Biological Psychology 123 (2017) 15–24

Contents lists available at ScienceDirect

Biological Psychology

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

Selective rehearsal is affected by the emotionality of the encoding context in item-method directed forgetting: An event-related potential study

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ARTICLE INFO

Article history:
Received 28 January 2016
Received in revised form
17 November 2016
Accepted 24 November 2016
Available online 24 November 2016

Keywords:
Item-method directed forgetting
Emotional context
ERPs

ABSTRACT

Emotional items are often remembered more clearly than neutral items. However, whether stimuli embedded in an emotional context are more resistant to directed forgetting than those presented in a neutral context remains unclear. This question was tested by recording event-related potentials (ERPs) in an item-method directed forgetting paradigm involving neutral words that were embedded in neutral or negative contexts. During the study phase, participants were asked to associate a neutral word with a negative or neutral picture. A remember (R) or forget (F) cue was then designated to indicate whether the word was a to-be-remembered (TBR) or to-be-forgotten (TBF) word. In the test phase, participants were asked to identify all previously presented old words regardless of the R/F cues. The behavioral results indicated a significant interaction between the valence of the encoding contexts and the R/F cues. The hit rate was lower for the TBR words encoded in negative contexts relative to those encoded in neutral contexts. No such valence effect was observed in the hit rates of the TBF words. For the ERP data, the R cues elicited a P3b-like effect that has been linked to the selective rehearsal of the TBR items. This effect was more sustained in the negative encoding context than in the neutral context. The F cues elicited a frontal positivity that has been linked to the active inhibition of the TBF words; however, this positivity was not modulated by the valence of the encoding context. The sustained P3b-like effect for the R cues in the negative encoding context might reflect a compensative encoding for the TBR words caused by the attention-capturing negative contexts. Therefore, we argue that the emotional context affected the selective elaboration of the TBR words; however, we also argue that there was no supportive evidence of an emotional effect on the forgetting of TBF items.

1. Introduction

Emotional items tend to receive more attention and elaborative processing and are hence remembered more effectively than neutral items (Buchanan, 2007; Hamann, 2001). How robust the mnemonic benefit of emotion is and whether emotional items, especially negative ones, are more resistant to intentional forgetting than neutral items are questions that have not been fully examined. In the present study, we recorded event-related brain potentials (ERPs) when participants engaged in an item-method directed forgetting paradigm in which they received instructions to remember or forget emotionally neutral words embedded in either a negative or neutral context picture.

Item-method directed forgetting is a commonly employed method for investigating intentional forgetting. In this procedure, a remember (R) or forget (F) cue is delivered to each study item on a trial-by-trial basis. Studies have shown that, for both recall and recognition memory tests, items that are cued to be remembered (TBR items) are more clearly remembered than those that are cued to be forgotten (TBF items) (Johnson, 1994; MacLeod, 1998). One interpretation for this "directed forgetting effect" argues that both TBR and TBF items are stored in the working memory. When people are provided with an R cue, TBR items receive further elaborative processing and enter the long-term memory, whereas the TBF items are left to decay following the presentation of the F cues. Supportive evidence for this selective rehearsal interpretation comes from ERP studies showing that, relative to F cues, R cues elicit a larger P3b-like wave, which has been linked to greater attention allo-

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http://dx.doi.org/10.1016/j.biopsycho.2016.11.012
0301-0511/

cation and stimulus evaluations (e.g., Hsieh, Hung, Tzeng, Lee, & Cheng, 2009; Paz-Caballero & Menor, 1999). However, studies have proposed that TBF items are actively inhibited following the presentation of F cues, rather than being left to decay (Zacks, Radvansky, & Hasher, 1996). The attentional inhibition account argues that the inhibitory function ceases processing the TBF item when an F cue is received, forgetting thus being an effortful process (Fawcett & Taylor, 2008). A few ERP studies have indicated that the frontally distributed positivity elicited by the F cues reflects the inhibitory process on the TBF items (Cheng, Liu, Lee, Hung, & Tzeng, 2012; Hsieh et al., 2009; Paz-Caballero, Menor, & Jiménez, 2004) because this positivity correlates with whether TBF items are subsequently forgotten (Hauswald, Schulz, Iordanov, & Kissler, 2011; Lin, Kuo, Liu, Han, & Cheng, 2013; Van Hooff & Ford, 2011).

The finding that active inhibition contributes to the forgetting of TBF items suggests that the item-method of directed forgetting can be utilized to examine how emotion modulates the control processes during encoding. A few functional imaging studies have employed emotional materials in item-method directed forgetting to address this issue, but results have been inconsistent. Nowicka, Marchewka, Jednoróg, Tacikowski, & Brechmann (2011) and Hauswald et al. (2011) have reported a reliable directed forgetting effect for neutral pictures but not for negative pictures. This diminished directed forgetting effect for emotional materials was also observed in a study that used neutral and negative words as stimuli (Bailey & Chapman, 2012). However, studies have also demonstrated that emotional materials yield a directed forgetting effect that is equivalent to (Yang et al., 2012) or greater than (Brandt, Nielsen, & Holmes, 2013) the effect elicited by neutral items. ERP results regarding the interaction between emotion and R/F instructions also vary across studies. Although the frontal positivity associated with the F cues and the P3b-like wave elicited by the R cues have been consistently observed in all related studies, some studies have found the P3b-like effect and frontal positivity elicited by the R/F cues to be modulated by emotional valence (Brandt et al., 2013; Yang et al., 2012) whereas others have reported no significant interaction between the R/F instructions and valence of the materials (Bailey & Chapman, 2012; Hauswald et al., 2011).

The inconsistency in findings may be the result of different materials (e.g., words and pictures) being employed and the manner in which the R/F cues were delivered (e.g., simultaneously with or subsequent to the presentation of items). One particular issue that should be considered is the means by which emotion is manipulated. In previous studies, the manipulation of emotion has been conducted using neutral and emotional materials as the study items. Naturally, the test items presented in subsequent recognition tests also have comprised emotional values. Hence, discerning the effects of emotion on memory encoding from those at the retrieval stage is difficult (Maratos & Rugg, 2001; Smith, Dolan, & Rugg, 2004). To avoid the potential confounding of retrieval with encoding, the current study manipulated the emotional valence by presenting neutral items in a negative or neutral encoding context at the study phase and without context at the test phase (Erk et al., 2003; Erk, Martin, & Walter, 2005; Maratos, Dolan, Morris, Henson, & Rugg, 2001; Smith et al., 2004). During the study phase, emotionally neutral words were each presented in a background picture that was either emotionally neutral or negative, followed by an R or F cue that instructed the participant to remember or to forget the word. In the following test phase, all studied old words (regardless of R/F cues) and new words were presented without background pictures. Because the emotional and nonemotional pictures were presented only in the study phase, if any emotional effect was detected, it could be attributed to the emotion modulation of the encoding processes.

Both the elaborative rehearsal of TBR items and inhibition of TBF items were expected to be disturbed by emotional context because, as suggested by a previous study, emotional pictures are attention-drawing (Talmi, Anderson, Riggs, Caplan, & Moscovitch, 2008) and both the rehearsal and inhibition processes are attention demanding. When the background pictures were emotionally negative, less attentional resources were expected to be available for the processing of following words and cues. Thus, a diminished directed forgetting effect may be caused by decreased memory for TBR words and/or increased memory for TBF words. ERPs were also recorded in the current study because memory performance is the output of a series of cognitive processes (processing on pictures, words, and mnemonic cues). Behavioral data alone are therefore insufficient for clarifying how emotions affect the memory formation at each stage. The ERPs, as a high temporal resolution tool, could provide further evidence for understanding the mechanisms underlying each process. The ERPs correlated with neutral and negative context pictures; the neutral words, and the R/F cues were recorded and analyzed respectively.

For the context pictures, we focused on the late positive potential (LPP). This posteriorly distributed slow potential, which onsets at around 250 ms after stimulus presentation, can sustain for 1000 ms after stimulus offset (Hajcak, MacNamara, & Olvet, 2010) and is believed to reflect augmented attention toward affective stimuli (Schupp, Junghofer, Weike, & Hamm, 2003). Compared with the negative pictures, the context pictures were expected to elicit a larger LPP. For the ERPs time-locked to the onsets of study words, we examined the P2 wave deflection and late positive component (LPC). P2 deflection has been linked to phonological processing and the LPC has been linked to semantic processing in visual word recognition (Carreiras, Vergara, & Barber, 2005; Hsu, Tsai, Lee, & Tzeng, 2009; Liu, Perfetti, & Hart, 2003; Van Petten & Senkfor, 1996). In addition, studies have proposed that the amplitudes of both P2 and LPC are sensitive to attentional influences (Blanchet, Gagnon, & Bastien, 2007; Mangels, Picton, & Craik, 2001; Miniussi, Marzi, & Nobre, 2005). Therefore, we hypothesized that when the encoding context is negative, the decrement in attention for word processing could lead to smaller P2 and LPC amplitudes than when the context is neutral. Notably, although the LPP and LPC components can be observed in similar time windows and are interchangeable under some circumstances, the LPP and LPC in the current study were used to denote ERP responses at different time points and in different processes. The LPP was used to denote the processes triggered by context pictures, whereas the LPC was used to study the effect on word processing. Regarding the ERPs elicited by the R/F cues, the P3b-like wave elicited by the R cues and the frontal positivity associated with the F cues were used to examine the modulation of the encoding context valence on the selective rehearsal of the TBR items and the active inhibition of the TBF items.

2. Materials and methods

2.1. Participants

Twenty college students (8 females, age from 18 to 26) from National Central University participated in this experiment. All of them were right-handed native Mandarin Chinese speakers with normal or corrected-to-normal vision. They were paid 500 New Taiwan Dollars (approximately 17 USD) for their participation. Data from 5 participants were excluded because they contributed insufficient (<16) valid ERP trials in at least one of the critical experimental conditions.

2.2. Stimuli

The critical stimuli consisted of 480 Chinese two-character words and 240 pictures. The words were all concrete nouns selected