Research Article

STATUS, TESTOSTERONE, AND HUMAN INTELLECTUAL PERFORMANCE: Stereotype Threat as Status Concern

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Abstract—*Results from two experiments suggest that stereotype-threat effects are special cases of a more general process involving the need to maintain or enhance status. We hypothesized that situations capable of confirming a performance stereotype might represent either a threat to status or an opportunity for enhancement of status, depending on the nature of the stereotype. The positive relationship between baseline testosterone and status sensitivity led us to hypothesize that high testosterone levels in males and females would amplify existing performance expectations when gender-based math-performance stereotypes were activated. In Study 1, high-testosterone females performed poorly on a math test when a negative performance stereotype was primed. In Study 2, high-testosterone males excelled on a math test when a positive performance stereotype was primed. The moderating effect of testosterone on performance suggests that a stereotype-relevant situation is capable of conferring either a loss or a gain of status on targets of the stereotype.*

Most performance-based stereotypes are explicit or implicit statements of comparison between two or more groups (e.g., women possess poor math ability compared with men, pit bulls are good fighters compared with other breeds). Viewing a stereotype in this manner suggests a connection between situations capable of confirming a performance stereotype and situations involving the gain or loss of status. For example, in studies of stereotype threat, when a woman finds herself about to take a math test, her lower status in the math domain has the potential for confirmation (e.g., Brown & Josephs, 1999; Shih, Pittinsky, & Ambady, 1999; Spencer, Steele, & Quinn, 1999).

In these situations, the confirmation of a negative (or positive) stereotype may be closely tied to a loss (or gain) of status among targets of the stereotype. If the target of a stereotype experiences the stereotype as a statement about status, factors associated with status seeking and status protection might moderate the effects that the stereotype has on performance. It follows from this argument that individual differences in baseline testosterone might moderate the relationship between stereotype threat and performance. The two studies presented here tested this logic by examining the consequences of both positive and negative stereotypes about math ability.

TESTOSTERONE AND STATUS IN MEN AND WOMEN

Across a wide variety of animal species, behaviors intended to achieve, maintain, and enhance status (i.e., dominant and power-seeking behaviors) are observed primarily among high-testosterone (high-T) individuals (e.g., Kraus, Heistermann, & Kappeler, 1999; Ruiz-de-la-Torre & Manteca, 1999). Not surprisingly, the relationship between testosterone and status seeking is not as strong in humans as it is in nonhuman species (Book, Starzyk, & Quinsey, 2000), probably because of the much greater complexity associated with human societies. Nonetheless, measuring testosterone in humans at a single point in time predicts dominance as well as status-related behaviors and occupations across a variety of situations (see, e.g., Dabbs, 1998; Dabbs, La Rue, & Williams, 1990; Mazur & Booth, 1998; Scaramella & Brown, 1978; van Honk et al., 1999).

Most of the research in this area has been conducted on male samples, owing in part to the assumption that females, because of their significantly lower testosterone levels, should not show a relationship between testosterone and status. However, the existing evidence supports a positive relationship rather strongly. Baseline testosterone levels in women have been positively related to occupational status (Purifoy & Koopmans, 1979), personality measures of dominance (Grant & France, 2001; Urdy & Talbert, 1988), and an absence of smiling—considered a nonverbal indicator of dominance (Cashdan, 1995). Furthermore, Grant and France (2001) argued that a review of the literature allows one to conclude that the various "personality characteristics found to have a positive association with testosterone in women are themselves indicative of the underlying core personality trait, dominance" (p. 42). Kemper (1990) drew a similar conclusion, arguing that women have as high a need for power and dominance as do men.[1]

TESTOSTERONE AND INTELLECTUAL PERFORMANCE

A large literature documenting the relationship between testosterone and human intellectual performance has indicated that testosterone exerts its effects neuroanatomically, by influencing the organization of the developing brain (e.g., Gouchie & Kimura, 1991; Williams, Barnett, & Meck, 1990). Curiously, despite more than a century of study on the relationship between testosterone and status, no attempts have been made to link testosterone's behavioral effects to intellectual performance.

Although the prototypical status struggle depicts two males squaring off in an aggressive encounter, concerns over status are often reflected in more genteel behaviors and decisions. For example, a high-T faculty member might be particularly concerned with his or her standing within the department, and may behave in ways intended to enhance or maintain this standing (e.g., increasing publication rate) without resorting to the types of dominant behaviors observed in other animal species (e.g., biting, scratching). Any time individuals are highly invested in a domain, a subset of these individuals (e.g., those high in testosterone) should care about their relative social standing in that domain.

Carrying this reasoning over to human intellectual performance, we suggest that, among individuals who are highly invested within an

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1. It should be pointed out that changes in testosterone resulting from the consequences of a dominance battle (i.e., winning or losing in a competitive situation) may be not as strong in women as in men, but this issue is not of primary concern in this article.

academic domain (e.g., mathematics), a subset of these individuals (e.g., high-T individuals) will care about their self-perceived standing in that domain. Performance should be influenced by status demands only when two conditions are met: Investment in the domain is high, and concern with status or dominance exists. This led us to hypothesize that, among individuals who are invested in an academic domain, performance capable of jeopardizing or maintaining status may be moderated by individual differences in baseline testosterone. When baseline testosterone is low, performance should not be influenced by the status consequences of the situation. Only when baseline testosterone is high should a status manipulation influence performance.

OVERVIEW OF THE PRESENT STUDIES

In the two studies reported here, we examined participants who had previously indicated that mathematics and math ability were very important to them. We predicted that behaviors that result from encountering stereotypes about math performance would become amplified in high-T individuals. As we reported previously (Brown & Josephs, 1999), men are faced with a positive stereotype about their math ability, and expect to do well on math tests. Thus, the possibility of confirming a positive stereotype should make high-T men more likely to view a math test as a way to maintain or enhance their high status in math, inspiring them to strive for excellence. This logic was tested in Study 2. Conversely, women face a negative stereotype about their math abilities, and expect to do poorly on math tests (Brown & Josephs, 1999). The possibility of confirming a negative stereotype should cause high-T women to view a math test as a potential threat to their status, resulting in poor performance among high-T women. This logic was tested in Study 1.

STUDY 1

In Study 1, we determined baseline testosterone levels in male and female participants, and administered a math test. The status manipulation used in this experiment was based on previous studies of stereotype threat, and was designed to activate the stereotype that females possess weak math abilities, relative to males. The manipulation was not expected to affect males' performance because males tend to judge the stereotype of weak math ability as pertaining only to females, and thus do not view the stereotype to be self-relevant (Brown & Josephs, 1999).

Thus, we expected an interaction among sex, the stereotype-threat prime, and testosterone levels such that high-T females for whom stereotype threat was primed would perform more poorly than high-T females who were not primed. The performance of low-T females was predicted to be unaffected by the stereotype-threat manipulation. Because the stereotype was not relevant to males, and because their status as possessing good quantitative skills should not have been threatened, the performance of high-T males was not expected to decline in the stereotype-threat condition (see Aronson et al., 1999, and Brown & Josephs, 1999, for discussions of male-relevant math stereotypes).

Method

Participants

Participants were 76 females and 75 males enrolled in introductory psychology at the University of Texas. They participated in partial fulfillment of the course's research requirement. Only participants who scored above the midpoint of the Math Identification Questionnaire (Brown & Josephs, 2000) during pretesting were eligible for inclusion in the study. On this questionnaire, respondents rate statements (e.g., "My math abilities are very important to me.") using a 9-point, Likert-type scale. In pilot testing (Brown & Josephs, 1999), we found that individuals scoring below the midpoint of this scale are relatively immune to the performance-impairing effect of stereotype threat, presumably because they are minimally invested in math (see also Aronson et al., 1999; Spencer et al., 1999).

Materials and procedure

Saliva collection. Testosterone was measured through enzyme immunoassays of salivary samples conducted by Salimetrics (State College, Pennsylvania). For a full description of the saliva collection procedures and the enzyme immunoassay procedure, see Granger, Schwartz, Booth, and Arentz (1999). Experimental sessions were conducted between 12 p.m. and 4 p.m. to control for a diurnal decline in testosterone (e.g., Granger et al., 1999).

Stereotype prime. Participants were run individually. Following saliva collection, participants were told that they would be taking a test of mathematical reasoning abilities. They then completed either a questionnaire designed to prime stereotype threat or a control questionnaire featuring questions about coming to college. The seven-item stereotype-prime questionnaire included items such as "I think that some people feel I have less math ability because of my gender" and "In math classes, I often feel that others look down on me because of my gender." The seven-item control questionnaire included items such as "School can be very rewarding" and "I have a very clear idea of what my major will be." Copies of both questionnaires are available by request.

Testing session. After completing the questionnaire, participants were given 20 min to solve 20 questions drawn from the quantitative section of the Graduate Record Exam (GRE-Q). Participants were informed that an incorrect answer would result in a point deduction, and advised not to guess blindly. Following the test, participants were given a questionnaire that included an item asking how nervous they felt at the moment (possible answers ranged from 1, *not at all*, to 5, *very nervous*). Participants were also asked to recall their math score on the Scholastic Assessment Test (SAT) and the number of math courses they had taken in high school.

Results and Discussion

For all analyses presented here, a median split was performed on testosterone levels within sex. High-T females (M = 46.10 pg/ml, SD = 40.23) were high relative to low-T females (M = 24.66 pg/ml, SD = 22.78). High-T males (M = 127.67 pg/ml, SD = 70.57) were high relative to low-T males (M = 79.60 pg/ml, SD = 39.11).

Manipulation checks

Supporting the notion that our female participants acknowledged the self-relevance of a sex-linked stereotype, a significant sex difference emerged on the stereotype-prime questionnaire, with females indicating significantly greater agreement with the questionnaire items than males did, $t(77) = 3.4$, $p < .05$. Another check of the manipulation was provided by our nervousness measure. If the manipulation was effective in priming stereotype threat, then females should have been more nervous than males. We found a statistically significant ef-

fect of the manipulation on nervousness, with females reporting greater nervousness than males, $F(1, 148) = 2.52$, $p < .05$. We also looked at the effect of the manipulation on the nervousness of the group that we predicted would be most upset by it, the high-T females. We found that, as expected, the average reported nervousness was higher in this group ($M = 3.44$) than in any other group (means in the other groups ranged from 2.16 to 2.92), but none of these differences were statistically significant (though many were marginally significant).

GRE-Q performance

GRE-Q performance was significantly related to math SAT scores and number of high school math classes (rs = .58 and .26, respectively, ps $< .05$). Thus, we were able to use these relationships to reduce error variance by examining our primary dependent measure after controlling for the combined effects of these math proficiency variables. Reported math SAT scores were not related to testosterone, $r(149) = .09$, n.s., suggesting that if some participants fabricated or erred in reporting their SAT scores, these problems were not systematically related to the primary individual difference variable.

We predicted that stereotype threat would impair performance among female participants high in testosterone, relative to high-T females in the control condition. We also predicted a lack of stereotype-prime effects among low-T females, and predicted no performance differences among male participants. As shown in Table 1, these hypotheses were supported. A 2 (testosterone level) × 2 (stereotype threat: prime, control) × 2 (sex) analysis of covariance (ANCOVA) revealed a statistically significant three-way interaction, $F(1, 142) = 4.94$, $p < .05$.

To interpret this interaction, we conducted a 2 (testosterone level) × 2 (stereotype threat: prime, control) ANCOVA within sex. Among female participants, we found no main effects but a statistically significant interaction, $F(1, 71) = 4.85$, $p < .05$. A planned comparison indicated that, as predicted, high-T females in the prime condition underperformed relative to high-T females in the control condition, $t(37) = 2.47$, $p < .05$, $d = .81$. In addition, as predicted, the stereotype-threat prime had no performance-altering effect among low-T females ($t < 1$). We next contrasted high-T females in the prime condition to all other females, and found that this group underperformed relative to all other female participants, $t(73) = 1.70$, $p < .05$ (one-tailed), $d = .45$. Finally, we conducted the critical planned comparison using means that were not adjusted for the covariates, finding a statistically significant difference between high-T females in the prime and control conditions, $t(37) = 2.11$, $p < .05$, $d = .69$. This suggests that the primary finding was not due to statistical problems associated with the ANCOVA.

Overall, men ($M = 15.1$, $SD = 3.0$) outperformed women ($M = 13.3$, $SD = 3.6$) in the current study, $F(1, 148) = 11.67$, $p < .05$. But, as hypothesized, the stereotype-threat prime did not have a significant effect on male participants' performance scores, nor did testosterone levels interact with the stereotype prime for the male participants (all ps $> .12$; see Table 1 for these means).

Table 1. *Study 1: Mean math performance scores by condition and testosterone (T) level*

	Stereotype-prime condition					
	Prime			Control		
Group	*M*	*SEM*	*n*	*M*	*SEM*	*n*
Females						
High T	12.1	0.62	19	14.4	0.69	18
Low T	13.7	0.71	17	13.0	0.67	22
Males						
High T	15.9	0.64	18	14.9	0.59	21
Low T	14.3	0.67	17	15.1	0.63	19

Note. Scores were adjusted using participants' reported SAT (Scholastic Assessment Test) math scores and number of math classes taken in high school.

Summary

We argued that confirmation of a negative stereotype might be closely tied to a loss of status. If a stereotype-threat situation is capable of conferring a loss of status or a confirmation of low status, then those individuals who are hypothesized to be concerned with such matters should be susceptible to the performance-impairing effects of the stereotype threat. Our results support this idea. We found that when stereotype threat was primed in females, math performance suffered, but only among females who were high in baseline testosterone. Only when both preexisting levels of testosterone were high and stereotype threat was primed did performance suffer, suggesting a moderating relationship between the two variables.

STUDY 2

Our previous study (Brown & Josephs, 1999) demonstrated that, as a result of negative stereotypes about their math abilities, females report that they are concerned about performing poorly in math, and do not expect to do well. Males, however, do not share these negative, math-related performance concerns. Instead, because of positive stereotypes about their math abilities, males expect to excel in mathematics (Brown & Josephs, 1999). In general, when anticipating having to take a math exam, females reported being threatened, whereas males viewed the upcoming exam not as a threat but as a challenge.

It is this distinction between threat and challenge, between negative and positive expectations, that we believe determines the direction of moderation associated with baseline testosterone. Sapolsky (1998) referred to testosterone as a "permissive" hormone—magnifying existing behaviors and tendencies, but not creating new ones. When one expects to fail, and this result has consequences for status, testosterone may magnify the behaviors and tendencies that make failure more likely. Conversely, expecting to succeed in a situation that has status consequences should lead to an increase, at least among high-T individuals, in behaviors that contribute to success.

Study 2 was designed to test the positive side of this status-performance relationship by placing half of our male participants into a situation that offered them the opportunity to confirm a positive stereotype, and enhance their status in mathematics. As in previous research (Brown & Josephs, 1999), our participants were told that they would be taking a math test that either distinguished people of low ability from everyone else or distinguished people of high ability from everyone else. In essence, we led participants to believe that their score would be compared with a predetermined cutoff. In the former case, this cutoff was quite low, and in the latter case, substantially higher.

We predicted that when high-T male participants were presented with an opportunity to excel, thus enhancing their math status, they

would rise to the challenge and perform at a high level. In contrast, we expected that when told that the test was scored in a way that would only distinguish those individuals possessing low ability from everyone else, high-T males would be unconcerned with their performance because of the absence of a status-enhancing opportunity. On the basis of previous literature and the findings from Study 1, we hypothesized that low-T males would be relatively unaffected by the opportunity to enhance status, and would perform similarly in the high-ability and low-ability conditions.

Method

Participants

Participants were 51 males enrolled in introductory psychology at the University of Texas. They participated in partial fulfillment of the course's research requirement. As in Study 1, all participants were preselected as being highly identified with mathematics.

Materials and procedure

Saliva collection. Saliva collection and analysis procedures were identical to those in Study 1.

Test instructions. Participants were run individually. After saliva collection, they were told that they would be taking a test of mathematical reasoning abilities. As in our previous study (Brown & Josephs, 1999), participants were given one of two sets of instructions for the math test. In the *exceptional-ability* (status-enhancement potential) condition, participants were told that the test would identify only individuals who were "exceptional" in math ability compared with everyone else. In the *weak-ability* (no status-enhancement potential) condition, participants were told that the test would identify only individuals "weak" in math ability compared with everyone else.

Manipulation check. Following the test instructions, participants were given a manipulation check asking them to indicate the nature of the test that they were about to take, by choosing one of four options: (a) "This test will determine whether I am exceptionally weak in my math abilities"; (b) "This test will determine whether I am exceptionally strong in my math abilities"; (c) "This test measures my non-verbal spatial abilities"; and (d) "This test measures my logical abilities, combined with my ability to mentally rotate 3-D pictures."

Testing session. The procedure for the testing session was identical to the procedure in Study 1. The performance measure was again the GRE-Q.

SAT scores. Before the start of the experimental session, participants were given a separate consent form that allowed us access to their math SAT scores. Participants were assured that they did not have to give this consent to participate in the experiment. SAT scores for those who consented ($n = 49$, 96% of the sample) were obtained at the end of the semester.

Results and Discussion

For all analyses presented here, a median split was performed on testosterone levels. High-T males ($M = 171.95$ pg/ml, $SD = 29.41$) were high relative to low-T males ($M = 101.73$ pg/ml, $SD = 19.45$). Scores on the Math Identification Questionnaire did not differ between conditions (overall $M = 6.75$, $SD = 0.94$).

Table 2. *Study 2: Mean math performance scores by condition and testosterone level*

	Test-instruction condition					
	Exceptional ability			Weak ability		
Testosterone level	*M*	*SEM*	*n*	*M*	*SEM*	*n*
High	15.7	0.87	14	12.5	0.95	12
Low	13.3	0.88	13	14.5	0.90	12

Note. Scores were adjusted using participants' SAT (Scholastic Assessment Test) math scores and number of math classes taken in high school.

Manipulation check

The manipulation check confirmed the success of the manipulation. All participants correctly indicated the testing condition to which they had been assigned. There were no main effects or interactions for the nervousness measure in Study 2 (all Fs < 1).

GRE-Q performance

As in Study 1, GRE-Q scores were adjusted for the combined effects of math SAT scores and the number of high school math classes completed.

We predicted that the exceptional-ability condition would provide an opportunity for our male participants to confirm a positive stereotype about their math abilities and enhance their status, and that this would lead to high-T males outperforming low-T males in this condition. As shown in Table 2, this hypothesis was supported. A 2 (testosterone level) $\times$ 2 (test instruction) ANCOVA on adjusted GRE-Q scores revealed no main effects (Fs < 1), but a significant interaction, $F(1, 44) = 5.47$, $p < .05$. Planned comparisons revealed that, as predicted, high-T males performed better than low-T males in the exceptional-ability condition, $t(24) = 2.07$, $p = .05$, $d = .81$, but not in the weak-ability condition, $t(21) = 1.36$, $p = .19$, $d = .57$. A planned comparison also revealed that, as predicted, high-T males performed better in the exceptional-ability condition than in the weak-ability condition, $t(22) = 2.25$, $p < .05$, $d = .92$. We also conducted a 2 (testosterone level) $\times$ 2 (test instruction) analysis of variance (ANOVA) on nonadjusted scores, and found the same pattern of means, $F(1, 45) = 5.57$, $p < .05$.[2] Consistent with our predictions, high-T males outperformed low-T males, but only when the situation provided the opportunity to enhance status in the math domain.[3]

Number of questions skipped

We hypothesized that high-T males who were given the opportunity to demonstrate their high status in the math domain—and confirm a positive stereotype—would "rise to the challenge," and perform well on the test. If this group was highly motivated to excel, they should

2. To provide an accurate comparison with the ANCOVA, we conducted this ANOVA using only the participants for whom we had obtained math SAT scores ($n = 49$).

3. For a discussion of the discrepancy between these results and Study 1 of Brown and Josephs (1999), see Newman, Josephs, and Brown (2002).

have been more likely than other participants to attempt every question in order to score as high as possible on the test.

In support of this prediction, a 2 (testosterone level) X 2 (test instruction) ANOVA on the number of questions skipped revealed no main effects (Fs < 1) but a significant interaction, $F(1, 47) = 4.83$, $p < .05$. Planned comparisons revealed that high-T males skipped significantly fewer problems than low-T males in the exceptional-ability condition, $t(25) = 2.07$, $p < .05$, $d = .80$, but not in the weak-ability condition, $t(22) = 1.06$, $p = .30$, $d = .43$.

Summary

We argued that confirmation of a positive stereotype might be tied to an enhancement in status. If a positive stereotype offers the opportunity to enhance status, then those individuals especially concerned with such matters should perform particularly well in the presence of the stereotype. Our results were consistent with this idea. We found that when males had the chance to confirm a positive stereotype, performance was increased, but only among males high in baseline testosterone, whose behavior tends to imply concern with status. High-T males outperformed low-T males, but only when the situation provided the opportunity to enhance status in the math domain, suggesting a moderating relationship between the two variables.

GENERAL DISCUSSION

Together, these studies suggest that stereotype-based performance effects occur as a result of a fundamental desire to maintain or enhance one's social status. Only those participants hypothesized to experience concern in the face of a possible change in status demonstrated stereotype-based performance effects. Specifically, both males and females high in testosterone appear more responsive to reminders of their stereotypical status in the math domain, compared with males and females low in testosterone. However, the nature of this response is very different for males and females. On the one hand, females have long faced negative stereotypes about their math abilities, and a reminder of these stereotypes poses a potential threat to status. When primed with a negative stereotype, only high-T females showed a decrease in math performance. Males, on the other hand, face positive stereotypes about their math abilities, and a reminder of these stereotypes presents an opportunity to enhance status. Thus, high-T males outperformed low-T males, but only when primed with a positive stereotype.

One alternative interpretation of these findings is that the moderating effects of baseline testosterone can be explained by baseline differences in physiological arousal. That is, the stereotype-threat prime may have pushed highly aroused individuals over the top of the performance-arousal curve. However, several points argue against this conclusion. First, no testosterone-based performance differences were observed in either of the control conditions. Second, in neither study did high-T participants report being more nervous than low-T participants across experimental conditions. Finally, a recent study (Josephs, Guinn, Harper, & Askari, 2001) found that testosterone showed no correlation with cortisol. Furthermore, raising cortisol levels via ingestion of licorice actually resulted in a slight decrease in testosterone levels. If baseline testosterone is related to chronic arousal, a positive relationship with cortisol levels should be observed.

We have argued throughout this article that, through its hierarchical ordering of two or more groups, a stereotype is essentially a statement about dominance or status. Thus, we have suggested that priming a stereotype leads persons high in testosterone to perceive the situation as having status implications, and subsequently to act on those perceptions. Although the results from these two studies are consistent with this explanation, what remains missing is a direct and face-valid manipulation of status. Recently, Josephs and his colleagues (Guinn, Newman, & Josephs, 2002; Josephs & Guinn, 2002) have sought to remedy this by examining the consequences of winning or losing on performance. This research has shown that when high-T participants perceive themselves to be dominating against a competitor, their subsequent performance relative to control participants increases. When high-T participants perceive themselves to be dominated, their subsequent performance declines. Low-T participants show minimal response to these dominance manipulations. We find these results encouraging in that a direct manipulation of status has yielded findings that are consistent with our stereotype-as-status explanation.

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