



Gender differences in the effects of post-learning emotion on consolidation of item memory and source memory[☆]

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ARTICLE INFO

Article history:

Received 2 September 2009
Revised 31 January 2010
Accepted 24 February 2010
Available online 1 March 2010

Keywords:

Gender differences
Post-learning emotion
Item memory
Source memory
Consolidation

ABSTRACT

Item memory and source memory are two integral elements of episodic memory. Although many studies have examined the effect of emotion on item memory, little research has simultaneously taken into account item memory and source memory. In addition, in the majority of previous studies, learning stimuli are used as the source of emotion, making it difficult to understand whether emotion has an effect on encoding or on consolidation of episodic memory. Furthermore, although gender differences exist in neurophysiological responses to emotional stimuli, in many studies gender differences were neglected and this leaves the picture incomplete regarding the effect of emotion on episodic memory. In this study, we examined gender differences in the effects of post-learning emotion on consolidation of item memory and source memory. Participants learned neutral Chinese nouns, took a memory pretest, and were then randomly assigned to three conditions, in which they either watched a 3-min negative video clip, or watched a 3-min positive video clip, or remained calm and relaxed for 3 min. Thirty minutes after the initial learning, participants took a memory posttest. We found that: (1) For females, post-learning negative emotion enhanced consolidation of item memory; however, neither negative emotion nor positive emotion had a significant effect on consolidation of source memory; (2) For males, neither negative nor positive emotion after learning had a significant effect on either item memory or source memory. Possible reasons for the gender differences, as well as the theoretical significance and practical implications of this study were discussed.

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1. Introduction

People tend to have more vivid episodic memory for the events that arouse emotions (Bradley, Greenwald, Petry, & Lang, 1992; Brown & Kulik, 1977; Kensinger & Corkin, 2003; LaBar & Cabeza, 2006). Many lab studies have shown that emotion has an enhancing effect on episodic memory, by using either words (Anderson & Shimamura, 2005; Bradley et al., 1992; Doerksen & Shimamura, 2001; Kensinger & Corkin, 2003; Kensinger & Schacter, 2006) or pictures (Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; D'Argembeau & Van der Linden, 2005; Mather & Nesmith, 2008) as the learning stimuli. However, some studies failed to find enhancement effect of emotion on episodic memory (Cook, Hicks, & Marsh, 2007; Kapucu, Rotello, Ready, & Seidl, 2008; Maddock & Frein, 2009; Maratos, Allan, & Rugg, 2000).

The majority of empirical studies, however, used a paradigm in which the source of emotion comes from the to-be-remembered

stimuli. The two inherent drawbacks of such a paradigm are that it is difficult to match stimuli for different conditions of emotion and that it is unclear whether the effect of emotion is on attention, encoding or consolidation, or a combination of them.

However, several recent studies have adopted a paradigm in which emotion is manipulated after learning (Anderson, Wais, John, & Gabrieli, 2006; Liu, Graham, & Zorawski, 2008; Nielson & Lorber, 2009; Nielson & Powless, 2007; Nielson, Yee, & Erickson, 2005), excluding the possibility that emotion has any effect on encoding and providing a way to clarify the role of emotion in memory consolidation. In a study of Nielson et al. (2005), participants learned a list of neutral words and then were assigned to watch a video clip that was either neutral or negatively arousing. Memory tests demonstrated that participants who watched a negatively arousing video clip remembered significantly more words than those who watched a neutral video clip, although the two groups had comparable pretest memory performance prior to watching the video clips. In a further study, Nielson and Powless (2007) examined the time-dependency of the effect of post-learning emotional arousal on memory consolidation. Participants learned a list of neutral words and then watched a positively or a negatively arousing video clip after delays of 0, 10, 30 or 45 min. The finding was that emotional arousal, whether positive or nega-

[☆] Project supported in part by grant from 973 Program (No. 2006CB303101) and the National Natural Science Foundation of China (No. 90820305).

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tive, caused equivalent pleasure increase induced up to 30 min after learning, enhanced item memory consolidation.

In the above studies, the learning stimuli were neutral in emotionality. What if the learning stimuli are emotionally arousing? [Nielson and Lorber \(2009\)](#) addressed this question in a recent study. Participants learned four types of words, which ranged from high to low respectively in the dimensions of arousal and valence (i.e. words with high arousal and high valence, words with high arousal and low valence, words with low arousal and low valence, and words with low arousal and high valence). Ten minutes after the learning, participants viewed either a positive or a neutral video clip. Memory test conducted one week after the learning indicated that post-learning emotional arousal significantly enhanced memory for words. Importantly, no interaction was found between the emotionality of learned words and the post-learning emotional arousal, meaning that the memory for all the aforementioned four types of words was enhanced.

In summary, the above studies demonstrated that emotion induced after learning could enhance consolidation of item memory. As we know, however, episodic memory consists of two integral elements: item memory and source memory. Source memory refers to recollection or recall of the context from which an item or fact is acquired, whereas item memory refers to recognition or recall of previously presented information itself. It is still unclear whether the enhancement effect of post-learning emotion can extend to source memory. To have a complete appreciation of how post-learning emotion affects episodic memory, it is necessary to investigate the effect of emotion on source memory.

Another aspect ignored by previous studies is gender differences. Some neuroimaging and electrophysiological studies have showed that gender differences exist in the processing and retrieval of emotional stimuli. [Cahill et al. \(2001\)](#) found that in responses to emotional films, enhanced activity of the right, but not the left, amygdala in males was related to enhanced memory. On the contrary, for females enhanced activity of the left, not the right amygdala was related with enhanced memory. In addition, the effect of emotion on the left amygdala in females seemed to be more anterior, and to include more of the “extended amygdala” regions, than did the effect of emotion on the right amygdala in males. [Canli, Desmond, Zhao, and Gabrieli \(2002\)](#) found that in retrieval of emotional pictures, in comparison to females, males demonstrated more activation in a network including the right amygdala. In addition, females had significantly more brain regions where activation correlated with both ongoing evaluation of emotional experience and with subsequent memory for the most emotionally arousing pictures. [Canli et al. \(2002\)](#) suggested that such greater overlap in brain regions may explain the greater benefit in emotional memory enjoyed by females. More recently, [Gasbarri et al. \(2007\)](#) obtained electrophysiological evidence. Negative pictures elicited more robust P300 in the left hemisphere in females than in males, yet elicited a stronger P300 component in the right hemisphere in males than in females. Despite the above evidence, few studies so far have taken into account gender differences in studying the effect of post-learning emotion on episodic memory.

Considering the above research background, we aimed to address the issue of gender differences in the effect of post-learning emotion on both item memory and source memory. Participants viewed Chinese nouns in a font color of blue or red, remembering both the nouns and their font colors. Immediately after the learning, they undertook a pretest, which examined memory for both the nouns (item memory) and their font colors (source memory). Following the pretest, participants were then randomly assigned to three conditions, in which they watched a 3-min negative video clip, or watched a 3-min positive video clip, or remained calm and relaxed for three minutes. Then they stayed in the lab until a posttest that took place thirty minutes after the beginning of learning.

Based on the studies showing the enhancing effect of post-learning emotion on item memory ([Nielson & Lorber, 2009](#); [Nielson & Powless, 2007](#); [Nielson et al., 2005](#)), and the modulatory role of the amygdala in consolidation of memory in other brain regions including the hippocampus ([McGaugh, 2002](#)), we hypothesized that post-learning would enhance the consolidation of item memory. Meanwhile, considering the finding that post-learning emotion only enhanced the memory for gist rather than details of to-be remembered stimuli ([Adolphs, Denburg, & Tranel, 2001](#); [Liu et al., 2008](#); [Zorawski & Killcross, 2003](#)), and that source memory tasks can be used to examine memory for details ([Kensinger & Corkin, 2003](#)), we expected that source memory would not be influenced by post-learning emotion. In addition, we hypothesized that females would be more likely than males to have better consolidation of item memory by watching a negative video. This hypothesis is based on the following findings: (1) Negative stimuli elicit more robust electrophysiological response in the left hemisphere in females than in males ([Gasbarri et al., 2007](#)); (2) Enhanced activity of the left amygdala in females was related to enhanced memory ([Cahill et al., 2001](#)). Furthermore, we hypothesized that females would also be more likely to have item memory benefit by watching a positive video, based on the following findings from previous research: (1) Females had greater overlap in brain regions in retrieval of emotional pictures ([Canli et al., 2002](#)); (2) Females were more emotionally reactive than males, and smiled more while reliving happiness and love ([Chentsova-Dutton & Tsai, 2007](#)).

2. Experiment for selection of video clips

2.1. Participants

Forty-five participants (23 male and 22 female; mean age = 22.86 years, SD = 1.88 years) were recruited to rate positive video clips. Forty-eight participants (24 male and 24 female; mean age = 23.20 years, SD = 2.44 years) were recruited to rate negative video clips, in a procedure identical to that for the rating of positive video clips. The experiment was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences.

2.2. Materials

In this study we needed a positive video clip and a negative video clip. In order to enhance the possibility of eventually coming up with two appropriate video clips, we prepared three positive video clips, respectively entitled *No Lacking Money (positive 1)*, *Dream Community (positive 2)*, and *Olympic Torchbearer (positive 3)*. We also prepared three negative video clips: *Wenchuan Earthquake (negative 1)*, *Dull Ice Flower (negative 2)* and *Titanic (negative 3)*. All video clips lasted for 3 min.

2.3. Procedure

Before watching a video clip, participants first reported their current pleasure and arousal on a 9-point Likert-type scale ranging from 0 to 8. Immediately after the viewing, they again reported their current pleasure and arousal and filled in a questionnaire selected from *Handbook of Emotion Elicitation and Assessment (Coan & Allen, 2007)*. Each participant was asked to watch all the three video clips, with the order of video presentation balanced across participants.

2.4. Results

Descriptive data for the six video clips were given in [Tables 1 and 2](#). Increase ratio was calculated by the formula: pleasure in-

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