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Discrete emotion-congruent false memories in the DRM paradigm

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Abstract

Research has shown that false memory production is enhanced for material that is emotionally congruent with the mood of the participant at the time of encoding. So far this research has only examined the influence of generic negative affective mood states and generic negative stimuli on false memory production. In addition, much of the research is limited as it focuses on valence and arousal dimensions, and fails to take into account the more comprehensive nature of emotions. The current study demonstrates that this effect goes beyond general negative or positive moods and acts at a more discrete emotional level. Participants underwent a standard emotion induction procedure before listening to negative emotional or neutral associative word lists. The emotions induced, negative word lists and associated non-presented critical lures, were related to either fear or anger, two negative valence emotions that are also both high in arousal. Results showed that when valence and arousal are controlled for, false memories are more likely to be produced for discrete emotionally congruent compared to incongruent materials. These results support spreading activation theories of false remembering and add to our understanding of the adaptive nature of false memory production.

Keywords: false memory; mood congruence; emotion; arousal; valence

Discrete emotion-congruent false memories in the DRM paradigm

Memory is not infallible. Often entire events or specific details of an event are falsely remembered. These false memories can have very detrimental effects. For example, Howe and Malone (2011) recently warned clinical practitioners not only to be aware of the presence of false memories during discussions in therapy, but also of the possibility of inducing new false memories. In their paper the authors demonstrate an increased production in depression relevant false memories within the group of participants with major depressive disorder compared to participants without the disorder. This finding raises an interesting question of whether this congruency effect is also present within typical everyday emotional experiences.

There is some literature on mood congruency and false memories. However, this branch of research is still in its infancy. Ruci, Tomes, and Zelenski (2009) investigated the effect of positive and negative valence on spontaneous false memory production for positive, negative, and neutral stimuli. The authors predicted that manipulating both the mood of participants and the emotion of the material would induce a mood congruence effect in memory. The recognition results supported this prediction. That is, false memory production was enhanced for emotional material that matched the emotional state of the participant at encoding. This finding has been replicated by Knott and Thorley (2013) and these authors also showed that mood congruence effects persisted over a one week delay.

Although informative, the focus of these studies has been solely on differences in valence, other research has shown that the level of arousal associated with emotions is another important factor that affects memory. In fact, valence and arousal have been shown to have very different effects on false memories. Brainerd, Holliday, Reyna, Yang, and Toglia (2010) measured the effects of arousal and valence when varied orthogonally across materials. False memory rates were found to be higher for low valence and high arousal, however the effects of arousal were only present for negatively valenced material (see also Howe, Candel, Otgaar, Malone, & Wimmer, 2010; Mickley Steinmetz, Addis, & Kensinger, 2010). In contrast, Corson and Verrier (2007) examined the effects of arousal and valence on false memory by inducing a range of discrete emotional states. A temporary mood induction technique was used to induce happiness, serenity, anger, and sadness; chosen to give distinctions between high and low arousal, and positive and negative valence. False memories were measured for neutral stimuli and the results revealed that high arousal led to more false memories, but there was no effect for valence. The authors concluded that higher arousal increased confidence leading to an increase in the number of false memories being reported. This research goes to furthering our understanding of how arousal and valence affect false memory production, however it fails to address any other dimensions of emotion that may also have an effect on false memory production.

In a review of the emotion and memory research literature, Levine and Pizarro (2004) argued that it made little sense to limit research to the effects of emotional arousal on memory. That is, people may feel elated, terrified, despairing, or furious – but they are never just "aroused". Levine and Pizarro highlight the fact that specific emotions are likely adaptive in nature, allowing us to respond appropriately to changes in our environment. Emotions are led by appraisals and these appraisals serve an adaptive purpose by helping people evaluate their environment based on their specific goals and guide appropriate action (Frijda, 1988; Moors, Ellsworth, Scherer, & Frijda, 2013). This aspect of emotion cannot be explained in terms of arousal and valence and therefore for a complete understanding of the effects of emotion on false memory we need to look beyond the effects of arousal and valence.

In an attempt to highlight the limitation of focussing on valence effects Lerner and Keltner (2000) looked at the effect of fear and anger, two emotions of similar valence, on risk perception. Fear led to more pessimistic decision making while anger led to more optimistic judgements. The results support appraisal theories of emotion and highlight the need to look beyond emotion effects driven by valence. Fear and anger have also been used to demonstrate the effect of discrete emotion on memory, regardless of arousal and valence. In an investigation of emotional arousal and negative affect on memory for peripheral and central details, Talarico, Berntsen, and Rubin (2009) found that although negative affect impaired recall of peripheral details, there were distinct differences in the results for fear and anger. Talarico et al. took a measure of reliving at retrieval and found that this was negatively correlated with peripheral recall for anger but not fear, regardless of the similarities in dimensions between these two emotions.

The role of specific emotions, irrespective of arousal and valence effect, on false memories has yet to be studied. However, research has recently shown how important specific emotional states may be in false memory. Although caution is appropriate when generalising from psychopathology to everyday emotional experiences, in a study mentioned earlier, Howe and Malone (2011) showed specific emotion congruent effects for false memories in individuals diagnosed with a major depressive disorder (see also Moritz, Gläscher, & Brassen, 2005). Based on these findings it is important to examine whether specific emotions have a distinct effect on the way people attend to, encode, and retrieve false information that may or may not be congruent to the experienced emotion. To do this we aim to expand up on the work of Ruci et al. (2009) and Knott and Thorley (2013), by manipulating fear and anger, to investigate whether there is a discrete emotion-congruency effect with spontaneous false memories. Fear and anger are dimensionally similar with regards to arousal and valence and therefore allow us to investigate more thoroughly this effect (Russell, 1980).

As with many of the experiments mentioned so far, we measured false memories using the Deese/Roediger-McDermott paradigm (DRM; Deese, 1959; Roediger & McDermott, 1995). In the DRM paradigm, participants are presented lists of words (e.g., *steal, robber, crook*…) that are all semantically related to one non-presented word (e.g., *thief*), known as the critical lure. The first word in the list will be the highest associate of the critical lure and subsequent words are ordered in decreasing associative strength. When asked to remember the lists participants often falsely remember the critical lure as being present in the original list. In order to further validate the false memories being reported, participants are asked to give a remember-know-guess judgement where 'remember' measures the presence of a distinctive recollective experience, 'know' measures a sense of familiarity, and 'guess' measures a level of uncertainty.

According to theories of spreading activation (Bower, 1981; Howe, Wimmer, Gagnon, & Plumpton, 2009) we would expect to see an increase in the production of false memories for material that is emotionally congruent to that of the participant. For example, associative-activation theory (AAT) hypothesizes that knowledge is stored in a semantic network and when a concept is activated, this activation spreads to other neighboring concepts. Once activation reaches a certain threshold the source of this activation can be misattributed to the original stimulus producing a false memory. Emotional states contribute to a concept's activation and therefore increase the chances of reaching this critical threshold, a mechanism that not only accounts for previous results (e.g., Knott & Thorley, 2013; Ruci et al., 2009) but is also able to predict the same pattern of congruency effects for discrete emotions. Fuzzy-trace theory (FTT; Brainerd & Reyna, 2002) would also predict such results. FTT theorizes that, as verbatim traces of memory deteriorate, gist traces are retrieved, ones that lead to false recognition of associated material. Congruent mood states are said to increase false memory rates because reliance on gist traces increases with emotion.

In the present research, we extend previous research on the emotional congruency effect (Howe & Malone, 2011; Knott & Thorley, 2013; Ruci et al., 2009) by using discrete emotions that are dimensionally similar with regard to arousal and valence. In order to better understand the link between memory and emotion, we need to go beyond a simple examination of the effects of emotional arousal and valence and instead be able to classify to-be-remembered information as emotionally congruent or incongruent with a specific emotional state (e.g., fear, anger).

Method

Participants

A total of 83 (25 male and 58 female) A-level students, all aged 18, took part in the experiment, voluntarily. The experiment was conducted at the participants' school, with the approval of the teachers. All participants gave written informed consent and were fully debriefed at the end of the experiment.

Design

A 3(Emotion: anger vs. fear vs. control) x 3(List: anger, fear, neutral) mixed design was used, with a standard DRM paradigm and recognition memory test. Emotion was the between-participants variable and list type was the within-participant variable. Recognition responses were taken for target words, filler items, and critical lures, along with additional judgements of either remember, know, or guess (R/K/G). Instructions were based on those from Rajaram (1993). Participants were randomly assigned to the anger condition (N = 27), fear condition (N = 28), or control condition (N = 28).

Materials, and Procedure

Participants in the control group underwent no emotion induction procedure. The two experimental groups, fear and anger, were presented with short film clips from Rottenberg, Ray, and Gross (2007). Anger was induced by showing people a clip from the film "My Bodyguard", in which one male was harassing and bullying another. Fear was induced by showing participants a clip from the movie "The Shining", in which a young boy is troubled and playing in a haunted building. To demonstrate that any differences in memory were not the result of a temporary mood change at retrieval, all participants watched a neutral video clip (from a wildlife documentary) lasting 5 minutes prior to retrieval. To monitor emotional states throughout the experiment participants reported levels of valence and arousal through the self-assessment manikin (SAM) questionnaire.

A total of six 10-item DRM word lists were presented, two of which were related to fear, two to anger, and two were neutral (see Appendix). Lists were presented in emotion consistent pairings and the list orders for the fear and anger groups were different so that the lists congruent to the participants' emotion always came first. This was done to prevent incongruent lists contaminating the emotional state of the participants at the beginning of encoding. To ensure this choice of list order was not a confounding variable, the different list orders were replicated and counterbalanced within the control group to enable later comparison[1]. Lists were created from those used by Stadler, Roediger, and McDermott (1999) and using The University of South Florida word association database (Nelson, McEvoy, & Schreiber, 2004). The six critical lures were *anger, war, fear, danger, earth,* and *hair*. Backward associative strength (BAS) was controlled across the lists and word frequency for the critical lures was equated across the negative lists, but was slightly higher for the neutral lists. Valence and arousal scores were taken from the Affective norms for English words database (ANEW: Bradley & Lang, 1999) for all available words. For both negative lists, valence was lower than the neutral lists and arousal was higher. Between the negative lists, both valence and arousal were equal. The recognition test contained 42 words. These were made up of the 6 critical lures, 18 "old" words, and 18 "new" words. Old words were those from positions 1, 5, and 10 in each of the 6 presented lists, and new words consisted of 3 emotionally congruent non-presented low associates for each of the critical lures.

Participants received a standard set of instructions at the start of the experiment, along with the first SAM questionnaire. Comprehensive instructions were given with the first SAM to avoid confusion later in the task (subsequent SAM questionnaires contained basic instructions). Experimental groups watched one of the short video clips, and completed a SAM questionnaire afterwards. All groups were then presented with the 6 DRM lists in auditory form, with words 2 seconds apart, and 3 seconds between lists. Following this the neutral video clip was presented, and again participants' filled out a SAM questionnaire. They then began the recognition test. Standard instructions to indicate old and new words were given, as well as instructions to report if recognition of old words was based on a *remember, know,* or *guess* judgement (*remember* meaning they experienced a memory of the word, *know* meaning the word feels familiar but they do not have the explicit memory of it, and *guess* meaning they are just guessing that it was presented). Finally, participants were asked to complete one more SAM questionnaire to ensure there were no lasting effects of the negative emotion induction.

Results

Emotion Manipulation

Of the 83 participants, 8 were removed from the analysis as their arousal scores decreased following the emotion induction video and 3 were removed because their valence scores increased following the video. Of the remaining participants 28 were in the control group, 21 in the fear group, and 23 in the anger group. No significant differences were found between the groups for arousal, $F(2, 69) = .51$, $p = .60$, or valence, $F(2, 69) = 2.93$, $p = .06$, before the emotion manipulation. However, following the emotion induction the difference between groups for arousal was significant, $F(2, 69) = 7.14$, $p < .01$, as was the difference in valence, $F(2, 69) = 16.47$, $p < .01$. Bonferroni pairwise-comparisons (alpha set at .05) indicated that arousal scores for the fear group (M = 5.85, SD = 1.62. *95% CI* [5.12, 6.60]) and anger group (M = 5.30, SD = 1.64, *95% CI* [4.60, 6.01]) were significantly higher than the control group (M = 4.21, SD = 1.26, *95% CI* [3.73, 4.70]) following the emotion induction. Valence scores were significantly lower in the fear (*M* = 4.80, *SD* = 1.36, *95% CI* [4.12, 5.43]) and anger group (*M* = 4.52, *SD* = 0.67, *95% CI* [4.23, 4.81]) compared to the control group (*M* = 6.39, *SD* = 1.52, *95% CI* [5.80, 6.98]) following the emotion induction. There were no differences in arousal or valence scores between the two negative emotion groups (p = .52 for arousal, and p = 1 for valence). Finally arousal and valence scores were compared between the groups following the neutral video, before the recognition test. No significant differences were found between the groups in either arousal, $F(2, 69) = 2.30$, $p = .35$, or valence, $F(2, 69) = 1.33$, $p = .49$. Thus, participant's emotions differed only at encoding, and not at retrieval.

Recognition Responses

Proportion of recognition responses were coded for correct recognition of old words, false recognition of critical lures, and false recognition of filler words. Separate 3 (Emotion: fear vs. anger vs. control) x 3 (List: fear vs. anger vs. neutral) ANOVAs were conducted for overall recognition responses for each set of words, one each for *remember* responses, for *know* responses, and for *guess* responses. Prior to analyzing data for all conditions, the responses for the control group were analyzed based on the order in which the lists were presented. No significant differences were found for overall recognition, and *remember* judgements, for all correct recognition and false recognition of critical lures ($p > .05$ in all cases). Thus, we concluded that the order of list presentation is not likely to have had an effect on performance on the memory task.

False recognition of critical lures. Where critical lures were recognized as being present in the original lists, responses were first analyzed for false recognition, and then separately for whether the recognition was accompanied by remember, know, or guess responses. For all false recognition of critical lures there was no significant main effect for Emotion, $F(2, 69) = .40$, $p = .70$, $\eta_p^2 = .01$, but a significant main effect of List $F(2, 138) = 10.00$, $p < .001$, $\eta_p^2 = .13$, and a significant interaction effect between List and Emotion $F(4, 138) = 3.83$, $p < .01$, $\eta_p^2 = .10$. Pairwise comparisons (see Table 1 for means and standard errors) using the Bonferroni correction showed that within the fear group the proportion of recognition of critical lures was significantly higher for fear lists compared to anger lists (p < .01) and neutral lists (p < .01) and there were no differences between the anger and neutral list (p = 1.00). Within the anger group the proportion of false recognition was significantly higher for anger lists compared to neutral lists (p < .05) but no significant difference was found between the anger and fear lists (p = .62) or fear and neutral lists (p = .33). Within the control group there were no significant differences between the lists (all p's > .05).

For 'remember' false recognition responses (see Figure 1) there was a significant main effect of Emotion, $F(2, 69) = 3.61$, $p < .05$, $\eta_p^2 = .10$, but no significant effect of List, $F(2, 138) = 2.63$, $p = .08$, $\eta_p^2 = .04$. However, there was a significant Emotion x List interaction, $F(4, 138) = 12.45$, $p < .01$, $\eta_p^2 = .27$. For the fear emotion group, pairwise comparisons revealed that the proportion of remember responses was significantly higher for fear lists than anger lists (p < .01) and neutral lists (p < .01), but the difference between the anger and neutral lists was not significant (p = .93). For participants in the anger group, the proportion of false memories for anger lists was significantly greater than fear lists (p < .01) and neutral lists (p < .05) but the difference between the fear and neutral lists was not significant (p = .78). For the control group there were no significant differences between the lists (all p's > .05). [2]

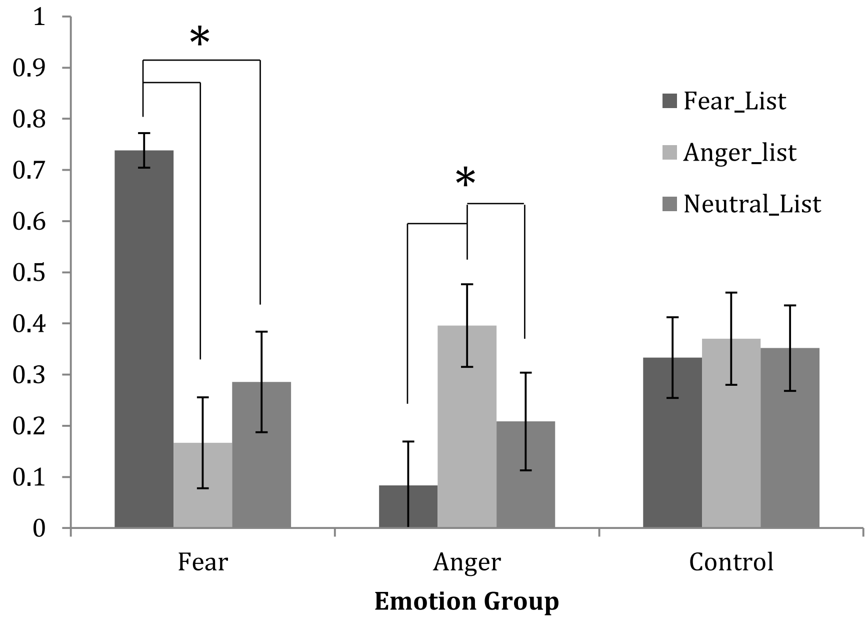

Figure 1. ***Proportion of false 'remember' responses as a function of emotion group and list emotion (Error bars represent SE) *p < .05***

Participants additionally made know or guess responses to a selection of the falsely recognized critical lures, however the figures for these categories were very low, thus reducing the power for any subsequent analyses. For the know judgements the main effect for List, $F(2, 138) = 1.08$, $p = .34$, $\eta_p^2 = .02$, main effect for Emotion, $F(2, 69) = 1.3$, $p = .28$, $\eta_p^2 = .04$, and the List x Emotion interaction, $F(2, 138) = 2.30$, $p = .06$, $\eta_p^2 = .06$, were all non-significant. For guess judgements the main effect of List, $F(2, 138) = 1.37$, $p = .26$, $\eta_p^2 = .02$, main effect of Emotion, $F(2, 69) = 1.10$, $p = .34$, $\eta_p^2 = .03$, and the Emotion x List interaction, $F(2, 69) = 1.25$, $p = .29$, $\eta_p^2 = .04$, were also non-significant.

True recognition of list items. For true recognition responses there was a significant main effect of List, $F(2, 138) = 5.63$, $p < .01$, $\eta_p^2 = 0.07$, no significant main effect of Emotion, $F(2, 69) = 0.84$, $p = .44$, $\eta_p^2 = 0.02$, and a significant List x Emotion interaction, $F(4, 138) = 3.75$, $p < .01$, $\eta_p^2 = 0.1$. Pairwise comparisons (see Table 2 for means and standard errors) within the fear group showed that recognition for fear lists was significantly higher than neutral lists ($p < .05$) but not anger lists ($p = 1.00$) and the difference between anger and neutral lists was non-significant ($p = .25$). For the anger group the proportion of correct recognition responses was significantly higher for anger lists compared to fear lists ($p < .01$), but the difference between the anger and neutral lists was non-significant ($p = .48$) as was the difference between neutral and fear lists ($p = .14$). In the control group there were no significant differences (all p's > .05).

For *remember* responses to correctly recognized items there was a significant main effect of List, $F(2, 138) = 3.56$, $p < .05$, $\eta_p^2 = 0.05$, but not Emotion, $F(2, 69) = 1.02$, $p = .37$, $\eta_p^2 = 0.03$, and a significant List x Emotion interaction, $F(4, 138) = 6.53$, $p < .05$, $\eta_p^2 = 0.16$. Pairwise comparisons for the fear group and control group revealed no significant differences between lists (all p's > .05). Within the anger group however the remember responses to anger lists were significantly greater than fear lists ($p < .01$), and responses for the fear lists were significantly greater than neutral lists ($p < .05$). The difference between the anger and neutral lists was not significant ($p = .18$).

For *know* responses to correctly recognised list items there was a significant effect of List, $F(2, 138) = 4.30$, $p < .05$, $\eta_p^2 = 0.06$, but not of Emotion, $F(2, 69) = 1.46$, $p = .24$, $\eta_p^2 = 0.04$, or the List x Emotion interaction, $F(4, 138) = 1.91$, $p = .11$, $\eta_p^2 = 0.05$. Within the fear group pairwise comparisons show that know responses for the fear lists were significantly higher than the neutral lists ($p < .05$). No significant differences were found between the fear and anger lists ($p = .78$) and anger and neutral lists ($p = .21$). Within the anger group and control group there were no significant differences (all p's > .05).

For *guess* responses there was no significant main effect of List, $F(2, 138) = 0.35$, $p = .70$, $\eta_p^2 = 0.01$, no main effect of Emotion, $F(2, 69) = 0.13$, $p = .88$, $\eta_p^2 = 0.00$, or any List x Emotion interaction, $F(4, 138) = 1.93$, $p = .11$, $\eta_p^2 = 0.05$. Within the fear group the guess responses for anger lists were significantly higher than fear lists ($p < .05$) however no other differences were significant (all *p*'s > .05).

False recognition of fillers*.* For recognition of filler items there was a significant main effect of List, $F(2, 138) = 35.59$, $p < .01$, $\eta_p^2 = 0.34$, but not Emotion, $F(2, 69) = 0.08$, $p = .93$, $\eta_p^2 = 0.00$, or the List x Emotion interaction, $F(4, 138) = 1.32$, $p = .27$, $\eta_p^2 = 0.04$. Pairwise comparisons (see Table 3 for means and standard errors) within the fear group show that recognition for fear lists was significantly higher than anger lists ($p < .01$) and neutral lists ($p < .01$) but the difference between anger and neutral lists was not significant ($p = .56$). For the anger group the proportion of recognition responses was significantly higher for fear lists compared to neutral lists ($p < .01$), but the difference between the anger and neutral lists was not significant ($p = .06$) nor was the difference between anger and fear lists ($p = .11$). In the control group recognition was significantly higher for fear lists compared to anger lists ($p < .01$) and neutral lists ($p < .01$). The difference between the anger and neutral lists was not significant ($p = 1.00$).

For *remember* responses there was a significant main effect of List, $F(2, 138) = 4.17$, $p < .05$, $\eta_p^2 = 0.06$, but not Emotion, $F(2, 69) = 1.59$, $p = .21$, $\eta^2 = 0.04$, or the List x Emotion interaction, $F(4, 138) = 0.91$, $p = .46$, $\eta_p^2 = 0.03$. Pairwise comparisons revealed no significant differences (all *p*'s > .05).

For *know* responses there was a significant effect of List, $F(2, 138) = 23.02$, $p < .01$, $\eta_p^2 = 0.25$, but not Emotion, $F(2, 69) = 0.98$, $p = .38$, $\eta_p^2 = 0.03$, or the List x Emotion interaction, $F(4, 138) = 2.43$, $p = .07$, $\eta_p^2 = 0.06$. Within the anger group the pairwise comparisons show no significant differences between lists (all *p*'s > .05). Within the fear group the know responses are significantly higher for fear lists compared to neutral ($p < .01$) and anger lists ($p < .01$). The difference between the anger and neutral lists was not significant ($p = 1.00$). Within the control group the responses to fear lists were significantly greater than responses to neutral lists ($p < .05$) but no other differences were significant (all *p*'s > .05).

For *guess* responses to filler items there was a significant effect of List, $F(2, 138) = 7.91$, $p < .01$, $\eta_p^2 = 0.10$, but not Emotion, $F(2, 69) = 2.98$, $p = .06$, $\eta_p^2 = 0.08$, and the List x Emotion interaction was significant, $F(4, 138) = 2.68$, $p < .05$, $\eta_p^2 = 0.07$. Within the fear and control group the pairwise comparisons show no significant differences between lists (all *p*'s > .05). For the anger group the guess responses to anger lists were significantly greater than neutral lists ($p < .05$) and the responses to fear lists were significantly greater than neutral lists ($p < .05$). The difference between the anger and fear lists was not significant ($p = 1.00$).

Discussion

The results presented here are the first to demonstrate the specificity of the emotion congruency effect with spontaneous false memories. Participants believed to be experiencing fear or anger falsely 'remembered' significantly more critical lures from the lists for which the content was congruent to their emotional state. Not only does this replicate previous findings of an emotion congruency effect driven by valence (Knott & Thorley, 2013; Ruci et al., 2009), but it extends these findings to reveal that the emotion congruency effect is present for discrete emotions, even when arousal and valence are similar across experimental conditions.

This pattern of discrete emotion congruency is consistent with spreading activation theories, such as AAT (Howe et al., 2009) and Bower's (1981) Network Theory of Affect, as well as other theories such as FTT (Brainerd & Reyna, 2002), and appraisal theories of emotion (see Oatley & Johnson-Laird, 2014). According to AAT, we would be more likely to produce false memories related to the emotion we are experiencing due to the heightened activation of the related emotion node in the associative network, which contains both semantic and affective memory structures. Where past research has demonstrated this through activation of general negative emotion nodes, our results show that this associative network activation is much more selective, activating discrete emotion nodes. Our results similarly support FTT, which would posit that the emotional state of the participant at encoding would increase the likelihood of extracting emotion-congruent gist from congruent stimuli, and therefore increase the chances of false retrieval. In addition to theories pertaining to false memory production, theories regarding emotion processing can also provide some explanation for the results found.

Specific emotions, such as fear and anger, appear to have a distinctive effect on the way people attend to, encode, and retrieve information. Emotions are believed to be adaptive mechanisms for survival. They can increase the efficiency of reactions to events and optimise the response by biasing cognitive resources toward relevant stimuli in the environment (Clore & Huntsinger, 2007; Oatley & Johnson-Laird, 2014). This biasing effect can subsequently increase activation of concepts, or gist strength. Although previous research has shown this to be the case in the memory accuracy literature, we have shown that this may be the case for false memory production too.

As well as emotions being adaptive, Howe (2011) highlights the adaptive nature of false memories, and their role in survival and goal attainment. Research has shown that memory is biased towards survival relevant conditions (Nairne, Thompson, & Pandeirada, 2007; Nairne, 2010). It adapts to encode information that will be most beneficial to the present goals and future survival of the person. The different appraisals and actions associated with different emotions therefore benefits from a memory system that is biased towards information most associated with that specific emotion and subsequently the desired goal. With regards to fear and anger, although both emotions are often associated with similar situations, their adaptive purposes are very different. Fear is considered to provoke avoidance behaviours, where an organism retreats from the stimulus, whereas anger would provoke an approach response, where the organism may attack the stimulus (Carver & Harmon-Jones, 2009; Elliot, 2006; Rutherford & Lindell, 2011). Although there may be other dimensions on which fear and anger differ, the approach/avoidance mechanism has clear adaptive value and could account for the findings of this experiment. Although it is important to understand the role of arousal and valence when investigating the effects of emotion, our findings demonstrate the need to go beyond these dimensions to fully understand differences that discrete emotions may have on many cognitive mechanisms.

Our results support the assumption that our emotion induction procedure was successful, however there are limitations in the method used. Ethically, we could not induce the same emotional state experienced when being attacked, however, our chosen induction technique has been normed extensively for producing the desired discrete emotions (see Bartolini, 2011; Gross & Levenson, 1995; Rottenberg et al., 2007). Our control condition was that of a no-induction condition, however past research differs in its use of a no-induction condition versus a neutral emotion induction. Although there are advantages to controlling the emotional state of the control participants, our aim here was to compare the results of our negative emotion groups to a true control group. With regards to our emotion groups, when inducing anger it must also be noted that there is often a subsequent induction of disgust. While this may be the case with our chosen film clip it would only be a mild induction and we do not feel it confounds our results. In addition, due to the nature of the stimuli being used we were unable to employ a more comprehensive subjective measure of emotion. The emotion words necessary for any such measure would have confounded the results of the memory test. Nevertheless, analysis of the SAM scales confirmed the appropriate changes in mood following the induction procedures, and the clips used are not known to induce the contrasting emotion.

With regards to the DRM lists used we were careful to ensure that none of the words presented had high BAS for the critical lures on the incongruent emotion lists. However, given the nature of fear and anger there may be weak, indirect, associations across lists, whereby words on the anger lists may be associated with words on the fear lists and vice versa. With most typical DRM studies we would expect to see relatively low false recognition rates for filler items. However, our filler items were congruent to each of the lists and therefore not strictly unrelated. We therefore expect to see the same congruency effects, if much weaker, as we do with the critical lures. According to AAT, very weak associates would not normally create a spreading of activation significant enough to produce false memories. However, the congruent emotional experiences would have enhanced these activations, subsequently bringing many to the necessary threshold for false memory production.

An alternative explanation for our pattern of results can be found in the response bias literature (REF: Dougal & Rotello, 2007; Windmann & Kutas, 2001). Dougal and Rotello (2007) demonstrated that when semantic densitiy was matched between negative, neutral, and positive stimuli there is no difference in sensitivity or memory accuracy between the three conditions. They did however find a difference in response bias, whereby participants were more liberal in their recognition responses to negative stimuli compared to neutral and positive, regardless of whether the stimuli was old or new. This finding suggests that negative stimuli generally elicits higher proportions of responding, and may therefore cause one to question whether an increased response to negative emotional stimuli is in fact due to a congruent emotion induction or simply an increased bias. However, this prediction can only account for a general increase for negative stimuli. In our experimental manipulation we have two different negative emotions, each with similar levels of valence and arousal, and any increase in recognition rates for negative stimuli within each of our groups is specific to the congruent emotion.

The results of this research have implications for clinical settings in which therapists may discuss emotional memories with patients, or therapies aimed at encouraging new positive memories. Research has shown how important specific emotional states may be in false memory. For example, Howe and Malone (2011) showed that the presence of major depressive disorder significantly increased false memory production for depression relevant information. Although caution is appropriate when generalizing from psychopathology to everyday emotional experiences, the current study expands on this finding to show that this highly specific emotion congruency effect is also present outside of the clinical disorder. Those not diagnosed with major depressive disorder are still at risk of producing false memories congruent to the specific negative mood that they experience at encoding.

Although further research is required to gain a more complete understanding of the effect of emotion on memory, our results demonstrate that even with a mild laboratory induced emotion false memories for specific emotion-congruent events will lead to an increase in susceptibility and a high production of false memories (see also, Howe et al., 2010; Knott & Thorley, 2013). Although research has shown that arousal and valence have distinct effects on memory production, this study is the first to show that when emotions are similar on both of these dimensions a discrete emotion congruency effect can occur. Future research should endeavor to establish the underlying mechanisms responsible for this effect.

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Appendix

Stimuli: DRM word lists

	Neutral		Anger		Fear	
Critical Lure	**Earth**	**Hair**	**War**	**Anger**	**Fear**	**Danger**
	planet	strand	battle	mad	terror	risk
	world	scalp	bomb	frustrate	fright	caution
	globe	lice	fight	hate	anxiety	warning
	ground	conditioner	revolution	rage	afraid	safe
	gravity	comb	nuclear	temper	panic	daring
	environment	headband	missile	fury	scared	trouble
	worm	dandruff	soldier	ire	horror	zone
	heaven	mousse	gun	wrath	monster	fire
	sphere	bald	destruction	fight	scream	accident
	geology	clippers	defeat	hatred	darkness	harmful

BAS for presented words has been checked across list categories. All values are negligible with the exception of “scream” (found in the fear list), which has a BAS of .02 with anger. In addition, fear and anger have BAS of .01 and .02.

Footnotes

[1] Independent samples t-tests were conducted for all true and false recognition responses, as well as for ‘remember’ responses, within the control group, to look at the different list orders used. No significant differences in recognition responses to list words were found between participants who received the anger lists first and those who received the fear lists first, all p’s > .1.

[2] Signal detection analyses (d' and C) did not reveal any patterns that differed from those of the main analysis. These analyses were calculated two different ways: First using fillers unrelated to the lists but matching in emotional content and second using only the neutral unrelated fillers.

Table 1: False recognition responses to critical lures as a function of emotion and list

	Fear Group				Anger Group				Control Group			
			95% CI				*95% CI*				*95% CI*	
	M	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*
Overall Recognition												
Fear lists	.93	.04	.85	1.01	.63	.07	.48	.78	.77	.06	.64	.89
Anger lists	.57	.08	.42	.77	.78	.07	.62	.90	.61	.07	.46	.75
Neutral lists	.53	.09	.34	.71	.48	.08	.31	.64	.61	.06	.47	.74
Remember												
Fear lists	.74	.07	.58	.89	.09	.05	-.02	.19	.36	.07	.21	.51
Anger lists	.17	.07	.02	.32	.39	.05	.28	.50	.39	.08	.23	.55
Neutral lists	.29	.08	.12	.46	.20	.07	.05	.34	.36	.06	.23	.48
Know												
Fear lists	.12	.05	.02	.22	.30	.06	.18	.43	.25	.05	.14	.36
Anger lists	.21	.07	.08	.35	.24	.07	.10	.38	.09	.04	.01	.16
Neutral lists	.12	.05	.02	.22	.15	.07	.01	.29	.21	.05	.12	.31
Guess												
Fear lists	.07	.04	-.01	.15	.24	.08	.08	.40	.16	.05	.05	.27
Anger lists	.19	.08	.02	.36	.15	.06	.03	.27	.13	.04	.04	.21
Neutral lists	.12	.06	.00	.24	.13	.05	.03	.23	.04	.02	-.02	.09

Table 2: Recognition responses to target items as a function of emotion and list

	Fear Group				Anger Group				Control Group			
			95% CI				*95% CI*				*95% CI*	
	M	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*
Overall Recognition												
Fear lists	.60	.05	.50	.70	.38	.04	.30	.45	.56	.05	.46	.65
Anger lists	.57	.05	.45	.68	.66	.06	.51	.76	.61	.05	.51	.70
Neutral lists	.42	.06	.30	.54	.50	.05	.40	.61	.52	.04	.44	.60
Remember												
Fear lists	.44	.05	.33	.56	.14	.03	.08	.20	.36	.05	.25	.47
Anger lists	.37	.06	.24	.49	.49	.04	.39	.58	.38	.05	.28	.47
Neutral lists	.33	.06	.21	.46	.33	.05	.24	.43	.35	.03	.28	.42
Know												
Fear lists	.13	.03	.06	.19	.15	.04	.08	.23	.12	.03	.06	.18
Anger lists	.09	.02	.04	.14	.10	.03	.04	.17	.18	.04	.11	.26
Neutral lists	.03	.01	.00	.06	.10	.02	.06	.14	.09	.03	.03	.15
Guess												
Fear lists	.03	.01	.00	.06	.09	.03	.03	.14	.08	.02	.03	.13
Anger lists	.11	.04	.03	.19	.07	.02	.03	.11	.05	.02	.01	.09
Neutral lists	.06	.02	.01	.11	.07	.02	.03	.11	.08	.02	.04	.11

Table 3: Recognition responses to filler items as a function of emotion and list

	Fear Group				Anger Group				Control Group			
			95% CI				*95% CI*				*95% CI*	
	M	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*	*M*	*SE*	*LL*	*UL*
Overall Recognition												
Fear lists	.34	.06	.22	.46	.28	.05	.21	.40	.36	.06	.25	.48
Anger lists	.15	.04	.05	.23	.20	.05	.10	.29	.11	.03	.06	.17
Neutral lists	.07	.03	.01	.14	.05	.03	.01	.12	.12	.03	.05	.20
Remember												
Fear lists	.08	.02	.03	.13	.07	.02	.02	.11	.11	.03	.04	.18
Anger lists	.09	.04	.01	.16	.01	.01	-.01	.04	.04	.01	.01	.07
Neutral lists	.04	.03	-.01	.09	.02	.02	-.02	.07	.04	.02	.01	.08
Know												
Fear lists	.18	.04	.10	.27	.08	.03	.02	.14	.14	.04	.06	.21
Anger lists	.02	.01	-.01	.04	.04	.02	.01	.08	.04	.02	.01	.08
Neutral lists	.01	.01	-.01	.02	.01	.01	-.01	.04	.04	.02	.01	.08
Guess												
Fear lists	.08	.02	.03	.13	.13	.03	.07	.19	.11	.03	.05	.17
Anger lists	.04	.02	.01	.07	.15	.05	.06	.25	.03	.01	.00	.06
Neutral lists	.02	.02	-.01	.06	.02	.01	.00	.05	.04	.02	.00	.08