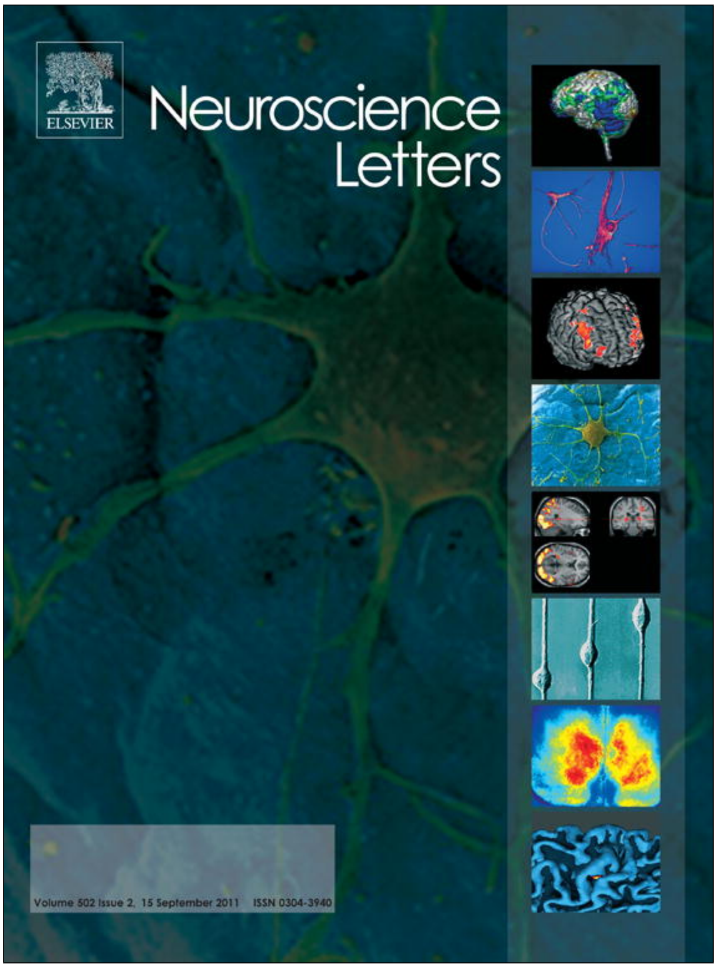

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The impact of emotion valence on brain processing of behavioral inhibitory control: Spatiotemporal dynamics

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ABSTRACT

Emotion is known to interact with behavioral inhibitory control (BIC), an ability critical for adaptive living. Nevertheless, how emotion valence influences this control, and the spatiotemporal dynamics underlying this influence, remain undetermined. For this purpose, the present study recorded event-related potentials (ERPs) for a standard stimulus which required no BIC, and for deviant stimuli that required controlling habitual responses during pleasant, neutral and unpleasant blocks. Behavioral results showed prolonged reaction times (RTs) and diminished accuracy rates for deviant than for standard stimuli, irrespective of the emotionality of deviants. Moreover, there were significant main effects of stimulus type, and significant stimulus and emotion interaction effects on the averaged amplitudes of the 200–300 ms and 300–500 ms intervals. Through analyzing the deviant–standard difference ERPs that index BIC directly, we found larger N2 and smaller P3 amplitudes during the unpleasant block than during the neutral block. The pleasant block, in contrast, showed a trend of more pronounced P3 amplitudes than the neutral block. Thus, by synchronizing BIC with emotion induction, we found distinct impact of pleasant and unpleasant emotions on behavioral inhibitory processing, not only in early monitoring of response conflicts but also in the late stage of response inhibition.

As an ability to inhibit inappropriate behaviors, behavioral inhibitory control (BIC) plays an indispensable role in adaptive living in the changing environments [13,17]. In life and lab settings, this control was known to be influenced by emotion, and the accomplishment of this control involves multiple processes, such as early monitoring of response conflicts and late conflict resolution through response inhibition [14,17]. In prior event-related potential (ERP) studies, these two processes were embodied by frontocentral N2 [8,12,14,16] and centroparietal P3 [11,17] components which, as indicated, were evoked in typical behavioral inhibitory control paradigms such as Go/Nogo tasks [11,16]. Accordingly, the emotion impact on brain processing of behavioral inhibitory control, shown by a handful of ERP studies, was evident in the early conflict monitoring or, in the late stage of response inhibition.

For example, using a Go/Nogo paradigm, Yu et al. [16] investigated the impact of auditory-induced emotion on the subsequent brain processing of behavioral inhibitory control. The results showed larger amplitudes for neutral than for emotional conditions in the Nogo-N2 component which indexes conflict monitoring [16] but not, in Nogo-P3 that directly reflects conflict resolution through top-down inhibitory processing. Recently, by presenting experimental trials in the context of emotional images, Albert et al. [1] observed larger amplitudes during positive than during negative contexts in Nogo-P3 but not, in Nogo-N2 associated with early monitoring of response conflicts. Apparently, despite using high time resolution ERP techniques, these studies observed an emotion impact on BIC only in a single stage of processing, unable to clarify the temporal dynamics underlying the entire phases of BIC processing [1,16].

Probably, this inability was attributed to the paradigm and the method of emotion induction, because preceding the task trials with emotion materials inevitably resulted in emotion attenuation [9,16]. Though Albert and colleagues requested subjects to perform the task in the context of emotional images, the repeated presentation of a single image in each block may result in emotion habituation that is most conspicuous for unpleasant emotion [9]. On the other hand, as Go trials involve motor responses that are absent in Nogo trials in the Go/Nogo paradigm, the inhibitory control effects in this task, indexed by amplitude differences between Nogo-P3 and Go-P3 components, is inevitably contaminated by

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motor response-related potentials [17]. Therefore, in order to clarify temporal dynamics of the emotion impact on behavioral inhibitory control, it is necessary to design a new paradigm that is able to overcome the emotion attenuation and the motor potential contamination.

With these considerations, the present study used a two-choice oddball task, during which behavioral inhibition was synchronous with emotion induction by different, non-repeated pictures; consequently to avoid the emotion attenuation/habituation that potentially undermines the quality of emotion induction. In the two-choice oddball task, Subjects were instructed to make a standard/deviant distinction by pressing different keys as accurately and rapidly as possible, irrespective of the emotionality of the deviants. Because the standard stimulus was presented much more frequently (85%) than deviants (15%), they have to inhibit prepotent responses to the standard stimulus during deviant trials. Consequently, reaction times (RTs) should be prolonged for deviant stimuli than for standard stimuli given effective inducement of BIC. Compared to the Go–Nogo task, the two-choice oddball task provides RT index of BIC, and supplies BIC specific ERPs free of motor contamination, as a result of counterbalanced responses to standard and deviant stimuli. Therefore, the impact of emotion on behavioral inhibitory control was realized by using emotionally unpleasant, neutral and pleasant pictures as deviant stimuli which, as analyzed above, involved inhibition of prepotent response tendency.

The present study used emotional pictures from the native Chinese Affective Picture System (CAPS) [2], in order to avoid the cultural bias when International Affective Picture System was used directly in Chinese subjects [6]. In order to avoid a possible trial-to-trial emotion interference that is prevalent in a random design, we used a block-design method for emotional inducement, which included a single category of emotional stimuli in each block. After overcoming the emotion attenuation/habituation through synchronizing behavioral inhibitory control with emotion induction, we hypothesized that emotion modulation effects may occur at each stage of BIC processing, probably both in early detection of response conflicts and in late conflict resolution through response inhibition.

Eighteen undergraduate students took part in the experiment as paid volunteers (9 female, 9 males; mean age: 21.2, range 19–24). All subjects were healthy, right-handed, with normal or corrected to normal vision, and reported no history of affective disorder. All participants signed an informed consent form for the experiment. The study was approved by the local review board for human participant research, and each subject gave informed consent prior to participating in the experiment.

The present study used a two-choice oddball task. A block design was adopted for emotional inducement. According to the valence of the deviant stimuli, the experiment was divided into three blocks: neutral, negative and positive. Thus, each block included a single category of pictures as the deviant stimuli. The sequence of the three blocks was counterbalanced across participants. Each block had 200 trials, including 170 standard and 30 deviant pictures (85% vs. 15%). All deviants were pictures taken from the CAPS [2]. A natural scene of a cup served as the frequent standard picture, and 90 pictures grouped as either neutral, negative, or positive served as the deviant stimuli. The pictures covered a variety of contents, such as emotionally positive, negative, or neutral animals (e.g. kittens, spiders, and eagles), natural scenes (e.g. sceneries, disasters, and harvests) and human activity (e.g. parties, violence, and sports). The sequence of standard and deviant pictures was randomized for each subject. In addition, we recruited another 65 subjects, who did not participate in the ERP experiment, to assess the arousal and valence of pictures used for this study. The results showed that the three groups of deviant pictures differed significantly in valence [M ± SD: Positive = 7.05 ± 0.29; Neutral = 5.58 ± 0.72; Negative = 2.04 ± 0.32; $F(2,87) = 839.934$, $P < 0.001$], but not in arousal [Positive = 6.07 ± 0.35; Neutral = 5.98 ± 0.29; Negative = 6.1 ± 0.26; $F(2,87) = 1.231$, $P > 0.05$], consistent with the data from the CAPS. All the pictures were identical in size and resolution (15 cm × 10 cm, 100 pixels per inch). In addition, the luminance level of the pictures was tested and controlled across the three picture conditions, while the contrast of the monitor was set to a constant value across subjects.

Subjects were seated in a quiet room at approximately 150 cm from a computer screen with the horizontal and vertical visual angles below 6°. Prior to the experiment, all subjects were told that this experiment was to investigate their ability to inhibit the prepotent response to the frequent standard picture when the deviant appears. At the end of each of the three blocks, accuracy rates for both standard and deviant stimuli were given to the subjects as a feedback of their performance. Each trial was initiated by a 300 ms presentation of a small black cross on the white computer screen. Then, a blank screen whose duration varied randomly between 500 and 1500 ms was presented and was followed by the onset of picture stimulus. The first 9 subjects were instructed to press the "F" key on the keyboard with their left index finger as accurately and then, quickly as possible if the standard picture appeared, and to press the "J" key with their right index finger if the deviant picture appeared. For the remaining subjects, the assignment of response hands was reversed for controlling the influence of response hands on ERPs that index brain processing of BIC. The presentation of stimulus picture was terminated by a key pressing, or was terminated when the picture elapsed for 1000 ms. Therefore, subject was informed that their responses must be made under 1000 ms. Each response was followed by 1000 ms of a blank screen. Pre-training with 10 practice trials was used before formal experiment in order to familiarize subjects with the procedure. All subjects achieved 100% accuracy on 10 practice trials prior to the formal experiment. In an interview session conducted immediately after the experiment, each subject was debriefed with respect to their performance during the task, in particular, in regards to their feelings about responses to deviant stimuli.

Electroencephalography (EEG) was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Products), with the references on the left and right mastoids and a ground electrode on the medial frontal aspect (average mastoid reference [10]), and a ground electrode was placed on the medial frontal aspect. Vertical electrooculograms (EOGs) were recorded supra- and infra-orbitally at the left eye. Horizontal EOG was recorded as the left vs. right orbital rim. EEG and EOG activity was amplified with a DC ∼ 100 Hz bandpass and continuously sampled at 500 Hz/channel. All electrode impedances were maintained below 5 kΩ. ERP averages were computed off-line; trials with remaining EOG artifacts (mean EOG voltage exceeding ±80 μV) and those contaminated with artifacts due to amplifier clipping, or peak-to-peak deflection exceeding ±80 μV were excluded from averaging.

EEG activity for correct responses during either condition was averaged separately. ERP waveforms were time-locked to the onset of stimuli and the average epoch was 1000 ms, including a 200 ms pre-stimulus baseline. The following 15 electrode sites [Fz, F3, F4 (3 frontal sites), FCz, FC3, FC4 (3 frontal–central sites), Cz, C3, C4 (3 central sites), CPz, CP3, CP4 (3 central–parietal sites), Pz, P3, and P4 (3 parietal sites)] were selected for statistical analysis. Because deviant stimuli were associated with BIC that was absent in the standard trials, the impact of emotion on BIC was quantified by analyzing how the size of deviant–standard differences in behavioral and ERP measures varied across emotion blocks. As shown in Fig. 1(a), amplitude differences between the standard and the deviant conditions started at about 200 ms post stimulus, and the size of amplitude differences varied as a function of emotion blocks

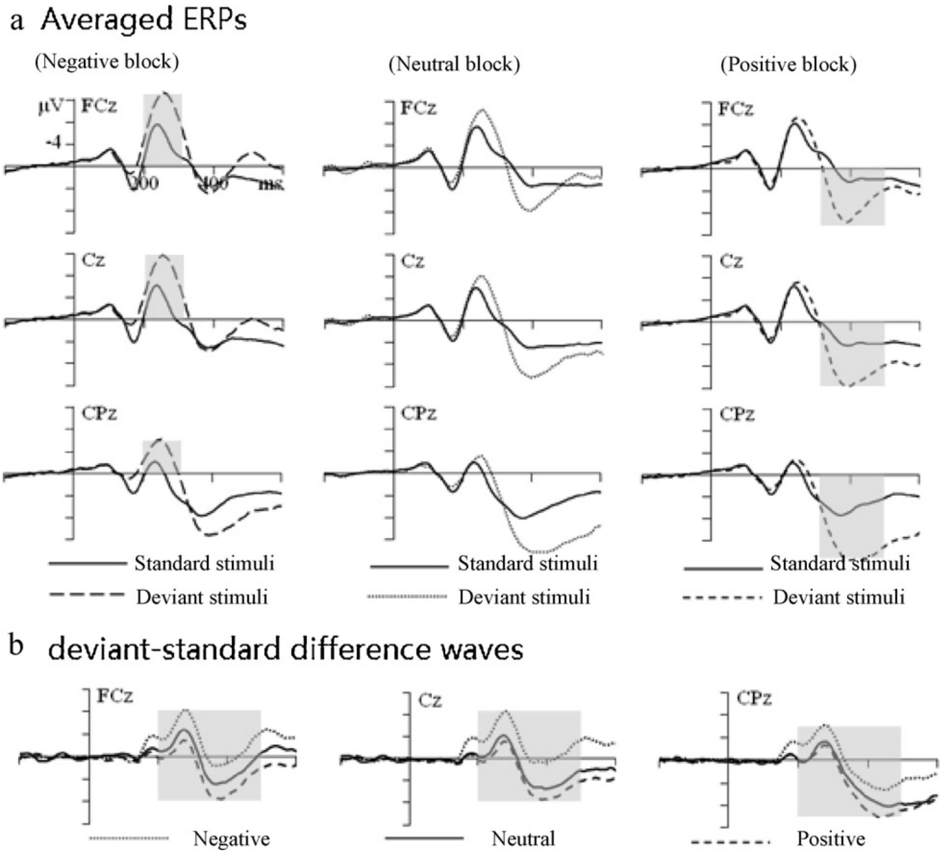

Fig. 1. Top: Averaged ERPs elicited by the standard and deviant stimuli during negative (left), neutral (middle) and positive (right) blocks. Bottom: The deviant–standard difference ERPs in the negative, neutral and positive blocks.

[Fig. 1(b)]. For each block, these differences were manifested by a N2 component at 200–300 ms and a P3 component at 300–500 ms intervals in the deviant–standard difference waves (Fig. 1).

Therefore, the present study first examined the effect of stimulus type and its interaction with emotion block (positive, neutral, negative) by conducting a three-way repeated measures analysis of variance (ANOVA) for the averaged amplitudes at 200–300 ms and 300–500 ms intervals, respectively. ANOVA factors were stimulus type (standard, deviant), block (neutral, negative, positive) and electrode sites (15 sites). Based on the significant stimulus by block interaction effects that indicate emotion impact on BIC processing, we further measured peak latencies and peak amplitudes (baseline to peak) of the BIC-related N2 and P3 components at corresponding intervals. A repeated measures ANOVA was conducted on the amplitudes and latencies of these components with block (neutral, negative, positive) and Electrode (15 sites) as factors. The degrees of freedom of the *F*-ratio were corrected according to the Greenhouse–Geisser method in all these analyses.

Behavioral accuracy reached a ceiling effect, possibly because the task highlighted accuracy over response speed. However, the ANOVA on the accuracy showed a significantly higher response accuracy for the standard (99%) than for the deviant (96%) conditions [$F(1,17) = 9.363$, $P < 0.01$]. In addition, deviant stimuli elicited longer response latencies than did standard stimuli [$F(1,17) = 250.504$, $P < 0.001$]. The RTs for deviant and standard stimuli were 545 ms vs. 417 ms for negative; 563 ms vs. 417 ms for neutral; and 555 ms vs. 429 ms for positive blocks. Nevertheless, there were no significant stimulus and block interaction effects in both accuracy [$F(2,34) = 1.044$, $P > 0.05$] and RT [$F(2,34) = 2.794$, $P > 0.05$] data. Thus, despite a significant effect of BIC in both accuracy and RT measures, there was no significant emotion impact on BIC in behavioral levels, possibly because behavioral measures are less sensitive than ERP measures in unraveling the emotion impact on BIC processing.

The repeated measures ANOVA on the averaged amplitudes of the 200–300 ms interval revealed significant main effects of stimulus [$F(1,17) = 16.173$, $P < 0.005$] and electrode sites [$F(14,238) = 47.076$, $P < 0.001$], as well as a significant three-way interaction amongst stimulus type, block, and electrode sites [$F(28,476) = 2.971$, $P < 0.05$]. The amplitudes in this interval were largest at frontocentral sites [e.g. FCz; Fig. 1(a)], while deviant stimuli elicited larger amplitudes than did the standard stimulus, regardless of block types. The breakdown of the three-way interaction showed a significant stimulus type × block interaction at frontal [$F(2,34) = 9.118$, $P < 0.01$], frontal–central [$F(2,34) = 8.305$, $P < 0.01$], central [$F(2,34) = 8.631$, $P < 0.01$] and central–parietal [$F(2,34) = 5.526$, $P < 0.01$] sites, but not in the parietal sites [$F(2,34) = 2.\ 05$, $P = 0.148 > 0.05$].

Moreover, there were significant main effects of stimulus [$F(1,17) = 12.94$, $P < 0.005$] and electrode sites [$F(14,238) = 56.832$, $P < 0.001$], as well as a significant stimulus type × block × electrode site interaction [$F(28,476) = 3.767$, $P < 0.005$] on the averaged amplitudes of the 300–500 ms interval. The deviant stimuli elicited larger amplitudes than did the standard stimulus, and the amplitudes were largest over parietal sites (e.g. Pz). To break down the three-way interaction amongst stimulus, block and electrode sites, we explored the stimulus & block interaction at each of the five scalp regions, respectively. The results showed a significant stimulus type by block interaction at frontal [$F(2,34) = 11.318$; $P < 0.001$], frontal–central [$F(2,34) = 10.647$, $P < 0.001$], central [$F(2,34) = 11.655$, $P < 0.001$] and central–parietal [$F(2,34) = 5.886$, $P < 0.01$] sites but not in the parietal [$F(2,34) = 2.53$, $P = 0.095 > 0.05$] sites. Therefore, the stimulus and block interaction effect was significant at central-to-frontal sites in both 200–300 ms, and

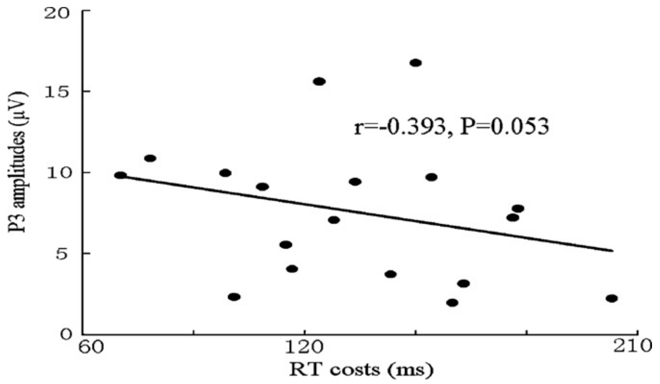

Fig. 2. The scatterplot for the correlation between the P3 amplitudes and deviant–standard RT costs ($n = 18$).

300–500 ms time intervals, implying that the impact of emotion valence on BIC happens in both early conflict detection and late response inhibition stages.

Based on the significant stimulus and block interaction at corresponding intervals, we further analyzed the peak amplitudes and latencies of N2 and P3 components which directly reflect processes of BIC, in the deviant–standard difference waves. The repeated measures ANOVA on the N2 amplitudes demonstrated significant main effects of emotion block [$F(2,34) = 6.279$, $P < 0.01$] and electrode sites [$F(14,238) = 3.496$, $P < 0.05$], as well as a significant block and electrode site interaction [$F(28,476) = 3.259$, $P < 0.005$]. The N2 amplitudes were more pronounced at central than at other sites. The negative block (Mean: −7.27 μV) elicited larger amplitudes than the neutral [Mean: −4.94 μV; $F(1,17) = 7.65$, $P < 0.05$] block which, however, exhibited similar amplitudes compared with the positive block [Mean: −4.04 μV; $F(1,17) = 0.94$, $P = 0.35$] from centroparietal to frontal sites. The main effect of block, however, was non-significant in the parietal sites [$F(2,34) = 2.\ 61$; $P > 0.08$]. The analysis of N2 latencies showed no any main or interaction effects.

Moreover, the analysis of P3 amplitudes demonstrated a significant main effect of emotion block [$F(2,34) = 7.707$, $P < 0.01$] and a main effect of electrode sites [$F(14,238) = 12.951$, $P < 0.001$]. The pairwise comparison for the main effect of block showed larger P3 amplitudes during the positive [$F(1,17) = 12.52$, $P < 0.01$] and the neutral blocks [$F(1,17) = 4.629$, $P < 0.05$] than during the negative block (Mean: 6.17 μV). The amplitude differences between positive (Mean: 10.19 μV) and neutral (Mean: 8.53 μV) blocks, however, failed to meet statistical significance [$F(1,17) = 4.03$, $P = 0.061$] despite a trend of larger amplitudes for the positive block. In addition, the P3 amplitudes were largest at centroparietal sites [Fig. 1(b)]. The analysis of P3 latencies showed no other main effect or interaction, except for a significant main effect of electrode sites [$F(14,238) = 20.753$, $P < 0.01$]. The P3 latencies were prolonged at posterior-parietal than at central-to-frontal sites.

Furthermore, to test whether the P3 amplitudes were valid predictors for BIC, we ran a correlation analysis between the P3 amplitudes, and deviant–standard RT costs that behaved as the behavioral index of BIC. The P3 amplitudes and the RT costs were both obtained by collapsing across the three blocks. The results displayed a trend of reduced RT costs as a result of increased P3 amplitudes, indicated by a marginally significant correlation between the two variables ($r = -0.393$, $P = 0.053$; Fig. 2). This suggested that the P3 amplitude was a valid index of response inhibitory processing.

In the present study, subjects were required to make a standard/deviant distinction by accurately pressing different keys. As indicated by previous studies, response conflicts should be large when a low-frequency response must be made in a context of producing stereotyped or habitual responses [12]. Consistent with this account, our behavioral data showed slower RTs and higher error rates during deviant vs. standard conditions, disregarding of block types. Moreover, the deviant stimuli elicited larger amplitudes compared to the standard stimulus, in the central-N2 (200–300 ms) and centroparietal P3 (300–500 ms) components whose morphology fits that of the classic BIC-related components [4,14,15]. These behavioral and ERP data jointly suggest that the two-choice oddball task used in this study was valid in inducing processes of BIC. In fact, in the post-experiment interview session, all subjects reported more hesitant in responding to deviant stimuli in case of stereotyped responses, despite many efforts they made for accurate responding to both stimulus types. The validity of the P3 in indexing response inhibition was confirmed by the correlation between the P3 amplitudes and the deviant–standard RT costs.

There was a significant main effect of stimulus type, and a significant stimulus type by block interaction on the averaged amplitudes of the 200–300 ms interval. In the present study, the significant main effect of stimulus was manifested by a pronounced central-N2 component in the deviant–standard difference waves that directly index brain processing of BIC. Similarly, the significant stimulus by block interaction was manifested by more pronounced N2 amplitudes during the negative than during the neutral and positive blocks in the deviant–standard difference waves. The central-N2 in response inhibition tasks was accepted as an index of response conflict monitoring, and increased attention engagement that forms the basis for later response inhibition [3,16,17]. Because negative emotion is associated with enhanced attention alerting [7,18], the enhanced N2 amplitudes in the negative block likely reflected the potentiation of response conflict monitoring with negative stimulation. In contrast, the task-irrelevant pleasant information did not produce such an enhancement, probably because pleasant stimuli are less biologically significant such that they did not evoke an emotion impact as early as unpleasant stimuli [19].

Also, there was a significant main effect of stimulus type, and a significant stimulus type by block interaction on the averaged amplitudes of the 300–500 ms interval. The significant main effect of stimulus was manifested by a pronounced centroparietal P3, while the stimulus by block interaction was embodied by the larger P3 amplitudes during the neutral and positive blocks than during the negative block, in the deviant–standard difference waves. In the present study, response inhibition resulted in larger P3 amplitudes during the deviant than during the standard conditions [Fig. 1(a)], which was in agreement with abundant prior reports [1,11,17]. However, the P3 enhancement during the deviant vs. standard conditions, shown by the size of P3 measured in the deviant–standard difference waves, was compromised during the negative than during the other two blocks. In our study, subjects performed the same task of standard/deviant distinction, and the onset frequency of the deviant stimuli was equated in different blocks. Thus, there should not have been amplitude differences in the BIC-related P3, if the deviant pictures did not include emotional information that required additional processing in the positive and negative blocks.

Though inhibition of prepotent motor responses was associated with increased P3 amplitudes [11], the inhibitory control of task-irrelevant distracting information was known to result in smaller P3, or LPC amplitudes as substantiated by abundant cognitive control studies [8,17,18]. This might account for the smaller amplitudes of difference P3 during the unpleasant than during the other two blocks. The human brain must recruit a process of cognitive control to inhibit the negativity bias in conflict detection-related N2 stage, since the emotionality is task-irrelevant (for a discussion, see [19]). On the other hand, the amplitudes tended to be larger in the pleasant than in the neutral blocks. This resembled Albert group's observation that response inhibition produced larger P3 amplitudes in pleasant context, as a result of increased approach motivation and heightened response tendencies [1,5]. This explanation, however, should be cautious because the P3 differences between positive and neutral blocks failed to meet statistical significance.

In summary, by synchronizing emotion induction with performance of behavioral inhibitory control, the present study developed our understanding of the emotion interaction with BIC, by showing that pleasant and unpleasant emotions are different in impact on brain processing of behavioral inhibitory control, not only in early monitoring of response conflicts but also in the late stage of response inhibition. Unpleasant emotion, but not pleasant emotion, influenced the early stage of BIC by enhancing the monitoring of response conflicts. In the subsequent response inhibition, the unpleasant block was associated with smaller P3 amplitudes probably as a result of cognitive control over distracting emotionality. In contrast, the mobilization of response inhibition tended to be more pronounced during the pleasant than during the neutral blocks, most likely due to enhanced response tendencies under pleasant stimulation. Future studies should consider using this paradigm to investigate the temporal features of the emotion impact on BIC in patients of inhibitory control dysfunction, such as in manic-depressive patients worse in self regulation. This is helpful for clarifying which stage (s) of BIC dysfunctions under emotion in these patients, which may lend an insight into the development of treatment strategies.

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References

[1] J. Albert, S. López-Martín, L. Carretié, Emotional context modulates response inhibition: neural and behavioral data, Neuroimage 49 (2010) 914–921.
[2] L. Bai, H. Ma, Y.X. Huang, Y.J. Luo, The development of native Chinese affective picture system-A pretest in 46 college students, Chin. Ment. Health J. 19 (2005) 719–722.
[3] M. Eimer, Effects of attention and stimulus probability on ERPs in a Go/Nogo task, Biol. Psychol. 35 (1993) 123–138.
[4] M. Falkenstein, J. Hoormann, J. Hohnsbein, ERP components in Go/NoGo tasks and their relation to inhibition, Acta Psychol. 101 (1999) 267–291.
[5] B.L. Fredrickson, The broaden-and-build theory of positive emotions, Philos. Trans. R. Soc. B. 359 (2004) 1367–1377.
[6] Y.X. Huang, Y.J. Luo, Native assessment of international affective picture system, Chin. Ment. Health J. 9 (2004) 631–634.
[7] J. Jiang, A.J. Scolaro, K. Bailey, A. Chen, The effect of music-induced mood on attentional networks, Int. J. Psychol. 46 (2011) 214–222.
[8] M. Liotti, M.G. Woldorff, R. Perez, H.S. Mayberg, An ERP study of the temporal course of the Stroop color–word interference effect, Neuropsychologia 38 (2000) 701–711.
[9] B.L. Liu, S. Xin, Z.X. Jin, Y. Hu, Y. Li, Emotional facilitation effect in the picture–word interference task: an ERP study, Brain Cogn. 72 (2010) 289–299.
[10] S.J. Luck, An Introduction to Event-Related Potentials and their Neural Origins, MIT, Cambridge, MA, 2005, p. 107.
[11] S. Nieuwenhuis, G. Aston-Jones, J.D. Cohen, Decision making, the P3, and the locus coeruleus–norepinephrine system, Psychol. Bull. 131 (2005) 510–532.
[12] S. Nieuwenhuis, N. Yeung, W. Van den Wildenberg, K.R. Ridderinkhof, Electrophysiological correlates of anterior cingulate function in a Go/NoGo task: effects of response conflict and trial type frequency, Cogn. Affect. Behav. Neurosci. 3 (2003) 17–26.
[13] D.A. Norman, T. Shallice, Attention to action, in: R.J. Davidson, G.E. Schwartz, D. Shapiro (Eds.), Consciousness and Self-regulation, vol. 4, Plenum Press, New York, 1986, pp. 1–18.
[14] A. Pfefferbaum, J.M. Ford, B.J. Weller, B.S. Kopell, ERPs to response production and inhibition, Electroencephalogr. Clin. Neurophysiol. 60 (1985) 423–434.
[15] N. Yeung, M. Botvinick, J.D. Cohen, The neural basis of error detection: conflict monitoring and the error-related negativity, Psychol. Rev. 111 (2004) 931–959.
[16] F.Q. Yu, J.J. Yuan, Y.J. Luo, Auditory-induced emotion modulates processes of response inhibition: an event-related potential study, Neuroreport 20 (2009) 25–30.
[17] J.J. Yuan, Y.Y. He, Q.L. Zhang, A.T. Chen, H. Li, Gender differences in behavioral inhibitory control: ERP evidence from a two-choice oddball task, Psychophysiology 45 (2008) 986–993.
[18] J.J. Yuan, S. Xu, J.M. Yang, Q. Liu, A.T. Chen, L.P. Zhu, J. Chen, H. Li, Pleasant mood intensifies brain processing of cognitive control: ERP correlates, Biol. Psychol. 87 (2011) 17–24.
[19] J.J. Yuan, Q.L. Zhang, A.T. Chen, H. Li, Q.H. Wang, Z. Zhuang, S.W. Jia, Are we sensitive to valence differences in emotionally negative stimuli? Electrophysiological evidence from an ERP study, Neuropsychologia 45 (2007) 2764–2771.