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Differential Forgetting for Emotional and Neutral Videos

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A thesis submitted to the Faculty of Emory College of Arts and Sciences

of Emory University in partial fulfillment

of the requirements of the degree of

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Abstract

Emotional memory research has been a significant area of research for many decades. Emotional experiences have not only been shown to be more memorable compared to neutral experiences (Bowen et al., 2018; Hamann, 2001; LaBar & Cabeza, 2006) but also less forgotten and recalled with more specific details compared to neutral experiences (LaBar & Cabeza, 2006; Sharot & Yonelinas, 2008; Kensinger, 2007). This phenomenon is often referred to as the emotional enhancement effect (Hamann, 2001). Most research on the emotional enhancement effect has analyzed memory for static emotional photos or words. However, very few studies have investigated the effect of emotion on memory for videos, stimuli that capture the full complexity and dynamic nature of human memory. Moreover, previous literature has focused primarily on memory for negative compared to neutral experiences; it remains unclear how positive experiences influence our memory. Our current study aimed to address the gaps in the current literature by examining differences in recall and forgetting for negative, positive, and neutral videos across two delay intervals (10-minute and 24 hours). We found positive videos were remembered significantly more than both negative and neutral videos, but there were no significant differences in forgetting (the extent memory performance decreased from 10-minute delay to 24 hour delay) between emotional and neutral videos. Additionally, recall performance and forgetting for negative and neutral videos were very similar. Although our results were inconsistent with our predictions, we speculate that memory for videos is differentially impacted by positive and negative stimuli.

Keywords: emotional video, memory, forgetting, episodic memory, cued-recall, delay intervals.

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1.Introduction

In everyday experiences, we encounter a variety of emotions, from love, happiness, and amusement to sadness, anger, and despair. How do these emotions interact with our memories? Broadly speaking, emotional experiences have repeatedly been found to be more memorable than neutral experiences (e.g., Bowen et al., 2018; Hamann, 2001; LaBar & Cabeza, 2006). In addition, although we encounter countless experiences in daily life, we also forget most of them —an inability to recall previously learned information. Studies have shown a slower forgetting for negative (unpleasant) experiences compared to neutral experiences (LaBar & Cabeza, 2006; Sharot & Yonelinas, 2008; Kensinger, 2007). However, in the very few studies that have investigated forgetting in positive (pleasant) experiences, the results have been mixed (Wang, 2014, 2018; Bennion et al., 2013). Therefore, the inclusion of positive stimuli is necessary to examine whether there is also a positive enhancement effect. In addition, though the current literature on emotional memory emphasizes similarity to a real-world setting, most studies only used simple, static stimuli, such as emotional pictures (Lang, Bradley, & Cuthbert, 2008) and words (Bradley & Lang, 1999), and few used dynamic stimuli, such as videos. Unlike static pictures and words, videos are more natural, integrate multimodal information such as sound auditory and visual information, and have dynamic elements from real-life experiences, thus serving as a more direct resemblance to real-life events. To our knowledge, it is currently unknown how negative, positive, and neutral videos interact with memory across time. Therefore, it is important to investigate both positive and negative emotional effects using videos, as videos will more closely reflect the memory of actual events. The aim of the present study was to examine the differences in forgetting between emotional experiences compared to neutral experiences through a more ecologically valid stimulus.

A wealth of evidence has suggested that emotional memories, particularly those associated with negative emotions, are more likely to be remembered in greater detail. Negative stimuli have been shown to attract heightened attention compared to neutral stimuli, which may in turn facilitate both encoding and memory retrieval (Kensinger & Corkin, 2003; Hamann, 2001). Neuroimaging studies have also shown that enhanced memory performance is correlated with the activation of the amygdala and medial temporal lobe regions during encoding (Hamann 2001; Labar & Cabeza, 2006; McGaugh, 2004).

Additionally, negative emotional memories have also been shown to be more resistant to forgetting than neutral memories (LaBar & Cabeza, 2006; Sharot & Yonelinas, 2008; Yonelinas & Ritchey, 2015). Considerable evidence indicates that a key mechanism contributing to slowed forgetting of emotional events is enhanced consolidation, a process by which initial memory traces are strengthened over time and become resistant to forgetting (Hamann, 2001). Sharot and Yonelinas (2008) examined the recognition of emotional and neutral pictures at two-time intervals (5 mins and 24 hours), and they found recollection of negative pictures relative to neutral pictures was not enhanced after the 5-minute delay, instead recollection of negative pictures was improved after the 24 hours delay indicating slowed forgetting for the negative pictures relative to the neutral pictures.

These early studies not only provided us with substantial understanding of how emotion interacts with memory, but also suggested a few considerations that we need to take into account to better understand the cognitive processes underlying emotional memory. First, given memory enhancements for emotional stimuli is most evident after a delay, it is important to test memory at multiple time points. Second, in order to gain a more comprehensive understanding of how memory operates in different contexts, we should use different modalities of sensory information (e.g., video) that can provide a more ecologically valid assessment of memory, which memories were often formed in ongoing events rather than as discrete pieces of information.

While recent research has shifted interest to using naturalistic videos to examine the cognitive processes underlying perception memory retrieval, there has been little research about emotional videos. For example, videos were used to investigate the impact of active rehearsal—actively reimagining previously watched videos—on episodic memory, and they found that actively rehearsed videos were recalled with more details after a week compared to unrehearsed videos (Bird et al., 2015). Videos were also used to demonstrate how cortical structure generates event representations in the brain, as well as how events are stored and retrieved from memory (Baldassano et al., 2017). These studies have provided us with a novel understanding of the cognitive and neural processes of episodic memory; therefore, it is important to continue using dynamic stimuli to understand how emotional videos interact with our memory. While there are rich resources of emotional videos on the internet, selecting emotional videos needs to be carefully done. First, videos taken from movies and TV shows could be processed differently because participants are aware that these videos are fake and fictional, and secondly, the familiarity could also impact both memory and emotion processing (Samide, Cooper, & Ritchey., 2019; Tulving et al., 1996; Abraham, von Cramon, & Schubotz, 2008)

To investigate how emotional experiences influence the way complex events are processed, one influential study by Samide et al. (2019) tested participants' subjective memory of emotional videos. They collected 126 real-life news clips from a news archive website that were about negative, positive, and neutral events. These videos were between 20 and 50 seconds long (average=42.15s). An example of a negative video would be a real scene of terrorists shooting at the sky in front of a group of people at a polling station. An example of a neutral video would be an interview with a manager who recently opened a tool bank. An example of a positive video is an actual scene of a butterfly landing on a boy's nose, and the boy was laughing in front of his parents and friends. In the experiment, they had 50 participants view the videos and rate each video on the emotional valence and arousal on a scale of 1 to 9 (from most negative to most positive for valence, and least arousing to most arousing for arousal). Additionally, they immediately tested participants' memory for these videos by first presenting them with a 3s cue (replays of original videos), and then asking participants to subjectively rate the visual and auditory vividness of their memory about the rest of the video (on a scale of 1 to 9, with 1 indicating not at all vividly and 9 indicating extremely vividly), and also recall the duration of the original video (on a scale from 10s to 60s). Their study session was divided into 4 test blocks, within each test block, participants were asked to first watch the video and then complete a memory test immediately afterward. Their results showed that positive videos were remembered as more vivid compared to neutral and negative videos, and participants' response to vividness predicted their accuracy of actual video duration.

While Samide et al.'s (2019) provided us with a novel understanding of how these dynamic and emotional stimuli interact with our memory, there are certain aspects of memory that remain unexplored. First, their memory assessment relied on a self-report paradigm, asking participants themselves to subjectively report how vividly they could remember about the video. Because these subjective reports of memory were not verified by asking participants to recall information from the videos, the extent to which these subjective reports accurately reflect memory for the videos remains unclear. Asking individuals to rate their own memory can be prone to bias or inaccuracies, as individuals may have varying perceptions of their own memory. Previous studies have shown that emotional arousal can inflate subjective confidence in memory accuracy, even when memory is inaccurate (Talarico & Rubin, 2003). Thus, it is important to extend this prior research and determine whether objectively measured memory is also enhanced for positive relative to neutral videos.

An additional reason why it is important to re-examine the issue of relative memory performance for positive, negative, and neutral videos is that, because memory tests followed immediately after each encoding session, the participants were aware that their memories would be tested, and they may have engaged in encoding strategies to boost their memory performance. It is unclear to what extent the results of this prior study were affected by intentional memory encoding strategies, and in particular, whether different findings would be obtained with an incidental encoding paradigm in which participants were not engaging in specific strategies due to knowing that memory would be subsequently tested.

Previous literatures suggested that memory for negative emotional stimuli is frequently enhanced relative to neutral stimuli (Kensigner & Corkin, 2003; Hamann, 2001; Sharot & Yonelinas, 2008). Thus, it is unexpected that Samide et al.'s (2019) study did not find a negative enhancement effect in emotional videos. One possibility is that they only measured memory at a short delay interval (i.e., immediately after each encoding session). Emotional enhancement of memory is found more consistently after longer delay intervals such as 24 hours (Sharot & Yonelinas, 2008; Yonelinas & Ritchey, 2015). In summary, the question of testing memory of emotional videos through an objective measure, incidental encoding, and two delay intervals remained unexplored.

Given that there are many remaining questions about the impact of emotion (both positive and negative) on memory for videos, we selected videos from the database developed by Samide et al. (2019), and examined participants' memory for these videos with a surprise cued-recall paradigm at two delay intervals, 10-minute and 24 hours. In the first encoding session, participants viewed negative, positive, and neutral videos and were instructed to rate both emotional valence and arousal after watching each video. After a short delay (10-minute), participants were given a cued-recall task, using the first 6 seconds from the original videos as cues to prompt participants' memory about the rest of the video. Participants completed another (second) cued-recall session 24 hours after the first session.

In addition to determining how many videos each participant could correctly recall, we were also interested in examining the amount of details that participants could recall from each type of video. A commonly used method to score videos was the "prose recall" measure (Wilson et al., 1991; Bird et al., 2015), in which participants were rewarded with 1 point for every concept in the video, apart from the cue, they mentioned correctly. We used this method to assess the proportion of details that the participants could remember about the video and examined how the proportion of details in each valence decreased over time. In short, we analyzed participants memory performance by looking at two scores: binary scores and detail scores. Binary scores indicated how many videos that participants could remember, and detail scores indicated how many details participants could remember about the video.

The aim of the current study was to address two key issues regarding differences in memory performance for emotional vs. neutral videos: 1) Would memory performance for emotional videos be better compared to neutral videos at two delay intervals? We expected that the memory performance (both binary scores and detail scores) for emotional videos would be better compared to neutral videos across delay intervals, but a more apparent difference would appear at 24 hours. 2) To what extent is forgetting slower for emotional videos compared to neutral videos? We predicted that compared with neutral videos, memory performance should decrease less for emotional videos, thus forgetting should be slower for emotional videos compared to neutral videos. Given previous literature, we expected this effect to be most prominent for negative videos compared to neutral videos.

2. Method

2.1 *Participants*

Participants (n=49) were undergraduate students taking introductory psychology courses (PSYC 110 and PSYC 111) at Emory University, but 22 participants were excluded due to video glitches, low performance, and failing to understand instructions. The sample size was determined before the study based on sample sizes in previous work (Sharot & Yonelinas, 2008*)*. Participants registered online with the SONA portal (Psychological and Brain Science Research System) and consented to participate in the study. The sample consisted of 7 males (26 %**)** 17 females (63**%**), and 3 non-binaries (11%). At enrollment, the participants' average age was 18.81 years (SD=0.96). Our procedures received approval from Emory University Institutional Review Board, and all participants received SONA credits after they completed the experiment.

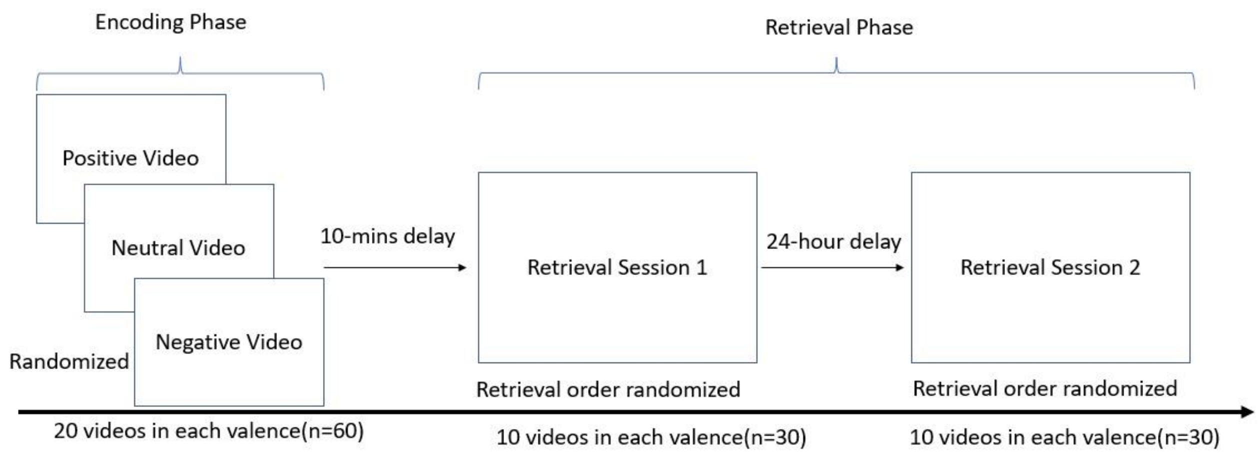
2.2 *Stimuli*

In a previous study (Samide et al., 2019), participants (n=50) rated 126 emotional news clips. Each video was between 20 and 52 seconds long. At the end of each clip, participants rated the clip's overall emotional intensity and valence, with higher scores indicating more arousing and positive. For this study, we selected 60 videos from the previous study's database (Samide et al.) of the 126 clips and their corresponding participant ratings for valence and arousal. We primarily selected videos containing live scenes from the reported event rather than pictures or scenes after the event. For example, choosing a video that included footage of an ongoing street protest rather than a picture showing the street after the protest. We selected these 60 clips based on visual content and average valence score. We chose 20 negative videos (M=2.35, SD=0.52), 20 neutral videos (M=5.31, SD=0.77), and 20 positive videos (M=7.67, SD=0.4); valence in both negative videos and positive videos differed from neutral videos, $t(19) = 18.02$, $p<.001$; $t(19) = 11.75$, $p<.001$. Negative videos had higher arousal ratings (M=5.76, SD=0.77) than both positive videos (M=4.05, SD=1.01) and neutral videos (=2.42, SD=0.57), $t(19)=5.76$, $p<.001$; $t(19)=-15.49$, $p<.001$. In addition, we trimmed all of the videos between 17s and 35s in order to prevent attentional fatigue by shortening the length of the encoding section. The average video length for negative, neutral, and positive videos were 27.75 seconds, 24.9 seconds, and 25.6 seconds. To reduce interferences between videos, we excluded videos that were semantically similar, for instance, we avoided selecting multiple videos about puppy adoption.

2.3 *Study Design*

We aimed to investigate differences in forgetting for emotional videos with a cued-recall study that examined differences in memory performance for negative, positive, and neutral videos at two delay intervals (10-minute and 24-hour delay intervals). For experimental design see Fig.1.

Figure 1.



This was a within-subject study design; the independent variables were the valence of the video and the delay interval (10-mins and 24 hours). The dependent measure was the percent of recall and the proportion of details that the participant remembered. Across all sessions, the order of video presentation was counterbalanced across participants. Participants were divided into 4 counterbalance groups (A=6, B=7, C=7, D=7) in order to avoid the order effect.

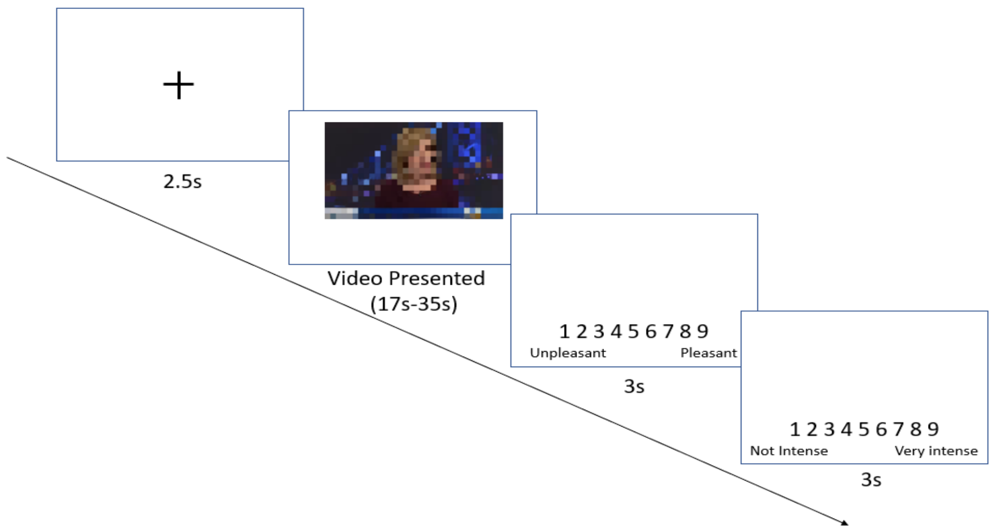
2.3.1 *Encoding Phase*

In the first session, participants completed an encoding phase, during which they were told to first watch 60 videos (20 per valence) and then rate the video based on its pleasantness and arousal; the order of videos was randomized. To avoid attentional fatigue, this viewing phase was divided into three test blocks, and each block contained 20 videos. During each viewing trial, participants watched the video, and after it ended, a valence scale appeared at the bottom of the screen, asking the participant to rate the pleasantness of the video on a scale from 1 (Very unpleasant) to 9 (Extremely pleasant). After 3 seconds, an arousal scale appeared at the bottom of the screen, asking participants to rate emotional intensity on a scale from 1 (Not arousing) to 9

(Very arousing). After another 3 seconds, participants saw a fixation cross on the screen for 2.5 seconds before they started the next trial. See Fig.2.

Figure 2.

Viewing Phase Procedure



Note. **Each trial began with 2.5s fixation cross appearing on the screen. After watching the video, a valence scale appeared on the screen for 3 seconds. The emotional intensity scale followed the valence scale and appeared on the screen for 3 seconds. After the valence scale disappeared, a fixation cross appeared on the screen for 2.5s before the next video began.**

2.3.2 *Delay Phase*

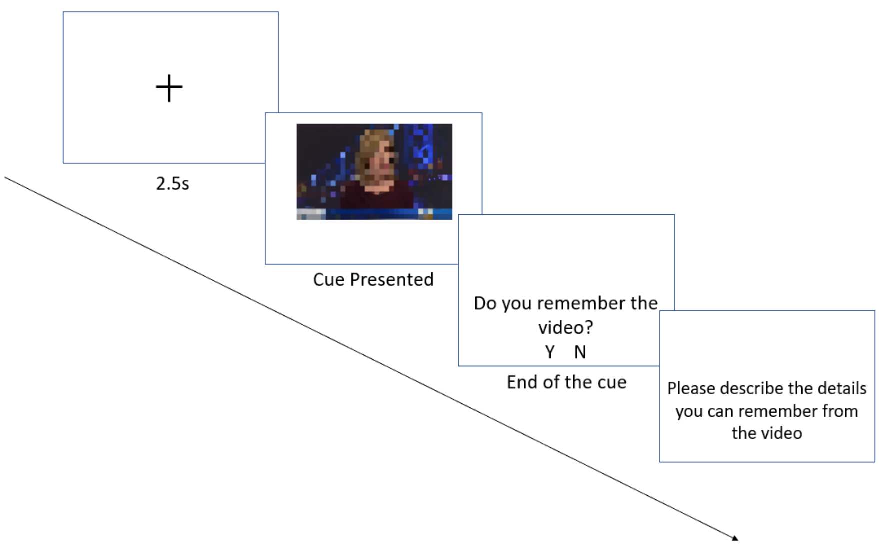
Immediately after the viewing phase, participants were asked to play a sudoku game for the next 10-minute in order to occupy participants' cognitive capacity (prevent them from actively rehearsing the videos they just watched) during the delay interval with an unrelated cognitive task. If participants finished the game within 10-minute, they were instructed to start a new sudoku game.

2.3.3 *Retrieval Phase*

There were two retrieval phases. The first retrieval phase followed a 10-minute delay, and the second retrieval phase was followed 24 hours after the first session. Each retrieval phase contained 30 videos: 10 positive videos, 10 neutral videos, and 10 negative videos. During each retrieval phase, we cued participants with the first 6 seconds of the original clip. Participants then were asked to indicate whether they could remember the video by pressing Y (Yes) and N (No) on the keyboard. If the participant responded Y, we further asked participants to describe out loud all of the details that they could remember from the rest of the video. See Fig.2. If the participant responded N, a fixation cross appeared on the screen for 2.5s before the next cue began. See Fig.3.

Figure 3.

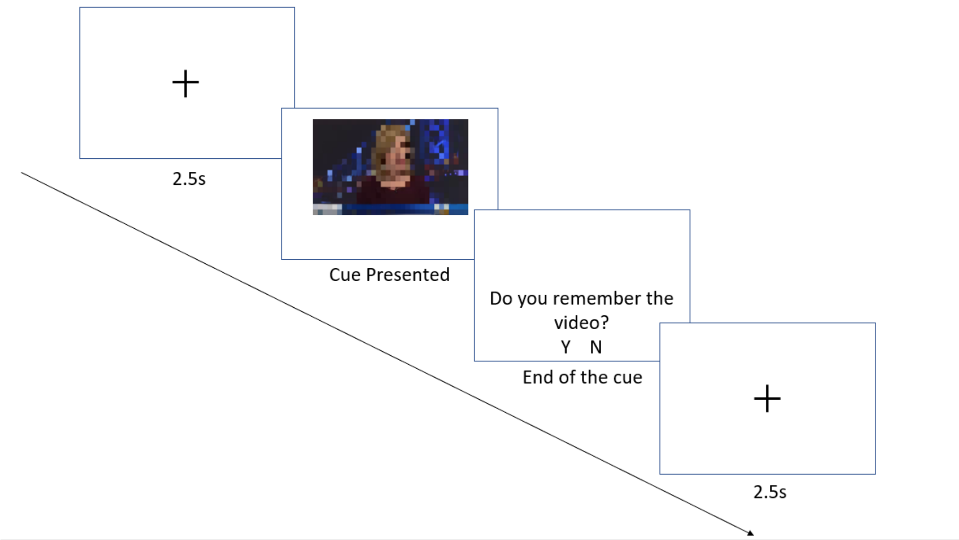
Retrieving Phase Procedure —Remember



Note. **Each trial began with 2.5s fixation cross appearing on the screen. Each cue was 6 seconds long, and after watching the cue, participants were asked to indicate whether they could remember or could not remember the original video. If they pressed Y (Yes), they were further asked to describe information that is not in the cue.**

Figure 4.

Retrieving Phase Procedure — Not Remember



Note. **Each trial began with 2.5s fixation cross appearing on the screen. After watching the cue, if participants indicated N (No)which they do not remember about the original video, the next cue would be presented before a 2.5s fixation cross.**

2.3.4 *Binary Scores Grading Procedure*

To figure out how many videos the participants correctly remembered for each valence, remember responses were scored as either 1 (remembered) or 0 (not remember). Participants were only given scores when they at least correctly identified one detail in the video that was not in the cue.

2.3.5 *Detail Scoring Procedure*

To determine how much the participant could remember about the video, we created a checklist of details for each video. Checklist for each video was created by at least 3 researchers. They watched the videos together and discussed the details that should be on the checklist. In addition, they refined this checklist by comparing it to the pilot responses, in which they could add details that pilot participants consistently recalled or remove details that were too imperceptible. Consequently, by combining the total details possible for each valence, negative videos had a total of 97 details, neutral videos had 89 details, and positive videos had 92 details. Participants' remembered responses were graded by 3 raters. Due to the complex nature of videos, in which each video contained a different number of details, scores of Participants' responses were calculated as proportional rather than numerical. For each response, a proportion score was calculated based on the point of each detail they mentioned correctly on the checklist divided by the total possible point they could possibly receive. For example, if a video had a total of 6 points based on our checklist, and the participant's response correctly identified 2 details that are each worth 1 point, then the participant would receive a score of 2/6 = 33%. In the case of disagreement of grading, raters were asked to regrade the responses that differed by over 1 point between raters (e.g., the scores given by the 3 graders were 1,2, and 3) as a group. Inter-rater reliability was found to be good, ICC=0.83.

2.3.6 *Data Analysis*

We calculated both binary scores and detail scores for each participant. We conducted repeated measures 2 (Time: 10-mins delay, 24-hours delay) x 3 (Valence: negative, neutral, positive) within-subjects ANOVAs to examine differences in binary scores as well as detail scores. Differences in forgetting were assessed by examining the interaction between valence conditions and delay intervals. Given there were significant differences in performance at the first delay interval, we also used a proportional forgetting analysis. Loftus recommends this method when memory performance at the initial delay interval is different for each valence group (Loftus, 1985). This method is designed to avoid scaling problems since it calculates the proportion of forgetting of the second delay interval relative to the first delay interval. A scaling problem can happen if, for example, there were two participants, the first participant's memory performance at two delay intervals dropped from 10 videos to 9 videos, and the second participant's memory dropped from 8 to 7 videos; their drop in memory performance was not the same (10% < 12.5%), but would be treated as the same if the initial level of learning is not matched.

For each memory measure, additional repeated-measures ANOVAs were conducted separately comparing the negative and neutral conditions and the positive and neutral conditions. These were planned comparisons motivated by our a priori theoretical interest in comparing forgetting patterns for each emotion condition relative to the neutral condition. Simple comparisons (pairwise t-tests) are reported comparing the valence conditions if there was a main effect of Valence, and these comparisons were all Bonferroni-corrected. All analyses were conducted using R (R Core Team, 2020).

3. Results

3.1 Valence and arousal ratings

The mean valence rating for the negative, neutral, and positive were 2.25 (*SD*=0.47), 5.25 (*SD*=0.71), and 7.3 (*SD*=0.58). The video with the lowest valence rating was a police beating a black motorist; The video with the highest valence rating was a soldier's reunion with his dog. Valence ratings for Positive videos were significantly higher than neutral videos, $t(19)=8.31$, $p<.001$, and negative videos, $t(19)=28.98$, $p<.001$. Valence ratings for negative videos were significantly lower than neutral videos, $t(19)=-15.17$, $p<.001$.

The mean arousal rating for the negative, neutral, and positive was 6.04 (*SD*=0.8), 2.37 (*SD*=0.58), and 3.43 (*SD*=0.73). The video with the lowest arousal rating was about an interview with a manager at a publishing company; The video with the highest arousal rating was about electric shocking a prisoner. Negative videos were rated as more arousing compared to neutral videos, $t(19)=19.08$, $p<.001$, and positive videos, $t(19)=11.09$, $p<.001$. Positive videos were rated as more arousing compared to neutral videos, $t(19)=5.59$, $p<.001$ (See Table 1).

Table.1 *Characteristics of Negative, Neutral, and Positive Videos*

	Neg		Neu		Pos	
	M	*SD*	*M*	*SD*	*M*	*SD*
Valence	2.25	0.47	5.25	0.71	7.3	0.58
Arousal	6.04	0.8	2.37	0.58	3.43	0.73

3.2 Overall video recollection for binary scores

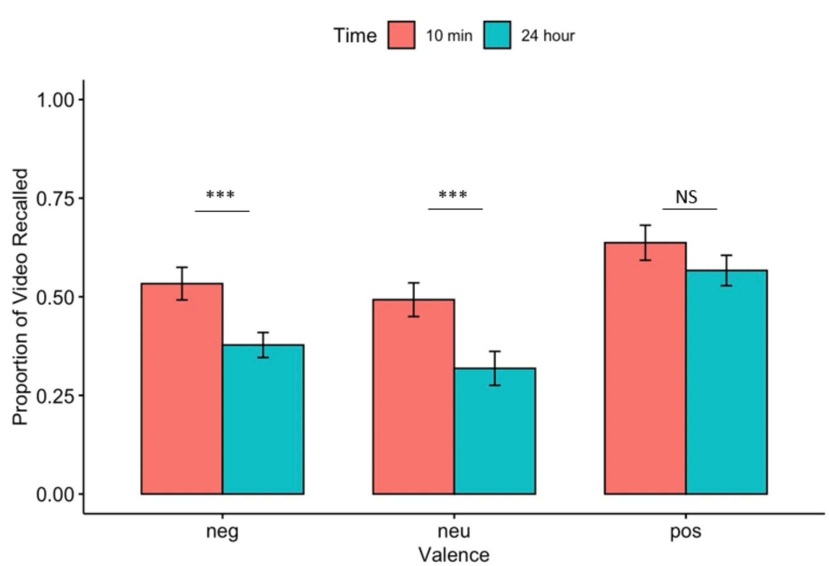
For binary scores, participants' responses were either scored as 1 (remembered) or 0 (not remember); for a remember response, participant had to correctly mention at least one detail that was from the rest of the video. There was no interaction between Time and Valence on binary scores, $F(2,52)=1.52$, $p=.22$, $\eta_p^2=.05$. There were main effects of Valence, $F(2,52)=25.79$, $p<.001$, $\eta_p^2=.50$, and Time, $F(1,26)=33.23$, $p<.001$, $\eta_p^2=.56$ (see Figure 5).

To assess the predictions regarding differential forgetting for negative vs. neutral videos and positive vs. neutral videos, planned follow-up within-subjects ANOVAs were conducted for each pair of conditions separately, with binary scores as the dependent variable. For the ANOVA with the negative and neutral conditions, there was no interaction between Time and Valence on binary scores, $F(1,26)=0.072$, $p=.7$, $\eta_p^2=.003$. In addition, there was no main effect of Valence, F(1,26)=3.656, p=.06, $\eta_p^2=.12$, but there was a main effect of Time, $F(1,26)=33.217$, p<.001, $\eta_p^2=.56$. For the ANOVA with the positive and neutral conditions, there was no significant interaction between Time and Valence, $F(1,26)=2.428$, p=.13, $\eta_p^2=.085$. However, there were main effects of Valence, F(1,26)=45.11, p<.001, $\eta_p^2=.63$ and Time, F(1,26)=16.73, p<.001, $\eta_p^2=.39$.

For the main effects of Valence, simple comparisons between the negative and neutral condition on binary scores showed no significant differences at 10-minute delay interval, $t(26)=0.99$, $p=.33$ or the 24-hour delay interval, $t(26)=1.31$, $p=0.2$. Whereas simple comparisons between the positive and neutral conditions on binary scores showed that participants remembered more positive videos than neutral videos at 10-minute delay interval, $t(26)=3.16$, $p<.01$ and at the 24-hour delay interval, $t(26)=5.79$, $p<.001$. In addition, for positive compared to negative binary scores, there was no difference at the 10-minute delay, $t(26)=2.44$, $p=.06$, but at the 24-hour delay, participants remembered significantly more positive videos than negative videos, $t(26)=5.04$, $p<.001$.

For the main effects of Time, simple comparison found that participants had significant decreases in binary scores between the 10-minute and 24-hour delay intervals for negative videos, $t(26)=3.85$, $p<.001$, and neutral videos, $t(26)=3.57$, $p=.001$. However, participants showed no significant difference between 10-minute and 24 hours for positive videos, $t(26)=1.75$, $p=.09$.

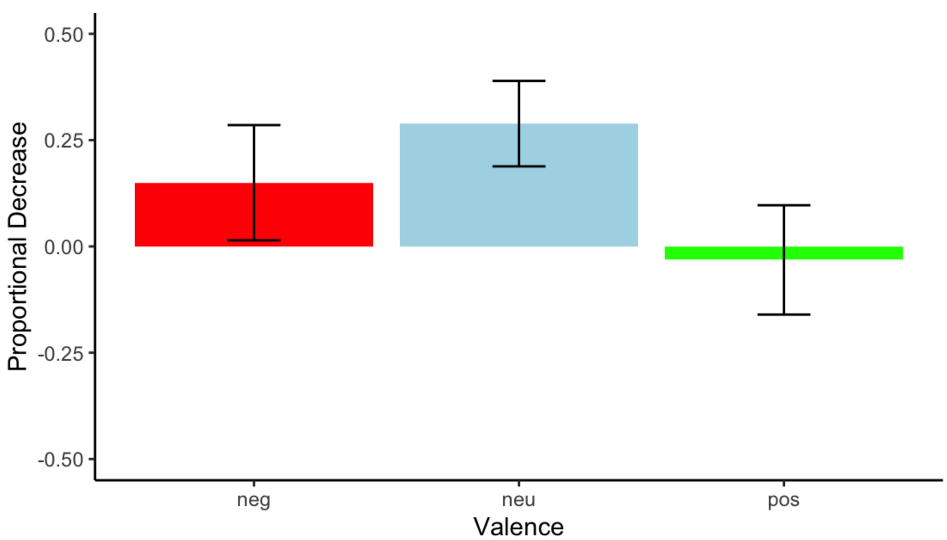
Figure 5. *Yes or No Binary Scores Results*



***Note.* remember responses were scored as either 1 (remembered) or 0 (not remember). *** *p*<.001. Error bars display standard error.**

Because memory performance was significantly different from each valence group at the 10-minute delay interval, we converted the binary recall scores at each delay interval into a proportional forgetting score by dividing the difference between the 10-minute delay interval and 24-hour delay interval by the 10-minute delay interval score $\left(\frac{Score\ at\ 10\ Minute - Score\ at\ 24\ Hour}{Score\ at\ 10\ Minute}\right)$. To assess the predictions regarding differential forgetting for negative, positive, and neutral videos, planned simple comparisons were conducted. Simple comparison found that there were no significant differences in the proportional decrease of binary scores for positive, negative, and neutral videos (*p*s > .05) (See Figure 6).

Figure 6. *Proportional Decrease in Binary Scores*



***Note.* Error bars display standard error.**

3.3 Overall video recollection for detail scores

For detail scores, which were calculated by dividing the number of details participants could correctly recall about original video by the total number of details in the video, there was no significant interaction between Time and Valence on detail scores, $F(2,52)=0.08$, $p=.92$, $\eta_p^2=.003$.

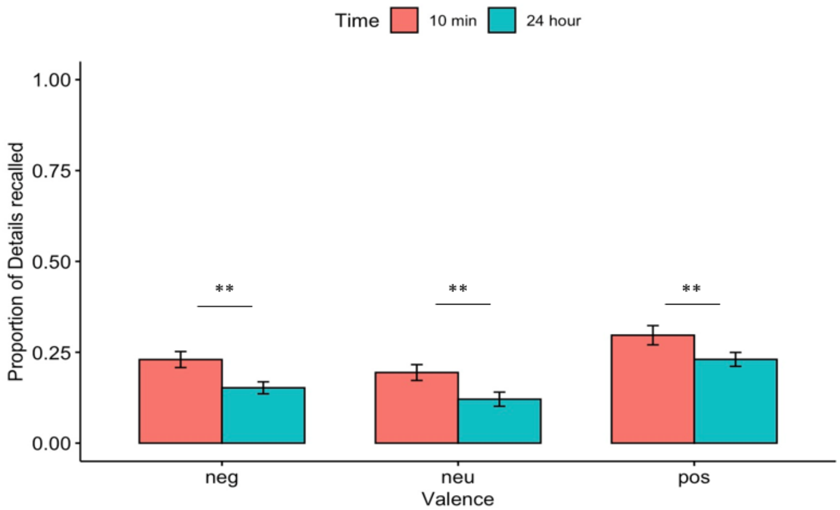
There were main effects of Valence, $F(2,52)=30.24$ $p<.001$, $\eta_p^2=.54$, and Time, $F(1,26)=29.18$, $p<.001$, $\eta_p^2=0.53$ (See Figure 7).

To assess the predictions regarding differential forgetting for negative vs. neutral videos and positive vs. neutral videos, planned follow-up within-subjects ANOVAs were conducted for each pair of conditions separately with detail scores as the dependent variable. For the ANOVA with the negative and neutral conditions, there was no interaction between Time and Valence on detail scores, $F(1,26)=0.02$, $p=.89$, $\eta_p^2=.001$. In addition, there was a main effect of Valence, $F(1,26)=8.36$, p=.008, $\eta_p^2=.24$, and a main effect of Time, $F(1,26)=28.30$, p<.001, $\eta_p^2=.52$. For the ANOVA with the positive and neutral conditions, there was no significant interaction between Time and Valence, $F(1,26)=0.062$, p=.80, $\eta_p^2=.002$. However, there were main effects of Valence, $F(1,26)=47.20$, p<.001, $\eta_p^2=.65$ and Time, $F(1,26)=20.17$, p<.001, $\eta_p^2=.44$.

For the main effects of Valence, simple comparisons between the negative and neutral condition on detail scores showed no significant differences at 10-minute delay interval, $t(26)=1.76$, $p=.20$, or at the 24-hour delay interval, $t(26)=1.67$, $p=.32$. Whereas simple comparison between positive and neutral condition on detail scores showed that participants remembered more details from positive videos than neutral videos at the 10-minute delay interval, $t(26)=4.21$, $p<.001$, and at the 24-hour delay interval, $t(26)=6.58$, $p<.001$. In addition, participants remembered more details from positive videos compared to negative videos at the 10-minute delay interval, $t(26)=3.11$, $p=.001$, and at the 24-hour delay interval, $t(26)=4.65$, $p<.001$.

For the main effects of Time, simple comparisons between the 10-minute delay interval and 24-hour delay interval found that participants had significant forgetting of details in negative videos, $t(26)=3.59$, $p<.01$, neutral videos, $t(26)=3.56$, $p<.01$, and positive videos, $t(26)=3.13$, $p<.01$.

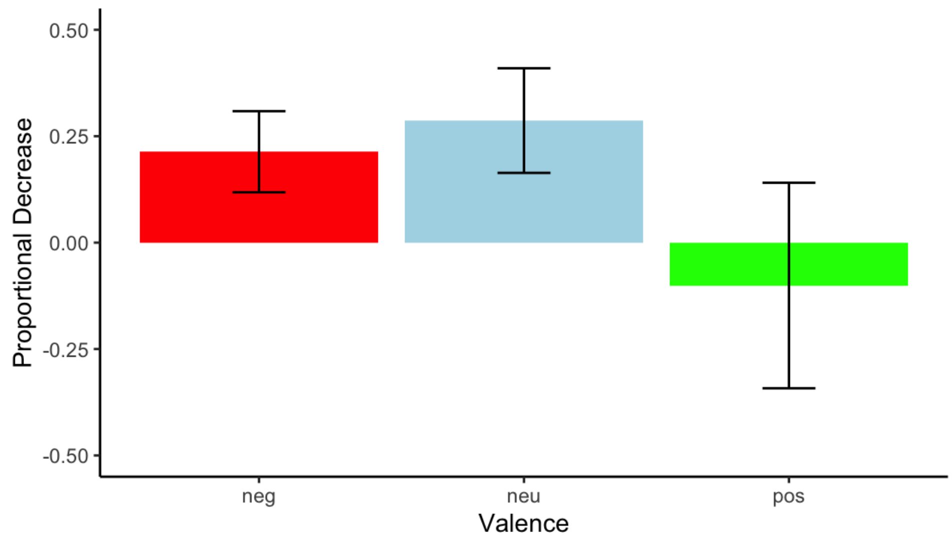
Figure 7. *Detail Scores Results*



***Note.* ** *p*<..01. Error bars display standard error.**

Because memory performance was significantly different from each valence group at the 10-minute delay interval, we converted the detail recall scores at each delay interval into a proportional forgetting score by dividing the difference between the 10-minute delay interval and 24-hour delay interval by the 10-minute delay interval score $\left(\frac{Score\ at\ 10\ Minute - Score\ at\ 24\ Hour}{Score\ at\ 10\ Minute}\right)$. To assess the predictions regarding differential forgetting for negative, positive, and neutral videos, planned simple comparisons were conducted. Simple comparison found that there were no significant differences in the proportional decrease of binary scores for positive, negative, and neutral videos (*p*s > .05) (See Figure 8).

Figure 8. *Proportional Decrease in Detail Score Results*

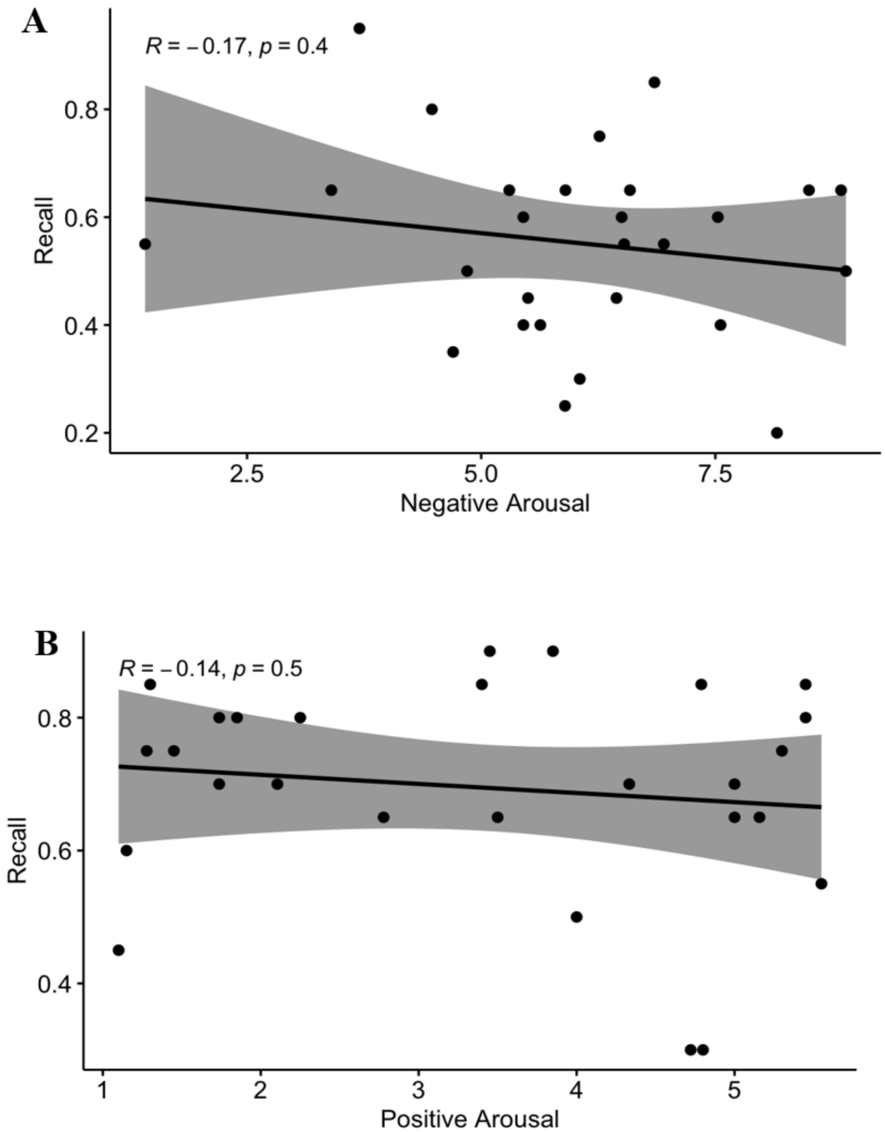


***Note.* Error bars display standard error.**

3.4 Correlations between arousal ratings and recall performance

As an additional analysis, we investigated whether there was a relationship between arousal ratings and recall performance for both the negative and positive videos. Each participant's arousal rating (1 – 9) for each negative video was averaged to calculate their average negative arousal rating, and the binary recall score (0 – 1) for each negative video (collapsing across the two delay intervals) was averaged to calculate their average binary recall score. The same procedure was done for the positive videos. For the negative videos, there was no significant correlation between arousal ratings and recall performance $r(26) = -0.17$, $p=0.4$ (See Figure 9A). For the positive videos, there was also no correlation between arousal ratings and recall performance, $r(26) = -0.14$, $p=0.5$ (See Figure 9B). These results indicate there is no relationship between arousal ratings and recall performance for either the negative or positive videos.

Figure 9. *Correlation Between Arousal Rating and Recall*



***Note.* Relationship between arousal rating and recall. A) Correlation between arousal and recall of positive videos. B) Correlation between arousal and recall of negative videos.**

4.Discussion

The goal of the current study was to examine the emotional enhancement effect on memories of videos. We examined this effect by measuring participants' memory for emotional videos at two delay intervals (10-minute and 24-hour) with a cued-recall paradigm. Our results demonstrated that both binary scores and detail scores were higher for positive videos than neutral and negative videos, and this effect was more apparent at a greater delay. On the contrary, binary scores and detail scores were similar between negative and neutral videos; Moreover, our results indicated forgetting of videos was not significantly different across positive, neutral, and negative videos. Our results were inconsistent with our predictions based on previous literature that memory performance for emotional videos would be better than neutral videos, and that this effect would be most prominent for negative videos.

Interestingly, our data suggested a strong positive enhancement effect in memory performance of videos. Importantly, however, this effect is less likely to be driven by differences in arousal, given that our current study demonstrated that participants rated negative videos as overall more arousing than positive videos, but consequently remembered fewer negative videos compared to positive videos. We predicted to find a negative enhancement effect because that is the consistent finding within recognition and recall studies (Bowen et al., 2018; Hamann, 2001; LaBar & Cabeza, 2006), which memories of emotional events are frequently retained more and less forgotten. But our results actually replicated Samide et al.'s (2019) finding. They found that participants remembered more vividly for positive videos than for negative and neutral videos.

It is currently unclear why emotion is affecting our videos differently than words and pictures. However, we speculate that such difference may be led by the time of exposure and frequency. Unlike pictures and words, videos typically consist of a sequence of images or scenes that are presented at a certain frame rate, and also encoding sessions are often longer for videos. Thus, by repetitive exposure to negative events for longer periods of time can lead to a reduction in the intensity of negative emotions, and such a phenomenon is known as *habituation* (Thompson, 1966). For example, if individuals are exposed to an unpleasant and loud noise for an extended period of time, their rating for emotional response is also likely to decrease. Given that this hypothesis is not supported by any evidence, it is insufficient to attribute such pattern to stimuli differences (e.g., emotional videos verse emotional words).

Moreover, there were a few other studies that have found positive emotion (but not negative) to enhance memory, for example, associative memories (Madan et al., 2019) and autobiographical memories (Walker et al., 2009; Schacter et al., 2012). Within associative memory, one study tested participants memory for paired words, and they found that participants were more likely to remember the paired words if both words were positive (Madan et al., 2019) compared to negative and neutral pairs, suggesting a positive enhancement effect. Further, some of these studies have identified impairing effects of negative stimuli pairs compared to neutral pairs (Madan, 2012; Rimmele et al., 2011). Within autobiographical memory, some studies have found a phenomenon known as "fading affect bias": emotional reaction tends to fade faster for negative autobiographical memories than positive autobiographical memories (Walker et al., 2009; Schacter et al., 2012). Walker described such phenomenon as an adaptive mechanism for humans that aid in regulating emotions, maintaining a positive self-image, and creating a hopeful outlook toward the future (Walker et al., 2009). Schacter supposed that because negative affect fades quickly over time compared to positive, it is more difficult to recall details with negative stimulation than for positive and neutral (Schacter et al., 2012). Given that past studies investigating the impact of emotion on associative memory and autobiographical memory have identified memory enhancement for positive information relative to negative information, our results are not fully inconsistent with the literature and positive videos can cause enhancement of memory relative to negative videos.

Importantly, however, given that our videos were selected from Samide et al.'s (2019) database, it is possible that this set of news clips appears to have a tendency to influence memory in favor of the positive videos, therefore this result may not be generalizable to other videos. For example, there might be a preference for positive videos over negative videos. Participants might be more interested in watching puppy news reports than watching battle-field news reports. It is still possible to observe negative enhancement effects from other sample of videos. For instance, one study has found a better recall performance for negative than neutral videos after 3 weeks (Cahill et al., 1966).

There were some limitations in our study that should be considered. Our study contained a relatively small number of videos for each valence at each delay (n=10), thus rather than forgetting, some participants showed an "improvement" of memory at the 24-hour delay interval compared to the 10-minute interval. We suspect that this improvement may be caused by our small sample of videos within each valence, thus a greater sample of videos is needed for future studies. Moreover, there were some cultural factors that needed to be considered. Since all of the videos were selected from a U.S. news archive, the processing of the videos may vary for participants who were familiar with U.S style news broadcasts than those who were not. Also, since all narration and text in our videos were presented in English, native speakers might have an advantage in encoding the information in the videos. Therefore, a larger and differently chosen sample of videos from other countries is preferred for future studies.

Given that it is possible that memories are remembered differently than static stimuli, future studies could include both static stimuli and videos to compare how different types of emotional stimuli influence memory recall. In addition, a future neuro-imaging study could also compare the brain activity underpinning video memory and photographic memory. For example, researchers could use neuroimaging techniques such as functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) to identify whether brain activity is different for encoding emotional video than for encoding emotional photos.

In conclusion, our current study found that overall memory performance was better for positive videos than neutral videos. In contrast, this enhancement effect was not shown in negative, which had a similar memory performance with neutral videos. Importantly, we showed that this positive enhancement effect was also identified in detail memory performance, participants not only could remember more positive videos, they could also retrieve more details from positive videos than negative and neutral videos at both delay intervals. Although it remains unclear why our study did not demonstrate a negative emotional enhancement effect, it suggests the possibility that memory for words and photos could be different from videos. In summary, our study contributes to the understanding of emotional forgetting by testing emotional memory with more dynamic and ecologically valid stimuli.

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