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Low social status decreases the neural salience of unfairness

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Social hierarchy exists in almost all social species and affects everything from resource allocation to the development of intelligence. Previous studies showed that status within a

found that individuals in low social standing are more generous, charitable, trustworthy, and helpful than their high status counterparts, who are more likely to break laws (e.g., fail to break for a pedestrian while driving) and social norms (e.g., take candy from a child, report false scores to their advantage) (Piff et al., 2010, 2012). Low status individuals also charge less than high status individuals in bargaining situations (Ball et al., 2001). In one study, Albrecht et al. (2013) used performance on a quiz to establish participants' social status and then instructed them to judge how satisfied they would be if given certain offers

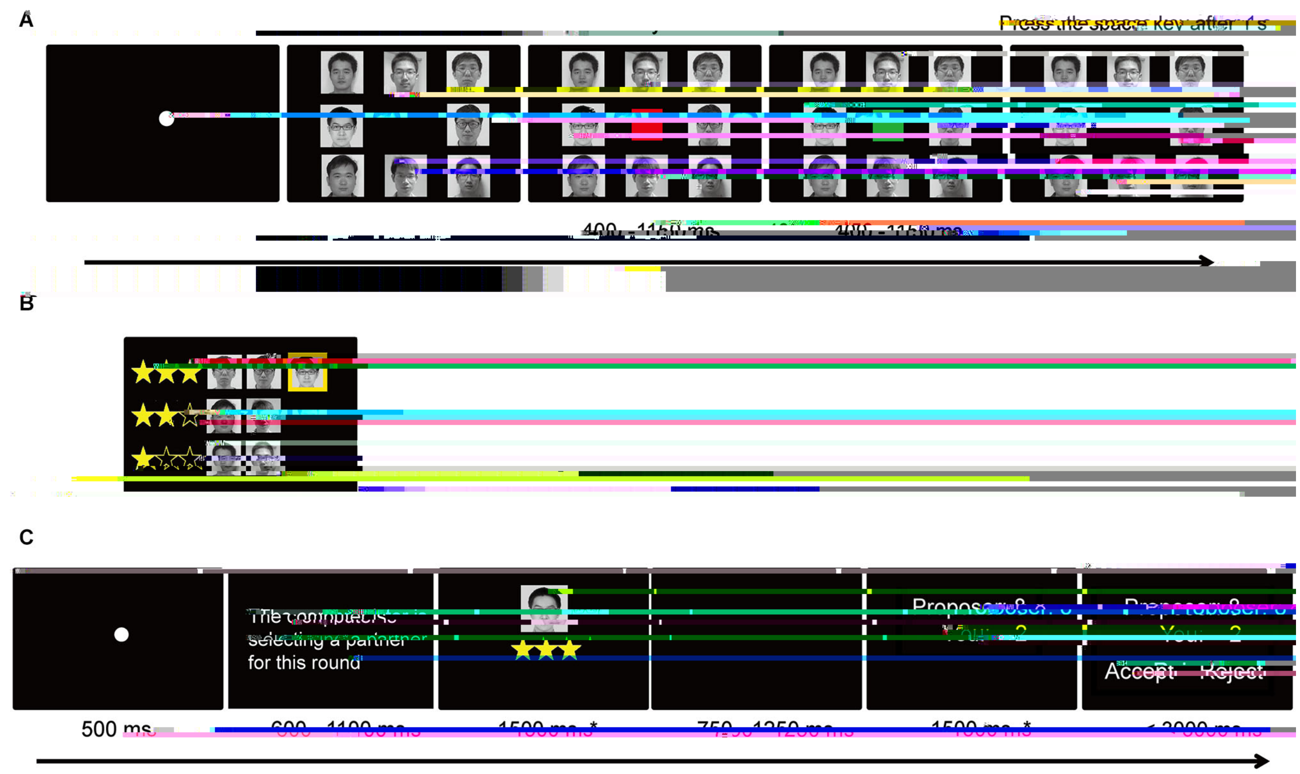

FIGURE 1 | Schematic diagram of the experiment. Each block in the experiment consisted of two sessions: the status-inducing session and the UG session. In the status-inducing session, the EEG participant completed 5 rounds of the time estimation task together with 7 other players by attempting to press the space key exactly 1 s after the green square disappeared **(A)**, and then viewed status information based on his/her estimation accuracy relative to others **(B)**. The EEG participant's photo was highlighted with a yellow background. In UG session **(C)**, the participant saw the cues indicating his/her social status before the reception of UG offers. We focused on the ERP responses time-locked to the screens with the asterisk.

2001; Caharel et al., 2006), possibly for the purpose of self-enhancement (Brown et al., 1988). We may therefore predict more negative N400 responses to one's own face associated with high status relative to the same face associated with low status.

For the neural responses to the offers in UG, we predicted that, compared with fair offers, unfair offers would elicit an enhanced medial frontal negativity (MFN, or feedback-related negativity, FRN) and a decreased P300. The MFN or FRN, which is a negative deflection peaking between 200 ms and 350 ms post-onset of feedback at frontocentral electrodes, has usually been shown to be more enhanced for unfair offers than for fair offers (Polezzi et al., 2008; Boksem and De Cremer, 2010; Hewig et al., 2011; Wu et al., 2012). It is suggested that the MFN or FRN reflects an earlier, automatic detection of social expectancy violation (Wu et al., 2011a). The P300, which is the most positive peak in the period of 200–500 ms post-onset of feedback at frontoparietal electrodes, has been found to be smaller for unfair offers than for fair offers (Wu et al., 2011b; Qu et al., 2013). It is suggested that the P300 reflects later, high-level motivational/emotional processes (Yeung and Sanfey, 2004). In one study, unfair offers were also found to elicit a smaller LPP than fair offers in a relatively late time window (450–650 ms) (Wu et al., 2011b), which is perhaps not surprising given that LPP and

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accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Department of Psychology, Peking University.

DESIGN AND PROCEDURE

The experiment had a 2

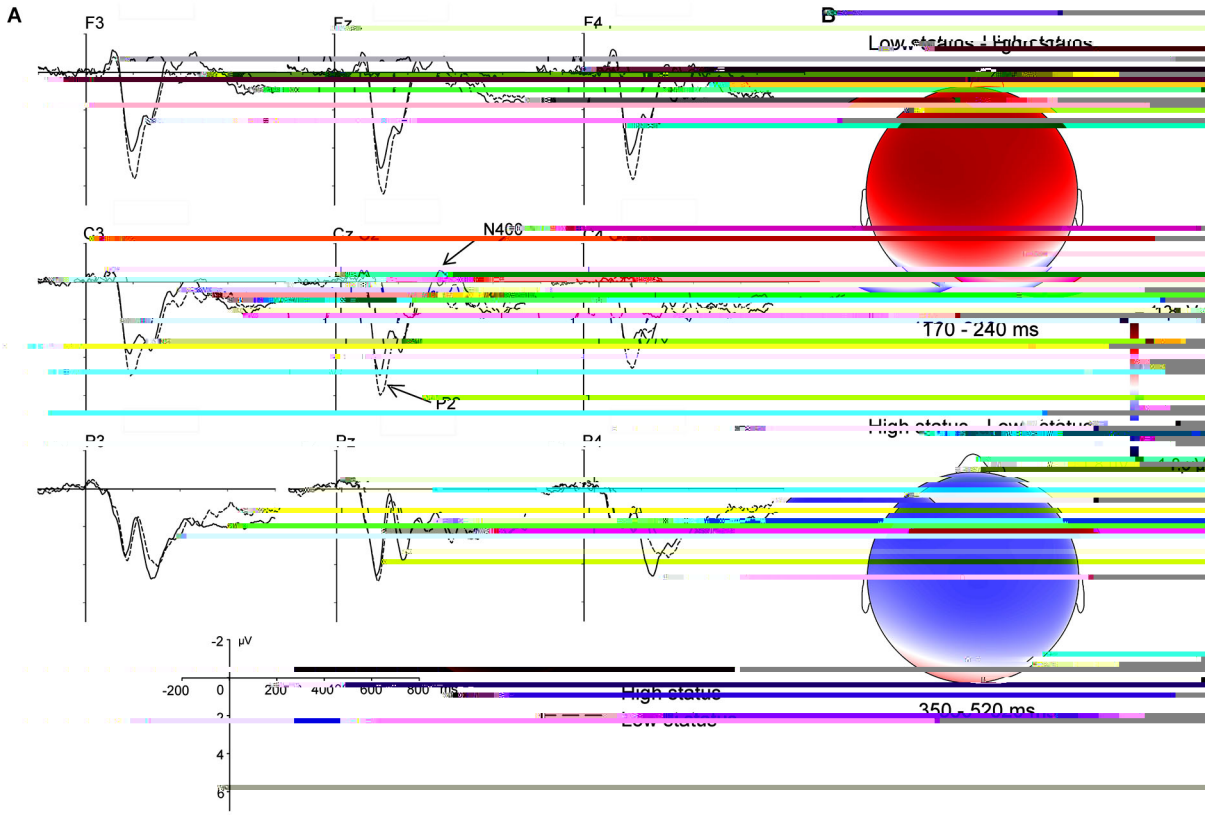

FIGURE 3 | ERP responses and topographic maps on the cues indicating social status. (A) ERP responses time-locked to the onset of the social status cue at the exemplar electrodes F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4. The mean amplitudes of the P2 were calculated within the 170–240 ms time window. The mean amplitudes of the N400 were calculated within the 350–520 ms time window. **(B)** Topographic map for the P2 effect in the 170–240 ms time window, upper; topographic map for the N400 effect in the 350–520 ms time window, lower.

LPP (2.29 0.40 mV) than sub-fair offers (1.66 0.41 mV), *p*s < 0.05. More importantly, the analysis also revealed a marginally significant interaction between offer fairness and social status, $F_{(2,50)} = 2.86$, $p = 0.067$, $\eta^2_{partial} = 0.10$. Further tests revealed that when participants were in high status, the LPP responses were stronger for both fair offers (2.86 0.51 mV) and unfair offers (2.64 0.46 mV) than for sub-fair offers (1.66 0.41 mV), *p*s < 0.005, with no difference between LPP responses to fair and unfair offers, $p > 0.1$. However, when participants were endowed with low status, the ERP responses were stronger for fair offers (3.07 0.39 mV) than for both unfair (1.94 0.38 mV) and sub-fair offers (1.66 0.48 mV), *p*s < 0.001, with no difference between responses to unfair and sub-fair offers, $p > 0.1$. From a different perspective, while social status did not affect the LPP response to fair and to sub-fair offers, *p*s > 0.1, social status did have a significant effect on unfair offers, $F_{(1,25)} = 7.68$, $p < 0.05$, $\eta^2_{partial} = 0.24$, with a stronger LPP for the high status condition (2.64 0.46 mV) than for the low status condition (1.94 0.38 mV), $p < 0.05$.

In addition, the interaction between offer fairness and hemisphere was also significant, $F_{(4,100)} = 7.20$, $p < 0.001$, $\eta^2_{partial} = 0.22$. Tests for simple effects suggested that in the left hemisphere, fair offers (2.71 0.41 mV) elicited a stronger LPP than unfair offers (1.94 0.39 mV), $p < 0.005$, and unfair offers (1.94 0.39 mV) elicited a stronger LPP than sub-fair offers (1.41 0.39 mV), $p = 0.07$; in the medial region, the aforementioned effect of offer fairness remained the same, *p*s < 0.05. However, in the right hemisphere, both fair (2.80 0.35 mV) and unfair offers (2.42 0.35 mV) elicited a stronger LPP than sub-fair offers (1.82 0.34 mV), $p < 0.001$ and $p < 0.005$, respectively, with no difference between LPPs elicited by unfair and fair offers, $p > 0.1$.

DISCUSSION

In the current study, we used a modified version of UG to investigate whether and how social status influences recipient fairness considerations. Behavioral results revealed that, consistent with previous studies, participant acceptance rates for offers increased with the fairness level of the offers. Moreover, participants were more likely to accept offers when endowed with low status than with high status. Electrophysiologically, the cue indicating low status elicited a more positive P2 than did the cue indicating high status in an earlier time window (170–240 ms); the cue indicating high status elicited a more negative N400 than did the low status

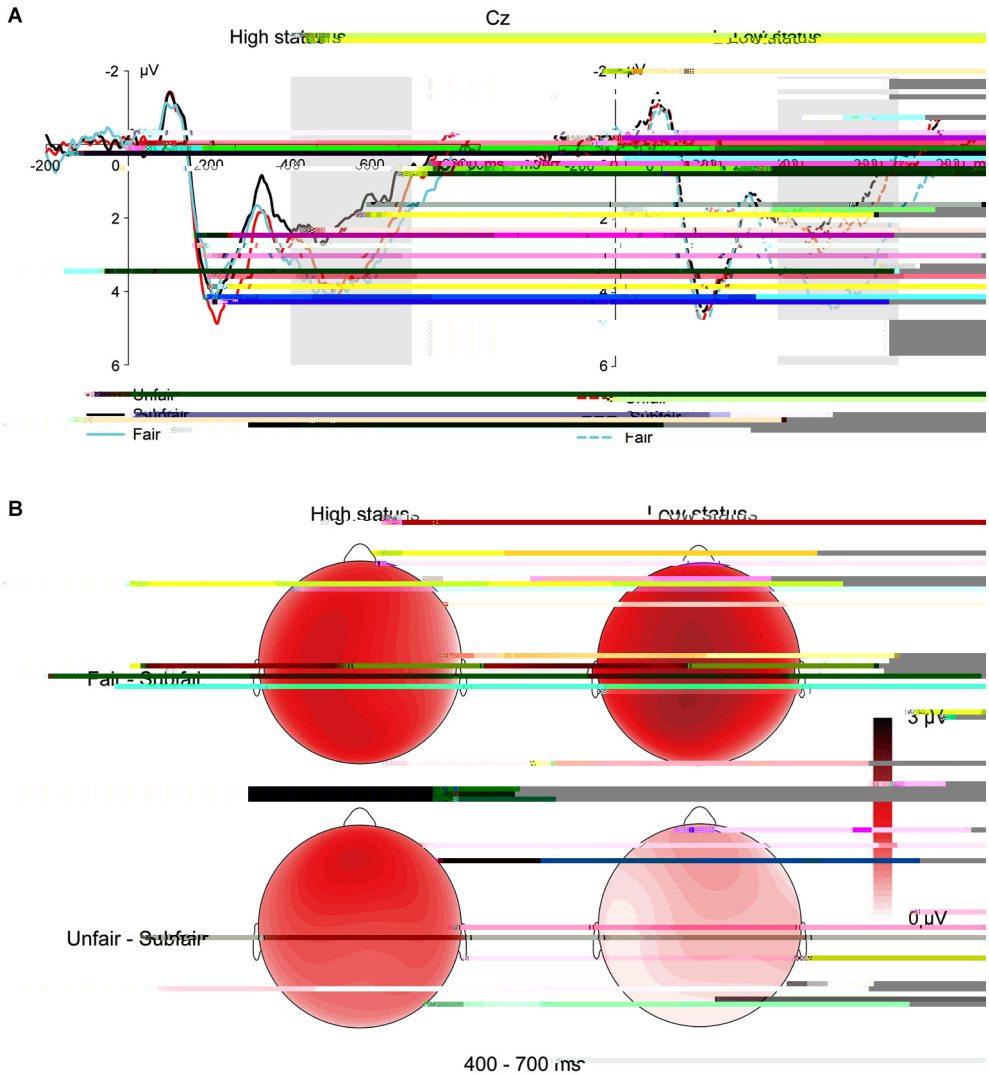

FIGURE 4 | ERP responses and topographic maps on the UG offers. **(A)** ERP responses time-locked to the onset of the offer at the exemplar electrode Cz. The shaded 400–700 ms time window represents the area used for the calculation of LPP mean amplitudes. **(B)** Topographic maps for the LPP effects in the 400–700 ms time window.

cue in a later time window (350–520 ms). For the presentation of UG offers, the LPP in the time window of 400–700 ms was modulated by participants' social status. Specifically, when the participants were in high status, the LPP for fair and unfair offers was more positive than for sub-fair offers; when the participants were in low status, the LPP for fair offers was more positive than for either sub-fair or unfair offers, which did not differ from each other. Alternatively, while social status modulated LPP responses to unfair offers, with a more positive LPP in the high status than in the low status conditions, it did not modulate LPP to

concerned with preserving self-esteem (Blader and Chen, 2012). Unfair offers and even some fair offers in the current study were perceived as challenges to one's self-esteem and rejecting such offers would serve to maintain social standing (Wu et al., 2012).

Although the post-experiment questionnaires also indicated that participants harbored more negative emotions toward unfair offers when they were in low status than in high status, this difference seemed to have no influence on the acceptance rate of UG offers. This finding is obviously inconsistent with other studies showing an increased demand for fairness after negative emotion priming (Harlé and Sanfey, 2007; Grecucci et al., 2013). It is likely that, in the current study, the negative emotion associated with low status was only a by-product and its effect on fairness consideration was overridden by the effect of social status.

THE P2 AND N400 EFFECTS ON SOCIAL STATUS

The increased P2 amplitudes for cues indicating low status may reflect an enhanced automatic attention to unpleasant stimuli (Carretié et al., 2001, 2004; Gerdes et al., 2013). The P2 is a positive deflection peaking around 200 ms post-onset of the stimuli, and is involved in semantic processing (van Schie et al., 2003), visual feature detection, and selective attention (O'Donnell et al., 1997). Recent studies further suggested that the P2 effect may reflect the evaluation of emotion valence (Schapkin et al., 2000; Wang et al., 2013). For instance, larger P2 amplitudes are found for unpleasant visual stimuli than for pleasant or neutral stimuli, suggesting that the negative valence of emotional stimuli can enhance the early attentional processing of the stimuli (Delplanque et al., 2004; Olofsson and Polich, 2007). In a study on stable and unstable social hierarchies, Zink et al. (2008) found that decreases in social rank led to increased activation in the insula and occipital/parietal cortices, suggesting that a decrease in rank was not only a negative experience, but that it increased participants' perceptual and attentional processing. Taken as such, we interpret the early increased response to low status information in the current study as a salience marker for critical social information.

The differentiation of low and high status was also present in a later time window (350–550 ms), with a more negative-going N400 for the cue indicating high status than for the cue indicating low status. The enhanced N400 effect for the cue indicating high status may reflect a stronger association between the preexisting representation of the self and positive social information. The N400 is a negative deflection peaking in the period of 300–600 ms post-onset of the stimuli at centro-parietal electrodes. In recent studies, this component was also found to be associated with self-identification (Bentin and Deouell, 2000; Eimer, 2000; Caharel et al., 2006; Butler et al., 2013). For instance, Butler et al. (2013) showed that the N400 amplitude for self and dizygotic twin faces were more negative than for unfamiliar faces. More importantly, when participants viewed self and twin photos over a life span, the N400 only tracked age changes in the self photos, suggesting the N400 as a unique neural response associated with retrieval of stored mental representation of the self in the self-identification process (Butler et al., 2013). According to the theory of self-enhancement, participants are more likely to attend to positive information related to the self (Brown et al., 1988); in the current study, this theory would suggest that participants would be more likely to form positive self-representations by associating themselves more with cues indicating high status than cues indicating low status. The more negative going N400 for high status cues most likely reflects an increased tendency to positively process information related to the self.

THE LPP EFFECTS ON UG OFFERS

The current study showed a main effect of offer fairness on LPP, with the mean amplitude of LPP being largest for fair offers, intermediate for unfair offers, and smallest for sub-fair offers, which is in line with previous studies (Wu et al., 2011a,b, 2012). These findings may suggest that attentional resources were differentially allocated to the three kinds of offers which had different motivational/arousal significance. The LPP, similar to the P300, is involved in social evaluation (Yeung and Sanfey, 2004; Leng and Zhou, 2010), with increased positive amplitudes reflecting enhanced motivated attention (Hajcak and Olvet, 2008; van Hooff et al., 2011). For instance, the LPP has been reported to be larger for both pleasant and unpleasant pictures than neutral pictures, indicating that more attentional resources are allocated to stimuli that are more motivationally relevant and arousing, irrespective of the emotional valence of the stimuli (Schupp et al., 2003, 2004; Hajcak and Olvet, 2008).

In the present setup, fair offers were linked with the largest reward, sub-fair offers with immediate rewards, and unfair offers with the lowest reward. Certain studies show that P300/LPP tracks reward values, with an enhanced response to a larger reward than a smaller reward (Yeung and Sanfey, 2004; Sato et al., 2005; Leng and Zhou, 2010). If this were the case, in the current study, the amplitude of the LPP should increase with the amount of the offers in UG. On the contrary, we found that LPP amplitudes were larger for both fair and unfair offers than for sub-fair offers. This difference is most likely due to the fact that in previous studies showing that P300/LPP is sensitive to reward magnitude (Yeung and Sanfey, 2004; Leng and Zhou, 2010), the monetary reward was presented as a single number to the participant. Whereas, due to the interactive nature of UG in the current study, the offers not only included the monetary reward but also conveyed social information such as the fairness level and proposer intention. Moreover, previous studies on fairness show that unfair offers are threatening to one's image of the self (low value, high arousal), whereas fair offers are affirming and abide by social norms (high value, high arousal) (Wu et al., 2011a, 2012). These two kinds of offers are highly likely to have equal or similar motivational/arousal levels and may lead to enhanced motivated attention relative to sub-fair, less salient offers. Therefore, we believe that the LPP effect is modulated by the motivational relevance or arousal intensity corresponding to different fairness levels of the offers, rather than by the reward magnitude of the offers (Hajcak and Olvet, 2008; van Hooff et al., 2011).

Importantly, we found an interaction between social status and offer fairness on the LPP, with different patterns of effects for the

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