Neuroscience Letters 583 (2014) 148–153

Contents lists available at ScienceDirect

Neuroscience Letters

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

The subliminal affective priming effects of faces displaying various levels of arousal: An ERP study

Tian-Tian Li[a], Yong Lu[a,b,*]

[a] Academy of Psychology and Behavior, Tianjin Normal University, Tianjin 300387, China
[b] Center of Cooperative Innovation for Assessment and Promotion of National Mental Health, Tianjin 300387, China

HIGHLIGHTS

- Subliminal affective priming (SAP) effect of aroused faces was studied using ERP.
- The affective priming effect occurred exclusively in the negative condition.
- Valence affected the subliminal affective priming effect of aroused faces.
- Low-arousing faces tended to elicit greater LPC and N400 potentials.
- SAP effect occurs when the prime affects the late stage processing of the probe.

ARTICLE INFO

Article history:
Received 3 June 2014
Received in revised form 18 August 2014
Accepted 9 September 2014
Available online 26 September 2014

Keywords:
Subliminal affective priming
Arousal
Face
Expression
Event-related potentials

ABSTRACT

This study on the subliminal affective priming effects of faces displaying various levels of arousal employed event-related potentials (ERPs). The participants were asked to rate the arousal of ambiguous medium-arousing faces that were preceded by high- or low-arousing priming faces presented subliminally. The results revealed that the participants exhibited arousal-consistent variation in their arousal level ratings of the probe faces exclusively in the negative prime condition. Compared with high-arousing faces, the low-arousing faces tended to elicit greater late positive component (LPC, 450–660 ms) and greater N400 (330–450 ms) potentials. These findings support the following conclusions: (1) the effect of subliminal affective priming of faces can be detected in the affective arousal dimension; (2) valence may influence the subliminal affective priming effect of the arousal dimension of emotional stimuli; and (3) the subliminal affective priming effect of face arousal occurs when the prime stimulus affects late-stage processing of the probe.

1. Introduction

Affective priming occurs when the probe acquires the same emotional information as the prime while individuals judge the emotion of the probe [16]. If the presentation time of the prime is reduced from tens of milliseconds to a few milliseconds, the effect is still observed [7,15,16]. Because the presentation time is very short, the participants are not aware of it; thus, the effect is called subliminal affective priming.

Two longstanding theories regarding the classification of emotion exist: basic emotions theory and emotional dimension theory. In past research, faces chosen to demonstrate the existence of subliminal affective priming were classified based on the basic emotions theory; these classifications included emotions such as anger [12] and fear [13]. Based on emotional dimension theories, the valence and arousal dimensions of emotional classification have been widely accepted and applied in numerous studies [1,10,20]. Valence is a measure of pleasure that ranges from happy to unhappy, while arousal is a measure of the activation level of body energy associated with an emotional state, which ranges from stimulating to calm. Some studies have proven the existence of subliminal affective priming of valence based on the emotional dimension theory [5,14]. However, no study has used arousal to measure subliminal affective priming. Therefore, we sought to answer the following questions: If the valence is controlled, can the arousal dimension of the prime produce subliminal affective priming? If the answer is yes, then what is the neural mechanism responsible for this process?

Unconscious emotional information may variably affect several steps of cognitive processing. For instance, such information can

* Corresponding author at: Academy of Psychology and Behavior, Tianjin Normal University, No. 241 Weijin Road, Hexi District, Tianjin 300074, China.
Tel.: +86 022 23540172x8500.
E-mail address: ly6312@163.com (Y. Lu).

http://dx.doi.org/10.1016/j.neulet.2014.09.027
0304-3940/

enhance perceptual processing or accompany the transfer of the focus of attention and influence responses, decision-making and implementation. To detect and distinguish between a processing series and understand the neural mechanisms of the subliminal affective priming of arousal, we used event-related potential (ERP) technology, which has a high temporal resolution. Therefore, in the present study, the valence was controlled, and high- and low-arousing faces were selected as the priming stimuli. Behavioral analyses were combined with ERP recordings to study the effect of arousal on subliminal affective priming.

The Chinese Affective Picture System (CAPS) is the universal emotional stimuli image system in China [1]. The materials of this study were selected from the CAPS. We initially used valence and arousal as independent variables. However, after we matched the images for valence, arousal, dominance, attractiveness and gender and removed some of the faces with obvious features, an insufficient number of pictures was available. Therefore, we divided the study into two experiments; the materials for Experiment 1 were negative, and those for Experiment 2 were positive.

2. Experiment 1: the subliminal affective priming of arousal by negative faces

2.1. Participants

Seventeen right-handed undergraduate students (eight males, nine females) ranging from 20 to 26 years old (mean = 22.6 years) volunteered for this study for partial course credit. The participants had normal or corrected-to-normal vision and no history of participation in neurological or psychiatric experiments.

2.2. Stimuli

The priming stimuli consisted of 10 high-arousing and 10 low-arousing pictures with negative emotional expressions (half male, half female). The probe stimuli consisted of 80 medium-arousing pictures with negative emotional expressions (half male, half female). To avoid interference from the individual features of the probe faces on the subliminal affective priming effect, all probe faces were transformed into mosaic pictures. The mask stimulus was a neutral face picture that was transformed into an intense mosaic picture.

The prime and probe stimuli were compared with a one-way analysis of variance (ANOVA). These analyses revealed the following results. (1) All stimuli were matched in valence ($F(2,97) = 0.79$, $p = 0.46$). (2) The main effect of arousal was significant ($F(2,97) = 197.80$, $p = 0.001$). High-arousing primes differed from low-arousing primes in the dimension of arousal ($p = 0.001$), and medium-arousing probes also differed from the high- and low-arousing primes in the dimension of arousal ($p = 0.001$). (3) All stimuli were matched in dominance and attractiveness ($F(2,97) = 0.53$, $p = 0.59$; $F(2,97) = 0.81$, $p = 0.45$, respectively).

2.3. Procedure

The stimuli were controlled with E-Prime software. A trial started with the presentation of a black fixation cross at the center of a white screen for 1000 ms. Next, a high- or low-arousing prime face was presented for 12 ms followed by the mask, which was presented for 200 ms. Then, a white screen was presented for 300 ms. Finally, the probe was presented until the participant responded. The intertrial interval was 1200 ms.

The 20 prime faces were randomly presented to the participant 8 times. Eighty probe faces were presented to the participant twice, once with a high-arousing prime and once with a low-arousing prime. The participant sat in a dimly lit, soundproof electromagnetic shielding chamber facing a CRT monitor located 1 m from the participant. A total of 160 trials were presented on the center of the screen, which subtended a visual angle of $5.25 \times 6.05^{\circ}$. The participants were instructed to rate the arousal of the probe on a 4-point scale using the D, F, J, and K keys of the keyboard. After the experiment, the visibility of the prime was assessed using the subjective measure method.

2.4. EEG recording

Electroencephalograms (EEGs) were recorded from 64 scalp sites using the 10–20 system with Ag/AgCl electrodes with the reference on the left mastoid. All electrode impedances were maintained below 5 kΩ. EEGs and EOGs were sampled at a digitization rate of 1000 Hz and filtered with a 0.05–100 Hz bandpass. Vertical electrooculogram (VEOG) recording electrodes were positioned above and below the left eye, and horizontal electrooculogram (HEOG) recording electrodes were positioned 1 cm from the outer canthus of each eye. EEGs and EOGs were re-referenced offline using the average of the right and left mastoid recordings.

2.5. Subject exclusion and behavioral data analysis

Two participants reported having perceived the effect of the prime. The ERP data from another participant contained too many artifacts. Thus, we included only 14 subjects in the behavioral and ERP analysis. Trials with reaction times (RTs) shorter than 200 ms or longer than the mean + 3 SD were not included in the analysis. The elimination rate was 1.22%. The remaining data were analyzed using repeated-measures ANOVA with one within-subject factor, i.e., prime arousal type (two levels: high and low), using the statistical software SPSS 16.0.

2.6. ERP data analysis

Offline correction of eye movement artifacts was performed. To exclude trials contaminated by artifacts, trials with voltages exceeding ± 80 μV at any electrode were discarded. A low-pass offline filter of 30 Hz (24 dB/oct) was applied. The signals were averaged offline over 1200 ms periods, and an additional 200 ms was recorded prior to the probe onset to allow for baseline correction. The ERPs were averaged separately for the low- and high-arousing trials.

The topographical distributions of the overall-averaged ERP activities (Fig. 1) indicated that the two experimental conditions provoked negative components that peaked at approximately 120 ms, 240 ms and 400 ms after the stimulus onset (i.e., the anterior N100, N200 and N400, respectively) and a positive component that peaked at approximately 180 ms after the stimulus onset (P200) on the front of the scalp. On the back of the scalp, the two experimental conditions provoked a positive component that peaked approximately 110 ms after the stimulus onset (P100) and a negative component that peaked approximately 140 ms after the stimulus onset (posterior N100). Furthermore, a positive component with an onset approximately 300 ms after the stimulus presentation (P300) was distributed over the medial anterior of the scalp, but this component was not obvious over the occipital scalp. An additional positive component that peaked approximately 560 ms after stimulus onset (i.e., the late positive component, LPC) was distributed over approximately the entire scalp.

Based on the topographical distribution of the grand-averaged ERP activities and previous studies, the ERP components and their time epochs were as follows: P100: 90–120 ms; anterior N100: 90–140 ms; posterior N100: 120–160 ms; P200: 150–210 ms; N200: 210–270 ms; P300: 270–330 ms; N400: 330–450 ms; and