

How (and Why) Emotion Enhances the Subjective Sense of Recollection

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ABSTRACT—*A growing body of evidence suggests emotion boosts memory accuracy to an extent but affects the subjective sense of recollection even more. The result is vivid memories for emotional events that are held with confidence but that may be surprisingly inaccurate in their details. We examine the neural circuitry underlying emotion's impact on memory and the subjective sense of recollection to provide insight into this puzzling phenomenon. This research suggests that for emotional stimuli the quality and strength of memory for a few details may mediate judgments of recollection, whereas for neutral stimuli the quantity of contextual details may be more important. Finally, we speculate that the enhanced subjective sense of recollection with emotion, in the absence of absolute veridicality, may have evolved to enable fast and unambiguous decision making in emotional situations.*

KEYWORDS—*memory; emotion; amygdala; recollection; hippocampus*

The impact of emotion on memory led William James in 1890 to suggest it is as if highly emotional events leave “a scar upon the cerebral tissues” (James, 1890, p. 670). Almost a century later, the vivid and detailed nature of memories for emotional events resulted in Brown and Kulik (1977) describing them as so seemingly realistic as to resemble a photograph taken with a flashbulb, resulting in the popular term “flashbulb memories.” These historical characterizations of emotion's impact on memory capture the subjective experience of remembering a highly emotional event. When recalling an event from our past we do not simply bring to mind the incident in question. Rather, we mentally re-experience the event. A growing body of evi-

dence suggests that a primary way by which emotion modulates memory is by intensifying the *recollective experience*—that is, the subjective vividness of the memory, the sense of reliving the event, and confidence in the accuracy of the memory (Talarico & Rubin, 2003).

EMOTION ENHANCES THE RECOLLECTIVE EXPERIENCE MORE THAN IT DOES MEMORY ACCURACY

It is often assumed by laypeople, as well as by the legal community, that a vivid, detailed, and confidently held memory is likely to be highly accurate (Deffenbacher, 1980). For neutral stimuli this appears to be the case. It has been shown that a rich and vivid recollective experience is coupled with improved accuracy for contextual details related to the stimulus presentation. This has led to the suggestion that the recollection component of recognition underlies both the subjective recollective experience and memory for context (Yonelinas, 2002). However, one of the more surprising findings to emerge from research on flashbulb memories over the last quarter century is that they are distinguished primarily by the *belief* that these memories are accurate. In spite of the fact that most people report high levels of confidence in their memories for these highly emotional events, the details of these memories are often incorrect. For example, a study examining students' recollection of the events of September 11, 2001 found that the accuracy for details of these memories did not differ from the accuracy for details in memories of everyday events, in both cases declining over time. Yet, ratings of vividness, recollection, and belief in the accuracy of memory declined only for memories of mundane events (Talarico & Rubin, 2003).

This dissociation between memory for contextual details and the subjective sense of recollection for emotional events is further supported by studies examining memory for stimuli learned in the laboratory. It has been consistently shown that emotion boosts the recollective experience (Sharot & Yonelinas, 2008).

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However, studies examining the modulation of memory for contextual information by emotion have reported inconsistent results, often failing to show improved memory with emotion (see Mather, 2007 for a review). For example, recent studies found that emotion did not improve memory for a task performed during encoding or increase memory for color–location associations. Sharot & Yonelinas (2008) directly contrasted the influence of emotion on the recollective experience and memory for contextual information. They found that emotional photos were remembered with a greater sense of recollection than neutral photos were, yet contextual memory for the task performed during encoding did not differ. These findings suggest that for emotional stimuli a strong subjective sense of recollection may not be a reliable indicator of the accurate recollection of contextual details, in spite of the common intuition that a vivid and detailed memory is more likely to be correct.

The finding that emotion does not consistently enhance memory for contextual details appears to be at odds with a large literature, in both humans and other species, suggesting emotion enhances memory accuracy. This contradiction is likely driven by how “accuracy” is defined across these studies. Studies that report enhanced accuracy with emotion often examine memory for the occurrence of the event itself. In contrast, when memory is examined for contextual details, particularly those details not perceptually bound to the event, emotion will often have no effect or even impair memory (Mather, 2007). For instance, studies of flashbulb memories examine accuracy for contextual features or details of learning about the event (e.g., where were you? Who were you with?), rather than memory for the event itself. Overall, it appears that emotion can enhance memory accuracy, particularly for the fact that an event occurred, but emotion’s impact on the sense of the vivid recollection of details exceeds its influence on memory for those details per se. In other words, emotion boosts memory accuracy to an extent, but it affects the subjective sense of recollection even more (see Fig. 1).

This behavioral dissociation is inconsistent with the intuitions people often have when reflecting on their memory and presents two intriguing questions. First, how might the mechanisms of emotion and memory interact to result in enhanced subjective sense of recollection above and beyond any effect on memory accuracy? Second, what is the adaptive value of an intense recollective experience without absolute veridicality? To address the first question, it is useful to begin with a review of how emotion enhances memory accuracy for the emotion-eliciting item or event, since most cognitive neuroscience research to date has focused on this topic.

THE NEURAL SYSTEMS MEDIATING EMOTION’S IMPACT ON MEMORY

Studies examining emotion’s influence on memory point to an interaction between the amygdala, an almond-shaped brain structure that is important for processing emotional information,

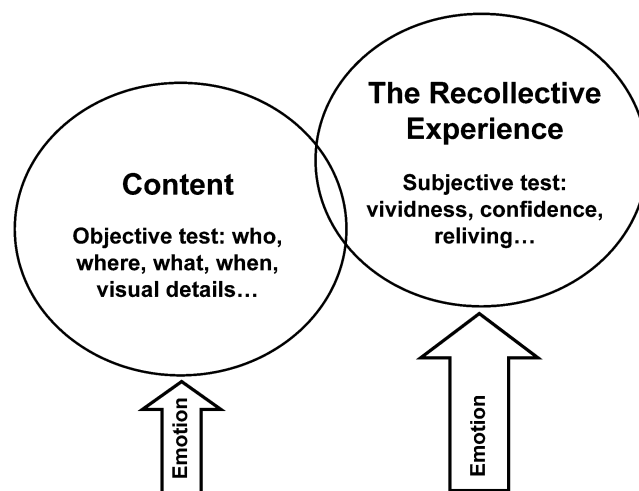


Fig. 1. Emotion’s impact on memory accuracy (content) and the subjective sense of recollection (recollective experience). Emotion’s enhancement of the recollective experience, the subjective judgment of a memory’s vividness and the rememberer’s sense of confidence in it, is more robust and consistent than is its enhancement of accuracy for objective details.

and the adjacent hippocampus, which is involved in episodic-memory formation, retention, and retrieval. Specifically, it has been demonstrated that the amygdala modulates the consolidation or storage of memories for arousing events, so that they are more likely to be retained over time. There is strong evidence in both humans and nonhumans that the physiological changes that occur with arousal enhance the retention of events via the interaction of the amygdala and hippocampus. For instance, studies have shown that amygdala activation at encoding predicts later memory for highly emotional, but not neutral, scenes, and that damage to the amygdala impairs delayed, but not immediate, memory for arousing words. These studies and others highlight the neural mechanisms by which emotion increases memory accuracy over time, at least for the occurrence of events (see Phelps, 2006 for a review).

Aside from arousal’s impact on the consolidation or retention of memory, emotion can also influence the encoding of an event through its impact on attention and perception. Emotion enhances the identification of emotion-eliciting items in situations where attentional resources are limited. It is proposed that, through reciprocal connections between the amygdala and visual cortices, emotional items lead to enhanced processing in the sensory cortices, allowing the facilitation of perception and attention. The impact of an emotion-eliciting item on the facilitation of attention does not appear to be limited to the item itself but may extend to other items presented in the same spatial location within a short time frame (Phelps, 2006). The enhanced spatial cuing of attention by emotion is suggested additionally to involve the inferior parietal sulcus (IPS), which is known to be important for the allocation of spatial attention. By combining event-related potential (ERP) and functional magnetic resonance imaging (fMRI) techniques, Pourtois and Vuilleumier

(2006) showed increased activation in the IPS and extrastriate cortex early in stimulus processing when a face with a fear expression was presented in the contralateral visual field. This fear-face cue facilitated the response to a subsequent neutral target stimulus in the same location. However, when the target was presented in a location on the opposite side of the visual field as the fear-face cue, processing of the target was impaired. Interestingly, activation of the IPS ipsilateral to the fear-face cue was diminished relative to a neutral cue or to no-cue conditions. These results outline a neural mechanism by which the presentation of an emotional stimulus not only facilitates the processing of emotion-eliciting items or neutral items presented in close spatial and temporal proximity but also impairs the allocation of attention to items presented in other regions of visual space.

The impact of emotion on attention has been suggested to be an important factor in memory for emotional events since the 1950s, when Easterbrook proposed the narrowing-of-attention hypothesis. It is suggested that the narrowing of attention around the emotional aspects of an event results in both enhanced memory for these central details and impaired memory for other details. This basic finding has been supported by a number of psychological studies, such as investigations of eyewitness testimony and weapon focus, and more broadly by studies comparing memory for the gist of an emotional scene with memory for peripheral details (see Reisberg & Heuer, 2004 for a review). Recently, it has been shown that damage to the amygdala only impairs memory for the gist of the emotional scene, whereas memory for peripheral details is unimpaired or even enhanced (Adolphs, Tranel, & Buchanan, 2005). By combining psychological paradigms and a range of neuroscience techniques, including use of animal models, we are beginning to delineate the complex ways components of emotion, such as arousal, can influence different stages of mnemonic processing, such as encoding and subsequent consolidation or retention.

THE COGNITIVE NEUROSCIENCE OF THE SUBJECTIVE SENSE OF RECOLLECTION

Investigations of the neural mechanisms underlying the subjective sense of recollection by definition examine retrieval, which reflects the outcome of encoding and consolidation, as well as additional processes. For neutral scenes, it has been shown that a strong subjective sense of recollection is accompanied by enhanced activation of the posterior parahippocampus. This same region has also been shown to be important for recognition of perceptual scene details (Kohler, Crane, & Milner, 2002). These fMRI results are consistent with the psychological findings mentioned earlier suggesting that a heightened subjective sense of recollection is coupled with more accurate memory for contextual details. Both a strong sense of recollection for complex scenes and memory for scene details seem to involve the posterior parahippocampus (see Yonelinas, 2002 for a review).

Interestingly, this same region does not show a similar pattern for emotional scenes retrieved with a strong subjective sense of recollection. In laboratory studies, participants were asked to indicate whether their recognition of photos was accompanied by recollection of details about the study episode (“remember”) or not (“know”). Increased amygdala activation was observed during encoding (Dolcos, LaBar, & Cabeza, 2004) and recognition (Sharot, Delgado, & Phelps, 2004) of emotional stimuli judged as remembered relative to stimuli judged as known, while enhanced activity in the parahippocampal cortex during encoding (Dolcos et al., 2004) and recognition (Sharot et al., 2004) was selectively related to neutral stimuli judged as remembered relative to stimuli judged as known (see Fig. 2). The same network of regions was shown to be involved during the retrieval of emotional memories acquired outside the laboratory. An fMRI study of memories of the terrorist attacks on 9/11 found the intensity of the recollective experience was related to increased activity in the amygdala and decreased activity in the parahippocampal cortex in participants who were in New York City at the time of the attacks (Sharot, Martorella, Delgado, & Phelps, 2006). This pattern of brain activity correlated with how close participants had been to the World Trade Center, suggesting that the effect may be mediated by the level of emotional arousal experienced on that day.

The studies examining the subjective sense of recollection for emotional and neutral scenes indicate there is a double dissociation between medial temporal lobe regions whose activity correlates with the subjective sense of recollection. Scenes judged to be retrieved along with the recollection of details are linked to greater activation of the posterior parahippocampus if they are neutral and to greater activation of the amygdala if they are emotional. These findings provide insight into the processes underlying the heightened sense of recollection for emotional stimuli that could not have been derived from psychological data alone. Participants in these studies are making the *exact same* mnemonic judgment about the emotional and neutral scenes, but different brain regions, and therefore different psychological processes, are mediating this judgment.

THE NEURAL MECHANISMS MEDIATING THE SUBJECTIVE SENSE OF RECOLLECTION PROVIDE INSIGHT INTO EMOTION’S ROLE

The question remains, however: What can the brain data tell us about the processes underlying the heightened subjective sense of recollection with emotion? In order to answer this question, we can take advantage of our knowledge of the mnemonic roles of the posterior parahippocampus and amygdala. As mentioned earlier, the posterior parahippocampus has been linked to the encoding and retrieval of complex scenes, particularly scene details (Kohler et al., 2002). Accurate memory for these details is the type of information that is often presumed to underlie a strong subjective sense of recollection. A vivid recollection is a

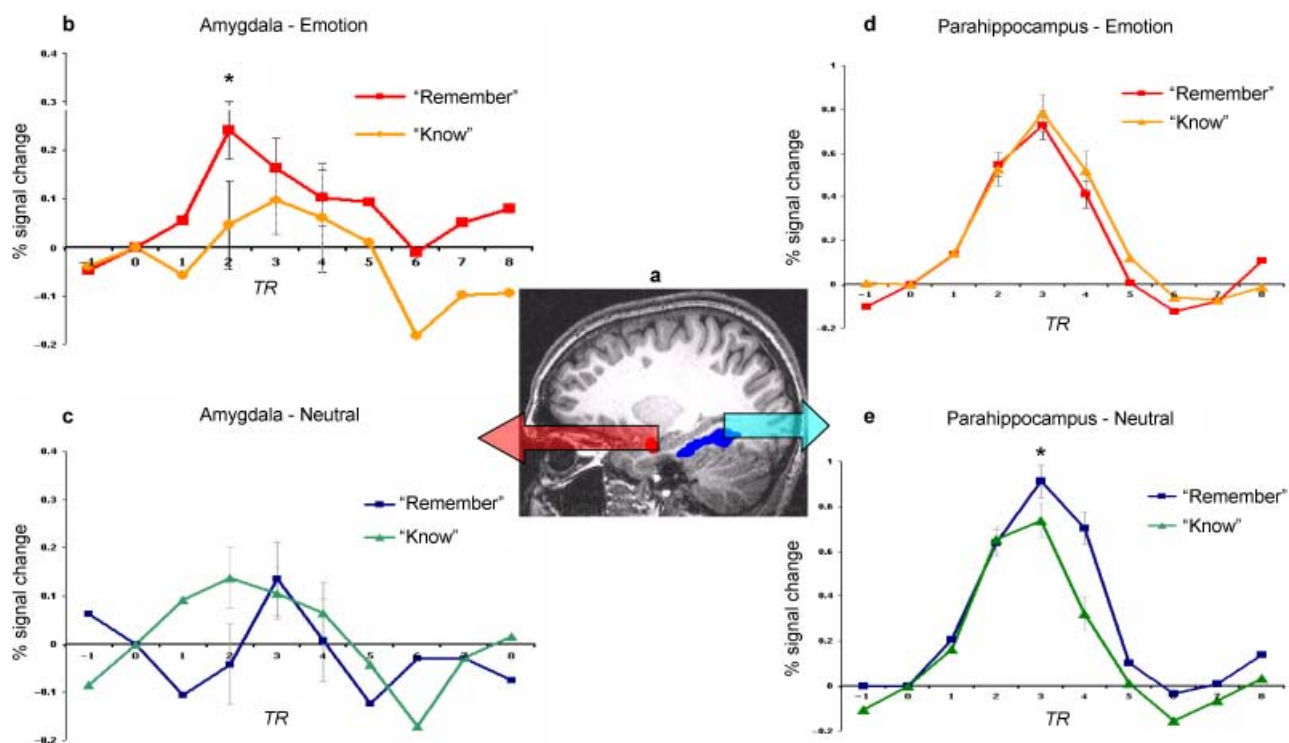


Fig. 2. Amygdala and parahippocampal cortex activity related to recollective experience of emotional and neutral photos. The central image (a) shows the location of the amygdala (highlighted in red) and the parahippocampal cortex (highlighted in blue). Time courses of activation for remembered and known photos in the right amygdala show (b) greater activation for emotional remembered photos relative to emotional known photos but no differentiation for (c) neutral photos. In the right parahippocampal cortex there is (d) no differentiation for emotional photos but (e) greater activation for neutral remembered photos relative to neutral known photos. Adapted from Sharot, Delgado, and Phelps (2004).

detailed one. Given this, it is not surprising that the same neural region has been linked to memory for scene detail and a strong subjective sense of recollection for neutral scenes. For these stimuli, the intuition that a vivid recollection is more likely to be accurate in mnemonic detail is supported by both psychological and neuroscience data.

What is more surprising is that the posterior parahippocampus does not seem to support the subjective sense of recollection for emotional scenes—rather, the amygdala does. As mentioned above, the amygdala plays two important roles in memory. First, studies examining the modulation of attention by emotion suggest that the amygdala, along with a perceptual/attentional network, results in enhanced encoding of emotion-eliciting items and spatially linked details and a cost in encoding spatially peripheral details (Pourtois & Vuilleumier, 2006). Given that the posterior parahippocampus plays an important role in the encoding and retrieval of complex scene details, it is possible that the narrowing of attention with emotion results in fewer of these contextual details being encoded and less involvement of this region during the recollection of emotional scenes.

The amygdala's other role in memory is to enhance the consolidation, or retention, of arousing events. For those details that are successfully encoded, the amygdala strengthens their representation. Given the amygdala's role in attention, these are

more likely to be central or gist details. A number of studies have shown that the magnitude of amygdala activation predicts later memory for arousing stimuli. However, the strength of this activation may specifically reflect memory for a few central details, or an item. In a study that directly compared memory for an emotion-eliciting item to memory for a contextual detail, amygdala activation only predicted memory for the item (Kensinger & Schacter, 2006).

Overall, the amygdala enhances memory strength for emotional items or for the gist of complex emotional scenes, but not for contextual details. The strength of this amygdala signal is linked to a strong subjective sense of recollection for emotional, but not neutral, scenes—as well as vivid memories for 9/11. This implies that the overall strength of memory for a single item or for central details of an emotional event may underlie the enhanced subjective sense of recollection with emotion. This is in contrast to neutral stimuli, for which the encoding and retrieval of a number of contextual details seems to underlie the subjective sense of recollection. Given emotion's role in narrowing attention and enhancing consolidation, it is likely that the mnemonic signal for the central details of emotional stimuli is stronger than it is for neutral stimuli. It is possible that the stronger memories for a few details may be driving the enhanced subjective sense of recollection with emotion. Even though people are making the

same mnemonic judgment, they may use different mnemonic signals to arrive at this judgment. For emotional stimuli the quality of memory for a few details may matter, whereas for neutral stimuli the quantity of contextual details may be more important.

In addition to emotion's role in enhancing memory strength for central details, there is some evidence that emotion may also shift the response bias, so that emotional events are more likely to be judged as having occurred even if they did not (Dougal & Rotello, in press). Although the effect is subtle, a greater false-alarm rate for emotional events has been reported with some consistency (Dougal & Rotello, in press; Sharot et al., 2004). Combined with emotion's impact on memory encoding and consolidation, its effect on memory retrieval suggests a number of factors may conspire to boost the subjective sense of recollection for emotional events.

WHY AN ENHANCED SUBJECTIVE SENSE OF RECOLLECTION WITHOUT VERIDICAL MEMORY FOR CONTEXTUAL DETAILS?

An examination of the neural mechanisms of emotion's influence on memory accuracy and the subjective sense of recollection can provide some insight into how emotion enhances the recollective experience, but not why it does so. It seems somewhat counter-intuitive that a strong memory for a few central details of an emotional event would result in a rich and vivid recollective experience that is judged, with confidence, to be accurate in its details. The most striking finding in recent studies of flashbulb memories is the stark contrast between the lack of accuracy for details and the strong confidence in that accuracy. People often assume that memory for a highly emotional event is more accurate in its details because of the rich recollective experience, but the data suggest otherwise. Why would a highly emotional event *feel* as if it "left a scar upon the cerebral tissues?"

Speculation as to why a psychological process exists requires a consideration of the potential adaptive value of the behavior. The function of memory is to be able to use past experiences to guide future thoughts and actions. Emotion serves to highlight what is important and potentially crucial for survival. Because emotion signals the stimuli in the environment that could be relevant for survival, emotion's impact on memory is proposed to allow us to remember stimuli and events that may be more important in the future.

But what is the role of the subjective sense of remembering? The quality of our memory, and the confidence with which it is held, can help guide our actions. If we are unsure about a memory, we may take additional time to search our memory or look for additional cues before acting. However, if we are highly confident in our memory, our subsequent actions are more likely to be quick and decisive. We propose that the enhanced subjective sense of recollection with emotion is to enable faster and less ambiguous decision making. If a stimulus previously led to a

strong emotional response, such as fear, encountering that stimulus in the future would indicate a situation that might require fast action. The fast action to avoid that stimulus may be more important than memory for the contextual details. For instance, it doesn't matter if it is the same dangerous animal in the same part of the forest, but rather that it is a similar, potentially dangerous animal. We suggest that contextual details may, in general, be more important in guiding future actions in situations that are neutral, whereas a vivid memory for a few critical details may be more important in guiding future actions in emotional situations. Although the enhanced subjective sense of recollection with emotion might, at times, mislead us to think our memories are more accurate than they actually are, for highly emotional situations it may be more adaptive to act quickly based on a few important details than to ruminate on the overall quality of our memory.

Recommended Reading

- Mather, M. (2007). (See References). Reviews the impact of emotion on memory for details.
- Phelps, E.A. (2006). (See References). Reviews emotion's impact on cognition, as it is linked to the human amygdala.
- Reisberg, D., & Heuer, F. (2004). (See References). Reviews emotion's impact on different aspects of the event.
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