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# *Summary*

# Effects of Fear vs. Anger on Recognition Memory when Emotion is Induced Before Encoding or Before Retrieval

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The present study investigated the effect of specific emotions on recognition memory and whether these effects are mediated by the motivational properties of emotions. The main purpose was to compare two theoretical perspectives of emotions in terms of their predictions about the emotion-memory relationship.

According to the first theoretical perspective that is prominent in the literature, emotions are defined along two main dimensions: valence and arousal (*Circumplex Model*: Lang, Bradley, & Cuthbert, 2008; Russell, 1980). Valence determines how negative or positive an emotion is, whereas arousal determines how exciting or calming an emotion is. For example, sadness and anger are both negative emotions (same valence) but sadness is associated with low arousal, whereas anger is associated with high arousal.

According to the second perspective, emotions are defined along basic motivational systems: approach and avoidance (Watson, Wiese, Vaida, & Tellegen, 1999). Generally positive emotions such as happiness and excitement are assumed to motivate approach behavior, while negative emotions such as anxiety and fear are associated with avoidance behavior. Anger, however, has been shown to be an exception within the negative valence category and is associated with approach motivation (Carver & Harmon-Jones, 2009).

Valence/arousal perspective has so far dominated the research investigating the effects of emotion on memory. Two main findings emerge from this literature. First, memory is enhanced for negatively-valenced stimuli (e.g., words, images, faces) as indicated by higher recall and recognition accuracy for negative than positive or neutral items (see Kensinger & Schacter, 2008 for a review). Second, in a recognition memory test in which studied (old) items are mixed with the new ones, emotional stimuli lead to a more liberal response bias compared to neutral stimuli. Participants are more willing to say "old" to the test items when those items are negative than neutral or positive, regardless of the accuracy of the decision. In other words, this bias is independent of their ability to discriminate between old and new items (i.e., memory sensitivity).

In two separate reviews, Levine and Pizarro (2004, 2006) discussed the limitations of studies based mainly on valence and arousal dimensions, and argued that investigating effects of specific emotions (within the same valence category) on memory would lead the literature to a more complete and comprehensive understanding of emotion-memory interactions. So far, research on this topic has been limited. In a recent study, disgusting images were reported to increase both sensitivity and response bias in a recognition memory test compared to fearful or neutral images (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2012). This study is important to show different effects of two emotions of the same valence category. Disgust and fear, however, are similar in terms of motivational properties; they are both associated with avoidance. It is an open question whether the two negative emotions differing on the motivation dimension would also have different effects on memory.

The present study aimed to determine whether the effect of emotional state (i.e., mood) on recognition memory is valence-based or motivation-based and also to explore whether the effects of emotion on memory are more visible during the encoding or retrieval of the information. Anger and fear were chosen as target emotions to compare these two perspectives because for these emotions, the predictions of the two perspectives are different. According to the valence/arousal perspective, anger and fear are similar: they are both negative and highly-arousing emotions. In terms of the motivational perspective, however, anger and fear are opposite emotions: fear triggers avoidance, whereas anger triggers approach motivation (Carver & Harmon-Jones, 2009). A third mood condition was also added (calm or happy) in order to test the valence-based predictions more directly.

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The main hypotheses of this study are: 1) According to the valence/arousal perspective, angry and fearful participants would have a higher recognition memory performance compared to the calm participants. Because anger and fear are similar on these dimensions, memory performance is not expected to differ between the two conditions, 2) According to the motivational perspective, participants in the approach-related anger condition would have a higher recognition performance compared to those in the fear condition. In particular, approach motivation is expected to lead to a more liberal response bias, 3) If emotion leads to an enhancement of the encoding processes, then emotion-related effects on memory performance would be observed when emotion is induced before encoding. Alternatively, if emotion leads to an enhancement of the retrieval processes, then effects on memory performance would be observed when emotion is induced right before the test phase, after encoding has been completed.

## Method and General Procedure

Two experiments were conducted to pit these two perspectives against each other in terms of their predictions on the emotion-memory interaction and to explore whether the effects of emotion on memory are more visible during the encoding or retrieval of information.

In Experiment 1, first, mood was induced by asking participants to write about an emotional event from their past in which they were really angry, afraid, or calm for about 15 minutes. Thus, mood condition was manipulated between-subjects. Immediately following the mood induction, participants were asked to study 40 neutral words for a later recognition memory test. After an approximately 15-minutes of a retention interval during which participants performed non-verbal attention-based tasks, they were given a recognition test including previously studied neutral words mixed with 40 new, unstudied neutral words. For each test item, they were asked to decide whether the word was "old" (studied) or "new" (unstudied) on a 6-point confidence rating scale.

Finally, participants completed a short mood assessment form on which they rated to what extent they felt each emotion during the autobiographical recall (mood induction) phase of the study, as well as giving general ratings for valence and arousal (Arikan İyilikci & Amado, 2017).

The methods and procedures in Experiment 2 were similar to those of Experiment 1 with two exceptions: first, anger and fear conditions were compared against a happy mood (as opposed to "calm" in Experiment 1) as a control condition; and second, mood was induced right before retrieval (before the recognition test), *after* participants studied 40 neutral words in order to examine whether emotion-induced memory effects are more prominent during encoding or retrieval.

## Results

First, ratings given on the mood assessment forms were analyzed in order to evaluate the effectiveness of the mood induction procedure. 3 (emotion type) x 3 (mood condition) mixed design ANOVAs on participants' ratings showed that main effects of both variables and the interaction between emotion type and mood condition were significant in both experiments. Bonferroni-corrected post-hoc comparisons from the two experiments showed that, target emotions which were anger, fear, and calm (Exp1) or happy (Exp2), were successfully induced in each corresponding emotion condition and at a higher level than in the other conditions. Target emotions were rated higher by the participants in the corresponding emotion condition, than those in the other conditions. For example, participants in the anger condition reported that they felt anger more than those in fear or calm/happy conditions. In addition, target emotions were rated the highest only in the corresponding emotion condition Specifically, "anger" ratings were highest in the anger condition, "fear" ratings were highest in the fear condition, and "calm/happy" ratings were highest in the calm/happy condition (all $p$'s < .01).

Second, recognition memory performance was measured with two dependent variables: memory sensitivity or accuracy ($d_a$) which indicates participants' ability to discriminate between studied and unstudied items; and response bias ($c_a$) which indicates participants' tendency to recognize items as studied or their willingness to respond "old" (Macmillan & Creelman, 2005). Data from the confidence ratings on the old/new decision were used to plot receiver-operating characteristic (ROC) curves to allow for an independent examination of sensitivity and response bias effects.

In Experiment 1 in which mood was induced before encoding, results from the one-way ANOVA showed that mood condition had a significant effect on memory sensitivity, $F$ (2, 56) = 3.16, $p$ = .05, $\eta^2$= .10, and a marginal effect on response bias, $F$ (2, 56) = 2.61, $p$ = .08, $\eta^2$= .085. Bonferroni-corrected post-hoc comparisons revealed that both effects were driven by the difference between anger and calm conditions (see Figure 1). Anger, compared to the calm mood, significantly increased memory sensitivity and also increased the tendency for a more liberal response bias. Anger and fear did not differ in terms of their effects on memory sensitivity or response bias ($p$ = 1.00). Values of response bias in the anger condition ($c_a$_Anger = -.29) were numerically more liberal than those in the fear condition ($c_a$_Fear = .02) but this difference did not reach statistical significance ($p$ = 1.00). Thus, findings from the Experiment 1 were more consistent with a valence-based account.

In Experiment 2, when mood was induced directly before retrieval, memory sensitivity did not differ across angry, fearful, or happy participants ($F < 1$). Mood condition, on the other hand, had a significant effect on response bias, $F$ (2, 69) = 3.98, $p < .05$, $\eta^2 = .103$. Anger increased bias significantly compared to fear ($p < .05$) and also marginally compared to happiness ($p = .076$). Fear and happiness did not differ from each other ($p = 1.00$). In other words, angry participants who were assumed to be approach-motivated had a more liberal bias to recognize neutral words as studied, but were not more accurate in doing so, than fearful participants.

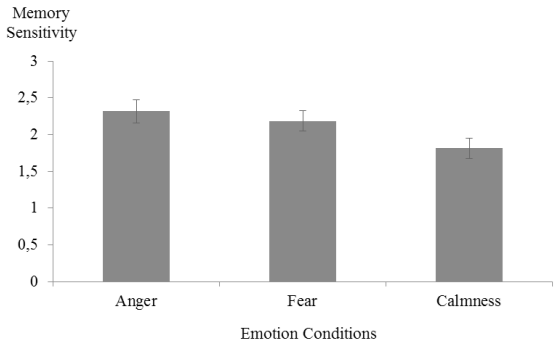


**Figure 1.** Memory sensivity as a function of emotion condition (experiment 1).
*Note.* Error bars represent ±1 standard errors.

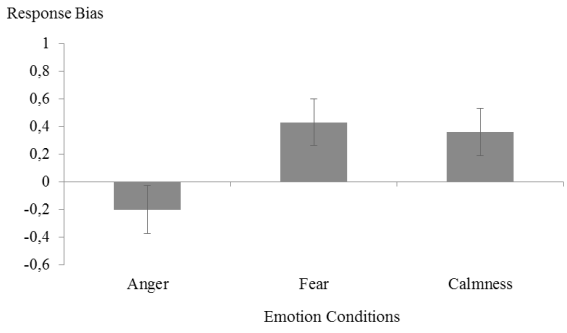


**Figure 2.** Response bias as a function of emotion condition (experiment 2).
*Note.* Error bars represent ±1 standard errors.

## General Discussion

In two experiments, we compared two perspectives in terms of their predictions on the emotion-memory interaction and explored whether the effects of emotion on memory were more visible during the encoding or retrieval of information.

When mood was induced before encoding in Experiment 1, we found a small but significant effect of mood on memory sensitivity and a marginal effect of mood on response bias. Both effects were driven by the difference between anger and calm conditions in that anger increased sensitivity and the tendency to respond more liberally. Importantly, anger and fear did not significantly differ from each other in terms of recognition memory performance. Thus, results from the first experiment were more in line with a valence-based account and did not provide evidence for motivational effects.

When mood was induced directly before retrieval in Experiment 2, however, angry participants who are approach-motivated had a more liberal bias to recognize neutral words as studied, but were not more accurate in doing so, than fearful participants who are avoidance-motivated. This response bias difference between anger and fear suggests that beyond valence, motivational properties of emotions play a role in determining memory decisions. The finding indicating the response bias was affected by mood specifically when it is induced right before retrieval suggests that the differential effects of anger vs. fear might be due to decision biases used during retrieval, rather than encoding processes.

The fact that negative emotions lead to a more liberal response bias in recognition tasks, regardless of memory accuracy, is a frequently observed finding in the literature (e.g., White et al., 2014; Kapucu et al., 2008; Windmann & Kutas, 2001). In an ERP study, Windmann and Kutas (2001) showed that bias towards "old" decisions in a recognition test was associated with early electrophysiological signals from the prefrontal areas. These early, possibly automatic, effects suggest that this bias serves an adaptive function in detecting information that is important for survival. Anger, as a negative emotion, might have increased this bias by motivating approach behavior.

However, as the other approach-motivated mood (happiness) did not increase bias in a way that anger did, we suggest that motivation-based approach may be not sufficient to explain the effects of specific moods on recognition memory. It seems that valence is still a contributing factor. Together, these results suggested that both emotional valence and motivational properties of emotions are important determinants of emotion-induced effects on recognition memory performance.