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## What factors need to be considered to understand emotional memories?

**Elizabeth A. Kensinger**

Department of Psychology, Boston College

### Abstract

In my original review (this issue), I proposed that to understand the effects of emotion on memory accuracy, we must look beyond effects of arousal and consider the contribution of valence. In discussing this proposal, the commentators raise a number of excellent points that hone in on the question of when valence does (and does not) account for emotion's effects on memory accuracy. Though future research will be required to resolve this issue more fully, in this brief response, I address some of the concerns outlined by the commentators and suggest a few steps that may help to elucidate the dimensions that should be incorporated in models of emotional memory.

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A hypothesis put forth in my review was that emotional valence can influence the likelihood that episodic details are remembered, with details of negative events being remembered more often than details of positive events. In reviewing this hypothesis, each of the commentators noted that there are some instances in which the behavioral effects of valence on memory are minimal. For example, Hamann, as well as Larson and Steuer (both this issue), cited evidence that when emotion is evoked via external means, valence may have less of an influence on memory for detail (Anderson et al., 2006). Mather and Sutherland (this issue) presented an item-based reanalysis of their data, showing that there are times when arousal explains more of the enhancing effects than valence. These findings led the commentators to raise a host of questions about when valence influences memory accuracy and about what other factors must be considered to fully understand the effects of emotion on memory.

As a first step toward examining the issues raised in the commentaries, we conducted an item analysis of our data (from Kensinger et al., 2007a, 2007b), similar to that conducted by Mather and Sutherland. Like Mather and Sutherland, both item valence and arousal correlated with memory accuracy ( $r=.16$  and  $r=-.24$ , respectively). In our own data, however, the effects of valence remained strong even when the effects of arousal were controlled ( $r=-.29$ ,  $p<.001$  – with negative [lower] valence associated with higher memory accuracy). We also compared the neural activity for IAPS pictures (Lang et al., 1997) that varied in valence and arousal. We found that valence had as strong an influence as arousal on the neural processes predicting subsequent memory (Mickley & Kensinger, submitted; see also Berntson et al., 2007 for evidence that item valence may influence the link between arousal and amygdala engagement). These findings suggest that arousal is not the whole story, at least not all of the time.

Though I would like to use these findings to make a case for incorporating valence into models of emotional memory, I appreciate Larson and Steuer's argument that factors beyond valence and arousal need to be included as well. Whether stimuli are evolutionarily relevant, biologically prepared, or personally important, and whether the emotions evoked by stimuli

motivate us to act or reflect an achieved goal, all are factors that are likely to contribute to emotion's modulation of memory. Indeed, there is tremendous interest in understanding how the self-relevance of information influences memory (e.g., Gutchess et al., 2007; Kelley et al., 2002; Turk et al., 2008) and in clarifying how reward-related motivation can lead to memory enhancements (e.g., Wittmann et al., 2007). There also have been recent attempts to understand whether the effects of self-referencing are interwoven with the effects typically attributed to valence or arousal (e.g., Moran et al., 2006). Thus, there is an increasing appreciation for the array of factors that should be considered when examining emotional memory. Mather & Sutherland also point out the importance of controlling for nonemotional factors when examining the effects of emotion on memory. Factors such as semantic relatedness, visual complexity, and item familiarity all influence memory, and if researchers are not careful to control for these factors, then variation along these dimensions can exaggerate (or mask) the emotional memory benefit (discussed by Talmi & Moscovitch, 2004; Buchanan et al., 2006).

A significant challenge facing researchers interested in emotion-memory interactions, then, is to figure out the best way to investigate the complex interactions among these myriad features. I don't presume to have the answer, but I believe these commentaries suggest three steps to move us in the right direction. First, as noted by Hamann, research must examine not only behavioral outcomes but also the underlying processes that support memory. Though an item's familiarity, complexity, self-relevance, evolutionary importance, valence, and arousal all may influence memory, the mechanisms by which they do so are likely to be dissociable. Neuroimaging methods provide an excellent way to examine these underlying processes, revealing which are dissociable and during which phase of memory each operates. Second, physiological arousal should be distinguished from subjective ratings of arousal. As noted by Mather and Sutherland, subjective feelings of arousal do not always correspond with physiological responses, and the strength of the connection can differ across different populations (e.g., Murnen & Stockton, 1997; Tsai et al., 2000). The effects of subjective arousal may not parallel the effects of physiological arousal on memory, and so by using the two measurements interchangeably, we may be inadvertently muddying the waters. Third, and cycling back to one of the main arguments in my initial review, studies of emotional memory should look for the influence of characteristics aside from arousal. As emphasized by Larson and Steuer, there are many dimensions that likely contribute to emotion's effects on memory. We need to understand when arousal is the dominant modulator of emotional memory and when other factors must be considered: Is the relative importance of arousal influenced by encoding task, retention delay, retrieval demands, or other variables? Incorporating factors beyond arousal into our models of emotional memory should allow us to assemble a more complete picture of emotion's influences on memory.

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