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Accounting for immediate emotional memory enhancement

Deborah Talmi [a,b,*], Lucy M. McGarry [b]

[a] School of Psychological Sciences, University of Manchester, UK
[b] Department of Psychology, University of Toronto, Canada

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ABSTRACT

Memory for emotional events is usually very good even when tested shortly after study, before it is altered by the influence of emotional arousal on consolidation. Immediate emotion-enhanced memory may stem from the influence of emotion on cognitive processes at encoding and retrieval. Our goal was to test which cognitive factors are necessary and sufficient to account for EEM, with a specific focus on clarifying the contribution of attention to this effect. In two experiments, participants encoded negative-arousing and neutral pictures. In Experiment 1, under divided-attention conditions, negative pictures were better attended and recalled even when they were matched with neutral pictures on semantic relatedness and distinctiveness, and attention at encoding predicted subsequent emotion-enhanced memory. The memory advantage for emotional stimuli was only abolished when attention to emotional and neutral stimuli was also matched, under full-attention in Experiment 1 and under divided-attention in Experiment 2. Emotional memory enhancement was larger in Experiment 1 when the control of organization and distinctiveness was relaxed. These findings suggest that attention, organization and distinctiveness provide a necessary and sufficient account for immediate emotion-enhanced free recall memory.

Introduction

Memory for moderately arousing emotional stimuli, such as images of violence, is better than memory for neutral stimuli. There is good evidence for emotion-enhanced memory (EEM) in both humans and non-human animals (Cahill & McGaugh, 1998; Labar & Cabeza, 2006). Evidence from animals shows that the sympathetic emotional arousal response enhances long-term memory by activating the amygdala, which modulates the long-term consolidation of memory traces in the hippocampus, so that after a prolonged delay, memory for emotional events is enhanced (McGaugh, 2004). Although this model can explain a host of data from human participants (Labar & Cabeza, 2006), researchers often overlook the fact that because the modulation mechanism only influences long-term memory consolidation, it does not account for the enhanced memory in immediate long-term memory tests (Cahill & McGaugh, 1998), namely tests that occur shortly after study but following a brief distractor activity, which clears working memory. In the general discussion section we review evidence from animal studies that shows conclusively that the mechanism used by the modulation model to account for delayed EEM *does not* account for immediate EEM (Bianchin, Mello e Souza, Medina, & Izquierdo, 1999; Ellis & Kesner, 1983; Frey, Bergado-Rosado, Seidenbecher, Pape, & Frey, 2001; Seidenbecher, Reymann, & Balschun, 1997). A complementary mechanism is therefore required to account for immediate EEM, which humans exhibit readily.

The goal of the current study was to establish a cognitive account of immediate EEM. The cognitive account attributes this effect to altered encoding and retrieval of emotionally arousing events, instead of to their modulated consolidation. The notion that cognitive factors contribute to immediate EEM is not new (Cahill & McGaugh, 1998; Kensinger & Corkin, 2004), yet it is unknown which factors

* Corresponding author at: School of Psychological Sciences, University of Manchester, Manchester M13 9PL, UK. Fax: +44 (0) 161 275 2623.
E-mail address: Deborah.Talmi@manchester.ac.uk (D. Talmi).

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are necessary and sufficient to account for this effect. Consequently, the cognitive account has had a relatively modest influence on neuroscience research. For example, a recent meta-analysis (Murty, Ritchey, Adcock, & Labar, 2010) highlighted the fact that although many brain regions are consistently associated with EEM, their contribution to EEM is under-investigated. This is likely due to the prominence of the modulation model, as researchers typically focus on brain regions relevant to that model and interpret their findings within its framework even when memory is tested shortly after study (Kensinger & Corkin, 2004; Sommer, Glascher, Moritz, & Buchel, 2008; Strange, Hurlemann, & Dolan, 2003). Moreover, researchers interested in modulated consolidation test memory after a prolonged delay, which complicates the isolation of an independent cognitive contribution (Ritchey, Bessette-Symons, Hayes, & Cabeza, 2011). Understanding the critical psychological determinants of immediate EEM can inspire and inform future research of its underlying brain mechanisms.

Our objective here was to show that the influence of three factors – organization, distinctiveness, and attention – on encoding and retrieval provides a necessary and sufficient account of immediate EEM in free recall. The two experiments reported here support this claim by showing that EEM can only be abolished when these three factors are controlled. Our approach relies on the assumption that to fully understand an empirical phenomenon, such as immediate EEM, we need to know the conditions for its manifestation, and that such understanding is evident in the ability to systematically influence the phenomenon by manipulating its triggering conditions.

The contribution of organization, distinctiveness, and attention to EEM will be reviewed next.

Organization

Organization is operationalized here simply as the semantic cohesiveness or inter-relatedness of a stimulus set. Organization improves memory (Hunt & McDaniel, 1993; Mandler, 1967) because it encourages inter-item elaboration at encoding (Einstein & Hunt, 1980) and serves as a cue at retrieval (Tulving & Pearlstone, 1966). Emotional events are often related to each other. They may belong to the same script, such as the sound of emergency sirens and the image of a smashed car; or be related thematically, as when thinking about poverty conjures up images of hungry children. This feature of emotional events is captured in the laboratory because experimental stimulus sets often include inter-related emotional stimuli, such as the words 'torture' and 'suicide', alongside unrelated neutral stimuli (Maratos, Allan, & Rugg, 2000; Talmi & Moscovitch, 2004).

When emotional, non-taboo words were compared to equally-related neutral words, participants recalled the neutral words as well as the emotional words (Talmi & Moscovitch, 2004), but follow-up work showed that organization only partly accounts for EEM. When more arousing stimuli were used, such as taboo words or pictures (De Houwer & Hermans, 1994; Kensinger & Schacter, 2006), controlling organization attenuated EEM in free recall but did not abolished it completely (Buchanan, Etzel, Adolphs, & Tranel, 2006; Talmi, Luk, McGarry, & Moscovitch, 2007; Talmi, Schimmack, Paterson, & Moscovitch, 2007). The semantic relatedness of emotional words also influences bias in recognition memory tests, where participants exhibit increased propensity to endorse emotional lures as 'old'; but its influence on recognition accuracy is less well established (Maratos et al., 2000; Windmann & Kutas, 2001). The finding that the magnitude of EEM depends on the semantic relatedness of neutral stimuli suggests that organization contributes to EEM. However, because these studies did not manipulate the semantic relatedness of emotional stimuli, they do not conclusively demonstrate that organization contributes to memory for emotional information.

Distinctiveness

Distinctiveness is not an inherent property of a stimulus, but a feature of the context in which it is embedded. Schmidt (1991) argued that emotional stimuli are distinct relative to the content of participants' long-term memory because they have unique attributes that they do not share with most stored stimuli, which are neutral. This form of distinctiveness, relative to stimuli stored in long-term memory, is termed secondary distinctiveness (Hunt & Worthen, 2006; Schmidt, 1991). Emotional stimuli also stand out relative to the neutral stimuli that typically surround them at the time of encoding, for example, neutral stimuli in the same study list or the peripheral details of a crime scene (Schmidt, 1991). Distinctiveness relative to stimuli stored in working memory is termed primary distinctiveness (Hunt & Worthen, 2006; Schmidt, 1991). To clarify, a picture of a nude model within a set of pictures of clothed models has both primary and secondary distinctiveness, but a picture of a clothed model within a series of nudes only has primary distinctiveness (Schmidt, 2002). There is strong evidence that primary distinctiveness improves memory, but that secondary distinctiveness does not (Hunt & McDaniel, 1993; Schmidt, 1991). For example, common sentences are remembered as well as sentences with high secondary distinctiveness, such as bizarre or humorous sentences, when each sentence type is presented to a separate group of participants or in separate blocks to the same participants. However, when all sentences are mixed and presented to the same group of participants, the bizarre or humorous sentences are remembered better than the neutral ones, an effect which must therefore stem from their primary distinctiveness (McDaniel, Einstein, Delosh, May, & Brady, 1995; Schmidt, 1994).

Emotional stimuli always have high secondary distinctiveness, but their primary distinctiveness can be manipulated by varying the composition of experimental stimulus sets. The primary distinctiveness of emotional stimuli is enhanced relative to the primary distinctiveness of neutral stimuli when the same experimental list includes a small number of emotional stimuli intermixed with a larger number of neutral stimuli. By contrast, both stimulus types have equivalent primary distinctiveness when they are presented in 'blocked' sets that only contain other stimuli