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Error-related brain activity reveals self-centric motivation: Culture matters

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Error-Related Brain Activity Reveals Self-Centric Motivation: Culture Matters

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To secure the interest of the personal self (vs. social others) is considered a fundamental human motive, but the nature of the motivation to secure the self-interest is not well understood. To address this issue, we assessed electrocortical responses of European Americans and Asians as they performed a flanker task while instructed to earn as many reward points as possible either for the self or for their same-sex friend. For European Americans, error-related negativity (ERN)—an event-related-potential component contingent on error responses—was significantly greater in the self condition than in the friend condition. Moreover, post-error slowing—an index of cognitive control to reduce errors—was observed in the self condition but not in the friend condition. Neither of these self-centric effects was observed among Asians, consistent with prior cross-cultural behavioral evidence. Interdependent self-construal mediated the effect of culture on the ERN self-centric effect. Our findings provide the first evidence for a neural correlate of self-centric motivation, which becomes more salient outside of interdependent social relations.

Keywords: self-centric motivation, self-serving bias, independent and interdependent self-construals, cultural neuroscience, error-related negativity (ERN)

Self-interest is considered a fundamental human motive. Indeed, many currents of modern Western thought, including theories in both neoclassic economics (Hobbes, 1651; Smith, 1759) and social and behavioral sciences (Campbell, 1975; Greenwald, 1980), are built on this premise. In this tradition of thought, the self is deemed to be autonomous and self-contained (Morris, 1972; Sampson, 1988), and, in part because of this, the self is assumed to justifiably pursue the interest of the self in lieu of the interest of others (Miller, 1999). So far, however, much of this debate is limited to cultural and historical analyses, with little known about its grounding in neurobiological mechanisms.

Our goal in the current work was twofold. First, we tested whether the assumed primacy of self-interest is reflected in neurobiological mechanisms of error processing, which are grounded in the ventral striatal, subcortical regions (Frank & Claus, 2006; Holroyd & Coles, 2002). Second, we examined whether such neurobiological mechanisms might be culturally bound. This effort will enable us to go beyond existing behavioral evidence to show the potential role of culture in shaping neurobiological processes.

Self-Centric Motivation

The hypothesis that self-interest is an important motive guiding social cognition and social behavior is strongly suggested by self-serving bias (Langer, 1975; Miller & Ross, 1975). For example, individuals take credit for their success while blaming external influences for their failure (Miller & Ross, 1975). Likewise, they tend to have unrealistically inflated and optimistic views of themselves (Taylor & Brown, 1988). Although these phenomena suggest the presence of a powerful psychological motive to pursue self-interest (herein called self-centric motivation), they fall short of identifying the nature of this motive itself.

It could be argued, on the one hand, that self-centric motivation is derived from a conscious, explicit goal of presenting the self in a favorable light (Schlenker, 1980). If this were the case, self-serving effects could be a product of deliberate self-presentation. On the other hand, it would seem also possible that self-centric motivation has a deeper neurophysiological root. For example, once the self becomes relevant and thus activated in a given situation, potential rewards available in the situation will become more salient (because the self is a direct beneficiary of the rewards), thereby recruiting neural mechanisms of "wanting"—the mesocorticolimbic system involving the ventral striatal regions that modulates incentive salience (Berridge, 2012). The reward value of achieving a desired outcome will be enhanced as a result. We predicted that if self-centric motivation has a deep neurobiological basis such as this, there should be an electrocortical marker of this motivation.

Neural Marker of Self-Centric Motivation

Our first aim in the current work was to explore electrocortical markers of self-centric motivation by examining neural responses involved in error processing (error-related negativity, or ERN; Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, Coles, Meyer, & Donchin, 1993). The ERN is an event-related brain potential, which is observed within 100 ms after an erroneous response in speeded reaction time tasks. Because of an emphasis given to response speed in such tasks, an individual sometimes responds on the basis of partially available information on the stimulus before the impinging stimulus is fully processed, thereby increasing the likelihood of errors. However, even after the actual response is executed, the stimulus processing will continue and eventually produce a more veridical representation of the stimulus, which implies a correct response. When the two representations (the actual response and the correct response) are unmatched, this gives rise to an error signal, the ERN (Coles, Scheffers, & Holroyd, 2001).

When the motivation to perform well in the task at hand is enhanced, the responder will allocate more processing resources to both the computation of the correct response and the comparison between the actual response and the correct response, resulting in a stronger mismatch signal. Consistent with this analysis, the ERN is known to increase as a function of motivational significance associated with the task at hand (e.g., Gehring et al., 1993; Hajcak, Moser, Yeung, & Simons, 2005). We therefore anticipated that the ERN would be greater when an erroneous response was made in a task the person performed to earn reward points for the self than when such an error was made in a task he or she performed to earn reward points for someone else (e.g., a close friend), as long as the person was self-centrically motivated.

Cultural Modulation of Self-Centric Motivation

Another important aim in the current work was to examine possible cultural variation in the neural marker of self-centric motivation. Over the last two decades, numerous cross-cultural studies have shown that self-serving effects are much weaker among Asians than among European Americans (see Heine, Lehman, Markus, & Kitayama, 1999). For example, self-serving attributions of success and failure appear quite weak in Asia (Kitayama, Takagi, & Matsumoto, 1995), and, likewise, Asians tend to hold more realistic assessments of the self vis-à-vis others (Heine & Lehman, 1995). Moreover, whereas European Americans spontaneously elaborate on positive self-relevant information, Asians do so with respect to negative self-relevant information (Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). The attenuation of self-serving bias among Asians is consistent with the hypothesis that Asian selves are more interdependent (vs. independent), and, thus, their construal of the self is extended to include close others (Endo, Heine, & Lehman, 2000). Accordingly, the motivation to enhance the self, relative to relevant social others, may be quite weak among Asians.

One important shortcoming of the current literature on cultural variation in self-serving bias is that it draws nearly exclusively on explicit self-reports. Thus, it is hard to preclude the possibility that the attenuation or absence of self-serving bias among Asians reflects a culture-specific tactic of self-presentation fostered by the culture's modesty norms. However, if Asians should show an attenuated self-centric effect even in the ERN—a neural activity that is arguably automatic (Amodio et al., 2004) and regulated closely by subcortical reward-processing systems (Holroyd & Coles, 2002; Münte et al., 2008)—this cultural difference would be hard to understand with self-presentation alone. We thus tested whether the increased ERN in a task individuals perform to earn rewards for the self (vs. a close other) would be either attenuated or vanished for Asians.

Present Work

To test the hypothesis that self-centric motivation manifests itself at an electrocortical level, we monitored the brain activities of European American and Asian participants via electroencephalogram (EEG) while a computer task was performed to earn reward points for themselves and for a close, same-sex friend. We anticipated that the ERN would be greater when individuals performed a task to earn rewards for themselves (vs. their friend), as long as they have strong self-centric motivation. We further anticipated that the self-centric effect would be weaker for Asians, who are likely to be more interdependent, than for European Americans.

Method

Participants

Thirty-nine University of Michigan undergraduates participated in the study (24 female, M_{age} = 19.59 years, SD_{age} = 1.37). Nineteen were European Americans (14 female, M_{age} = 19.47 years, SD_{age} = 1.31), and the remaining 20 were Asians (10 female, M_{age} = 19.70 years, SD_{age} = 1.45). Nine Asian participants were born in East Asian countries such as China, Korea, and Taiwan, spending no more than 7 years in the United States, and the remaining 11 participants were Asian Americans, who were born in the United States. Participants received $20 or course credit in exchange for their participation. All participants were right-handed and had normal or corrected-to-normal vision. No gender effect was found.

Procedure

Upon their arrival in the lab, participants were told that their brain activities would be monitored while they performed a simple computer task. After the attachment of EEG electrodes, participants were asked to perform a letter version of the flanker task (Eriksen & Eriksen, 1974) in a darkened room. The stimuli were presented on a Dell E551c 15-in. CRT monitor wth E-Prime software version 1.1. Participants were instructed to identify a center letter among a set of five letters that were flashed at the center of the screen (*HHHHH, SSSSS, HHSHH,* or *SSHSS*). One third of the trials were congruent trials (*HHHHH* or *SSSSS*), and the remaining two thirds were incongruent trials (*HHSHH* or *SSHSS*). Each letter sequence occupied 0.4° of visual angle vertically and 2.2° of it horizontally. Each trial started with a fixation cross that appeared at the center of the screen for 100 ms. After a blank screen (300 ms), participants saw one of the four letter sequences, which lasted on the screen for 100 ms. They then reported the identity of the center letter by pressing one of two

response keys on the typing board. The key assignments were counterbalanced across participants. The next trial started 900 ms after each response. In order to keep the minimum 10% of error rate, whenever the error rate in a given block did not reach 10%, we instructed participants to respond faster in the next block.

Participants were encouraged to respond as quickly as possible without sacrificing accuracy. They were told that their response would be monitored and correct responses that were faster than their median response time would be converted into points. Presented with colored photos of 15 gift items (e.g., mug, hoodie), they were further told that they would have an opportunity to use the points they would earn to choose one gift item for themselves and another gift item for their friend, respectively. At this point, they were asked to nominate a close, same-sex friend who lived on the campus and write down the name of the friend. Thus, their goal was to earn as many reward points as possible to receive gifts for both the self and the friend. Participants were told that the gift items of their choice would be mailed to both them and their friend at a later date.

The computer task consisted of a total of 16 blocks, with 60 trials in each block (960 trials in total). During half of the blocks, participants earned points for themself (self blocks), whereas during the remaining half they did so for their friend (friend blocks). The order of the self versus friend blocks was counterbalanced across participants, such that half of the participants performed the self blocks first (i.e., 4 self, 4 friend, 4 self, and 4 friend) and the other half performed the friend blocks first (i.e., 4 friend, 4 self, 4 friend, and 4 self).

Physiological Recording and Processing

The EEG was recorded with 64 electrodes placed according to the extended International 10–20 system in a nylon cap and referenced to the left mastoid. The electrooculogram (EOG) was recorded from additional channels at the outer canthi of both eyes and above and below the left eye. EEG and EOG signals were amplified with a band-pass of DC to 104 Hz by BioSemi ActiveTwo system and were sampled with 512 Hz. All data were re-referenced to the averaged left and right mastoid off-line and then resampled at 256 Hz. The data were baseline corrected by using 200- to 100-ms pre-response voltage and were corrected for ocular artifacts (Gratton, Coles, & Donchin, 1983). The EEG recordings for incorrect and correct responses were then averaged separately. Trials with amplitudes exceeding ± 100 μV were eliminated from the final averages. The number of error trials included in the analysis after artifact rejection was no different across the cultural groups (European Americans: $M = 60.76$, $SE = 7.07$; Asians: $M = 64.50$, $SE = 6.89$) or between the self and friend conditions (self condition: $M = 61.53$, $SE = 5.09$; friend condition: $M = 63.73$, $SE = 7.49$), Fs < 1. Because the ERN peaked around 35 ms after erroneous responses, it was quantified as the mean amplitude between 10 ms and 60 ms after the erroneous response at the frontocentral midline electrode (FCz).

Post-Experimental Questionnaire

After finishing the flanker task, participants filled out a 24-item Singelis self-construal scale (Singelis, 1994), which yielded separate scores for independent self-construal (e.g., "I always try to have my own opinions"; αs = .78 and .82, for European Americans and Asians, respectively) and interdependent self-construal (e.g., "I avoid having conflicts with members of my group"; αs = .54 and .75). Participants then filled out measures that assessed the quality of the relationship with the friend they chose at the beginning of the study (who was to receive the gift earned for him or her). They rated perceived closeness by choosing one of seven varying degrees of overlap between two circles (Inclusion of Other in the Self Scale; Aron, Aron, & Smollan, 1992), length of the relationship in years, and perceived supportiveness (12-item Interpersonal Support Evaluation List; Cohen, Mermelstein, Kamarck, & Hoberman, 1985; αs = .92 and .97, for European Americans and Asians, respectively).

Participants also responded to two questions designed to assess their motivation to perform the task well in both the self condition and the friend condition. They indicated how engaged (1 = *not engaged at all*, 7 = *very much engaged*) they were when they performed the task in the self condition and in the friend condition and how satisfied (1 = *not satisfied at all*, 7 = *very much satisfied*) they were with their performance in the self and the friend condition, respectively. Finally, participants rated how difficult (1 = *not difficult at all*, 7 = *very much difficult*) the task was.

Results

Self-Report Measures

The post-experimental questionnaire showed that the friends that European American and Asian participants chose were no different in terms of closeness (4.90 vs. 4.20 for European Americans and Asians, respectively), $F(1, 37) = 2.26$, $p > .14$; length of relationship (4.26 vs. 3.45), $F < 1$; and supportiveness (4.47 vs. 4.04), $F = 2.72$, $p > .10$. Participants were also reportedly engaged as strongly in the task of earning points for the self as they were in the task of earning points for the friend (European Americans: 4.82 vs. 4.82; Asians: 5.03 vs. 5.08), Fs < 1. The engagement rating was no different across the cultural groups in both the self condition and the friend condition (Fs < 1). They also reported that they were equally satisfied with their performance in the self and in the friend condition (European Americans: 3.95 vs. 3.84; Asians: 3.08 vs. 3.10), Fs ≤ 1. The mean satisfaction was higher for European Americans than for Asians (3.90 vs. 3.09), $F = 5.04$, $p < .05$, $\eta_p^2 = .12$. This is likely due to a general tendency of European Americans to respond more positively than Asians do (Heine et al., 1999). In addition, the two cultural groups did not differ in their perceived task difficulty, suggesting that the task was equally demanding for both groups (3.68 vs. 3.95 for European Americans and Asians, respectively), $F < 1$. For descriptive statistics for the questionnaire measures, see Table 1.

Behavioral Performance

We found little difference in the performance of the flanker task between the self condition and the friend condition regardless of the cultural backgrounds of the participants. First, we submitted accuracy to a 2 (culture: European Americans vs. Asians) × 2 (condition: self vs. friend) × 2 (congruency: congruent trials vs. incongruent trials) × 2 (condition order:

Table 1
Descriptive Statistics of the Post-Experimental Questionnaire Measures

Measure	European Americans		East Asians		Cultural differences	
	M	*SE*	*M*	*SE*	$F(1, 37)$	η_p^2
Relationship with the friend						
Perceived closeness	4.90	0.33	4.20	0.32	2.26	.06
Length of relationship	4.26	1.03	3.45	1.00	0.32	.01
Perceived supportiveness	4.47	0.19	4.04	0.18	2.72	.07
Task engagement						
Self condition	4.82	0.26	5.03	0.25	0.34	.01
Friend condition	4.82	0.25	5.08	0.25	0.54	.01
Performance satisfaction						
Self condition	3.95	0.27	3.08	0.27	5.27*	.13
Friend condition	3.84	0.26	3.10	0.25	4.29*	.10
Task difficulty						
Overall	3.68	0.32	3.95	0.40	0.26	.01

* $p < .05$.

self first vs. friend first) × 2 (key assignment: use of the left/right response key for the "S" response and the right/left response key for the "H" response) repeated measures analysis of variance (ANOVA) with culture, condition order, and key assignment as between-subjects factors and condition and congruency as within-subjects factors. One Asian participant's data were lost due to a computer program malfunction. The analysis showed that accuracy was higher on congruent (vs. incongruent) trials (94.19 vs. 81.70), $F(1, 30) = 134.00$, $p < .001$, $\eta_p^2 = .82$. This effect, however, did not significantly interact with culture and/or condition (Fs < 1). The two cultural groups showed virtually identical levels of accuracy in the self condition and in the friend condition (European Americans: 88.77 vs. 88.41; Asians: 87.36 vs. 87.23). Neither condition order nor key assignment had any systematic effects.

Next, response time (RT) was analyzed within a 2 (culture) × 2 (condition) × 2 (congruency) × 2 (response accuracy) × 2 (condition order) × 2 (key assignment) ANOVA. Three European American participants who did not make any error response on congruent trials in the friend condition were excluded from this analysis. Overall, Asians were faster than European Americans (238.23 vs. 279.55 ms), $F(1, 27) = 9.69$, $p < .005$, $\eta_p^2 = .26$. Importantly, however, the two cultural groups did not differ in their response time in the self versus the friend conditions (correct trial RTs: 305.67 vs. 306.67 ms for European Americans and 269.25 vs. 271.22 ms for Asians; error trial RTs: 252.95 vs. 252.90 ms for European Americans and 203.17 vs. 209.29 ms for Asians), Fs < 1. For more detailed discussion on response time, see the online supplemental materials.

The absence of any self-centric effects in task performance might seem puzzling. However, in the present procedure, whenever participants made errors on less than 10% of the trials, we encouraged them to respond faster on the next block. This procedure was designed to ensure that the participants would make a sufficiently large number of errors. The performance might have therefore been constrained to mask any effects that would be otherwise expected.

Error-Related Negativity

At the level of self-report, both European American and Asian participants appear to have worked as hard for their friends as they did for themselves. We anticipated, however, that the ERN would reveal a contrastingly different picture. Although the magnitude of the correct-response negativity (CRN) did not vary as a function of either culture or condition, it was somewhat more positive for Asians than for European Americans (6.46 vs. 4.38), $F(1, 37) = 2.53$, $p = .12$. To take this CRN difference into account, we analyzed the ERN-CRN difference scores as in previously work (e.g., Luu, Collins, & Tucker, 2000; Tops, Boksem, Wester, Lorist, & Meijman, 2006).

We performed a 2 (culture) × 2 (condition) × 2 (condition order) × 2 (key assignment) repeated measures ANOVA on the ERN (vs. CRN) magnitude. Congruency (i.e., congruent vs. incongruent trials) was not included in the design, because the error rate was very low on the congruent trials. We found that European Americans showed a clear self-centric effect (see Figure 1A). The ERN (relative to the CRN) was significantly greater in the self condition than in the friend condition (−12.04 vs. −9.06), $F(1, 15) = 10.93$, $p < .005$, $\eta_p^2 = .42$. The topographic maps in Figure 1B show that the ERN is centered at the FCz site. This pattern demonstrates the existence of self-centric motivation, insofar as the same event becomes motivationally more significant, at the neural level, when it implicates the interest of the self versus other. In contrast, there was no ERN difference between the self condition and the friend condition for Asians (−9.79 vs. −10.04; see Figure 1C), $F(1, 16) < 1$. Although the ERN was clearly centered at the FCz site, as in the European American data (Figure 1B), the ERN was no greater in the self (vs. friend) condition among Asians (Figure 1D). Thus, consistent with previous cross-cultural work, we found no evidence of self-centric motivation among Asians.

As implied by the pattern discussed above, the Culture × Condition interaction was significant, $F(1, 31) = 9.08$, $p = .005$, $\eta_p^2 = .23$ (see Figure 2A). This interaction was not qualified by any other variables. When the absolute magnitude of the ERN was analyzed within a 2 (culture) × 2 (condition) × 2 (condition order) × 2 (key assignment) ANOVA, the results were no different, with a significant Culture × Condition interaction, $F(1, 31) = 7.34$, $p < .05$, $\eta_p^2 = .19$ (see the online supplemental materials for two additional interactions that were significant).

Post-Error Slowing

Previous work suggests that increased ERN is often accompanied by post-error slowing—a prolonged response time on a trial subsequent to commission of an error. Post-error slowing is considered to reflect one's effort to avoid making a further error on the subsequent trial after an error, commonly assessed by subtracting each participant's average response time on post-correct trials from the average response time on post-error trials (Holroyd, Yeung, Coles, & Cohen, 2005). The post-error slowing was submitted to a 2 (culture) × 2 (condition) × 2 (condition order) × 2 (key assignment) repeated measures ANOVA. As shown in Figure 2B, European Americans exhibited a significant post-error slowing in the self condition (18.87), $F(1, 15) = 18.69$, $p < .001$, $\eta_p^2 = .56$, but not in the friend condition (5.78), $F = 1.72$, $p > .20$. In contrast, post-error slowing for Asians was virtually absent for both self and

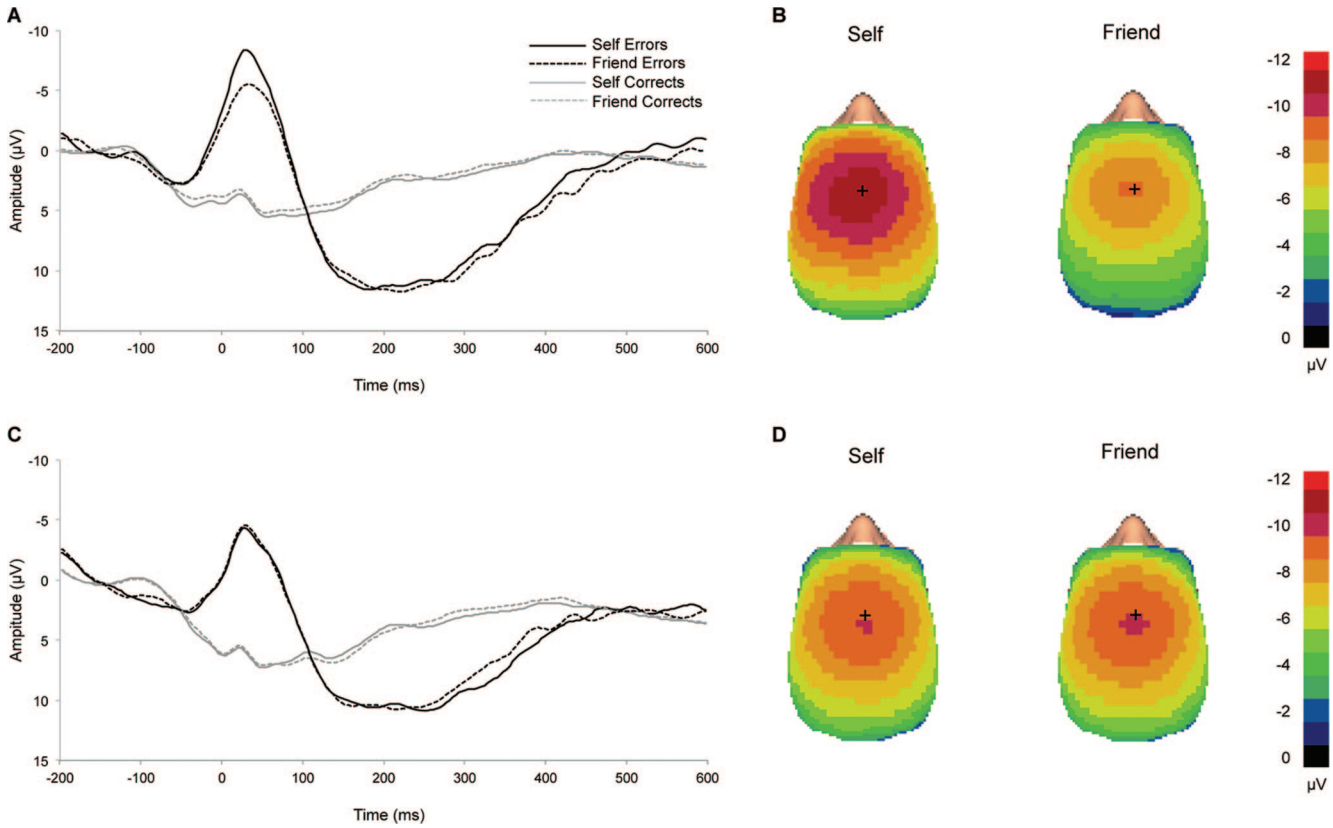

Figure 1. ERN (error-related negativity) and CRN (correct-response negativity) waveforms at FCz (A: European Americans; C: Asians) and topographic maps of the mean ERN (error-correct difference) amplitudes between 10 ms and 60 ms after the response (B: European Americans; D: Asians). In the topographic maps, red colors represent regions of greater negativity. The view shows the top of the head, with the nose pointing upward. The scalp maximum of the ERN occurs at the FCz electrode, indicated by the cross.

friend conditions (−0.89 vs. 1.65), *F*s < 1. The Culture × Condition interaction was significant, $F(1, 30) = 4.91$, $p < .05$, $\eta_p^2 = .14$. No other effects achieved statistical significance.

Self-Centric Effects and Interdependent Self-Construal

Because interdependent social relations require attention and care paid to others, attention to the personal self that is detached from social relations in general, and commitment to self-interest in particular, may be antithetical to interdependence (Markus & Kitayama, 1991). We thus expected that interdependent self-construal would negatively predict self-centric motivation.

First, two indices of self-centric motivation were obtained by subtracting the self condition ERN (vs. CRN) from the friend condition ERN (vs. CRN), on the one hand, and the friend condi-

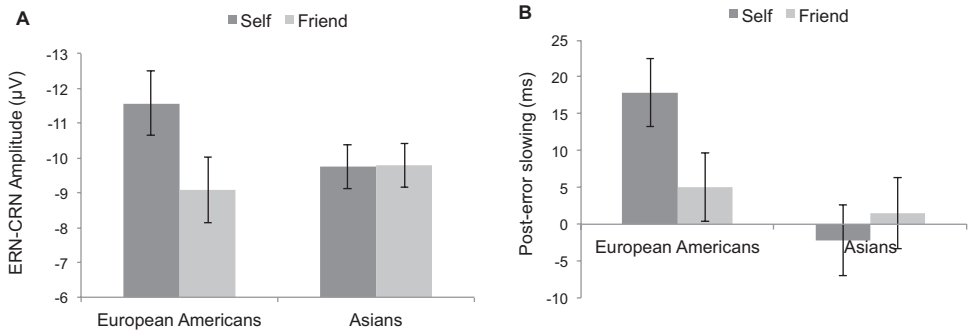

Figure 2. ERN-CRN amplitude (A) and post-error slowing (B) in the self condition and in the friend condition for European Americans and Asians. Standard errors are indicated by the vertical bars. ERN = error-related negativity; CRN = correct-response negativity.

tion post-error slowing from the self condition post-error slowing, on the other hand. For both measures, positive scores show greater self-centric motivation. These two indices were significantly correlated ($r = .36$, $p < .05$).

Next, we examined independent and interdependent self-construals as assessed by the Singelis self-construal scale (Singelis, 1994). There was no cultural difference in independent self-construal (4.88 and 4.82, for Asians and European Americans, respectively), $F < 1$. As expected, however, interdependent self-construal was higher for Asians than for European Americans (4.98 vs. 4.64), although the difference was statistically marginal, $F(1, 37) = 3.54$, $p < .07$, $\eta_p^2 = .09$. Of importance, interdependent self-construal was negatively associated with both indices of self-centric motivation, albeit marginally for post-error slowing (ERN vs. CRN: $r = -.44$, $p < .01$; post-error slowing: $r = -.30$, $p < .07$; see Figures 3A and B). Although the negative relationship between the two variables was evident for both cultural groups (ERN vs. CRN: rs $= -.47$ and $-.31$; post-error slowing: rs $= -.30$ and $-.10$, for Asians and European Americans, respectively), it was no longer significant when analyzed separately for each cultural group, except for one (the Asian correlation on the ERN vs. CRN, $r = -.47$, $p < .05$). This may be due to reduced sample size. In neither case was the apparent cultural difference significant (Zs < 1). No correlations were significant between independent self-construal and the two indices of self-centric motivation ($-.08 < r < .03$, all ps $> .60$).

Note that culture (Asians = 0 vs. European Americans = 1) was related, albeit marginally, to interdependent self-construal, $b = -0.34$, $t(37) = -1.88$, $p < .07$. Moreover, culture was significantly related to the ERN self-centric effect (the enhanced ERN vs. CRN in the self condition relative to the friend condition), $b = 2.53$, $t(37) = 2.45$, $p < .05$. Because interdependent self-construal is linked to the ERN self-centric effect, the cultural difference in the ERN self-centric effect may prove to be mediated by interdependent self-construal. We found in a formal test of this analysis that when both culture and interdependent self-construal were included as joint predictors of the ERN self-centric effect, the path from culture to the ERN self-centric effect was no longer significant, $b = 1.73$, $t(36) = 1.57$, *ns*. Importantly, the effect of interdependence on the self-centric effect remained significant, $b = -2.32$, $t(36) = -2.43$, $p < .05$. As shown in Figure 4, the mediated path (culture → interdependent self-construal → the ERN self-centric effect) was statistically significant (95% bias-corrected bootstrapping confidence interval = [0.04, 2.35]). See the online supplemental materials for the mediational results on post-error slowing.

Discussion

Neural Markers of Self-Centric Motivation

The most important contribution of the current work was to establish a reliable neurophysiological marker of self-centric motivation. European American participants clearly showed an increased ERN when trying to earn reward points for themselves (vs. a friend). Following previous evidence that the ERN originates from the anterior cingulate cortex with a close link to mesocorticolimbic reward-processing systems and plays a significant role in monitoring errors (Holroyd, Dien, & Coles, 1998; Miltner, Braun, & Coles, 1997), we have reasoned that the key mediating mechanism of the ERN self-centric effect may involve increased salience of reward when the self is involved as its direct beneficiary. Under these conditions, individuals may be motivated strongly to pursue rewards while avoiding punishments. This enhanced incentive salience results in increased allocation of processing resources on task-relevant information, thereby leading to a greater activation of the veridical representation of the stimulus, as well as a more meticulous comparison between the response implied by this representation (i.e., correct response) and a response that is actually executed before the stimulus processing is complete (i.e., actual response). The ERN signal should be potentiated as a result. Moreover, the increased potency of the error signal should result in a slowing of response on the next trial (i.e., post-error slowing),

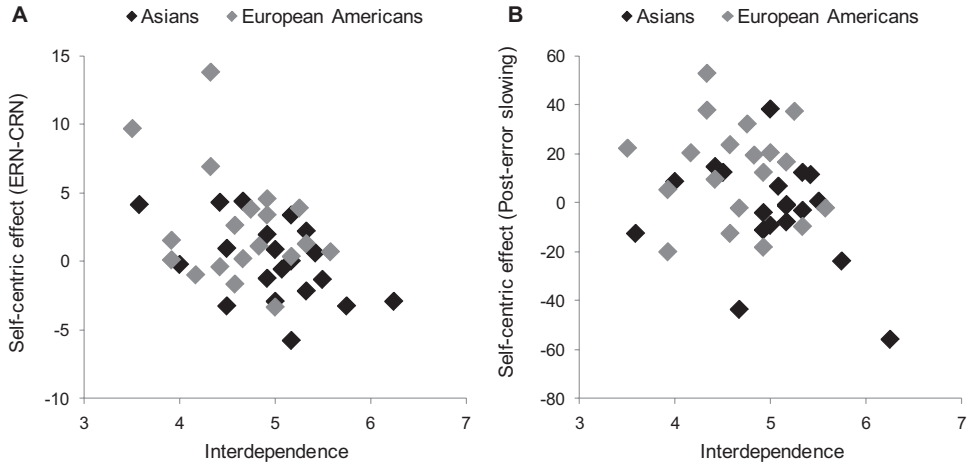

Figure 3. The scatterplots with interdependent self-construal on the *x*-axis and the self-centric effect (A: ERN-CRN; B: post-error slowing) on the *y*-axis. ERN = error-related negativity; CRN = correct-response negativity.

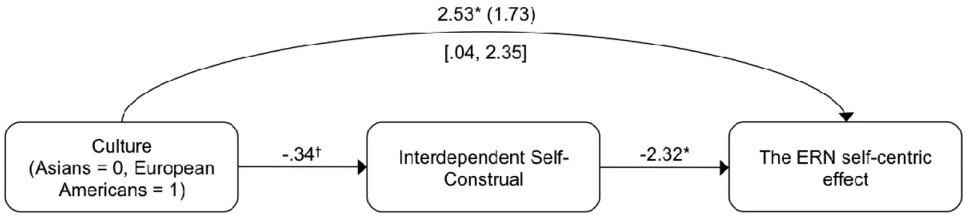

Figure 4. The mediation of the cultural difference in the ERN self-centric effect by interdependent self-construal ($N = 39$). Unstandardized coefficients are shown. The relationship between culture and the self-centric effect is no longer significant after controlling for interdependent self-construal, as indicated in a parenthesis at the top (1.73). The values in square brackets are 95% bias-corrected confidence interval from a bootstrap test with 2,000 replications; the mediation is significant if the confidence interval does not include zero. ERN = error-related negativity. † $p < .10$. * $p < .05$.

because the responder tries to base his or her response on more fully processed stimulus information.

The finding that the self-centric effect was absent among Asians, not only in self-report but also in both the ERN and post-error slowing, indicates that the absence of self-serving bias among Asians is not due merely to self-presentation. In Asian cultural contexts, interdependence is emphasized and, as a consequence, significant others are incorporated into the concept of the self (Markus & Kitayama, 1991). We should hasten to note that the absence of the self-centric effect among Asians does not necessarily mean that they have no need or desire to pursue self-interest. This effect shows, instead, that Asians have a more extended self that encompasses close others as its part. The significant mediation of the cultural difference on self-centric motivation by interdependent self-construal is consistent with this analysis. Future work should use a neural measure of the overlap of representations between the self and close others (Zhu, Zhang, Fan, & Han, 2007) and test whether our ERN finding would be moderated by this neural measure of the self–other overlap.

Although European Americans showed clear evidence of self-centric motivation in the ERN marker, on a post-experimental questionnaire they reported that they worked just as hard for their friend as they did for themselves. The impartiality these participants claimed in their self-report might be a deliberate social presentation. Alternatively, the self-report ratings might reflect what our European American participants genuinely believed about their own behaviors, and, if so, the awareness regarding their own impartiality at the conscious level might prove to be self-deceptive. This issue also deserves further investigation.

ERN as an Indicator of Motivation

Along with other researchers, we have suggested that the ERN might have a strong motivational component. Given the cumulative evidence attesting to this possibility, it might not be too far-fetched to expect that the self-centric effects would be more pronounced for those who are genetically predisposed toward reward seeking. Numerous studies have shown that carriers of certain variants of a dopamine receptor gene, particularly, 7- or 2-varying number tandem repeat polymorphisms of DRD4 (relative to its more ancient 4-VNRP variant), are strongly disposed to novelty/reward seeking and vulnerable to attention-deficit/hyperactivity disorder (Grady et al., 2003). Future work should explore whether the current finding might be modulated by the DRD4 polymorphisms. The DRD4 gene variant that strongly predisposes its carriers to heightened reward sensitivity (7-VNTR) is quite prevalent among European Americans, but this variant is virtually absent among Asians (Chang, Kidd, Livak, Pakstis, & Kidd, 1996). Thus, there might be some genetic contribution to the cultural variation in self-centric motivation we documented in the current work.

Future work should also explore whether the ERN might be used to capture other motivational effects. For example, Hajcak et al. (2005) showed that the ERN is greater when the experimenter stands right behind the participant and monitors his or her performance, thereby giving rise to a condition for self-evaluative threat. Further, this type of social evaluative threat might be induced by mere exposure to an image of a watching face, especially for those who are interdependent (e.g., Asians; Park & Kitayama, 2012). The hypothesis that the ERN is potentiated under the conditions of threat to the self also comes from other recent studies. For example, the magnitude of the ERN is correlated with an increase of a defensive startle reflex right after the commission of an error (Hajcak & Foti, 2008). Conversely, the magnitude of the ERN is attenuated after manipulations designed to give a sense of security (Inzlicht & Al-Khindi, 2012).

Recent research increasingly suggests that the ERN has a motivational component, but it should be clear that the motivation that is evoked is intrinsically intertwined with cognitive mechanisms underlying the detection of errors or the monitoring of conflicts. Future work should address exactly how the motivational processes might have impacts on specific cognitive or neural computations of error detection or conflict monitoring.

Conclusions

Researchers have documented that many psychological findings are limited to people from Western, educated, industrial, rich, and democratic (or WEIRD) societies (Henrich, Heine, & Norenzayan, 2010; Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001). Our finding extends this claim by demonstrating that the primacy of the personal self (vs. social others), widely assumed as universal in the current social and behavioral science literature, must be qualified under certain conditions that are characterized by enhanced degrees of interdependence. Further, it showed that the cultural variation is not limited solely to behavioral effects. To the contrary, if anything, it was more pronounced at the neural, electrocortical level rather than in self-report, thereby directing the

field in the direction of cultural neuroscience (Chiao, 2011; Kitayama & Park, 2010; Kitayama & Uskul, 2011). Future work should examine alternative principles of motivation to account for various behavioral characteristics that are more evident among non-Western populations.

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