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Gender differences in behavioral inhibitory control: ERP evidence from a two-choice oddball task

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Abstract

The inhibition of inappropriate behaviors is important for adaptive living in changing environments. The present study investigated gender-related behavioral inhibitory control by recording event-related potentials for standard and deviant stimuli while subjects performed a standard/deviant distinction task by accurately pressing different keys within 1000 ms. The results showed faster reaction times (RTs) for deviant stimuli in women than in men, although RTs for standard stimuli were similar across genders. There were significant gender and stimulus interaction effects on mean amplitudes during each of the 170–230-ms, 250–330-ms, and 350–600-ms intervals, and women exhibited shorter latencies and larger amplitudes than men at deviant-related P2, N2, and P3 components. As an accurate, fast response to the rare deviant stimuli involves behavioral inhibitory control on the prepotent response whereas the response to the standard stimuli does not, it is clear that there is a general gender difference in behavioral control for human adults. This may relate to differential inhibitory demands by each gender during evolution.

Descriptors: ERP, Gender differences, Response conflict, Behavioral control

Behavioral control, which enables humans to withhold inappropriate behaviors in some contexts, allows people appropriate responses to meet complicated demands and to live adaptively in the changing environments (Goldstein et al., 2007; Li, Huang, Constable, & Sinha, 2006a; Norman & Shallice, 1986). As an important executive function, this ability is essential to the success of both men and women in modern (and, presumably, ancestral) society and may have played a critical role in the evolution of human intelligence, particularly social intelligence (Bjorklund & Shackelford, 1999; Li, Huang, Constable, & Sinha, 2006a). There is some evidence suggesting that men may be less able to control inappropriate behaviors than women. For instance, men were reported to be more sensation seeking and more frequently engage in risk-taking behaviors (Li et al., 2006; Rosenblitt, Soler, Johnson, & Quadagno, 2001). Moreover, it was indicated that behavioral inhibitory control of women was less impaired by alcohol consumption relative to that of men (Fillmore & Weafer, 2004). Using a cued go/no go task, Fillmore and colleagues demonstrated that, when the same dose of alcohol was administered, male subjects exhibited more failures in inhibiting a response to the no-go targets preceded by a go cue compared with women. This was suggested to relate with more alcohol-induced aggressions and other socially inappropriate behaviors in men versus women (Fillmore, 2003; Fillmore & Weafer, 2004).

This evidence implies that there might be gender differences in behavioral inhibitory control for human individuals. In addition, the studies on behavioral self-control in young children also suggested this difference (Cole, 1986; Kochanska, Murry, & Harlan, 2000). An early study indicated that female children (from 4 years and up) were better able to control their emotional expressions than their male peers, despite the fact that girls were more emotionally expressive than boys (Cole, 1986). More recently, several studies consistently indicated that girls were better in behavioral self-control than boys at a very young age, such that female children aged between 22 and 33 months outperform their male peers in nearly all respects of behavioral self-control (Chen & Sang, 2002; Kochanska et al., 2000). Nonetheless, whether gender differences in behavioral control during early years can predict the existence of the same difference in adults is still unknown. It is still unclear whether there is a general difference between men and women in behavioral control. Therefore, the present study investigates behavioral control and its association with gender, which may provide an insight into our knowledge about behavioral inhibitory control and its related individual differences.

As is known, the go/no go task is frequently used to investigate behavioral inhibitory control and its related neural correlates (Donkers and van Boxtel, 2004; Goldstein et al., 2007). In the go/no go task, subjects are typically asked to generate a response as fast as possible when the go stimulus is presented and

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to withhold their response if the no go stimulus is given. Because no go trials involve behavioral inhibitory control that is absent during go trials in this task, the differences, behaviorally or neurally, between no go and go trials are suggested to index inhibitory control effects (Donkers & van Boxtel, 2004; Nieuwenhuis, Yeung, Van den Wildenberg, & Ridderinkhof, 2003). However, as go trials involves motor responses whereas no go trials do not, the inhibitory control effects observed in studies using the go/no go paradigm are likely to be contaminated by response-related processes. This may be more noticeable in ERP studies, where late positive components, which index higher cognitive processes such as response inhibition, are particularly susceptible to motor potentials (Kok, 1988). Therefore, the present study used a two-choice oddball task that requires subjects to respond to both standard and deviant stimuli by pressing different keys as quickly as possible, instead of only responding to go stimuli in a go/no go task. The two-choice oddball task is similar to the classic go/no go task, with an exception that the former requires responses to both go and no go stimuli for an exclusion of motor contamination.

As the behavioral inhibitory control involves multiple processes such as earlier perceptual processing, conflict detection, and later response inhibition (Donkers and van Boxtel, 2004; Pfefferbaum, Ford, Weller, & Kopell, 1985), the present study employed the dense-array event-related potentials technique, which is known for high temporal resolution, to explore the temporal course of behavioral inhibitory control and its association with gender. Specifically, as the frontal-central P2 component was believed to index the early attentional recruitment that forms a basis for the later cognitive processing (Carretié, Mercado, Tapia, & Hinojosa, 2001; Chen et al., 2007; Yuan et al., 2007), it is likely that the early attentional enhancement for deviant stimuli is different between genders. Accordingly, it is likely to observe an amplitude or latency difference between men and women in the deviant-related P2 component. Furthermore, because frontal-central N2 is accepted as an index for conflicts detection (Chen et al., 2007; Liotti, Woldorff, Perez, & Mayberg, 2000; Nieuwenhuis et al., 2003; Yeung, Botvinick, & Cohen, 2004) whereas the later response inhibition was suggested to modulate P3 amplitudes (Chen et al., 2007; Donkers & van Boxtel, 2004; Nieuwenhuis, Aston-Jones, & Cohen, 2005), we expect to see a modulation effect of gender on amplitudes or latencies of N2 and P3 components in the deviant–standard difference wave that indexes processes of behavioral inhibitory control. In addition, we hypothesize that posterior N1, which is associated with the early visual processing and is less relevant to cognitive processing (Chen et al., 2007; Mangun, 1995; Yuan et al., 2007), would not be different between genders and stimulus types.

In the current study, subjects were instructed to make a standard/deviant categorization by pressing different keys as accurately and, then, as quickly as possible. The onset sequence of standard and deviant stimuli was randomized for each subject, and accurate responses to both standard and deviant stimuli were emphasized during the task. Because standard stimuli were presented much more frequently than deviants, subjects had to inhibit prepotent responses to standard stimuli during deviant stimulus onset, consequently, to make a correct response to deviant stimuli. Thus, the present study was interested in the reaction times of each gender to deviant stimuli, and men and women may differ in their reaction times (RTs) for deviant stimuli given the existence of gender differences in behavioral control. Moreover, as the processing of deviant stimuli involves behavioral inhibitory control that was absent during standard trials, we focused on the effect of gender on the deviant–standard difference ERPs that reflect processes of behavioral inhibitory control.

Methods

Participants

As paid volunteers, 15 female (18–22 years old; $M = 21.1$ years) and 15 male (18–22 years old; $M = 20.8$ years) undergraduate students participated in the experiment. All participants were healthy, right-handed, and had normal or corrected-to-normal vision. All participants signed an informed consent form for the experiment. The experiment was approved by the Academic Committee of the School of Psychology, Southwest University in China.

Stimuli and Experimental Procedure

The present study used a modified oddball task, and the experiment had four blocks of 100 trials, with each block including 75 standard and 25 deviant stimuli (75% vs. 25%). A natural scene of a cup served as the standard stimulus and 100 emotionally neutral images as the deviant stimuli (Bai, Ma, Huang, & Luo, 2005). The onset sequence of the standard and deviant pictures was randomized for each subject. In addition, all the pictures used in the current study were identical in size and resolution (15×10 cm^2, 100 pixels per inch).

Subjects were seated in an acoustically isolated room at approximately 150 cm from a computer screen; thus, the horizontal and vertical visual angles were both below 6°. Prior to the experiment, subjects were told that the experiment investigated their ability to make a fast response selection and their ability to inhibit the prepotent response to the frequent standard picture when the deviant appeared. At the end of each block, accuracy rates for both standard and deviant stimuli were offered as 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 from 500 to 1500 ms was presented and was followed by the onset of the picture stimulus. Within each gender, the first 8 subjects were instructed to press the "F" key with their index finger (as accurately and quickly as possible) if the standard picture appeared and to press the "J" key 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 behavioral inhibitory control (Alexander & Polich, 1995). The presentation of the stimulus picture was terminated by a key pressing or was terminated when the picture appeared for 1000 ms. Therefore, subjects were informed that their responses must be made within 1000 ms. Each response was followed by 1000 ms of a blank screen. Pretraining with 10 practice trials was used before the experiment to familiarize subjects with the procedure, and the deviant images used during the practice were not used in the experiment. All subjects achieved 100% accuracy during practice. 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.

ERP Recording and Analysis

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. Vertical electrooculograms (EOGs) were recorded supra- and infraorbitally at the left eye. Horizontal EOG was recorded as the left versus right orbital rim. EEG and EOG activity was amplified with a DC $\sim$ 100 Hz bandpass and continuously sampled at 500 Hz/channel. All electrode impedances were maintained below 5 kΩ. An automated eye-movement correction program was used before artifact rejection. ERP averages were computed off-line; trials with remaining EOG artifacts (mean EOG voltage exceeding ± 80 μV), amplifier clipping artifacts, or peak-to-peak deflection exceeding ± 80 μV were excluded from averaging.

EEG activity for correct response during either condition was overlapped and averaged separately. ERP waveforms were time-locked to the onset of stimuli, and the average epoch was 900 ms, including a 200-ms prestimulus baseline. The following 15 electrode sites were selected for statistical analysis: F3, FC3, C3, CP3, P3, Fz, FCz, Cz, CPz, Pz, F4, FC4, C4, CP4, and P4. Firstly, to see whether there is a gender difference in early visual processing, the posterior N1 component, which peaked approximately 160 ms after stimulus onset, was measured and analyzed at 130–190 ms across six inferior parietal and occipital sites (P7, P8, PO7, PO8, O1, and O2; Figure 1). More importantly, as shown by Figures 2 and 3, amplitude differences between standard and deviant conditions started at about 200 ms across genders, and these differences were manifested by a P2 at 170–230 ms, an N2 at 250–330 ms and a P3 at 350–600 ms in the deviant–standard difference wave. Moreover, the deviant-related P2, N2, and P3 components were more prominent in women than in men. Thus, the present study first examined Stimulus (standard, deviant) $\times$ Gender (male, female) interaction effects for the averaged amplitudes at 170–230 ms, 250–330 ms, and 350–600 ms, by conducting a repeated measures analysis of variance (ANOVA) (Stimuli and Electrode were repeated factors whereas Gender was a between-subjects factor). Based on significant Stimulus $\times$ Gender interaction effects, we further measured peak latencies and amplitudes (baseline to peak) of the deviant-related P2, N2, and P3 components at corresponding intervals. A repeated measures ANOVA was conducted on the latencies and amplitudes of these components with Electrode (15 sites) as a within-subject factor and Gender as a between-subjects factor. The degrees of freedom of the F-ratio were corrected according to the Greenhouse–Geisser method in all these analyses.

Results

Behavioral Results

False responses were rare, as accuracy rates for both standard and deviant stimuli approached 100% in all subjects. The mean reaction times of each gender for the standard and deviant stimuli were shown in Table 1. The repeated measures ANOVA (Stimulus as a repeated factor and Gender as a between-subjects factor) showed a significant Stimulus main effect, $F(1,28) = 35.17$, $p < .001$, and a significant Stimulus $\times$ Gender interaction effect, $F(1,28) = 4.51$, $p < .05$. The further analysis of the Gender $\times$ Stimulus interaction effect showed a significant Stimulus effect in men, $F(1,14) = 28.52$, $p < .001$, and in women, $F(1,14) = 8.39$, $p < .02$. Both genders showed longer RTs for deviant stimuli than for standard stimuli. Moreover, the RTs for deviant stimuli were significantly shorter in women than in men, $F(1,28) = 10.71$, $p < .01$, whereas the two groups exhibited comparable RTs for standard stimuli, $F(1,28) = 0.15$, $p > .1$. Obviously, both genders

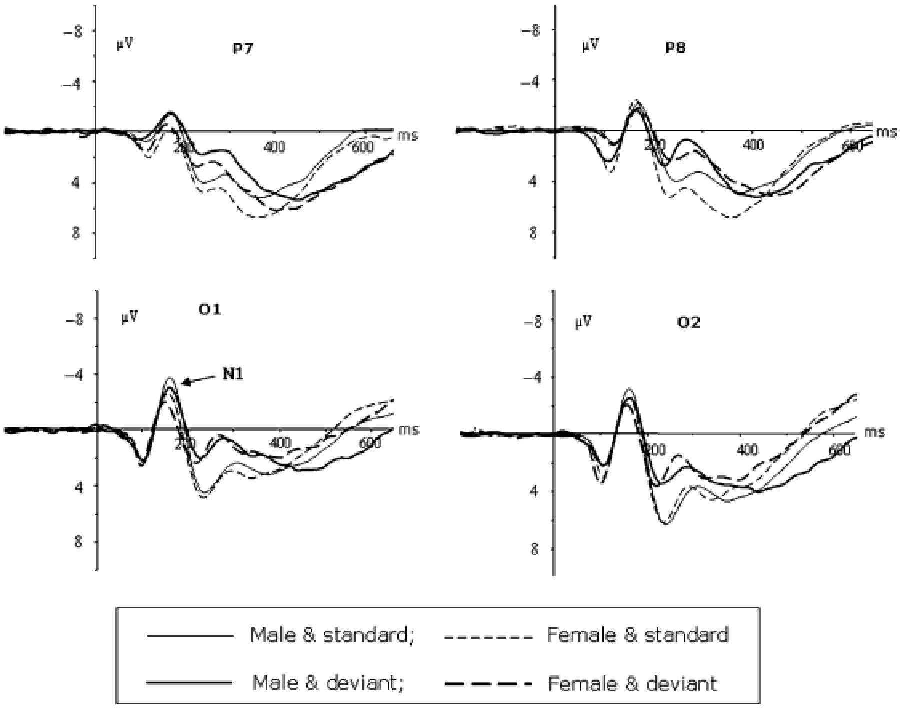

Figure 1. Grand averaged ERPs elicited during standard (women: fine dashed lines; men: fine solid lines) and deviant (women: bold dashed lines; men: bold solid lines) conditions at inferior parietal and occipital sites (P7, P8, O1, and O2).

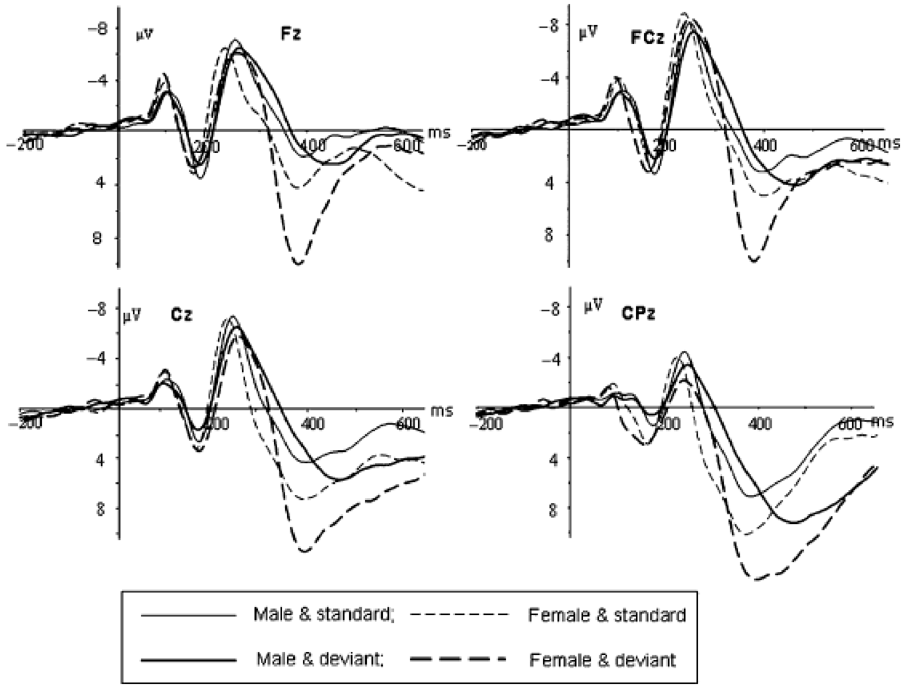

Figure 2. Grand averaged ERPs elicited during standard (women: fine dashed lines; men: fine solid lines) and deviant (women: bold dashed lines; men: bold solid lines) conditions at Fz, FCz, Cz, and CPz electrode sites.

exhibited effects of behavioral inhibitory control during deviant condition, as indexed by longer RTs elicited across genders. Women responded to deviant stimuli faster than men, suggesting a better ability of behavioral inhibitory control in women than in men.

ERP Analysis

Posterior N1. The repeated measures ANOVA for posterior N1 showed no significant main or interaction effects for either amplitude or latency, except for a main effect of amplitude at Electrode Site, $F(5,140) = 4.80$, $p < .01$. The N1 amplitudes recorded at occipital sites (O1, O2) were larger than those at other sites.

Stimulus and gender interaction effects. The repeated measures ANOVA on the mean amplitudes during the 170–230-ms interval showed a significant main effect of Electrode Site, $F(14,392) = 67.96$, $p < .001$, and a significant Gender × Stimulus interaction effect, $F(1,28) = 5.63$, $p < .05$. The averaged amplitudes across four conditions were larger at anterior sites than at posterior sites, and the amplitude differences between standard and deviant conditions were larger in women than in men. Similarly, the repeated measures ANOVA conducted at the 250–330-ms interval revealed a significant interaction effect between Stimulus and Gender, $F(1,28) = 5.77$, $p < .05$, in addition to significant main effects at Stimulus, $F(1,28) = 20.63$, $p < .001$, and Electrode Site, $F(14,392) = 50.05$, $p < .001$. Deviant stimuli elicited increased negativity compared to standard stimuli across genders, and the amplitudes were larger at anterior sites than at posterior sites.

Moreover, the repeated measures ANOVA also demonstrated a significant Stimulus × Gender interaction effect at 350–600 ms. In addition, the main effects of Stimulus, $F(1,28) = 9.48$, $p < .01$, Electrode Site, $F(14,392) = 27.05$, $p < .001$, and Gender, $F(1,28) = 8.99$, $p < .01$, were also significant during this interval. Deviant stimuli elicited greater positivity than standard stimuli across genders, and the amplitudes were larger in women than in men across stimulus conditions.

Gender effects in difference ERPs. Therefore, the Stimulus × Gender interaction effect was significant at each of the 170–230-ms, 250–320-ms, and 350–600-ms time intervals. The repeated measures ANOVA conducted in the deviant–standard difference ERPs revealed a significant main effect of Gender for the P2, $F(1,28) = 5.28$, $p < .05$, N2, $F(1,28) = 8.21$, $p < .05$, and P3 amplitudes, $F(1,28) = 11.03$, $p < .01$. Larger deviant-related amplitudes were recorded in women than in men across the P2, N2, and P3 components. Additionally, a main effect of amplitude at electrode sites was significant for both P2, $F(14,392) = 23.71$, $p < .001$, and P3, $F(14,392) = 31.67$, $p < .001$, components. P2 amplitudes were larger at central and frontal sites than at parietal sites, whereas P3 amplitudes were largest at parietal sites. Moreover, a significant main effect of Gender was observed for P2, $F(1,28) = 7.39$, $p < .05$, N2, $F(1,28) = 8.40$, $p < .01$, and P3, $F(1,28) = 9.72$, $p < .01$, latencies, and a main effect of Electrode Site was also significant for the P3 latency, $F(14,392) = 10.03$, $p < .001$. Men elicited longer peak latencies than did women across the P2, N2, and P3 components whereas P3 latency was longer at posterior sites than at anterior sites. Because P2, N2, and P3 are all deviant-related components that are associated with processes of behavioral control, it is apparent that there are general gender differences in behavioral control for human individuals.

Discussion

In the present study, subjects were required to make a standard/deviant distinction by accurately pressing different keys within 1000 ms. As indicated by previous studies, response conflicts

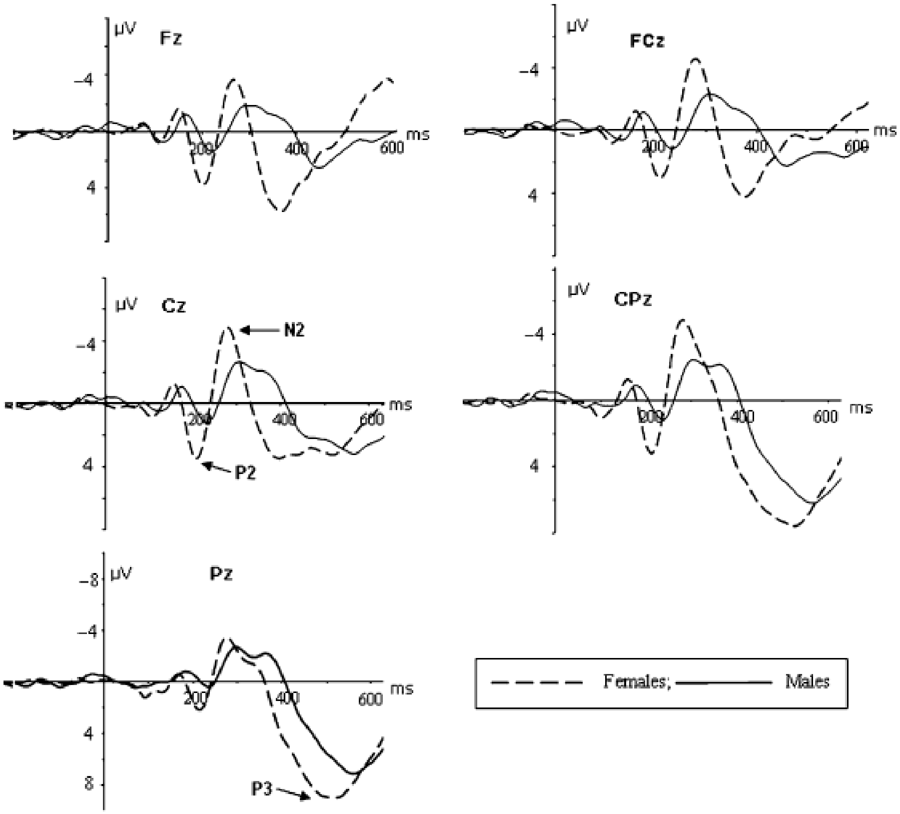

Figure 3. The averaged deviant minus standard difference ERPs in female (dashed lines) and male (solid lines) subjects at the scalp midline electrode sites (Fz, FCz, Cz, CPz, and Pz).

should be large when a low-frequency response must be made in a context of producing stereotyped or habitual responses: For the low-frequency response to be executed, it must compete with and eventually overcome the bias toward producing the prepotent response tendency (Braver, Barch, Gray, Molfese, & Snyder, 2001; Jones, Cho, Nystrom, Cohen, & Braver, 2002; Nieuwenhuis et al., 2003). Consistent with these observations, the present study recorded slower RTs during deviant versus standard conditions, irrespective of gender (Table 1). The standard stimulus, which resembles frequent go stimuli that elicit prepotent response in go/no go or stop-signal tasks (Li et al., 2006 a and b; Nieuwenhuis et al., 2003), was presented frequently in the present study. This set up a prepotent response tendency that facilitates participants' performance during the standard condition. Therefore, processes of behavioral inhibitory control must be recruited on the prepotent response during the presentation of deviant images, consequently, for subjects to respond correctly to deviant stimuli.

In the present study, we found that early visual processing reflected by posterior N1 was not significantly different across stimulus conditions and genders. This was most likely because both standard and deviant stimuli are natural scenes, equal in size and resolution. In addition, this suggests that processes of behavioral inhibitory control, as a higher cognitive activity, may occur at later stages. At the 170–230-ms interval, a prominent frontal P2 component was observed in the deviant–standard difference wave, and women elicited larger amplitudes and shorter latencies than men at this component (Figure 3). It has been established that frontal P2 that occurs around 200 ms post-stimulus is indicative of early perceptual processing and features detection (Chen et al., 2007; Thorpe, Fize, & Marlot, 1996; Yuan et al., 2007). Also, frontal P2 activity is considered as mirroring early attentional recruitment that provides a basis for subsequent cognitive processing (Carretié et al., 2001; Chen et al., 2007; Yuan et al., 2007). Therefore, the prominent P2 observed in the

Table 1. *Averaged Reaction Times for Deviant and Standard Stimuli in Each Gender ($M \pm SD$) and the Results of Simple Effects Analyses for the Interaction Effect between Stimulus and Gender*

	Women	Men	Simple effects
Standard	455.4 ± 46.0	461.93 ± 47.0	$F(1,28) = 0.15$, $p = .70$
Deviant	498.0 ± 46.5	552.0 ± 43.9	$F(1,28) = 10.71$, $p = .003$
Simple effects	$F(1,14) = 8.39$, $p < .02$	$F(1,14) = 28.52$, $p < .001$	

deviant–standard difference wave suggests that the brain detected some features that deviate from the context formed by standards. Accordingly, increased attentional resources were recruited for perceptual processing of deviant stimuli compared to that of standard stimuli, which most likely contributed to the occurrence of deviant-related P2 in both genders. Women elicited larger amplitudes and shorter latencies than men at this stage, which suggests that women were faster in detecting the occurrence of deviant stimuli and directed more attentional resources to these deviant features compared to men. The fast detection of deviant stimulus onset, as indexed by the deviant-related P2 across genders, formed the basis for the following detection and resolution of response conflicts that are central to behavioral control (Chen et al., 2007). Similarly, the gender effect observed during deviance detection implies that there may be gender differences in the detection and resolution of response conflicts at later stages (Nagy, Potts, & Loveland, 2003).

Furthermore, the present study revealed a significant Stimulus × Gender interaction effect during the 250–330-ms interval. A prominent N2 component, whose amplitudes were largest at central and frontal sites, appeared in the deviant–standard difference wave across genders. This interaction was expressed as the larger N2 amplitudes in women than in men. Previous studies indicated that frontocentral N2 is closely related to the detection of conflicts (Chen et al., 2007; Van Veen & Carter, 2002), and N2 amplitude was larger with conflict detection than without conflict detection (Chen et al., 2007). Moreover, as has been established, the centrofrontal oddball N2 elicited by deviant stimuli, which resembles "no-go" N200 evoked during a go/no-go task (Nieuwenhuis et al., 2003), is associated with detection of response conflicts (Nieuwenhuis et al., 2003; Yeung et al., 2004). In the present study, both genders displayed a pronounced deviant-related N2 component. This suggests that with the detection of features that deviate from context (Nagy et al., 2003), men and women both detected response conflicts that occurred during the deviant condition: The prepotent response tendency had to be inhibited for a correct response to deviant stimuli. More importantly, women exhibited higher amplitudes as well as shorter latencies than men in the deviant-related N2 component. This suggests that women were faster than men in detecting response conflicts, and greater processing resources were elicited in women versus men, to prepare for the subsequent resolution of response conflicts in later stages (Yuan et al., 2007).

Moreover, there was a conspicuous P3 component that appeared in the 350–600-ms interval of the deviant–standard difference wave in both genders. P3 amplitudes were largest at parietal sites. Our analyses revealed a significant Stimulus × Gender interaction effect during this interval. As judged by the scalp distribution of voltage amplitudes and the peak latencies (Campanella et al., 2002; Delplanque, Silvert, Hot, & Sequeira, 2005; Li, Yuan, & Lin, 2008), the P3 observed in the present study was actually a P3b component, which was widely accepted as relevant to later response decision making and inhibitory control processes (Donkers & van Boxtel, 2004; Nieuwenhuis et al., 2005). Usually, P3 amplitudes increase with the amount of cognitive resources recruited for response inhibition (Donkers & van Boxtel, 2004; Sebanz, Knoblich, Prinz, & Wascher, 2006): The more intense the inhibitive processes, the larger are the P3 amplitudes (Donkers & van Boxtel, 2004; Pfefferbaum et al., 1985). More noticeably, P3 elicited by no go stimuli, which indexes later response inhibition, was consistently reported to be more pronounced than that elicited by go stimuli during go/no go tasks (Donkers & van Boxtel, 2004; Pfefferbaum et al., 1985). Consistent with these findings, deviant stimuli, which involved response inhibition in the present study, elicited larger P3 amplitudes than standard stimuli across genders (Figure 2). This result coincided with our behavioral data showing longer RTs for deviant stimuli than for standard stimuli, irrespective of gender. Moreover, women exhibited larger deviant-related P3 amplitudes than men, suggesting that women recruited more intense processes of response inhibition than men during the deviant condition. Presumably, it is the enhanced response inhibition that contributed to women's faster response decision making for deviant stimuli. This probably accounts for our observation that women elicited shorter deviant-related P3 latencies and faster RTs for deviant stimuli compared to men (Figure 3; Table 1).

Thus, in the current study, ERP and behavioral data consistently demonstrated a better behavioral inhibitory control in women than in men during a two-choice oddball task. The female advantage in behavioral control was mainly expressed as the faster detection and the earlier resolution of response conflicts, which was unraveled by the gender effects at the N2 and P3 components. In more detail, during deviant stimulus onset, women were earlier in detecting stimulus features that deviate from the context; this facilitated women's detection and resolution of response conflicts during later stages (Nieuwenhuis et al., 2003). Thereafter, women were faster in detecting response conflicts, and this conflict elicited more processing resources in women versus men to prepare for later conflict resolution. Moreover, women recruited an increased response inhibition at the later stage, which contributed to their earlier response decision and faster RTs during thte deviant condition.

These results are supported by some pieces of evidence from prior behavioral studies. Some studies showed that women are better than men in withholding some socially inappropriate behaviors such as aggressive responses and improper sexual arousal (Bjorklund & Shackelford, 1999; Cerny, 1978). Furthermore, there is evidence that women are better than men on tasks that involve resisting temptation and delaying gratification (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996) or during tasks that require controlling emotional expressions (Cole, 1986). In addition, there is neuroimaging evidence showing similar gender differences in response inhibition. Using a stop-signal task that comprised a frequent go signal and a less frequent stop signal, the functional MRI study by Li and colleagues (2006b) investigated gender differences in response inhibition. The results showed that women engaged less cortical and subcortical activations to achieve comparable stop signal RTs and accuracy rates than men. All this evidence implies a female advantage in behavioral inhibitory control, though no prior studies used a typical behavioral control task, such as a go/no go task or the present two-choice oddball task, to find electrophysiological correlates for this difference and its temporal features. In fact, in the postexperiment interview session, all subjects reported that they tried their best to respond accurately during both stimulus conditions, and they were more hesitant in responding to deviant than to standard stimuli, in case of making a habitual response during the deviant condition. These self-reports provided evidence that the present two-choice oddball task, similar to go/no go or stop-signal tasks, is effective in eliciting response conflict and inhibition and that subjects indeed recruited processes of behavioral control for a correct response to deviants in the present study. In addition, subjects, irrespective of gender, also reported that they were highly engaged in the fast standard/deviant distinction such that they did not even notice the details of deviant images before key pressing. All these self-reports suggest that, despite multiple deviant images used, the behavioral as well as ERP results observed in the present study indeed index gender differences in behavioral inhibitory control.

The reasons for the gender difference in behavioral inhibitory control, however, are far from clear as yet. One possibility is that it is beneficial for women to have greater behavioral inhibitory control ability during the evolutionary process (Bjorkland & Kipp, 1996; Bjorklund & Shackelford, 1999). Prior studies suggested that ancestral women may have needed greater inhibitory abilities than ancestral men in many contexts (Bjorkland & Kipp, 1996). For example, because of their greater parental investment, it is evolutionarily beneficial for ancestral women to have greater control of their sexual arousal and related behaviors. Similarly, child-care responsibilities mainly fall to women after infants' birth, which may also require greater behavioral inhibitory abilities (Bjorkland & Kipp, 1996). For example, mothers have to put the needs of their infants ahead of their own and inhibit their aggressive behaviors toward their infants who disobey or cry continuously (Kochanska et al., 1996). Evidently, this hypothesis requires further investigation.

Conclusions

The present study revealed a female advantage in behavioral inhibitory control by use of a two-choice oddball task. Overall, women are faster in detection and resolution of response conflicts. Moreover, women recruited increased neural resources relative to men during processes of conflicts detection and resolution. Thus, gender differences in behavioral inhibitory control are existent not only with alcohol consumption but also when subjects are under normal consciousness. This may relate to differential demands of behavioral inhibitory control by each gender during evolution.

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