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Attention and implicit memory: priming-induced benefits and costs have distinct attentional requirements

Margaret M. Keane · Matt E. Cruz · Mieke Verfaellie

Abstract Attention at encoding plays a critical and ubiquitous role in explicit memory performance, but its role in implicit memory performance (i.e., priming) is more variable: some, but not all, priming effects are reduced by division of attention at encoding. A wealth of empirical and theoretical work has aimed to define the critical features of priming effects that do or do not require attention at encoding. This work, however, has focused exclusively on priming effects that are beneficial in nature (wherein performance is enhanced by prior exposure to task stimuli), and has overlooked priming effects that are costly in nature (wherein performance is harmed by prior exposure to task stimuli). The present study takes up this question by examining the effect of divided attention on priming-induced costs and benefits in a speeded picture-naming task. Experiment 1 shows that the costs, but not the benefits, are eliminated by division of attention at encoding. Experiment 2 shows that the costs (as well as the benefits) in this task are intact in amnesic participants, demonstrating that the elimination of the cost in the divided attention condition in Experiment 1 was not an artifact of the reduced availability of explicit memory in that condition. We suggest that the differential role of attention in priming-induced performance costs and benefits is linked to differences in response competition associated with these effects. This interpretation situates the present findings within a theoretical framework that has been applied to a broad range of facilitatory priming effects.

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Common sense dictates that the ability to remember an event depends upon the degree to which one paid attention to the event when it occurred. A wealth of research in the laboratory bears out this notion: if attention is diverted during the initial encoding of information, performance suffers when one is subsequently asked to recall or recognize that information (e.g., Anderson & Craik, 1974; Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Fisk & Schneider, 1984; Murdock, 1965; Wolford & Morrison, 1980).

This common sense notion, however, does not appear to apply in all instances of memory. An important distinction may be drawn between explicit memory tasks, in which information from a prior experience is deliberately and consciously retrieved from memory (exemplified in the studies cited above), and implicit memory tasks, in which information from a prior experience influences subsequent behavior in the absence of deliberate retrieval from memory, a phenomenon termed ‘priming’ (Roediger & McDermott, 1993; Schacter, 1987). A striking dissociation between implicit and explicit memory effects is observed in amnesic individuals, who may show normal priming despite markedly impaired explicit memory capacities (for review, see Moscovitch, Vriezen, & Goshen-Gottstein, 1993). Interest in the role of attention in implicit memory tasks was driven in part by this dissociation in amnesia, and by the consequent possibility that these two kinds of memory would be differentially affected in normal cognition by a variety of experimental manipulations including (but not limited to) attentional ones (e.g., Graf & Mandler, 1984; Graf & Schacter, 1987; Jacoby & Dallas, 1981; Parkin & Russo, 1990; Schmitter-Edgecombe, 1996). Indeed, some early results suggested that attentional manipulations produced a parallel dissociation in normal cognition to that observed in amnesia, such that performance on explicit memory tasks, but not implicit memory tasks, was reduced by division of attention at encoding (Isingrini, Vazou, & Leroy, 1995; Jacoby, Woloshyn, & Kelley, 1989; Parkin, Reid, & Russo, 1990; Parkin & Russo, 1990; Schmitter-Edgecombe, 1996; Szymanski & MacLeod, 1996).

Further investigation, however, revealed that attentional manipulations had variable effects across different implicit memory tasks, reducing priming on some tasks (e.g., Gabrieli et al., 1999; Light, Prull, & Kennison, 2000; Mulligan & Hartman, 1996; Rajaram, Srinivas, & Travers, 2001; Schmitter-Edgecombe, 1999), but not on others (e.g., Bentin, Kutas, & Hillyard, 1995; Mulligan & Hartman, 1996; Mulligan & Peterson, 2008; Smith & Oscar-Berman, 1990; Spataro, Mulligan, & Rossi-Arnaud, 2010; Spataro, Mulligan, & Rossi-Arnaud, 2011). These mixed findings gave rise to various theories aiming to delineate the critical features of priming effects that do or do not require attention at encoding (e.g., Gabrieli et al., 1999; Mulligan, 1998).

Given the remarkable range and depth of the literature on attention and implicit memory, it is notable that this literature has focused exclusively on priming-induced benefits. This focus reflects the fact that, for decades, priming was characterized as an essentially facilitatory phenomenon, whereby prior exposure to an item enhances the likelihood that the item will be successfully identified or generated in a subsequent task. Ratcliff, McKoon and colleagues (Ratcliff, Allbritton, & McKoon, 1997; Ratcliff & McKoon, 1996, 1997; Ratcliff, McKoon, & Verwoerd, 1989), however, demonstrated that prior exposure to stimuli can be associated with subsequent performance costs as well as benefits. Performance costs are evident when one is asked to identify or generate words or objects that are similar but not identical to studied items. For example, if one is asked to identify the word 'CARE' under perceptually degraded conditions, the probability of accurate identification is reduced by prior exposure to the similar word 'CAKE'.

No study has examined the effect of divided attention on priming-induced performance costs. Such an examination is important for two reasons. First, by filling a gap in the empirical literature on attention and implicit memory, these findings may inform theoretical accounts about the conditions under which priming is attention-dependent.

Second, such findings could speak to theories about the mechanisms underlying priming-induced costs and benefits. By one theoretical account, costs and benefits reflect a bias in the decision process during test-phase stimulus identification that is due to study-induced changes in the 'weighting' of word or object representations (Ratcliff & McKoon, 1997; Ratcliff et al., 1989; Rouder, Ratcliff, & McKoon, 2000). By another account, (Marsolek, 2008; Marsolek et al., 2010; Marsolek, Schnyer, Deason, Ritchey, & Verfaellie, 2006), priming-induced costs and benefits in picture identification are due to the superimpositional nature of object representations and to the changes those representations undergo as a result of study-phase exposure. While these theoretical views differ in many important respects, they have in common the notion that the costs and benefits associated with priming have a unitary source. Thus, by either account, a manipulation of attention should have parallel effects on priming-induced costs and benefits.

The present study examined the effect of divided attention on priming-induced performance costs and benefits in a speeded picture-naming task. The stimuli were pairs of visually confusable objects (Ratcliff & McKoon, 1996; Rouder et al., 2000) (see Fig. 1). Participants were exposed to pictures in a study phase, and in a subsequent test phase were asked to name studied and unstudied pictures as quickly as possible. In the 'old' condition, test pictures were identical to ones that had appeared in the prior study phase, and in the 'lure' condition, test pictures were similar but not identical to ones that had appeared in the prior study phase. In the 'new' condition, test pictures did not resemble pictures from the study phase. The performance benefit in this task is manifested as faster response times in the test phase to old than to new pictures, and the cost as slower response times to lure than to new pictures (Ratcliff & McKoon, 1996; Rouder et al., 2000). While prior work has shown that divided attention at encoding does not reduce the benefit in picture naming (Gabrieli et al., 1999), no study has examined the effect of this manipulation on the cost.

Experiment 1

Experiment 1 examined the effect of divided attention on priming-induced costs and benefits in a speeded picture-naming task. A measure of explicit memory was also included to assess the effect of divided attention on explicit memory for pictures under conditions that paralleled those in the implicit memory task.

Method

Participants In the implicit memory task, we initially tested 24 subjects in the full-attention condition and 24 in the divided-attention condition. Using the data from the full attention condition, we conducted a power analysis and determined that 52 participants would be required to have power of .80 to detect a cost in the divided-attention condition of the magnitude observed in the full-attention condition. A fully counterbalanced design required that the sample size be a multiple of six. Therefore, in the implicit task, we included 54 participants in the full-attention and 54 in the divided attention condition. (Six additional participants were initially tested and excluded; see Results section for further explanation.) A separate group of 48 participants completed the

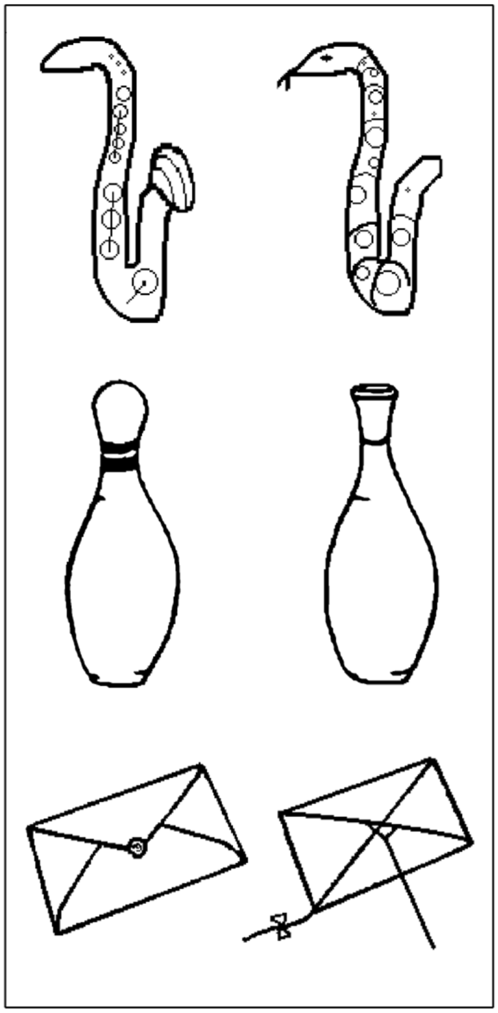

Fig. 1 Sample stimuli

explicit memory task. Participants in the study were undergraduates from Wellesley College and Boston University. All participants were paid for their participation and provided informed consent in accordance with the procedures of the Institutional Review Boards at Wellesley College, Boston University, and the VA Boston Healthcare System.

Design In the implicit memory task, attention at encoding (full vs. divided) was manipulated between groups, and study condition (old vs. new vs. lure) was manipulated within groups. In the explicit memory task, attention was manipulated between groups, with 24 participants in the full-attention condition, and 24 in the divided-attention condition.

Materials The critical stimuli were 30 picture pairs (line drawings of objects), of which 24 were taken from Ratcliff and McKoon (1996) and Rouder et al. (2000). The two members in each pair were designed to be visually similar to each other (see sample stimuli in Fig. 1). We randomly designated one member of each pair as the 'target' item (which was the item that was always presented in the test phase) and the other member as the 'mate.' The 30 pairs were divided into three lists of ten for purposes of counterbalancing across the old, new, and lure conditions.

Procedure The implicit and explicit memory tasks consisted of a study phase and a test phase. The test phase always occurred four days after the study phase to prevent ceiling effects in explicit memory for the pictures, which might obscure the effect of the attentional manipulation on this measure.

Study phase In the study phase, which was identical for the implicit and explicit memory tasks, 20 pictures were presented one at a time on a computer screen, and remained on the screen until the participant responded. Each picture came from a different pair; ten were target items, and ten were mates. Three filler items (pictures that did not resemble any of the critical stimuli) appeared at the beginning and end of the list to blunt any primacy and recency effects on later memory for the stimuli. Both in the full-attention and in the divided-attention conditions, participants were told that the pictures would be part of a later memory task and were asked to name each picture aloud as quickly as possible. In the divided-attention condition, participants were asked additionally to monitor a series of auditorily presented digits (presented at a rate of one per second) and to press a button whenever they heard three consecutive odd numbers. Participants in the divided-attention condition were given practice with the digit-monitoring task before they began the study phase.

Test phase for implicit memory task In the test phase for the implicit memory task, 30 target pictures (each taken from a different pair) were presented one at a time on a computer screen, and participants were asked to name each picture aloud as quickly as possible. Each picture remained on the screen until the participant responded, and response time was recorded. For ten of these pictures, the identical picture had been presented in the study phase (old condition); for ten of the pictures, the mate from that pair had been presented in the study phase (lure condition); and for ten of the items, neither that picture nor its mate had been presented in the study phase (new condition). Across participants, items were counterbalanced across conditions such that each pair appeared equally often in the old, lure, and new conditions. See Fig. 2 for illustration of the three experimental conditions.

Test phase for explicit memory tasks The test phase for the explicit memory task differed from that for the implicit memory task only with respect to the task instructions: participants were told that they would see a series of pictures, and that they should indicate for each one (yes/no) whether it had appeared in the list they had seen in the last session. Thirty pictures were

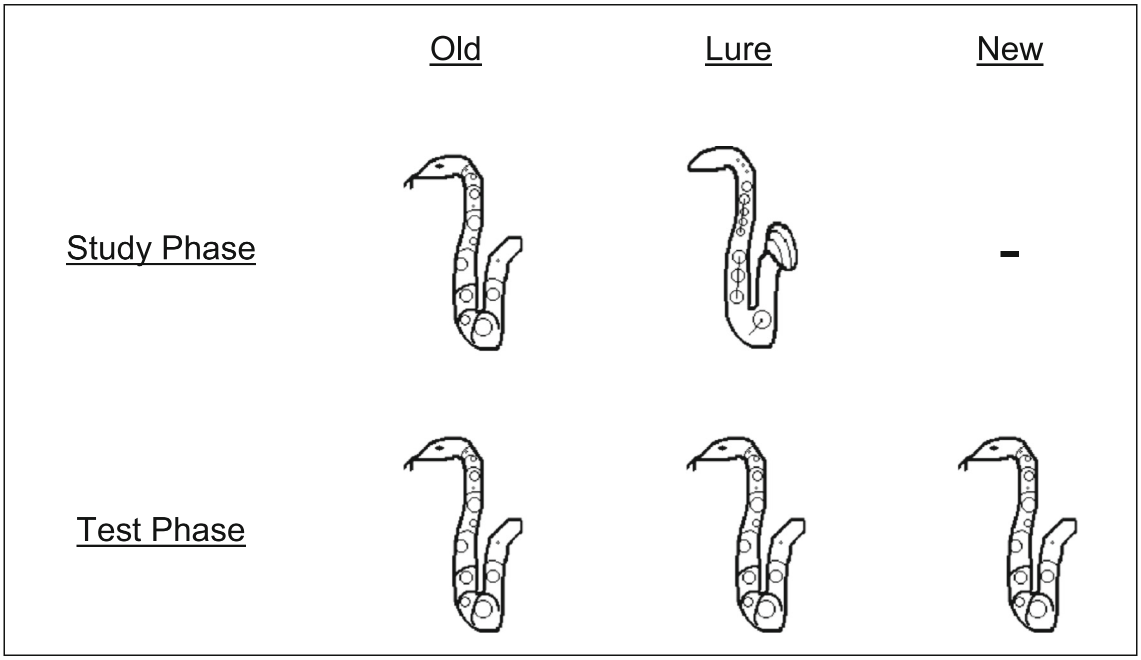

Fig. 2 Experimental conditions

presented one at a time, and items were counterbalanced across participants such that each pair appeared equally often in the old, new, and lure conditions.

Results

Implicit memory task Trials were excluded from the analysis if the participant did not provide a correct name for the item in the study or test phase, if they provided different names for the same item in the study and test phases, or if a technical problem prevented accurate recording of reaction time (RT) in the test phase. If exclusion of such trials resulted in fewer than six (out of a possible ten) trials in any of the three experimental conditions for a given participant, that participant was replaced. This process resulted in the replacement of three participants in the full-attention condition and two in the divided-attention condition. (One additional participant in the divided attention group was excluded and replaced because she failed to follow the speeded response instructions in the test phase, exhibiting a mean RT of 3565 ms in the new condition.) To eliminate outliers in this final data set, trials that elicited RTs more than 2 standard deviations (SD) above the participant's mean in a given condition were excluded. The mean number of items excluded from the analysis for any of the reasons listed above did not differ between the two attentional conditions (mean = 5.3 and 4.8 in the full- and divided-attention groups, respectively, $p = .26$).

For each participant in the full- and divided-attention groups, we calculated the response time (RT) to identify pictures in the old, new, and lure conditions (Fig. 3). We conducted separate analyses to evaluate performance benefits and costs, and to assess the impact of the attentional manipulation on these effects. All *t*-tests were one-tailed because of the directional nature of the predicted effects.

A performance benefit would be reflected in faster RTs for pictures in the old than in the new condition. We submitted the data from these conditions to a 2-way mixed factorial ANOVA with a between-group factor of attention (full vs. divided) and a within-group factor of study condition (old vs. new). Overall, there was a significant benefit, $F(1, 106) = 82.44$, $p < .001$, $\eta_p^2 = .44$. The interaction between attention and study condition showed a trend toward significance $F(1, 106) = 3.12$, $p = .08$, $\eta_p^2 = .03$, but this effect reflected a numerically larger benefit in the divided-attention condition (132 ms) than in the full-attention condition (89 ms).

A performance cost would be reflected in slower RTs in the lure condition than in the new condition. The data from these conditions were submitted to a 2-way mixed factorial ANOVA with a between-group factor of attention and a within-group factor of study condition (lure vs. new). Although the main effect of study condition was not significant ($p = .39$), there was an interaction between attention and study condition, $F(1, 106) = 5.68$, $p = .019$, $\eta_p^2 = .051$. Follow-up *t*-tests indicated that the cost was significant in the full attention condition, $t(53) = 2.12$, $p = .02$, $d = .24$, but not in the divided attention condition, $p = .12$. Indeed, in the divided attention condition, the non-significant difference between RTs in the lure and new conditions was in the direction *opposite* to that of

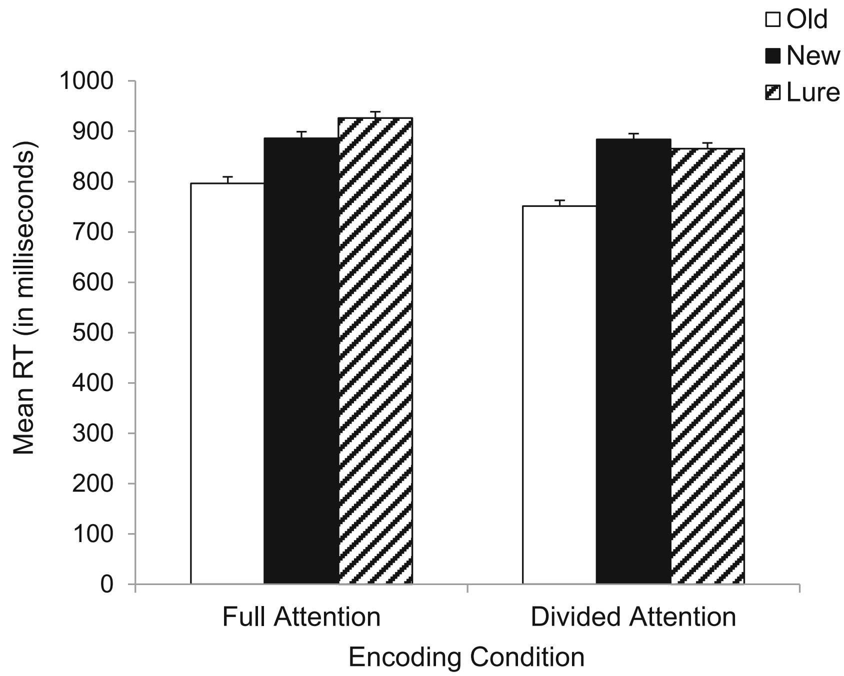

Fig. 3 Experiment 1: Mean reaction times (RTs) in picture naming task in full- and divided-attention encoding conditions. Error bars represent within-subject standard error

a performance cost, with the lure condition eliciting a numerically faster mean RT than the new condition.

Explicit memory task For each participant in the full- and divided-attention groups, we calculated the percentage of hits (correct 'yes' responses to old items) and false alarms (incorrect 'yes' responses to lure or new items), and the corrected recognition score (hits minus false alarms) (Table 1). Corrected recognition was higher in the full- than in the divided-attention group, $t(46) = 2.18$, $p = .018$, $d = .60$.

Discussion

The results of Experiment 1 demonstrate that dividing attention at encoding does not disrupt the facilitatory effect that prior exposure to pictures has upon subsequent performance in a speeded picture-naming task: regardless of whether pictures were studied under full or divided attention, participants were faster to identify old than new pictures in the test phase, and the magnitude of this effect was not reduced by dividing attention at encoding. This aspect of our results is consistent with prior findings in a picture-naming task (Gabrieli et al., 1999). The novel aspect of the present results is the finding that the performance cost associated with prior exposure to stimuli (i.e., slowed latencies to identify pictures that resemble studied ones) is eliminated under conditions of divided attention.

Before considering further the implications of these findings, it is important to address the possibility that this result is an artifact of the differential availability of explicit memory in the full- and divided-attention encoding conditions. It has been argued that performance costs in priming tasks may in some instances reflect the operation of explicit rather than implicit memory processes. For example, Keane et al. (Keane, Martin, & Verfaellie, 2009; Keane, Verfaellie, Gabrieli, & Wong, 2000) demonstrated that amnesic participants sometimes fail to show the priming-induced performance costs observed in control participants, raising the possibility that such costs are an artifact of explicit memory strategies rather than a manifestation of implicit memory mechanisms (see Schacter, Bowers, & Booker, 1989).

The same reasoning may be applied in the context of the current findings: explicit memory performance was higher in the full- than in the divided-attention encoding condition, raising the possibility that the cost, which was present only in the full-attention condition, was the product of explicit memory strategies that were less available to participants in the divided-attention condition. By this view, the effect of the attentional manipulation on a performance cost presumably arising from implicit memory mechanisms may in fact have reflected its effect on a cost arising from explicit memory mechanisms.

If this account is correct, it follows that the cost should be reduced or eliminated under any condition associated with a

Table 1 Experiment 1: mean proportion hits, false alarms (FA), and corrected recognition (Hits-FA) (standard deviation in parentheses)

Condition	Hits	FA	Hits-FA
Full attention	.86 (.16)	.10 (.07)	.76 (.15)
Divided attention	.83 (.16)	.18 (.14)	.65 (.21)

reduction in explicit memory comparable to that produced by divided attention. We tested this prediction in Experiment 2 by examining the performance of amnesic and control participants in the same picture-naming task used in Experiment 1. If the performance cost in Experiment 1 was an artifact of explicit memory, such that the absence of a cost under divided attention was due to the reduction of explicit memory in that condition, then we should not observe a normal cost in amnesic participants whose explicit memory deficit is comparable to that produced by divided attention. If we do observe a normal cost in amnesia, this finding would suggest that the absence of a cost under divided attention in Experiment 1 was not a consequence of reduced explicit memory. Rather, these results could be understood as reflecting the attention-dependent nature of an implicit memory phenomenon.

Experiment 2

In Experiment 2, the picture-naming priming task from Experiment 1 was administered to amnesic and control participants under full attention encoding instructions. The explicit memory task was administered as well to document the explicit memory impairment in amnesia. Prior studies have shown that the priming-induced performance benefit in picture naming is normal in amnesia (Cave & Squire, 1992; Verfaellie, Gabrieli, Vaidya, Croce, & Reminger, 1996), and we expected to replicate that finding in Experiment 2. The critical question was whether the cost would be equivalent in the two groups.

Method

Participants The amnesic group consisted of 11 participants (three women) with etiologies including anoxia (n = 6), anoxia and left temporal lobectomy (n = 1), encephalitis (n = 3), and bithalamic stroke (n = 1). This group had a mean age of 57.7 years, a mean education level of 15.2 years, and a mean verbal IQ score of 103.9 as measured by the Wechsler Adult Intelligence Scale-III (WAIS-III). Their attentional abilities were intact, as indicated by a mean Working Memory Index of 98.4 on the Wechsler Memory Scale-III (WMS-III). Their memory functioning was severely compromised, as indicated on the WMS-III by a mean General Memory Index of 57.6, a mean Visual Delay Index of 63.5, and a mean Auditory Delay Index of 61.7.

The control group included 15 healthy participants (12 women) and was matched to the amnesic group in terms of age (mean = 61.0 years), education (mean = 15.3 years), and WAIS-III Verbal IQ (mean = 107.5; all p's > .30). All participants were paid for their participation and provided informed consent in accordance with the procedures of the Institutional Review Boards at the VA Boston Healthcare System and Boston University.

Stimuli and procedure The stimuli and procedure were the same as those described in Experiment 1 with the following exceptions. First, due to the limited number of amnesic participants, it was not feasible to employ a between-subjects design for the implicit and explicit memory tasks as we had in Experiment 1. For this reason, each participant completed both the implicit and explicit memory tasks (one control and one amnesic participant were unavailable for testing in the explicit memory task). Because the same stimuli were used in both tasks, the implicit memory task was always administered first, and the explicit memory task was administered on a later date separated from the implicit task by at least two months. Second, all participants studied the pictures under full attention, with instructions to name each picture aloud as quickly as possible. Third, the delay between the study and test phases of each task was 5 min (rather than 4 days) because we were confident that an explicit memory impairment would be evident in the amnesic group even at this delay.

Results

Explicit memory task Before examining the results from the implicit task, it was important to ensure that we had obtained the expected explicit memory impairment in the amnesic group. For each participant, we calculated the percentage of hits (correct 'yes' responses to old items), false alarms (incorrect 'yes' responses to lure or new items), and corrected recognition (Table 2). Corrected recognition was impaired in the amnesic group, $t(22) = 5.09$, $p < .001$, $d = 2.16$. Notably, corrected recognition in the amnesic group was numerically lower than that in the divided attention group in Experiment 1.

Implicit memory task In the implicit memory task, trials were excluded using the same criteria described in Experiment 1. The mean number of items excluded from the analysis did not differ in the two groups (mean = 5.8 and 6.3 in the control and amnesic groups, respectively, $p > .50$).

For each participant, we calculated the mean RT to identify pictures in the old, new, and lure conditions. As shown in Fig. 4, RTs were longer and more variable in the amnesic group than in the control group. Because this difference complicates the comparison between groups regarding the effect of the manipulation of interest (Faust, Balota, Spieler, & Ferraro, 1999), we converted RT scores to z-scores by using the group-specific mean and standard deviation of RTs in the new condition as the referent. Thus, for each participant, and in each of the three conditions, we subtracted the group mean RT in the new condition from the participant's mean RT in the condition under consideration, and divided that number by the group's standard deviation in the new condition. As in

Table 2 Experiment 2: mean proportion hits, false alarms (FA), and corrected recognition (Hits-FA) (standard deviation in parentheses)

Group	Hits	FA	Hits-FA
Control	.99 (.03)	.07 (.08)	.92 (.08)
Amnesic	.82 (.20)	.29 (.15)	.53 (.27)

Experiment 1, we conducted separate analyses to evaluate performance benefits and costs.

To evaluate the performance benefit, we submitted the z-scores from the old and new conditions to a 2-way mixed factorial ANOVA with factors of group (control vs. amnesic) and study condition (old vs. new). Overall, there was a significant benefit, $F(1, 24) = 25.92$, $p < .001$, $\eta_p^2 = .52$. The absence of an interaction between group and study condition ($p > .50$) indicated that the benefit did not differ between the amnesic and control groups.

To evaluate the performance cost, we submitted the z-scores from the lure and new conditions to a 2-way mixed factorial ANOVA with factors of group and study condition. The cost was marginally significant, $F(1, 24) = 4.22$, $p = .051$, $\eta_p^2 = .149$, and did not differ between the amnesic and control groups (group x study condition, $p = .63$).

Discussion

The results of Experiment 2 were straightforward. As expected, the performance benefit was equivalent in the amnesic and control groups. Critically, the performance cost was also normal in the amnesic group despite an impairment in explicit memory comparable to that produced by divided attention in Experiment 1. These findings suggest that the elimination of the cost in Experiment 1 under conditions of divided attention is not attributable to the reduction of explicit memory in that condition. If it were, then the cost should have been eliminated in the amnesic group as well. Taken together, these findings suggest that the dissociable effect of divided attention on priming-induced costs and benefits in picture naming reflects the distinct attentional requirements of two implicit memory mechanisms.

General discussion

Prior studies have provided rich information about the role of attention in implicit memory, but those studies have focused exclusively on priming effects that are beneficial in nature. The present study represents the first examination of the role of attention in a priming effect that is manifest as a cost in performance. In Experiment 1, we found that the benefits and costs associated with priming in a speeded picture-naming task are dissociably affected by division of attention at encoding: whereas the benefit was unaffected by division of attention, the cost was eliminated by division of attention. In Experiment 2, we found that amnesic patients showed a normal pattern of benefits and costs in this task despite impaired explicit memory for the task stimuli. This finding suggests that the elimination of the cost in the divided attention condition in Experiment 1 was not an artifact of the reduced availability of explicit memory in that condition, but reflected an effect of divided attention on an implicit memory process.

The present findings indicate that priming-induced costs and benefits in a picture-naming priming task are the product

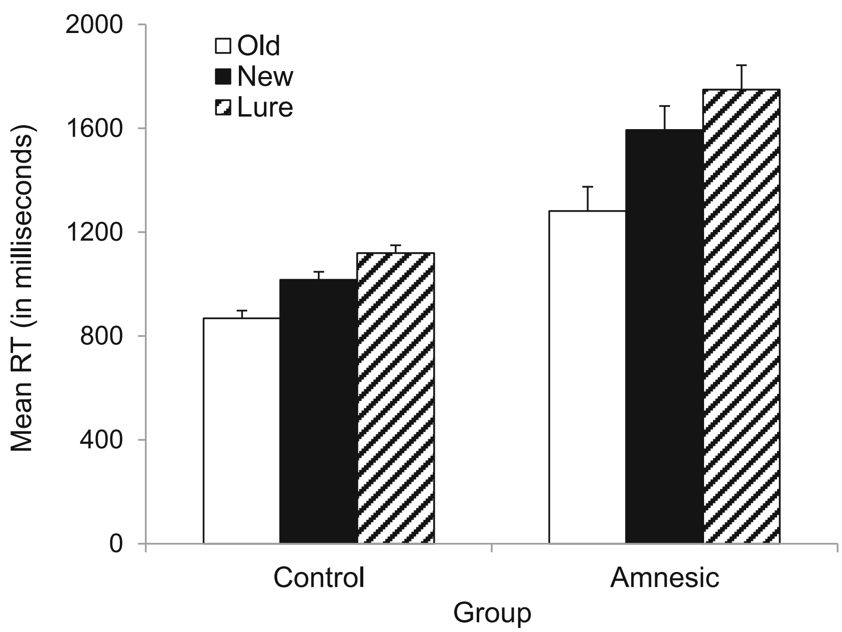

Fig. 4 Experiment 2: Mean reaction times (RTs) in picture naming task in amnesic and control participants. Error bars represent within-subject standard error

of at least two distinct mechanisms, one that is attention dependent and mediates the cost, and another that is independent of attention and mediates the benefit. These findings pose a challenge to current theoretical models of priming-induced costs and benefits in picture identification. According to one view, (Rouder et al., 2000), priming-related benefits and costs are both due to the selective weighting of decision nodes associated with recently encountered items, and to the resulting bias to identify test stimuli in accord with those items. According to another view (Marsolek, 2008), such effects are due to the experience-induced strengthening of object representations for studied items (producing a benefit) that is inextricably linked to a weakening of representations for unstudied objects with which the strengthened object representations overlap (producing a cost). Thus, neither theory apparently predicts or explains a dissociation between benefits and costs in priming. The present finding that costs and benefits in priming are differentially affected by divided attention therefore poses a challenge to both theories insofar as it suggests that the source of these two effects, or the process by which they are manifested, is not identical.

Insight into the basis of the observed dissociation may come from a consideration of the empirical and theoretical literature concerning the role of attention in priming. Prior studies on this topic have focused exclusively on priming tasks that yield performance benefits, but have nonetheless found that attention does not play a uniform role in all of these effects. One view proposes that the dissociable effects of divided attention on priming can be understood with reference to whether the priming task engages perceptual or conceptual processes (Mulligan, 1998; Mulligan & Hartman, 1996), and another posits that the dissociation can be understood with reference to whether the task requires stimulus identification or cue-based production (Gabrieli et al., 1999).

A closer consideration of the demands of the present picture-naming task suggests that our findings may be understood with reference to the identification-production distinction. By this account, the critical distinction between priming effects that do or do not require attention at encoding is whether the test stimulus activates a number of possible responses from which one must be chosen (as in production tasks), or guides the participant to a single correct response (as in identification tasks), with divided attention at encoding having a greater effect on priming in production than in identification tasks. In other words, priming effects that depend on cue-driven selection of a target from among alternatives require greater attention to that target at encoding (and are more sensitive to differential levels of attention at encoding) than priming effects that depend on cue-guided access to a single appropriate response (cf. Vaidya et al., 1997).

The identification-production distinction may map usefully onto benefits and costs in a picture-naming task. Although the benefits and costs are observed in a single task, the processing demands in the old and lure conditions are not identical. The old condition (which elicits the benefit) resembles other identification priming tasks in that it guides participants to a single correct response at test. By contrast, the lure condition (which elicits the cost) resembles production priming tasks in that it entails response competition at test: Because participants have studied a picture that is perceptually similar to the test cue, it is likely that the test cue elicits activation of that (incorrect) response, as well as the correct (but unstudied) response, requiring participants to select a response from these alternatives. (For a similar argument regarding priming in perceptual identification of words, see Mulligan & Peterson, 2008.) Thus, the absence of an attentional effect for the benefit, and the presence of such an effect for the cost, may be linked to the absence or presence of response competition at test, respectively, in accord with the identification-production account. The proposed link between the attentional requirements of priming and the presence/absence of response competition may point to fruitful avenues for reconciling the present findings with current theories about the mechanisms underlying costs and benefits in priming.

Conclusion

The present study is the first to examine the attentional requirements of performance costs in an implicit memory task. We found that, in a speeded picture-naming task, the priming-induced performance cost was eliminated under conditions of divided attention at encoding, but the priming-induced performance benefit was unaffected by division of attention. The preservation of costs in amnesia in this task eliminates the concern that the dissociable effect of divided attention on costs and benefits is an artifact of its effect on explicit memory. We suggest that the differential attentional requirements of costs and benefits in implicit memory may be better understood with reference to differences in response competition associated with these effects. This interpretation situates the present findings within an extensive literature elucidating the role of attention in a broad range of facilitatory priming effects.

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