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Stress-induced cortisol facilitates threat-related decision making among police officers

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Word count: 4,773

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Abstract

Previous research suggests that cortisol can affect cognitive functions such as memory, decision making and attentiveness to threat-related cues. Here, we examine whether increases in cortisol, brought on by an acute social stressor, influence threat-related decision making. Eighty-one police officers completed a standardized laboratory stressor and then immediately completed a computer simulated decision making task designed to examine decisions to accurately shoot or not shoot armed and unarmed Black and White targets. Results indicated that police officers who had larger cortisol increases to the social stress task subsequently made fewer errors when deciding to shoot armed Black targets relative to armed White targets, suggesting that HPA activation may exacerbate vigilance for threat cues. We conclude with a discussion of the implications of threat-initiated decision making.

Keywords: cortisol; stress; decision making; threat, police

Stress-induced cortisol facilitates threat-related decision making among police officers

A growing body of literature has demonstrated that glucocorticoids, secreted from the adrenal glands during stress, can influence decision making (Roelofs, Bakvis, Hermans, van Pelt, & van Honk, 2007; Starcke, Wolf, Markowitsch, & Brand, 2008; Starcke, Polzer, Wolf, & Brand, 2011; van den Bos, Harteveld & Stoop, 2009; van Honk, Shutter, Hermans, & Putman, 2003), yet the direction of these effects differs depending on the level of cortisol, how cortisol levels were induced, and the type of decision making under investigation. Here, we examine the effects of stress-induced cortisol changes on threat-related decision making. We examine these effects among a sample of participants for whom threat-related decision making is a necessary component of their everyday lives – police officer's quick decision to fire their gun or not.

Cortisol and decision making

Recently, an increasing number of studies suggest that cortisol can influence risky decision making. Studies using the Iowa Gambling Task (IGT; Bechara, Tranel, & Damasio, 2000), for example, have shown that individuals lower in basal cortisol engage in more risky decision making than those higher in basal cortisol (van Honk et al., 2003). However, studies that exogenously administer cortisol show elevated cortisol can increase risky decision making, particularly for males (e.g., Putman, Antypa, Crysovergi, & van der Does, 2010). These findings are consistent with the idea that cortisol may facilitate approach-related behavior by exerting affective influence over complex cognitive processes (Putman & Roelofs, 2011).

Similarly studies inducing cortisol increases through stress manipulations have found that acutely elevated cortisol can influence risk taking behaviors in males (van den Bos, Harteveld, & Stoop, 2009). In one study, males who were high in cortisol responsiveness following a stress induction using an evaluated speech and math task (Trier Social Stress Task [TSST]; Kirschbaum, Pirke, & Hellhammer, 1993) made riskier decisions (i.e. performed worse) on a subsequent IGT relative to low cortisol responders and relative to control participants who did not receive the stress manipulation (van den Bos et al., 2009). While in this study, the inverse relationship was seen in females, studies inducing cortisol using *anticipatory* stress have offered converging evidence that cortisol increases can lead to riskier decision making for both males and females (Starcke et al., 2008). Starcke and colleagues (2008) examined participants' performance on the Game of Dice Task (GDT: Brand et al., 2005), a task examining decision making under risk conditions, after exposure to a stress task. In the experimental group, participants had to anticipate giving a speech and then engaged in the GDT. In the comparison group, participants thought about their last holiday then engaged in the GDT. Results indicated that male and female participants in the anticipatory stress condition scored significantly lower on the GDT than those in the comparison group; that is, they made riskier decisions. Furthermore, GDT performance was negatively correlated with cortisol increases.

Stress, and its concomitant increases in cortisol, has been thought to influence decision making by affecting executive functioning and feedback processing (Preston, Buchanan, Stansfield, & Bechara, 2007). Decision making tasks typically involve feedback processing, requiring participants to frequently update their learning based on feedback received during the task. Since stress can reduce executive functioning (al'Absi, Hugdahl, & Lovallo, 2002;

McCormick, Lewis, Somley, & Kahan, 2007), it is thought to impair the feedback processing required to perform well on decision making tasks. Moreover, drawing upon the somatic marker hypothesis (Bechara & Damasio, 2005; Damasio, 1996), when stress is induced using an unrelated paradigm to the decision making task, these incidental emotions generated by the stress task can further interfere with feedback processing and impair performance (Preston et al., 2007; Starcke et al., 2008). This interaction between stress, emotions, and decision making has been examined in the context of both risky and ambiguous decision making, as well as moral decision making, with studies demonstrating that cortisol responses can influence egoistic decision making in emotional dilemmas (Starcke et al., 2011).

Taken together, studies examining baseline cortisol as well as those increasing cortisol through exogenous administration of cortisol, anticipatory stress manipulations, and actual stress manipulations, offer evidence that cortisol influences decision making. However, the direction of these effects can differ by gender, are affected by the emotional context, and may even depend on the type of decision making examined.

Cortisol and selective attention to threat

One context in which individuals' decision making processes may be especially vulnerable to fluctuations in cortisol levels is when making decisions about potentially threatening or dangerous situations. In these contexts, making decisions that help avoid danger might be facilitated during high stress states when cortisol levels increase by enhancing attention to threat-related cues in the environment. Indeed, several studies have found that cortisol can influence selective attention to threat-related material (Roelofs et al., 2007; van Honk et al., 1998; van Honk et al., 2000). These studies use supraliminal and subliminal versions of pictorial emotional Stroop tasks and measure attentional bias to threat by examining whether the color naming latencies for angry or fearful faces significantly differ from the color-naming latencies for neutral or happy faces (van Honk et al., 1998).

Researchers using this paradigm have shown mixed findings regarding the direction of the effects of cortisol on selective attention to threat. When examining baseline cortisol levels, for example, studies have found that individuals with higher relative to lower baseline cortisol attend away from masked angry faces (van Honk et al., 1998). This pattern of cortisol associated with reduced selective attention to negatively valenced faces has also been seen in studies that exogenously administer cortisol, relative to placebo; participants given 40mg of cortisol showed reductions in selective attention to fearful faces, but only when low in anxiety (Putman, Hermans, & van Honk, 2010).

However, a different pattern emerges when examining selective attention to threat cues during rest and under stress for high and low cortisol responders (Roelofs et al., 2007). Whereas at rest, high cortisol responders showed avoidant attentional bias to threat relative to low cortisol responders, this pattern was reversed under conditions of stress. Specifically, high cortisol responders following a TSST showed an increase in selective attention for angry faces compared to low cortisol responders. In other words, under stress, high cortisol responders were more vigilant, measured through longer latencies to respond to angry compared to neutral faces. In contrast, low cortisol responders under stress became avoidant to angry faces (Roelofs et al., 2007).

In sum, studies examining the relationship between cortisol and selective attention to threat suggest that individual differences in basal cortisol and cortisol responsiveness to stress can influence vigilance to threat cues. These findings have implications for understanding the role that cortisol may play in threat-related decision making. Studies on cortisol and decision making have shown that as cortisol increases, performance on risk-related and ambiguous decision making tasks may decrease; the emotion generated through stress inductions unrelated to the task can possibly disrupt feedback learning which ultimately may impair performance. Yet in contexts that require vigilance, stress-induced cortisol increases may improve performance by facilitating attention to threat-related cues.

Present study

The aim of this study was to investigate the effect of stress-induced cortisol increases on threat-related decision making. We recruited active male police officers for a study in which we induced cortisol increases with an adapted Trier Social Stress Task and then had police officers complete a shoot/don't shoot computerized decision making task (Correll, Park, Judd, & Wittenbrink, 2002) as our measure of performance. This task requires decision making about whether to shoot or not shoot potentially hostile targets, making it threat-relevant, and provides real time feedback on performance as well as specific metrics for performance. This task also includes a race-related component allowing us to test whether cortisol increases differentially affect decision making depending on the race of the potentially hostile (i.e., armed) target. Cortisol levels were obtained before and after the stress task. We hypothesized that as cortisol levels increased, performance on the decision making task would also increase. Specifically, we expected that, consistent with studies showing heightened cortisol reactivity can enhance vigilance and attentiveness to threat-related cues, larger cortisol increases would be associated with fewer errors when deciding to shoot an armed target. The race-based nature of the task also allowed us to examine the possibility that the race of the target might be associated with differential errors in decisions to shoot as well. Finally, given that testosterone has also been found to influence attentiveness to threat cues (van Honk et al., 1999; van Honk et al., 2001), increase appetite for risk (Booth, Johnson, & Granger, 1999; Ronay & von Hippel, 2010), and can enhance performance in daily risky decision making (Coates & Herbert, 2008), we included an examination of the effect of testosterone on the decision making task with the prediction that elevated testosterone would be associated with fewer errors to armed targets as well.

Method

Participants

Eighty-one active male police officers employed by a Massachusetts police department participated in the study. Officers were recruited for the study with the help of the command staff during roll call and through email communication from the Commissioner of the police department. Participation was voluntary and officers were informed that their participation would not be made known to the command staff. In addition, officers were informed that all information provided by them would be anonymous and that their responses would never be matched to their identifying information or shared with the command staff. Officers were required to complete the study during off-duty hours and were paid $80.00 for their participation. The study was approved by Harvard University's Institutional Review Board, and all participants gave informed consent in compliance with institutional and federal guidelines.

The goal was to recruit primarily patrol officers and to this end, 84% of the sample listed patrol as their job category. Sergeants accounted for 7% of the sample, and 9% of the sample were investigative officers. The racial composition of the 81 officers was as follows: 44 White, 25 Black, 10 Latino, and 2 Asian. The mean age of the officers was 40.2 years (*S.D.* = 8.33 years, range 24 to 59 years). Eight officers were excluded from the analysis due to problems with their decision making data: seven because they either timed out on all 40 trials of the shoot/don't shoot task or had fewer than five correct trials for at least one of the four cells of the simulation design (Correll et al., 2007; Plant & Peruche, 2005) and one because he did not complete the full study, leaving a sample of 73 officers. Thus, the reported results for this sample are based on 73 officers (41 White, 21 Black, 10 Latino, 1 Asian).

Procedure

The training academy at the Massachusetts police department served as the experimental setting. Participants arrived at the police department's training academy during afternoon hours to minimize variations in neuroendocrine responses due to circadian changes (Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004). Participants signed an informed consent and completed the practice trial of the video game simulation to familiarize themselves with the task. After a 20-minute rest period, participants provided a saliva sample that was later assayed for cortisol and testosterone. Saliva was obtained in sterile tubes using the passive drool method, which required participants to expectorate into a cryovial tube via a plastic straw.

Following the saliva sample, stress was induced through a modified TSST that included critical elements of the TSST like social evaluation and spontaneous speech delivery, but we modified the standard protocol by describing the task as a role play scenario. Participants were instructed that they would engage in a five-minute role play in a mock job interview during which they served in the role of the supervisor and had to interact with a disgruntled citizen who had a complaint about an incident he experienced with another officer (Schroeder & Lombardo, 2004). Importantly, this role play was conducted in front of two evaluators (one male and one female) who we explained would be evaluating the effectiveness of the officer in handling the situation. The disgruntled citizen, a black male actor, alleged that he had been subjected to physical and verbal abuse by an officer and that this treatment was racially motivated.

To make the role play highly self-relevant and to increase the likelihood that participants would be actively engaged in the task, participants were told that they would be videotaped and that their performance on the mock job interview would assist the police department in determining whether role plays should be incorporated into the promotion process. The two evaluators watching the role play engaged in carefully scripted, coordinated, and timed behavior so that all participants had a consistent experience. Evaluators displayed neutral non-verbal expressions throughout the role play.

Immediately following the role play, participants completed the video game simulation (i.e., the shoot/don’t shoot task). The evaluators remained in the room observing the participant while the officer completed the task. After the video game simulation ended, a second saliva sample was obtained that was timed to capture the height of the evaluative role play, approximately 20 minutes after the start of the role play task. Participants were then debriefed, thanked, and paid.

Materials

Neuroendocrine responses. To measure changes in neuroendocrine responses, saliva samples were obtained before and after the stress induction using IBL SaliCap sampling devices. Upon completion of the study, saliva samples were stored immediately at -80 °C until they were shipped overnight on dry ice to a laboratory in College Park, PA. Saliva samples were assayed for cortisol and testosterone using a highly sensitive enzyme immunoassay (Salimetrics, PA). The cortisol test used 25 ul of saliva per determination, has a lower limit of sensitivity of .003 ug/dL, range of standard curve from .003 to 3.0 ug/dL, and average intra- and inter-assay coefficients of variation are 3.5% and 5.1% respectively. The testosterone test used 25 ul of saliva per determination, has a lower limit of sensitivity of 1 pg/mL, and average intra-and inter-assay coefficients of variation are 2.5 % and 5.6 % respectively.

Decision making task. Participants completed a shoot/don't shoot video game simulation designed by Correll and colleagues (see Correll et al., 2002) and developed in PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993). The video "game" uses images of 50 men (25 Black, 25 White) photographed in five poses with a variety of guns (a large black 9 mm, a small black revolver, a large silver revolver, and a small silver automatic) and a variety of non-guns (a large black wallet, a small black cell phone, a large silver soda can, and a small silver cell phone). For each individual photographed, two images were selected, one with a gun and one with an innocuous object, resulting in 60 distinct images (15 of each type: armed White, armed Black, unarmed White, and unarmed Black). These served as targets in the shoot/don't shoot task and the pictures were embedded in 20 unpopulated background scenes, including images of the countryside, city parks, facades of apartment buildings, etc. Targets were randomly assigned to backgrounds, with each target type represented with equal frequency in each background (see Figure 1 for examples of the stimuli).

Responses to the shooting game included two within subjects factors resulting in a 2 x 2 design, with Target Race (Black vs. White) and Object Type (gun vs. non-gun) as repeated factors (see Correll et al., 2002). To prevent anticipatory responding, on any given trial of the game, a random number (0–3) of preliminary background scenes, drawn from the set of 20 backgrounds, appeared in slideshow fashion. Each background remained on the screen for a random period of time (500 ms–800 ms). Following this, a final background appeared (e.g., an apartment building), again for a random duration. This background was then shown with an image of a target person embedded in that background (e.g., an armed Black man standing in front of the apartment building). From the player's perspective, the target simply seemed to appear in the scene.

Participants were instructed to respond as quickly as possible whenever a target appeared, by pressing the "a" button on the computer keyboard indicating "shoot" if the target was armed and pressing the "l" button on the computer keyboard indicating "don't shoot/holster gun" if the target was unarmed. Participants were awarded points based on their performance. Correctly pressing don't shoot in response to an unarmed target earned 5 points, but shooting an unarmed target earned a penalty of 20 points; pressing shoot in response to an armed target earned 10 points, but pressing don't shoot to an armed target earned a penalty of 40 points. Failure to respond to a target within 850 ms of target onset resulted in a penalty of 10 points. Visual feedback and point totals were presented at the conclusion of every trial. The game consisted of one 20-trial practice block and one 40-trial test block.

Results

Demographic Variables

Given the racial and demographic diversity of the participants we recruited, participants were compared for differences in age and years on the police force, as well as for baseline differences in neuroendocrine responses. Means and standard deviations for demographic variables are provided in Table 1. Minority and White participants showed no significant differences in any of the variables tested.

Neuroendocrine Reactivity

The effectiveness of the role play in engendering stress was assessed by examining participants' neuroendocrine reactivity. Changes in cortisol and testosterone levels from baseline were measured to assess whether participants experienced increases following the role play. Consistent with our expectations, participants experienced significant increases in cortisol levels from baseline levels during the role play, t (71) = -7.25, p <.0001. Participants also showed increases in Testosterone, t (70) = -4.76, p <.0001. Means and standard deviations for all neuroendocrine measures are provided in Table 2.

Decision-Making Task

We then examined performance on the shooting task. Error scores were submitted to a 2 (Object: gun vs. no gun) x 2 (Target Race: black vs. white) repeated measures ANOVA. Results revealed a significant effect of object; officers made more errors with armed targets (M = .11) compared to with unarmed targets (M = .08), F (1, 72) = 5.96, p < .02. There was also a main effect for race of the target; officers made fewer errors with Black targets (M = .08) compared to White targets (M = .11), F (1, 72) = 5.84, p < .02 (see Table 3 and Figure 1).

These main effects, however, were qualified by a target race x object interaction, F (1, 72) = 4.23, p <.04. Simple effects tests among armed targets showed that officers made more errors when the target was White than when the target was Black, F (1, 72) = 10.41, p < .002. Stated another way, when the target was Black and armed officers were more likely to shoot than when the target was White and armed. However, when the target was unarmed, officers were no more likely to mistakenly shoot a White target than a Black target, F (1, 72) = 0.06, p < .80 (see Figure 1).

Effects of Neuroendocrine Reactivity on Shoot/Don't Shoot Task Performance

We then turned to our primary question: would increases in cortisol be associated with improved task performance during a threat-relevant task (measured by lower error rates) given that heightened cortisol levels have been associated with vigilance and enhanced attentiveness to perceived threat (Carrasco & Van de Kar, 2003; Charney, 2004; Roelofs et al., 2007). We observed a significant negative correlation between cortisol reactivity and error rates to armed targets, r (73) = -.25, p < .04; heightened cortisol reactivity was associated with fewer errors (better performance) to armed targets (Figure 2). However, for unarmed targets, cortisol reactivity was not significantly related to participants' error rates, r (73) = -.07, p < .54. We then re-ran these analyses controlling for officers' age and the strength of the correlations remained.

Given the interaction between target race and object, we then examined the correlations between cortisol reactivity and errors separately for target race. Again, there was a significant negative relationship between cortisol reactivity and error rates to armed Black targets, r (73) = -.25, p < .03, but a much weaker and non significant association between cortisol reactivity and errors to armed White targets, r (73) = -.14, p < .23, though these correlations were not significantly different from each other (Figure 2). Again, controlling for officers' age produced similar effects.

We also examined whether increases in testosterone affected error rates and found no significant relationships between testosterone reactivity and shooting errors, nor did we find evidence of a curvilinear trend between cortisol and error rates.[1]

Signal detection parameters

We also conducted signal detection analysis to examine the effects of neuroendocrine reactivity on officers' shooting decisions. Signal detection theory (SDT; Green & Swets, 1966) is valuable in the context of the shoot/don't shoot task as it disentangles two distinct factors that can influence the pattern of errors. Signal detection analysis yields an estimate of participants' ability to accurately discriminate between armed and unarmed targets (discriminability: d'), and estimates whether the threshold to shoot a target is low (resulting in frequent shooting) or high (resulting in infrequent shooting) (decision criterion: c). We predicted that as neuroendocrine responses increased, d' and c would increase since heightened cortisol reactivity has been associated with enhanced threat perception and vigilance to threat-related cues.

The ability to accurately discriminate armed from unarmed targets and the criterion for making a shoot response were calculated separately for Black and White targets.[2] Both d' and c estimates were submitted to separate repeated measures ANOVAs examining the effect of target race on these measures. Discriminability (d') and decision criterion (c) analysis revealed that target race did not affect police officers' ability to discriminate armed from unarmed targets, *Fs*< 1. However, there was a significant relationship between cortisol reactivity and d' for Black targets, t (70) = 2.02, $p < .05$. As cortisol levels increased, officers were better able to discriminate between armed and unarmed targets when targets were Black. This relationship between cortisol reactivity and discriminability was not seen for White targets, t (70) = .27, p < .79.

Discussion

This study was designed to examine the relationship between stress-induced cortisol increases and threat-related decision making. Our data show that police officers who had larger cortisol increases to the stress task subsequently made fewer errors in the decision making task, suggesting that HPA activation may enhance attention to threat cues. However, the relationship between increased cortisol reactivity and fewer error rates in the decision making task was stronger when the targets were armed and Black than when the targets were armed and White. That is, the greater the cortisol response the fewer the shooting errors, but only when responding to armed Black targets. Using a more refined measure of decision making, discriminability (d')--that simultaneously considers decisions to respond to armed and unarmed targets—the relationship between cortisol and decision making was even more pronounced. At higher levels of stress-induced cortisol, officers were better able to discriminate armed Black targets from unarmed Black targets, but cortisol levels had no influence on discriminability of White targets.

Historical and contemporary social psychological literature are replete with examples that African American targets (especially Black male targets) can be a source of potential threat, danger, and uncertainty among perceivers. For example, respondents in the U.S. on average have greater implicit negative associations of African Americans relative to Whites (Nosek et al., 2009), show neural responses linked to fear and uncertainty (i.e., amygdala reactions) to

African American faces relative to White faces (Cunningham et al., 2004), and exhibit malignant cardiovascular responses during social interactions with unfamiliar African Americans relative to unfamiliar White Americans (Mendes, Blascovich, Lickel, & Hunter, 2002; Mendes, Major, McCoy, & Blascovich, 2008). Our findings regarding fewer errors and better discriminability when deciding to shoot armed Black targets relative to armed White targets at higher levels of stress-induced cortisol are consistent with the idea that increases in cortisol can result in heightened vigilance for danger.

To our knowledge, this is the first study to report an effect of cortisol on threat-related decision making. While studies have found that cortisol increases can impair risky and moral decision making (Starcke et al., 2008; Starcke et al., 2011), we find the opposite effect for cortisol and threat-related decision making. These divergent findings underscore the importance of understanding the nature of decision making tasks when making predictions about the influence of glucocorticoids on decision making as they type of task can dictate whether cortisol can facilitate or impair performance.

Limitations

It is important to highlight some limitations of our study design. First, we did not include a control condition, as we were interested in understanding how stress-induced fluctuations in cortisol affect decision making. As such, a comparison between decision making under resting conditions and conditions of stress should be tested in future research. Several studies have suggested that acute stress may increase decision making speed (Keinan, Friedland, & Ben-Porath, 1987; Porcelli & Delgado, 2009) which could have implications for accuracy and performance on decision making tasks. Indeed, Roelofs and colleagues (2007) find differences in selective attention to threat for resting cortisol levels compared to cortisol levels following a stress induction, which suggests that the effects of cortisol on threat-related decision making should differ between resting and stress states. Similarly, since we only measured officers' cortisol levels at two points (at baseline and 20-minutes after the TSST), we are unable to examine how officers' recovery from the stressor may have influenced performance on the decision making task, which is another direction for future research.

Second, by using a laboratory based stressor that endogenously activates cortisol we lose precision over controlling levels of cortisol across participants as well as possibly conflating personality characteristics that invoke high cortisol reactivity with those that also result in vigilance for threat cues. For instance, one element of our experimental design that could have invoked higher cortisol reactivity for some officers was that the evaluators remained in the room while officers engaged in the shoot/don't shoot task, potentially contributing to an additional stress response. Therefore, it is very possible that there is an unmeasured "third" variable that accounts for both high cortisol and enhanced vigilance to threat cues. A study that uses an exogenous administration of cortisol that controls levels of cortisol reactivity across individuals could provide important constraints to the data observed here. However, even with this limitation we view these results as important from an ecologically valid perspective. As more police cars and officers are equipped with surveillance equipment, constant evaluation is more likely the rule rather than the exception.

In summary, this study found that police officers showing higher cortisol responses to stress made fewer errors in a threat-related decision making task, but this was especially the case when the targets they were making decisions about whether to shoot or not were Black.

These results indicate that cortisol responsiveness may enhance vigilance to threat cues. These findings provide insight into the role that corticosteroids play in influencing cognitive processes by demonstrating that certain processes of cognitive function in humans can be enhanced by cortisol increases, particularly processes that rely on a heightened attentiveness to emotionally relevant situational cues.

Our results are intriguing from a societal perspective as it is unclear whether officers' accuracy and discriminability for Black targets is helpful or harmful. We observed higher cortisol not only enhancing accuracy but also discriminability for Black targets which suggests that strong HPA activation during quick and important decision making tasks can be helpful by heightening officers' sensitivity to potential danger. Yet, making more errors by not shooting armed White targets (relative to armed Black targets) is certainly harmful as this inaccuracy could put officers' lives and potentially civilians in danger.

References

Al'Absi, M., Hugdahl, K., & Lovallo, W. R. (2002). Adrenocortical stress responses and altered working memory performance. *Psychophysiology, 39,* 95-99.

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior, 52,* 336-372.

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain, 123,* 2189–2202.

Booth, A., Johnson, D., & Granger, D. (1999). Testosterone and men's depression: The role of social behavior. *Journal of Health and Social Behavior, 40,* 130-140.

Brand, M., Fujiwara, E., Borsutzky, S., Kalbe, E., Kessler, J., & Markowitsch, H. J. (2005). Decision-making deficits of Korsakoff patients in a new gambling task with explicit rules-associations with executive functions. *Neuropsychology, 19,* 267–277.

Carrasco, G. A., & Van de Kar, L.D. (2003). Neuroendocrine pharmacology of stress. *European Journal of Pharmacology, 463*, 235.

Charney, D. S. (2004). Psychobiological mechanisms of resilience and vulnerability: Implications for successful adaptation to extreme stress. *The American Journal of Psychiatry*, *161*, 195-216.

Coates, J.M., & Herbert, J. (2008). Endogenous steroids and financial risk taking on a London trading floor. *Proceedings of the National Academy of Sciences, 105,* 6167-6172.

Cohen, J. D., MacWhinney, B., Flatt, M. R., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers, 25*, 257–271.

Correll, J., Park, B., Judd, C.M., & Wittenbrink, B. (2002). The police officer's dilemma: Using ethnicity to disambiguate potentially threatening individuals. *Journal of Personality and Social Psychology, 83*, 1314-1329.

Correll, J., Park, B., Judd, C. M., Wittenbrink, B., Sadler, M. S., & Keesee, T. (2007). Across the thin blue line: Police officers and racial bias in the decision to shoot. *Journal of Personality and Social Psychology, 92*, 1006-1023.

Cunningham, W.A., Johnson, M.K., Raye, C.L., Gatenby, J., Gore, J.C., & Banaji, M.R. (2004). Separable neural components in the processing of Black and White faces. *Psychological Science, 15*, 806–813.

Damasio, A.R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions: Biological Sciences, 351,* 1413-1420.

Green, D. M., & Swets, J. A. (1966). Signal detection theory and psychophysics. Oxford England: Wiley.

Keinan, G., Friedland, N., Ben-Porath, Y. (1987). Decision making under stress: Scanning of alternatives under physical threat. *Acta Psychologica, 64*, 219-228.

Kirschbaum, C., Pirke, K., & Hellhammer, D.H. (1993). The 'trier social stress test'- a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*, 76-81.

Kudielka, B. M., Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2004). Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. *Psychoneuroendocrinology, 29,* 983–992.

McCormick, C.M., Lewis, E., Somley, B., Kahan, T.A. (2007). Individual differences in cortisol and performance on a test of executive function in men and women. *Physiology and Behavior, 91*, 87-94.

Mendes, W. B., Blascovich, J., Lickel, B., & Hunter, S. (2002). Challenge and threat during social interactions with white and black men. *Personality and Social Psychology Bulletin, 28*, 939–952.

Mendes, W. B., Major, B., McCoy, S., & Blascovich, J. (2008). How attributional ambiguity shapes physiological and emotional responses to social rejection and acceptance. *Journal of Personality and Social Psychology, 94(*2), 278–291.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., Bar-Anan, Y., Bergh, R., Cai, H., Gonsalkorale, K., Kesebir, S., Maliszewski, N., Neto, F., Olli, E., Park, J., Schnabel, K., Shiomura, K., Tulbure, B., Wiers, R. W., Somogyi, M., Akrami, N., Ekehammar, B., Vianello, M., Banaji, M. R., & Greenwald, A. G. (2009). National differences in gender-science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences, 106*, 10593-10597.

Plant, E. A., & Peruche, B. M. (2005). The consequences of race for police officers' responses to criminal suspects. *Psychological Science, 16*, 180-183.

Porcelli, A.J., Delgado, M.R. (2009). Acute stress modulates risk taking in financial decision making. *Psychological Science, 20*, 278-283.

Preston, S. D., Buchanan, T. W., Stansfield, R. B., & Bechara, A. (2007). Effects of anticipatory stress on decision making in a gambling task. *Behavioral Neuroscience, 121,* 257–263.

Putman, P., Antypa, N., Crysovergi, P., & van der Does, W. A. J. (2010). Exogenous cortisol acutely influences motivated decision making in healthy young men. *Psychopharmacology, 208*, 257-263.

Putman, P., Hermans, E.J., & van Honk, J. (2010). Cortisol administration acutely reduces threat-selective spatial attention in healthy young men. *Physiology & Behavior, 99*, 294-300.

Putman, P., & Roelofs, K. (2011). Effects of single cortisol administrations on human affect reviewed: Coping with stress through adaptive regulation of automatic cognitive processing. *Psychoneuroendocrinology, 36,* 439-448.

Roelofs, K., Bakvis, P., Hermans, E.J., van Pelt, J., & van Honk, J. (2007). The effects of social stress and cortisol responses on the preconscious selective attention to social threat. *Biological Psychology, 75,* 1-7.

Ronay, R., & von Hippel, W. (2010). The presence of an attractive woman elevates testosterone and risk-taking in young men. *Social Psychological and Personality Science, 1*, 57-64.

Schroeder, D. J., & Lombardo, F. A. (2004). *How to prepare for the police sergeant examination* (4th ed.). New York: Barron's Educational Series, Inc.

Starcke,K., Polzer, C., Wolf, O.T., & Brand, M. (2011). Does stress alter everyday moral decision-making? *Psychoneuroendocrinology, 36*, 210.

Starcke, K., Wolf, O. T., Markowitsch, H. J., & Brand, M. (2008). Anticipatory stress influences decision making under explicit risk conditions. *Behavioral Neuroscience, 122,* 1352–1360.

Van den Bos, R., Harteveld, M., Stoop, H. (2009). Stress and decision-making in humans: Performance is related to cortisol reactivity, albeit differently in men and women. *Psychoneuroendocrinology, 34*, 1449-1458.

Van Honk, J., Shutter, D.J., Hermans, E.J., & Putman, P. (2003). Low cortisol levels and the balance between punishment sensitivity and reward dependency. *Neuroendocrinology, 14,* 1993-1996.

Van Honk, J., Tuiten, A., Hermans, E., Putman, P., Koppeschaar, H., Thijssen, J., Verbaten, R., & van Doornen, L. (2001). A single administration of testosterone induces cardiac accelerative responses to angry faces in healthy young women. *Behavioral Neuroscience, 115,* 238-242.

Van Honk, J., Tuiten, A., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., & Verbaten, R. (1998). Baseline salivary cortisol levels and preconscious selective attention for treat: A pilot study. *Psychoneuroendocrinology, 23*, 741-747.

Van Honk, J., Tuiten, A., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., & Verbaten, R. (2000). Conscious and preconscious selective attention to social threat: Different neuroendocrine response patterns. *Psychoneuroendocrinology, 25(6)*, 577.

Van Honk, J., Tuiten, A., Verbaten, R., van den Hout, M., Koppeschaar, H., Thijssen, J., de Haan, E., (1999). Correlations among salivary testosterone, mood, and selective attention to threat in humans. *Hormones and Behavior, 36*, 17-24.

Acknowledgements

Support for this work was provided by a donation from Hansjoerg Wyss to the HBS Doctoral Programs and from a NHLBI Grant (RO1 HL079383) to WBM.

Footnotes

1. In addition to examining the relationship between cortisol reactivity and error rates for armed Black and White targets, we also examined the relationship between errors and: a)baseline cortisol, b)baseline testosterone, c)testosterone response, d)baseline cortisol/baseline testosterone ratio, e)cortisol response/ testosterone response ratio, and f)cortisol response/baseline testosterone ratio. We found the cortisol response/testosterone response ratio significantly predicted errors to armed targets ($r = -.23$, $p < .05$), but this correlation was not significant when examining armed Black targets or armed White targets separately. No other variables were significantly correlated with armed error rates.
2. $c = 0.5 * (zFA + zH)$; $d' = zH - zFA$, where FA is the proportion of false alarms (relative to correct rejections) and H represents the proportion of hits (relative to misses). The z operator is the translation of these proportions to z-scores.

Table 1

Sample Demographics

	Officer Ethnicity	
Variable	White	Minority
Age		
Mean	40.2	40.2
SD	8.0	9.0
Range	24-56	25-59
N	40	31
Years as an officer		
Mean	12.2	12.4
SD	7.1	8.1
Range	0.7-25	0.8-25

Note: Age and years as an officer were not provided by two officers.

Table 2

Neuroendocrine Responses Means and Standard Deviations

	Timing of Sample	
Variable	Baseline	Post Role Play
Cortisol (ug/dL)		
Mean	0.19_a	0.33_b
SD	0.11	0.20
Testosterone (pg/mL)		
Mean	101.46_a	117.13_b
SD	31.90	40.45

Note: Different subscript letters across the row indicate a significant difference at $p < .05$.

Table 3

Error Rates Means and Standard Deviations

Measure	All Targets	Black Targets	White Targets
Error Rates	0.10 (0.07)	0.08 (0.08)$_a$	0.11 (0.09)$_b$
Armed	0.11 (0.08)	0.08 (0.09)	0.13 (0.11)
Unarmed	0.08 (0.08)	0.08 (0.10)	0.09 (0.11)

Note: N = 73. Standard deviations are in parentheses. Different row subscript letters indicate a significant difference at $p < .05$.

Figure Captions

Figure 1. Target and background example scenes from the shoot/don't shoot video game simulation. (A) armed Black target, (B) unarmed Black target, (C) armed White target, (D) unarmed White target.

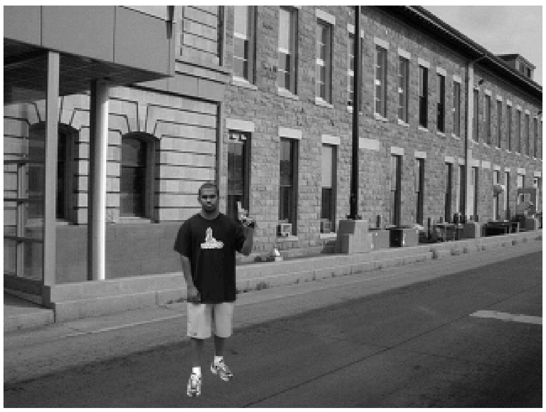
Figure 2. Mean error rates for armed and unarmed Black and White targets.

Figure 3. Relationship between cortisol reactivity and error rates to armed Black targets and cortisol reactivity and error rates to armed White targets. Armed Black targets are represented by filled triangles, armed White targets by open squares. The thick solid line is the regression fit for both armed Black and armed White targets; the dashed line is the regression fit for armed Black targets; the dashed and dotted line is the regression fit for armed White targets.

Figure 1

Target and Background Example Scenes From Video Game

A



B

C

D

Figure 2

Error Rates for Armed and Unarmed Black and White Targets

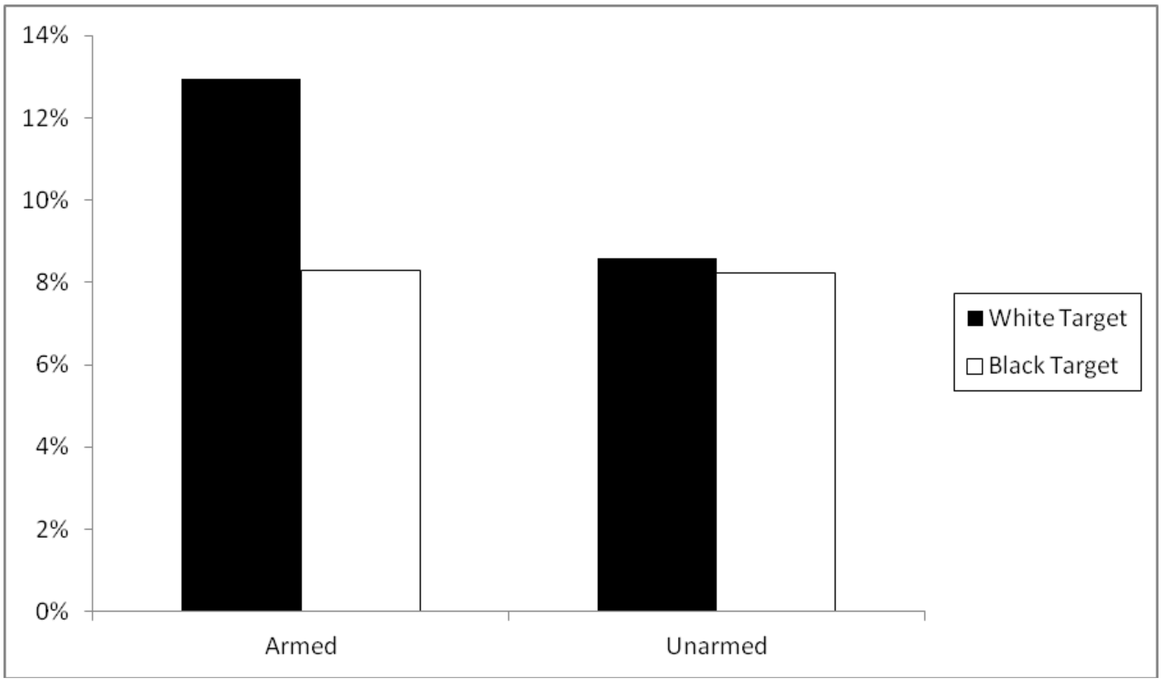


Figure 3

Relationship Between Cortisol Reactivity and Error Rates for Armed Black and White Targets