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# Convergent, but not divergent, thinking predicts susceptibility to associative memory illusions

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ABSTRACT

The relationship between creativity and susceptibility to associative memory illusions in the Deese/Roediger–McDermott procedure was investigated using a multiple regression analysis. Susceptibility to false recognition was significantly predicted by performance on a measure of convergent thinking (the Remote Associates Task) but not by performance on a measure of divergent thinking (the Alternative Uses Task). These findings suggest that the ability to engage in convergent (but not divergent) thinking underlies some of the individual variation in susceptibility to associative memory illusions by influencing the automaticity with which critical lures are activated at encoding.



## 1. Introduction

Roediger and McDermott (1995) showed that illusions of memory can be created when participants study lists of associated words. In the Deese/Roediger–McDermott (DRM) procedure (Deese, 1959; Roediger & McDermott, 1995), participants study lists of associates of a nonpresented "critical lure". For example, participants study words such as *sour*, *candy*, and *sugar*, which are associates of the critical lure *sweet*. When memory for the lists is tested, participants frequently claim to remember the critical lures, with levels of false memory equalling or even exceeding levels of correct memory. The DRM illusion has been explained in terms of an activation-monitoring account (Roediger, Watson, McDermott, & Gallo, 2001) whereby participants spontaneously generate associates of the studied words. The critical lures are then subject to errors of source monitoring (Johnson, Hashtroudi, & Lindsay, 1993) and falsely endorsed as having been studied. An alternative explanation is provided by fuzzy-trace theory (FTT, see Reyna & Brainerd, 1998) whereby critical lures are falsely remembered because they match the "gist" of the related items presented at study.

Although Roediger and McDermott's findings have been replicated many times (see Gallo, 2006, for a review), one phenomenon that has yet to be explained is the considerable individual variation in susceptibility to the DRM illusion. Elevated levels of false memory have been reported in elderly adults (Balota et al., 1999) and patients with frontal lobe damage (Melo, Winocur, & Moscovitch, 1999), while reduced levels of false memory have been observed in children (e.g., Brainerd, Reyna, & Forrest, 2002). Other studies have attempted to identify the causes of individual variation within the general adult population. For example, elevated levels of false memory have been observed in individuals who reported high levels of dissociative experiences and vivid imagery (Winograd, Peluso, & Glover, 1998), individuals with low working memory capacity (Watson, Bunting, Poole, & Conway, 2005), individuals high in need-for-cognition (Graham, 2007), and extraverts (Sanford & Fisk, 2009).

Given the extensive use of the DRM procedure in the study of false memories, it is important to identify other cognitive and personality factors that influence susceptibility to the illusion. The aim of the current research was to investigate whether susceptibility to the DRM illusion is predicted by creativity. A number of previous studies have shown that creative individuals are particularly susceptible to false autobiographical memories. For example, Hyman and Billings (1998) found that creativity (as measured by the Creative Imagination Scale) was positively related to the creation of false childhood memories. However, to the best of our knowledge, no studies have as yet investigated the influence of creativity on susceptibility to the DRM illusion.

Although creativity is a complex mental faculty that encompasses a variety of cognitive abilities (see Dietrich, 2004, for a review), a number of measurable components have been identified. It is possible that some, but not all, aspects of creativity may predict susceptibility to the DRM illusion. The aspects of creativity

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that were the focus of the current study are commonly referred to as convergent and divergent thinking (Guilford & Hoepfner, 1971). Convergent thinking requires the production of the best single answer to a problem or set of problems and can be measured by the Remote Associates Task (RAT; Mednick, 1962). In the RAT, participants are presented with three words (e.g., food/forward/break) and asked to generate a semantic associate that can be paired with each of the three to form a compound word or phrase (e.g., fast). Divergent thinking requires the generation of multiple answers to a single problem and can be measured by the Alternative Uses Task (AUT; Guilford, 1967) in which participants are asked to generate alternative uses for a common object (e.g., a brick).

Mednick (1962) developed the RAT on the basis of his theory that creative individuals generate more and broader associations to a given stimulus. Our hypothesis, therefore, was that the false recognition of critical lures would be predicted by performance on the RAT, as both involve the generation of semantic associations. In contrast, the AUT measures the ability to generate novel or atypical ideas, which has less overlap with the processes that underlie the DRM illusion; therefore we did not expect the false recognition of critical lures to be predicted by performance on the AUT.

## 2. Method

### 2.1. Participants

Participants were 55 undergraduate students (41 females) who took part for course credit. Mean age was 21 years (SD = 5.29). They were tested at individual workstations in groups of up to 12 and participated for course credit. The research was carried out in accordance with *The Code of Ethics of the World Medical Association* (*Declaration* of Helsinki) *for experiments involving humans*.

### 2.2. Stimuli and design

Study items consisted of 16 DRM lists rated by Stadler, Roediger, and McDermott (1999) as producing high levels of false recognition. Each list comprised 12 associates of a nonpresented critical lure. The lists were divided into two sets of 8. Each set was studied by half the participants and the other set provided the distractor items for the recognition test. The recognition test consisted of a printed sheet containing 8 studied words (one from each list), the 8 critical lures of the studied lists, plus 8 list items and the 8 critical lures from the unstudied lists. The stimuli for the RAT consisted of 24 three-item problems taken from Bowden and Jung-Beeman (2003) presented on a two-sided response sheet with two columns of six items on each side. The items in each problem were presented one above the other with a line to the right for participants to record their responses. All participants saw the same stimuli in the same order. The AUT (Guilford, 1967) required participants to list alternative uses for a brick.

### 2.3. Procedure

The DRM lists were presented one at a time on PCs at a rate of 2 s per word with a 1 s interval. Each list was preceded by the list number (List 1, List 2, etc.) displayed for 2 s. After the presentation of the final list, participants were given a letter cancellation task for 1 min. They were then given the recognition test, which they completed at their own pace. Participants were then allowed 8 min to complete the AUT, followed by a further 8 min to complete the RAT (these times were based on the results of pilot studies). As an example of the RAT, participants were shown that the word *pin* could be paired with *safety*, *cushion*, and *point* to make *safety pin*, *pincushion*, and *pinpoint*.

## 3. Results

Multiple regression was used to assess the ability of convergent and divergent thinking to predict critical lure, studied word, and distractor item recognition rates. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. The sample size ($n = 55$) was also sufficient for this procedure according to the guidelines of Stevens (2009).

The AUT responses were rated for creativity on a scale of 0–4. Impossible uses (e.g., a time machine) were given a score of 0, standard uses (e.g., to build a wall) were given a score of 1 (with no additional scores for repetition of uses), and alternative uses were given scores of 2, 3, or 4 depending on the rated creativity. Initial ratings were made by the third author, and 20% were blind double-rated by the second author. The initial inter-rater reliability score was 92%, with all disagreements resolved through discussion.

### 3.1. Critical lure results: hierarchical multiple regression

A 61% false recognition rate for critical lures was observed ($M = 4.90$, SD = 1.72), indicating that the DRM effect was successfully replicated. It was expected that convergent thinking ($M = 7.14$, SD = 2.43) would be a significant predictor of critical lure recognition whereas divergent thinking ($M = 26.91$, SD = 11.77) would not. Given these strong predictions, a Hierarchical Multiple Regression was conducted with the convergent thinking scores entered at Step 1 and the divergent thinking scores at Step 2 (see Table 1).

The initial correlations revealed a significant relationship between convergent thinking and critical lure recognition ($r = .33$, $p < .01$), but no significant relationship between divergent thinking and critical lure recognition ($r = .15$, $p = .13$), or between convergent thinking and divergent thinking ($r = .02$, $p = .44$). The regression analysis revealed that convergent thinking accounted for 11% ($R^2 = .11$) of the variance in false recognition $F(1, 53) = 6.29$, $p < .05$. The addition of the divergent thinking scores in Step 2 resulted in a non-significant 2% increase in the explained variance, $\Delta F(1, 53) = 1.25$, $p = .27$. Convergent thinking therefore appears to be a significant predictor of critical lure false recognition ($\beta = .32$, $p < .05$), whereas divergent thinking does not ($\beta = .14$, $p = .27$).

### 3.2. Distractor items: simultaneous multiple regression

As no relationship was expected between either convergent or divergent thinking and the false recognition of distractor items ($M = 2.16$, SD = 2.15), a simultaneous multiple regression was used for this second analysis (see Table 3). Initial correlations revealed a significant relationship between convergent thinking and

**Table 1**
Summary of the hierarchical multiple regression analysis for convergent and divergent thinking in relation to critical lure false recognition.

| Step | *B* | SE *B* | $\beta$ |
|---|---|---|---|
| 1 | | | |
| Constant | 3.26 | .69 | |
| CT | .23 | .09 | .33* |
| 2 | | | |
| Constant | 2.70 | .85 | |
| CT | .23 | .09 | .32* |
| DT | .02 | .02 | .14 |

CT = convergent thinking, DT = divergent thinking.
* $p < .05$.

distractor item recognition ($r = .40$, $p < .01$), but no significant relationship between divergent thinking and distractor item recognition ($r = -.15$, $p = .14$). The regression analysis revealed that convergent and divergent thinking together accounted for 18% ($R^2 = .18$) of the variance in distractor item recognition, $F(2, 52) = 5.91$, $p < .01$. However, distracter item recognition was significantly predicted only by convergent thinking ($\beta = .40$, $p < .01$) and not by divergent thinking ($\beta = -.15$, $p = .22$).

### 3.3. Convergent thinking: simultaneous multiple regression for critical lure and distractor item recognition

The above results demonstrate that convergent thinking predicts both critical lure false recognition and distractor item recognition. A simultaneous multiple regression was therefore used to determine whether critical lure false recognition or distractor item false recognition is the strongest predictor of convergent thinking (see Table 2). Initial correlations revealed no significant relationship between critical lure false recognition and distractor item recognition ($r = .10$, $p < .23$). The two predictors together accounted for 24% ($R^2 = .24$) of the variance in convergent thinking, $F(2, 52) = 8.34$, $p = < .01$. Both critical lure false recognition ($\beta = .29$, $p < .05$) and distractor item recognition ($\beta = .37$, $p < .01$) were significant predictors of convergent thinking, with $\beta$ values indicating that distractor item recognition is a slightly stronger predictor.

### 3.4. Studied words: simultaneous multiple regression

Neither convergent nor divergent thinking were expected to predict studied word recognition ($M = 5.85$, SD = 1.58), therefore a simultaneous multiple regression was used to assess this (see Table 3). Initial correlations revealed no significant relationship between convergent thinking and studied word recognition ($r = .06$, $p < .32$), or divergent thinking and studied word recognition ($r = -.02$, $p = .44$). The regression analysis revealed that the two predictors together accounted for less than 1% ($R^2 = .004$) of the variance in studied word recognition, $F(2, 52) = .12$, $p = .89$, confirming that neither convergent ($\beta = .06$, $p = .65$) nor divergent thinking ($\beta = -.02$, $p = .88$) were significant predictors of correct recognition.

**Table 2**
Summary of the simultaneous multiple regression analysis for critical lures and distractor items in relation to convergent thinking.

| | *B* | SE *B* | $\beta$ |
|---|---|---|---|
| *Convergent thinking* | | | |
| Constant | 4.25 | .91 | |
| CL | .40 | .17 | .29* |
| DI | .42 | .14 | .37** |

CL = critical lures, DI = distractor items.
* $p < .05$.
** $p < .01$.

**Table 3**
Summary of the simultaneous multiple regression analysis for convergent and divergent thinking in relation to studied word and non-studied distractor item recognition.

| | *B* | SE *B* | $\beta$ |
|---|---|---|---|
| *Studied words* | | | |
| Constant | 5.63 | .83 | |
| CT | .04 | .09 | .05 |
| DT | −.01 | .02 | −.02 |
| *Distractor items* | | | |
| Constant | .36 | 1.03 | |
| CT | .36 | .11 | .40* |
| DT | −.02 | .02 | −.15 |

CT = convergent thinking, DT = divergent thinking.
* $p < .01$.

## 4. Discussion

The main finding from the current study was that susceptibility to the DRM illusion was significantly predicted by convergent thinking (as measured by the RAT) but not by divergent thinking (as measured by the AUT). This pattern is consistent with the activation-monitoring account of the DRM procedure (Roediger et al., 2001), as both the RAT and the DRM illusion rely on the activation of semantic associates. In contrast, the AUT requires participants to generate novel uses for a common object, which has less in common with the processes underlying the DRM procedure. In terms of fuzzy-trace theory (Reyna & Brainerd, 1998), it is possible that participants' ability to connect the gist of semantically related words underlies performance on the RAT, which relies on semantic connections, but not on the AUT, which does not rely on such processes.

The current findings are consistent with the proposal by Mednick (1962) that creative individuals generate more and broader associations to a given stimulus. Recent findings by Rossmann and Fink (2010) also support this view by showing that the rated associative distance between unrelated words was lower for creative individuals than for individuals rated as less creative. According to Howe, Wimmer, Gagnon, and Plumpton (2009), it is the automaticity with which critical lures are activated that determines the likelihood that they will be falsely remembered. It is possible that the shorter associative pathways used by creative individuals increase the automaticity with which the critical lures are generated in the DRM procedure.

It is, perhaps, surprising that the ability to engage in convergent thinking (considered a positive trait in terms of creativity) has the negative consequence of increasing susceptibility to false memory. However, previous research has shown that other ostensibly positive traits can increase susceptibility to false memory. For example, Castel, McCabe, Roediger, and Heitman (2007) reported that expertise in a given domain has what they termed a "dark side", whereby experts were more prone than novices to domain-relevant intrusions. Castel et al. suggested that experts' superior organizational processes, which usually enhance memory for domain-relevant information, also support the associations that give rise to memory illusions. More broadly, the DRM illusion itself is a negative corollary of spreading activation processes that support normal memory functions (see Roediger & McDermott, 1995). The increased susceptibility to false memory as a function of convergent thinking can also be seen as the "dark side" of an otherwise adaptive process.

An unexpected finding from the current study was that convergent thinking significantly predicted levels of false recognition of the unrelated distracters. Although we did not anticipate such an effect, it is consistent with Mednick's (1962) proposal that creative individuals make broader associations to a given stimulus. It is possible that participants who scored high on the RAT in the current study generated associations that went beyond the themes of the DRM lists, leading to the partial priming of words not directly associated with the list items. One way to test the influence of the breadth of associative pathways would be to manipulate the backwards associative strength of the critical lures. If increased susceptibility to the DRM illusion is the result of creative people using broader associative pathways, then it is likely that participants who score high on convergent thinking will falsely recall

lures of low BAS to a greater degree than participants who score low on convergent thinking.

Although both critical lure false recognition and distractor false recognition were significant predictors of performance on the RAT, comparison of the $\beta$ values in Table 2 suggests that distractor items were a slightly stronger predictor than critical lures. Although this finding was unexpected, one possible explanation is that the greater predictive power of distractors relative to critical lures reflects the differential use of a recall-to-reject strategy. Previous research has shown that participants can use a recall-to-reject strategy to avoid false recognition in the DRM procedure, whereby they reject critical lures because they can recall the associated items that were presented at study (e.g., Gallo, 2004). It is likely that the effectiveness of such a strategy will depend on the strength of association between the critical lure and the associated study item. A recall-to-reject strategy will, therefore, be less effective at reducing the false recognition of unrelated distractors. We acknowledge, however, that this is a post hoc explanation and that the effect observed with the unrelated distracters warrants replication.

To summarise, the current study found that levels of false recognition in the DRM procedure were significantly predicted by performance on a test of convergent thinking but not by performance on a test of divergent thinking. These findings suggest that individuals who perform well on tests of creativity may be at increased risk of false memories, at least the false memories produced by the DRM procedure. This effect is, however, highly specific and depends on the overlap between the processes that underlie the creativity test and those that give rise to the DRM illusion. Although the current findings do not arbitrate between the two main theories of the DRM illusion (activation-monitoring and fuzzy-trace theory), they suggest one possible source of the individual variation in susceptibility to the DRM illusion.

## 5. Ethical statement

The research was carried out in accordance with *The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.* There are no conflicts of interest in relation to this research. The work described has not previously been published and is not currently under consideration for publication elsewhere. Publication is approved by all authors and by the responsible authorities where the research was carried out. The work will not be published elsewhere, including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

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