Reduced Source Memory for Emotional Pictures

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***Abstract*—Although many studies have examined the effect of emotion on item memory for pictures, the evidence is scanty on the effect of emotion on source memory for them. In this study, participants learned a list of neutral, positive, and negative pictures, and then took tests for item and source memory. We found that emotion did not affect accuracy of item memory; however, positive emotion enhanced subjective feeling of remembering. Both positive and negative emotions reduced source memory, which is consistent with some previous studies. The findings suggest that emotion have differential effects on item and source memory, and have some implications for evaluating eyewitness testimony.**

Key words-emotion; item memory; source memory; recollection; familiarity

I. INTRODUCTION

Episodic memory, namely memory for events that can be explicitly stated, consists of item memory and source memory [1]. Item memory refers to recognition or recall of an event itself, whereas source memory refers to recollection or recall of the context under which an event occurs [2].

The effect of emotion on episodic memory has received increased attention from psychologists over the past several decades. In laboratory studies, emotional words [3-7] or emotional pictures [8-11] are used to examine the influence of emotion on episodic memory. It is worth noting that the intensity of elicited emotional arousal may vary depending on the specific stimuli. Emotional pictures (e.g., those depicting bloody accident scenes) may elicit emotional arousal with greater intensity than do emotional words.

Some researchers have used pictures to examine the effect of emotion on item memory as tested by recall. In a study by Dolcos and Cabeza [8], participants viewed neutral, positive and negative pictures while their event-related potentials were being recorded. Recall for both positive and negative pictures were significantly better than for neutral pictures. Harris and Pashler [12] also investigated the effect of emotion on recall; however, they controlled for the effect of selective rehearsal by presenting 4 pictures per second. Consistent with Dolcos and Cabeza[8], they found an enhancement of recall for negative pictures. The results from the above studies were replicated in other studies [13-14] that used similar experimental paradigms. In summary, emotion has a robust enhancement effect on recall for pictures.

Other studies have used pictures to examine the effect of emotion on item memory as tested by recognition. Ochsner [15] found that although recognition for negative pictures did not significantly differ from that for neutral pictures, recollection for negative pictures, namely conscious remembering for details associated with a learning episode, was significantly higher than for neutral pictures. However, no significant difference was found between recollection for positive and neutral pictures. Consistent with Ochsner [15], Abrisqueta-Gomez[16] found that recognition for both negative and positive pictures was significantly better than for neutral ("indifferent" in their study) pictures in healthy participants. The findings from the two studies were replicated in Sharot and Yonelinas [11] who, however, observed the enhancement of recollection only at a 24h delay test, bur not at an immediate test. In summary, these studies suggest that emotion (especially negative emotion) enhances item memory for pictures.

The aforementioned studies all focused on the effect of emotion on item memory. Thus far, only several studies have used pictures to examine the effect of emotion on source memory and the results obtained are mixed. Mather et al. [18] found that negative emotion disrupted the binding of pictures to their spatial information in a working memory test. The disruptive role of negative emotion in source memory was replicated by Touryan et al. [14], who found a trade off phenomenon: item memory for negative pictures was significantly better than for neutral pictures, whereas associative memory for negative pictures was significantly worse than for neutral pictures. Inconsistent with the above two researchers, however, Sharot and Yonelinas [11] failed to find any effect of emotion on source memory (i.e., memory for cognitive processing), either in the immediate test or in a 24h delay test. The reason for such a discrepancy might be that different types of source memory were examined in different studies.

The above studies provide insights into investigating the effects of emotion on item and source memory for pictures. However, a limitation in those studies is that only negative and neutral pictures were used. Using positive pictures, therefore. is necessary to glean complete evidence, because valence is a critical factor in modulating the effect of emotion on episodic memory [18].

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Considering the above research background, we aimed to use pictures to examine simultaneously the effects of emotion on item and source memory. Participants viewed neutral, positive, and negative pictures that were surrounded by a rectangular frame whose color is either green or purple. They were asked to remember both the pictures and the colors of their surrounding frames. After a 5-min delay, they took a recognition test by giving "remember" (R) and "know" (K) responses as described by Rajaram [19], and a source memory test by specifying the frame color of a picture that received a R or K response.

Based on the results from previous studies [15-16], we expected that recognition, particularly recollection, for emotional pictures would be better than for neutral pictures. However, because emotional arousal can disrupt the associative binding of peripheral information to central emotional information [14], source memory for emotional pictures would be worse than for neutral pictures.

II. METHOD

A. Participants

Thirty-two undergraduates and graduate students (14 female and 18 male, mean age = 22.56 years, SD = .29 year) from several universities in Beijing attended this experiment. All participants reported themselves to be non-smoking and free from any emotional disorders. Participants were monetarily compensated. This study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences.

B. Stimuli

One hundred and twenty-four pictures (44 neutral pictures, 40 positive pictures and 40 negative pictures) were selected from based on their normative ratings of pleasure and arousal in the International Affective Picture System (IAPS) [20]. All pictures were resized to 256 × 192 pixels. Four neutral pictures were used to buffer primacy and recency effects. The remaining 120 pictures were divided into set 1 and set 2 such that each set contains 20 neutral pictures, 20 positive pictures, and 20 negative pictures. All pictures are depictions of either people or objects. Care was taken to match the number of pictures depicting people versus the number of pictures depicting objects across neutral, positive, and negative pictures.

Table I presents descriptive statistics for pleasure and arousal of the two sets of pictures. Analysis of variance (ANOVA) indicates that the two sets of pictures do not significantly differ in pleasure (both *ps* > *.05*). In addition, in both set 1 and set 2 pleasure ratings of positive pictures are significantly greater than that of both neutral pictures ($p < .001$) and negative pictures ($p < .001$); pleasure ratings of negative pictures are significantly less than that of neutral pictures ($p < .001$). In both set 1 and set 2 arousal ratings of positive and negative pictures are significantly greater than that of neutral pictures ($p < .001$). However, in both set 1 and set 2 arousal ratings of positive pictures do not significantly differ from those of negative pictures (*ps* > .05).

Picture set	Neutral pictures		Positive pictures		Negative pictures	
	p	a	p	a	p	a
Set 1	4.99 (.07)	3.19 (.12)	7.00 (.10)	6.14 (.01)	1.94 (.08)	6.32 (.10)
Set 2	4.98 (.15)	3.25 (.14)	6.99 (.15)	6.19 (.01)	1.97 (.10)	6.37 (.12)

Table I *Pleasure and arousal for the two sets of pictures*.

Note: Values in the parentheses represent standard errors. p: pleasure; a: arousal

C. Design and Procedure

A within-subject design was used, with emotion (negative, positive, and neutral) representing the independent variable, and item memory and source memory performances representing the dependent variables.

During the learning, participants sat about 50 centimeters in front of computer screens, preparing themselves to view 60 pictures. Four neutral pictures (2 pictures at the beginning and 2 pictures at the end of the learning list) were used to buffer primacy and recency effects. In each trial a crosshair first appeared at the center of screen for 1 second, followed by a picture at the center of screen lasting for 4 seconds. Each picture was surrounded by a rectangular frame (36.5 cm × 35.7 cm), whose width is 0.2 cm and whose color is either green or purple. The two frame colors were counterbalanced across the three types of pictures and were used as two sources as was the case in Doerkson and Shimamura[3]. An empty screen lasting for 1 second followed after the disappearance of each picture, and then the next trial started. Participants were asked to memorize each picture and the color of its surrounding rectangular frame. The learning phase lasted about 6 minutes.

Immediately after learning, participants conducted a 5-min mathematical task in which they firstly subtracted 3 from 2000, and then subtracted 3 from 1997, and so forth. Then the 60 old pictures and 60 new pictures were mixed and randomly presented to participants at the center of screen, without any surrounding rectangular frames. Participants first determined whether they "remember" a picture (consciously recollect it), "know" a picture (thought it to be only familiar but could not have any recollection of details), or thought a picture was new by clicking a corresponding button on the screen. After they decided that they "remember" or "know" a picture, they continued to determine the color of the surrounding frame by clicking a button on the screen. Their responses were self-paced. The testing phase lasted about 10 minutes.

After the memory tests, participants were asked to use a 9-point Likert type scale (ranging from 1 to 9) to rate pleasure and arousal of all pictures, including old and new pictures. Following the rating, they filled in Beck Depression Inventory.

D. Data Analysis

Data analyses were conducted using SPSS for Windows version 13.0. The level of significance was set at $p = .05$.

Analysis of Variance (ANOVA) was used for analyzing the data of picture rating. Repeated-measures analyses were made with emotion (neutral, positive, and negative) being the within-subject factor. The dependent measure of recognition memory was determined by subtracting false alarm rates from hit rates, according to the two-high threshold model[21]. The dependent measure of source memory was calculated as the percentage of correctly recalled frame colors for those pictures that were correctly judged as having been presented in the learning phase. Repeated measures analyses were also conducted on recollection and familiarity derived respectively from "remember" (R) and "know" (K) responses. Recollection was calculated by subtracting false alarm rates of R responses from hit rates of R responses; familiarity was calculated by subtracting false alarm rates of K responses from hit rates of K responses.

III. RESULTS

A .Participants' ratings of pleasure and arousal

Table II gives the data of pleasure and arousal for the two sets of pictures as rated by the participants in our study.

Table II Pleasure and arousal for the two sets of pictures as rated by the participants

Picture set	Neutral pictures		Positive pictures		Negative pictures	
	p	a	p	a	p	a
Set 1	4.83	3.60	5.68	5.46	2.60	6.35
	(.04)	(.08)	(.08)	(.09)	(.08)	(.10)
Set 2	5.01	3.63	5.66	5.25	2.47	6.66
	(.05)	(.09)	(.07)	(.10)	(.08)	(.10)

Note: Values in the parentheses represent standard errors. p: pleasure; a: arousal

ANOVA based on the participants' ratings indicates that the two sets of pictures do not significantly differ in pleasure and arousal (both *ps* > *.05*). In addition, in both set 1 and set 2, pleasure ratings of positive pictures are significantly greater than that of both neutral and negative pictures (both *ps* < .001); pleasure ratings of negative pictures are significantly less than that of neutral pictures ($p < .001$). In both set 1 and set 2 arousal ratings of positive and negative pictures are significantly greater than that of neutral pictures ($p < .001$). However, in both set 1 and set 2 arousal ratings of negative pictures were significantly greater than those of positive pictures (*ps* > .05). The above results, generally consistent with those based on the original ratings from IAPS (Lang et al., 2008), indicate that the pictures used were effective in eliciting positive and negative emotions in our participants.

B. Item memory and source memory

Table III gives descriptive statistics for item memory and source memory.

Table III Descriptive statistics for item and source memory for neutral, positive, and negative pictures

Measures	Neutral pictures	Positive pictures	Negative pictures
Hit rates	.841 (.024)	.917 (.016)	.873 (.020)
False alarm rates	.042 (.009)	.113 (.014)	.067 (.012)
Recognition	.798 (.027)	.805 (.021)	.806 (.019)
Proportion for R	.609 (.054)	.713 (.057)	.625 (.051)
Proportion for K	.273 (.050)	.317 (.057)	.316 (.052)
Recollection	.597 (.052)	.606 (.047)	.591 (.047)
Familiarity	.202 (.045)	.198 (.052)	.216 (.051)
Source memory	.658 (.029)	.594 (.029)	.587 (.021)

Note: Values in parentheses represent standard errors.

Analysis indicated a significant main effect of emotion on hit rates, F (2, 62) = 6.594, p = .003, η^2 = .175. Hit rates for positive pictures were significantly higher than for neutral pictures, F (1, 31) = 14.913, p = .001, η^2 = .325, and than for negative pictures, F (1, 31) = 4.589, p = .04, η^2 = .129. However, no significant difference was found between hit rates for neutral and negative pictures, F (1, 31) = 2.023, p = .165, η^2 = .061. False alarm rates for positive pictures were significantly higher than for neutral pictures, F (1, 31) = 30.787, $p < .001$, η^2 = .498, and than for negative pictures, F (1, 31) =20.008, $p < .001$, η^2 = .392. False alarm rates for negative pictures were marginally significantly higher than for neutral pictures, F (1, 31) = 4.000, p = .054, η^2 = .114.

Repeated measures analysis indicated that there was no significant main effect of emotion on recognition, F (2, 62) = .062, p = .94, η^2 = .002, indicating that recognition performance for neutral, positive, and negative pictures were equivalent.

The proportions of "remember" (R) and "know" (K) responses were presented in Table 2. Repeated measures analysis on the proportion of K responses indicated that there was no significant main effect of emotion, F (2, 62) = 1.586, p = .213, η^2 = .049. However, repeated measures analysis on the proportion of R responses indicated a significant main effect of emotion, F (2, 62) = 7.177, p = .002, η^2 = .188. Further analysis revealed that the proportion of R responses for positive pictures was significantly greater than for neutral and negative pictures, F (1, 31) = 10.824, p = .003, η^2 = .259, and F (1, 31) = 9.435, p = .004, η^2 = .233, respectively. However, no significant difference was found between the proportion of R responses for neutral and negative pictures, F (1, 31) = .31, p = .582, η^2 = .01.

Analysis indicated that there was no significant main effect of emotion on recollection, F (2, 62) = .159, p = .853, η^2 = .005, nor was there significant main effect of emotion on familiarity, F (2, 62) = .338, p = .714, η^2 = .011.

One sample t tests indicated that source memory for neutral, positive, and negative pictures were all above chance level of 0.5 (all *ps* < .05). Repeated measures analysis indicated a significant main effect of emotion, F (2, 62) = 3.711, p = .03, η^2 = .107. Source memory for positive pictures was marginally worse than for neutral pictures, F (1, 31) = 3.9, p = .057, η^2 = .112. Source memory for negative pictures was significantly worse than for neutral pictures, F (1, 31) = 6.072, p = .019, η^2 = .164. No significant difference was found

between source memory for positive and negative pictures, F (1, 31) = 6.072, p = .785, η^2 = .002.

Because of a technical problem, the data of 2 participants were not collected and depression scores of 30 participants (13 female and 17 male) were finally collected. Based on the median score of 6, the participants were split into two groups, with one group's depression scores above or equal to 6 and the other group's depression scores below 6. The incorporation of group as a between-subject factor into the previous repeated measures analyses did not alter the patterns of results for the main effect of emotion on recognition, recollection and familiarity. Likewise, the analysis indicated a significant main effect of emotion on source memory, F (2, 56) = 5.388, p = .007, η^2 = .161. No significant interaction was found between group and emotion (p > .05). The important results lied in post hoc pair wise comparisons: Whereas the previous analysis indicated that source memory for only negative pictures was significantly worse than for neutral pictures, the current analysis indicated that source memory for both positive and negative pictures were significantly worse than for neutral pictures, F (1, 28) = 6.193, p = .019, η^2 = .183, and F (1, 28) = 7.924, p = .009, η^2 = .221, respectively.

IV. DISCUSSION

This study investigated the effects of emotion on item and source memory for pictures and yielded several findings: 1) Neither positive nor negative emotions affected recognition, as well as recollection and familiarity; 2) Positive emotion enhanced the proportion of R responses without increasing their accuracy; 3) Both positive and negative emotions reduced source memory. The first and second findings do not support our hypothesis on recognition and recollection, but the third finding supports our hypothesis on source memory.

In contrast to the findings from many previous studies [13][14][16], we did not find enhancement of recognition for either positive or negative pictures. However, our result is consistent with that from Emery and Hess[7], who observed no significant difference between recognition for neutral, positive and negative pictures under the condition that participants conducted valence rating during learning. In addition, our result is consistent with that from Sharot and Yonelinas[11], whose immediate test did not reveal significant difference between recognition for negative and neutral pictures. The time interval between learning and test may be a crucial factor in modulating the effect of emotion on recognition, considering that many studies that revealed enhancement of recognition used longer intervals than we did.

This study indicated that positive emotion enhanced the proportion of R responses, which means that participants felt that they had a vivid, detailed memory. However, their actual accuracy of R responses for positive pictures was statistically equivalent to that for neutral pictures. In addition, their false alarm rates for positive pictures were statistically significantly higher than for neutral pictures, sugesting that positive emotion actually increased the likelihood of false memory. Consistent with some studies[7][15], our result suggests that positive emotion may simply produce a subjective feeling of vivid memory without necessarily improving memory accuracy of recognition.

Consistent with Touryan et al.[14], we found a reduction of source memory for negative pictures. The novel finding is that source memory for positive pictures was also worse than for neutral pictures. Broadly speaking, our result is also consistent with that from Anderson and Shimamura[22], who found that source memory was reduced under negative context, and with that from Maddock and Frein[23], who found that source memory for both spatial and temporal information was reduced for negative words. Such impairment of source memory can be explained by the attention-narrowing hypothesis proposed by Easterbrook[24], who posited that emotional arousal reduced the cues an individual could attend to and thus led him or her to focus attention on the central aspects of an event, at the expense of attention on the peripheral aspects. Such attention narrowing can compromise the encoding of the peripheral aspects and impair source memory for an event. In fact, it has been demonstrated in a study by Mather et al.[18] that emotional arousal could impair encoding process of source memory for spatial information.

It is worth noting that the enhancement effect of emotion on source memory has been well documented in many studies[3][5][25]. A careful examination, however, reveals that those studies used words as the stimuli. It is reasonabe to assume that even a word(i.e. blood) and a picture (i.e., a bloody scene) receive the same rating of arousal, there can be a sharp difference in emotional arousal they respectively induce. In fact, some researchers[3]have suggested that words may not elicit emotional arousal as intense as do pictures. Therefore, that the intensity of arousal can be modulatory in the effect of emotion on source memory. In other words, it can be speculated that there may be a critical degree of arousal below which emotion enhances source memory and beyond which emotion impairs it. Such a speculation at least receives support from the studies showing the weapon-focus effect[26]: Eyewitnesses, due to great emotional arousal, are only capable of remembering the weapon held by a criminal, but are oblivious to other details associated with the crime scene.

Our study has some implications for evaluating eyewitness testimony. Eyewitness testimony can make a deep impression on a jury, which is often exclusively assigned the role of sorting out credibility issues and making judgments about the truth of witness statements[27]. However, on occasions jurors may be insufficiently aware of the many factors that can influence eyewitness testimony and may sometimes overestimate its validity. Our study suggests that recognition for a negative scene itself is not necessarily better than that for a neutral scene. More importantly, memory for peripheral details related to an emotional scene is actually worse than that for a neutral one. Therefore, even when an eyewitness evinces strong confidence in his or her own statements, jurors need to exercise great caution in evaluating eyewitness testimony, especially those parts that are associated with peripheral aspects of a crime scene.

There are some issues needed to be resolved in future studies. First, there is one study [25] indicating that learning instructions (intentional vs. incidental) can modulate the effect of emotion, so what would the effect of emotion be if participants are asked to conduct incidental learning? It is reasonable to expect that a different pattern of results, particularly an enhancement of recognition may appear under the condition of incidental learning where participants are simply asked to read sliently words without intentionally committing them to memory. Second, what would the effect of emotion be if tests are conducted at a longer delay? Sharot and Yonelinas[11]observed that the enhancement effect of emotion on recognition only occurred at a 24h delay. Therefore, a similar enhancement of recognition may be found by arranging memory tests at a longer delay. Third, according to the framework proposed by Johnson et al.[2] source memory can be classified as depending on external, internal and reality monitoring. It is interesting to ascertain whether the reduction in source memory observed in this study extend to other types of source memory (i.e., those based on internal and reality monitoring).

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