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The impact of emotion intensity on recognition memory: Valence polarity matters

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ABSTRACT

Although the effects of emotion of different emotional intensity on memory have been investigated, it remain unclear whether the influence of emotional intensity on memory varies depending on the stimulus valence polarity (i.e., positive or negative). To address this, event-related potentials were recorded when subjects performed a continuous old/new discrimination task, for highly negative (HN), mildly negative (MN) and neutral pictures in the negative session; and for highly positive (HP), mildly positive (MP) and neutral pictures in the positive session. The results showed that relative to neutral stimuli, both HN and MN stimuli showed increased memory discrimination scores, and enhanced old/new effect in early FN400 (Frontal Negativity), but not late positive component (LPC) amplitudes. By contrast, relative to MP stimuli, HP and neutral stimuli showed increased memory discrimination scores and enhanced old/new effect in LPC but not FN400 amplitudes. Additionally, we observed a significant positive correlation between the memory discrimination score and the old/new effect in the amplitudes of the FN400 and LPC, respectively. These results indicate that both HN and MN stimuli were remembered better than neutral stimuli; whereas the recognition was worse for MP stimuli than Neutral and HP stimuli. In conclusion, in the present study, we observed that the effect of emotion intensity on memory depends on the stimulus valence polarity.

1. Introduction

The question of how emotions affect memory is not only important for clinical interference of affective disturbances (Bremner et al., 1999; Drevets, 1998; Gorman et al., 2000), but is also important for forensic practices (Kiehl et al., 1999). Since the 1990s considerable studies have been published concerning the relationship between emotion and memory (Uttl et al., 2006). A pervasive observation is that emotional events are more likely to be remembered with a greater amount of perceptual and sensorial details, as well as an enhanced confidence in accurate recollection of the previous encounter (Schaefer and Philippot, 2005). This, in turn, facilitates judgment of whether the events have been previously learned (Schaefer and Philippot, 2005; Schaefer et al., 2011).

Emotional stimuli, however, differ not only in respect to the valence polarity (negative or positive), but also in respect to emotional intensity. In fact, a great number of previous studies demonstrated that the intensity of emotional stimuli is important (Leppänen et al., 2007; Meng et al., 2009; Schaefer et al., 2009; Yuan et al., 2007), and emotion of diverse intensities modulates cognitive functions, such as novelty detection, and behavioral control, differently (Yuan et al., 2012; Yuan et al., 2008). Nevertheless, to the best of our knowledge, currently no study has explored whether the influence of emotional intensity on memory varies depending on the stimulus valence polarity when subjects performed a continuous recognition task.

Negative emotion was thought to reflect defensive motivation, whose activation has been established to narrow attentional focus and enhance attention to emotion features (Gable and Harmon-Jones, 2010a). Previous studies showed that attention plays an important role in memory and enhanced attention facilitates the encoding of stimuli (Glass and Newman, 2009). Despite the same valence polarity, negative scenes of increasing emotion intensity, may activate defensive motivational reaction more rapidly (Yuan et al., 2007), and evoke narrower, more focused attentional scope (Rowe et al., 2007). Thus, highly negative scenes, which are characterized by salient threat features, are likely to be memorized better relative to mildly negative stimuli. Similarly, mildly negative stimuli are likely to be memorized better relative to neutral stimuli, which are free of negative features.

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However, the impact of positive emotion on memory does not necessarily follow this linear trend. Previous studies have shown that increased attentional focus enhances attention to emotion features and facilitates the encoding of stimuli, whereas increased attentional breadth diverts attention and impairs the encoding of emotional features (Gable and Harmon-Jones, 2010a). Moderate levels of positive stimuli have been reported to broaden attentional breadth than neutral stimuli (Gable and Harmon-Jones, 2010a; Rowe et al., 2007). Thus, mildly positive stimuli are likely to be memorized worse relative to neutral stimuli. In contrast, highly positive stimulus activates strong appetitive motivation, which may lead to impulsive behavior, unexpected cost and consequently, ambivalent rather than simple positive emotions (Mauss et al., 2011). Thus, this impairing effect may not apply to highly pleasant stimuli. On the other hand, according to the reward saliency hypothesis verified by recent converging evidences (Jensen et al., 2007; Madan and Spetch, 2012), the extreme reward values are experienced more saliently than the medium values, and consequently the effect of reward intensity on memory will show a U-shaped relationship, with both the highest and the lowest reward being remembered better than the intermediate reward. Consistent with this view, Madan and Spetch (2012) manipulated multiple reward intensity and observed that highest and lowest value items are remembered best while intermediate-value items remembered worst. In addition, prior studies have consistently suggested that reward is the major source where positive emotion is from (Heller and Mcewen, 2009; Yuan et al., 2012). Thus, highly positive stimuli are likely to be memorized better relative to mildly positive stimuli, and as a result, the impact of pleasant stimulus intensity on memory-related processing probably follows a nonlinear, U-shaped trajectory. Therefore, based on these analyses, we hypothesized that the memory accuracy of negative stimuli is increased with the emotional intensity of negative stimuli, whereas the memory accuracy of positive stimuli does not necessarily follow this linear trend.

Thus, the present study aims to investigate whether the influence of emotional intensity on memory varies depending on the stimulus valence polarity (i.e., positive or negative), by using ERP technique and a continuous recognition task. ERP technique was used in the current study as it is helpful in depicting the timing features, specifically; the automatic and controlled retrieval of emotional stimuli. ERP recognition was examined by using either a study-test paradigm or a continuous recognition task. In both tasks, the electrophysiological old/new effect has been established to represent recognition function (Van Strien et al., 2005; Van Strien et al., 2007; Rugg et al., 1998; Rugg and Curran, 2007). The old/new effect concerns the difference between the ERPs elicited by new and old stimuli, where the ERP waveform for old stimuli is usually more positive going than for new stimuli. This ERP old/new effect comprises an early Frontal Negativity (FN400) which is larger for new relative to old items in the 300–500 ms post stimulus, and a later parietal old/new difference (500–800 ms). With the study-test task, the early mid-frontal old/new effect has been thought to reflect familiarity (i.e. recognition without retrieval of details), whereas the later parietal old/new effect is thought to reflect recollection (i.e. recognition with the retrieval of associated details, see Curran and Dien, 2003; Rugg and Curran, 2007).

However, in the continuous recognition procedure, the time interval between the first and second presentation of a stimulus is shorter than with the study-test task. While the study-test task separates the stimulus encoding and retrieval into two different phases, the continuous recognition procedure alternates the stimulus encoding and retrieval. Thus, using a familiarity vs. recollection account for the distinctions between early FN400 vs. late LPC old/new effects may not apply to the continuous recognition task. For instance, there are evidences showing that the old/new effect related FN400 amplitudes were independent of stimulus repetition that increases familiarity (Van Strien et al., 2005). Van Strien et al. (2005) presented each word nine times in a modified continuous recognition paradigm. They observed that the early old/new effect did not change with the number of repetitions. These results indicate that the early old/new effect in the continuous recognition task reflects an automatic matching process that is independent of memory strength or familiarity. In addition, it has been reported that this early old/new effect is larger during immediate relative to delayed repetitions, and this enhancement of early old/new effects was linked with better recognition but weaker recalled memory (Van Strien et al., 2007). Therefore, the early ERP old/new effect in continuous recognition paradigm was later interpreted as a reflection of implicit, automatic memory retrieval rather than familiarity-based deliberate process (Van Strien et al., 2009).

Recently, several studies investigated whether and how ERP old/new effects are impacted by emotion (Inaba et al., 2005; Schaefer et al., 2009; Schaefer et al., 2011; Van Strien et al., 2005). These studies reported inconsistent results. Several studies reported that both FN400 and LPC old/new effects have been shown to be influenced by the emotional salience of the stimuli (Schaefer et al., 2011) whereas other studies demonstrated that emotion did not affect FN400 or the parietal LPC old/new effect (Windmann and Kutas, 2001). Notably, many studies have established that negative stimulus and its emotional intensity are preferentially encoded and analyzed in the brain relative to neutral and positive stimuli (Huang and Luo, 2007; Ito et al., 1998), even in shortage of attention (Kang and Wang, 2013; Meng et al., 2009; Yuan et al., 2012). By contrast, the encoding and analysis of positive information and its intensity entail the involvement of controlled processing resources (Kang and Wang, 2013). Thus, we hypothesize that negative but not positive emotion intensity would influence the ERP old/new effect at earlier, automatic retrieval stage associated with the FN400 component, whereas positive emotion intensity influences the ERP old/new effect only in the later, controlled recollection stage.

Additionally, in order to avoid cultural bias that has been reported by Chinese subjects when IAPS (International Affective Picture System) was adopted directly (Huang and Luo, 2004), the pictures used to elicit emotional responses in the present study were chose from the native Chinese Affective Picture System (CAPS), which was established in a similar way to IAPS (Bai et al., 2005). Additionally, The widely accepted dimensional theory of emotion proposed that the affective significance of a stimulus is defined from the two primary dimensions: valence and arousal (Bradley et al., 2001; Lang et al., 1997). As is common in life setting, intense emotional stimuli are normally associated with higher arousal in comparison with mildly emotional stimuli, irrespective of the positive or negative stimuli (Bradley et al., 1990; Keil et al., 2002; Kuppens et al., 2012; Lang et al., 1997). Thus, we selected emotional stimuli in the laboratory setting to more closely resemble emotional events in natural settings, that is, intense negative experiences defined by the valence dimension and intense physiological activations defined by the arousal dimension (Yuan et al., 2012). Based on above considerations, we chose that the rating of highly positive pictures would be more positive and more arousing than that of mildly positive pictures; and the rating of highly negative pictures would be more negative and more arousing than that of mildly negative pictures. Additionally, in order to avoid that stimuli of one valence (e.g. positive) may obscure the intensity effect of the other valence (e.g. negative), we used a design with one block presenting highly positive, mildly positive and neutral pictures while the other block presenting highly negative, mildly negative and neutral pictures.

2. Materials and methods

2.1. Subjects

As paid volunteers, 34 students (17males, 17 females) undergraduate students participated in the experiment. All subjects were healthy, right-handed, had normal or corrected to normal vision, and had no history and current symptoms of affective disorder. The experimental procedure was in accordance with the ethical principles of the 1964 Declaration of Helsinki (Organization, World Medical, 1996). All