Acta Psychologica 188 (2018) 1–8

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Emotional arousal and memory after deep encoding

Jacqueline S. Leventon[a,*], Gabriela L. Camacho[b], Maria D. Ramos Rojas[b], Angelica Ruedas[b]

[a] Towson University, Psychology Department, 8000 York Road, Towson, MD 21252, USA
[b] California State University, San Bernardino, Department of Psychology, 5500 University Parkway, San Bernardino, CA 92407, USA

ARTICLE INFO

Keywords:
Emotional memory
Encoding
Arousal
Depth of processing

ABSTRACT

Emotion often enhances long-term memory. One mechanism for this enhancement is heightened arousal during encoding. However, reducing arousal, via emotion regulation (ER) instructions, has not been associated with reduced memory. In fact, the opposite pattern has been observed: stronger memory for emotional stimuli encoded with an ER instruction to reduce arousal. This pattern may be due to deeper encoding required by ER instructions. In the current research, we examine the effects of emotional arousal and deep-encoding on memory across three studies. In Study 1, adult participants completed a writing task (deep-encoding) for encoding negative, neutral, and positive picture stimuli, whereby half the emotion stimuli had the ER instruction to reduce the emotion. Memory was strong across conditions, and no memory enhancement was observed for any condition. In Study 2, adult participants completed the same writing task as Study 1, as well as a shallow-encoding task for one-third of negative, neutral, and positive trials. Memory was strongest for deep vs. shallow encoding trials, with no effects of emotion or ER instruction. In Study 3, adult participants completed a shallow-encoding task for negative, neutral, and positive stimuli, with findings indicating enhanced memory for negative emotional stimuli. Findings suggest that deep encoding must be acknowledged as a source of memory enhancement when examining manipulations of emotion-related arousal.

1. Introduction

Across various to-be remembered experiences, memory performance is stronger for emotionally arousing stimuli than for neutral stimuli (scenes: e.g., Bradley, Greenwald, Petry, & Lang, 1992; videos: e.g., Cahill et al., 1996; faces: e.g., Johansson, Mecklinger, & Treese, 2004; words: e.g., Buchanan, Etzel, Adolphs, & Tranel, 2006). This pattern may help us better remember meaningful experience, such as the birth of a child or death of a loved one, versus the date you renewed your driver's license at the DMV. Emotional arousal may play its enhancing role at the time of encoding (e.g., Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000), consolidation and storage (e.g., McGaugh, 2004), and/or retrieval (e.g., Dolan, Lane, Chua, & Fletcher, 2000). In the case of encoding, both neurological and physiological research supports the role of emotional arousal driving memory performance (e.g., Buchanan et al., 2006; Cahill et al., 1996, etc.). However, a growing number of findings challenge the enhancing role of emotional arousal, whereby reduced arousal does not impair subsequent memory (in fact, often improves memory: Dillon, Ritchey, Johnson, & LaBar, 2007; Hayes et al., 2010; Kim & Hamann, 2012; Richards & Gross, 2000). That is, when emotional arousal is reduced via reappraisal, memory performance remains enhanced for emotional versus neutral stimuli. We argue that this finding may be due to deep processing during encoding that is required during reappraisal of emotional stimuli (see Levels of Processing, Craik & Lockhart, 1972). Thus better encoding due to emotional arousal may be replaced by better encoding due to deeper processing. Across three studies, we examine the role of emotional arousal in subsequent memory as a function of deep vs. shallow encoding conditions. Do enhancing effects of emotion remain even when all stimuli are processed deeply or, does deeper encoding outweigh enhancing effects of emotion?

A large body of behavioural, physiological, and neurological research supports the idea that emotional arousal experienced during encoding drives memory performance at retrieval. For example, in both recognition and recall measures, Bradley et al. (1992) found that positive and negative picture stimuli which were rated as high arousal were better remembered than self-reported low arousal stimuli. Physiological measures of emotional arousal, such as heart rate and skin conductance, are also predictive of subsequent memory performance (e.g., Buchanan et al., 2006). Neural investigations further support this pattern. Dolcos and Cabeza (2002) found that ERP signatures of subsequent memory were larger for positive and negative versus neutral

* Corresponding author. All subsequent authors contributed equally to the manuscript and are listed in alphabetical order.
E-mail addresses: JLeventon@towson.edu (J.S. Leventon), Gabylcamacho5@gmail.com (G.L. Camacho), Mariaramos.rojas12@gmail.com (M.D. Ramos Rojas), Ruedasa@coyote.csusb.edu (A. Ruedas).

https://doi.org/10.1016/j.actpsy.2018.05.006
Received 29 June 2017; Received in revised form 16 May 2018; Accepted 17 May 2018
0001-6918/

picture stimuli. Further, amygdala activity during encoding predicts memory for emotional versus neutral picture stimuli (e.g., Canli et al., 2000). The focus here is on long-term memory performance for everyday experiences of emotion, as opposed to other memory systems (e.g., working memory), or emotion beyond the everyday experience (e.g., stressful or traumatic experience).

Thus there is strong support for the role of emotional arousal driving enhancing effects on long-term memory performance. These data suggest that if emotional arousal was reduced, memory should be impaired. Research on emotion regulation (ER) and memory examines exactly this, and paints a mixed picture depending on the ER strategy tested. When the effortful ER strategy of suppression is used to reduce emotional arousal, memory is often impaired (Dillon et al., 2007; Richards & Gross, 1999, 2000, 2006). Yet when more efficient strategies are used, such as cognitive reappraisal, memory is not reduced, and often improved (Dillon et al., 2007; Hayes et al., 2010; Kim & Hamann, 2012; Richards & Gross, 2000). The goal of cognitive reappraisal is to change the meaning of an emotional experience, often to a less-arousing and more neutral interpretation. It is argued to be a healthy emotion regulation strategy because it supports experiencing positive and negative emotion without depleting cognitive resources (Gross, 2002). The cognitive mechanisms involved in reappraisal may provide a deeper level of processing during encoding of reappraised experience, which may facilitate the continued memory enhancement for emotional stimuli even when arousal has been reduced via reappraisal efforts (for more on Levels of Processing, see Craik & Lockhart, 1972). Neuroimaging evidence strengthens this argument: frontal areas involved in cognitive reappraisal overlap with those involved in memory tasks (e.g., Hayes et al., 2010; Ochsner & Gross, 2005). Further, cognitive neuroscience explanations of emotional memory (without ER) suggest that emotional arousal may promote greater attention and elaboration (cognitive processes) in supporting enhanced memory performance (Hamann, 2001). In fact, when a depth of encoding task was applied during encoding of positive, negative, and neutral images, overall memory was better under deep encoding and enhancing effects of emotion were reduced: larger enhancing effects of emotion on memory were observed under shallow vs. deep conditions (Ritchey, LaBar, & Cabeza, 2011). Thus the cognitive processes triggered by arousal-modulated amygdala activity may be replaced by cognitive processes involved in reappraisal: both facilitate memory performance (see Hayes et al., 2010 for similar argument).

1.1. Research design and hypotheses

As examined to date, tests of reappraisal and emotional memory have only manipulated emotionally negative stimuli, with neutral comparison stimuli encoded without instruction (shallow encoding) or with deep processing that changes the affective value (e.g., increase/decrease/suppress instructions, Dillon et al., 2007). That is, there is not a neutral comparison that includes deep encoding and maintains the neutral affective value. In the current research, we examine the role of emotional arousal on recognition memory where all stimuli, emotional and neutral, were processed in a deep encoding task (Study 1). The deep encoding featured a reappraisal instruction for half of the emotional stimuli (aimed to reduce arousal). If emotional arousal is the stronger influence on memory performance, then memory should be better for the non-reappraised emotion stimuli than neutral and reappraised emotion trials (even if the arousal manipulation is ineffective, emotion trials of all types, reappraised and non-reappraised, should be better remembered than neutral trials). But if deep encoding is a stronger influence than emotional arousal, then memory should be strong in all conditions, regardless of emotion or encoding instruction. We favor the latter prediction, given Ritchey et al. (2011) findings where overall memory was strong and enhancing effects of emotion were reduced under deep encoding conditions.

2. Study 1

2.1. Method

2.1.1. Participants

Twenty-nine adults (26 female) participated in two laboratory sessions (M_{age} = 23.90 years, *SD* = 7.12 years). The participants were students recruited from a large public university in the United States. Twenty-seven participants reported their ethnicity: 19 identified as Hispanic, and 8 as non-Hispanic. Twenty participants reported their race: 11 identified as White, 2 as Asian, 2 as Black or African American, 1 as Native Hawaiian or Other Pacific Islander, and 5 as more than one race. Participants provided written informed consent prior to testing, and received course credit after their participation. A university IRB approved all procedures.

2.1.2. Materials

A set of 126 images (42 positive; 42 neutral; 42 negative) was selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), and a lab-collected set of supplemental stimuli of similar content. Of the larger set, 6 images served as stimuli for practicing the encoding task (2 positive; 2 neutral; 2 negative), and 120 images served as the experimental stimulus set (40 in each emotion condition). Half of the experimental stimuli (20 in each emotion condition) were viewed during the encoding and retrieval presentations, and the remaining half was viewed during retrieval only (counterbalanced across participants). Within the encoding presentation, half of each the positive and negative trials were in the maintain condition and the other half in the reduce condition (counterbalanced across participants). All neutral trials were in the maintain condition. Thus at encoding, participants viewed 20 negative images (10 maintain, 10 reduce), 20 neutral images (all 20 maintain), and 20 positive images (10 maintain, 10 reduce). Within each condition, half of the images included humans and half did not include humans to account for reported biases in processing affective content with humans (Proverbio, Adorni, Zani, & Trestianu, 2009). All images were presented in full colour.

Participants provided subjective valence and arousal ratings of the images using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994; see Fig. 1, Panels a and b). The SAM was abbreviated from the 9-point version of the scale to reduce participant burden, and the modified version consisted of two 5-point scales: one for valence (1 = very negative, 3 = neutral, and 5 = very positive), and one for arousal (1 = very low arousal, 5 = very high arousal).

2.1.3. Procedure

The study consisted of two sessions separated by a 5–14 day delay (*M* = 9.38 days, *SD* = 2.35 days). Both sessions took place in the laboratory.

2.1.3.1. Session 1. Participants viewed 60 images from the stimulus set (20 in each condition) and wrote a brief description of each picture in the cued condition (encoding task). Session 1 lasted approximately 45 min.

Participants were seated in front of a computer screen where the images were presented and a researcher explained the encoding task. Specifically, participants were told that they would view various images and write a brief description for each image following the instruction ('maintain' = keep the emotion the same, and 'less' = decrease the emotion), then they should continue to think about their description when the image reappeared immediately after. Two practice presentations were administered to ensure that participants understood the task. The first practice presentation demonstrated the task with pre-written examples, and the second presentation allowed the participants to practice the experimental task. Each presentation had five trials.

In the first practice presentation, participants viewed five example trials with three practice stimuli (one neutral, one negative presented