Running Head: MOOD AND FALSE MEMORIES

Mood-Congruent False Memories Persist Over Time

Lauren M. Knott[1] and Craig Thorley[2]

City University London[1]

University of Liverpool[2]

Address correspondence to: Dr. Lauren Knott

Department of Psychology

City University London

London, EC1V 0HB

Phone: +44 (0)20 7040 3354

E-mail: lauren.knott.1@city.ac.uk

Abstract

In this study we examined the role of mood-congruency and retention interval on the false recognition of emotion laden items using the Deese/Roediger-McDermott (DRM) paradigm. Previous research has shown a mood-congruent false memory enhancement during immediate recognition tasks. The present study examined the persistence of this effect following a one-week delay. Participants were placed in a negative or neutral mood, presented with negative-emotion and neutral-emotion DRM word lists, and administered with both immediate and delayed recognition tests. Results showed that a negative mood state increased *remember* judgments for negative-emotion critical lures, in comparison to neutral-emotion critical lures, on both immediate and delayed testing. These findings are discussed in relation to theories of spreading activation and emotion enhanced memory, with consideration of the applied forensic implications of such findings.

Keywords: False memory, DRM paradigm, emotion, delay, mood-congruency

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False memories occur when people recollect events that did not happen or incorrectly recollect events that did happen. In legal contexts, the inaccurate recollection of events can lead to unsafe convictions. Of the first 250 individuals in the United States to have their convictions overturned as a result of DNA evidence, 76% were convicted, at least in part, as a result of eyewitness error (Innocence Project, 2010). It is therefore important to establish the conditions under which false remembering can occur. When people are exposed to a crime, either as a witness or a victim, they often experience a negative event that has the potential to induce negative affect. Furthermore, there can then be a potentially indefinite delay between experiencing this negative event and recalling it during a legal trial (Neubauer & Fradella, 2011). The current study is the first to examine whether negative affect whilst encoding negatively valenced information can impact upon false remembering when recollection occurs both immediately and after a delay.

A popular method of studying false remembering in the laboratory is the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In this paradigm, participants study a list of semantic associates (e.g., *cigar*, *cigarette*, *chimney*) that all converge on a single non-studied critical lure (e.g., *smoke*). On subsequent testing, participants often falsely recall and recognize these critical lures as frequently as studied items. Moreover, when participants are asked to make *remember-know* judgments to the critical lures (where a *remember* response indicates participants can mentally re-experience the presentation of a studied item and a *know* response indicates participants believe an item is familiar but cannot recollect its presentation) they typically make a *remember* response (e.g., Roediger & McDermott). The DRM paradigm can therefore produce vivid false memories.

Theoretical explanations for DRM lists false memories focus on spreading activation and the associative relations between the studied list items and the critical lure (e.g., Howe, Wimmer, Gagnon, & Plumpton, 2009; Roediger & McDermott, 1995). Spreading activation theories posit that semantically associated words are stored in a connectionist network. Activation can spread through this network from studied words to related non-studied words. As DRM lists are composed of semantically related words that are associates of a non-studied critical lure, the critical lure is repeatedly activated during encoding. This activation is powerful enough for participants to mistakenly believe the critical lure was generated externally (from the study list) rather than internally (from spreading activation).

The impact of emotion on false remembering has only recently been considered. For example, Storbeck and Clore (2005, 2011) examined the impact of negative affect on false remembering. They induced negative moods in participants and compared their DRM test performance to a control group who received no mood induction. Both studies found that negative affect reduced false remembering, with the latter showing this only occurred when a negative mood was induced prior to encoding. The explanation for this effect focused on the impact of emotion on encoding, whereby a negative mood promotes item-specific processing over relational processing (see Clore & Huntsinger, 2007). As false remembering in the DRM paradigm arises from relational processing, negative moods reduce the likelihood of the critical lures being activated during encoding and subsequently falsely remembered.

The impact of valenced DRM word lists on false remembering has also been examined. For example, Budson et al. (2006) developed emotional DRM lists (e.g., *risk, harm, threat*) that are associated with negative-emotion critical lures (e.g., *danger*). They found that false recognition rates for negative-emotion critical lures were higher than for neutral critical lures (see also, Brainerd et al., 2010; Howe, Candel, Otgaar, Malone, & Wimmer, 2010). One possible explanation for this effect is that emotional word lists are high in semantic density, as emotion enhances the association between list items (see Talmi, Schimmack, Paterson, & Moscovitch, 2007, and Howe et al.). Although not directly assessed in the false memory literature, it can be speculated that emotional DRM lists are more likely to activate critical lures due to this enhanced semantic association.

Negative affect and negative-emotion DRM lists have been used by Ruci, Tomes, & Zelenski (2009) to determine whether there is a mood-congruency effect on false remembering. In their study, participants were assigned to one of three mood-induction conditions (positive, negative and control) and presented with positive, negative, and neutral DRM word lists. A mood-congruency effect was observed, whereby participants in the mood induction conditions were more likely to falsely recognize critical lures that matched their mood state. Moreover, they were more likely to make *remember* judgments to these items. Ruci et al. suggest this effect can be understood by considering the similarities between spreading activation theory and Bower's (1981) Network Theory of Affect. Bower argued that our semantic network contains six emotion nodes where moods are represented. When a mood state is induced, activation spreads throughout the semantic network towards information that is being encoded at that time. Mood-congruent information receives superior processing at both encoding and retrieval, creating a mood-congruent memory enhancement. Mood states therefore provide an additional source of activation for valenced critical lures when emotional DRM lists are studied, increasing the likelihood that they will be falsely *remembered* at test.

Several studies have also shown that false memories persist over time. In standard DRM studies, with neutral lists, false memory rates remain constant after retention intervals of more than two days, while veridical memory rates decline (e.g., McDermott, 1996; Seamon et al., 2002). In studies of veridical memory, it has also been found that emotional material is better remembered than neutral material when testing occurs after delays of more than one hour (LaBar & Cabeza, 2006). Building upon these findings, Howe et al. (2010) examined whether false memories deriving from negative DRM lists, in comparison to neutral DRM lists, would exhibit persistence when memory was tested both immediately and after a one-week delay. They found that negative false memory rates increased after one-week whereas neutral false memory rates remained unchanged. Howe et al. suggest emotional words lists are semantically denser than neutral word lists, meaning critical lures are more likely to be activated. Additionally, over time, negative DRM lists may give rise to higher rates of false recognition because consolidation of emotional material is a more protracted process (e.g., Sharot et al., 2007). The exact mechanism by which this persistence occurs is still to be determined.

The current study aimed to extend the findings of Ruci et al. (2009) by examining whether the mood-congruent false memory enhancement they observed on an immediate recognition test, when participants studied negative and neutral-emotion DRM lists, persists after a one-week delay. This study will also use the *remember-know* procedure to examine differences in phenomenological experience of recognizing negative and neutral-emotion critical lures before and after a delay. Ruci et al. found that negative critical lures were *remembered* more often than neutral critical lures in the mood-congruent condition, but also raised concerns that a prior recall test in their study may have inflated the number of *remember* responses they observed. The present study will therefore provide a more definitive test of this effect.

In line with Bower's (1981) Network Theory of Affect, which would predict that mood-congruent critical lures receive heightened activation at encoding, and consistent with Howe et al.'s (2010) demonstration that false recognition of negative critical lures can increase after one-week, it is anticipated a negative mood-congruent false memory enhancement will be observed on both immediate and delayed testing and that this enhancement will be driven by a higher number of *remember* judgments towards the mood-congruent critical lures.

Method

Participants

Forty-eight undergraduate students (12 males and 36 females) aged 18-36 (M =21.04, SD = 4.96) participated for course credit.

Materials, Design, and Procedure

Participants were randomly assigned to either a negative (n = 24) or neutral (n = 24) mood condition. Mood was induced using two five-minute video clips. The negative mood was induced by showing participants the final scene of the movie *Dancer in the Dark*, where the main protagonist is hung in prison for committing a murder. The neutral mood was induced by showing participants a scene from a wildlife documentary. As this study focuses on the influence of mood at encoding, all participants were presented with a final neutral film clip (another wildlife documentary) before the immediate recognition test to revert their mood to a neutral state. The participants' mood throughout the study was assessed using the valence rating taken from the Self-Assessment Manikin scale (SAM; Bradley & Lang, 1994). The SAM is a 9-point Likert scale that assesses a person's affective state. Low values represent a negative mood, whereas high values represent a positive mood. Mood measures were taken before and after the initial film clip to ensure successful mood induction and then again immediately before each recognition test to ensure all participants were in a neutral mood prior to having their memory tested.

There were 12 DRM lists, 6 neutral and 6 negative-emotion. The neutral lists were taken from Stadler, Roediger, and McDermott (1999) and each consisted of 12 words associated with the following critical lures: *sleep, chair, car, smoke, needle, smell.* The negative-emotion lists were taken from Dewhurst et al. (2012). Each list consisted of 12 negatively valenced associates to the following critical lures: *anger, cry, fear, hate, alone, lie.* Mean valence and arousal ratings for list items and critical lures were taken from Affective Norms for English Words (ANEW; Bradley & Lang, 1999). Independent samples *t*-tests showed that negative list items and critical lures had lower ratings of valence than neutral list items ($p < .05$ for both), and higher levels of arousal ($p < .05$ for both).

The 12 lists were recorded for auditory presentation, with a 3-second interval between each item. Half of the participants studied the lists in the order shown above with negative and neutral lists alternating, and half were presented in the reverse order. Participants were asked to listen carefully to the lists, as they would receive two recognition tests: the first taking place immediately and the second one-week later. After the presentation of all 12 lists, participants were asked to complete the SAM and were provided with instructions to complete the recognition test. As time of test was a within-subjects factor, two recognition tests were created from the 12 DRM lists. Half of the lists and the associated critical lures were used to produce the first recognition test, and half were used to produce the second recognition test. The immediate 48-item recognition test consisted of 6 critical lures (3 negative and 3 neutral), 24 targets (2 items from 6 neutral lists and 6 negative lists), and 18 unrelated and non-studied fillers (9 neutral words and 9 negative words). The delayed 48-item recognition test was constructed in the same fashion, but contained critical lures, target words from the remaining studied lists, and a further 18 unrelated fillers. Use of these recognition tests at each time of test was counterbalanced. Test items were presented in a random order on a response sheet, with the labels *old/new* and *remember/know/guess* next to each item. If participants circled *old*, they were asked to make an additional *remember/know/guess* judgment. Instructions for these responses were modeled after those of Rajaram (1993) but with the addition of a *guess* response to remove the element of guessing typically associated with a *know* response.

Results

Mood-manipulation check

Two participants in the negative mood group were removed from the analysis because their valence scores increased after the negative mood induction. There was no difference in valence scores of the participants in the negative and neutral mood groups before mood induction (M = 6.42 vs. M = 6.68), $t(44)$ = .77, p = .45, d = .23, but the negative mood group scored lower in valence than the neutral mood group after mood induction (M = 3.55 vs. M = 6.63), $t(44)$ = -9.68, p < .001, d = 2.92. The valence scores for negative and neutral mood groups did not differ before the immediate recognition test, (M = 6.27 vs. M = 6.00), $t(44)$ = .85, p =.40, d = .26, or the delayed recognition test (M = 6.36 vs. M = 6.41), $t(44)$ = -.19, p =.85, d = .05, confirming the two groups moods only differed prior to encoding.

Recognition test analyses

Recognition test responses (*old*, *remember, know,* and *guess* judgments to critical lures, list items, and unrelated fillers) were analyzed separately using 2 (mood: neutral vs. negative) x 2 (stimuli: neutral vs. negative) x 2 (time of test: immediate vs.

one-week) ANOVA's with repeated measures on all but the first factor. Significant interactions were explored using Bonferroni pairwise-comparisons (alpha set at .05). Mean proportions and standard errors for the dependent measures are reported in Table 1.

INSERT TABLE 1 HERE

False recognition of critical lures

For *old* responses, there were significant main effects of stimuli, $F(1, 44) = 5.45$, $p = .02$, $\eta_p^2 = .11$, and time, $F(1, 44) = 5.97$, $p = .02$, $\eta_p^2 = .12$, but not mood, $F(1, 44) = 1.55$, $p = .22$, $\eta_p^2 = .03$. These main effects were qualified by a stimuli x time interaction, $F(1,44) = 13.16$, $p = .001$, $\eta_p^2 = .23$. Pairwise-comparisons revealed no difference in false recognition rates for negative lures ($M = .74$) and neutral lures ($M = .78$) on immediate testing ($p =.34$), but false recognition was higher for negative lures ($M = .78$) compared to neutral lures ($M = .55$) after a one-week delay.

For false *remember* judgments, there was a significant main effect of time, $F(1, 44) = 7.81$, $p = .008$, $\eta_p^2 = .15$. Although there were no significant effects of mood or stimuli (both *F's* < 1, *ns*), there was a significant mood x stimuli interaction, $F(1, 44) = 7.81$, $p = .01$, $\eta_p^2 = .14$, revealing a mood-congruency effect. Pairwise-comparisons revealed that false *remember* judgments were higher for negative lures in the negative mood group, compared to the neutral mood group, but there was no difference in false *remember* judgments for neutral lures between the two mood groups ($p = .48$). Figure 1 highlights this interaction for immediate and delayed recognition. A stimuli x time of test interaction was found for false *remember* judgments, $F(1, 44) = 6.59$, $p = .01$, $\eta_p^2 = .13$. Pairwise-comparisons showed that false recognition was marginally higher for negative lures ($M = .33$) compared to neutral lures ($M = .22$) after a one-week delay ($p = .06$). However, the significant interaction derived from each stimuli type at time of test. There was no reduction in false *remember* judgments for negative lures over the one-week interval (M = .34 vs. M = .33, p = .89), but false *remember* judgments for neutral lures went down (M = .41 vs. M = .22).

For *know* judgments, although there were no significant main effects for time, mood condition (both, $F < 1$, *ns*), or stimuli, $F(1, 44) = 3.36$, $p = .07$, $\eta_p^2 = .07$, there was a significant stimuli x time of test interaction, $F(1, 44) = 6.39$, $p = .02$, $\eta_p^2 = .13$. There was no difference in false recognition rates for negative and neutral lures on immediate testing (M = .26 vs. M = .29, p =.57), but false recognition was higher for negative lures (M = .36) compared to neutral lures (M = .20) after a one-week delay. *Guess* judgments were low, and analysis revealed no significant main effects (all *F's* < 1, *ns*). There was a significant mood x time of test interaction, $F(1, 44) = 4.50$, $p = .04$, $\eta_p^2 = .09$, but no pairwise-comparisons were significant (all p's > .05).

In sum, false recognition was higher for negative lures compared to neutral lures after a one-week delay. Moreover, a mood-congruency effect was observed for *remember* judgments towards critical lures at both time intervals.

INSERT FIGURE 1 HERE

Correct recognition

For *old* responses, there was no significant main effect of mood, $F(1, 44) = 2.15$, $p = .15$, $\eta_p^2 = .05$. There were significant main effects of time, $F(1, 44) = 96.79$, $p < .001$, $\eta_p^2 = .69$, and stimuli, $F(1, 44) = 20.22$, $p < .001$, $\eta_p^2 = .32$, and a significant stimuli x time interaction, $F(1, 44) = 13.01$, $p < .001$, $\eta_p^2 = .23$. Pairwise-comparisons showed no significant difference between neutral (M = .79) and negative-emotion stimuli (M = .78, p = .65) on the immediate test, but correct recognition was higher for negative (M = .64) compared to neutral (M = .47) stimuli on the delayed test.

For correct *remember* judgments there were no main effects of mood or stimuli (both *F's* < 1, *ns*). There was a main effect of time, $F(1, 44) = 93.51$, $p < .001$, $\eta_p^2 = .68$, and a significant stimuli x time interaction, $F(1, 44) = 12.93$, $p < .001$, $\eta_p^2 = .22$. Correct *remember* judgments decreased across the one-week delay, however on immediate testing *remember* judgments were higher for neutral stimuli ($M = .52$ vs. $M = .41$) and, after a one-week delay, higher for negative stimuli ($M = .26$ vs. $M = .17$).

For the analysis of *know* judgments, correct recognition was higher for negative compared to neutral stimuli, $F(1, 44) = 14.61$, $p < .001$, $\eta_p^2 = .25$. *Guess* judgments were low, but increased over time, $F(1, 44) = 10.96$, $p = .002$, $\eta_p^2 = .20$. No other main effects or interactions were significant (all *F*'s < 1, *ns*).

In sum, correct recognition was generally higher for negative items compared to neutral items after a delay. No mood-congruency effects were observed.

False recognition of unrelated fillers

False recognition rates for unrelated fillers were low. For overall recognition, there were main effects of time, $F(1, 44) = 22.37$, $p < .001$, η_p^2 =, .34, and stimuli, $F(1, 44) = 21.28$, $p < .001$, η_p^2 =, .33, with higher false recognition of unrelated fillers over time and for negative compared to neutral stimuli, but no significant interactions (all *F's* < 1, *ns*). False *remember,* $F(1, 44) = 4.40$, $p = .04$, $\eta_p^2 = 09$, and *know* judgments, $F(1, 44) = 7.60$, $p = .008$, $\eta_p^2 = .15$, were higher for negative compared to neutral stimuli. False *guess* judgments were also higher for negative compared to neutral stimuli, $F(1, 44) = 7.72$, $p = .008$, $\eta_p^2 = .15$ and increased over a delay, $F(1, 44) = 16.47$, $p < .001$, $\eta_p^2 = .27$, but there were no further significant main effects or interactions for this analysis (all *F*'s < 1, *ns*). The higher false alarm rate for negative unrelated filler items could support previous research suggesting that negative valence leads to a more liberal response bias (Howe et al., 2010).

Discussion

The present study demonstrated a mood-congruent false memory enhancement whereby participants who were in a negative mood at encoding were more likely to assign *remember* judgments (indicative of a rich recollective experience) to negative-emotion critical lures than neutral-emotion critical lures. This effect was observed regardless of whether testing occurred immediately or after a one-week delay. This is the first demonstration that a mood-congruent false memory enhancement can persist over time.

The mood-congruent false memory enhancement for *remember* judgments observed after immediate testing replicates the findings of Ruci et al. (2009). This pattern of results is consistent with spreading activation models of false remembering (Howe et al., 2009; Roediger & McDermott, 1995) and Bower's (1981) Network Theory of Affect. According to spreading activation theories, when lists of semantic associates are studied at encoding, semantically related non-studied items are automatically activated. In the present study, the list items all converged on a single sematic associate (the critical lure) and this repeated activation results in participants mistakenly believing they have studied the critical lure. Bower's (1981) Network Theory of Affect suggests mood states can further activate mood-congruent critical lures through excitation of emotion nodes in the semantic network. This additional source of activation increases the likelihood of mood-congruent critical lures being falsely *remembered*. Ruci et al. had concerns that a recall test prior to their recognition test may have artificially inflated the number of *remember* responses observed in their study. As the current study replicated this effect using only a recognition test, this suggests their concerns were unfounded.

The observed persistence of the mood-congruent false memory effect for *remember* judgments builds upon previous research demonstrating that negatively-valenced false memories also persist over time (Howe et al., 2010). Although not tested in this study, the findings are consistent with recent evidence suggesting that emotionally arousing experiences cause the release of adrenal stress hormones that increase norepinephrine in the amygdala. Here, amygdala activity during encoding of negative-emotion material modulates memory consolidation and thus influences long-term memory (see McGaugh, 2005). The persistence of the mood-congruent false memory effect could be a result of enhanced associative activation and binding of emotional context at encoding (see Talmi et al., 2007) and long term consolidation processes selective to the encoding of negative-emotion material (e.g., Sharot et al., 2007). The finding that this occurs for false memories is likely due to the consolidatory nature of long-term retention. Payne et al. (2009) argued that a long delay does more than just consolidate veridical memories, it restructures them to allow for insights and inferences to be drawn and allows integration into preexisting memory structures. They concluded that susceptibility to false memories might be the price we pay for such flexible use of our memories.

The current study has applied implications with regards the formation of false memories in forensic settings. For example, an eyewitness to a violent robbery will be exposed to a negative event that may induce negative emotional arousal. The eyewitness may be asked to provide a statement regarding the robbery to the police in the immediate aftermath of its occurrence in order to facilitate arrests. The mood-congruency between the eyewitness' affective state at the time of the robbery and the nature of the robbery itself could enhance the likelihood of vivid false memories being incorporated into this statement. The eyewitness may also be asked to provide a testimony in court, but there is a potentially indefinite delay between the crime taking place and this testimony occurring as arrests need to be made and trials in the US typically only commence between 90 and 120 days after arrests (Neubauer & Fradella, 2011). The findings from the current study suggest that any false memories generated in the original police statement could persist and also be made at trial.

Caution is needed when generalizing laboratory based findings to real world events. A possible shortcoming of the present experiment is that it used recognition tests, rather than free recall, which is potentially less representative of real-life recollection of autobiographical events. However, Howe et al. (2010) argued that autobiographical recollection could be cued when looking at photographs of an event, talking to others about a past event, or indeed, answering specific yes/no questions about the event, thus adding legitimacy to the use of recognition tests here.

A further potential shortcoming is that the present experiment used word lists to induce false remembering. The experience of studying word lists is clearly different from experiencing a life event. Moreover, the induced mood states in this study could be less intense than those evoked in real life situations. However, Wade et al. (2007) argued that any changes observed in memory should be representative of a general model of memory construction, regardless of the conditions under which these changes occur. Indeed the results from the current study can be compared to those of Otgaar, Candel, & Merckelbach (2008), who found it easier to elicit false autobiographical memories in relation to negative events than neutral events. As Howe et al. (2010) concluded, although the procedures used to investigate false autobiographical memories differ from those used in the DRM paradigm, the results are often similar. There is, therefore, reason to speculate that the mechanisms responsible for the construction of DRM list false memories are also responsible for the development of false memories outside the laboratory.

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Table 1. *Proportions of false and correct recognition as a function of mood state, list valence, and retention interval*

	Immediate Recognition Test				Delayed Recognition Test			
	Negative Mood		Neutral Mood		Negative Mood		Neutral Mood	
List Valence	Negative	Neutral	Negative	Neutral	Negative	Neutral	Negative	Neutral
Item Type								
Critical Lures								
Old responses	.76 (.05)	.80 (.07)	.72 (.06)	.67 (.06)	.89 (.03)	.55 (.08)	.67 (.07)	.56 (.06)
Remember	.41 (.06)	.39 (.06)	.26 (.06)	.43 (.05)	.40 (.07)	.20 (.06)	.25 (.07)	.25 (.05)
Know	.27 (.05)	.33 (.05)	.25 (.06)	.25 (.05)	.36 (.07)	.20 (.05)	.35 (.06)	.19 (.04)
Guess	.08 (.04)	.08 (.04)	.20 (.04)	.08 (.03)	.12 (.04)	.15 (.05)	.07 (.03)	.11 (.04)
List Items								
Old responses	.81 (.03)	.78 (.03)	.77 (.04)	.77 (.03)	.67 (.04)	.52 (.05)	.61 (.04)	.42 (.04)
Remember	.38 (.04)	.49 (.05)	.43 (.04)	.55 (.04)	.25 (.04)	.18 (.05)	.26 (.04)	.17 (.03)
Know	.29 (.04)	.19 (.04)	.24 (.03)	.14 (.02)	.21 (.04)	.18 (.04)	.22 (.03)	.14 (.02)
Guess	.14 (.02)	.22 (.04)	.10 (.02)	.09 (.01)	.22 (.04)	.17 (.04)	.13 (.03)	.11 (.02)
Unrelated Fillers								
Old responses	.23 (.04)	.07 (.02)	.22 (.04)	.14 (.03)	.32 (.05)	.19 (.05)	.32 (.04)	.20 (.04)
Remember	.03 (.01)	.01 (.01)	.04 (.02)	.02 (.01)	.05 (.02)	.04 (.02)	.06 (.02)	.02 (.01)
Know	.10 (.02)	.04 (.02)	.07 (.02)	.06 (.03)	.11 (.03)	.05 (.02)	.10 (.02)	.07 (.02)
Guess	.10 (.03)	.04 (.01)	.11 (.02)	.06 (.02)	.16 (.03)	.10 (.03)	.16 (.03)	.11 (.03)

Note: SE in parentheses

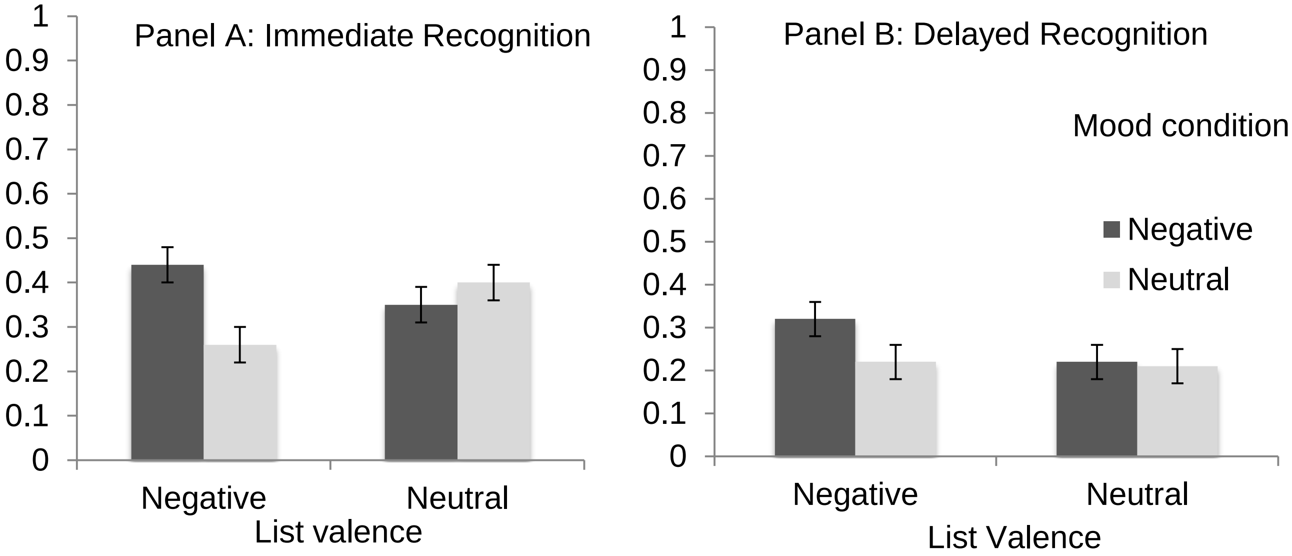

Figure 1. Proportions of false *remember* responses as a function of mood states and list valence.

Note: Error bars represent SE.