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## Negative emotion elicited in high school students enhances consolidation of item memory, but not source memory



Bo Wang

Department of Psychology, School of Social Development, Central University of Finance and Economics, Beijing 100081, China

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### ABSTRACT

The study examined the effect of negative emotion on consolidation of both item and source memory. Participants learned words read by either a male or female. Then they watched either a negative or a neutral video clip. Memory tests were carried out either 25 min or 24 h after learning. The study yielded the following findings. First, negative emotion enhanced consolidation of item memory as measured by recognition memory in the 25-min delay, and enhanced consolidation of item memory as measured by free recall in both the 25-min and the 24-h delay. Second, negative emotion had little effect on consolidation of source memory, either in the 25-min or the 24-h delay. These findings provide evidence for the differential effects of negative emotion on item memory and source memory and have implications for using emotion as a strategy to intervene memory consolidation.

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## 1. Introduction

Despite the many studies on the effect of emotion on memory consolidation, it is unclear whether emotion has similar or differential effects on different aspects of memory and whether the effect of emotion is contingent upon retention interval. The current study therefore examines whether post-learning negative emotion affects consolidation of item memory and source memory and whether there is a modulatory role of retention interval.

### 1.1. Item memory and source memory

Episodic memory consists of two elements: item memory and source memory, with item memory referring to memory for an event itself and is usually tested by free recall and recognition memory (Slotnick, Moo, Segal, & Hart, 2003), and source memory referring to memory for the origins or contexts of an event (Johnson, Hashtroudi, & Lindsay, 1993). In laboratory studies, source memory can be tested in different paradigms. In one paradigm, source memory is tested in conjunction with item memory. For instance, in a study by Doerkson and Shimamura (2001), participants studied a list of words in either yellow or blue font. In subsequent tests, they were first asked to determine whether a word had been presented or not during the initial learning phase and, when they decided that a word had been presented, they were further asked to recall the font color in which the word was initially presented. Another paradigm features independent measuring of item memory and source memory. For example, in a study by Davidson, McFarland and Glisky (2006), participants listened to a list of neutral and emotional words spoken by a male or a female. In the source memory test, participants were asked to determine the

E-mail address: [709534442@qq.com](mailto:709534442@qq.com)

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speaker (male versus female) for each word using a paradigm of two-alternative forced choices. In the item memory test, participants were asked to recall the words they had previously learned. The advantage of independent testing is that source memory is not restricted by the number of hits in a recognition test. However, in order to enable comparisons with prior studies (e.g., Wang & Fu, 2010), in the current study source memory was tested in conjunction with item memory.

There has been evidence showing the dissociation between item memory and source memory (e.g., Bayer et al., 2011; Glisky, Polster, & Routhieaux, 1995; Macklin & McDaniel, 2005; Slotnick et al., 2003). For instance, in a prior study, participants encoded abstract figures during encoding and took an item memory (old/new judgements) and a source memory test (judgement of previous positions of figures). The results showed that item memory, rather than source memory, was associated with activity in the medial temporal lobes (Slotnick et al., 2003).

### 1.2. *Effect of emotion on consolidation of item and source memory*

Memory consolidation is a process whereby an initial fragile memory trace becomes stable over time (Dudai, 2004; McGaugh, 2000). Studies have shown that memory consolidation can be influenced by a variety of factors including stress (Cahill, Gorski, & Le, 2003; Preuß & Wolf, 2009; Yonelinas, Parks, Koen, Jorgenson, & Mendoza, 2011), pharmacological manipulations (McGaugh & Roozendaal, 2009), and muscle tension (Nielson, Wulff, & Arentsen, 2014). Particularly, recent studies have demonstrated the enhancement effect of post-learning emotion on memory consolidation. Specifically, post-learning emotion enhances consolidation of memory for not only neutral words (e.g., Nielson & Meltzer, 2009; Wang & Fu, 2010; Nielson & Powless, 2007) but also for emotional words (Nielson & Lorber, 2009). Furthermore, the enhancement effect has also been shown to extend to consolidation of memory for pleasant and negative pictures rather than neutral pictures regardless of gender of participants (Liu, Graham, & Zorawski, 2008). The mechanism may be associated with the release of a number of substances such as epinephrine and norepinephrine during emotion (Gerra et al., 1996; McCarty & Gold, 1981). These substances in turn activate the amygdala (especially the basolateral amygdala), a structure in the limbic system that plays a key role in modulating consolidation of hippocampus-dependent memory (McGaugh, 2002).

Thus far some studies have examined the effect of post-learning emotion on consolidation of item memory. For instance, in a study of Nielson and Bryant (2005), participants intentionally learned a word list and then, for induction of emotion, they watched a 3-min video either about dental surgery (the negative condition) or about tooth brushing (the control condition). Delayed tests showed better item memory performance (as derived from tests of free recall and recognition memory) for participants in the negative condition than in the control condition. This finding was replicated in other studies (e.g., Nielson & Meltzer, 2009; Nielson & Powless, 2007). Particularly, a recent study has shown that emotion induced by watching a video of dental surgery enhanced consolidation of item memory for materials encoded in a classroom lecture (Nielson & Arentsen, 2012), indicating the applicability of post-learning emotion to real educational settings to enhance memory consolidation.

Although there has been much research into the effect of emotion *elicited during encoding* on source memory (e.g., Doerksen, & Shimamura, 2001; Kensinger & Corkin, 2003; Wang & Fu, 2011), very few studies have investigated the effect of *post-learning* emotion on consolidation of source memory. In a study by Wang and Fu (2010), participants learned a list of Chinese words and were instructed to memorize both the words (for item memory) and their associated font colors (for source memory). Following the learning they watched a comic, a sad, or a neutral video clip. Delayed tests conducted 30 min after learning showed an enhancement effect of negative emotion (i.e., sadness) on consolidation of item memory for females. However, neither positive nor negative emotion had a significant effect on consolidation of source memory. For males, neither negative nor positive emotion after learning had a significant effect on the consolidation of either item memory or source memory.

### 1.3. *Research gaps*

Although prior studies have examined the effect of post-learning emotion on memory consolidation, some research gaps remain to be filled. First, despite the evidence showing the dissociation between item memory and source memory (e.g., Glisky et al., 1995; Slotnick et al., 2003), little evidence exists regarding whether post-learning emotion would have differential effects on consolidation of item and source memory. The answer to this question is important because item and source memory are two integral elements of episodic memory. Second, in the majority of prior studies only one retention interval (e.g., 1 week) was used and as such it is unknown whether the effect of post-learning emotion is contingent upon retention interval. Understanding this issue may provide insight into the boundary conditions under which emotion affects memory consolidation. Previous studies in which a 1-week interval was used have indicated the enhancement effect of post-learning emotion. However, if it turns out that with a shorter interval the effect of post-learning emotion disappears, then it is necessary to consider this time-dependency in establishing a theory for the effect on emotion on memory consolidation. The time-dependency may suggest that it is inappropriate to claim a general, ubiquitous effect of post-learning emotion. Investigating the modulation of retention interval may also have implications for forensic practices. If the effect of post-learning emotion on memory accuracy of eyewitnesses can be affected by retention interval, then care must be exerted so as to choose an appropriate time period in which to conduct questioning of eyewitnesses. Thus far, there have been studies investigating the role of retention interval in modulating eyewitness memory for emotional events. For instance, in a study by Paz-Alonso and Goodman (2008), participants viewed a traumatic event (a vivid murder), underwent a misinformation procedure and took a test either immediately or 2 weeks after learning. The results showed that, with a longer retention

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