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The Mismatch Effect: When Testosterone and Status Are at Odds

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Why do some people strive for high status, whereas others actively avoid it? In the present studies, the authors examined the psychological and physiological consequences of a mismatch between baseline testosterone and a person's current level of status. The authors tested this *mismatch effect* by placing high and low testosterone individuals into high or low status positions using a rigged competition. In Study 1, low testosterone participants reported greater emotional arousal, focused more on their status, and showed worse cognitive functioning in a high status position. High testosterone participants showed this pattern in a low status position. In Study 2, the emotional arousal findings were replicated with heart rate, and the cognitive findings were replicated using a math test. In Study 3, the authors demonstrate that testosterone is a better predictor of behavior than self-report measures of the need for dominance. Discussion focuses on the value of measuring hormones in personality and social psychology.

Keywords: testosterone, status, individual differences

Saint Peter Celestine has been referred to as "the most pathetic figure in the history of the papacy" (Walsh, 1991). Celestine was born Peter Morrone of Italy, in the early 13th century, and was ordained as a priest in his early thirties. Content to spend the rest of his life as a hermit in a small monastery in the mountains near his home, Morrone was renowned for his wisdom and well-loved by those around him. Unfortunately, his peaceful existence was doomed to end after what many might have considered good news. When Morrone was in his early eighties, Pope Nicholas IV died without a successor. After two years of searching, the cardinals finally settled on Morrone and despite his reservations he submitted to their wishes. Consecrated as Celestine V in August 1294, he quickly became a pawn in the political games of King Charles II, miserable at his readily noticeable failures. After less than five months as pope, overwhelmed by "the burden of the office he had not sought and was incapable of filling" (Walsh, 1991), Celestine finally abdicated his position, the first ever to do so. His troubles did not end there, however. Celestine's successor, Boniface VIII, was worried that Celestine's popularity as a holy man might challenge his own authority, and launched a preemptive strike. Boniface VIII ordered Celestine hunted down and imprisoned, where he died 10 months later.

Needless to say, Celestine and Boniface had different reactions to the same high status position. Whereas Boniface eagerly welcomed the opportunity the papacy represented, Celestine's unwillingness to assume the papacy was borne out by his miserable and ultimately tragic experience as pope. This sad story raises a number of questions. What factors might lead someone to prefer high status, whereas another shuns it? What happens when someone desires high status, but does not have it? And what about the person who does not want high status, but gets it anyway? In this paper, we attempt to answer these questions by proposing that one of the major contributors to these individual differences is one's baseline level of testosterone.

We begin by reviewing evidence linking testosterone to status-related behaviors including dominance, suggesting that individual differences in basal testosterone levels are correlates for status preference. Then, we will present evidence showing the relevance of testosterone to the social situation, and suggest that the relative status of others within the group can exert powerful influences on psychological and physiological functioning, depending on one's testosterone level and social standing. The interaction between one's status with respect to the group and one's basal testosterone level forms the basis of what we are calling the *mismatch effect*.

Testosterone, Status, and Social Situations

From a psychological perspective, one of the most interesting things about testosterone is its relationship to dominant behaviors (e.g., Archer, in press; Mazur & Booth, 1998). Research with humans and a wide variety of animal species suggests that under specific conditions, individuals higher in baseline testosterone are: (1) more driven to gain and maintain high status; and (2) more responsive to information about their status in particular situations. These responses to status include a number of issues that are of interest to social psychologists such as aggression, increased

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arousal, emotion, and cognitive performance. However, with few exceptions (e.g., Dabbs, Alford, & Fielden, 1998; Josephs, Newman, Brown, & Beer, 2003; Schultheiss, Dargel, & Rohde, 2003), this research has escaped the attention of social psychologists.

Much of the evidence linking testosterone and status comes from research with nonhuman species. Naturally occurring levels of testosterone are correlated with position in the hierarchy, as well as with dominant behavior (Beaver & Amoss, 1982; Cavigelli & Pereira, 2000; Coe, Mendoza, & Levine, 1979; Collias, Barfield, & Tarvyd, 2002; Elofsson, Mayer, Damsgârd, & Winberg, 2000; Kraus, Heistermann, & Kappeler, 1999; Oliveira, Almada, & Canario, 1996). These effects seem to be situation dependent. For example, when Ruiz-de-la-Torre and Manteca (1999) injected male lambs with testosterone, dominance struggles increased only *after* unfamiliar lambs were introduced. Similarly, Collias et al. (2002) found that tropical birds increased their dominance behaviors (viz., singing, establishing territory) only if they were injected with testosterone *and* the dominant male was removed from the area (see also Briganti, Seta, Fontani, Lodi, & Lupo, 2003 for conceptually similar results among rabbits). The common theme behind this pattern is that testosterone predicts status-related behaviors only when status is up for grabs, not in a stable status-hierarchy (e.g., Koyama & Kamimura, 1999; Morgan et al., 2000; Ostner, Kappeler, & Heistermann, 2002; Sapolsky, 1991).

Testosterone and Status in Humans

A number of studies with humans supports a positive relationship between testosterone and status. Indeed, measuring testosterone at a single point in time predicts status-related behaviors across a variety of situations and occupations (e.g., Cashdan, 1995; Dabbs, La Rue, & Williams, 1990; Dabbs et al., 1998; Mazur & Booth, 1998; Grant & France, 2001; Scaramella & Brown, 1978; van Honk et al., 1999). For example, Dabbs et al. (1998) report that people in high status occupations such as trial lawyers tend to have higher levels of testosterone compared with people in lower status occupations, such as patent lawyers. However, these results are largely correlational, and have come under attack by some critics who charge that the results from many of these studies are weak, especially relative to the animal literature (see, e.g., the commentaries following the target article by Mazur & Booth, 1998). In defense of the testosterone-status relationship in humans, a sociological analysis of testosterone employed by Kemper (1990) suggests that, as has been observed in other species, the relationship between testosterone and behavior should appear *only* when certain situational pressures interact with individual differences in baseline testosterone. Despite the appeal of this interactionist perspective, only a handful of studies have employed the experimental or quasi-experimental methods necessary for proper tests of the interactionist model (e.g., Josephs et al., 2003; Mazur, Booth, & Dabbs, 1992; Mazur, Susman, & Edelbrock, 1997; McCaul, Gladue, & Joppa, 1992).

Closely related to need for status, testosterone levels have also been linked to implicit power motives (e.g., Schultheiss et al., 2003) and selective attention to threatening faces (van Honk et al., 1999; 2001). Van Honk et al. showed that participants high in testosterone spent more time gazing at angry, potentially status-threatening faces than did participants low in testosterone, but were no more attentive to neutral faces than were low testosterone participants. In fact, low testosterone participants actually attended away from threatening faces. These motivational and attentional differences map nicely onto the behavioral differences reviewed earlier, suggesting the possibility that the dominance-submission distinction associated with testosterone may have motivational and information processing correlates.

Taken together, the literature suggests that when status is threatened, high testosterone individuals are motivated to try and regain it. What about the outcome of dominance battles? Are high testosterone individuals more likely to be successful at regaining status? The prototypical dominance contest involves a physical challenge, and dominance must be regained through physical means (e.g., winning a fight, intimidation). In these cases, testosterone, which enhances muscle mass and metabolism (e.g., Bhasin, Woodhouse, & Storer, 2001; Tsai & Sapolsky, 1996), should provide an advantage to those who wish to regain lost status. Not surprisingly, higher T animals are more likely to be the winners of these types of encounters (e.g., Morgan et al., 2000; Ostner et al., 2002).

But what if dominance must be regained through nonphysical means? We explored this in several recent papers (Josephs et al., 2003, Study 1; Newman, Sellers, & Josephs, 2005). High and low testosterone participants were placed in a low status position (or a control group) before taking a complex test that was framed as being capable of restoring status. Consistent with predictions, those high in testosterone performed considerably worse in a low status position. This provides some preliminary evidence for the idea that attempting to regain status impairs cognitive performance on a complex task. However, other psychological and physiological consequences of response to status threat (e.g., affective, motivational, cardiovascular) have yet to be explored. This was one of our primary goals in designing the present studies.

The Mismatch Effect

As reported above, there is strong and abundant evidence linking testosterone levels to rank, dominant behaviors, and status in nonhuman animals, and some evidence in humans as well. In addition, as Sapolsky and others have speculated (cf. Sapolsky, 1991), testosterone may serve as a biological correlate for concerns about status. When high status is threatened or challenged, the typical response is an attempt to restore status through some type of antagonistic behavior, and this response is typically seen among individuals high in testosterone. However, what happens when an individual who is on the low end of the status hierarchy—an individual low in testosterone—experiences upward pressure on his or her status quo? In other words, how does such an individual react to having unwelcome status thrust upon him or her?

There is only one empirical example that we are aware of in which low-ranking members of a species other than humans are, through no fault of their own, forcibly moved up into a higher status position. In Rohwer's (1977) classic study on the effects of social cheating in Harris's sparrows, researchers bleached the feathers of some of the dominant birds so that they appeared submissive (i.e., lighter feathers) and colored some of the feathers of some of the submissive birds so that they appeared dominant (i.e., darker feathers). The formerly dominant birds with the new subordinate signal of white plumage became inexhaustible bullies, picking fights with every bird around, presumably in an attempt to restore their lost status. The newly appointed dominant birds suffered a different misfortune. The attacks against them grew so frequent that many of them chose to leave the flock to feed in solitude.

Clearly, humans share a number of commonalities with other animal species, and thus it is perhaps not surprising that in humans testosterone has been shown to bear a positive relationship to status-related behaviors such as dominance and subordinance. However, it has been argued elsewhere (Kemper, 1990) that unlike other species, humans are unique in their ability to achieve high status through routes *other* than dominance. Kemper (1990) argues that a position of high status can be achieved through the person's "eminence." For example, achieving greatness in one's discipline or field can elevate one to a position of high status without the need for the more typical mano-a-mano dominance battles. A reluctant but eminent academic can be appointed to a high status position such as that of chair, dean, or president as a result of scholarship. Another route to high status that avoids dominance battles is birthright, in which an individual is born into a high status position without necessarily welcoming the attention, power, and privilege that status brings. There are undoubtedly other routes that do not require dominance battles. The point is that it is precisely because humans can find themselves in positions of high status without having to engage in dominance battles that human societies may periodically produce a mismatch between a person's desired level of status, as indicated by testosterone level, and actual status.

We intentionally chose examples that illustrated only one-half of the mismatch between a person's desired level of status and his or her actual status, because the other half is not only more intuitive and frequent, but it is also not unique to humans. So, for example, a high testosterone individual denied his perceived due (e.g., a trial lawyer losing a trial) might be more likely to have a car accident on the way home from the courthouse due to experiencing a range of negative and positive psychological and physiological reactions, ranging from anger, reduction of cognitive function, and stress, to a misplaced motivation to regain his lost status by raging against his fellow drivers.

Although it might be apparent why someone high in testosterone might react strongly to a drop in status, we have only hinted at the question of why someone low in testosterone might also react strongly after experiencing an increase in status. On the one hand, this reaction appears to defy the undeniable reproductive advantage that high status confers (e.g., Buss, 2003). However, it is exactly because of the well-known advantages of high status that those in such positions must occasionally, and sometimes constantly, fend off others who wish to enjoy its advantages. The literature on dominance is replete with examples of dominance challenges, some of which end in serious injury or even death to the combatants.

We suggest that low testosterone individuals might shun high status positions and dominance battles because they lack a strong power motive (Schultheiss et al., 2003), they lack a dominating, aggressive personality (e.g., van Honk et al., 1999), and they may not believe they have what it takes physically to maintain such positions and win such battles (cf. Tsai & Sapolsky, 1996). If a less assertive, low testosterone individual lands a high status position, the resulting mismatch between desire to "fly below the radar" and current position of high status might generate a strong reaction, ranging from fear to confusion to arousal to a motivation to return to a safer level of status. These speculations led us to the current set of studies.

The Current Studies

In the present studies, we sought to test the mismatch effect by placing a low or high testosterone individual into a position of low or high status, and taking various measures of psychological and physiological functioning. The design of each experiment was straightforward. Participants took part in a rigged competition against another participant (Study 1) or against a confederate (Study 2), and either won (high status) or lost (low status). In Study 3, testosterone was pitted against several popular self-report measures of individual and social dominance to determine whether testosterone is a worse or better predictor of status-seeking behavior than scores on self-report measures of dominance. At various points during each experiment, cognitive, affective, and physiological measures were obtained.

Based on our earlier work (Josephs et al., 2003; Newman et al., 2005), we expected that changes in cognitive performance in each study would result from the interaction between testosterone levels and the status manipulation. Specifically, individuals high in testosterone should perform worse in a low status position than in a high status position, despite the fact that performing well could lead to high status. This result would serve to replicate previous research. The present studies extend our prior work by extending the model to low testosterone individuals who are moved out of their status comfort zone. The research reviewed above suggests that low testosterone individuals might be uncomfortable with high status, and this discomfort might have consequences for higher-order cognitive functioning. Study 1 was designed to explore this.

In addition to the cognitive performance measures in each study, we included several measures of emotion, attention, and physiological responses. Our goal in including these measures was to explore the consequences of a psychological mismatch. As such, we did not make any a priori predictions about these measures.

Study 1

In this first study, we were interested in exploring how a state of mismatch would influence a person's psychological functioning. To test this, participants competed in same-sex dyads on a series of tasks that were described as measures of intelligence. The difficulty of the first task was rigged so that, via random assignment, one participant was guaranteed victory. After this task was completed and the two participants were aware of who had won and who had lost, they were given the opportunity to gain, regain, or maintain their status through performance on a complex cognitive task (a section from the GRE analytic exam). This task also allowed us to explore a person's capacity for complex cognitive operations. To further explore the consequences of matched and mismatched status, we administered: (1) a measure of implicit attention to status to explore a person's awareness of status-relevant stimuli; and (2) a measure of self-reported emotional arousal to explore a person's affective and motivational state.

Methods

Participants and Design

Ninety-two students at the University of Texas at Austin participated in this study in exchange for partial fulfillment of an introductory psychology course research requirement. Nineteen participants were dropped from the analysis because of insufficient salivary samples. Of the remaining people, 34 participants were women and 39 were men. These participants completed the experimental tasks in a 2 (testosterone-level: high or low) × 3 (status: submissive, dominant, or solo control) between-subjects quasi-experimental design.[1]

Materials and Procedure

Participants arrived two at a time to the experiment in same-sex dyads, except in the control condition in which they arrived individually. Upon arriving, a male experimenter greeted them and asked them to take a swig of water from a nearby drinking fountain, swoosh the water around in their mouths, and then spit the water out into the drain. This was done to clear their mouths out of any food particles or other particulates that might contaminate the saliva sample used to test for baseline testosterone levels. The experimenter then gave participants a piece of Trident original flavor, sugar-free gum to chew, to facilitate salivary secretion.

After providing informed consent, participants then spit out their gum and drooled into a 1.8 mL vial, while in separate rooms. Participants were told that we were interested in the "effects of caffeine and other stimulants that might affect their performance." We avoided telling them up front that we were measuring testosterone, due to its association with competition and dominance. We also assured them that we would only test for these stimulants (i.e., they didn't have to worry about illegal drugs being detected). The saliva samples were kept in a freezer at 0° C until later testosterone analysis. Salivary collection was consistent with the procedure described by Granger, Schwartz, Booth, and Arentz (1999). All experimental sessions were conducted between noon and 4 p.m. to control for diurnal fluctuations in testosterone (e.g., Granger et al., 1999). Testosterone levels were measured in saliva using enzyme immunoassay kits produced by Salimetrics. For a description, see Granger et al. (1999).

After the salivary samples were obtained, the experimenter escorted both participants into one room and told them that they were going to be completing three tests of intelligence. The first of these tests served as our status manipulation, and the other two served as dependent measures of psychological functioning. Participants were led to believe that they were competing with one another, based on their total score across the three tests.

The status manipulation. The first ostensible test of intelligence was the spatial processing test. The instructions for this task were to trace through a series of numbers in sequential order until the highlighted number was reached (Schultheiss, Campbell, & McClelland, 1999). The test was composed of a packet of 10 such tasks, and they were to complete the test as quickly as possible because their timed score would be recorded. In reality this test served as the status manipulation. Our goal was to place one person at a relative advantage by assigning them to win this first task. Assignment to either the submissive or dominant condition was rigged by handing participants either a short (dominant assignment) or long (submissive assignment) version of the line tracing task to complete so that we could manipulate how long it took participants to finish. When each of the participants was finished with all 10 tests, they said, "Done," and raised their hands. Therefore, all were aware of their relative performance on the timed number tracing task. Participants in the control condition completed the short version of this task and no mention was made about completing the assignment quickly nor was their time recorded.

Implicit attention to status. Following the status manipulation, participants worked on a measure of implicit status concerns, which was presented as a measure of visual perceptual speed. This test was presented as one component of the total score on which winning or losing would be based. Participants had 7 min to complete a word search similar to the jumble puzzles that appear in many Sunday newspapers. The word search contained a mix of 10 status occupations (advisor, advisee; doctor, hygienist; director, staff; lawyer, paralegal; president, secretary) and a collection of neutral words. All participants completed the same version. A copy of this measure is available from the authors.

Measure of cognitive ability. To test for cognitive functioning, participants were then given a version of the analytic section of the Graduate Record Exam (GRE), presented as a measure of verbal analytical ability. This test was also presented as one component of the total score on which winning or losing would be based. Thus, performing well could potentially offset an initial (randomly assigned) loss, just as performing poorly could offset an initial (randomly assigned) win. Participants were given 20 min to complete 20 questions of moderate difficulty. The experimenter informed them that points would be deducted for each incorrect answer to discourage guessing.

Self-reported emotion. After completing the GRE analytic test, participants completed the PANAS (Watson, Clark, & Tellegen, 1988) to measure self-reported emotions. Finally, participants were debriefed for suspicion and told the true nature of the experiment.

Results

Preliminary Analyses

Testosterone levels were standardized separately for men and women as well as for time of assay to control for sex differences in baseline testosterone level and variability among assay batches, respectively. (Participants were randomly selected for each assay batch, in order to minimize the effects of storage time on testosterone levels.) Furthermore, baseline testosterone levels were separated into two groups (high and low baseline testosterone) based on the upper and lower thirds of the standardized distributions. We chose to investigate the upper and lower thirds instead of the entire distribution because we were interested in the behavior of individuals high and low in their need for dominance, and less interested in explaining normal dominance strivings. This is common practice among researchers interested in individual differences (e.g.,

[1] We ran the study with an additional between-subjects factor of competition (competitive or noncompetitive). In the subsequent status manipulation for the competitive condition, participants were given a buzzer to ring every time they finished each of the 10 number tracings. This was done to reinforce the competitive element of the task. In the noncompetitive condition, no comments were made about competition and there was no buzzer to ring after finishing any of the number tracings. When each of the participants in both conditions was finished with all 10 tests, the participant said, "Done," and raised a hand. Therefore, all participants in both the competitive and noncompetitive condition were aware of their relative performance on the timed number tracing task; this served as the status manipulation.

Preliminary analyses with a Hotelling's T test revealed that assignment to the competitive or noncompetitive condition did not affect responses on any of the dependent variables, $F(1, 46) = .91$, $p = .53$. We speculate that this is because participants in both the competitive and noncompetitive conditions were all aware of the other participants' performance as they were seated in close proximity to one another. Another possibility is that we did not have enough power to see the subtle effects of the differences between the two conditions. For study, all reported analyses are collapsed across the conditions. Future research should assess the effects of different competitiveness manipulations.

need for closure, Webster & Kruglanski, 1994; self-consciousness, Schlenker & Weigold, 1990; self-esteem, Giesler, Josephs, & Swann, 1996). After removing the middle third of the sample, we were left with 47 participants (21 women and 26 men).

Thus, high T men (M = 139.25; SD = 34.58) were high relative to low T men (M = 56.85; SD = 14.96). High T women (M = 103.30; SD = 33.03) were high relative to low T women (M = 36.46; SD = 16.28).[2] To test the hypothesis that individuals high and low in baseline testosterone (T) would show differential responses on all the measures of psychological functioning, a 3 (submissive vs. dominant condition vs. control) × 2 (high baseline T level vs. low baseline T level) multivariate analysis of variance (MANOVA) on GRE performance, status words, PA, and NA was conducted. Consistent with predictions, there was a significant interaction between status condition and T level, $F(3, 41) = 3.36$, $p < .01$. There were no main effects for either T level $F(3, 41) = 2.01$, $p = .10$, or condition $F(3, 41) = 0.88$, $p = .55$. Univariate results for measures of cognitive performance, attention to status, and affective arousal are presented below. Table 1 presents the descriptive statistics for these dependent measures.

Table 1
Descriptive Statistics for Study 1

Condition	Testosterone Level		Mean	Standard Deviation	N
Dominant	Low	GRE	6.75	2.25	8
		Status Words*	4.52	4.38	
		Neg PANAS	1.35	.31	
		Pos PANAS	2.81	.81	
	High	GRE	10.67	1.58	9
		Status Words*	3.90	4.56	
		Neg PANAS	1.15	.12	
		Pos PANAS	2.17	.81	
Control	Low	GRE	7.57	2.64	7
		Status Words*	2.20	3.86	
		Neg PANAS	1.63	.69	
		Pos PANAS	2.09	.83	
	High	GRE	7.57	1.81	7
		Status Words*	6.60	4.27	
		Neg PANAS	1.28	.36	
		Pos PANAS	2.11	.68	
Submissive	Low	GRE	9.25	1.98	8
		Status Words*	.90	2.62	
		Neg PANAS	1.26	.40	
		Pos PANAS	2.16	.54	
	High	GRE	7.25	1.91	8
		Status Words*	5.90	4.40	
		Neg PANAS	1.61	.80	
		Pos PANAS	2.74	.74	

* Means are adjusted controlling for gender.

Cognitive Performance

Cognitive performance was measured by the total numbers of items answered correctly on the analytic section of the GRE. Did mismatched status affect cognitive performance? This question was tested using a 3 (submissive vs. dominant vs. control condition) × 2 (high baseline testosterone level vs. low baseline testosterone level) analysis of variance (ANOVA).

Mismatched status was strongly related to cognitive performance. Consistent with the findings of Josephs et al. (2003), the interaction between baseline T level and status condition was significant, $F(2, 41) = 9.01$, $p < .01$. See Figure 1. Participants high in baseline T performed worse in the low status condition than in the high status condition, $t(14) = 3.45$, $p < .01$. Conversely, participants low in baseline T showed better cognitive performance in the low status condition than in the high status condition, $t(15) = 3.33$, $p < .01$. When status was not up for grabs, however, T had no effect on cognitive performance. There were no significant differences between the control group and either of the experimental conditions for either low T (dominant condition: $t(13) = 1.08$, $p = .15$; subordinate condition: $t(13) = .77$, $p = .23$) or high T (dominant condition: $t(14) = 1.2$, $p = .12$; subordinate condition: $t(13) = .31$, $p = .38$) participants.

Implicit Attention to Status

Implicit attention to status was measured by counting the number of status-relevant words found in the word search task, dividing them by the total number of words found, and multiplying by 100%. Did mismatched status affect a person's tendency to notice status-relevant information? To test for the effects of status and testosterone level on implicit attention to status, a 3 (submissive vs. dominant condition vs. control) × 2 (high baseline T level vs. low baseline T level) ANCOVA was conducted controlling for gender. Gender was controlled for because our word search used occupations as our status words, and Eagly and Wood (1999) have proposed that men and women differentially occupy status roles. An ANCOVA revealed a significant interaction between T and condition for percentage of status-relevant words, $F(2, 51) = 3.06$, $p = .056$. As can be seen in Figure 2, attention to status-relevant words increased as conditions changed from status match to mismatch. Under conditions of dominance, the presumed status needs of low T participants were not met; they showed superior status word search performance compared to low T submissive participants whose status needs were presumably being met, $t(15) = 2.03$, $p = .03$. Although not reaching significance, the opposite picture emerged for high T participants. Under conditions of dominance, high T participants had their status needs met and showed better status word search performance than in the submissive condition, when these needs were presumably unmet, $t(23) = 1.05$, $p = .15$. In conceptual replication of van Honk et al.'s (1999) findings, there was a main effect for testosterone level such that high testosterone participants had a greater implicit attention to status-relevant words than did low testosterone participants, $F(2, 51) = 6.37$, $p < .03$. (Van Honk et al.'s conditions are most closely replicated in the control condition, and in replication of van Honk et al., high T control participants found approximately 3 times as many status words as did low T controls.) Finally, there was no significant effect of either T, $F(1, 33) = .688$, $p = .413$, or condition, $F(2, 33) = 1.081$, $p = .351$, on the total number of words (status plus neutral) found. Furthermore, the interaction was not significant, $F(2, 33) = .254$, $p = .777$)

[2] Mean testosterone levels were also computed prior to removing the middle third of the sample distribution. The mean for women was 64.07 (SD = 34.99), and the mean for men was 94.82 (SD = 41.39). We computed interassay and intraassay CV averages, and these were 5.3% and 4.5%, respectively (both fell within the precision ranges reported by Salimetrics).

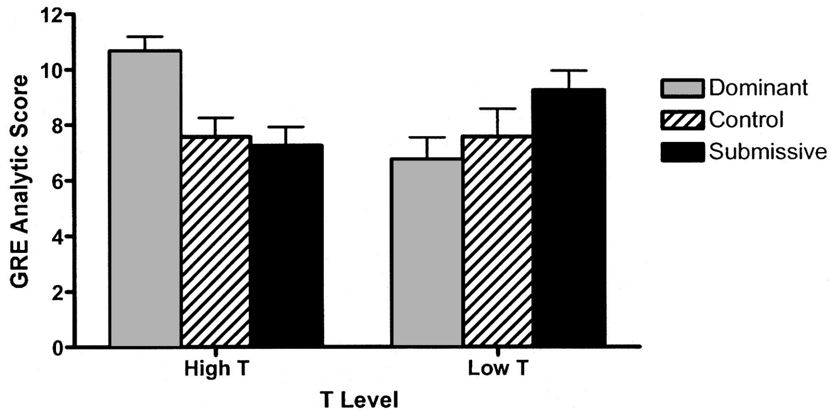

Figure 1. *Study 1: The effects of status and testosterone on cognitive performance.* T level is divided into upper and lower third. The *y*-axis represents number correct on GRE analytical. Error bars represent 1 standard error.

Self-Reported Emotion

To examine the effects of matched versus mismatched status on emotional arousal, we conducted a 3 (status condition) × 2 (T-level) MANOVA, with positive (PA) and negative (NA) affect as the dependent variables. There was a significant multivariate interaction, $F(4, 66) = 2.90$, $p = .03$, but no significant multivariate main effects.

We first examined whether mismatched status had an effect on PA ($\alpha = .87$). We found a significant interaction between condition and testosterone level on PA, $F(2, 40) = 3.80$, $p = .03$. High T participants reported marginally more PA in the submissive condition than in the dominant condition, $t(15) = 1.58$, $p = .07$, whereas low T participants reported more PA in the dominant condition than in the submissive condition, $t(14) = 1.80$, $p = .05$. This same pattern of elevated PA was observed when comparing mismatched participants against control participants, $t(13) = 1.71$, $p = .06$, for high T submissives compared to controls, and $t(13) = 1.70$, $p = .06$ for low T dominants compared to controls. There were no significant differences between matched participants and the control group for high T winners compared to controls, $t(14) = .16$, $p = .44$, nor for low T losers compared to controls, $t(13) = .20$, $p = .42$. See the bottom panel of Figure 3 for these means.

We next examined whether mismatched status had an effect on NA ($\alpha = .85$). Although there were no significant main effects or interactions, we wanted to explore these findings to see if a pattern of effects similar to those that emerged for PA had emerged for NA. As with PA, high T submissives did report more NA than high T dominants, $t(23) = 1.91$, $p = .03$. High T submissives did not report more NA than in the control condition, $t(13) = 1.00$, $p = .17$, nor did high T dominants report more NA than in the control condition, $t(14) = 1.02$, $p = .16$. Low T dominants did not report significantly different NA from low T submissives, $t(22) = .51$, $p = .31$, although this pattern was in the same direction as with PA. There were no significant differences between low T dominants $t(13) = 1.04$, $p = .16$, or losers, $t(13) = 1.29$, $p = .11$, and the control condition. See the top panel of Figure 3 for these means.

Discussion

The results from Study 1 provide insight into the consequences of a mismatch between one's desired level of status and actual

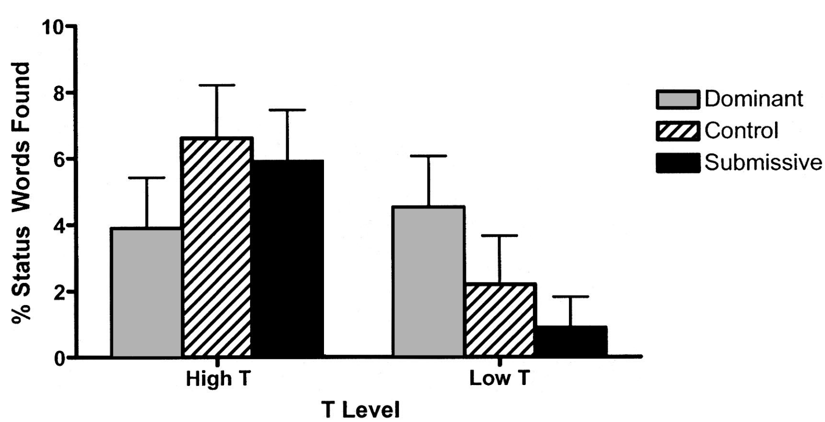

Figure 2. *Study 1: The effects of status and testosterone on implicit attention to status words.* T level is divided into upper and lower third. The *y*-axis represents percentage of status words found in the word search. Error bars represent 1 standard error.

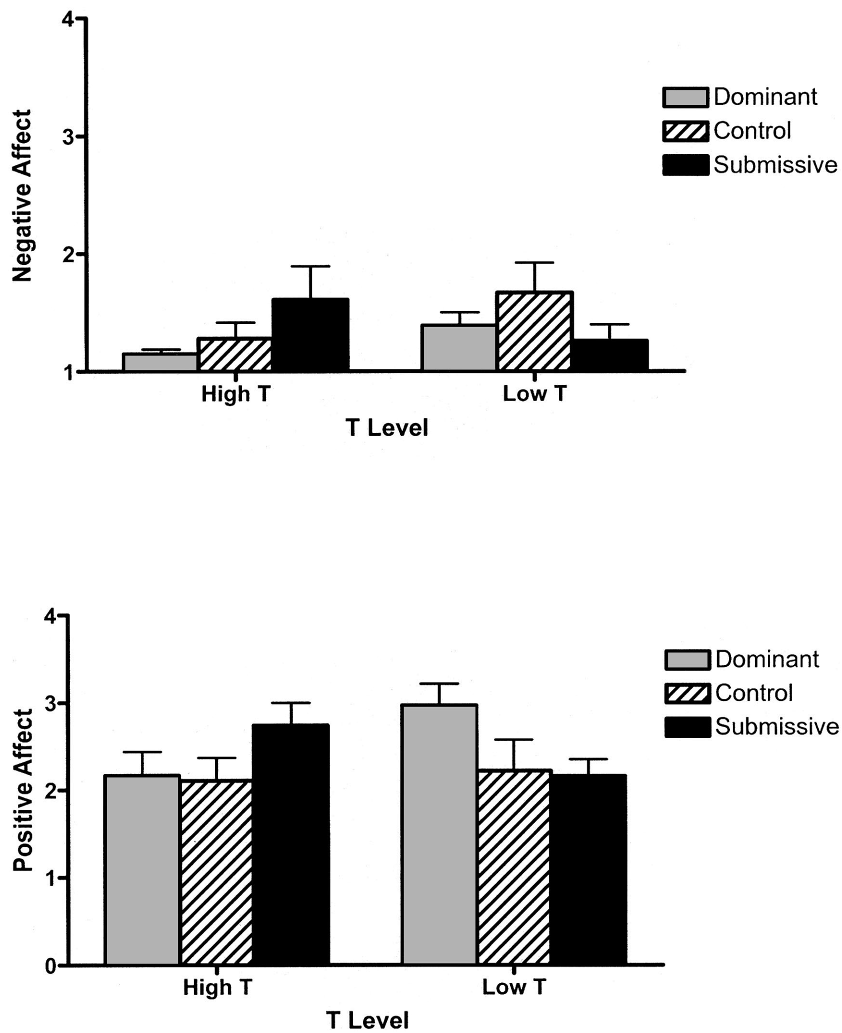

Figure 3. *Study 1: The effects of status and testosterone on emotional arousal.* Top panel = negative affect; bottom panel = positive affect. T level is divided into upper and lower third. The *y*-axis represents average emotion ratings on the affective arousal composite. Error bars represent 1 standard error.

level of status. First, consistent with our previous research, we found that cognitive functioning was impaired under conditions of mismatch. Participants high in testosterone performed worse on the analytical GRE when they were in a position of low status. Building on previous research, we found that participants low in testosterone showed the opposite effect. They performed worse on the analytical GRE when they were placed into a position of high status. Although it remains speculative at this point, it is possible that the desire for status change may prove too distracting for the proper functioning of complex higher-order cognition. It remains to be seen if all cognition is interfered with by a desire for status. Research by Zajonc, Heingartner, and Herman (1969) and others suggest that task complexity may determine task performance in the face of desire for status change, with simple, overlearned tasks benefiting whereas performance on complex and novel tasks showing impairment. Perhaps, similar to findings in other species in which testosterone activity is positively correlated with successful dominance battles (presumably because these battles feature straightforward tasks requiring energy and physiological arousal but very little complex thought), simple, physical tasks in humans might be facilitated by a desire for status change whereas complex cognitive (or physical) tasks might be interfered with. This possibility was not tested in this paper.

Second, findings from the word search task suggest that individuals who do not have their status needs met tend to pay more attention to their status. Under conditions of mismatch, participants who had their status desires presumably frustrated found more status-relevant words compared to those whose status desires matched their level of status. Curiously, high testosterone participants found as many status words in the control condition as they did in the low status (mismatched) condition. This is consistent with work by van Honk and colleagues who also found basal testosterone differences in the absence of a status challenge (van Honk et al., 1999; 2001). Although speculative, it is possible that when exposed to status-relevant stimuli, high testosterone individuals become attentive, regardless of the presence or absence of a previous status challenge. However, comparisons with the control group should be interpreted with caution. In hindsight, there is a potential confound between condition (control vs. status conditions) and working alone versus working with others. It is unknown to what degree this biased the control group, but we suggest that future studies work to eliminate this confound.

Third, we found that participants reported heightened negative and positive emotional arousal when their preference for status, as indicated by their testosterone level, was not congruent with their actual status level. Do the PA findings indicate that mismatched participants were happier than their matched counterparts? This is unlikely, as the PANAS does not include happiness among its positive affect items. Rather, Watson (2000) has conceptualized PA and NA as measures of approach and avoidance motivation, respectively. In fact, Harmon-Jones, Vaughn, Mohr, Sigelman, and Harmon-Jones (2004) found that PA increased in response to insults that aroused anger. Evidently, existing at the wrong status level is distressing (high NA) as well as motivating (high PA). One interpretation is that mismatched participants were both unhappy (high NA) and motivated to reclaim their lost state of desired status (high PA).

The status search and PA results also dovetail with the work of Wright and his colleagues (e.g., Wright, Martin, & Bland, 2003) who have argued that people will experience arousal in the process of tackling a desired challenge or goal as long as the goal is not perceived as insurmountable. Extending these ideas to Study 1, a mismatched participant would be motivated to restore his or her desired level of status, and if so, might experience the type of arousal associated with approach motivation (and, consequently, with PA). Indeed, mismatched participants showed an increase in PA and NA, which is the type of affective arousal one would expect when one is distressed and aroused to pursue a desired goal (in this case, a change in status).

In addition to exploring the mismatch effect, Study 1 was noteworthy in demonstrating that testosterone related to psychological functioning *only* when status was threatened (except in the word search task in which high T participants performed equivalently under status threat and control conditions). In the absence of status threat, high testosterone participants did not perform better (or worse) on the GRE than did low testosterone participants, and they did not differ in emotional arousal. So, the results of Study 1 showed that only under conditions of mismatch—when high testosterone participants lost and low testosterone participants won—was testosterone linked to GRE performance and emotional arousal.

Study 2

In designing Study 2, four issues struck us as critical. First, in order to determine the generality and robustness of the findings from Study 1, we wanted to attempt a manipulation of status that was methodologically different from the one used in Study 1. Whereas in Study 1 a participant experienced winning or losing before our dependent measures, in Study 2 we wanted feelings of dominance or subordination to emerge during the battle to achieve dominance. In Study 2, participants did not experience an actual loss or win, but rather were led to believe that they were either being dominated or were in a position of dominance during the competition. In naturally occurring dominance battles, feedback is often continuous (e.g., battles for job promotions, mate-selection, sports competitions, etc.). In most experiments, however, the typical status manipulation is discrete—two participants compete with no knowledge of their status until the task ends. Thus, we attempted to design a status manipulation to reflect naturally occurring dominance battles.

Second, we wanted to extend our findings on reported affective arousal to heart rate. Instead of asking people to report on their feelings, we measured changes in heart rate. According to Wright and his colleagues, reactions by people attempting to overcome challenges involve heightened cardiovascular responses. Similarly, recent work by Schultheiss and his colleagues (Schultheiss, in press; Wirth, Schultheiss, & Welsh, in press) showed that individual differences in preference for dominance predicted physiological reactivity, such that those whose dominance needs were met showed a decline in stress levels whereas those whose needs were not met (e.g., those who feared dominance and were unwillingly placed into a high status position) showed an increase in stress. The research of Wright and Schultheiss both suggest an increase in heart rate in our mismatched participants but a decrease when participants are placed into positions of desired status, albeit for somewhat different reasons.

Third, we wanted to generalize the higher-order cognitive performance findings to a different, yet equally important, domain, so we switched from analytic to mathematics performance.

Fourth, men and women in Study 1 had higher T levels than are often observed. Although there are many reasons for these higher-than-typical levels, one disturbing possibility is that the antibody kits used to determine T concentrations might have had high cross-reactivity (i.e., been capturing other steroids or androgens in addition to T, thus inflating the observed levels). If so, then attributing the observed effects to T may be wrong—rather, these effects may be the result of a combined androgen or steroid profile, rather than attributable solely to T, as we have been claiming. To test this, the saliva from Study 2 was sent to an outside laboratory (DSL, Webster, TX) for analysis.

In this second study, participants again competed in same-sex dyads on what they were told was a measure of intelligence. Unbeknownst to the participants, the person they were competing against was a confederate, acting out the part of either a self-professed expert or novice. During the course of the contest, measures of heart rate and blood pressure were collected.

Methods

Participants and Design

Sixty-four students (17 women and 45 men) at the University of Texas at Austin participated in this study in exchange for partial fulfillment of an introductory psychology course research requirement.[3] These participants completed the experimental tasks in a 2 (T-level: high or low) × 2 (status: submissive or dominant) between-subjects quasi-experimental design.

[3] The reported ethnic heritage was 68% Caucasian, 16% Hispanic or Latino, 10% Asian, and fewer than 1% were African American, American Indian, or did not report their ethnic heritage. This information was only collected in Study 2.

Materials and Procedure

Prior to the experimental session, participants completed a demographic questionnaire indicating their race, gender, and prior performance on the quantitative section of the SAT. Participants arrived at the experiment alone and were greeted by a same-sex experimenter and introduced to a same-sex confederate playing the part of another participant in the study. Both the participant and the confederate were then instructed to rinse their mouths out and chew a piece of gum to prepare for the salivary sample. Saliva collection procedures were identical to those in Study 1, although as noted above, testosterone analysis was conducted at a different laboratory.

After the salivary samples were obtained, and approximately 15 min after the start of the experiment, participants sat quietly while the experimenter took three back-to-back baseline measures of heart rate and blood pressure using a Walgreen's Automatic Inflation Electronic Digital Blood Pressure/Pulse Monitor Kit (Model 93A). This baseline procedure varied slightly from that suggested by Shapiro et al. (1996) who recommend waiting 20 min before obtaining readings, calibrating the blood pressure instrument, discarding the first few readings to allow participants time to habituate to the procedure, and taking 3 to 5 readings at 1 to 2 min intervals separated by quiet rest. After these baseline measures were obtained (taking, on average 5 min), the experimenter then escorted the participant and confederate into a room together and placed them at separate desks facing away from one another.

For the next portion of the experiment, participants were told they would be competing against one another to win a gift certificate to Tower Records. This was done to reinforce the competitive element of the testing situation as well as to ensure that participants were taking the experiment seriously. Participants were then instructed they would have 20 min to complete 20 questions on the quantitative section of the GRE, and that they would be stopped three times during the test to take additional heart rate and blood pressure measures. These intervals occurred every 5 min after the start of the test.

The status manipulation. Unbeknownst to the participants in the study, the person they were competing against was, in reality, a confederate. His or her role in the study was to manipulate the participant's perceived dominance in the competition. Right before the competition began and during each of the breaks to take cardiovascular measures, the confederate acted from a script to be either dominant or submissive. In the dominant condition, the confederate played the role of submissive and periodically uttered comments along the lines of "You have to be kidding me. I stink at math," and "I don't know if my brain's not working or if I'm just an idiot because I can't even answer one of these questions." In the submissive condition the confederate played the role of dominant, and said such lines as "What, this is taken from the GRE quant? I just took this to get into grad school and aced it," and "Jeez, I can't even believe how easy this is."

After the experiment was over, participants were debriefed for suspicion and told the true nature of the experiment.

Results

Preliminary Analyses

As in Study 1, testosterone (T) levels were standardized separately for men and women as well as for time of assay to control for sex differences in baseline T level and variability among assay trials, respectively. Furthermore, baseline T levels were separated into two groups (high and low baseline T) based on the upper and lower thirds of the standardized distributions. Thus, high T men ($M = 131.34$; $SD = 42.13$) were high relative to low T men ($M = 41.75$; $SD = 10.71$). High T women ($M = 29.16$; $SD = 5.82$) were high relative to low T women ($M = 9.87$; $SD = 1.19$). Mean T levels were also computed prior to removing the middle third of the sample distribution. The mean for women was 20.01 ($SD = 12.36$), and the mean for males was 89.28 ($SD = 27.39$). These means reflect T concentrations that are within the range of values typically seen in the literature.

Cognitive Performance

Cognitive performance was measured by the corrected score on the quantitative section of the GRE. The corrected score (used in scoring the actual GRE) was computed by adding the number of correct answers, and then subtracting the number of incorrect answers multiplied by .25. The corrected score was strongly correlated with the total number of items correct, $r(42) = .99, p < .01$.

A 2 (submissive vs. dominant condition) × 2 (high baseline T level vs. low baseline T level) ANCOVA was conducted on these corrected scores, controlling for math SAT scores. Three participants were dropped from this portion of the analysis because they did not report their SAT scores.

Consistent with the mismatch effect, there was a significant interaction between T level and status, $F(1, 34) = 6.44, p < .02$. See Figure 4. High T participants performed significantly better in the dominant condition than they did in the subordinate condition, $t(19) = 1.91, p < .04$. Conversely, low T participants performed marginally significantly better in the subordinate condition than they did in the dominant condition, $t(18) = 1.45, p = .09$. There were no main effects for T level or for status condition. See Table 2 for descriptive statistics.

Heart Rate

The initial reading for heart rate was discarded to allow participants time to habituate to the heart monitor. Baseline heart readings were then computed for the cardiovascular measure by averaging the remaining two preexperimental measures. The experimental heart rate measure was then computed by averaging the three heart rate readings obtained during the testing session. There were no significant differences across the three measures collected during the testing session (p's $> .38$).

If participants high in T desire to achieve high status, then when denied this by being placed into a low status position, they should experience an increase in heart rate as a reflection of the motivation to restore high status. Furthermore, participants low in T would show an opposite effect, experiencing greater heart rate in a high status position than in a low status position. To test this, a 2 (submissive vs. dominant condition) × 2 (high baseline T level vs. low baseline T level) ANCOVA was conducted predicting experimental heart rate while controlling for baseline heart rate.

Consistent with the mismatch effect, the interaction between T level and status barely missed significance, $F(1, 36) = 4.01, p = .052$. See Figure 5. Reminiscent of the affective arousal pattern observed in Study 1, heart rate increases were observed under conditions of mismatch. Planned comparisons revealed that low T participants had significantly higher heart rates when they were in the dominant condition than when they were in the subordinate condition, $t(20) = 2.18, p < .03$ (although in the predicted direction, high T participants did not show a statistically significant difference in heart rate between the two conditions, $t(20) = .64, p = .26$). See Table 2 for descriptive statistics.

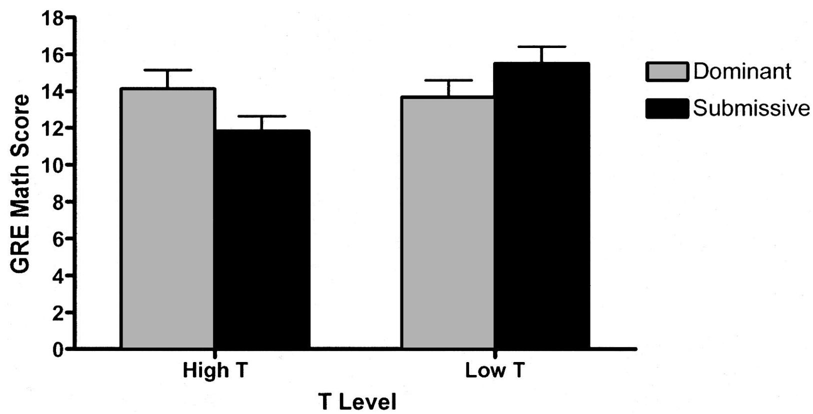

Figure 4. *Study 2: The effects of status and testosterone on cognitive performance.* T level is divided into upper and lower third. The *y*-axis represents number correct on GRE quantitative (means adjusted controlling for SAT). Error bars represent 1 standard error.

Blood Pressure

As with heart rate, the initial readings for systolic and diastolic blood pressure were discarded to allow participants time to habituate to the heart monitor. Baseline systolic and diastolic readings were then computed by averaging the remaining two preexperimental measures. The experimental systolic and diastolic measures were then computed by averaging the three readings obtained during the testing session.

Systolic blood pressure. Although we had no a priori predictions about the effects of T and status on systolic blood pressure, we subjected the experimental systolic blood pressure to a 2 (submissive vs. dominant condition) × 2 (high baseline T level vs. low baseline T level) ANCOVA controlling for baseline systolic blood pressure. There were no significant main effects for T level, $F(1, 37) = .42$, $p = .52$, condition, $F(1, 37) = .003$, $p = .95$ nor the interaction, $F(1, 37) = .002$, $p = .96$ on systolic blood pressure when controlling for baseline systolic blood pressure. Descriptive statistics are reported in Table 2.

Diastolic blood pressure. As with systolic blood pressure, we had no a priori predictions about the effects of T and status on diastolic blood pressure. We performed a 2 (submissive vs. dominant condition) × 2 (high baseline T level vs. low baseline T level) ANCOVA on experimental diastolic blood pressure controlling for baseline diastolic blood pressure. There were no significant main effects for testosterone level, $F(1, 37) = .07$, $p = .80$, condition, $F(1, 37) = 2.58$, $p = .12$ nor the interaction, $F(1, 37) = .34$, $p = .56$ on diastolic blood pressure when controlling for baseline diastolic blood pressure. See Table 2 for descriptive statistics.

Table 2
Descriptive Statistics for Study 2

Condition	Testosterone Level		Mean	Standard Deviation	*N*
Dominant	Low	GRE*	13.67	4.28	9
		Heart rate**	78.92	13.80	
		Systolic BP***	108.87	10.85	
		Diastolic BP****	69.13	8.36	
	High	GRE*	14.13	3.53	8
		Heart rate**	73.57	10.07	
		Systolic BP***	116.85	16.39	
		Diastolic BP****	72.41	7.74	
Submissive	Low	GRE*	15.52	2.74	10
		Heart rate**	72.59	10.58	
		Systolic BP***	114.12	16.85	
		Diastolic BP****	69.45	11.37	
	High	GRE*	11.81	3.13	12
		Heart rate**	75.23	9.86	
		Systolic BP***	118.47	17.13	
		Diastolic BP****	66.94	5.06	

* Means are adjusted controlling for Math SAT performance. ** Means are adjusted controlling for baseline heart rate. *** Means are adjusted controlling for baseline systolic blood pressure. **** Means are adjusted controlling for baseline diastolic blood pressure.

Discussion

Based on evidence linking testosterone to dominant behaviors, we hypothesized that basal testosterone level might function as a biological correlate for desired status level. The mismatch effect describes an incongruence between one's desired level of status and one's actual level of status. The results from Study 2 replicated those of Study 1, demonstrating that persons high in testosterone show poor higher-order cognitive function when losing a dominance battle, whereas persons low in testosterone show poor higher-order cognitive function when winning a dominance battle. Consistent with the PA result from Study 1, we found heart rate increases in the mismatched conditions as well (although the findings in Study 2 were a bit weaker than they were in Study 1).

We find it encouraging that the hypothesis is robust to fairly dramatic alterations in status manipulations, as revealed by the fact that the Study 2 results replicated those of Study 1. Math performance showed the same pattern in Study 2 as analytic performance in Study 1, and heart rate mirrored self-reported emotional arousal results found in Study 1. Finally, we were relieved to find that the testosterone concentrations obtained in Study 2 were well within the range of typical values, in contrast to the somewhat high concentrations obtained in Study 1. This, coupled with the fact that the pattern of results from Study 1 replicated across to Study 2,

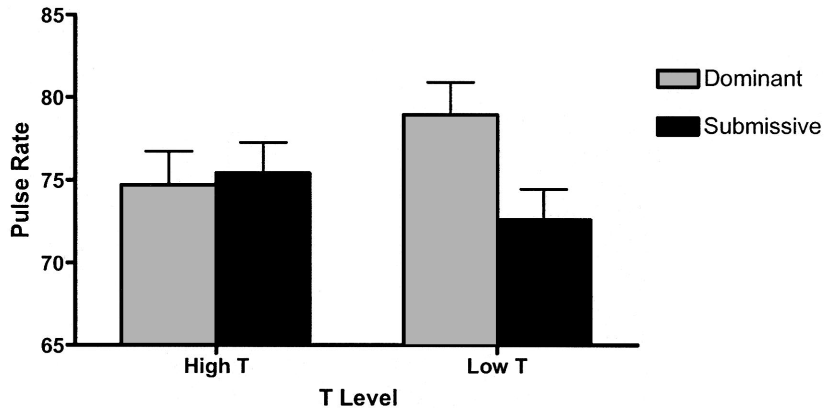

Figure 5. *Study 2: The effects of testosterone and status on heart rate.* T level is divided into upper and lower third. The *y*-axis represents heart rate during the test, controlling for baseline heart rate. Error bars represent 1 standard error.

suggests that the results obtained in both studies can be safely attributed to testosterone.

Study 3

In Study 3, our goal was to address a lingering question about the psychological meaning of testosterone levels. We have argued throughout this paper that testosterone levels are a proxy for a person's need for status. One remaining question is whether testosterone is a better predictor of status-seeking behavior than scores on self-report measures of dominance. Although testosterone has been linked to implicit power and dominance strivings in humans, few attempts have been made to link testosterone to self-reports of dominance or status, and those that have demonstrated modest relationships (e.g., Archer, Birring, & Wu, 1998). This may be because questionnaire measures often ask about "typical" behavior or traits, whereas as demonstrated by Sapolsky, Wingfield, and others, testosterone activity is linked to behavior in very specific situations and thus oftentimes bears no relationship to behavior. Another possibility, suggested by Schultheiss's work, is that preferences and aversions to high status may exist outside of conscious awareness. To date, few published reports linking self-reported dominance to aggressive or status-related behaviors exist (but see Diekmann, Tenbrusel, & Galinsky, 2003).

However, no study to date has examined whether these self-report measures predict dominant behavior in situations in which status is manipulated. We hypothesized that testosterone would remain a better predictor than self-reports of behavior in these situations. To test this hypothesis, we analyzed a subset of participants from Studies 1 and 2, and compared the predictive power of testosterone levels and self-reported need for dominance.

Methods

Participants

Participants for Study 3 were a subset of those in Studies 1 and 2 who had completed self-report measures during a pretest session. This sample ($N = 49$) was 47% women, and the testosterone (T) means were similar to those in the separate studies.

Materials and Procedure

During a pretest session, participants completed self-report measures tapping into the need for dominance. The dominance subscale of the *Personality Research Form* (*PRF*; Helmes & Jackson, 1977) contains 16 *true/false* items assessing one's desire to hold power over others. The *Social Dominance Orientation* scale (*SDO*; Pratto, Sidanius, Stallworth, & Malle, 1994) contains 14 items (1–7) assessing one's belief that certain social groups should hold more power in our society.

Participants were then invited to the laboratory to take part in one of the two studies described above. For the purposes of these analyses, we combined participants from both studies, after converting the dependent measures into z-scores. This conversion allowed us to generalize across different distributions in the cognitive measures.

Results

Correlations between T and Self-Reports

Consistent with our predictions and with previous null findings, neither scale was significantly correlated with T levels. The correlation between T and PRF scores was $r(48) = -.073$, $p = .62$. The correlation between T and SDO scores was $r(49) = -.193$, $p = .18$. Additionally, the correlation between SDO scores and PRF scores was nonsignificant, $r(49) = .209$, $p = .15$.

Predicting Cognitive Performance

To compare the predictive power of T with that of the self-report measures, we conducted a separate stepwise linear regression using each self-report measure, with cognitive performance (standardized) as the dependent variable. In the first step, we entered T levels, status condition, and scores on the self-report measure of interest. In the second step, we entered the T $\times$ status interaction and the self-report $\times$ status interaction. See Table 3 for the regression coefficients for both of these analyses.

We first analyzed these relationships using PRF dominance scores. The first step explained 4.1% of the variance ($p = .184$). Status condition was a marginally significant predictor ($\beta = .28$; $p = .054$), but neither T levels nor PRF scores approached significance on their own. Adding the interactions in the second step

Table 3
T vs. Self-Reports as Predictors of Cognitive Performance

Analysis #1: PRF Dominance Scores				
Step 1		Beta (Std. Error)	β	*p*
	Constant	−.10 (.36)		.780
	T Level	.18 (.14)	.19	.198
	Status	.33 (.17)	.28	.054
	PRF-Dom	.01 (.04)	.05	.728
Step 2				
	Constant	−.24 (.36)		.499
	T Level	.17 (.14)	.18	.221
	Status	.64 (.42)	.55	.133
	PRF-Dom	.04 (.04)	.18	.344
	PRF × Status	.00 (.04)	−.30	.414
	T × Status	.39 (.18)	.32	.033
Analysis #2: SDO Scores				
Step 1		Beta (Std. Error)	β	
	Constant	−.15 (.45)		.737
	T Level	.19 (.14)	.19	.190
	Status	.32 (.17)	.27	.070
	SDO	.07 (.18)	.05	.699
Step 2				
	Constant	−.13 (.44)		.777
	T Level	.21 (.14)	.21	.140
	Status	.21 (.50)	.18	.669
	SDO	.07 (.17)	.06	.659
	SDO × Status	.00 (.01)	.09	.833
	T × Status	.36 (.17)	.30	.035

Note. "PRF-Dom" refers to the dominance subscale of the PRF. "Beta" represents unstandardized regression coefficients; "β" represents standardized regression coefficients. $N = 49$ for all analyses.

explained an additional 9% (adj $R^2 = 13\%$; $p = .045$). The only significant predictor was the T × status interaction ($\beta = .32$; $p = .033$). See the top half of Table 3 for the coefficients.

We next analyzed these relationships using SDO scores. The first step explained 4.2% of the variance ($p = .182$). Status condition was a marginally significant predictor ($\beta = .27$; $p = .070$), but neither T levels nor SDO scores approached significance on their own. Adding the interactions in the second step explained an additional 6% (adj $R^2 = 10\%$; $p = .094$). The only significant predictor was the T × status interaction ($\beta = .30$; $p = .035$). See the bottom half of Table 3 for the coefficients.

Discussion

Consistent with our predictions, testosterone appears to be a better predictor of how individuals will respond when their status is threatened than their self-reports of how much they desire status. This suggests that testosterone levels may capture something unique about an individual's motives. As discussed in our introduction to Study 3, self-report measures may not capture these motives for several reasons. Namely, these motives may exist outside of conscious awareness (cf. Schultheiss et al., 1999; 2003). These motives may also be situational, and therefore not detected by measures that ask about typical, trait-like behavior.

These reasons likely explain the lack of relationships with the PRF dominance scale, but the SDO's failure to predict behavior may be due to additional factors. Since its introduction, the SDO has distinguished itself as a remarkably robust and reliable predictor of group-level dominance phenomena. However, testosterone's relationship to behavior appears to function on a more individual level. The person who scores high on the SDO is concerned about group-based hierarchies as well as his or her group's status, and presumably reacts to challenges and threats to the group. On the other hand, the person high in testosterone is hypothesized to react to personal status challenges *within* a group, and may or may not have a care in the world about how that group is perceived, as long as he or she is a high-ranking member of the group. Indeed, Pratto et al. (1994) report that the SDO was uncorrelated with interpersonal dominance, and the same was true in our sample. So, it makes sense that one's SDO score should not predict behavior in our experiments, in which status is manipulated as an interpersonal construct. Would testosterone fail to predict status challenges if these challenges were to one's group? A promising direction for future research would be to manipulate the nature of the status challenge, thereby creating an individual or group-level challenge.

General Discussion

The data presented here provide the first evidence for what we have termed the mismatch effect. Evidence from three studies suggests that people have a strong preference or aversion to high status positions, linked to their baseline levels of testosterone. When one's preferred level of status matches actual level in a situation, one is evidently satisfied to remain at that level. However, when a mismatch between preferred and actual status level occurs, one becomes aroused and motivated to regain the desired level. A mismatched person also becomes emotionally distressed, exhibits a hyper-vigilance toward status-related information, and experiences a decline in complex cognitive processing. It is important that testosterone was shown to be a better predictor of cognitive performance than was either of two self-report measures of dominance. In this final section, we briefly outline some of the theoretical implications of these data.

Theoretical Implications

Testosterone and dominance. It is worth noting that some distinguished scholars have argued that the behavioral link with testosterone in humans is weak or even nonexistent (see, e.g., the peer commentaries following the target article by Mazur & Booth, 1998). However, in the face of interactional effects such as those shown in this paper as well as by Josephs et al. (2003) and Newman et al. (2005), these claims are not surprising. Indeed, whereas there is a large array of experimental testosterone studies in the animal literature, the great majority of human studies is correlational, and thus collapsed across situations. Only if a participant's behavior is situated in circumstances that "activate the apparatus" (i.e., when status is challenged or threatened) should one find strong and predictable effects. Only under these conditions should testosterone relate to behavior. Indeed, as stated earlier, ample evidence for an interactionist perspective comes from other animal species. This animal research has determined that only when status is uncertain, and there is a possibility of imminent dominance battles, does testosterone relate to dominant and aggressive behaviors (Collias et al., 2002; Ruiz-de-la-Torre & Manteca, 1999).

Mediation of the mismatch effect. It makes conceptual and intuitive sense that the cognitive deficit that is a consequence of the mismatch effect should be mediated by one or more of the intervening variables that were measured in these studies (e.g., PA, NA, heart rate). For example, the relationship between mismatched status and cognitive performance might be explained by changes in negative affect. However, tests of mediation (Baron & Kenny, 1986) confirmed that neither partial nor full mediation was observed for any of these variables. Why? One possibility is that none of the variables included in these studies were mediators. Another possibility might be that the test of mediation that was used possessed low statistical power (see, e.g., Mackinnon, Lockwood, Hoffman, West, & Sheets, 2002 for a compelling empirical confirmation of this, and for a comparison of 14 different tests of mediation). Regardless, one promising direction for future research might be to search for the mediators that are responsible not only for changes in cognition, but also in motivation (e.g., PA), affect (e.g., NA), and physiological arousal. Perhaps with the aid of new and emerging technologies, such a search will bear fruit.

Testosterone as a personality variable. One obvious limitation associated with the current studies is the lack of multiple measurements of the predictor variable. We are claiming that a particular testosterone level reflects that participant's baseline level of testosterone. Ideally, as with any personality measure, multiple measures would provide a more stable measurement base. However, it is possible that a portion of the variance in some participants' testosterone concentrations is the result of situationally induced changes (e.g., Gonzalez-Bono, Salvador, Serrano, & Ricarte, 1999, Gonzalez-Bono, Salvador, Ricarte, Serrano, & Arnedo, 2000; Josephs, Guinn, Harper, & Askari, 2001). Is this problematic? As Dabbs (2000) and others have pointed out, chronic baseline individual differences far outweigh the changes that arise as a result of the situation.

Rather, it has been demonstrated that in humans, testosterone levels are relatively stable over time (e.g., Dabbs, 2000; Granger et al., 1999; Sellers, Mehl, & Josephs, in press), and have high predictive validity in certain situations—namely, those situations under which status is uncertain (e.g., Sapolsky, 1991). These characteristics suggest that baseline levels of testosterone meet the basic criteria for a good personality variable (cf. John & Benet-Martinez, 2000). Social psychology has a natural and understandable reluctance to measuring hormone levels and to treating them as a stable individual difference variable. After all, it is difficult to ask people "the degree to which you have high testosterone, on a scale from 1 (not at all) to 5 (very much)." But a large body of data, including those in the present study, suggests that testosterone could shed new light on how people function in group settings.

Although highly speculative at this point, it is possible that after an increase in status, a person's physiology will gradually change in concert to the new position. Indeed, Mazur and Booth (1998) have argued that as status increases, so does testosterone. According to the reciprocal model of testosterone's effects on dominant behavior (Mazur & Booth, 1998), changes in circulating levels of testosterone act as a buy or sell signal. When testosterone increases, this informs the individual that the environment is safe for further attempts at maintaining or enhancing status. When testosterone decreases, the individual is being flashed a sell signal and should flee the situation to avoid further loss of status. These changes in testosterone have likewise been found at the group level when individuals felt that their victory was dependent on their personal contribution (Gonzalez-Bono et al., 1999; 2000). It is possible that fluctuations in testosterone may have more to do with long-term success than initial basal levels of testosterone, but the present studies only examined the latter. Further studies are needed to parcel out the long-term predictive validity of each of these two models. We are currently conducting experiments examining androgen reactivity in the context of changing status conditions.

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