



## Time course of effects of emotion on item memory and source memory for Chinese words

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### ABSTRACT

Although many studies have investigated the effect of emotion on memory, it is unclear whether the effect of emotion extends to all aspects of an event. In addition, it is poorly understood how effects of emotion on item memory and source memory change over time. This study examined the time course of effects of emotion on item memory and source memory. Participants learned intentionally a list of neutral, positive, and negative Chinese words, which were presented twice, and then took test of free recall, followed by recognition and source memory tests, at one of eight delayed points of time. The main findings are (within the time frame of 2 weeks): (1) Negative emotion enhances free recall, whereas there is only a trend that positive emotion enhances free recall. In addition, negative and positive emotions have different points of time at which their effects on free recall reach the greatest magnitude. (2) Negative emotion reduces recognition, whereas positive emotion has no effect on recognition. (3) Neither positive nor negative emotion has any effect on source memory. The above findings indicate that effect of emotion does not necessarily extend to all aspects of an event and that valence is a critical modulating factor in effect of emotion on item memory. Furthermore, emotion does not affect the time course of item memory and source memory, at least with a time frame of 2 weeks. This study has implications for establishing the theoretical model regarding the effect of emotion on memory.

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### 1. Introduction

Over the past several decades the relation between emotion and memory has increasingly attracted attention from cognitive psychologists (Uttl, Ohta, & Siegenthaler, 2006). To elucidate the relation between emotion and memory, it is important to understand how emotion affects memory.

Memory for events or episodes in particular places at particular times is called episodic memory; most laboratory tasks that psychologists had used over the past century to study memory could be classified as requiring episodic memory (Tulving, 1972). The concept of episodic memory has not only been treated as a psychological construct useful for heuristic and descriptive purposes, but has been used to refer to a specialized mind-brain system (Tulving, 2002). Episodic memory is composed of two elements: item memory and source memory (Slotnick, Moo, Segal, & Hart, 2003). In laboratory studies, item memory refers to recognition or recall of previously presented information itself, whereas source memory refers to recollection or recall of the context from which the fact

or information is acquired. The term source can refer to a variety of characteristics that, collectively, specify the conditions under which a memory is acquired (e.g., the spatial, temporal, and social context of the event; the media and modalities through which it was perceived) (Johnson, Hashtroudi, & Lindsay, 1993).

Studies have shown that item memory and source memory are dissociable elements of episodic memory. For example, under certain circumstances, people can correctly recall a piece of information without being able to recollect its source such as who told them or how they came to know about it (e.g., Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991). Neuropsychological evidence also supports the dissociation between item memory and source memory (e.g., Glisky, Polster, & Routhieaux, 1995).

Many studies have investigated the effect of emotion on item memory; however, the findings are contradictory. Some studies have shown that emotion enhances item memory (Aycicegi-dinn & Caldwell-Harris, 2009; Blake, Varnhagen, & Parent, 2001; Bradley, Greenwald, Petry, & Lang, 1992; Comblain, D'Argembeau, Van Der Linden, & Aldenhoff, 2004; Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Grider & Malmberg, 2008; Guya & Cahill, 1999; Hertel & Parks, 2002; Kensinger & Corkin, 2003; Mathews & Barch, 2006; Shigemune et al., 2010); some studies have shown that emotion impairs item memory (Corson & Verrier, 2007; Maratos, Allan, & Rugg, 2000); other studies have

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demonstrated that emotion has no effect on item memory (Doerksen & Shimamura, 2001; Dougal & Rotello, 2007; Johansson, Mecklinger, & Treese, 2004; Kapucu, Rotello, Ready, & Seidl, 2008; Windmann & Kutas, 2001).

With regard to the scenario of the effect of emotion on source memory, the findings are likewise mixed. Although a number of studies have demonstrated an enhancement effect of emotion (Anderson & Shimamura, 2005; D'Argemba and Van der Linden, 2005a, 2005b; Doerksen & Shimamura, 2001; Guillet & Arndt, 2009; Kensinger & Corkin, 2003; Kensinger & Schacter, 2006; Mather & Nesmith, 2008), some studies have found the impairment effect on source memory (e.g., Cook, Hicks, & Marsh, 2007; Maddock & Frein, 2009) and one study have found that emotion has no effect on source memory (Sharot & Yonelinas, 2008).

The current controversy may be because the effect of emotion on episodic memory can be modulated by a variety of factors, such as type of memory task (e.g., Ramponi, Handelsman, & Barnard, 2010) and the time at which memory is tested (e.g., Sharot & Yonelinas, 2008).

Although many studies have examined the effect of emotion on both item memory and source memory, to the best of our knowledge very few studies have concerned themselves with how emotion affects item memory and source memory over time. In a study by Kleinsmith and Kaplan (1963), for learning participants were presented paired associates either of high arousal or low arousal, and were tested at various time intervals: 2 min, 20 min, 45 min, 1 day, and 1 week. Low arousal paired associates led to high immediate recall value and rapid forgetting, whereas high arousal paired associates resulted in low immediate recall and high permanent memory, indicating that emotional arousal is conducive to memory retention over time. In a recent study by Sharot and Phelps (2004), recognition of neutral and arousing words were examined at two time points. Recognition of neutral words became worse over time, whereas recognition of arousing words remained the same and was better than neutral word recognition at a 24-h delay. This study indicates that emotion serves to maintain item memory over time. Sharot and Yonelinas (2008) examined the time course of both item memory and source memory for emotional and neutral pictures at two retention intervals. Consistent with the finding from Sharot and Phelps (2004), recollection was enhanced for emotional compared to neutral photos after a 24-h delay, but not immediately after encoding. However, at both time points, no effect of emotion on source memory was observed. The above studies demonstrate that the time course of the effect of emotion on item memory is different from that on source memory.

Although previous studies provided important insights into the time course of effect of emotion, they have the limitation that only two time points were used, which makes it difficult to have a comprehensive understanding of the time course of the effect of emotion. To better capture the pattern for the time course, in this study we used the following eight time points: immediate, 19-min delay, 63-min delay, 4.9-h delay, 8.8-h delay, 24-h delay, 6-day delay, and 2-week delay (see Ebbinghaus, 1885). During learning, participants memorized intentionally both the words themselves and their associated font colors. All words were presented twice. Then they were randomly assigned to eight delay conditions in which to take test of free recall, followed by recognition and source memory tests, at corresponding time points.

There has been a number of research investigating on the difference between free recall and recognition. According to some theorists (e.g., Anderson & Bower, 1972; Kintsch, 1970), the process of free recall consists of two major sub-processes: a search process and a recognition process. First, information in the long-term store must be searched. Once a piece of information has been located, a recognition process than starts to ascertain whether that piece of information has indeed occurred. If the judgment is that it has

not, the search process continues until a next piece of information is located. In a recognition test, however, there is no need for the search process because all the information is presented and the participant only needs to decide which piece of information had indeed occurred during initial learning.

Given the above theories on the difference between free recall and recognition, it is not surprising that some studies have shown the effect of emotion over time can be modulated by whether memory is tested by free recall or by recognition. It was only at a delay that emotion enhanced recognition (Sharot & Phelps, 2004; Sharot & Yonelinas, 2008), and such enhancement effect remained at 2-week delay tests (Comblain, D'Argemba, Van Der Linden, & Aldenhoff, 2004; Hamann, Monarch, & Goldstein, 2000). However, emotion enhanced free recall either at a 5-min delay (Hertel & Parks, 2002) or at 1-week delay test (Guya & Cahill, 1999).

Based on the above findings as well as the theory regarding the difference regarding free recall and recognition (Anderson & Bower, 1972; Kintsch, 1970), we hypothesized that emotion would enhance recognition only at delayed tests and that emotion would enhance free recall both at immediate and delayed tests.

It has been suggested that emotion affects memory consolidation via the modulation of the amygdala, specifically the basolateral (BLA) region (McGaugh, 2002). In fact, studies have shown that lesions of the BLA can lock the induction of long-term potentiation (LTP) in the dentate gyrus of the hippocampus (e.g., Ikegaya, Nakanishi, Saito, & Abe, 1997). Memory consolidation takes time, and the slow consolidation serves an adaptive function by enabling neurohormonal processes triggered by an arousing stimulus to modulate memory strength (McGaugh, 2000). In fact, studies have shown that the effect of emotion on memory would be apparent following a delay (e.g., Sharot & Phelps, 2004). Therefore, we hypothesized that the magnitude of effect of emotion would become more marked over time.

Based on the finding from Sharot and Yonelinas (2008), we hypothesized that emotion would not have any effect on source memory whether at immediate or at 24-h delay test or other shorter delay tests (i.e., 19-min delay, 63-min delay, 4.9-h delay and 8.8-h delay tests). However, if consolidation of source memory takes longer than 24 h, emotion would enhance source memory in other longer delayed tests.

## 2. Methods

### 2.1. Participants

One hundred and thirty-six undergraduates and graduate students (86 female and 50 male, mean age = 22.91 years) from several universities attended this experiment. All participants reported themselves to be non-smoking and free from any emotional disorders. Participants were paid 20 Yuan (RMB) an hour. Data from four participants were not included for final analysis because they failed to follow the instructions. This study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences.

### 2.2. Material

#### 2.2.1. Material for memory ability test

In the memory ability test 16 abstract pictures were used. These pictures were downloaded from <http://www2.bc.edu/~slotnics/scripts.htm>.

#### 2.2.2. Material for primary test

A total of 333 Chinese words, selected from *Dictionary of Word Frequency of Modern Chinese* (Compiled by Beijing Institute of

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