



## Original Articles

# Electrophysiological evidence for the effects of emotional content on false recognition memory



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## ABSTRACT

Two competing hypotheses attempt to explain the effects of emotional content on the production of false memory. The conceptual relatedness account posits that negative emotion increases false memory by strengthening familiarity process, whereas the distinctiveness heuristic account postulates that negative emotion reduces false memory by influencing recollection process. Here, using the categorized pictures paradigm, we examined these hypotheses by investigating emotional influences on false recognition memory performance and the event-related potential (ERP) correlates of familiarity and recollection. Participants were presented with positive, neutral, or negative pictures from various categories during encoding and later completed a recognition test while electroencephalogram data were recorded. Behavioral results revealed lower corrected false recognition rates for negative and neutral pictures than for positive ones, with no significant difference between negative and neutral pictures. In addition, negative pictures were associated with a more conservative response bias in comparison with neutral and positive pictures. Importantly, ERP results revealed enhanced recollection-related parietal old/new effects for negative pictures relative to positive and neutral pictures, but comparable familiarity-related early frontal old/new effects across each type of emotional valence category during both true and false recognition. Our results suggest that emotionally negative content may affect production of false memory mainly by engaging a distinctiveness heuristic. Methodological implications of these findings are discussed.

## 1. Introduction

Episodic memory is regarded as a constructive process that may lead to memory distortions (Schacter, 1999; Schacter & Addis, 2007; Schacter, Norman, & Koutstaal, 1998). Individuals may falsely recognize or recall events which had not been previously encountered. For example, in the Deese–Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995), participants study a series of words (e.g., *thread, sewing, sharp, point, and injection*) that are all related to an unrepresented lure word (e.g., *needle*). At subsequent test, they frequently falsely recognize the lure word with high confidence. In addition, subjectively compelling memory errors can also be reliably induced using categorized stimuli (Koutstaal & Schacter, 1997; Seamon, Luo, Schlegel, Greene, & Goldenberg, 2000). In this procedure, several exemplars (words or pictures) per category are presented during

encoding. The non-studied exemplars of a given category are used as lures to measure false memory during retrieval. Research on the production of false memory provides a basis for advancing our understanding of cognitive processes underlying human memory function (Arndt, 2012; Schacter & Slotnick, 2004).

It is well established that emotion has a significant impact on memory for studied events (Buchanan, 2007; Talmi, 2013). Emotionally arousing stimuli are usually remembered with greater vividness and details than neutral stimuli (Kensinger & Corkin, 2003; Kensinger & Schacter, 2016; Sharot, Delgado, & Phelps, 2004). Moreover, there is increasing evidence that negative and positive emotion may differentially affect memory retrieval processes. For example, Ochsner (2000) found that recollection contributes more to the retrieval of negative items, whereas the contribution of familiarity does not differ between negative and positive emotions during test. Event-related potential

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(ERP) studies have consistently shown enhanced recollection-related electrophysiological activity for negative items than for positive items (Inaba, Kamishima, & Ohira, 2007; Inaba, Nomura, & Ohira, 2005; Johansson, Mecklinger, & Treese, 2004; Schaefer, Pottage, & Rickart, 2011; Weymar, Loew, & Hamm, 2011). These findings suggest that memory vividness is boosted for negative stimuli compared to positive stimuli in true memory.

With respect to the effects of emotional content on false memory, there are two competing hypotheses which make opposing predictions. The conceptual relatedness account proposes that emotional content, particularly negative emotion, can elevate false memory (Bookbinder & Brainerd, 2016). This account evolved from fuzzy-trace theory (FTT), which suggests that gist and verbatim traces of items are stored in parallel during encoding. Gist traces represent the semantic content shared among study items, while verbatim traces represent the surface details of these items. During retrieval, gist traces foment familiarity-based false memory by increasing the similarity between lures and study items, whereas verbatim traces suppress false memory by recollecting item-specific information of study items (i.e., recollection rejection, Brainerd & Reyna, 1998, 2002; Brainerd & Reyna, 2005; Brainerd, Reyna, Wright, & Mojardin, 2003). Regarding the effects of emotion on false memory, the conceptual relatedness account supposes that emotional content enhances conceptual relatedness among study items, relative to neutral content, and conceptual cohesion are stronger for emotionally negative content than for positive content. Negative emotional content can be much more easily integrated and organized in memory due to the more conceptually overlapping features (Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Talmi & Moscovitch, 2004; Talmi, 2013). Therefore, negative emotional content is associated with enhanced gist traces relative to positive content. In addition, it is argued that negative emotional content has weaker verbatim traces, but positive emotional content has stronger verbatim traces (Bookbinder & Brainerd, 2016). Consequently, it is postulated that negative emotion will increase false memory by strengthening gist traces while weakening verbatim traces. Furthermore, it is postulated that false memory for positive emotional content depends on a tradeoff between gist and verbatim traces.

Consistent with this account, two representative studies, namely Bookbinder and Brainerd (2017) using the categorized pictures paradigm, and Brainerd et al. (2008) using the DRM paradigm, provided converging evidence that negatively valenced stimuli elevates false memory, relative to neutral and positive stimuli (see Bookbinder and Brainerd (2016) for a comprehensive review). Importantly, these two studies consistently showed that negative items increased engagement of familiarity process during false recognition using the conjoint recognition model (Brainerd, Reyna, & Mojardin, 1999; Brainerd et al., 2003). However, some different patterns of results also emerged. For example, Choi, Kensinger, and Rajaram (2013) found that emotion did not increase or even reduced false memory when thematic relatedness was equivalent between emotional and neutral items. In addition, Dehon, Laroi, and Van der Linden (2010) found more “Remember” responses for false recognition of negative lures (e.g., *sorrow, grief, tears, despair, mourning...*; lure = *sadness*) compared with neutral and positive lures (e.g., *journey, relaxation, beach, sun, serenity...*; lure = *holidays*) when using the Remember/Know procedure (Tulving, 1985). That is, negative false memories were associated with higher rates of recollections relative to neutral and positive false memories.

The distinctiveness heuristic account offers an alternative perspective. This proposes that negative emotional content is less prone to memory distortions (Schacter, Gallo & Kensinger, 2007; Schacter & Wiseman 2006). Specifically, it is suggested that the false recognition of lures rely on the distinctiveness of study items and retrieval expectations associated with them (Dodson & Schacter, 2002; Schacter, Israel, & Racine, 1999). The distinctiveness heuristic can suppress false recognition of lures during retrieval based on metacognitive expectations (e.g., “I did not take the airplane home last Spring Festival, because

airplanes are distinctive and I would remember that”) (Gallo, 2010). Here, distinctiveness refers to the uniqueness of an item (Kensinger & Corkin, 2004). Negative stimuli may be more distinctive because of their high relevance to survival (Dolan, 2002; LeDoux, 2002). Additionally, research has consistently shown that negative items are associated with increased recollective details compared with neutral and positive items (e.g., Johansson et al., 2004; Ochsner, 2000). Therefore, participants are likely to form more detailed recollective expectations for negative stimuli. Subsequently, they may be more conservative in responding “old” to emotionally negative stimuli and avoid falsely recognizing the lures that fail to elicit expected detailed recollections.

There is a great deal of prior research supporting the distinctiveness heuristic account by revealing a reduction in memory errors for negative lures compared to neutral and positive lures (Kensinger & Corkin, 2004; Kensinger, O'Brien, Swanberg, Garoff-Eaton, & Schacter, 2007; Kensinger & Schacter, 2005a, 2005b; Kensinger & Schacter, 2006; Pesta, Murphy, & Sanders, 2001). Nevertheless, it should be noted that more direct evidence for a reduction of false recognition rates for emotionally negative items comes from studies that examined reality monitoring ability (i.e., the ability to distinguish between previously imagined and perceived events; Kensinger et al., 2007; Kensinger & Schacter, 2005a, 2005b, 2006), making it difficult to make parallel comparisons with studies using the DRM or categorized lists to experimentally induce false memories. Moreover, most of the previous studies did not estimate the relative contribution of familiarity and recollection to false recognition memory (Kensinger & Corkin, 2004; Kensinger et al., 2007; Kensinger & Schacter, 2005a, 2005b, 2006).

In summary, theoretical explanations regarding how emotional content affects the production of false memory remain controversial. To this end, the present study was designed to further explore how emotion modulates behavioral performance and the cognitive processes associated with false recognition memory using the categorized pictures paradigm. Specifically, participants were presented with positive, neutral, or negative pictures from various categories during encoding. Participants then performed an old/new recognition test, during which studied items were intermixed with lures from studied categories and new items drawn from non-studied categories. Electroencephalogram (EEG) data were recorded during the test phase to measure the relative contribution of familiarity and recollection to false recognition. It is well known that ERP techniques provide an objective and reliable measure of the retrieval processes involved in episodic memory. Previous ERP studies have identified two distinct ERP old/new effects that are associated with familiarity and recollection. The early frontal old/new effect from 300 to 500 ms is thought to reflect familiarity-based recognition (Curran, 2000; Rugg & Curran, 2007; but see Paller, Voss, and Boehm (2007) and Voss and Federmeier (2011) for an alternative interpretation), while the parietal old/new effect from 500 to 800 ms is believed to reflect recollection-based recognition (Rugg & Curran, 2007). In addition, there are two old/new effects reported to be associated with post-retrieval processes that occur later than the parietal old/new effect. The late frontal old/new effect has been related to post-retrieval monitoring and evaluation processes (Cruse & Wilding, 2009; Hayama, Johnson, & Rugg, 2008). The late posterior negativity, characterized by more negative-going deflections for correctly classified old items than correctly rejected new items, is regarded as reflecting reconstructive mnemonic processes when memory attributes cannot easily be recovered (Mecklinger, Rosburg, & Johansson, 2016).

According to the conceptual relatedness account, gist traces are strengthened for negative content due to the enhanced conceptual relatedness among study items, relative to neutral and positive content. Accordingly, negative valence is then associated with increased false recognition of lures, and false recognition of negative lures will evoke a greater familiarity related early frontal old/new effect, relative to neutral and positive lures. Conversely, according to the distinctiveness heuristic account, participants will be more likely to adopt a distinctiveness heuristic for negative pictures due to their increased

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