

Negative Emotion Enhances Memory Accuracy

Behavioral and Neuroimaging Evidence

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ABSTRACT—*There have been extensive discussions about whether emotional memories contain more accurate detail than nonemotional memories do, or whether individuals simply believe that they have remembered emotional experiences more accurately. I review evidence that negative emotion enhances not only the subjective vividness of a memory but also the likelihood of remembering some (but not all) event details. I then describe neuroimaging evidence suggesting that engagement of emotion-processing regions (particularly the amygdala and orbitofrontal cortex) relates to the encoding and retrieval of details intrinsically linked to negative items.*

KEYWORDS—*affect; amygdala; fMRI; memory distortion*

People experience many events that elicit emotional reactions: They greet loved ones at the airport, visit sick children at the hospital, and attend friends' weddings. Such events often are remembered vividly, and for a while researchers believed that these emotional memories might be immune to disruption (Brown & Kulik, 1977). Over the past 30 years, research has demonstrated convincingly that emotional memories are not impervious to forgetting or distortion. However, whether emotion enhances the detail with which information is remembered or whether emotion simply biases a person to believe that they have retained a vivid memory continues to be debated. This issue is of central importance for characterizing emotion's mnemonic influences.

Suggestive evidence for people's inflated confidence in emotional memories has come from studies asking participants to distinguish old (studied) from new (nonstudied) items and also to indicate whether they vividly remember something specific

about the old items or simply know those items had been presented previously (Yonelinas, 2002). Emotional and nonemotional items sometimes are judged as old with equal accuracy, but emotional items are more likely to be judged to be remembered and not just known (Ochsner, 2000). This pattern could signify participants' inflated confidence for emotional memories: Participants believe they remember the emotional items' details, but there is nothing about their recognition-memory accuracy to suggest that they actually do remember the emotional information with more detail. However, such a pattern could also arise if emotion influenced the amount of detail remembered about each item but not the number of items remembered: Although participants are equally likely to remember emotional and nonemotional items, perhaps they remember emotional items with additional detail.

To differentiate these alternative explanations, my colleagues and I (Kensinger, Garoff-Eaton, & Schacter, 2006) compared the effects of emotion on memory for general item features with emotion's effects on memory for specific item details. After viewing negative and neutral objects (Fig. 1A), participants indicated whether items were identical to ones they had studied (*same*), shared the same verbal label but not the same visual details as a studied object (*similar*), or were unrelated to any studied object (*new*; Fig. 1B). This design could separate a person's memory for a general type of item (calling a *same* item "same" or "similar" rather than "new") from their memory for the exact visual details of an item (calling a *same* item "same").

Participants were more likely to remember the visual details of negative items compared with those of neutral items (Fig. 1C; red portion of bars). Importantly, this mnemonic enhancement for visual detail occurred even when there was no effect of emotion on the ability to recognize that a particular item type had been studied (Fig. 1C; total height of bars). In other words, emotion affected the likelihood that details were remembered about a studied item but did not affect the overall proportion of items remembered. These findings converge with other evidence to suggest that, although emotional experiences are not remem-

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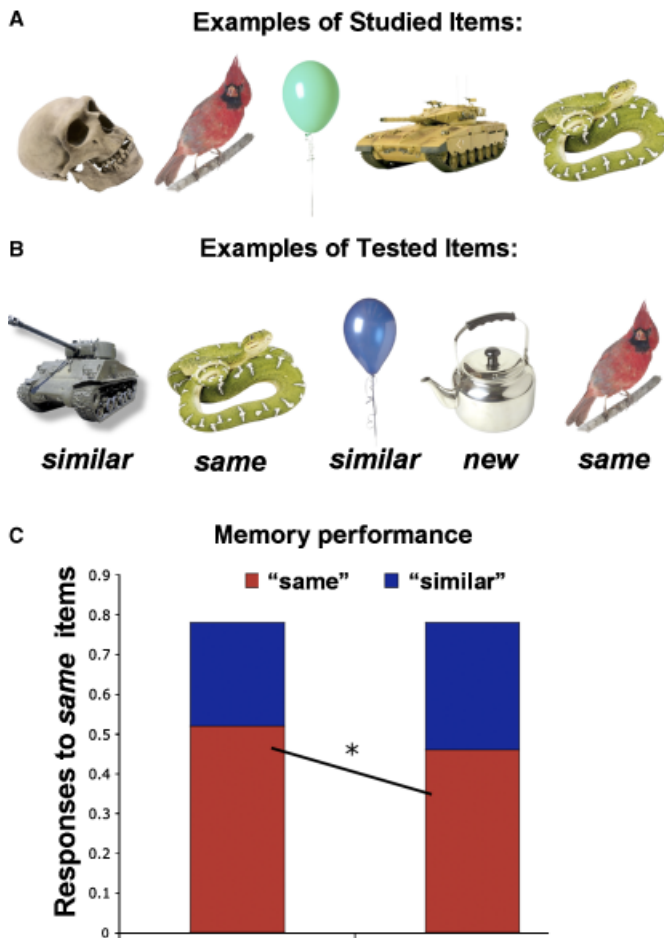


Fig. 1. Memory performance for negative versus emotionally neutral items. Participants viewed a series of objects (A) and determined whether each would fit into a drawer. A couple of days later, participants were asked to distinguish objects that were the *same* as studied objects (identical) from objects that were *similar* to studied objects (sharing the verbal label but not the exact visual details) or that were *new* objects (nonstudied; B). The graph (C) shows the proportion of time that participants gave a “same” response to a *same* item (red portion of bars) or a “similar” response to a *same* item (blue portion of bars). Participants were equally likely to remember whether a particular type of negative or neutral object had been studied (e.g., to know whether a snake or a kettle had been studied; note that the overall height of the bars is equal for the negative and neutral items). However, participants were better at remembering the exact visual details of negative objects than of neutral objects (notice that the red portion of bars is higher for the negative items than for the neutral items). Thus, even when participants had a similar ability to recognize a general type of negative or neutral item, their ability to remember the exact visual details of the recognized objects was enhanced for the negative items. Data from Kensinger, Garoff-Eaton, and Schacter (2006).

bered with picture-perfect accuracy (Neisser & Harsch, 1992), emotion can enhance memory for many details, including the color of the font in which a word was presented, the spatial location of a word on a computer screen, or whether information was visually presented or mentally imagined (reviewed by Mather, 2007).

NEGATIVE EMOTION ENHANCES MEMORY ACCURACY MORE THAN POSITIVE EMOTION DOES

The results just described point to a role for negative emotion in boosting not only the subjective vividness of a memory but also the likelihood that event details are remembered. Although it would be simple to conclude from these studies that any emotional experience is likely to be remembered with additional detail, the story may not be so straightforward. The valence of an event (i.e., whether it is pleasurable or aversive) seems to be a critical determinant of the accuracy with which the event is remembered, with negative events being remembered in greater detail than positive ones.

In tasks requiring people to indicate whether they vividly remember an event or simply know that it occurred, negative events tend to be “remembered” more often than positive ones (Ochsner, 2000). Negative items also are more likely to be remembered with specific details than positive items are: Although individuals are good at distinguishing *same* from *similar* negative items (Fig. 1C), they perform equally poorly when distinguishing *same* from *similar* positive or neutral items (Kensinger, Garoff-Eaton, & Schacter, in press). When examining what people remember about public events, negative emotion also appears to confer mnemonic benefits. Levine and Bluck (2004) asked participants who were either pleased or displeased with the verdict in the O.J. Simpson trial to indicate whether particular events had occurred during the trial. We (Kensinger & Schacter, 2006b) asked Red Sox and Yankees fans to report what they remembered about the final game of the 2004 playoff series, in which the Red Sox defeated the Yankees. In both of these studies, the valence of a person’s response to the event outcome did not affect the quantity of remembered information, but it influenced the likelihood of memory distortions. Individuals who were pleased about the O.J. Simpson verdict were more likely to falsely believe that something had occurred during the trial than were individuals displeased about the verdict, and the pleased individuals were confident in their inaccurate endorsements. Similarly, Red Sox fans, who found the outcome positive, showed more memory inconsistencies, and more overconfidence, than Yankees fans did (Fig. 2). These findings suggest that negative emotion can lead to fewer reconstructive-memory errors than positive emotion, consistent with evidence that individuals in a negative mood process information in an analytical and detailed fashion, whereas people in a positive mood rely on broader schematic or thematic information and ignore the details (Bless & Schwarz, 1999).

EFFECTS OF NEGATIVE EMOTION ON MEMORY ACCURACY: IT’S ALL IN THE DETAILS

Although a consideration of valence helps in understanding the effects of emotion on memory accuracy, another piece of the puzzle hinges on the realization that there are many types of

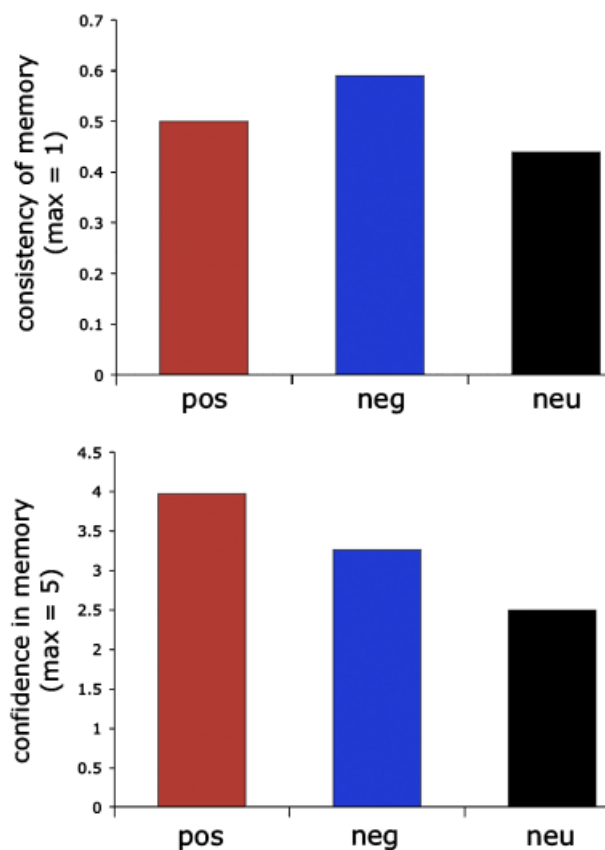


Fig. 2. Consistency of and confidence in memory for a Boston Red Sox victory over the New York Yankees. Fans were asked to report what they remembered immediately after the game, and then they were asked to report what they remembered 6 months later. Red Sox fans, who found the game outcome positive (red bars), were less consistent in their memories (top panel) and yet showed greater confidence in the accuracy of their memories (bottom panel) than the Yankees fans, who found the game outcome negative (blue bars). These findings suggest that positive memories may undergo more distortion, and may be more prone to overconfidence, than negative emotional memories. Neutral bars represent data from participants who watched the game but who were not fans of either team. Data from Kensinger & Schacter (2006b).

event details that can be remembered. If a person is remembering the time she was robbed on her walk home from work, she could remember external details tied to the emotional element of the event (e.g., the gun), external details not directly tied to the emotional element (e.g., the street she was walking along), or internal details tied to her own thoughts and feelings as the event unfolded (e.g., feeling faint, trying to recall techniques taught in a self-defense course). A number of studies examining negative emotion's influence on memory have revealed that individuals remember elements that are centrally tied to the emotional item but forget elements more peripheral to the emotional aspect of the event (e.g., Loftus, 1979). For example, we (Kensinger, Garoff-Eaton, & Schacter, 2007) asked participants to view a series of scenes, some consisting of a negative object against a neutral background (e.g., a snake by a river; Fig. 3A) and others consisting of a neutral object against a neutral background (e.g., a monkey in a forest). When later asked to indicate which objects

and backgrounds they had studied (Fig. 3B), participants were better at remembering the details of the negative objects than of the neutral ones (e.g., were more likely to remember what the snake had looked like than what the monkey had looked like), but they were worse at remembering the details of the backgrounds presented with a negative item compared to those presented with a neutral item (e.g., were less likely to remember what the river looked like than what the forest looked like; Fig. 3C). These results emphasize that the effects of emotion on memory for detail can be critically affected by the type of detail being assessed.

Distinguishing different types of details goes a long way toward explaining the effects of emotion on memory for contextual details (or source information). Although there is no consensus regarding the best way to characterize the types of information enhanced by emotion (c.f. Mather, 2007; Reisberg & Heuer, 2004), the contextual details that are reliably enhanced for negative events (e.g., the spatial location or visual details of information) may be those that are “intrinsic” attributes of the emotional element (i.e., those details that must be attended in order to process the affective relevance of the information). In contrast, negative emotion may not enhance, and sometimes may even impair, memory for other details that are more extrinsic to the item. This distinction between extrinsic and intrinsic detail may hold not only for external details but also for internal thoughts or feelings evoked by the events: There is suggestive evidence that individuals remember internal details closely linked to the emotional meaning of the event but do not remember more tangential thoughts and feelings. We (Kensinger & Schacter, 2006a) found that emotion had no effect on participants' abilities to remember whether they had been asked to decide whether an item was animate (something living) or whether it was common (something encountered in a typical month). Although remembering the decision requires memory for thoughts associated with the item, it is unlikely that these thoughts (e.g., deciding whether a gun is animate) are directly linked to the emotional meaning of the item. In contrast, feelings elicited by the stimulus or thoughts tied to the emotional meaning of the stimulus may be more likely to be retained for emotional items than for nonemotional ones. Thus, individuals may be good at remembering how emotional stimuli made them feel (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005) and may remember more thoughts and feelings evoked by emotional stimuli than by nonemotional ones (Schaefer & Philippot, 2005).

LIMBIC ENGAGEMENT CORRESPONDS WITH MEMORY FOR DETAIL

As I discussed, negative emotion confers a memory benefit for some, but not all, details. It has been debated whether the benefits of negative emotion on memory for detail stem from increased engagement of the same processes that benefit memory for nonemotional information or whether the benefits result

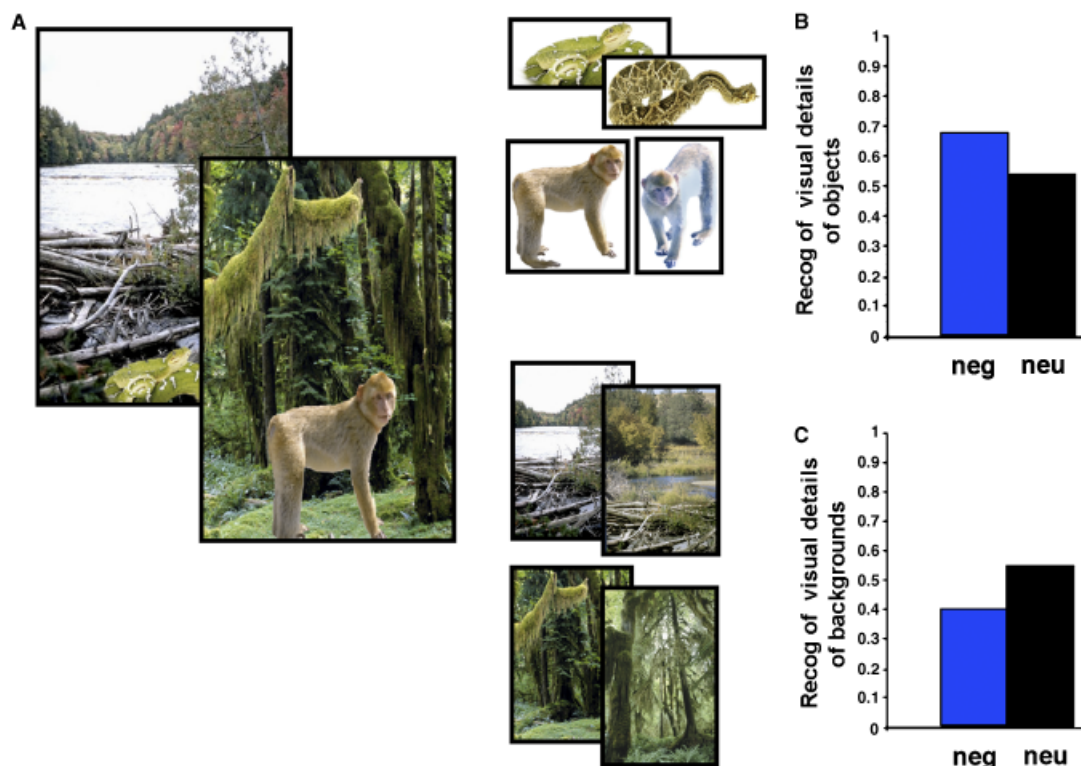


Fig. 3. Recognition of visual details of negative versus neutral objects and their backgrounds in scenes. After viewing scenes, some consisting of a negative object such as a snake against a neutral background (A, left) and others consisting of a neutral object such as a monkey against a neutral background (A, right), participants were asked to distinguish *same* from *similar* objects and backgrounds. Participants were better at distinguishing *same* from *similar* negative objects compared to neutral objects (panel B) whereas they were worse at distinguishing *same* from *similar* backgrounds if they had been presented with a negative object than if they had been presented with a neutral object (panel C). Thus, the effect of negative emotion on memory for detail was critically influenced by whether the visual detail was tied to the emotional object or was a detail more extrinsic to that object. Data from Kensinger, Garoff-Eaton, and Schacter (2007).

from engagement of processes specific to emotional memory (Brown & Kulik, 1977; Neisser & Harsch, 1992). Behavioral examinations of emotional memory do not provide easy traction on this question. Neuroimaging, in contrast, provides an effective way to address this issue. If emotion enhances memory for detail due to engagement of emotion-specific processes, then accurate memories for negative information and those for non-emotional information should be associated with distinct neural processes. In contrast, if emotion enhances memory for detail due to engagement of the same processes that lead to accurate memories of nonemotional information, then the same neural processes should be recruited for both types of memories.

To examine the extent to which emotion-specific versus domain-general processes influence the accuracy of emotional memories, we (Kensinger & Schacter, 2005) asked participants to undergo a functional magnetic resonance imaging scan as they viewed some objects and only imagined others. This design allowed an investigation of the processes that, when engaged upon initial encounter with an item, lead participants to accurately distinguish the items they have seen from the ones they have only imagined. The results revealed important distinctions in the neural processes that lead to accurate memories for the negative

items and those that lead to accurate memories for the neutral items. Activity in the amygdala and in the orbitofrontal cortex—regions often engaged during the processing of emotional information—corresponded with accurate memory for the negative items but not with accurate memory for the neutral ones (Fig. 4A).

These emotion-processing regions seemed to interact with memory regions typically recruited during the processing of nonemotional information. Activity in the hippocampus was related to accurate memory for the negative and neutral items, and there was a strong correlation between amygdala and hippocampal activity during the processing of the negative items. Thus, it appears that individuals do not use an entirely distinct set of neural processes to remember emotional information. Rather, the emotion-specific processes seem to influence the processes (hippocampal memory mechanisms) that typically are recruited for successful encoding of the details of nonemotional information.

Although these findings indicate that engagement of emotion-specific processes can correspond with memory accuracy, emotion-related activity does not ensure that all event details will be accurately remembered. For example, amygdala activity does not correspond with the ability to remember whether an

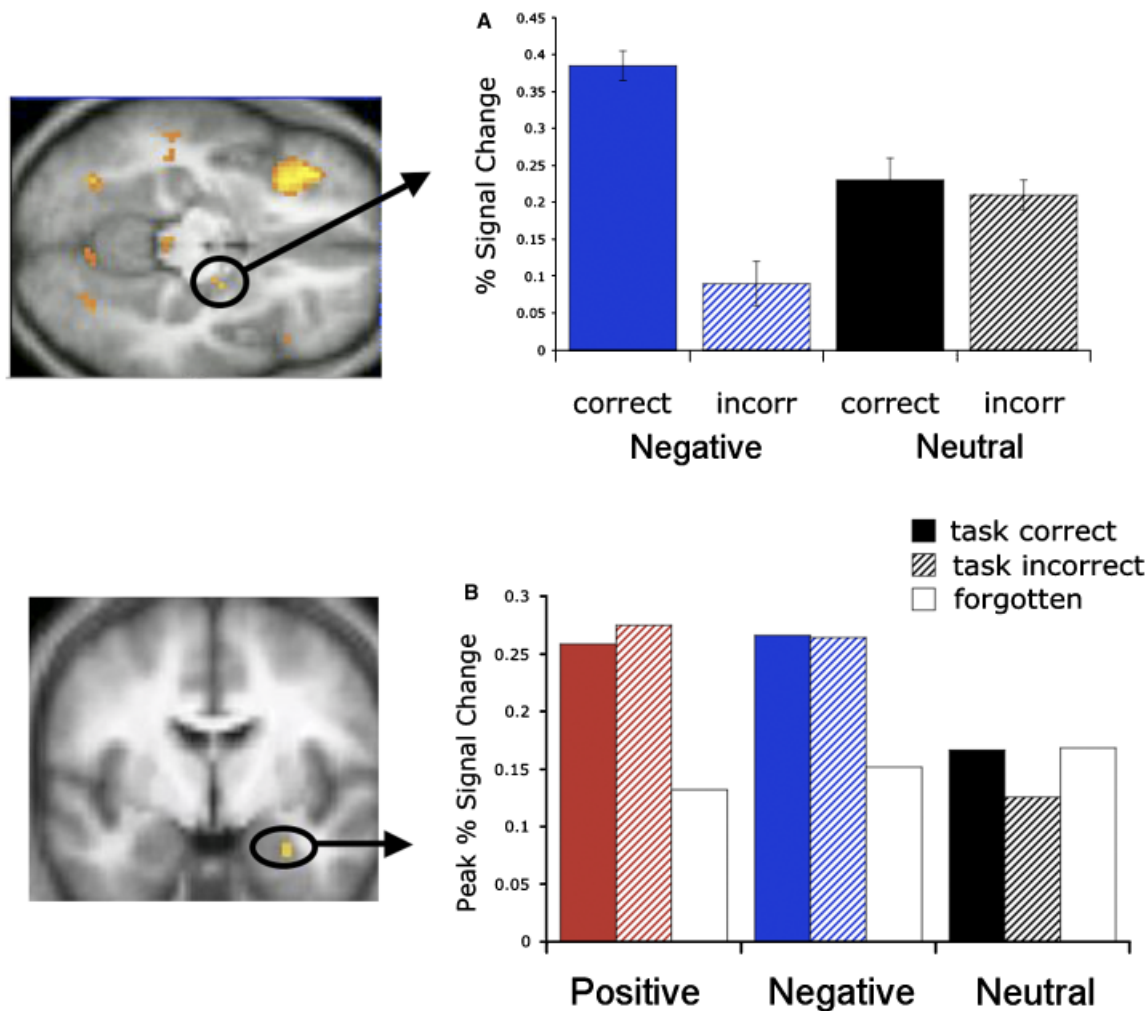


Fig. 4. Activity in the amygdala as related to participants' abilities to later know whether a negative object had been presented as a picture or had only been imagined (panel A) and to memory for the task performed with the item (panel B). Amygdala activity (recorded as % signal change) was higher during the processing of negative items for which a correct "picture" or "no picture" response would later be made (solid blue bar in top graph), whereas activity was lower during the processing of negative items for which an incorrect response would later be made (striped blue bar in top graph; data from Kensinger & Schacter, 2005). However, amygdala activity does not always correspond with memory for detail: In another study (Kensinger & Schacter, 2006a; panel B), amygdala activity was equally high regardless of whether the task performed with an item was remembered—note similar heights of the red (positive items) and blue (negative items) solid and striped bars. In neither study did amygdala activity relate to memory for the neutral items.

item was judged as "animate" or "common" (Fig. 4B). Although further research is needed to examine the circumstances in which amygdala activity relates to the encoding of event details, it has been proposed (Whalen, 1998) that the amygdala plays an important role in determining whether a stimulus in the environment is potentially threatening. It is plausible that the amygdala is most attuned to the details that are highly relevant to that decision (i.e., details intrinsic to the emotional item).

SUMMARY AND FUTURE DIRECTIONS

Although emotional memories are susceptible to distortion, negative emotion conveys focal benefits on memory for detail. These benefits make sense within an evolutionary framework.

Because a primary function of emotion is to guide action and to plan for similar future occurrences (Lazarus, 1991), it is logical that attention would be focused on potentially threatening information and that memory mechanisms would ensure that details predictive of an event's affective relevance would be encoded precisely. However, it also may be adaptive to re-experience only a subset of the details of a prior event when simulating a future one: In considering how one would respond during a future mugging, the location of the gun likely would be more relevant than the street on which one is standing.

Though the focal effects of negative emotion on memory for detail make evolutionary sense, further investigations are needed to examine the basis of this selectivity: Are only certain details processed? Are some details more likely to become solidified in memory? Do retrieval cues benefit some details more

than others? Additional research also is needed to clarify why, and under what circumstances, negative information is remembered with more detail than positive information. The details retained may differ depending upon the particular emotion elicited (e.g., disgust, fear, sadness) or depending on the intensity of the emotional response. Most studies of emotional memory have examined short-lived emotional reactions to stimuli (e.g., a picture of a gun) presented within a safe laboratory environment. It remains unclear whether such mnemonic influences are comparable to those that arise when individuals experience highly arousing events in real life (e.g., being robbed).

Clarifying how emotion augments or alters our recollections should have far-reaching consequences for understanding how memory operates. This line of research is likely to inform studies of autobiographical memory and eyewitness testimony by putting forth testable hypotheses not only about the types of events people should remember but also about the aspects of the events that should be most durably recorded. This research also may provide insight into the memory biases that occur in affective disorders—for example, helping explain why patients with posttraumatic stress disorder vividly replay particular aspects of highly emotional events but often fail to remember other experiences vividly. More broadly, because so much of what we remember are events infused with emotional relevance, clarifying the nature of emotion's modulation of memory should provide us with knowledge about how (and how accurately) we retain memories of those events that define our past.

Recommended Reading

- Labar, K.S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience*, 7, 54–64.
- Phelps, E.A. (2004). Human emotion and memory: Interactions of the amygdala and hippocampal complex. *Current Opinion in Neurobiology*, 14, 196–202.
- Reisberg, D., & Heuer, F. (2004). (See References)
- Whalen, P.J. (1998). (See References)
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REFERENCES

- Bless, H., & Schwarz, N. (1999). Sufficient and necessary conditions in dual process models: The case of mood and information processing. In S. Chaiken & Y. Trope (Eds.), *Dual process theories in social psychology* (pp. 423–440). New York: Guilford Press.
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5, 73–99.
- Kensinger, E.A., Garoff-Eaton, R.J., & Schacter, D.L. (2006). Memory for specific visual details can be enhanced by negative arousing content. *Journal of Memory and Language*, 54, 99–112.
- Kensinger, E.A., Garoff-Eaton, R.J., & Schacter, D.L. (2007). Effects of emotion on memory specificity: Memory trade-offs elicited by negative visually arousing stimuli. *Journal of Memory and Language*, 56, 575–591.
- Kensinger, E.A., Garoff-Eaton, R.J., & Schacter, D.L. (in press). Effects of emotion on memory specificity in young and older Adults. *Journal of Gerontology*.
- Kensinger, E.A., & Schacter, D.L. (2005). Emotional content and reality-monitoring ability: fMRI evidence for the influence of encoding processes. *Neuropsychologia*, 43, 1429–1443.
- Kensinger, E.A., & Schacter, D.L. (2006a). Amygdala activity is associated with the successful encoding of item, but not source, information for positive and negative stimuli. *Journal of Neuroscience*, 26, 2564–2570.
- Kensinger, E.A., & Schacter, D.L. (2006b). When the Red Sox shocked the Yankees: Comparing negative and positive memories. *Psychonomic Bulletin and Review*, 13, 757–763.
- Lazarus, R.S. (1991). *Emotion and adaptation*. New York: Oxford University Press.
- Levine, L.J., & Bluck, S. (2004). Painting with broad strokes: Happiness and the malleability of event memory. *Cognition and Emotion*, 18, 559–574.
- Loftus, E.F. (1979). The malleability of human memory. *American Scientist*, 67, 312–320.
- Mather, M. (2007). Emotional arousal and memory binding: An object-based framework. *Perspectives on Psychological Science*, 2, 33–52.
- Mikels, J.A., Larkin, G.R., Reuter-Lorenz, P.A., & Carstensen, L.L. (2005). Divergent trajectories in the aging mind: Changes in working memory for affective versus visual information with age. *Psychology and Aging*, 20, 542–553.
- Neisser, U., & Harsch, N. (1992). Phantom flashbulbs: false recollections of hearing the news about Challenger. In E. Winograd & U. Neisser (Eds.), *Affect and accuracy in recall: Studies of flashbulb memories* (pp. 9–31). New York: Cambridge University Press.
- Ochsner, K.N. (2000). Are affective events richly “remembered” or simply familiar? The experience and process of recognizing feelings past. *Journal of Experimental Psychology: General*, 129, 242–261.
- Reisberg, D., & Heuer, F. (2004). Remembering emotional events. In D. Reisberg & P. Hertel (Eds.), *Memory and emotion* (pp. 3–41). New York: Oxford University Press.
- Schaefer, A., & Philippot, P. (2005). Selective effects of emotion on the phenomenal characteristics of autobiographical memories. *Memory*, 13, 148–160.
- Whalen, P.J. (1998). Fear, vigilance, and ambiguity: Initial neuroimaging studies of the human amygdala. *Current Directions in Psychological Science*, 7, 177–188.
- Yonelinas, A.P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language*, 46, 441–517.