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Emotion regulation during the encoding of emotional stimuli: Effects on subsequent memory

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ABSTRACT

In the adult literature, emotional arousal is regarded as a source of the enhancing effect of emotion on subsequent memory. Here, we used behavioral and electrophysiological methods to examine the role of emotional arousal on subsequent memory in school-age children. Furthermore, we implemented a reappraisal instruction to manipulate (down-regulate) emotional arousal at encoding to examine the relation between emotional arousal and subsequent memory. Participants (8-year-old girls) viewed emotional scenes as electrophysiological (EEG) data were recorded and participated in a memory task 1 to 5 days later where EEG and behavioral responses were recorded; participants provided subjective ratings of the scenes after the memory task. The reappraisal instruction successfully reduced emotional arousal responses to negative stimuli but not positive stimuli. Similarly, recognition performance in both event-related potentials (ERPs) and behavior was impaired for reappraised negative stimuli but not positive stimuli. The findings indicate that ERPs are sensitive to the reappraisal of negative stimuli in children as young as 8 years. Furthermore, the findings suggest an interaction of emotion and memory during the school years, implicating the explanatory role of emotional arousal at encoding on subsequent memory performance in female children as young as 8 years.

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Introduction

Emotion permeates our everyday lives from birth to adulthood. As adults, we demonstrate better memory for emotional relative to neutral events, words, stories, and scenes (LaBar & Cabeza, 2006). Enhancing effects of emotion are attributed to emotional arousal and can occur at different stages during the memory process—at encoding (Hamann, Ely, Grafton, & Kilts, 1999), consolidation (Dolcos, LaBar, & Cabeza, 2005; McGaugh, 2004; Smeets, Otgaar, Candel, & Wolf, 2008), and retrieval (Maratos & Rugg, 2001; Weymar, Low, & Hamm, 2011). There is mixed evidence as to whether children show better memory for emotional events and, if so, when during the memory process enhancing effects of emotion occur. Manipulating emotional arousal at the time of encoding offers the opportunity to examine functional links between emotional experience and subsequent memory and, thus, the relative integration of emotion and memory processes in development. If arousal at encoding is reduced (down-regulated), does this impair enhancing effects of emotion on subsequent memory? In the current study of the developmental status of emotional memory in school-age children, we implemented an emotion regulation manipulation (reappraisal) at encoding to examine the explanatory role of arousal on subsequent memory.

An excellent tool for measuring emotion processing is event-related potentials (ERPs), which capture the dynamics of neural responses to discrete stimuli on the order of milliseconds. As such, ERPs are sensitive to real-time emotional arousal during the encoding of an event. In adults, a prominent emotion response in ERP signal is the late positive potential (LPP). The LPP is a sustained positive-going amplitude that begins at around 300 ms post-stimulus onset, is maximal over posterior sites, and is larger for emotional and arousing stimuli than for neutral stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). In adults, LPPs at encoding are predictive of subsequent recall performance (i.e., larger LPPs at encoding positively predict subsequent memory) (e.g., Dolcos & Cabeza, 2002), and ERP recognition effects are larger for emotional stimuli than for neutral stimuli (e.g., Weymar, Löw, Melzig, & Hamm, 2009). Thus, in adults, ERPs index not only real-time emotion responses but also enhancing effects of emotion on memory during the stages of encoding and retrieval.

During a first-time viewing of emotional stimuli (e.g., encoding in memory studies), children as young as 5 years show similar emotion responses in ERPs as adults (e.g., Hajcak & Dennis, 2009; Leventon, Stevens, & Bauer, 2014; Perez-Edgar & Fox, 2007). Almost no research has included ERPs in examination of emotional memory in children. Most studies of children's emotional memory include behavioral measures only and present a mixed pattern of memory effects. That is, some studies indicate better memory for emotional stimuli (e.g., Cordon, Melinder, Goodman, & Edelstein, 2013), whereas others show no enhancing effects of emotion on memory (e.g., Peterson & Bell, 1996). As described above, ERPs have the power to elucidate emotion and emotional memory processes, yet to date only one study has included ERPs in examination of children's emotional memory. In Leventon and colleagues' (2014) study, ERPs were collected at encoding and recognition in examination of 5- to 8-year-olds' memory for emotional scenes. To examine effects of age, the sample was divided into two groups: younger (5.0–7.5 years) and older (7.5–8.0 years). Across the age groups, children showed robust LPPs to negative and positive emotional stimuli at encoding, indicating strong emotion responses to the stimuli. Recognition was measured in behavioral responses and ERPs after a 24-h delay. Across age groups, emotion did not affect behavioral recognition performance. However, ERP recognition effects indicated enhanced memory for negative stimuli in the oldest children in the sample (7.5- to 8.0-year-olds); there was no effect of emotion for 5.0- to 7.5-year-olds. The absence of enhancing effects of emotion on memory in children under 7.5 years (in ERP and behavioral measures), coupled with emerging effects in children over 7.5 years (in ERPs for negative stimuli specifically), is suggestive of emotion and memory processes becoming more integrated during the school-age years, with continued development into adolescence to mature to the adult-like pattern. Moreover, robust LPPs during encoding were paired with limited enhancing effects on subsequent memory, indicating that emotion–memory relations are not as strong in school-age children as they are in adults.

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