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**The Effect of Mood States on the Reduction of False Memories: A Replication and  
Extension Study**

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## THE EFFECT OF MOOD STATES ON THE REDUCTION OF FALSE MEMORIES

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**Abstract**

Previous research has documented that mood affects memory accuracy. The present study aims to (1) replicate earlier work showing that mood (negative, positive, neutral) and valence affects memory consolidation, (2) examine whether retrieval processes are more likely to preserve false memories when a mood is induced, (3) identify error prevalence associated with memory consolidation. A recognition-memory standard for photographs depicting script-like events was used. Individuals in both negative and positive moods—similar in arousal levels—correctly identified more target events and are more confident in fewer false memories comparing to individuals in a neutral mood. This shows that arousal (but not valence) helps predict memory performance. These findings suggest that arousal state affects memory while mood mediates true and false memory.

*Keywords:* arousal, valence, memory, gap-filling, causal, emotion, false memories

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### **Introduction**

It has been well observed that emotional stimuli generally increase the errors incurred during the several stages of memory. Many studies have concentrated their research around the variables that influence memory (Henckens, et al., 2005). Such variables include the level of valence—high valence implying attractive and low implying aversive emotions—as well as the level of emotional arousal. Previous results concluded that negative mood induces false memories while positive mood lessens errors. However, similar studies established that arousal, as supposed to valence, escalates the creation of memory errors; these studies emphasized that arousal influences memory during consolidation rather than just during encoding (Payne, et al., 2007). Moreover, further studies have attempted to examine the effect of valence and arousal on memory during the retrieval-related processes; however, evidence of this correlation was not found when inducing mood during encoding or retrieval (Nielson & Lorber, 2009).

The current study aims to clarify these gaps by examining whether negative, positive, and neutral mood induced before the retrieval process creates false memory. The methodology employed a false-memory paradigm that presents photos of events to memorize. Participants were then instructed to state a non-presented event consistent with the photo script or state a non-presented cause of a certain action within the photo. To test variables on the retrieval process, mood was induced immediately prior to the recognition of photos. Previous studies that prompt mood before recognition obtained expected results, in which negative mood prevented false-memory production and positive mood increased error; however, these studies only

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analyzed low arousal mood conditions without examining the effect of various arousal levels on pre-retrieval mood induction.

### **False Memory**

False memories can be studied using the misinformation program, in which the impression of an event changes due to misinformation after exposure. Studies have shown that encoding processes are important in affecting the outcome of true or false memories (Okado & Stark, 2005).

Valence and arousal are two measures of how information is perceived. Valence refers to the positive or negative effects of certain situations, events, or objects, thus differentiating specific emotions. Arousal measures the degree to which information is exciting or calming. The present study suggests that valence mediates true and false memory, whereas arousal affects memory.

### **Context of memory remembering**

Studies have shown that information is better retained when it is linked to a broader event context. It was found that people do not access a single object during retrieval, yet they reactivate an episode. (Jonker, Dimsdale-Zucker, Ritchey, Clarke, & Ranganath, 2018) Thus, in the present study, photographs associated with scripts were presented to participants, rather than random images without a broad context.

## **Methods and Materials**

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### **Participants:**

This study included 75 participants (Females:32, Male: 43). All participants were Italian undergraduate students from the University of Padova (M = 22.8 years, SD = 1.8). Using the International Affective Picture System (IAPS; 24), a method proven effective in inducing certain emotional states in past studies (e.g., [1, 25]), pictures were presented to expose participants to negative, positive, or neutral moods (n = 25 for each group). Since this study took place in Italy, it met the ethical requirements set by the Italian Psychological Association (AIP) for research studies. In addition, this study is also approved by the Ethical Committee for Psychological Research (Area 17) of the University of Padova. Based on an initial survey on fears or phobias, participants with certain phobias were excluded from the study while others were selected and briefed on the general goals of the study. All participants gave consent to the study and the publication of data obtained before any task was administered.

### **Mood-induction:**

Arousing images were assessed on a scale from 1 (low) to 9 (high) arousal using the IAPS ratings. Negative pictures were chosen if they had a low valence and high arousal, and positive pictures were chosen if they had high valence and low arousal. The neutral pictures had low arousal. 24 pictures were ultimately selected for each of the mood conditions. A one-way analysis of variance (ANOVA) showed valence differed among the groups and post-hoc tests revealed that negative images had a lower valence than both positive and neutral images, and positive images had a higher valence than both negative and neutral images. In addition to the valency, it also indicated that negative and positive images had a higher arousal than neutral images.

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### **Self-assessment manikin:**

To confirm that mood-induction was effective through the IAPS presentation, SAM scales were used before the experiments (pre-SAM) and after the IAP picture presentation (post-SAM). The Self-Assessment Manikin (SAM) technique is a way to measure an arousal in a person's reaction to multiple stimuli. The SAM scales had a 9-point rating scale that allowed participants to rate their happiness/unhappiness (valence) and activation/non-activation (arousal). 9 reflected high arousal and high valence, whereas 1 reflected low arousal and low valence. Previous studies have used similar SAM rating scales to determine the effectiveness of mood induction (e.g., [22]).

### **False memory paradigm:**

**Encoding:** Participants were shown colored pictures of people engaged in 8 everyday episodes or scripts. The episodes showed: having a family dinner at home, playing at the playground, going shopping, waking up, doing homework after school, going on a bike trip, going to the doctor, and children performing a drama piece in a theater. Since the paradigm was designed to be suitable in developmental studies (such as in [17]), the main person in each episode is a child. Each episode had 11 pictures that showed actions for the event and the effect of actions, but not the cause. 10 different pictures were shown at the beginning and at the end of the presentation to prevent possible primacy and recency effects on the material being used in the study. Examples of what these pictures consisted of are children playing an instrument or going to a party.

### **Retrieval:**

In total, 80 different photographs, which were divided into eight episodes, were presented to participants during retrieval. Each of the eight episodes had recognition tests that included: (a) four target photographs—photographs presented during encoding; (b) three new



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photographs—photographs consistent with one of the scripts but not presented at encoding; (c) one cause photograph—photograph whose effect had been presented during the encoding phase, such as a photo of a child knocking over a glass bottle to correspond to the effect scene depicting pieces of a broken bottle on the floor and a father about to hit his son; (d) one target photograph—photograph presented at encoding that was different from the scripts; and (e) one new photograph—photograph not presented and inconsistent with any of the scripts.

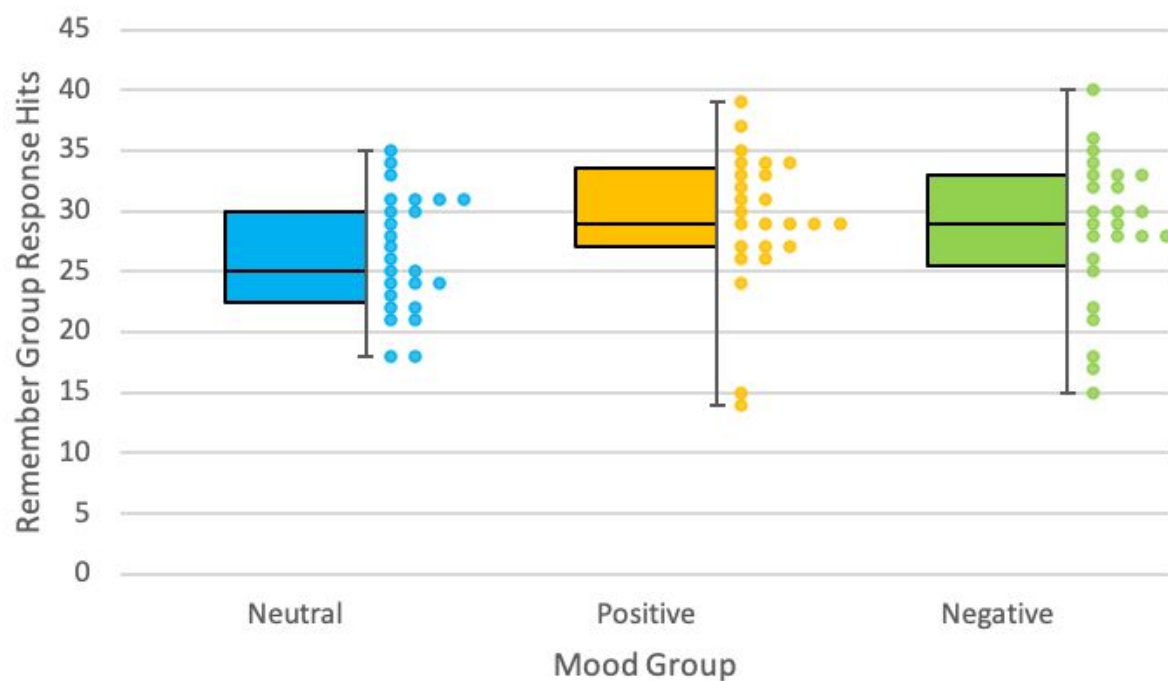
### **Procedure**

Participants were asked to rate their valence and arousal using the 9-point pre-SAM scales after five minutes of conversation. They were told to pay attention and recognize the stories represented by a series of pictures showing everyday situations. However, they did not know they would be tested later on their memory. The pictures were presented on a screen for 2 seconds with a gap of 2 seconds between each image. Participants were then given the false memory paradigm, in which the encoding phase lasted for approximately 7 minutes. After the encoding phase, they were instructed to complete filler tasks and complete the mood-induction procedure. The IAPS images were displayed on the screen for 5 seconds each. Each participant then completed the post-SAM ratings in order to assess the effectiveness of the mood induction. In order to test recognition, participants were given a series of “old” and “new” images. They were instructed to say “yes” if they recognized the image from the original encoding and “no” if they did not recognize it. If the participants said yes, they were instructed to choose the “remember” option if they could clearly remember the image and some of its features. They were instructed to choose “familiar” when they could recognize the picture but did not remember any details about it.

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**Data & Results**

Results showed that overall participants who were in positive or negative mood states were more confident in their remembering of events. Remember responses show a higher average of hits on positive and negative mood states than neutral, indicating that participants in positive and negative mood states were more confident in their remembering of events than those in a neutral state (Fig. 1).

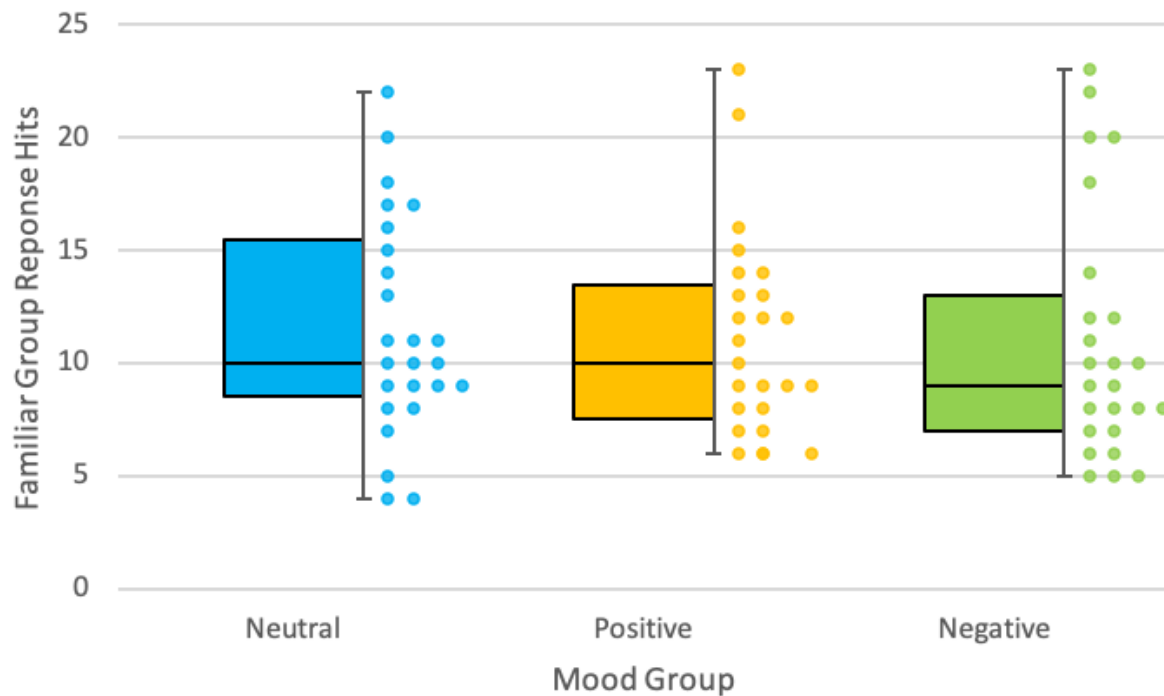


*Fig 1. Mixed box and whisker and scatter plot of remember response hits per participant.*

Whereas on examination of familiar responses, the average hits on neutral was greater than the average for positive and negative mood states, indicating that participants in a neutral state were

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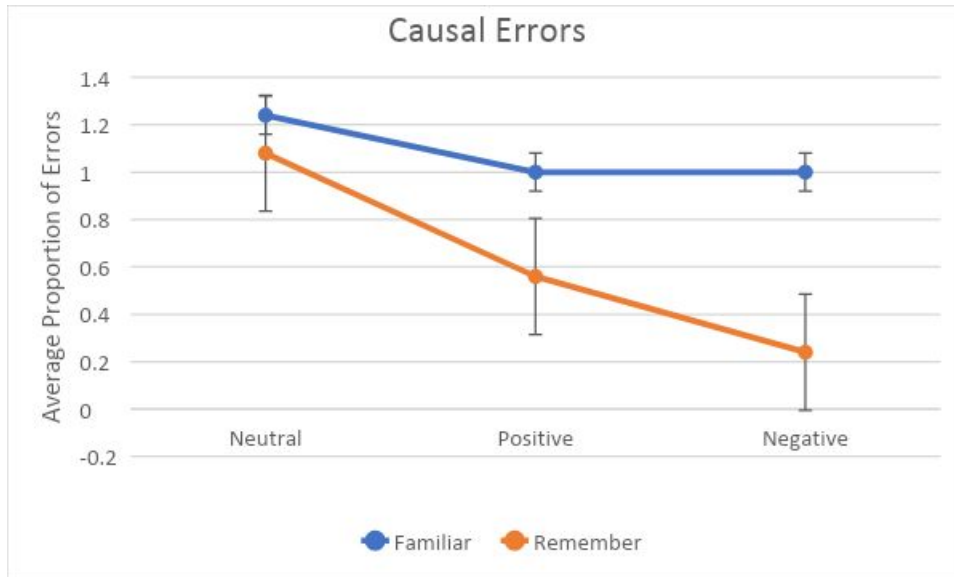
less confident in their remembering of events (Fig. 2).



*Fig 2. Mixed box and whisker and scatter plot of familiar response hits per participant.*

Two errors, causal and gap-filling, were examined more closely. Gap-filling errors are errors in which a subject fills in a gap in their memory such as if a child was leaving the house in the morning and the subject identifies that the child went to school rather than a dentist appointment. Causal errors are errors in which a subject identifies the cause of a situation they did not see such as seeing a cat on a counter and a broken glass on the ground and assuming the cat was the cause.

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*Fig. 3 Average proportion of causal errors of participants in each mood state.*

Higher causal error hits occurred with neutral participants with both remember and familiar responses. Gap-filling errors were higher in neutral mood state than negative and positive mood states with familiar responses (Fig. 3). However, gap-filling errors were higher in positive mood states than negative and neutral with remember responses (Fig. 4).

*Fig. 4 Average proportion of gap-filling errors of participants in each mood state.*

### Discussion

Results of this study show that both true and false memories of events are affected by the mood induced before retrieval. For both positive and negative mood groups, arousal, in general, resulted in lower probability of making causal errors. When examining the relationship between memory errors and the difference in participant ratings from pre- to post-mood induction, it was found that the amount of positive increase in arousal rating after being exposed to emotional scenes was a strong predictor for their memory performance. The bigger the increase in rated arousal, the lower the probability was of producing false memories, and the better the subjects performed. Valence, on the other hand, did not have any kind of predictive power over memory performance. This was tested using IAPS images that fit into three different mood conditions, and they did this in order to test for arousal and valence. The three categories were negative pictures that had low valence and high arousal, positive pictures that had high valence and high arousal, and neutral pictures with average valence and low arousal. This procedure was a recommendation by Bradley and Lang, which allows them to accurately induce the proper mood and get significant results (Bradley, Lang, 2007) . It was concluded that self-assessed mood ratings are better predictors of false memory performance than mood groups— in other words, assigning participants into mood groups did not yield much difference, and more significant results were discovered when participants were asked to analyze their own moods and rate their arousal on a continuum. By letting participants rate their own mood, the study accounts for the possibility that the mood induction treatment would not have the same effect on mood for all

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participants. Additionally, this system provides valuable data on the individual's perception of their own emotional state, and the effects of this perception on memory performance.

In the original study by Mirandola and colleagues, the null hypothesis was rejected and they had concluded that high arousal at retrieval is a predictor of false memory and memory performance (Mirandola, Toffalini, 2016). They were also able to conclude that valence had no significant impact on the results, which strengthened the fact that arousal is indeed the factor that affects this false memory. Our replication was able to mostly reproduce these results, further confirming this and leading us to be confident in accepting the hypothesis. However, there is more to analyze in terms of the results and what they mean. The previous study focused on why arousal affects memory and why their findings were significant but neglected the effect of valence. In order to completely accept the hypothesis, we have to show not only that arousal is in fact the dynamic factor, but that valence makes no difference in the results. Mirandola and Toffalini conducted an in-depth analysis of their data, but once they found that the data for valence was not significant, they just deemed it to not have any effect on memory retrieval (Mirandola, Toffalini, 2016).

The original study referenced multiple studies involving how timing and different systems in the brain affect memory retrieval. One of these studies by Ackermann and colleagues showed that a delay in timing can activate the hypothalamic-pituitary-adrenal axis which secretes glucocorticoids (cortisol) which impair memory retrieval (Schonfeld, Ackermann, Schwabe, 2014). This timed release of cortisol can also be used to further show that valence actually has no effect on retrieval. A study done by Kuhlmann and colleagues looked at the effects of valence on reversing the effects that cortisol has on retrieval (Kuhlmann, Kirschbaum, Wolf, 2005). Cortisol

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was given to the participants before they were tested on recall, and were then shown wordlists with different levels of valence in order to test the interaction of valence and cortisol. It was shown that cortisol did have a negative effect on retrieval and that the valence had no bearing on the results. With that conclusion, it is safe to say that the original study's results and conclusions on valence are valid.

Finally, our findings showed very little difference from the original experiment, and therefore they also support the hypothesis that arousal and not valence is a predictor of memory performance. Research shows that valence has no bearing on mediating effects on memory, as shown through the insignificant effects in our study and the lack of effects on cortisol. However, our timing plays a huge role in memory retrieval as it determines the onset of different hormones in our brain that affect memory. Further research that could be done to strengthen our results would involve exploring the timing of arousal and recall, and the different brain systems and hormones that are released in those periods.

### **Conclusion**

The relationship between arousal and performance has been widely studied. Relationships such as the Yerkes-Dodson law, which states that increased arousal can aid in performance, have been developed. Our study examined the effect of arousal and valence on the consolidation of false memories. The results indicate that inducing a mood state – positive or negative – before memory consolidation increases memory confidence and reduces error in memory, therefore reducing false memories. Our study rejected the null hypothesis that induced mood has no effect on reducing false memories in recall, therefore supporting the conclusion that

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induced mood aids in reducing false memories. Applications of this research could include looking at educational studies to enhance learning via inducing arousal.



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