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Brief article

Sex differences in how erotic and painful stimuli impair inhibitory control

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ABSTRACT

Witnessing emotional events such as arousal or pain may impair ongoing cognitive processes such as inhibitory control. We found that this may be true only half of the time. Erotic images and painful video clips were shown to men and women shortly before a stop signal task, which measures cognitive inhibitory control. These stimuli impaired inhibitory control only in men and not in women, suggesting that emotional stimuli may be processed with different weights depending on gender.

1. Introduction

Emotional stimuli such as those associated with erotic or painful feelings are highly salient to humans. For example, unconsciously processed nude pictures can capture attention and alter eye movement paths even when the pictures are not consciously perceived (Jiang, Costello, Fang, Huang, & He, 2006; Phelps, 2006; Tamietto & de Gelder, 2010). Indeed, studies on the topic of inhibitory control mechanisms have shown that seeing emotional stimuli (positive, neutral or negative) prior to performing a stop signal task, which assesses efficiency in inhibiting planned responses (Logan, Cowan, & Davis, 1984), can significantly impair people's inhibitory control (Verbruggen & De Houwer, 2007). Later studies further suggest that such impairment, and sometimes improvement, is closely associated with different levels of emotional salience (Pessoa, 2009). Together these studies highlight an important role for affective processes and how they interact with cognitive processes during response inhibition.

To measure the effects of emotional stimuli, we combined a stop signal task with either erotic pictures or painful video clips to test whether these emotional stimuli may induce different effects on inhibitory control for males and females. There are two types of trials in a stop signal task, go trials and stop trials. Participants were required to respond to a directional probe by pressing a corresponding button as quickly as possible in go trials, and withhold their response and not press the button when they saw a stop signal which was sometimes presented after the go signal. Since the paradigm can be set to adjust difficulty by altering the time of onset of the stop signal (stop signal delay, SSD) with a staircase procedure, the obtained measures, SSD and go reaction time, as well as their difference (stop signal reaction time, SSRT), provide an estimate of subjects' ability to inhibit a prepotent response.

Previous studies have illustrated that emotional stimuli can impair response inhibition, and that there are also different affective values between sexes when evaluating emotional pictures. Together, we proposed the hypothesis

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that differences between the two sexes in their emotional responses would result in differences in effects on response inhibition. We used erotic pictures and pain-related clips combined with a stop signal task to evaluate any sex differences in inhibitory control. There were two predictions: (1) erotic stimuli would only affect inhibitory control in the male group; (2) the effects of pain related stimuli would interact with sex. Additionally, the error monitoring process (e.g., Li et al., 2008) was analyzed to compare the different emotion conditions for the two genders. This was done by evaluating the effects of erroneous responses on subsequent trials. Typically, elevated responses times are seen as a consequence of errors on preceding trials (i.e. post-error slowing).

2. Materials and methods

2.1. Subjects

The erotic and pain sessions each involved twenty-eight subjects (14 male and female, mean age: 24.6, age range 22–28; all were right handed and all had normal or corrected-to-normal vision). All were students from the National Central University, Taiwan. All experimental procedures were approved by the Institutional Review Board of the Kaohsiung Medical University Chung-Ho Memorial Hospital, Kaohsiung, Taiwan.

2.2. Stimuli and procedures

All emotional stimuli were matched in terms of emotional valence between men and women. This was done to avoid any difference in the perception of erotica between men and women that would confound the experimental manipulation. To this end, 65 erotic (31 non-specific, 17 male-specific, 17 female-specific) and 48 neutral images (picture size: 300 × 300 pixels) were retrieved from the International Affective Picture System (IAPS), and the selected images were matched on erotic ratings (using the ratings previously obtained by Lang, Bradley, and Cuthbert (2008)) to ensure that our results were not due to a threshold difference in perception of erotica [Erotic: male valence (mean = 7.2, std err = 0.74), male arousal (mean = 6.5, std err = 0.89); female valence (mean = 6.4, std err = 0.96), female arousal (mean = 5.7, std err = 0.84). Neutral: male valence (mean = 5.0, std err = 0.4), male arousal (mean = 2.73, std err = 0.67); female valence (mean = 5.1, std err = 0.55), female arousal (mean = 2.94, std err = 0.61)].

In the pain session, stimuli were 10 pairs of 2000 ms clips (five frames, each presented for 400 ms) that either had a painful action or its matched neutral control. Fifty college students (n = 50, 25 male and 25 female) who were naïve to the experimental hypothesis and were not a part of the formal experimental sessions were asked to give their subjective judgments of painfulness for each picture. These ratings were not different between males and females [$t_{(48)} = 0.933$, $p = 0.355$].

All participants completed the erotic (two erotic and two neutral blocks on the same day in a counterbalanced order; 144 go trials and 48 stop trials in each block) and painful (two pain and no-pain blocks on the same day; 120 go trials and 40 stop trials in each block) sessions in two separate days (Fig. 1). One erotic image or clip of physical pain (e.g., stepping on a nail), or their matched control, was shown to participants shortly before each trial. The duration of each erotic image and pain clip was 1 and 2 s, respectively. All participants completed the pain and no-pain block with the no-pain block always preceding the pain block because the no-pain control clips cannot be judged as "pain free" once the participants have seen the analogous painful version that uses the same actions.

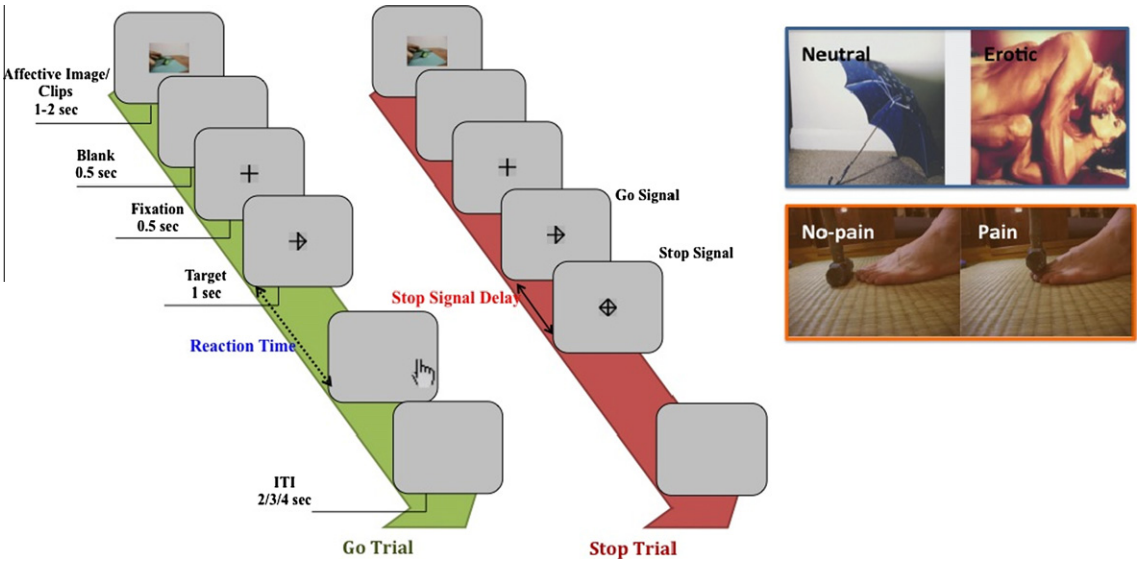

Fig. 1. Emotional stop signal task experimental procedure. The emotional picture/clips were presented before a classic stop signal task. Examples of the erotic session (erotic and neural pictures) and the painful session (clips of painful and no-pain condition) stimuli are shown in the right panel.

2.3. Data analysis

The go RTs were filtered by removing incorrect trials. Trials with latencies more than two standard deviations away from each subject's mean go RT for each emotional condition were also excluded. Each participant's critical SSD was calculated by averaging the stop signal durations of all stop trials. The SSRT was calculated using each subject's mean go RT to subtract the critical SSD. Repeated measures ANOVAs were carried out for correct go RT, SSD and SSRT under the two emotional conditions between the sexes. For the post-error slowing, successful go trials were categorized into two types: go trials after a correct go trial (pG) and go trials after a stop error trial (pSE). In the present study, the difference between pSE and pG served as an index of error monitoring.

3. Results

In the erotic and pain conditions, mean go accuracy on the go trials was high for both males (Exp 1: erotic 99.7%, neutral 99.7%; Exp 2: pain 98.6%, no-pain 99.0%) and females (Exp 1: erotic 98.5%, neutral 99.0%; Exp 2: pain 99.4%, no-pain 99.7%). The mean go RT of the erotic condition was higher in the erotic condition than in the neutral one (Fig. 2a). In the stop trials, the noncancelled (i.e. error) rates were approximately 50% for both males (Exp 1: erotic 49.6%, neutral 51.5%; Exp 2: pain 52.5%, no-pain 53.4%) and females (Exp 1: erotic 47.8%, neutral 48.8%; Exp 2: pain 49.6%, no-pain 49.5%), which is as expected due to the tracking method used in the task.

In the erotic experiment a main effect of emotion [$F_{(1,26)} = 4.853$, $p = 0.037$], no effect of participant sex

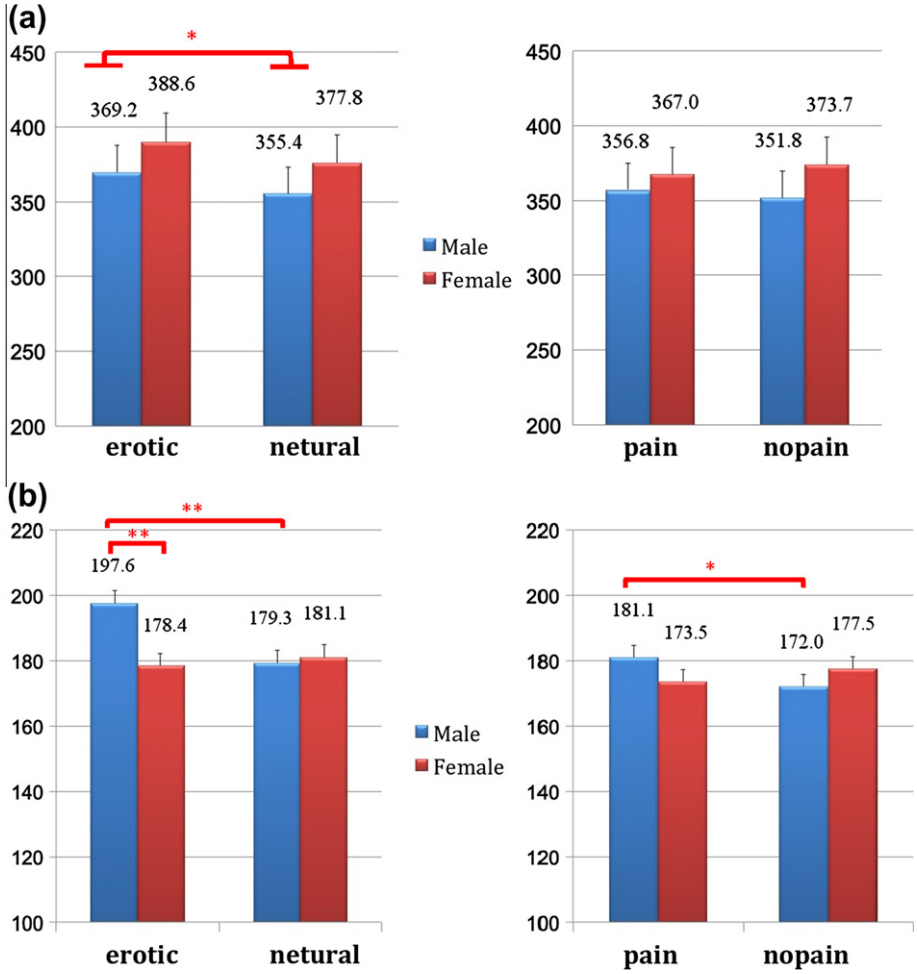

Fig. 2. (a) The Go RT from the emotional stop signal task. There were no sex differences for the erotic session or the painful session. However, the Go RT for the erotic condition was increased comparing with the neutral condition. (b) The SSRT of the emotional stop signal task. In the erotic experiment a main effect of emotion, and a significant interaction between emotion and sex was seen. There was a significantly slower SSRT in males when viewing erotic pictures, compared to the neutral pictures and their female counterparts. In the pain experiment, there was a significant interaction between emotion and sex. This interaction came from men's slower SSRTs in the pain condition relative to the no-pain condition, which was absent in women. Note that although the number of subjects was small, the effects were significant. The results would be even more conclusive if further studies can confirm this finding with a larger number of subjects.

[$F_{(1,26)} = 1.503$, $p = 0.231$], and a significant interaction between the two [$F_{(1,26)} = 8.735$, $p = 0.007$] was observed. Paired t-tests showed a significantly slower SSRT in males when viewing erotic pictures, compared to the neutral pictures [$t = 3.221$, $p = 0.007$] and their female counterparts [$t = 2.095$, $p = 0.046$]. No significant effect was seen versus neutral pictures for female participants [$t = 0.628$, $p = 0.541$]. No evidence of post-error slowing was observed [pSE-pG; emotion: $F_{(1,26)} = 0.087$, $p = 0.77$, sex: $F_{(1,26)} = 0.021$, $p = 0.886$, interaction: $F_{(1,26)} = 2.037$, $p = 0.165$].

In the pain experiment, there was no effect of painful stimuli [$F_{(1,26)} = 0.906$, $p = 0.35$] or participant sex [$F_{(1,26)} = 0.024$, $p = 0.877$], but there was a significant interaction between the two [$F_{(1,26)} = 6.135$, $p = 0.02$]. Paired t-tests revealed that the interaction came from men's slower SSRT in the pain condition relative to the no-pain condition [$t = 2.391$, $p = 0.033$], which was absent in women [$t = 0.872$, $p = 0.391$]. Again, no significant post-error slowing was seen [pSE-pG; emotion: $F_{(1,26)} = 0.013$, $p = 0.911$, sex: $F_{(1,26)} = 0.947$, $p = 0.339$, interaction: $F_{(1,26)} = 2.288$, $p = 0.142$]; Fig. 2b).

4. Discussions

Emotional events can affect on-going cognitive processes in two different ways: by resulting in either enhancement or impairment. However, any such effects may not be consistent between male and female groups. Previous studies have categorized emotion into positive, neutral and negative, and used such emotional stimuli as a probe to affect a subsequent stop signal task (Verbruggen & De Houwer, 2007). The results suggested that emotional stimuli affect performance on response inhibition as a consequence of altered arousal levels. In the present study, even though both arousal and valence levels of the stimuli used were matched between males and females, there were still different effects on inhibitory control between the two genders. We found similar results for both erotic and pain related stimuli, namely, male's inhibitory control mechanisms were vulnerable to disruption by both of these types of stimuli whereas females were unaffected. Together, these results suggest that both erotic and painful stimuli have an impairing effect on male's inhibitory control.

The fact that men and women react differently to these stimuli, despite equal emotional arousal levels and painfulness ratings, presents a new insight to the interaction between emotion and inhibitory control in males and females. It is worth noting that in the erotic session, both men and women's go reaction time increased significantly, suggesting that both sexes were attentionally distracted or aroused by the emotional stimuli, but only men's performance was impaired in terms of inhibitory control (SSRTs were elevated in the erotic condition compared with the neutral condition). Similarly, both males and females' post-error slowing rate remained the same, suggesting that both sexes' error monitoring ability were equally affected by errors. The absence of a sex difference in go RT and post-error slowing narrows down the cognitive processes on which emotional stimuli may assert their influence. The data here suggest that the effect may be confined to the processes involved in inhibitory control.

One possible explanation for the equal increase in go reaction time but not response inhibition is how deep the emotional stimuli were processed between men and women. A recent study carried out by Pessoa, Padmala, Kenzer, and Bauer (2012) used a fear conditioning method to pair some sounds either with electric shock (high threat) or without electric shock (low threat) to study the interaction between emotion and cognition. In their testing phase, the high and low threat sounds were used as stop signals. Although electric shock was no longer used in the testing face, their results showed that participants' SSRT still increased when a previously high-threat sound was presented as the stop signal. Pessoa et al. proposed that this pattern was due to the different levels of affective-cognition processing, where a stimulus previously paired with a shock may impact more central stages of cognitive processing. Following this logic, it is possible that males were engaged in a deeper processing of the emotional stimuli, despite equivalent arousal and valence levels between the two sexes. To this end, we conducted an even more stringent arousal-matching procedure to ensure that the observed sex difference was not due to the 0.8 arousal difference between males (mean = 7.2) and females (mean = 6.4). In this procedure, we excluded images with valence ratings higher than 6.4 from the male group, which was the mean rating from the female group. Reanalysis showed no significant difference between male SSRT before and after the image exclusion ($t = 1.662$, $p = 0.12$). Thus, it is likely that the observed gender differences may be due to the fact that the male subjects were processing these emotional stimuli to a deeper extent.

Another interesting issue is how emotional stimuli interacted with the cognitive processes of error detection and monitoring. It is generally assumed that, in addition to inhibitory processes, error monitoring is also important in cognitive control. In the present paradigm, 25% of trials were stop trials, and subjects were told to cancel their response when a stop signal was presented. Typically, whenever participants made an error on a stop trial, their reaction time on the immediately following go trial would increase. This is called post-error slowing and is a consequence of error monitoring processes. While SSRT was the index used to study interactions between emotional and cognitive control, it may also be important to consider whether emotion affects error-monitoring processes. However, studies have indicated that there are no significant differences in the inhibition function between males and females (Li, Huang, Constable, & Sinha, 2006), and no differences in error monitory processes (Li et al., 2009). Based on these findings, without emotional manipulations there is no difference in response inhibition and error monitoring between genders. For both the erotic and pain experiments, we found no significant gender differences in post-error slowing (pSE-pG), which is consistent with the previous report by Li and colleagues (Li et al., 2009). Therefore, although response inhibition was impaired when presenting erotic stimuli in the male group, monitoring processes were not significantly affected.

It remains to be determined what the origins of the differences in the responses to the emotion information of the type used in the present study are the origin of the reported gender difference in inhibitory control remains to be determined. One possibility is that they are a consequence of historical differences relating to gender roles but this remains a topic for future investigation. Nevertheless, irrespective of the origin of these differences, the present findings highlight an important sex difference in the effect of emotional stimuli on inhibitory control that future studies in the field need to address.

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