided attention at study reduced false recognition. They used the category repetition procedure, in which participants study exemplars from a range of semantic categories (e.g., occupations, colors, or parts of the body). Previous research has shown that participants often falsely recognize nonstudied members of target categories (Dewhurst, 2001; Dewhurst & Anderson, 1999; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000). Dewhurst et al. also investigated the subjective experience of true and false recognition by asking participants to categorize their positive decisions as R, know (K), or guess (G) responses (Gardiner, 1988; Tulving, 1985). The participants studied the categorized lists with full attention or while performing articulatory suppression (AS) or random number generation (RNG). Dewhurst et al. found that RNG (the more demanding of the two secondary tasks) significantly reduced both correct and false R responses, relative to the full-attention and AS conditions.

Dewhurst et al. (2005) argued that the contrast between their findings and those of Pérez-Mata et al. (2002) was due to the nature of the secondary tasks. Although the tasks used by Pérez-Mata et al. were sufficiently resource demanding to prevent the participants from monitoring the status of the study items, they were unlikely to prevent the participants from generating the semantic associates in the first place, as was acknowledged by Pérez-Mata et al. In contrast, the secondary tasks used by Dewhurst et al. (particularly RNG) were chosen specifically for their disruptive effects on the generation of semantic associates. Dewhurst et al. argued that RNG reduced both correct and false R responses because both depend on semantic elaboration at study. They further claimed that the increase in false recall reported by Pérez-Mata et al. was likely to have been due to a criterion change, in that the participants were aware that their performance was impaired in the divided-attention conditions and attempted to compensate by adopting a lower threshold for producing a word at recall.

A further difference between the studies above is that Dewhurst et al. (2005) measured recognition memory, whereas Pérez-Mata et al. (2002) measured free recall. That the type of test is critical in determining the effects of divided attention on false memory is supported by the fact that Dewhurst et al. also presented their participants with tests of recall prior to the final recognition test and, like Pérez-Mata et al., found that false recall increased with divided attention, a finding that they again attributed to a criterion shift. This interpretation is supported by the fact that correct recall was significantly reduced both by RNG and by the monitoring tasks used by Pérez-Mata et al.

The reduction in false R responses reported by Dewhurst et al. (2005) is consistent with previous findings reported by Seamon, Luo, and Gallo (1998). Although the main focus of their study was on the effects of presentation duration on false recognition, they also found that the false recognition of critical lures was significantly reduced when the participants had to retain a seven-digit number sequence during the presentation of the study lists. The number sequence was presented prior to the first DRM list, and recall of the sequence was tested after the final list had been completed. Concurrent memory load therefore differs from the divided-attention tasks used by Dewhurst et al. and Pérez-Mata et al. (2002) in that it does not require focused attention throughout the presentation of the study lists. Seamon et al. (1998) also found that the disruptive effect of concurrent memory load depended on the nature of the experimental design, in that it was present when level of attention was manipulated in a between-group design (Experiment 1) but absent when manipulated in a within-group design (Experiment 2). They suggested that the concurrent memory task was less taxing when the number of memory load trials was reduced by half (as was done when there was a switch from a between-group to a within-group design). Nevertheless, when the effect was present, it was in the same direction as that reported by Dewhurst et al., in that both correct and false recognition were reduced.

In a later study, Seamon et al. (2003) used a range of orienting tasks to manipulate the level of attention allocated to DRM lists. Two tasks (writing the words or writing the second letter of each word as it was presented) were designed to focus attention on the DRM lists, whereas a third task (counting backward in threes and writing the numbers in pace with the presentation of the DRM stimuli) was designed to divide attention. Both focused-attention tasks reduced false memory, relative to a control condition of simply listening to the words. In contrast, the divided-attention task reduced correct recall and correct recognition but did not significantly affect false recall or false recognition.

It is clear that the issue of how divided attention influences false memory remains unresolved. The studies described above produced inconsistent results, with divided attention reducing, increasing, or having no effect on false memory. These inconsistencies most likely reflect methodological differences, such as the use of different secondary tasks (video/digit-monitoring, RNG, backward counting, or concurrent memory load), different tests of memory (recall or recognition), different experimental designs (between or within groups), and different study materials (DRM or categorized lists). The aim of the present study was to untangle the issue of how divided attention influences false memory by investigating the effects of digit monitoring and RNG on false recall and false recognition. These secondary tasks were chosen because they have been shown to produce significant effects on false memory and because they require focused attention throughout the presentation of the study lists. A comparison of recall and recognition memory also allowed us to investigate whether the discrepancy between the findings of Dewhurst et al. (2005) and Pérez-Mata et al. (2002) was due to their use of different test procedures. We decided to use the DRM procedure in the present study, since it consistently produces high levels of false recall and false recognition. We also chose to manipulate attention in a within-group design, owing to the wide individual variation in susceptibility to the DRM illusion.

We report three experiments in which participants studied DRM lists with either full or divided attention. In Experiments 1 and 2, the participants studied six DRM lists with full attention and six under one of two divided-attention conditions (RNG or digit monitoring). The participants in Experiment 1 were given tests of free recall after each list. The participants in Experiment 2 were not tested by recall but were, instead, given a test of recognition memory 10 min after studying the final list. In Experiment 3, the effects of the two secondary tasks were compared in a within-group design in which the participants studied six lists while performing RNG, six while performing the digit-monitoring task, and six with full attention. The participants were then tested either by free recall or by recognition memory.

The remember–know procedure (Gardiner, 1988; Tulving, 1985) was used in the recognition experiments in order to measure the subjective experience of false recognition. Using the category repetition procedure, Dewhurst et al. (2005) found that divided attention reduced false R responses, but not false K responses, and suggested that RNG prevented the generated associates from reaching conscious awareness. Roediger and McDermott (1995) suggested that false K responses are caused by automatic spreading activation processes, whereas false R responses are caused by failures to remember the source of generated associates that reach conscious awareness. It is therefore possible that divided attention will selectively reduce false R responses in the DRM procedure.

EXPERIMENT 1

Method

Participants. A group of 48 undergraduate and postgraduate students from Lancaster University participated in Experiment 1. All were native English speakers. They were tested individually and received a payment of £4 for their participation.

Stimuli. The stimuli consisted of 12 DRM lists rated by Stadler, Roediger, and McDermott (1999) as producing high incidences of false recall and false recognition. Each of the original lists contains 15 associates of a nonstudied critical lure. In order to increase the potential for false recall, 12 words from each list were presented at study, and the three remaining items (all moderate associates of the critical lure) were counted as related intrusions if falsely recalled at test. The lists were divided into two sets of 6, of which 1 was studied under divided-attention conditions (RNG or digit monitoring) and the other with full attention.

Design. The participants were divided into two groups of 24. Each group studied six DRM lists with full attention and six with divided attention. The type of secondary task was manipulated between groups, with one group performing RNG in the divided-attention condition and the other performing digit monitoring. Order of study conditions was counterbalanced, so that half the participants in each group studied the first six lists with full attention and half studied the first six lists with divided attention. Each list appeared in each condition for equal numbers of participants.

Procedure. The words were presented one at a time on Apple Macintosh computers in descending order of associative strength. Each word remained on the screen for 1 sec, with an interstimulus interval of 750 msec. In the control condition, the participants were instructed to read the words silently in preparation for a recall test. At the end of each list, the participants counted down aloud from 20 and were then given 1 min to write down their responses. Printed instructions at the top of each response sheet reminded the participants to write down only those words that they were confident had appeared in the list. The participants then folded their response sheet before the next list was presented.

In the RNG condition, the participants were additionally instructed to generate numbers between 1 and 20 at a rate of one per second throughout the presentation of the study lists. An electronic metronome was used to maintain the timing. The participants were given 30 sec of practice in this task prior to the first list. They were instructed to use random sequences of numbers and to avoid repeated or familiar sequences. The participants were asked to commence the RNG 10 sec before pressing the space bar to start the presentation of the words and to continue generation until the full list was presented. The importance of maintaining the speed and the randomness of their responses throughout the presentation of the list was emphasized. At the end of each list, the participants counted down from 20 before attempting to recall the words.

In the digit-monitoring condition, the participants listened to a tape recording of random letters and numbers presented at a rate of one item per second. The participants were instructed to press the "Q" key if they heard a letter or the "P" key if they heard a number. The tape was played for 10 sec before the words were presented and was maintained throughout each list. The tape was then paused during the recall tests.

Results and Discussion

Table 1 shows the mean scores for correct recall of studied items, false recall of critical lures, false recall of other associated words, total related intrusions (critical lures plus other associated words), and unrelated intrusions. Associated intrusions consisted of words included in the Stadler et al. (1999) lists but omitted from the shorter versions used in the present study and other obvious associates of the critical lures (e.g., *angry* instead of *anger*). Statistical analyses consisted of a 2 × 2 mixed ANOVA with a between-group factor of type of secondary task (RNG vs. monitoring) and a within-group factor of attention (full vs. divided). Alpha was set at .05 for all the analyses.

The analysis of correct recall showed a significant main effect of attention [$F(1,46) = 224.15$, $MS_e = 34.93$], with

Table 1
Mean Numbers of Correctly Recalled Items, Falsely Recalled Critical Lures, Associated Intrusions, Related Intrusions (Critical Lures Plus Associated Intrusions), and Unrelated Intrusions as a Function of Attention in Experiment 1 (With Standard Errors)

	RNG				Digit Monitoring			
	Full		Divided		Full		Divided	
Measure	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Correct recall	41.38	1.91	17.17	1.46	42.21	1.30	30.29	1.62
Critical lures	2.46	0.31	2.71	0.36	2.71	0.32	3.21	0.37
Associated intrusions	0.71	0.20	1.54	0.35	1.29	0.31	2.17	0.53
Related intrusions (critical + associated)	3.17	0.46	4.25	0.57	4.00	0.46	5.38	0.78
Unrelated intrusions	0.17	0.10	0.25	0.66	0.13	0.09	0.46	0.15

divided attention significantly reducing correct recall. A significant main effect of secondary task was also observed [$F(1,46) = 13.59$, $MS_e = 34.93$], although this was qualified by a significant interaction with attention [$F(1,46) = 25.95$, $MS_e = 34.93$]. Pairwise comparisons showed that RNG reduced correct recall to a greater degree than did digit monitoring [$t(23) = 4.90$] but that the two groups did not differ reliably in the full-attention conditions.

As can be seen from Table 1, the effects of group and attention were in the same direction for both the critical lures and the other associated words. We therefore combined these scores and conducted the main analysis of false recall on the total numbers of related intrusions (critical lures plus associated words), in order to increase statistical power. This analysis produced a significant main effect of attention [$F(1,46) = 9.13$, $MS_e = 3.92$], whereby divided attention increased the numbers of related intrusions, relative to the full-attention condition. Related intrusions were not reliably influenced by the type of secondary task [$F(1,46) = 1.87$, $MS_e = 3.97$, $p = .18$]. The interaction between attention and type of secondary task was not significant ($F < 1$), indicating that false recall was increased by both RNG and digit monitoring.

Divided attention also increased the false recall of unrelated items. An intrusion was classed as unrelated if it had no obvious semantic association with the overall list theme. Intrusions from previous lists were also classed as unrelated. Since these data were not evenly distributed, they were analyzed in separate Wilcoxon signed-ranks tests, each comparing one divided-attention condition with the corresponding full-attention condition. The false recall of unrelated words was significantly increased by both RNG ($W = 3.32$) and digit monitoring [$W(23) = 1.88$].

The findings of Experiment 1 are consistent with those of Pérez-Mata et al. (2002) in showing that divided attention at study increases the false recall of related words. This effect reached statistical significance only when the critical lures and other associated intrusions were combined. However, this is likely to be a power issue, since Pérez-Mata et al. found a significant increase in false recall of the critical lures alone, using much larger sample sizes. Divided attention also led to a significant increase in the false recall of unrelated items. It is therefore possible that the increase in false recall represents a criterion effect. Despite being instructed not to guess, it is likely that the participants were aware that their recall performance was poorer in the divided-attention conditions and attempted to compensate by adopting a lower threshold for accepting an item as old.

The increase in false recall following divided attention at study contrasts with the finding of Dewhurst et al. (2005) that divided attention reduced false R responses. However, Dewhurst et al. used the category repetition procedure to measure false recognition. It therefore remains to be seen whether divided attention also reduces false R responses in the DRM paradigm. Recognition memory was not measured in Experiment 1, since there is evidence that recall tests can influence subsequent levels of false recognition (e.g., Roediger, McDermott, Pisoni, & Gallo, 2004). Instead, the effects of divided attention on false recognition were investigated separately in Experiment 2.

EXPERIMENT 2

Method

The method was the same as that of Experiment 1, with the following modifications. A new group of 48 undergraduate and postgraduate students from Lancaster University took part in the experiment. The participants again studied six DRM lists with full attention and six in one of the two divided-attention conditions (24 of the participants performed RNG, and the remaining 24 performed the digit-monitoring task). Recall of the lists was not tested in Experiment 2. Instead, the participants were asked to count down from 30 after each list. Following the presentation of the final list, the participants were given a nonverbal distractor task (math problems) for 10 min and then received instructions for the recognition test.

The recognition test consisted of the 12 critical lures from Stadler et al. (1999), 12 studied items (the strongest associates of each critical lure), and 12 unrelated lures taken from other DRM lists, presented 1 at a time on Apple Macintosh computers. The participants were instructed to respond using the number pad on the right hand side of the keyboard and to press "1" for an old item and "2" for a new item. They were then instructed to indicate their subjective experience by pressing the "R," "K," or "G" key. Instructions for R, K, and G responses were taken from Dewhurst and Anderson (1999). Briefly, the participants were instructed to press "R" if they could consciously recollect seeing the item in one of the study lists, "K" if the item felt familiar from the study lists, and "G" if their previous response had been a guess.

Results and Discussion

Table 2 shows the mean proportions of correct and false R, K, and G responses as a function of attention.

Table 2
Mean Proportions of Correct and False Remember, Know, and Guess Responses as a Function of Attention in Experiment 2 (With Standard Errors)

	RNG				Digit Monitoring			
	Full		Divided		Full		Divided	
Response	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Correct recognition								
Remember	.61	.06	.11	.03	.60	.05	.17	.04
Know	.20	.03	.23	.03	.23	.04	.22	.03
Guess	.04	.01	.05	.02	.02	.01	.04	.01
False recognition of critical lures								
Remember	.40	.05	.07	.02	.57	.06	.17	.05
Know	.29	.04	.29	.05	.19	.03	.27	.04
Guess	.06	.01	.10	.02	.06	.02	.14	.03

Correct and false R and K responses were entered into separate mixed ANOVAs with a between-group factor of group (digit monitoring or RNG) and a within-group factor of attention (full or divided). G responses were not analyzed, since they are typically made at chance levels.

Correct R responses showed a significant main effect of attention [$F(1,46) = 143.60$, $MS_e = 1.99$], whereby divided attention reduced R responses, relative to full attention. Neither the main effect of group nor the interaction between task and attention were significant ($F < 1$ in both cases). False R responses to critical lures were also significantly reduced by divided attention [$F(1,46) = 66.54$, $MS_e = 2.10$] and were higher for the digit-monitoring group than for the RNG group [$F(1,46) = 7.16$, $MS_e = 2.10$]. The interaction between attention and group was not significant ($F < 1$). The analysis of correct and false K responses showed no significant main effects or interactions. False alarms to unrelated lures were entered into a 2 × 2 (group × response type) mixed ANOVA that showed that they were more likely to be categorized as K responses (.09) than as R responses (.03) [$F(1,46) = 23.39$, $MS_e = 1.17$]. The main effect of group and the interaction were not reliable.

The findings of Experiment 2 show that divided attention at study reduces both correct and false R responses, and this was the case for both the digit-monitoring and the RNG groups. The reduction in correct R responses under divided-attention conditions is consistent with previous findings by Gardiner and Parkin (1990). The reduction in false R responses is consistent with the findings of Dewhurst et al. (2005), using the category repetition procedure. One interpretation of the parallel reduction in correct and false R responses is that it is simply a criterion effect. However, Dewhurst et al. argued against this account on the grounds that the recognition test contained items from both full- and divided-attention conditions in a random order. A criterion explanation would have to explain why the participants constantly changed their decision criterion during the course of the test when previous research has shown that participants are reluctant or unable to do this (Morrell, Gaitan, & Wixted, 2002; Wixted & Stretch, 2000).

Dewhurst et al. (2005) argued that a critical factor in determining the effect of divided attention on false memory is the nature of the secondary task. They suggested that RNG reduces false recognition because it inhibits the activation of semantic associates at study. In contrast, digit monitoring does not disrupt the activation of associates and should, therefore, have less of a disruptive effect. However, Experiment 2 showed that both secondary tasks significantly reduced false R responses. False recall in Experiment 1 also showed parallel effects of RNG and digit monitoring. In order to compare the effects of RNG and digit monitoring, we conducted Experiment 3, in which the same participants studied the DRM lists under both of the divided-attention conditions. For completeness, we investigated both recall and recognition memory with separate groups of participants.

EXPERIMENT 3

Method

The method was the same as that of Experiments 1 and 2, with the following modifications. The participants were a new group of 51 undergraduates from Lancaster University, of whom 27 took part in a recall study and 24 in a recognition study. The participants in each study saw 18 DRM lists: 6 with full attention, 6 with concurrent RNG, and 6 with concurrent digit monitoring. The order in which the lists were presented was the same for all the participants, but the order of the study conditions was counterbalanced. Each list was seen in each condition by equal numbers of participants. The recall study followed the procedure used in Experiment 1, with free recall tests administered after each list. The recognition study followed the procedure used in Experiment 2 and featured a recognition test consisting of 36 studied items (2 from each list), 18 critical lures, and 18 unrelated lures taken from other DRM lists.

Results and Discussion

Recall. Table 3 shows the mean scores for correct recall, false recall of critical lures, false recall of other associated words, total related intrusions (critical lures plus other associated words), and unrelated intrusions. Numbers of correctly recalled items and related intrusions were analyzed in separate one-way ANOVAs with a within-group factor of attention (full, RNG, or digit monitoring). As in Experiment 1, related intrusions included the critical lures and other associates of the studied items.

The analysis of correct recall showed a significant main effect of attention [$F(2,52) = 67.39$, $MS_e = 23.90$]. Planned comparisons showed that correct recall was significantly reduced by both RNG and digit monitoring [$t(26) = 8.99$ and 10.86, respectively]. The RNG and digit-monitoring conditions did not differ significantly [$t(26) = 1.87$]. In contrast, divided attention significantly increased the false recall of related items [$F(2,52) = 3.55$, $MS_e = 1.69$]. Pairwise comparisons showed that RNG increased false recall, relative to both full attention and digit monitoring [$t(26) = 2.20$ and 2.41, respectively]. The full-attention and digit-monitoring conditions did not differ significantly [$t(26) = 0.21$]. Both secondary tasks also increased the false recall of unrelated items. Since these data were not evenly distributed, they were entered into a nonparametric one-way ANOVA (Friedman). The main effect of attention was significant [$Xr^2(2) = 16.94$]. It is clear from Table 3 that both divided-attention conditions led to considerably more unrelated intrusions than did the control condition.

Table 3
Mean Numbers of Correctly Recalled Items, Falsely Recalled Critical Lures, Associated Intrusions, Related Intrusions (Critical Lures Plus Associated Intrusions), and Unrelated Intrusions As a Function of Attention in Experiment 3 (With Standard Errors)

	Full Attention		RNG		Digit Monitoring	
Measure	*M*	*SE*	*M*	*SE*	*M*	*SE*
Correct recall	33.04	1.61	21.07	1.35	18.59	1.31
Critical lures	2.89	0.25	3.22	0.27	2.89	0.26
Associated intrusions	0.85	0.23	1.30	0.37	0.78	0.20
Related intrusions (critical + associated)	3.74	0.36	4.52	0.51	3.67	0.32
Unrelated intrusions	0.22	0.12	1.11	0.36	1.82	0.46

Recognition. Table 4 shows the mean proportions of correct and false R, K, and G responses as a function of attention. The numbers of correct and false R and K responses were also entered into separate one-way ANOVAs with attention as the within-group factor. The analysis of correct R responses showed a significant main effect of attention [$F(1,46) = 122.81$, $MS_e = 2.02$]. Planned comparisons showed that full attention led to more correct R responses than did both the RNG and the digit-monitoring conditions [$t(23) = 13.72$ and 13.42, respectively]. The RNG and digit-monitoring conditions did not differ significantly [$t(23) = 0.30$]. Correct K responses were not reliably influenced by the manipulation of attention ($F < 1$).

Analysis of the false R responses to critical lures also showed a significant main effect of attention [$F(1,46) = 48.94$, $MS_e = 1.26$]. Planned comparisons showed that full attention led to more false R responses than did both the RNG and digit-monitoring conditions [$t(23) = 8.23$ and 8.87, respectively]. The RNG and digit-monitoring conditions did not differ significantly [$t(23) = 0.64$]. False K responses were not reliably influenced by attention ($F < 1$). As in Experiment 2, the false recognition of unrelated lures was low and more likely to be categorized as a K response (.14) than as an R response (.03) [$t(23) = 3.98$].

The results of Experiment 3 are broadly consistent with those of Experiments 1 and 2. Dividing attention at study produced dissociable effects in false memory by increasing the false recall of critical lures but reducing their false recognition. However, the increase in false recall was found only in the RNG condition. This supports the argument that the increase in false recall with divided attention is a criterion effect, whereby participants adopt a lower threshold for endorsing an item as old in the more difficult conditions. In contrast to the effects of divided attention in false memory, the effects observed in correct memory were parallel, in that both correct recall and correct recognition were reduced by divided attention.

Table 4
Mean Proportions of Correct and False Remember, Know, and Guess Responses As a Function of Attention in Experiment 3 (With Standard Errors)

	Full Attention		RNG		Digit Monitoring	
Response	*M*	*SE*	*M*	*SE*	*M*	*SE*
Correct recognition						
Remember	.58	.04	.11	.03	.12	.03
Know	.17	.02	.16	.03	.19	.03
Guess	.06	.01	.11	.02	.11	.02
False recognition of critical lures						
Remember	.58	.07	.14	.04	.10	.03
Know	.22	.05	.24	.04	.24	.05
Guess	.04	.02	.15	.03	.08	.02

GENERAL DISCUSSION

The results of three experiments indicate that the critical factor in determining the effect of divided attention on false memory is the manner in which memory is tested. Both of the secondary tasks used in the present study (RNG and digit monitoring) produced dissociable effects in false memory by increasing false recall and reducing false recognition. These findings confirm those previously reported by Pérez-Mata et al. (2002) and Dewhurst et al. (2005) and suggest that the dissociation in the effects of divided attention reported in these studies reflects the use of different memory measures. However, digit monitoring did not increase false recall in Experiment 3 when the participants took part in both divided-attention conditions. The effect of divided attention on false recall therefore appears to be less robust than the effect on false recognition. Nevertheless, when the effect is present, it is in the opposite direction to that observed in recognition.

Pérez-Mata et al. (2002) suggested that divided attention at study increases false recall because it prevents participants from monitoring the status (externally presented or internally generated) of the studied items and the critical lures. However, this account does not explain why divided attention also increased the false recall of unrelated items, which are unlikely to be generated in response to the DRM lists. We have argued that the increase in false recall is the result of a criterion shift whereby participants realize that their performance is impaired under divided-attention conditions and attempt to compensate by adopting a lower threshold for endorsing an item as old. The increase in false recall of unrelated items in the divided-attention conditions is consistent with this account. A criterion account is also consistent with the finding that digit monitoring increased false recall in Experiment 1 when the type of secondary task was manipulated between groups, but not in Experiment 3 when the participants took part in both secondary tasks. Feedback from the participants indicated that they found RNG the more demanding of the two secondary tasks. They may, therefore, have adopted a lower criterion in the RNG condition, relative to the digit-monitoring condition.

The simultaneous reduction in correct and false R responses observed in Experiments 2 and 3 could also be interpreted as a criterion effect. However, we believe this account is untenable, given that the recognition tests used in these experiments contained items from both full- and divided-attention conditions in a random order. As was discussed above, previous research has shown that participants are reluctant to change their decision criterion during the course of a single recognition test (Morrell et al., 2002; Wixted & Stretch, 2000). In contrast, the recall studies in Experiments 1 and 3 featured separate tests after each study condition. The participants in these experiments therefore had the opportunity to change their criterion in what they perceived as the more difficult conditions.

The simultaneous reduction in correct and false R responses is more likely due to the fact that both rely on semantic associations at study. For example, correct R responses are enhanced by semantic, relative to phonological, processing at study (Gardiner, 1988) and are reduced by divided attention (Gardiner & Parkin, 1990). Similarly, false R responses are enhanced by encoding conditions that facilitate semantic associations, such as deep versus shallow processing (Toglia et al., 1999) and explicit instructions to generate associations to the study items (Dewhurst et al., 2005). Preventing participants from making such associations by dividing attention therefore prevents the processes that support both correct and false R responses (see Dewhurst et al., 2005, for further discussion of this).

Parallel effects in correct and false memory have been reported in other studies. For example, Thapar and McDermott (2001) found that both correct and false recognition and correct and false recall were reduced by shallow, relative to deep, processing and by long, relative to short, retention intervals. Their findings are thus consistent with those of the present study, with the exception of the effects observed in false recall. In Thapar and McDermott's study, the same manipulations reduced performance on all measures of memory, both correct and false. In contrast, divided attention in the present study reduced correct recall and correct and false recognition but increased false recall. If false recall is reduced by manipulations that inhibit semantic processing (see also Toglia et al., 1999), it is somewhat surprising that false recall should be increased by divided attention. This gives further weight to our suggestion that the increase in false recall is a criterion effect.

Dewhurst et al. (2005) suggested that false recognition should be reduced more by RNG than by digit monitoring, since the latter does not prevent the generation of associates. However, Experiments 1 and 3 showed that the two secondary tasks led to equivalent reductions in false R responses. These findings suggest that any task that is sufficiently resource demanding will prevent the generation of associates and thereby reduce false recognition. This is supported by the finding of Dewhurst et al. that AS, which places relatively low demands on cognitive resources, did not significantly reduce false R responses, relative to the full-attention condition. Seamon et al. (1998) also found that concurrent memory load did not reduce false recognition (at least when attention was manipulated in a within-group design). Although concurrent memory load is cognitively demanding, it is unlikely to divide attention throughout the presentation of the DRM lists and therefore does not prevent the generation of associates.

It is also noteworthy that the effects of divided attention were observed in R responses, but not in K responses, which were unaffected by the manipulation of attention. The same dissociation between R and K responses was also reported by Dewhurst et al. (2005) and therefore appears to be a robust finding. That false K responses were not reduced by divided attention is consistent with the suggestion by Roediger and McDermott (1995) that semantic associates can be activated implicitly without conscious awareness (see McRae & Boisvert, 1998, and Thompson-Schill, Kurtz, & Gabrieli, 1998, for evidence that spreading activation occurs automatically). The present findings suggest that dividing attention at study does not prevent the implicit generation of associates but may prevent such associations from reaching conscious awareness. Although this is a circular argument, it is consistent with previous findings that false K responses are observed when the activation of associates does not reach conscious awareness—for example, when study items are presented at rapid presentation rates (Seamon et al., 1998).

The finding that false R responses are reduced by divided attention is consistent with previous findings reported by Dewhurst et al. (2005), using the category repetition procedure. The parallel effects of divided attention thus suggest that the memory illusions produced by the DRM and category repetition procedures share a common locus. We have argued that the false memories produced by both procedures rely on the generation of associates at encoding. Preventing such associative processes by asking participants to perform a demanding secondary task reduces false R responses in both procedures. The parallel effects of divided attention are, however, at odds with the views of Smith, Gerkens, Pierce, and Choi (2002) regarding the origin of the DRM and category repetition effects. They argued that false memories produced by the DRM procedure are caused by associations made at encoding, whereas false memories produced by the category repetition procedure are caused by associations made at retrieval. This claim is based primarily on the results of priming experiments, in which participants studied DRM and categorized lists and were then given a stem completion task. Smith et al. found large priming effects with DRM lists, whereby participants frequently completed the word stems with critical lures, but no priming effects with categorized lists, relative to a baseline condition. In contrast, both the DRM and the categorized lists produced high levels of false recall.

It is possible that the dissociations reported by Smith et al. (2002) reflect differences in the associative structure of DRM and categorized lists. Specifically, both the DRM illusion and priming in a stem completion task rely on item-to-item associations. In contrast, the memory illusion caused by categorized lists may rely more on superordinate-to-item associations, in that category exemplars are more likely to be generated in response to the category label than in response to other exemplars. If this is the case, categorized lists will lead to false memories on the basis of superordinate-to-item associations (especially when the categorized lists are preceded by the category label, as was the case in the Dewhurst et al., 2005, study) but will not show priming effects, due to the relatively weak item-to-item associations. It is therefore possible that both the DRM and the category repetition effects are caused by associations made at encoding, with the former based on item-to-item associations and the latter on superordinate-to-item associations. We are currently investigating this possibility.

To summarize, the findings from the present study show that the effect of divided attention on false memory depends on whether memory is tested by recall or by recognition. Divided attention at study increased false recall but reduced false recognition. In contrast, divided attention led to parallel reductions in correct recall and recognition. These findings resolve the inconsistencies observed in previous investigations of divided attention. We have argued that the increase in false recall is a criterion effect whereby the more difficult encoding conditions cause participants to lower their threshold for endorsing an item as old. In contrast, the simultaneous reduction in correct and false recognition occurs because both depend on the elaborative encoding processes that are inhibited by divided attention.

AUTHOR NOTE

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