

The role of devaluing and discounting in performance monitoring: a neurophysiological study of minorities under threat

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Psychological disengagement allows stigmatized individuals to cope with negative outcomes in stereotype-relevant domains, but its role in online performance monitoring and adjustment is unknown. This study examined how two forms of disengagement (devaluing and discounting) predict performance monitoring at an early (motivational) and later (interpretational) stage of error processing. Among minority college students, event-related brain activity was measured in response to errors on tasks described neutrally or as diagnostic of intelligence. Results found dissociable effects for error-related negativity (ERN) and later positivity (Pe). When the task was linked to intelligence, valuing academics predicted larger ERNs. Unexpectedly, discounting tendencies predicted smaller PEs when the task was described neutrally, a relationship that was attenuated and somewhat reversed when explicitly linking the task to intelligence. In the diagnostic condition, valuing also predicted more efficient behavioral responses to errors, whereas discounting predicted more negative task construals. Results suggest that among stereotype threatened minority students, devaluing has implications for early stage motivational processes involved in monitoring and responding to errors, whereas discounting may have implications for later construal processes.

Keywords: psychological disengagement; stereotype threat; ERN; Pe; event-related potentials; social neuroscience; stigma; performance monitoring

Stigmatized minority students often experience stereotype threat, a fear that their performance may confirm negative stereotypes, in situations where their intellectual merit is evaluated (Steele and Aronson, 1995). To cope with these intellectually threatening environments, some individuals psychologically disengage from performance feedback at the benefit of maintaining self-esteem (Major *et al.*, 1998; Schmader *et al.*, 2001). Although a great deal of research has examined how situations of threat impair performance as an outcome (Schmader *et al.*, in press), we know very little about how individual differences in psychological disengagement predict the degree to which stigmatized targets monitor their performance as it is unfolding. On the one hand, disengaged targets of negative stereotypes might be less likely to even detect their errors on a threatening task in the first place (Aronson and Inzlicht, 2004). On the other hand, if such errors are viewed as confirming a negative stereotype, the tendency to detect those errors might be particularly strong among minorities most motivated to disengage from them.

In this study, two distinct forms of chronic disengagement, *devaluing* the academic domain and *discounting* intellectual tests (Major and Schmader, 1998), were

examined as predictors of performance monitoring processes of stigmatized minorities taking a putative intelligence test. During performance, two neuronal indices of performance monitoring were measured: error-related negativity (ERN/Ne; Gehring *et al.*, 1990) and error-related positivity (Pe; Falkenstein *et al.*, 2000). Approaching psychological disengagement from this perspective provides an online assessment of: (i) how stigmatized minorities monitor their performance in an intellectually threatening environment and (ii) to what extent these processes are moderated by motivational and attributional orientations toward academics.

Psychological disengagement

Psychological disengagement allows stigmatized minorities to buffer self-esteem from threatening feedback received in a stereotype-relevant domain (Major and Schmader, 1998; van Laar, 2000; Crocker and Knight, 2005). For example, Major *et al.* (1998) found in two experiments that African-American college students' self-esteem was less reactive to positive or negative feedback regarding their performance on a bogus intelligence test compared to their Caucasian counterparts. This pattern was especially pronounced for those who reported being chronically disengaged with academic feedback.

Moreover, theory and research suggests that minority students can psychologically disengage from academic

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feedback by two distinct routes: discounting or devaluing (Schmader *et al.*, 2001). Whereas those who chronically discount their academic outcomes assume that intelligence tests are biased and inaccurate measures of their intellect, devaluing refers to the tendency to disinvest one's sense of self in the academic domain more generally. Although either tendency can lead to a detachment of self-esteem from academic outcomes, these two types of disengagement are psychometrically distinct (Major and Schmader, 1998). Thus, minorities can be protected from failure either because academics is a devalued part of their self-definition or because they do not trust intellectual tests to be fair measures of ability.

Prior research on psychological disengagement has employed only self-report measures, often inferring overall psychological disengagement from the lack of correlation between performance and self-esteem (Major *et al.*, 1998). This lack of relationship, however, could reflect either a failure to detect or encode errors at an early stage of processing, or a defensive denial that results after errors have been evaluated as threatening to the self. The former might result from low motivation to excel (perhaps stemming from chronic devaluation of the domain), whereas the latter suggests heightened sensitivity to the significance of poor performance (perhaps stemming from a chronic desire to discount such feedback). The present study examined whether devaluing and discounting served as distinct predictors of these two processes.

Devaluing as a predictor of early error detection. There is ample evidence to suggest that students are explicitly motivated to succeed in academics to the extent that they value the domain (Eccles *et al.*, 1983, Wigfield and Eccles, 2000). What is not known is whether this motivation engages individuals' fast, automatic performance monitoring processes. Theoretical arguments by Schultheiss (2001) and Klinger and Cox (2004) suggest that it might. These theorists posit that when individuals find themselves in a valued domain, motives are activated that automatically guide attention toward goal-relevant stimuli. By this logic, those who value academics should demonstrate vigilance to situational variables critical for success on a test (e.g. learning from past errors). Furthermore, if situations of stereotype threat prompt a motivation to disconfirm negative stereotypes (Steele, 1997), then minority students who value academics should engage more automatic motivational processes such as early detection of errors during an intellectual task. Likewise, those who devalue academic success might be relatively insensitive to errors on an intellectual task.

Discounting as a predictor of later error evaluation. Whereas the value placed on a domain might be expected to predict an early stage of error detection, discounting academic feedback may necessitate a later evaluation of errors so that negative outcomes can be attributed to external factors rather than to the self

(Schmader *et al.*, 2001). Attributions that take external factors into account, however, require executive processes to evaluate incoming information and make a causal determination (Kelley, 1971; Lieberman *et al.*, 2002). According to Gilbert (1991), people's default response is to first accept information at face value. The individual must then actively work to discount the information believed to be untrue. Thus, evaluation of the significance of errors seems to occur at a slightly later (perhaps more conscious) stage in the performance monitoring process. Given this, minority students with a chronic tendency to discount academic feedback may be attuned to evaluate the significance of errors, which they might experience as more threatening, so that they can ultimately discount them. This evaluative process should occur at a later stage in performance monitoring.

The anterior cingulate cortex and performance monitoring

The challenge in testing these hypotheses is to identify a technique for measuring performance monitoring online while one performs a task. To meet this challenge, the present study employed a cognitive neuroscience paradigm to assess activity in the anterior cingulate of the prefrontal cortex (ACC) in response to errors. The ACC is implicated in monitoring one's environment for goal conflict (Carter *et al.*, 1998; Kiehl *et al.*, 2000) and in alerting areas in the prefrontal cortex of attributional discrepancies (Lieberman *et al.*, 2002). Past research assessing ACC-generated event-related potentials (ERPs) has identified the ERN as a negative-going deflection in the ERP waveform that is most pronounced at the fronto-central region on the midline of the scalp 30–180 ms after an error has been made (Yeung *et al.*, 2004). The ERN has been interpreted as evidence for early stage detection of errors (Nieuwenhuis *et al.*, 2001). Consistent with the suggestion that motivation can heighten alertness for errors or conflict, past research has shown stronger ERN amplitudes when individuals internally motivated to not be prejudiced experience automatic stereotype activation (Amodio *et al.*, 2008) or among individuals likely to value the outcome of the task compared to those who do not (Dikman and Allen, 2000).

Following the ERN, there is a distinct positive-going deflection in the ERP waveform known as the Pe, with a parietal maximum ~200–500 ms after an error response (Falkenstein *et al.*, 2000; Hajcak *et al.*, 2004). Although the Pe has received less empirical attention and its neural generators are not circumscribed to a single region, the Pe is thought to index the subjective salience of an error or the arousal elicited by an error response (Hajcak *et al.*, 2003). Thus, larger Pe amplitudes may provide online insight into the extent to which individuals find errors made on an intelligence test subjectively disconcerting. By this logic, Pe amplitudes in response to errors should be sensitive to individual differences in the desire to discount threatening intellectual feedback.

Study overview

The present study investigated how different forms of psychological disengagement predict online performance monitoring processes. As part of a larger study, minority participants completed a response conflict task, described as either diagnostic of intelligence or as a neutral task, while continuous EEG activity was recorded. We hypothesized that valuing would predict greater ERN amplitudes when the task was described as a measure of intelligence as this would activate goal-relevant motivations and more vigilant early stage error monitoring. Hypotheses for the Pe were more tentative given that relatively less is understood about the cognitive correlates of this potential. If discounting requires a later evaluation of errors to cue an external attribution in response to perceived threat, however, then discounting might predict greater Pe amplitudes to errors when the task is described as a measure of intelligence.

In addition, the role of disengagement tendencies and diagnosticity information on performance (e.g. errors, posterror slowing) and task construals (e.g. perceived difficulty, self-doubt) was examined. If the value placed on academics has implications for motivation, then valuing should predict performance-related variables such as fewer total errors and a tendency to slow down following an error.¹ In contrast, if discounting has implications for how the situation is construed, then discounting should predict more negative perceptions of a task linked to intelligence.

Examining psychological disengagement utilizing a social neuroscience approach provides several unique contributions to our understanding of how negative stereotypes affect those who are targeted by them. First, whereas research has investigated the effects of intellectually threatening environments on performance, little is known about how these situations affect basic aspects of the learning process (e.g. attending and adjusting to errors). Second, this study extends prior research distinguishing different forms of disengagement to assess how chronic tendencies to devalue academics and discount intelligence tests may operate at different levels of awareness to predict performance monitoring processes during an intellectually threatening task. Finally, whereas past studies have almost exclusively relied on self-report methodologies to measure the correlates of psychological disengagement, utilizing unobtrusive psychophysiological measures provides a more objective assessment of how stigmatized minorities monitor their performance online.

METHODS

Participants

Participants were 57 minority undergraduates (46 Latino, 11 African American) who participated for credit or \$20. Eligible participants were permanent US residents and had no disabilities that would impair task performance.

One participant suspicious of the hypothesis and two participants who failed to follow instructions were excluded from analyses. Due to equipment malfunction, an additional 11 participants were excluded from ERP analyses, yielding a final sample of 43 participants (35 Latino, 9 African American) for the main ERP hypotheses.

Measures of devaluing and discounting

In an earlier pretest, participants completed scales measuring devaluing (five items, $\alpha = 0.82$, e.g. 'Being good at academics is an important part of who I am'—reversed) and discounting (four items, $\alpha = 0.57$, e.g. 'Most intelligence tests do not really measure what they are supposed to'; Major and Schmader, 1998).² Items were rated from 1 (strongly disagree) to 7 (strongly agree).

Procedure

After being prepared for electroencephalographic recording by a white male experimenter, participants were seated at a computer screen in a sound-dampened chamber and completed a baseline version of the Eriksen-Flankers task (Eriksen and Eriksen, 1974; Gehring *et al.*, 1993), while EEG activity was recorded. Before completing a second flankers task, participants were randomly assigned to diagnosticity condition. In the *control* condition, the task was described as a pattern recognition task that would allow the researchers to identify physiological correlates for the task and establish norms for different students. In the diagnostic of intelligence (*DIQ*) condition, the task was described as predictive of intelligence with the goal being to identify physiological correlates of intelligence and establish norms for different groups. After completing demographic items (including race/ethnicity in the *DIQ* condition), participants completed the second flankers task while EEG activity was recorded. Participants completed the final questionnaire while hooked up to physiological equipment in order to take advantage of bogus pipeline effects that encourage more accurate responding (Sigall and Page, 1971). Finally, participants were debriefed and compensated.

The Eriksen-flankers tasks

Each task trial began with the presentation of an asterisk fixation point in the middle of the screen for 500 ms followed by the presentation of a string of four 'flankers' that were either arrows or letters that appeared directly above the asterisk for 400 ms. The middle letter or arrow (the target) was either congruent or incongruent with the flankers and appeared 135 ms after the onset of the four flankers to enhance response conflict. The *baseline flankers task* consisted of 320 congruent (e.g. $\rightarrow \rightarrow \rightarrow \rightarrow \rightarrow$) or incongruent arrow trials ($\rightarrow \rightarrow \leftarrow \rightarrow \rightarrow$), while the *postmanipulation flankers task* consisted of 480 congruent (e.g. M M M M M) or

¹ Because the task used in this study was fairly simple, lower performance was expected to indicate lower motivation as opposed to threat-induced impairments caused by reduced working memory (O'Brien and Crandall, 2003; Schmader and Johns, 2003).

² Reliability of this measure has been satisfactory in other samples ($\alpha = 0.81$; Major and Schmader, 1998). The lower reliability here should only increase the difficulty of testing predictions.

incongruent letter trials (e.g. MMNMM). Participants were instructed to make a dichotomous decision about the central target (e.g. M or N?) as quickly and accurately as possible. In both the tasks, participants were given 850 ms to identify the target using a response button (response hand assignment was counterbalanced within-subjects). After a correct response, the next trial began. Incorrect responses were followed by the presentation of the word 'WRONG' in red letters for 500 ms in the middle of the screen. Participants were able to self-correct after an error within the 850 ms response window, in which case no feedback appeared.

EEG recording and data reduction

EEG was recorded from 32 tin electrodes embedded within a stretch-lycra cap, with a Cz reference and a ground lead located anterior to Fz on the mid-line of participants' scalps. All impedances were reduced to below 10 k Ω prior to recording EEG activity. All EEG signals were filtered online from 0.05 to 200 Hz, amplified by a factor of 500 with Synamps digital amplifiers, and sampled at 1000 Hz. Offline, EEG signals were filtered with a 3003 point finite impulse response filter that passed signals from 1.5 to 15 Hz. Artifacts other than blinks were manually rejected off-line, and the effect of blinks was corrected using an ocular artifact regression correction procedure (Semlitsch *et al.*, 1986). EEG signals were then epoched off-line using Neuroscan© software, response locked to the participant's incorrect or correct responses, extending from 500 ms prior to the response onset and 1500 ms postresponse. Epochs were baseline corrected by subtracting the average value of EEG 50 ms before the response from the entire epoch. All participants had at least 20 error epochs, and average waveforms were generated for correct and incorrect responses (including both self-corrected and uncorrected errors). Following procedures typical of this paradigm (Hajcak *et al.*, 2004), error-specific activity was isolated by subtracting average waveforms for correct responses from the average waveforms for error responses. From these difference waveforms, the ERN was defined as the most negative deflection at site Fz between 50 and 130 ms after the response, and the Pe was defined as the most positive deflection at site Pz between 200 and 500 ms after the error (Falkenstein *et al.*, 2000).

Final questionnaire

After the task, participants rated (on a 7-point scale) the extent to which they felt doubtful, foolish, inferior, insecure and unsure while completing the flankers task. These responses were averaged to form a composite measure of self-doubt ($\alpha = 0.90$). Perceived difficulty was assessed with two items ($r = 0.44$): 'At any point during the task did you feel like the task was too difficult to accurately complete?' and 'How difficult did you think the pattern recognition task was?'

RESULTS

Descriptive statistics

Table 1 presents means and correlations for all variables involved in analyses. Devaluing and discounting were uncorrelated and did not vary by diagnosticity condition. Consistent with past research (Schmader *et al.*, 2001), these two variables were distinct, and minority students generally reported valuing academics but discounting intelligence tests.

General error effects on brain electrical activity

A general ERN pattern (Figure 1) was established by a repeated measures analysis on premanipulation early stage amplitudes as a function of site (Fz, Cz, Pz) and accuracy (correct, error) that revealed two main effects, $F_{\text{site}}(1, 40) = 42.43$, $P < 0.001$; $F_{\text{accuracy}}(1, 40) = 71.43$, $P < 0.001$, qualified by a significant interaction, $F(1, 40) = 29.57$, $P < 0.001$.³ Consistent with past research (Fabiani *et al.*, 2000), planned contrasts revealed that ERN differences between error and correct trials were maximal at Fz ($\eta^2 = 0.53$) and Cz ($\eta^2 = 0.66$) compared to Pz ($\eta^2 = 0.47$), $F(1, 40) = 3.00$, $P = 0.09$.

The Pe was established by a repeated measures analysis on premanipulation later stage amplitudes that revealed two main effects, $F_{\text{site}}(1, 40) = 55.08$, $P < 0.001$; $F_{\text{accuracy}}(1, 40) = 77.68$, $P < 0.001$, qualified by a significant interaction, $F(1, 40) = 13.29$, $P < 0.001$. Consistent with the more centro-parietal scalp distribution of the Pe (Nieuwenhuis *et al.*, 2001), planned contrasts indicated that Pe differences between error and correct trials were larger at Pz ($\eta^2 = 0.71$) and Cz ($\eta^2 = 0.57$) compared to Fz ($\eta^2 = 0.48$), $F(1, 40) = 67.34$, $P < 0.001$. For simplicity, ERN and Pe results were analyzed for sites Fz and Pz, respectively.

ERP results

In a series of hierarchical regression analyses, devaluing and then discounting were tested as moderators of diagnosticity effects on postmanipulation ERN amplitudes (recorded during the letters task at site Fz) and Pe amplitudes (at site Pz).⁴ Step 1 of these analyses included site-specific baseline activity recorded during the arrows task as a covariate.⁵ The mean centered disengagement variable (devaluing or discounting) and diagnosticity condition (0 = control, 1 = DIQ) were entered on Step 2, with their interaction entered on Step 3 (Aiken and West, 1991).

ERN: devaluing as a moderator. The analyses of *devaluing* as a moderator of diagnosticity on ERN amplitudes yielded the predicted interaction at Fz, $\beta = 0.33$,

³ Degrees of freedom for analyses at Pz vary due to equipment malfunction for two participants.

⁴ The small sample size prevents examination of more complex interactions between devaluing and discounting. Results are unchanged when either discounting or devaluing is included as a covariate when analyzing the other variable as a moderator.

⁵ There were unexpected diagnosticity condition, $t(40) = 2.00$, $P = 0.05$, and devaluing main effects on baseline ERN amplitudes at site Fz, $\beta = -0.30$, $P = 0.05$. The influence of these differences on the analyses is minimized by the inclusion of site-specific baseline scores as a covariate. There were no effects on baseline Pe amplitudes.

Table 1 Descriptive statistics and correlations for all variables involved in analyses

	Mean (s.d.)		1	2	3	4	5	6	7	8
	Control	DIQ								
1. Devaluing	2.41 (0.87)	2.59 (1.22)		−0.07	−0.33	0.23	−0.29	0.17	0.00	−0.26
2. Discounting	4.90 (0.89)	4.67 (1.10)	0.02		0.32	−0.23	0.45	−0.55*	−0.19	−0.21
3. ERN ^a (μV)	−4.89 (2.97)	−4.71 (3.41)	0.68**	0.22		−0.51*	0.81***	−0.08	0.21	0.03
4. Errors	82.85 (30.87)	83.56 (40.10)	0.57**	0.08	0.36		−0.53*	−0.06	0.08	0.19
5. Post-error slowing ^a (ms)	0.06 (0.04)	0.06 (0.04)	0.46*	0.04	0.59**	−0.12		−0.11	−0.04	0.09
6. Pe ^a (μV)	8.29 (5.14)	8.12 (3.24)	−0.43*	0.31	−0.33	−0.22	−0.13		0.10	−0.31
7. Doubt	2.87 (1.20)	2.81 (1.73)	0.10	0.23	−0.02	0.22	−0.07	−0.01		0.28
8. Task difficulty	3.00 (1.02)	3.06 (1.26)	0.25	0.44*	−0.01	0.33	−0.10	−0.12	0.71**	

^aAll correlations involving the ERN, Pe or post-error slowing partial out variance associated with pre-manipulation ERN or Pe amplitudes, and pre-manipulation post-error slowing, respectively.

ERN, error-related negativity; Pe, error-related positivity. Numbers in the upper right portion of the correlation matrix represent correlations between the variables in the control condition, while numbers in the lower left portion represent correlations between the variables in the DIQ condition.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

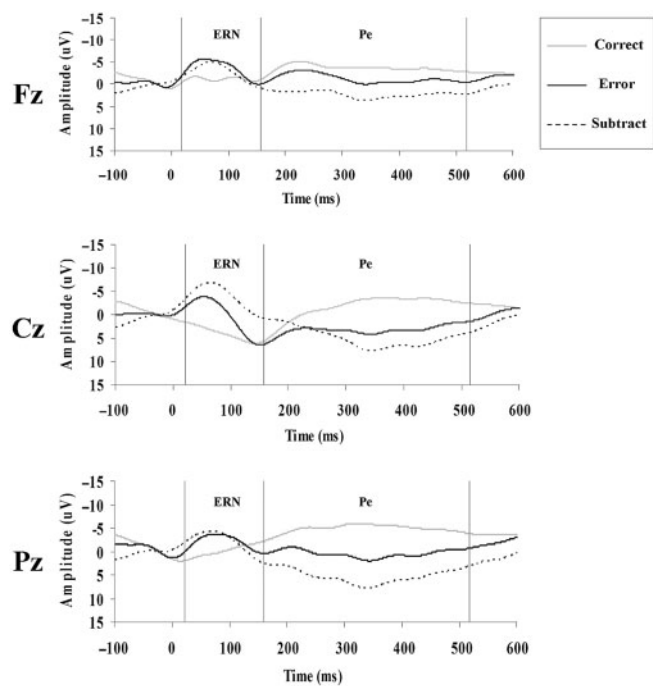


Fig. 1 Premanipulation ERP average wave forms elicited in response to error and correct trials (collapsed across diagnosticity condition). Correct, correct trial grand average wave form; error, error trial grand average wave form; subtract, subtraction wave form (error trials – correct trials).

$P < 0.02$, $R^2 = 0.40$ (Figure 2). Simple slope analyses revealed that devaluing predicted smaller ERN amplitudes in the DIQ condition, $\beta = 0.46$, $P < 0.01$, but not in the control condition, $\beta = -0.21$, $P = 0.37$. In addition, the diagnosticity effect was significant at 1 s.d. below the mean of devaluing, $\beta = -0.48$, $P < 0.02$, but not at 1 s.d. above the mean, $\beta = 0.20$, $P = 0.30$. Because more negative ERN amplitudes indicate increased error monitoring, these results suggest that minority students exhibited more error monitoring to the degree that they valued the academic domain but only when the task was linked to intelligence.

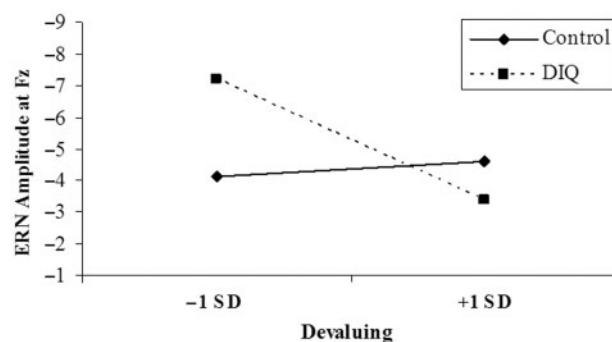


Fig. 2 Devaluing as a moderator of task diagnosticity effects on subtraction ERN amplitudes at site Fz (residualized on premanipulation ERN). Note negative is up on the y-axis, to reflect larger ERN amplitude.

The same analysis using *discounting* as a moderator yielded no significant effects, P 's > 0.10 .

Pe: discounting as a moderator. Whereas discounting did not moderate diagnosticity effects on ERN amplitudes, discounting did moderate diagnosticity effects on Pe amplitudes at Pz, $\beta = 0.29$, $P < 0.03$, $R^2 = 0.52$ (Figures 3).⁶ Unexpectedly, discounting predicted lower Pe amplitudes when the task was neutral ($\beta = -0.41$, $P < 0.05$). But when the task was linked to intelligence, this association tended to be positive although non-significant ($\beta = 0.19$, $P = 0.20$). Linking the task to intelligence led to smaller Pe amplitudes compared to control among participants low in discounting ($\beta_{Low} = -0.39$, $P < 0.04$); whereas this pattern tended to reverse among participants high in discounting ($\beta_{High} = 0.20$, $P = 0.23$). These results suggest that a tendency to discount academic performance predicts less error salience among

⁶ The moderating effects of discounting and task description on early and late components of the Pe as defined by van Veen and Carter (2002) were also assessed. Both peak amplitudes and mean area were investigated in the positive deflections that occurred between 160–200 ms after an error response at site Cz (the early Pe) and 280–320 ms at site Pz (the late Pe). No significant interactions were found for the early Pe (P 's > 0.90), but there was a significant interaction found for the average area in the late Pe window, $\beta = 0.27$, $P < 0.04$, that mirrored the pattern shown in Figure 3 using the 200–500 ms scoring window recommended by Falkenstein *et al.* (2000).

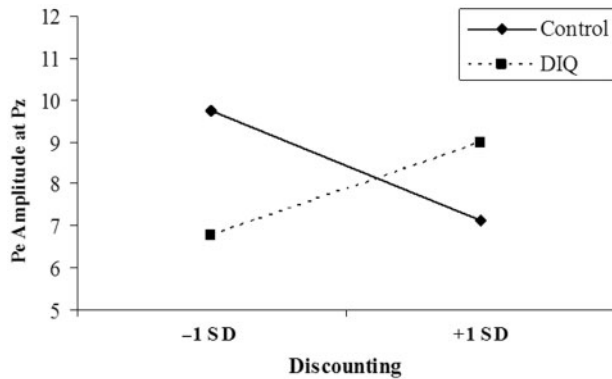


Fig. 3 Discounting as a moderator of task diagnosticity effects on subtraction Pe amplitudes at site Pz (residualized on premanipulation Pe).

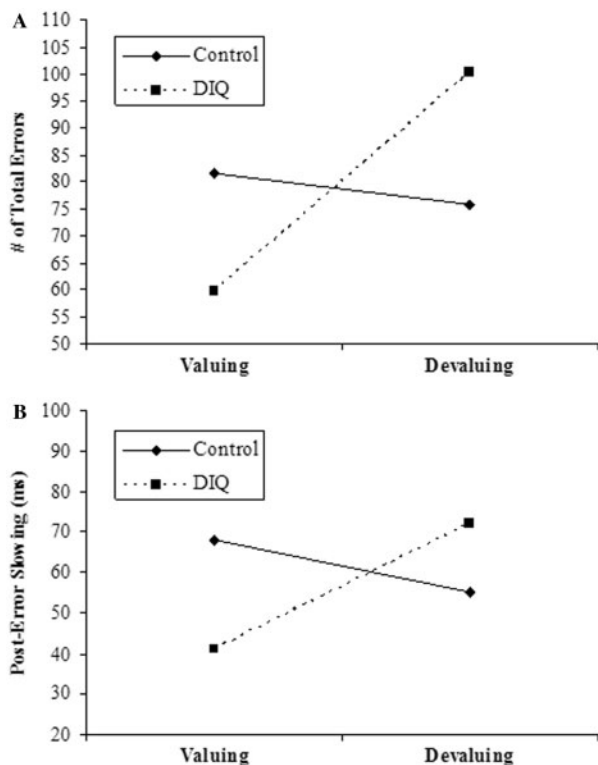


Fig. 4 Devaluing as a moderator of task description effects on (A) number of postmanipulation errors and (B) posterror slowing (residualized on premanipulation posterror slowing).

minority students only when the task is not explicitly framed as a measure of intelligence.

When *devaluing* was tested as a moderator of diagnosticity effects on Pe amplitudes at Pz, no effects were significant, P 's > 0.10, except for a devaluing main effect, $\beta = -0.27$, $P < 0.03$, suggesting that errors were generally more salient to academic valuers.

Error analyses

On average, participants made 16.72% (s.d. = 37.00) of errors on the postmanipulation flankers task. Analyses of the

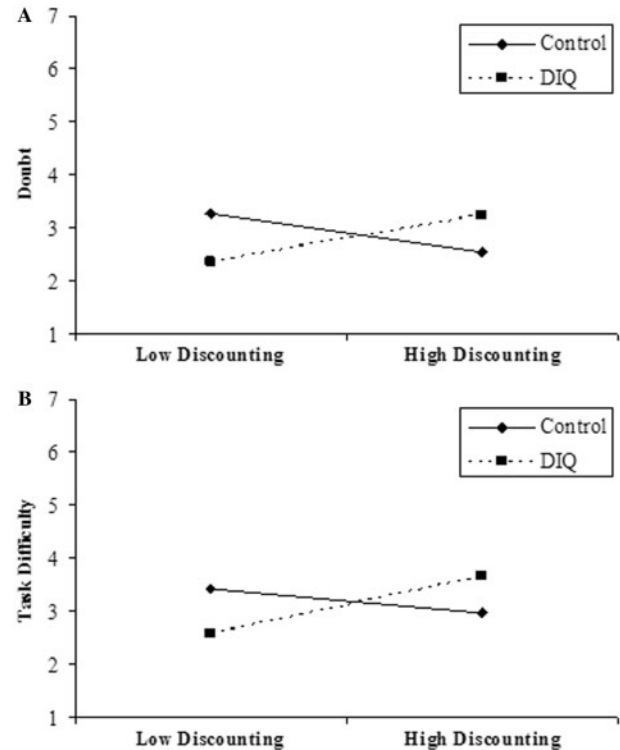


Fig. 5 Discounting as a moderator of task description effects on (A) self-reported doubt and (B) perceived task difficulty.

number of errors made on the task yielded only a devaluing by diagnosticity interaction on total errors, $\beta = 0.31$, $P < 0.03$, $R^2 = 0.15$. Indicative of the idea that devaluing would entail lower motivation, devaluing predicted more errors when the task was linked to intelligence, $\beta = 0.46$, $P < 0.01$, but not when it was described neutrally, $\beta = -0.17$, $P = 0.45$. (Figure 4A). No other effects (including those with discounting) were significant.

Posterror slowing

There were no effects on overall reaction time, P 's > 0.10; however, consistent with past evidence of posterror slowing (Rabbitt, 1981; Luu *et al.*, 2000), reaction times for trials following errors were significantly slower than reaction times on error trials [$M_{RT \text{ Correct not following error}} = 455$ ms; $M_{RT \text{ Correct following Error}} = 517$ ms; $F(1, 53) = 53.56$, $P < 0.001$]. An index of posterror slowing was created by subtracting mean reaction times on correct trials following a correct response from mean reaction times on trials following an error (higher numbers equal more slowing). After first accounting for posterror slowing at baseline, devaluing and discounting were examined as moderators of diagnosticity effects on posterror slowing, yielding a devaluing by diagnosticity interaction, $\beta = 0.27$, $P < 0.04$, $R^2 = 0.28$ (Figure 4B). Simple slopes revealed that, unexpectedly, devaluing predicted more posterror slowing when the test was linked to intelligence, $\beta_{DIQ} = 0.32$, $P < 0.05$, but not when

it was described neutrally, $\beta_{\text{Control}} = -0.24$, $P = 0.24$. When paired with effects on the ERN and errors, these results suggest that among minorities who value academics, stereotype threat cues an automatic vigilance toward errors, and a tendency to make fewer errors and actually speed up on trials following errors.

Self-reported difficulty and self-doubt

Analyses of perceived difficulty and self-doubt yielded only discounting by diagnosticity interactions, $\beta_{\text{difficulty}} = 0.33$, $P < 0.02$, $R^2 = 0.13$; $\beta_{\text{doubt}} = 0.29$, $P < 0.05$, $R^2 = 0.08$ (Figure 5). When the task was linked to intelligence, discounting predicted greater perceived difficulty, $\beta = 0.40$, $P < 0.03$, and a non-significant trend toward greater self-doubt, $\beta_{\text{DIQ}} = 0.26$, $P = 0.15$. In the control condition, these patterns were reversed but non-significant, $\beta_{\text{difficulty}} = -0.27$, $P = 0.22$; $\beta_{\text{doubt}} = -0.33$, $P = 0.14$. Thus, discounting, but not devaluing, predicted greater subjective evaluations of threat in the diagnostic condition.

DISCUSSION

Previous research has distinguished devaluing and discounting as two distinct means by which minorities can become psychologically disengaged from their intellectual performance. However, no prior research has investigated the role of psychological disengagement in online performance monitoring processes. The current study addressed this lacuna using neuronal indices of error monitoring to determine if disengaged minority students are less motivated to monitor their errors in the first place or if errors are detected and engender greater subjective threat. The present results suggest that the answer lies in the extent to which stigmatized minorities tend to devalue the academic domain or discount intellectual tests. Specifically, devaluing and discounting were distinguished as two forms of disengagement that have different motivational and interpretative implications for minority students' performance monitoring processes in intellectually threatening environments.

When performance was framed in terms of intelligence, valuing predicted early stage motivational processes in performance monitoring (ERN amplitudes as an indicator of error detection) and behavior (faster reaction times following an error and fewer errors overall). These findings suggest that stigmatized minorities who value academics respond to stereotype threatening cues by becoming implicitly vigilant for performance relevant stimuli and more efficient in responding to them. These results highlight the increased motivation to excel that situations of stereotype threat elicit in domain identified targets (Jamieson and Harkins, 2007) and help delineate the processes by which threat-induced motivation translates into more efficient responding on tasks that are simple or well-learned (O'Brien and Crandall, 2003; Ben-Zeev *et al.*, 2005).

It is noteworthy that high levels of valuing predicted larger ERN amplitudes under threat compared to control, but there

was no evidence that devaluing related to smaller ERN amplitudes under threat compared to control. This pattern is consistent with the proposal that factors of the person (valuing the domain) and the situation (cues to domain relevance) might both be necessary to cue implicit processing of goal relevant stimuli (Klinger and Cox, 2004). Without both, the situation may seem less relevant to valued goals, muting the potency of error detection processes. However, since this college sample did not include students who strongly devalue academics, it cannot be ruled out that a diagnostic task frame would cue significantly less error detection among those who clearly devalue academic success.

Whereas valuing moderated diagnosticity effects on the ERN, discounting moderated diagnosticity effects on Pe amplitudes. Unexpectedly, discounting predicted smaller Pe amplitudes when the task was described neutrally. Although this relationship was not anticipated, it mirrors recent research showing that minority students who report a history of discrimination exhibit lower cardiovascular reactivity to a negative interracial interaction (Salomon and Jaguszyn, *in press*). Salomon and Jaguszyn posit that for these individuals, the default expectation is that intergroup interactions will be uncomfortable and thus any given negative encounter is not noticed as requiring attribution, particularly if ethnicity is not made salient. Similarly, minority students used to distrusting academic situations might not find errors at a task run by a White male to be surprising or worthy of attention, unless the task is explicitly framed as an intelligence measure signaling that errors should be evaluated. In line with this reasoning, we observed a default tendency for discounting to predict lower Pe amplitudes (less error salience), but this relationship was not present, and tended to reverse, when the task was linked to intelligence.

It is worth noting that the Pe has received relatively little attention, and research is still trying to isolate its psychological correlates (Overbeek *et al.*, 2005). The interpretation we provide here is consistent with the view that this neural response might underscore evaluative salience of an error (Amodio *et al.*, 2006). Admittedly, however, the findings on the Pe did not conform exactly to our predictions, as discounting did not predict significantly larger Pe amplitudes in the diagnostic condition. Although the above interpretation offers a tentative interpretation for these results, further research is needed to replicate and extend these findings.

Additional evidence that discounters were more threatened by their errors in the diagnostic condition was found in their posttask ratings of difficulty and self-doubt. Whereas discounting was unrelated to task construals in the neutral condition, it predicted greater perceived difficulty and relatively more self-doubt when the task was linked to intelligence. Although it might seem that discounters should have been unfazed by the task when it was linked to intelligence, it is important to keep in mind that these individuals report a mistrust of traditional measures of

intelligence (i.e. standardized tests). A task purported to assess intelligence by measuring brain waves might engender a level of threat that their typical coping response is unable to counter. Consequently, minority students with a tendency to discount standardized tests expressed frustration with the difficulty of the task when they believed that neurological responses would reveal their true ability. Devaluing, on the other hand, was not related to these subjective construals.

In sum, the present study utilized neurological measures to test whether discounting and devaluing operate through distinct processes that manifest at different levels of awareness during a performance situation. Whereas the value assigned to a domain acts at an early stage in the performance monitoring process to direct attention toward domain relevant errors and to adjust behavior accordingly, discounting tendencies play less of a role in this early processing of errors. Instead, discounting tended to predict subjective perceptions of an intellectual test as being difficult and self-doubt inducing. This subjective evaluation of the threat would seem to be a necessary precursor to the sort of defensive external attributions that discounters might use to reduce the threat of negative feedback on self-esteem.

Although this study provides evidence for the role of psychological disengagement in performance monitoring, future research is needed to examine the degree to which the present patterns are unique to minority students and to tasks where errors are easily identified. More research is also needed to understand how the error monitoring processes examined here affect learning and performance on more complex tasks that students are faced with during their academic careers. As African American and Latino college students are likely to find themselves in intellectually threatening environments on a daily basis (Osborne and Walker, 2006), it is imperative to understand the repercussions psychological disengagement can have on minority individuals' academic success in hopes that one day these effects can be mollified.

REFERENCES

- Aiken, L.S., West, S.G. (1991). *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage Publications.
- Amodio, D.M., Devine, P.G., Harmon-Jones, E. (2008). Individual differences in the regulation of intergroup bias: the role of conflict monitoring and neural signals for control. *Journal of Personality and Social Psychology*, 94, 60–74.
- Amodio, D.M., Kubota, J.T., Harmon-Jones, E., Devine, P. (2006). Alternative mechanisms for regulating racial responses according to internal vs external cues. *Social Cognitive and Affective Neuroscience*, 1, 26–36.
- Aronson, J., Inzlicht, M. (2004). The ups and downs of attributional ambiguity: stereotype vulnerability and the academic self-knowledge of African American college students. *Psychological Science*, 15, 829–36.
- Ben-Zeev, T., Fein, S., Inzlicht, M. (2005). Arousal and stereotype threat. *Journal of Experimental Social Psychology*, 41, 174–81.
- Carter, C.S., Braver, T.S., Barch, D.M., Botvinick, M.M., Noll, D., Cohen, J.D. (1998). Anterior cingulate cortex, error detection, and the online monitoring of performance. *Science*, 280, 747–9.
- Crocker, J., Knight, K.M. (2005). Contingencies of self-worth. *Current Directions in Psychological Science*, 14, 200–3.
- Dikman, Z.V., Allen, J.J.B. (2000). Error monitoring during reward and avoidance learning in high- and low-socialized individuals. *Psychophysiology*, 37, 43–54.
- Eccles, J.S., Adler, T.F., Futterman, R., Goff, S.B., Kaczala, C.M., Meece, J.L., et al. (1983). Expectancies, values, and academic behaviors. In: Spence, J.T., editor. *Achievement and Achievement Motivation*. San Francisco: W.H. Freeman, pp. 75–146.
- Eriksen, B.A., Eriksen, C.W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, 16, 143–9.
- Fabiani, M., Gratton, G., Coles, M.G.H. (2000). Event-related brain potentials: methods, theory, and applications. In: Cacioppo, J.T., Tassinary, L.G., Berntson, G.G., editors. *Handbook of Psychophysiology*, 2nd edn. Cambridge, UK: Cambridge University Press, pp. 53–84.
- Falkenstein, M., Hoormann, J., Christ, S., Hohnsbein, J. (2000). ERP components on reaction errors and their functional significance: a tutorial. *Biological Psychology*, 51, 87–107.
- Gehring, W.J., Coles, M.G.H., Meyer, D.E., Donchin, E. (1990). The error-related negativity: an event-related brain potential accompanying errors. *Psychophysiology*, 27, S34.
- Gehring, W.J., Goss, B., Coles, M.G.H., Meyer, D.E., Donchin, E. (1993). A neural system for error detection and compensation. *Psychological Science*, 4, 385–90.
- Gilbert, D.T. (1991). How mental systems believe. *American Psychologist*, 46, 107–19.
- Hajcak, G., McDonald, N., Simons, R.F. (2004). Error-related psychophysiology and negative affect. *Brain and Cognition*, 56, 189–97.
- Hajcak, G., McDonald, N., Simons, R.F. (2003). To err is autonomic: error-related brain potentials, ANS activity, and post-error compensatory behavior. *Psychophysiology*, 40, 895–903.
- Jamieson, J.P., Harkins, S.G. (2007). Mere effort and stereotype threat performance effects. *Journal of Personality and Social Psychology*, 93, 544–64.
- Kelley, H.H. (1971). Attribution in social interaction. In: Jones, E.E., Kanouse, D.E., Kelley, H.H., Nisbett, R.E., Valins, S., Weiner, B., editors. *Attribution: Perceiving the Causes of Behavior*. Morristown, NJ: General Learning Press, pp. 1–26.
- Kiehl, K.A., Liddle, P.F., Hopfinger, J.B. (2000). Error processing and the rostral anterior cingulate: an event-related fMRI study. *Psychophysiology*, 37, 216–23.
- Klinger, E., Cox, W.M. (2004). Motivation and the theory of current concerns. In: Cox, W.M., Klinger, E., editors. *Handbook of Motivational Counseling: Concepts, Approaches, and Assessment*. New York, NY: John Wiley & Sons Ltd, pp. 3–27.
- Lieberman, M.D., Gaunt, R., Gilbert, D.T., Trope, Y. (2002). Reflection and reflexion: a social cognitive neuroscience approach to attributional inference. *Advances in Experimental Social Psychology*, 34, 199–249.
- Luu, P., Collins, P., Tucker, D.M. (2000). Mood, personality, and self-monitoring: negative affect and emotionality in relation to frontal lobe mechanisms of error monitoring. *Journal of Experimental Psychology*, 129, 43–60.
- Major, B., Schmader, T. (1998). Coping with stigma through psychological disengagement. In: Swim, J.K., Stangor, C., editors. *Prejudice: The Target's Perspective*. San Diego, CA: Academic Press, Inc, pp. 219–41.
- Major, B., Spencer, S.J., Schmader, T., Wolfe, C.T., Crocker, J. (1998). Coping with negative stereotypes about intellectual performance: the role of psychological disengagement. *Personality and Social Psychology Bulletin*, 24, 34–50.
- Nieuwenhuis, S., Ridderinkhof, K.R., Blom, J., Band, G.P.H., Kok, A. (2001). Error-related brain potentials are differentially related to awareness of response errors: evidence from an antisaccade task. *Psychophysiology*, 38, 752–60.

- O'Brien, L.T., Crandall, C.S. (2003). Stereotype threat and arousal: effects on women's math performance. *Personality and Social Psychology Bulletin*, 29, 782–9.
- Osborne, J.W., Walker, C. (2006). Stereotype threat, identification with academics, and withdrawal from school: why the most successful students of colour might be most likely to withdraw. *Educational Psychology*, 26, 563–77.
- Overbeek, T.J.M., Nieuwenhuis, S., Ridderinkhof, R.K. (2005). Dissociable components of error processing: on the functional significance of the Pe vis-à-vis the ERN/Ne. *Journal of Psychophysiology*, 19, 319–29.
- Rabbitt, P.M.A. (1981). Sequential reactions. In: Holding, D., editor. *Human Skills*. New York: Wiley, pp. 153–75.
- Salomon, K., Jagusztyń, N.E. (in press). Resting cardiovascular levels and reactivity to interpersonal incivility among Black, Latina/o and White Individuals: the moderating role of ethnic discrimination. *Health Psychology*.
- Schmader, T., Johns, M. (2003). Converging evidence that stereotype threat reduces working memory capacity. *Journal of Personality and Social Psychology*, 85, 440–52.
- Schmader, T., Johns, M., Forbes, C.E. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review*, 115, 336–56.
- Schmader, T., Major, B., Gramzow, R.H. (2001). Coping with ethnic stereotypes in the academic domain: perceived injustice and psychological disengagement. *Journal of Social Issues*, 57, 93–111.
- Schultheiss, O.C. (2001). An information processing account of implicit motive arousal. In: Maehr, M.L., Pintrich, P., editors. *Advances in Motivation and Achievement*, Vol. 12: New directions in measures and methods. Greenwich, CT: JAI Press, pp. 1–41.
- Semlitsch, H.V., Anderer, P., Schuster, P., Presslich, O. (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology*, 23, 695–703.
- Sigall, H., Page, R. (1971). Current stereotypes: a little fading, a little faking. *Journal of Personality and Social Psychology*, 18, 247–55.
- Steele, C.M., Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, 69, 797–811.
- Steele, C.M. (1997). A threat in the air: how stereotypes shape intellectual identity and performance. *American Psychologist*, 52, 613–29.
- van Laar, C. (2000). The paradox of low academic achievement but high self-esteem in African American students: an attributional account. *Educational Psychology Review*, 12, 33–61.
- van Veen, V., Carter, C.S. (2002). The timing of action-monitoring processes in the anterior cingulate cortex. *Journal of Cognitive Neuroscience*, 14, 593–602.
- Wigfield, A., Eccles, J.S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology Special issue: Motivation and the Educational Process*, 25, 68–81.
- Yeung, N., Cohen, J.D., Botvinick, M.M. (2004). The neural basis of error detection: conflict monitoring and the error-related negativity. *Psychological Review*, 111, 939–59.