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## Intergroup anxiety effects on the control of racial stereotypes: A psychoneuroendocrine analysis <sup>☆</sup>

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## ABSTRACT

Anxiety associated with an intergroup interaction is often thought to interfere with the cognitive control of automatic racial stereotypes. However, this link remains elusive, as self-reported anxiety is not typically associated with assessments of control. The present research tested a neuroendocrine model for how intergroup anxiety may affect controlled processing. White participants met with a Black or White interviewer to discuss their racial attitudes and to complete a measure of stereotype inhibition. Baseline and post-interaction assessments of self-reported anxiety and salivary cortisol were obtained. Although self-reported anxiety was heightened for participants in the Black interviewer condition, it was not associated with control on the stereotyping task. Rather, greater cortisol reactivity to the interracial interaction predicted reduced controlled processing. This pattern was not observed in the White interviewer condition. Implications for theories of intergroup anxiety, self-regulation, and resource depletion are discussed.

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## Introduction

Interracial interactions can pose a regulatory challenge: a White person interacting with an African American may monitor his- or herself for unintentional expressions of racial stereotypes, whereas an African American may work to avoid behaviors that corroborate such stereotypes (Devine, Evett, & Vasquez-Suson, 1996; Gaertner & Dovidio, 1986; Shelton & Richeson, 2006). To manage this challenge, one must engage in controlled processing to ensure that intended egalitarian responses are expressed in behavior, while stereotypes are not (Richeson & Shelton, 2003; Schmader & Johns, 2003). Self-regulatory efforts in an interracial interaction may be further influenced by social anxiety and stress (Ickes, 1984; Mendes, Blascovich, Lickel, & Hunter, 2002; ; Shelton, 2003; Stephan & Stephan, 1985), which is believed to undermine cognitive control (Easterbrook, 1959). However, past published research has not examined the direct effect of anxiety on control within an interracial interaction, and therefore the notion that intergroup anxiety may lead to control failures and increased expressions of bias remains untested. The purpose of the present research was to test the effects of subjective and physiological aspects of intergroup

anxiety on the inhibition of stereotypes within an interracial interaction.

*Effects of intergroup anxiety on control*

The notion that intergroup contact can elicit both subjective anxiety and a physiological stress response has a long history in social psychology (Guglielmi, 1999; Rankin and Campbell (1955), Stephan & Stephan, 1985). However, little is known about how intergroup anxiety and stress relate to controlled processing, as few (if any) studies have examined the control of stereotypic responses within the context of an interracial interaction. Nevertheless, some previous studies are relevant to this issue. Lambert et al. (2003) examined controlled processing among White participants as they anticipated an upcoming public discussion about a Black person. Just before the discussion was to take place, participants reported their state affect and then completed the weapons identification task (Payne, 2001), a computerized assessment of automatic stereotyping and response control. As expected, subjects who anticipated a public discussion reported experiencing heightened anxiety, compared with participants who did not anticipate the public discussions. They also exhibited a lower degree of controlled processing on the weapons identification task, as revealed by process-dissociation estimates of controlled processing computed from task performance (Payne, 2001). However, although these results are consistent with the idea that anxiety may undermine control, anxiety ratings were not directly correlated with

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subjects' degree of controlled processing.<sup>1</sup> As such, these findings suggest that intergroup anxiety may not have a direct effect on controlled processing, contrary to previous theorizing.

A related program of research by Richeson, Shelton, and colleagues has examined the implications of an actual interracial interaction on cognitive control, but without the direct focus on anxiety (Richeson & Shelton, 2003; Richeson & Trawalter, 2005). In the typical paradigm used in these studies, participants first complete an Implicit Associations Test of evaluative associations with White vs. Black people (Greenwald, McGhee, & Schwartz, 1998), a test that raises subjects' concerns about appearing prejudiced (Monteith, Voils, & Ashburn-Nardo, 2001). Participants are then led to a second room, where they discuss issues related to racial prejudice with either a Black or White interviewer. Following the interaction, they return to the first room to complete a computerized measure of cognitive control that is unrelated to race (e.g., the color-naming Stroop task; Stroop, 1935). Across several studies, Richeson and colleagues have found that participants perform worse on the Stroop task after an interracial interaction, compared with those who had a same-race interaction (e.g., Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Trawalter & Richeson, 2006). This program of research has shown that an interracial interaction can have negative effects on controlled processing. But because this research has not examined the role of anxiety, it is unknown whether the observed effects on control were linked to intergroup anxiety. Furthermore, this program of research has examined controlled processing only on tasks that were unrelated to racial bias and were completed outside the context of the interaction. Thus, the present question of whether intergroup anxiety impairs the control of racial stereotypes within the context of an interracial interaction remains unanswered.

Considered together, previous research suggests that the mechanism through which intergroup anxiety affects control may be more complex than previously believed. That is, although the subjective experience of anxiety was not related to control in past work, it is possible that other components of the broader stress response may have more direct effects on controlled processing. In the next section, I describe how the physiological response associated with intergroup anxiety may constitute a pathway through which intergroup anxiety affects control.

#### *A neuroendocrine model of interracial interaction effects on self-regulation*

Anxiety is the experiential component of a broader psychophysiological stress response (Lang, Bradley, & Cuthbert, 1998). In the intergroup context, this response begins with the perception of social-evaluative threat within an interracial interaction (Amodio, Harmon-Jones, & Devine, 2003; Shelton & Richeson, 2006; Stephan & Stephan, 1985), which initiates coordinated changes in neural, autonomic, endocrine, and immune systems, as well as in subjective experience (McEwen, 1998). In the brain, the perception of threat is associated with amygdala activation (LeDoux, 2000), which triggers the release of norepinephrine from the locus coeruleus (Morilak et al., 2005). Relevant to the present concerns, an important target of norepinephrine signaling during threat is the anterior cingulate cortex (ACC; Aston-Jones & Cohen, 2005), a region involved in monitoring response tendencies for conflict and for recruiting cognitive control (Botvinick, Braver, Carter, Barch, & Cohen, 2001). Past research has shown that the ACC is critical for

the regulation of intergroup responses, such that greater ACC activity is associated with control over automatic stereotyping on reaction time measures such as the weapons identification task (Amodio et al., 2004). A moderate degree of norepinephrine signaling to the ACC is associated with optimal control. But as norepinephrine signaling increases beyond this moderate level, the ACC's response to phasic (e.g., stimulus-driven) sources of conflict is impaired, and cognitive control becomes less effective (Aston-Jones & Cohen, 2005). It is through this neurochemical pathway that intergroup anxiety may reduce cognitive control over unwanted expressions of racial bias (cf. Amodio et al., 2004).

The effect of norepinephrine on the ACC provides a within-brain account for how intergroup interaction stress may affect cognitive control. However, this model cannot be tested directly, because it is not feasible to measure within-brain neurochemical changes during the course of a social interaction. As an alternative, it is possible to index changes in hormone levels that are associated with these within-brain norepinephrine effects. Another target of threat-related norepinephrine signaling in the brain is the hypothalamus, which triggers activity along the hypothalamic–pituitary–adrenal (HPA) axis (Han et al., 2007; Sapolsky, Romero, & Munck, 2000). Activation of the HPA axis produces a set of physiological changes to facilitate a response to the threat (Cannon, 1932; McEwen, 1998). One product of HPA activity is the secretion of the glucocorticoid *cortisol* into the bloodstream. Changes in blood cortisol levels can be detected in saliva  $\approx$ 20 min after cortisol secretion, and thus the measurement of cortisol concentrations in saliva provides a non-invasive way to assess activity of the proposed neurochemical pathway during the course of a social interaction. Using a salivary measure of cortisol, one can test the physiological stress effects of an interracial interaction on the behavioral control of stereotypes.

#### *Study overview*

The present research examined the relation between cortisol reactivity and control on a stereotype inhibition task within the context of an interracial or same-race interaction. White participants were recruited for a study of “social attitudes,” in which they discussed issues of race with either a White or Black experimenter, as in Richeson and Shelton (2003). Salivary cortisol and self-reported anxiety were assessed at baseline and during the interaction. As part of the interaction, participants completed Payne's (2001) weapons identification task, from which independent estimates of automatic stereotyping and control were computed using the process-dissociation procedure (Jacoby, 1991). The weapons identification task was selected because it elicits responses that reflect automatic stereotyping effects rather than evaluative associations (Amodio & Devine, 2006; Judd, Blair, & Champleau, 2004), thereby providing a cleaner index of cognitive control that is not strongly influenced by potential effects of anxiety on evaluations (Amodio, 2008).

In building a hypothesis of cortisol effects on control in the context of an interracial interaction, it was important to consider how cortisol functions in situations where perceived control is high vs. low. That is, although cortisol functions to prepare an organism for an adaptive fight or flight response, strong cortisol reactivity is maladaptive in situations where one feels helpless, such as during social-evaluative tasks and, by extension, interracial interactions (Dickerson & Kemeny, 2004; McEwen, 1998). For this reason, stronger cortisol reactivity should be associated with impaired control during interracial interactions, in which one may feel helpless, but not during same-race interactions. Additionally, given past work, we did not expect all participants to perceive the interracial interaction as stressful (Plant & Devine, 2003). Because a social interaction presents a more subtle form of stress than the

<sup>1</sup> In additional analyses, Lambert et al. (2003) observed that the effect of public vs. private response condition on controlled processing was stronger for high-anxiety participants than for low-anxiety subjects, as determined by a median split on self-reported anxiety scores. However, these analyses did not show evidence of a direct correlation between anxiety and control.

extreme stress batteries required to elicit significant cortisol increases in past work (Kirschbaum, Pirke, & Hellhammer, 1993), a main effect increase in cortisol for the interracial (vs. same-race) interaction was not necessarily anticipated. However, we expected that individual differences in cortisol reactivity to the interracial interaction would predict participants' degree of controlled processing on the weapons identification task. Finally, stress-related norepinephrine effects are not known to target neural processes associated with implicit stereotype activation (Amodio & Devine, 2006), and therefore cortisol reactivity was not expected to relate to estimates of automatic processing on the task.

## Methods

### Participants

Forty (72% female) White American undergraduate students participated in exchange for course credit. Participants were instructed to abstain from alcohol consumption for 24 h prior to their session, and from sugary drinks (e.g., fruit juice or soda) for 1 h prior to the session. Participants who failed to comply were rescheduled or excluded.

### Procedure

All experimental sessions took place between 2:00 and 7:00 pm, when cortisol levels are more stable relative to during the morning hours. Upon arrival, all participants provided informed consent and were probed for compliance regarding restricted substances. The experiment was introduced as a study about social attitudes. Participants were told that the purpose of the saliva samples was to obtain measures of hormone levels that might relate to social attitudes. Because it takes about 20 min for circulating cortisol levels to be evident in saliva (Kirschbaum et al., 1993), collection of saliva was carefully timed to begin 20 min following each psychological event of interest.

### Baseline

To establish a resting baseline, participants relaxed while browsing popular magazines for 10 min. Participants then completed a baseline affect checklist and a set of filler personality questionnaires, none of which were arousing or related to racial issues. After 20 min of rest, participants provided the first saliva sample.

Next, participants were informed that they would be interviewed about their attitudes concerning race, as part of the study's broader interest in social attitudes. Half learned that the interviewer's name was Tina, and the other half learned it would be Tanisha, implying a White or Black woman, respectively. Participants then completed a set of questionnaires assessing racial attitudes, stereotype endorsement, and motivations to respond without prejudice, presumably in preparation for the upcoming interaction. These measures were included to amplify participants' concerns about the upcoming interaction (particularly for those in the interracial condition). However, it is likely that responses on these questionnaires were influenced by demand characteristics, such as the desire to appear non-prejudiced, and so these measures were not included in data analyses.

### Interaction and weapons identification task

Following completion of the self-report measures, the experimenter left the room and the interviewer entered. The interviewer sat in a chair 3–4 ft from the participant and, after initial greetings, began a standardized set of interview questions. Example questions included "Do you think racism is still prevalent in our society?" and "Do you think your schools taught you about African

Americans as leaders (other than discussions about Martin Luther King)?" The conversation on racial attitudes lasted 8 min, after which the interviewer asked the participant to complete a second state affect questionnaire, followed by the weapons identification task. The interviewer waited at a nearby desk while these measures were completed. Participants then provided a second saliva sample, timed carefully to correspond to changes in cortisol associated with the interview (and not the weapons identification task). The interviewer then left the room, and the experimenter returned to probe the participant for suspicion and to provide a debriefing.

### Materials

#### State affect

Participants rated the extent to which they experienced each of a list of emotions "at this moment," on a scale from 1 (not at all) to 7 (extremely), at baseline and immediately following the interview. Participants' ratings of anxiety-related words were the primary focus, and thus ratings on these items (*tense*, *uneasy*, *bothered*, *nervous*) were averaged to form separate baseline ( $\alpha = .73$ ) and post-interview ( $\alpha = .79$ ) anxiety indices. In addition, items from the affect checklist relevant to feelings of helplessness (*helpless*, *timid*, *disappointed with myself*, and *angry at myself*) were averaged to form baseline ( $\alpha = .62$ ) and post-interview ( $\alpha = .70$ ) indices.

#### Weapons identification task

Stimuli and instructions for the weapons identification task were adapted from Payne (2001) and presented using DMDX software (Forster & Forster, 2003). Each trial began with a pattern mask (1 s), followed by a Black or White male face prime (200 ms). The prime was replaced by a target picture of either a gun or tool (200 ms), followed by a second pattern mask that remained on-screen until a response was made. The intertrial interval was 1 s. Stimuli included pictures of two White faces and two Black faces, and four handguns and four handtools. Participants were encouraged to classify targets as guns or tools via button-press within 500 ms of the target presentation, although responses were recorded until a 1500 ms limit. When the 500 ms deadline was exceeded, the response was followed by a "too slow" message. Prime-target pairs were equally probable and randomly ordered. The task included 26 practice trials and 188 critical trials. Accuracy feedback was given only during practice trials.

Correct response latencies occurring between 250 and 1500 ms were natural-log transformed and averaged within trial type for analysis. Error rates were computed within each trial type.

#### Computation of process-dissociation estimates

Using formulas described by Payne (2001), the PD-control estimate was computed by subtracting participants' error rate on Black-tool trials from their accuracy rate on Black-gun trials. Conceptually, this estimate reflects the ability to respond accurately on all trials types, even when the stereotype favors the incorrect response. The PD-automatic estimate was computed by dividing participants' error rate on Black-tool trials by the reciprocal of their control estimate score. This estimate represents the tendency to make an unintentional stereotype-consistent response that is presumably driven by automatic tendencies, given the absence of control.

#### Salivary cortisol

At each time of saliva collection, participants provided duplicate 0.8 ml samples of saliva through a 2" length of drinking straw (via passive drool) into cryovial tubes, which were then stored at  $-80^{\circ}\text{C}$ . Salivary cortisol concentrations were determined from a

25- $\mu$ l sample by radioimmunoassay with the High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit (Salimetrics, State College, PA), processed in a single batch. This assay is robust when saliva samples have a pH within 3.5–9.0. All samples were within this range. Raw cortisol concentration values were log-transformed to normalize distributions for analysis.

## Results

A set of preliminary analyses examined self-reported affect, weapons identification task responses, and cortisol, before testing the central hypothesis that individual differences in cortisol reactivity during an interracial interaction would predict controlled processing on the behavioral task. Data from five participants were excluded from analyses: two expressed suspicion that the interviewer's race was part of the manipulation, two had extreme cortisol scores (greater than 3 SDs), and one had an extreme PD-control score. Effect-size  $r$  or  $\beta$  is reported for key effects.

### Preliminary analyses

#### Self-reported anxiety

A 2 (interviewer race: Black vs. White)  $\times$  2 (time: baseline vs. post-interview) mixed-factors analysis of variance (ANOVA) on anxiety produced a significant effect for time,  $F(1,33) = 14.04$ ,  $p < .001$ , which was qualified by a significant interaction,  $F(1,33) = 4.38$ ,  $p = .04$ ,  $r = .34$  (Fig. 1). Simple effects indicated that participants' baseline anxiety did not differ as a function of interview race,  $t(33) = .71$ ,  $p = .48$ . However, a significant interview-related increase in anxiety was observed in the Black condition,  $t(17) = 3.56$ ,  $p = .002$ ,  $r = .66$ , but not in the White interviewer condition,  $t(16) = 1.50$ ,  $p = .15$ .

#### Self-reported helplessness

A 2 (interviewer race: Black vs. White)  $\times$  2 (time: baseline vs. post-interview) mixed-factors ANOVA on helplessness produced a marginally significant interaction,  $F(1,33) = 3.75$ ,  $p = .06$ ,  $r = .32$  (Fig. 2). Simple effects indicated that helplessness levels did not differ by condition at baseline,  $F < 1$ . However, a significant interview-related increase in helplessness was observed in the Black interviewer condition,  $t(17) = 3.15$ ,  $p = .006$ ,  $r = .62$ , but not in the

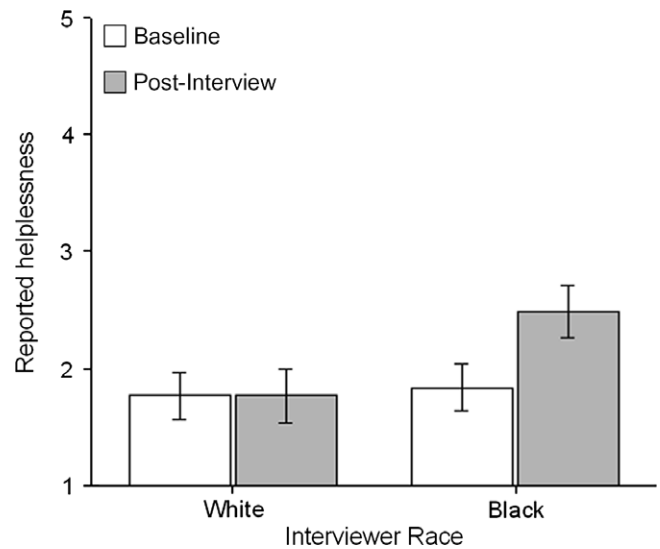


Fig. 2. Self-reported helpless affect at baseline and during the interaction for participants in the White vs. Black interviewer conditions. Scores ranged from 1 (does not apply at all) to 7 (applies very much).

White interviewer condition,  $t(16) = .00$ ,  $ns$ . These results validate the assumption that participants would feel helpless during an interracial interaction, but not during a same-race interaction. Given previous research on the function of cortisol (McEwen, 1998), cortisol reactivity should therefore predict lower control in the interracial condition, but not in the same-race condition (Dickerson & Kemeny, 2004).

#### Weapons identification task

To establish that the behavioral task elicited the expected pattern of race bias (and consequent need for control) across subjects, a 2 (prime: White vs. Black)  $\times$  2 (target: gun vs. tool) ANOVA was conducted on log-transformed reaction times and on error rates. The expected interaction was significant for reaction times,  $F(1,33) = 14.36$ ,  $p < .001$ ,  $r = .55$ , indicating that following Black-face primes, responses were faster to guns than to tools,  $t(34) = 5.39$ ,  $p < .001$ ,  $r = .62$  (Fig. 3). White face primes did not

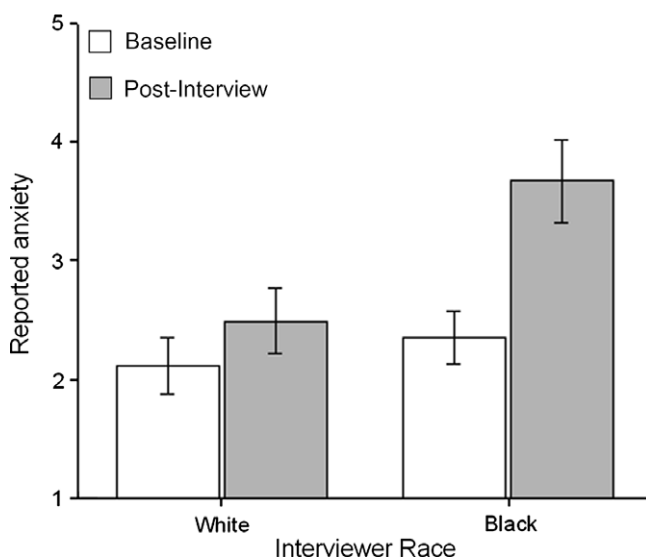


Fig. 1. Self-reported anxiety at baseline and during the interaction for participants in the White vs. Black interviewer conditions. Scores ranged from 1 (does not apply at all) to 7 (applies very much).

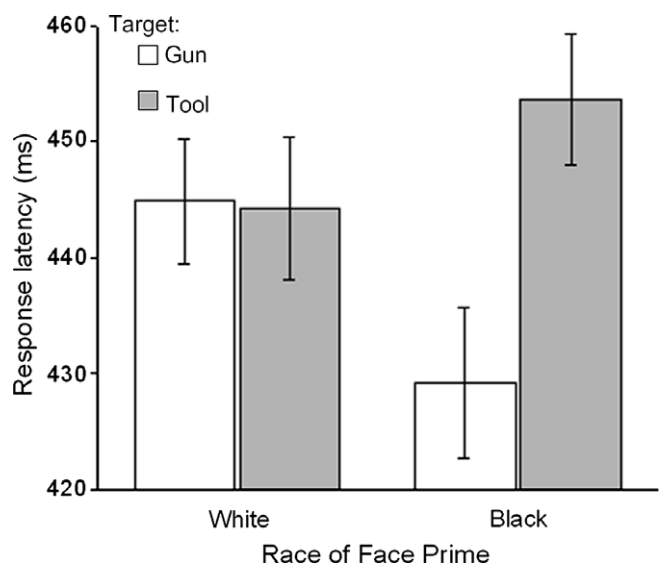


Fig. 3. Response latencies for correct responses to gun vs. tool targets on the weapons identification task, as a function of the race of the face prime.

affect reaction times to guns vs. tools,  $t(34) = .37, p = .72$ . The Prime  $\times$  Target interaction was also significant for error rates,  $F(1, 33) = 14.10, p < .001, r = .55$ , revealing a similar pattern. These results confirmed that the task elicited a pattern of automatic stereotyping and the need for control on certain trials.

Next, PD estimates were examined, as they comprised the primary dependent measures of control and automaticity. As in past work, PD-automatic estimates were higher for Black faces ( $M = .55, SD = .25$ ) than White faces ( $M = .34, SD = .22$ ),  $t(34) = 3.70, p < .001$ , indicating the influence on automatic stereotypes of African Americans on responses. Analysis of PD-control estimates indicated higher control estimates for Black faces ( $M = .70, SD = .17$ ) than White faces ( $M = .65, SD = .18$ ),  $t(34) = 2.04, p = .05$ . However, PD estimates did not differ as a function of interviewer race. This finding is consistent with past work showing that during an interracial interaction, participants exert additional control in order to deliver non-prejudice responses (Amodio, Kubota, Harmon-Jones, & Devine, 2006; Richeson & Shelton, 2003). Nevertheless, it was possible that individual differences in the degree of control would be associated with self-reported anxiety or cortisol reactivity.

#### Cortisol

A 2 (interviewer race: Black vs. White)  $\times$  2 (time: baseline vs. interview) analysis of covariance on log-cortisol scores, with time of day included as the covariate, did not produce significant effects for race,  $F(1, 32) = 3.32, p = .08$ , time,  $F < 1$ , or the interaction,  $F(1, 32) = 2.25, p = .14$ .<sup>2</sup> This was anticipated given that the interaction constituted a subtle manipulation of stress compared with the high-impact stress batteries needed to elicit large cortisol changes (Dickerson & Kemeny, 2004). However, an inspection of cortisol change scores, in which baseline cortisol was covaried from interview-related cortisol levels using a regression procedure, revealed sufficient variability, such that cortisol levels increased during the interaction for some participants but decreased for others.

#### Primary analyses: Interaction effects on response control

Our primary interest concerned the effects of interaction-related cortisol and self-reported anxiety on controlled processing. Anxiety change scores were calculated by covarying baseline from interview-related anxiety scores, using regression. Change in self-reported anxiety and cortisol were not correlated,  $r = -.02$ , replicating past work (e.g., Abercrombie, Kalin, & Davidson, 2005; Lerner, Gonzalez, Dahl, Hariri, and Taylor, 2005).

To test the effect of self-reported intergroup anxiety on control, average PD-control scores were regressed onto effects of interviewer race, anxiety change, and their interaction. None of these effects were significant,  $ps > .24$ , indicating that subjective anxiety was not associated with controlled processing. This null effect replicated Lambert et al. (2003).

The main prediction in this research was that relative increases in cortisol would relate to reduced controlled processing during the interracial interaction. To test this prediction, average PD-control scores were regressed onto effects of interviewer race, cortisol reactivity, and their interaction. The analysis produced only a significant interaction,  $\beta = -.40, t = 2.46, p < .02$  (Fig. 4). Simple slope analyses indicated that within the interracial interaction, higher cortisol reactivity predicted lower PD-control estimates,  $\beta = -.51,$

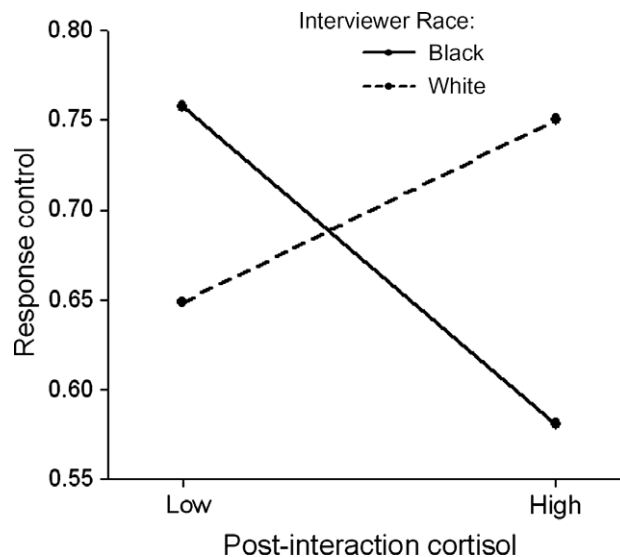


Fig. 4. Predicted values for the process-dissociation estimate of response control, illustrating the interaction of Interviewer Race and interview-related cortisol change. Cortisol change values were computed at one standard deviation above and below the means. Process-dissociation (PD) estimates of control represent probability scores ranging from 0 to 1.

$t = 2.27, p = .03$ . By contrast, in the same-race interaction, cortisol reactivity was not significantly associated with PD-control,  $\beta = .30, t = 1.24, p = .23$ . Although not significant, the positive relation between cortisol reactivity and control in the same-race interaction condition is consistent with the idea that cortisol is adaptive in situations appraised as controllable (McEwen, 1998). A follow-up regression analysis that included self-reported anxiety as a covariate produced only the significant Interviewer Race  $\times$  Cortisol Reactivity interaction,  $\beta = -.49, t = 2.37, p = .02$ , which replicated the pattern of simple slopes reported above. Finally, analyses of PD-automatic estimates for Black and White face trials did not produce effects for interviewer race, cortisol, or their interaction,  $ps < .34$ . Overall, this pattern of results supported the main hypothesis that greater cortisol reactivity during an interracial interaction predicts poorer response control on a stereotype inhibition task.

#### Supplementary analyses: Effects of helplessness in intergroup responses

A supplementary set of analyses explored the relation between feelings of helplessness with cortisol reactivity and PD-control estimates, as a function of interviewer race. In these analyses, a residualized helplessness change variable was used, in which baseline helplessness scores were covaried from post-interview scores using a regression procedure.

A regression testing the effects on helplessness change, interviewer race, and their interaction on PD-control scores indicated that stronger increases in helplessness were associated with lower control,  $\beta = -.36, t = -2.09, p = .04$ . Although the interaction did not reach significance,  $\beta = -.25, t = -1.54, p = .13$ , simple slope analyses revealed the expected trend, whereby increased helplessness was associated with worse control only in the Black interviewer condition,  $\beta = -.59, t = -2.62, p = .01$ , but not in the White interviewer condition,  $\beta = -.06, t = -.25, p = .81$ . The main effect for race was nonsignificant,  $p = .93$ . A second regression analyses tested the effects of helplessness, race, and their interaction on cortisol reactivity scores, but did not produce any significant effects (all  $ps > .49$ ).

To further probe the role of helplessness in the observed effects of cortisol reactivity on control, helplessness scores were included

<sup>2</sup> Mean raw cortisol concentrations ( $\mu\text{g}/\text{dl}$ ) for participants in the Black and White interviewer conditions were 0.14 ( $SD = 0.06$ ) and 0.18 ( $SD = 0.06$ ) at baseline, and 0.13 ( $SD = .05$ ) and 0.15 ( $SD = .06$ ) following the interview, respectively. The means reveal a marginal overall decline in values, consistent with the typical descending slope (Kirschbaum et al., 1993), but this decline is less evident in the Black condition than the White condition.

as a covariate in a regression testing the effects of race, cortisol reactivity, and their interaction on PD-control. This analysis produced only a main effect for helplessness,  $\beta = -.36$ ,  $t = -2.09$ ,  $p = .04$ , and replicated the Interviewer Race  $\times$  Cortisol Reactivity interaction reported above,  $\beta = -.36$ ,  $t = -2.09$ ,  $p = .04$ . A final regression tested the effects of helplessness, cortisol reactivity, and their interaction (across race) on PD-control, as a way to determine whether feelings of helplessness alone might account for the effects of interviewer race on controlled processing. This analysis revealed a main effect for helplessness, as reported above, and marginal Helplessness  $\times$  Cortisol reactivity interaction,  $\beta = -.28$ ,  $t = -1.71$ ,  $p = .09$ . Simple slope analyses were not significant, but they revealed trends in the expected pattern: when helplessness was low, greater cortisol reactivity predicted better control,  $\beta = .35$ ,  $t = 1.25$ ,  $p = .22$ , but when helplessness was high, greater cortisol reactivity was associated with worse control,  $\beta = -.26$ ,  $t = -1.35$ ,  $p = .19$ . Although not significant, this pattern is consistent with the theory that high cortisol reactivity is only maladaptive in situations where one feels helpless to take action (McEwen, 1998).

Taken together, the results suggest that feelings of helplessness are associated with reduced response control. They are also consistent with the notion that helplessness is a moderating factor, in conjunction with race, in determining the effects of cortisol reactivity on controlled processing. Although helplessness accompanies the physiological stress response to an interracial interaction, there was no evidence that helplessness mediated the effect of cortisol on response control. Future research will be needed to more directly examine the role of helplessness in self-regulatory processes during intergroup interactions.

## Discussion

Despite the well-accepted notion that anxiety elicited during an interracial interaction may interfere with self-regulation, direct evidence for anxiety effects on control has been lacking. As a result, the mechanism through which intergroup anxiety may affect control has been unclear. The present research tested and found support for a physiological pathway through which intergroup anxiety can affect control. As in past work, participants in this study felt anxious during the interracial interaction, yet their self-reported anxiety was not associated with controlled processing in their behavioral responses (Lambert et al., 2003). By contrast, and as predicted from the neuroendocrine model proposed here, participants showing larger cortisol reactivity to the interracial interaction exhibited lower controlled processing on the weapons identification task. These results support the idea that interaction anxiety is indeed associated with self-regulatory demands during an interracial interaction, but suggest that the effect of intergroup anxiety on controlled processing are driven by the physiological component of this response, rather than by the experiential component. Although additional human and non-human animal research will be required to further delineate the components of the proposed pathway, the present findings take the first steps toward integrating neural and endocrine models of the stress response and cognitive control to understand self-regulation in social interactions.

The present study differed from past work in some important ways. First, this research focused on the direct effects of intergroup anxiety on the control of stereotypes, whereas most past research (e.g., Richeson & Shelton, 2003) has focused on the effect of resource depletion on control. Second, participants completed the control task within the context of the interaction, whereas in previous research, the task has been completed out-

side the context of the interaction (i.e., either before or after). Third, the task used in the present research assessed control on a stereotype inhibition task, whereas most previous studies have employed cognitive control tasks that were unrelated to racial bias, such as the Stroop task. By having participants complete a stereotype inhibition task during the interaction, the present study permitted a more direct examination of how anxiety and stress affect the regulation of intergroup bias within an interracial interaction. More broadly, this work is unique among studies of cortisol reactivity because it included cortisol as a predictor of behavior in order to probe the mechanism through which stress affects control. By comparison, past research has generally treated cortisol only as an outcome index of the physiological stress response, without examining its relation to behavior.

It is notable that the interracial interactions examined here involved discussions of racially sensitive topics. As in previous experiments on anxiety effects in interracial interactions (e.g., Richeson & Shelton, 2003; Richeson & Trawalter, 2005), this procedure was explicitly designed to elicit a degree of intergroup anxiety so that these effects could be studied. By discussing race-related topics, issues of race were made salient to participants, which in turn likely enhanced their racial group identification (see Shelton and Richeson (2006) for a discussion of this issue). Together, these factors likely contributed to participants' anxiety and stress (as was our intent). When race is not made salient in an interaction, individuals would not be expected to feel as anxious, and the set of processes proposed to follow from intergroup anxiety—increases in subjective anxiety and physiological stress response, and impairments in control—should be less evident. It is important to note, however, that although one's stress response may vary according to the situation (e.g., depending on whether race is salient), the relationship between the endocrine stress response and controlled processing observed in the present research is likely to be similar across situations.

### *Experiential vs. physiological components of intergroup anxiety*

In this study, physiological components of the stress response predicted response control, but the subjective experience of anxiety did not. Why? The notion of discordance between experiential and physiological components of emotion dates back over a century (Lange, 1885/1922; Mandler & Kremen, 1958), and more recent research has described how experiential and physiological components of an affective responses serve different, yet complementary, adaptive functions (e.g., Lang et al., 1998; LeDoux, 2000). For example, subjective experience is a critical component of social behavior and self-regulation, but rather than having direct effects on rapidly unfolding behaviors, past research suggests it functions primarily to inform appraisals and the planning of future behaviors (Monteith, 1993; Schwarz & Clore, 1983). By comparison, physiological components of a stress response have more direct influences on the neurophysiological mechanisms governing basic behavioral action and inhibition (Lang et al., 1998). The fact that subject anxiety and cortisol reactivity were uncorrelated should not be surprising given the long-standing precedent for such dissociations in the psychological literature (e.g., Mandler & Kremen, 1958). An important new contribution of the present research was to show how the physiological component of intergroup anxiety has a unique effect on the control of race-biased behavior, distinct from the subjective component. An important direction for future work will be to examine the interacting, multi-level effects of physiological and subjective components of intergroup anxiety on intergroup behavior.

### Implications of social neuroendocrinology for intergroup relations

Recently, there has been much interest in the finding that self-regulatory processes may be impaired following a resource-intensive interracial interaction (Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Trawalter & Richeson, 2005). The results of the present study may provide new insights into the mechanism underlying these effects. Recent neuroendocrinology research has shown that the physiological stress response can modulate cognitive control through a hormone → brain feedback pathway. Unbound cortisol in the bloodstream feeds back to the brain via glucocorticoid and mineralocorticoid receptors on the paraventricular nucleus of the hypothalamus, which in turn influences norepinephrine signaling throughout the brain via modulatory effects on the locus coeruleus (de Kloet, Vreugdenhil, Oitzl, & Joels, 1998; Dunn, Swiergiel, & Palamarchouk, 2004). As described in the Introduction, there is strong bidirectional communication between the locus coeruleus and ACC via noradrenergic projections, and thus it is possible that cortisol circulating in the bloodstream may modulate cognitive control through this hormone–brain feedback pathway (Aisa, Tordera, Lasheras, Del Rio, & Ramirez, 2007). In addition, proinflammatory cytokines, a component of the immune response, may also affect neural mechanisms of control. Cytokines stimulated peripherally by the HPA axis during the stress response promote the release of cytokines within the brain, via the vagus nerve, which then interact with ACC and medial temporal lobe processes associated with cognitive function (Capuron et al., 2005; Maier & Watkins, 1998). Hence, there are multiple pathways through which the physiological stress response may interact with neural mechanisms of control.

Because glucocorticoid levels may remain elevated in the bloodstream for several minutes following an acute stressor, cortisol may affect neurocognitive mechanisms of control for a sustained period of time. Although this feedback hypothesis is speculative and difficult to test directly in humans, it suggests a new explanation for the sustained effects of stress on cognitive control seen in recent work related to intergroup interactions (e.g., Richeson & Shelton, 2003; Richeson & Trawalter, 2005; Trawalter & Richeson, 2006). This neuroendocrine feedback hypothesis suggests a specific pattern of stress-related impairments on self-regulation, such that it primarily affects the conflict-monitoring component of control, as compared with the more global effects predicted by the glucose-depletion hypothesis (Gailliot et al., 2007).

Although the present work extends the social neuroscience approach to intergroup relations in the direction of endocrinology, it is notable that cortisol is but a small part of the complex hormonal function in the context of social interactions, and there remains much more to be learned. For example, it is important consider the interaction of different classes of hormones, such as anabolic and catabolic steroids (e.g., Mendes, Gray, Mendoza-Denton, Major, & Epel, 2007), as well as their broader interactions with the immune system and the brain (Maier & Watkins, 1999). A consideration of these complex psychophysiological systems promises to open new avenues for theorizing on the effects of stress on social behavior, which in turn will inform intergroup relations.

### Conclusion

The present research provides an initial step in understanding the effects of intergroup anxiety, and the broader psychophysiological stress responses associated with it, on participants' ability to control expressions of racial stereotypes. These findings highlight the complex relationship between intergroup anxiety and control, and suggest that an expanded, multi-level analysis that incorporates theories and methods of neuroscience and endocrinology will

enable a more comprehensive understanding of intergroup social behavior.

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