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Low self-esteem and the neural basis of attentional bias for social rejection cues: Evidence from the N2pc ERP component

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ABSTRACT

Previous studies have indicated that individuals with low self-esteem show an attentional bias toward information concerning social rejection. The present study used event-related potentials (ERPs) to investigate whether task-irrelevant rejection cues could capture the visuo-spatial attention of low self-esteem individuals during a demanding visual detection task. The N2pc ERP component was measured as an index of the allocation of spatial attention. Results revealed that rejection cues induced greater N2pc component responses among individuals with low levels of self-esteem than for those with high levels of self-esteem. These results suggest that task-irrelevant rejection cues are likely to capture the attention of individuals with low self-esteem but not those with high self-esteem. These findings provide direct electrophysiological support for the idea that individuals with low levels of self-esteem show an attentional bias for cues related to social rejection.

1. Introduction

Individuals with low levels of self-esteem are often extremely sensitive to social rejection (Brown, 2010; Richter & Ridout, 2011; Sommer & Baumeister, 2002). This sensitivity is believed to stem from the fact that individuals with low self-esteem have often experienced a considerable amount of social rejection during their lives compared to other individuals (e.g., Harter, 1983; Leary & Baumeister, 2000; MacDonald & Leary, 2012). This history of social rejection may provide a partial explanation for some of the cognitive patterns and behaviors exhibited by those with low self-esteem including their tendency to anticipate rejection (Downey & Feldman, 1996), devote considerable attentional resources to potential rejection cues (Dandeneau & Baldwin, 2004, 2009), exhibit high levels of cortisol activity in response to rejection (Ford & Collins, 2010), fail to engage in strategies to prevent rejection (Sommer & Baumeister, 2002), and react strongly to rejection when it actually occurs (Murray, Rose, Bellavia, Holmes, & Kusche, 2002). This pattern of findings is not surprising because it has frequently been argued that self-esteem serves as a personal resource that buffers individuals from negative experiences such as social rejection (e.g., Brown, 2010; Zeigler-Hill, 2011). That is, high self-esteem appears to provide some degree of protection from adverse experiences. Individuals with low self-esteem are believed to be more reactive to negative events because they lack the protection that those with high self-esteem derive from their positive feelings of self-worth. This vulnerability may explain why those with low levels of self-esteem display heightened vigilance for events that have the potential to threaten their relatively impoverished self-esteem resources (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007).

Individuals with low self-esteem are often much more attentive to information concerning social rejection than are those with high self-esteem (Dandeneau & Baldwin, 2004, 2009). For example, individuals with low self-esteem have been found to be especially attentive to evaluative threats in studies using the Emotional Stroop task (Dandeneau & Baldwin, 2004) and Visual Probe tasks (Dandeneau & Baldwin, 2009). These results suggest that individuals with low self-esteem develop cognitive strategies that emphasize vigilance for social rejection cues (Dandeneau & Baldwin, 2004, 2009; Dandeneau et al., 2007). This vigilance may, in turn, increase the likelihood of these individuals perceiving ambiguous social information as being indicative of rejection which may perpetuate their feelings of low self-worth.

Previous studies concerning the attentional biases of individuals with low self-esteem have most often relied on behavioral indicators of these biases such as response times. The limitation of this approach is that these behaviors (e.g., pressing a button on a keyboard) reflect a series of processes that include everything from the earliest stages of sensation to later decision making processes. Behavioral measures are indirect indicators of attention that require inferences to connect the actual behavior with attentional

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orientation. Behavioral measures are also limited because they are—at best—only capable of providing a snapshot of the deployment of attention rather than clearly reflecting shifts in attention over time (Horley, Williams, Gonsalvez, & Gordon, 2004). To provide a more detailed account of the temporal unfolding of attentional bias for those with low self-esteem, it is important to utilize a continuous measure of attentive processing. Unlike behavioral measures, event-related potentials (ERPs) allow researchers to identify the precise time course of neural processes involved in the allocation of visuo-spatial attention (Luck, Woodman, & Vogel, 2000). ERPs are neurophysiological responses to stimuli that can be captured with electroencephalography (EEG).

Despite an extensive literature describing the connection between self-esteem and rejection, there have been relatively few studies examining the direct physiological reactions of individuals with low self-esteem to social rejection. The few studies have examined physiological mechanisms such as startle eye-blink responses (Gyurak & Ayduk, 2007) as well as activity in the ventral anterior cingulate cortex and the medial prefrontal cortex (Somerville, Kelley, & Heatherton, 2010). The existing data suggests the intriguing possibility that individuals with low self-esteem show a different pattern of neurophysiological responses to social rejection cues than are observed for individuals with high levels of self-esteem. This pattern suggests the intriguing possibility that individuals with low levels of self-esteem may differ from those with high self-esteem in terms of their neurophysiological responses to social rejection including the allocation of attentional resources.

The present study attempted to extend what is known about the physiological responses of individuals with low self-esteem to rejection cues by examining the time course of their neurophysiological responses to rejection-related stimuli using ERPs. More specifically, we examined whether individuals with low self-esteem were more likely than those with high self-esteem to demonstrate greater ERP activity in response to task-irrelevant rejection cues that were presented during a visual detection task. If rejection cues are more likely to capture the attention of low self-esteem participants than those with high self-esteem, then individuals with low self-esteem should demonstrate heightened levels of activity in ERP components that serve as electrophysiological markers for selective spatial attention. We assessed the allocation of spatial attention using the N2pc ERP component which is a negative-going deflection that occurs in the "N2" time range (approximately 180–280 ms following stimulus presentation) that is largest at posterior ("p") sites on the scale and that is contralateral ("c") to the location of the attended visual item. It appears that the N2pc component reflects the location of visual spatial attention (Eimer, 1996; Luck & Hillyard, 1994). This ERP component is computed by taking voltage differences between corresponding pairs of electrodes located on the left and right posterior scalp after taking into account the hemifield in which attention is deployed (Jolicoeur, Brisson, & Robitaille, 2008; Woodman & Luck, 2003). Source localization analyses of magnetoencephalographic recordings suggest that the neural generators of the N2pc are in the extra-striate visual cortex with the possibility that there is some degree of early parietal contribution (Hopf et al., 2000).

The N2pc ERP component has been used as a moment-to-moment index for measuring the time course of the allocation of visual spatial attention in many studies (Jolicoeur et al., 2008; Kiss, Van Velzen, & Eimer, 2008; Woodman & Luck, 2003). Unlike other attention-related ERP components such as the P1 and N1 that are linked to early location-specific sensory gating mechanisms prior to target selection (e.g., Mangun & Hillyard, 1987), the N2pc component is assumed to reflect the direct spatial attention target selection among distractors in visual displays (e.g., Kiss et al., 2008). Therefore, the N2pc ERP component appears particularly suitable for an online tracking of the allocation of attention to the visual field and for the assessment of any spatial bias created by stimuli conveying social rejection. Thus, the aim of the present study was to examine whether individuals with low self-esteem display biases in spatial attention by showing more attention to task-irrelevant social rejection cues than is shown by those with high self-esteem. According to previous research, we hypothesized that a bias in visuo-spatial attention would be observed by an enhanced N2pc component in response to task-irrelevant rejection cues in individuals with low self-esteem. In contrast, we did not expect to find this enhanced N2pc component in response to task-irrelevant rejection cues for those with high self-esteem.

2. Method

2.1. Participants

Participants were selected from a pool of 190 undergraduate students at a university in China based on their scores on the Rosenberg Self-Esteem Scale (Rosenberg, 1965). Previous research has found that Chinese participants have a different understanding of the eighth item of the scale ("I wish I could have more respect for myself") than do participants from Western cultures (Kwan, Bond, & Singelis, 1997; Tian, 2006; Zhou & Wang, 2005). As a result, this item has a low correlation with the other items among Chinese participants and is sometimes excluded when computing the composite self-esteem score. We followed this process in the present study such that we excluded this item when we computed the composite score. Scores for the Rosenberg Self-Esteem Scale ranged from 10 to 36 (Cronbach's $\alpha = 0.87$). Participants were selected for either the high self-esteem group (i.e., score on the Rosenberg Self-Esteem Scale was in the highest tertile) or the low self-esteem group (i.e., score on the Rosenberg Self-Esteem Scale was in the lowest tertile). Although we will refer to participants in the lowest tertile as possessing *low self-esteem* it is important to note that many of these participants actually reported self-esteem scores near the midpoint of the scale. That is, their self-esteem was actually somewhat moderate in an absolute sense and they only possessed *low self-esteem* in the relative sense (i.e., in comparison with the other participants in the study). This is extremely common in studies concerning self-esteem because of the distribution of self-esteem scores (Baumeister, Heatherton, & Tice, 1993). This suggests that the participants that we will refer to as possessing *low self-esteem* are likely to have relatively neutral attitudes about themselves rather than actually disliking themselves.

The high self-esteem group consisted of 13 students (7 men, 6 women; mean age = 20.08 years [range 19–24 years]) and the low self-esteem group consisted of 13 students (6 men, 7 women; mean age = 21.25 years [range 19–24 years]). These participants were randomly selected from the appropriate tertiles. By design, the high self-esteem group reported higher levels of self-esteem than the low self-esteem group ($t[24] = 8.41$, $p < 0.001$, $d = 3.43$; high self-esteem group: $M = 31.08$, $SD = 2.69$; low self-esteem group: $M = 22.62$, $SD = 2.43$). All participants were healthy, right-handed, possessed normal vision (or corrected-to-normal vision), and reported no history of affective disorder. The study was approved by the local review board for human participant research and each participant provided informed consent prior to participating in the experiment.

2.2. Stimuli and procedure

Facial stimuli were used to convey rejection. The facial stimuli were achromatic photographs of 12 different actors (6 men, 6 women) taken from the NimStim Set of Facial Expressions (Tottenham et al., 2009). Adobe Photoshop software was used to equate the luminance and contrast values of these photographs. Photographs were selected for each actor displaying both disgust and neutrality expression. We selected disgust faces to communicate social rejection because these expressions should convey revulsion and a desire to withdraw from the observer (see Richter & Ridout, 2011 for a similar approach). The degree to which each photograph conveyed rejection or not was rated by 11 independent judges using scales that ranged from 1 (*rejecting*) to 5 (*neutral*). The evaluations of the judges confirmed that the disgust expressions ($M = 2.60$, $SD = 0.31$) were perceived as significantly more rejecting than the neutral photos ($M = 4.54$, $SD = 0.29$, $t[22] = 15.76$, $p < 0.001$, $d = 6.72$).

Each face was modified to fit a square frame subtending to $3.1^\circ \times 3.4^\circ$ of the visual angle. The stimulus displays consisted of bilateral 3×4 arrays of grayscale faces (total size: $14.2^\circ \times 10.78^\circ$) against a light grey background (RGB: 128, 128, 128). Each stimulus array contained a single rejection cue among neutral cues that was located next to the central fixation cross on the left or right side. A central fixation cross ($0.5^\circ \times 0.5^\circ$) was continuously present throughout the experimental blocks.

Twelve experimental blocks of 32 trials each were run. On each trial, a stimuli array was presented for 200 ms. And the inter-trial interval was 2000 ms. Each array had the same probability of occurrence within each block and throughout the experiment. The participants were instructed to maintain their focus on the fixation cross and to report any changes in its luminance (i.e., it would shift from dark grey [RGB: 80, 80, 80] to black [RGB: 0, 0, 0] on certain trials) by pressing the spacebar on the keyboard. The response hand was alternated for each successive block. Luminance changes occurred concurrently with the onset of the array for 25% of the trials (8 trials per block) and lasted until stimulus offset (i.e., 200 ms). These luminance change trials were accompanied by arrays of stimuli with a social rejection cue embedded in either the left or right side of the array. The location of the rejection cue was manipulated to allow us to control for any potential differences in attention that may be elicited by cues appearing on opposite sides of the screen. To be clear, the presence or absence of the social rejection cue was irrelevant to the task assigned to the participants (i.e., press the spacebar if the luminance of the fixation cross changed). The fixation cross remained dark grey for the remaining 24 trials per block and did not require a response. Stimulus presentation was controlled using E-Prime software at a viewing distance of 1 m.

2.3. Electrophysiological recording and data analyses

EEG was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Products) with reference on the left and right mastoids. Vertical electrooculograms (EOGs) were recorded with electrodes placed above and below the right eye. The horizontal EOG was recorded from the left versus right orbital rim. The EEGs and EOGs were amplified using a DC = 100 Hz bandpass and continuously sampled at 500 Hz/channel for off-line analysis. All inter-electrode impedance was maintained below 5 kΩ. ERPs were time-locked to the onset of the search display with epochs extending from 100 ms before the stimulus onset until 400 ms afterward (Eimer & Kiss, 2007). Eye movement artifacts (eye blinks, eye movements) were rejected off-line and 16 Hz low-pass filter was used. Trials with EOG artifacts (mean EOG voltage exceeding ±100 μV) and those contaminated with artifacts due to amplifier clipping, bursts of electromyography (EMG) activity, or peak-to-peak deflection exceeding ±100 μV were excluded from averaging. Artifact-free trials with correct behavioral responses were separately averaged for luminance change and no-change, rejection cue location (left vs. right), and contralaterality (electrode ipsilateral vs. contralateral to the location of the rejection cue). Time windows representing the N2pc ERP component were determined using visual inspection of individual participant waveforms as has been done in previous research (e.g., Eimer & Kiss, 2007). Analyses focused on the luminance no-change trials only and on lateral occipital electrodes (PO7/PO8) within two successive time windows (early N2pc: 180–220 ms post-stimulus; late N2pc: 225–280 ms post-stimulus) where the N2pc component was maximal (Kiss et al., 2008). ThePO7/PO8 sites were selected in accordance with previous research (e.g., Eimer & Kiss, 2007). Statistics were adjusted by the Greenhouse–Geisser epsilon correction for nonsphericity if the number of factor levels exceeded two. Uncorrected degrees of freedom but corrected *p* values are reported.

3. Results

3.1. Behavioral responses

Mean reaction times to changes in the luminance of the fixation cross were entered into a 2 (Self-Esteem: High vs. Low) × 2 (Rejection Cue Location: Left vs. Right) repeated-measures ANOVA. Neither the main effects nor the interaction approached conventional levels of significance. Error rates did not differ between the self-esteem groups nor did they differ based on the location of the rejection cue. These results show that participants with low self-esteem do not differ from those with high self-esteem in how they behave when exposed to task-irrelevant social rejection cues.

3.2. Electrophysiological responses

The ipsilateral waveform (average of voltage at the PO7 electrode for rejection cues on the left-side and the PO8 electrode for rejection cues on the right-side) and contralateral waveform (average of the PO7 electrode for rejection cues on the right-side and the PO8 electrode for rejection cues on the left-side) were time-locked to the visual display for luminance no-change conditions at PO7/PO8 electrode sites. These waveforms are shown in Fig. 1 (top). The N2pc component was quantified following the subtraction of the ipsilateral waveforms from the contralateral waveforms separately for individuals with low and high self-esteem. In these difference waves, a negative deflection corresponds to greater negativity in the hemisphere contralateral to the rejection cues relative to the ipsilateral hemisphere. These subtraction waveforms are shown in Fig. 1 (bottom).

Mean difference amplitudes of the N2pc ERP component were submitted to a 2 (Self-Esteem: High vs. Low) × 2 (Timing: Early N2pc vs. Late N2pc) repeated-measures ANOVA. There was a significant main effect of self-esteem ($F[1, 24] = 4.63$, $p < 0.05$, $\eta^2 = 0.16$) such that rejection cues evoked stronger responses (higher N2pc amplitude) from those with low self-esteem than those with high self-esteem. The main effect of timing was not significant ($F[1, 24] = 0.06$, *ns*) nor was the interaction of self-esteem and timing ($F[1, 24] = 0.28$, *ns*). Follow-up *t*-tests were conducted separately for those with low and high self-esteem were used to determine whether the N2pc amplitudes of each group showed a significant degree of laterality. The results showed that the amplitude of the N2pc component was significantly more negative than zero for those with low self-esteem ($t[12] = 2.41$, $p < 0.05$, $d = 1.39$) whereas the amplitude of the N2pc component did not differ from zero for those with high self-esteem ($t[12] = 0.84$, *ns*).

4. Discussion

The purpose of the present study was to examine whether individuals with low self-esteem show an attentional bias toward cues

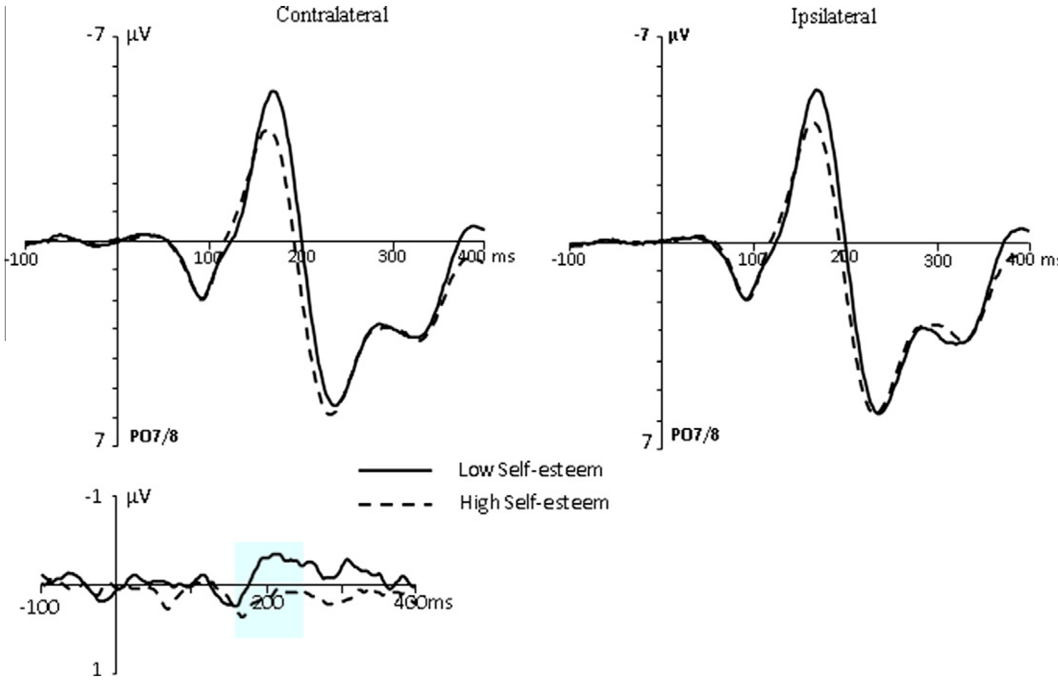

Fig. 1. *Top*: grand average ERPs to arrays containing a single rejection cue among neutral cues in low (solid line) and high self-esteem participants (dashed line) at electrodes PO7/8 contralateral (left panel) and ipsilateral (right panel) to the single rejection cue when no luminance change occurred. *Bottom*: Grand average contralateral minus ipsilateral difference waves for individuals with low (solid line) and high self-esteem (dashed line).

conveying social rejection. This was accomplished by measuring N2pc ERP components during exposure to task-irrelevant rejection cues that accompanied a continuous visual detection task. Electrophysiological results revealed that rejection cues induced a reliable shift of spatial attention during the interval of N2pc (from early N2pc to late N2pc) in individuals with low self-esteem but not for those with high self-esteem. Our findings are consistent with previous results suggesting that individuals with low self-esteem pay more attention to social rejection cues than do those with high self-esteem (e.g., Dandeneau & Baldwin, 2004, 2009). These results extend previous research by showing that this attentional bias extends to selective visuo-spatial attention. The present results are important because they provide additional support for the idea that individuals with low self-esteem are especially sensitive to information concerning social rejection. This attentional bias may be maladaptive for individuals with low self-esteem because it may increase their likelihood of noticing rejection cues and the attentional resources these individuals allocate to these cues. This enhanced attention to social rejection cues may perpetuate their already low levels of self-esteem.

Analyses concerning the N2pc ERP component indicate a significant difference between contralateral and ipsilateral activity in response to rejection cues for those with low self-esteem but not for those with high self-esteem. This pattern of results suggests that the spatial distribution of attention resources in individuals with low self-esteem may be biased toward rejection cues that are presented outside the focus of attention even when these cues are irrelevant to the task being conducted. These results suggest that selective attention to rejection cues may act as an initial filter or gate in the information processing of individuals with low self-esteem. This vigilance for rejection cues is consistent with the idea that low self-esteem individuals have more rejection experiences in their past which may cause them to be particularly attuned and sensitive to negative social evaluations (Leary & Baumeister, 2000). These findings are consistent with previous research suggesting that individuals with low self-esteem exhibit a greater attentional vigilance for rejection (e.g., Murray, Griffin, Rose, & Bellavia, 2003) and show greater physiological responses to cues of rejection (Gyurak & Ayduk, 2007; Somerville et al., 2010). According to the model of risk regulation in close relationships (Murray et al., 2003), individuals with low self-esteem are likely to have a prevention-oriented cognitive-motivational system that is quick to detect signs of rejection, send warning signals concerning the possibility of emotional harm, and motivate protective actions. As a result, low self-esteem people are more likely to attend to rejection cues and to perceive rejection in ambiguous social behaviors (Bellavia & Murray, 2003; Dandeneau & Baldwin, 2004). In contrast, high self-esteem individuals have far less need for such a defensively calibrated social alarm system because social rejection poses a much smaller risk to these individuals because they have more of this resource to "lose" (Murray, Holmes, & Collins, 2006).

Despite the neurophysiological differences in the amplitude of the N2pc component for those with low self-esteem compared to those with high self-esteem, these individuals did not differ in terms of their overt behavioral responses during the task. However, it is important to note that our behavioral task was quite simple so it is possible that different results may emerge if a more complex task is used. The present results suggest that some of the behavioral strategies that are used to assess the allocation of spatial attention may not be sensitive to the effects that social rejection has on those with low self-esteem. It may be important for future research concerning the responses of individuals with low self-esteem to rejection to utilize various assessments that include direct neurophysiological measures such as ERP or fMRI.

Several potential limitations of the present research should be noted. First, the only valenced cues that we examined concerned social rejection. Consequently, it is impossible to determine whether the heightened N2pc reactivity that was observed for those with low self-esteem is unique to social rejection cues or if similar responses would also emerge for other negative cues such as those indicating achievement failure. This is potentially important because the present study cannot rule out the possibility that individuals with low self-esteem may pay more attention towards various stimuli even if they are not overtly social in nature. However, it is important to note that even experiences such as achievement failure may have social implications for certain individuals (i.e., individuals with low self-esteem expect to be rejected following failure; Baldwin & Sinclair, 1996). Exploring the extent to which similar patterns of neurophysiological activation extend to other domains for individuals with low self-esteem is an important avenue for future research. Second, it may have been helpful for us to have gathered information concerning other individual differences that may have qualified the present results such as symptoms of anxiety or depression. Third, we employed an extreme groups approach such that we selected participants to participate in the ERP laboratory session who reported extreme self-esteem scores. This is not an ideal approach because self-esteem is generally considered to be a continuous measure and our strategy over-represented individuals with extreme levels of self-esteem at the same time that it did not adequately represent those with moderate levels of self-esteem (see Preacher, Rucker, MacCallum, & Nicewander, 2005 for a review of the extreme groups approach). Despite its limitations, we adopted this extreme groups approach because it offers more statistical power than using the entire distribution. This allowed us to collect relatively few participants which minimized the costs associated with the present research. Future research should extend these results by utilizing larger samples that draw from the entire range of self-esteem rather than focusing only on its extremes. Studies utilizing larger samples would also have the benefit of being able to detect relatively weak effects which may allow for a better understanding of the neurophysiological reactions of those with various levels of self-esteem to social rejection. Despite these limitations, the present study reveals that social rejection cues automatically capture spatial attention in individuals with low self-esteem but not those with high self-esteem. These results are important because they provide new electrophysiological evidence concerning the attentional bias that individuals with low self-esteem display for information concerning social rejection.

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