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The Interaction of Testosterone and Cortisol Is Associated With Attained Status in Male Executives

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Are hormone levels associated with the attainment of social status? Although endogenous testosterone predicts status-seeking social behaviors, research suggests that the stress hormone cortisol may inhibit testosterone's effects. Thus, individuals with both high testosterone and low cortisol may be especially likely to occupy high-status positions in social hierarchies while individuals with high testosterone and high cortisol may not. We tested this hypothesis by recruiting a sample of real executives and examining testosterone, cortisol, and a concrete indicator of attained status: the number of subordinates over which the executive has authority. Despite the myriad nonhormonal factors that determine organizational promotion, the executives' endogenous testosterone and cortisol interacted to significantly predict hierarchical position: Testosterone positively predicted executives' number of subordinates, but only among low-cortisol executives. The results imply that reducing cortisol levels via stress reduction may be a critical goal not only because doing so will improve health but also because doing so may enhance leadership potential.

Keywords: power, social status, hormones, neuroendocrine, stress

In fields ranging from primatology to psychology, there has been longstanding cross-disciplinary interest in the hormonal correlates of social hierarchy (Mazur & Booth, 1998; Sapolsky, 1991). This is not surprising, as social position matters: For better or worse, those at the top of hierarchies—whether alpha male baboons or corporate CEOs—have disproportionate influence on groups and organizations (Dávid-Barrett & Dunbar, 2012). Thus, it is important to determine the factors influencing who attains high-status social roles. In the present paper, we seek to clarify the role of endogenous hormone levels in the attainment of a particular high-status role among humans: the high-level executive.

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The present work was motivated by two recent findings: (a) that higher-level executives have lower levels of the stress hormone cortisol than their lower-level counterparts, even when accounting for socioeconomic status and other key demographic variables (Sherman et al., 2012), and (b) that cortisol has an inhibitory and antagonistic influence on testosterone (Chen, Wang, Yu, Liu, & Pearce, 1997; Liening & Josephs, 2010; Viau, 2002). Together, these findings suggest that a particular hormonal profile—low cortisol and high testosterone—may be especially conducive to status attainment (because high testosterone would be free to drive status pursuits unconstrained by cortisol; Mehta & Josephs, 2010). If so, individuals with this combination may come to occupy high-level positions. Little, if any, research has examined these variables within real-world social hierarchies. To address this gap, we recruited a sample of real executives and examined testosterone, cortisol, and a concrete indicator of attained status: the number of subordinates over which the executive has authority.[1]

Testosterone and Social Behavior

Testosterone, an end-product of the hypothalamic-pituitary-gonadal (HPG) axis, has long attracted the attention of researchers studying aggression, social dominance, and social status (e.g., Dabbs, Carr, Frady, & Riad, 1995; Eisenegger, Haushofer, & Fehr, 2011; Sapolsky, 1991). Indeed, testosterone influences a range of social behaviors when social status is at stake (for reviews, see

[1] We define executive as a person with managerial responsibility in an organization.

Liening & Josephs, 2010; Mazur & Booth, 1998). Although testosterone, like many hormones, can fluctuate with environmental changes, there are stable, trait-like individual differences in testosterone concentrations (Dabbs, 1991; Granger, Shirtcliff, Booth, Kivlighan, & Schwartz, 2004; Liening, Stanton, Saini, & Schultheiss, 2010; Sellers, Mehl, & Josephs, 2007) that predict indicators of status striving, such as implicit power motives (Schultheiss, Dargel, & Rohde, 2003) and aggressive or competitive behavior when one's social status is threatened (Beehner, Bergman, Cheney, Seyfarth, & Whitten, 2006; Ehrenkranz, Bliss, & Sheard, 1974; Josephs, Newman, Brown, & Beer, 2003; Josephs, Sellers, Newman, & Mehta, 2006; Mehta, Jones, & Josephs, 2008; Sapolsky, 1991; Schultheiss et al., 2003). Moreover, testosterone reduces fear (as indicated by the fear-potentiated startle reflex; Hermans, Putman, Baas, Koppeschaar, & van Honk, 2006) and predicts risk-seeking behavior (Sapienza, Zingales, & Maestripieri, 2009; Stanton, Liening, & Schultheiss, 2011).

By prioritizing status enhancement, decreasing fear, and increasing risk tolerance, testosterone may influence status attainment. However, the relevant literature is inconclusive, at least in human populations. Although some studies of nonhuman animals have found no relationship between testosterone and social rank (e.g., Steklis, Brammer, Raleigh, & McGuire, 1985; Ungerfeld & González-Pensado, 2009), numerous studies have found a relationship, with higher testosterone—both endogenous and exogenous—associated with higher social rank, in both males (Beehner et al., 2006; Czoty, Gould, & Nader, 2009; Muehlenbein, Watts, & Whitten, 2004; Rose, Holaday, & Bernstein, 1971; for a review, see Sapolsky, 1991) and females (Veiga, Viñuela, Cordero, Aparicio, & Polo, 2004). In humans, studies linking testosterone to job status (Dabbs, 1992; Dabbs, de la Rue, & Williams, 1990) have compared status *across* occupations—comparing low- and high-status occupations—rather than *within* occupations, thereby limiting connections to status attainment.

Beyond Main Effects: The Interactive Effects of Testosterone and Cortisol

The surprisingly mixed evidence tying testosterone to status attainment in humans may be partly due to other hormones, namely cortisol, constraining testosterone's influence (Carré & Mehta, 2011). Cortisol, an end-product of the hypothalamic-pituitary-adrenal (HPA) axis, inhibits testosterone by reducing HPG activity and blocking androgen receptors (Chen et al., 1997; Viau, 2002). Accordingly, the dual-hormone hypothesis (Mehta & Josephs, 2010; Mehta & Prasad, 2015) proposes that testosterone and cortisol jointly regulate status-related behaviors (Montoya, Terburg, Bos, & van Honk, 2012). Indeed, a growing literature has found that endogenous testosterone *only* predicts aggressive, antisocial, or status-related behaviors, such as competitive motivation, when endogenous cortisol is low (Dabbs, Jurkovic, & Frady, 1991; Denson, Ronay, von Hippel, & Schira, 2013; Edwards & Casto, 2013; Mehta & Josephs, 2010; Mehta, Mor, Yap, & Prasad, 2015; Mehta, Welker, Zilioli, & Carré, 2015; Pfattheicher, Landhäuβer, & Keller, 2014; Popma et al., 2007; Tackett, Herzhoff, Harden, Page-Gould, & Josephs, 2014; van den Bos, Golka, Effelsberg, & McClure, 2013; Zilioli & Watson, 2012; cf. Welker, Lozoya, Campbell, Neumann, & Carré, 2014, for evidence that endogenous testosterone predicts trait psychopathy for those with *high* cortisol).

There are several possible explanations for these findings. It is possible that cortisol directly inhibits the behavioral effects of testosterone, consistent with the antagonistic relationship between cortisol and testosterone at the biological level (Chen et al., 1997; Viau, 2002). This direct inhibitory effect would be a mechanism by which the HPA axis can suppress dominance-related systems, thereby prioritizing stress management over status enhancement (Carré & Mehta, 2011; Liening & Josephs, 2010). Alternatively, high endogenous cortisol may be a marker of other dispositional factors, such as elevated stress reactivity, that are associated with changes—in biology, psychology, and/or behavior—that limit or override testosterone's behavioral effects. Regardless of the specific mechanism, low endogenous cortisol has emerged as a reliable marker of increased sensitivity to testosterone's behavioral effects.

The Present Study

Applied to status attainment, dual hormone research suggests the compelling but untested possibility that having low cortisol and high testosterone may promote status attainment. If this neuroendocrine profile allows testosterone's status-promoting effects to operate unconstrained, executives who possess this profile may come to hold powerful positions. Conversely, having low cortisol and low testosterone may work against status attainment. Individuals with low testosterone do not simply lack status motivations; rather, they actively avoid dominance, show a marked cognitive decline when they are in high-status positions, and are prone to submission and appeasement behaviors (e.g., Josephs et al., 2006; van Honk et al., 1999; Zyphur, Narayanan, Koh, & Koh, 2009). As such, executives with low testosterone and low cortisol would be expected to be worst off in terms of status attainment. Without high cortisol to keep their (low) testosterone levels from being expressed behaviorally, these individuals may engage in status-avoidant or status-diminishing behaviors and actively avoid socially dominant positions. This prediction is consistent with the finding that low-cortisol, low-testosterone undergraduate students were rated the lowest on dominance traits when engaged in a laboratory group task (Mehta & Josephs, 2010, Study 1).

We tested our predictions in a sample of male executives. We studied men for methodological reasons, reasoning that if an effect exists, it would likely be easiest to detect among men. There is some evidence that testosterone predicts social aggression in both men and women (Harris, Rushton, Hampson, & Jackson, 1996) and that the dual hormone pattern may also apply to women. Specifically, several studies have found that the interaction of testosterone and cortisol in predicting status-relevant behaviors, such as risk-taking and desire to compete after a loss, is not moderated by gender (Mehta & Josephs, 2010, Study 1; Mehta et al., 2015; Mehta et al., 2015). Moreover, one study of women found that testosterone and cortisol interacted in predicting reactive aggression, with greater testosterone associated with more reactive aggression but only for women with *high* cortisol (Denson, Mehta, & Ho Tan, 2013). Nevertheless, women's testosterone levels tend to be lower and less variable (across women) than men's levels (Dabbs, 1991; Harris et al., 1996). Thus, for women there is less variation in testosterone to potentially relate to behav-

ior, a problem that may be compounded if women show similarly limited variation in the outcomes typically measured in dual hormone studies (e.g., antisocial behaviors, dominance). Thus, as an initial step in exploring the associations among testosterone, cortisol, and status attainment, we focused on a sample of male executives. This methodological choice should not be taken as a theoretical assertion that women are unlikely to show the hypothesized relationship. As we note in the discussion, there is a need for follow-up research that explores these relationships among women.

We operationalized status attainment as the number of subordinates over which the executive has direct or indirect authority, an objective, quantitative criterion that captures the type of high-status positions that status-seeking individuals target. This measure of objective attained status follows from previous studies of organizational status and power, which have used number of subordinates as an index of an individual's hierarchical position (e.g., Boxman, De Graaf, & Flap, 1991; Lyness & Thompson, 1997; Reskin & Ross, 1992; Spaeth, 1979, 1985).[2]

Executives with more subordinates may be more educated and earn higher salaries than executives with fewer subordinates. To determine whether hormone levels *uniquely* relate to executives' number of subordinates, we also measured their income and education level. We predicted that testosterone and cortisol would jointly predict number of subordinates but would not predict income or education.

Method

Participants

Participants were 78 male executives (M_{age} = 48.68, SD_{age} = 5.94; range = 33–65) enrolled in an executive education program at Harvard University designed for senior-level officials in the public sector, including federal government officials, senior military officers, and some private-sector managers whose work relates to the public sector. This program, one of several at Harvard University, targets individuals with a rank of GS14 or GS15 on the General Schedule ranking for civilians (for the military, this corresponds to Lt. Colonel or Colonel in the Army, Marines, and Air Force, and Commander or Captain in the Navy and Coast Guard). Participants must apply to the program; admission is based on several criteria, including the applicant's experience, responsibilities, and the extent to which the applicant's organization is committed to his or her professional advancement. The most common industries/sectors in the sample were *government* (n = 38), *military* (n = 9), *law enforcement* (n = 6), and *defense* (e.g., Department of Defense; n = 6). The ethnic composition of the sample was fairly diverse. A majority of participants self-identified as White (66.7%). The next most common race/ethnicity was Black (11.5%), followed by Asian (9%) and Hispanic (5.1%). Most participants (84.6%) were born in the United States. Of the 15.4% born outside of the United States, 4 were from China, 2 from Vietnam, 2 from Germany, and 1 each from France, Morocco, New Zealand, and the Philippines. Of the 78 participants, 74 consented to hormone testing and provided samples of sufficient volume for testing.

Primary Measures

Hormones. Participants were instructed that within an hour of the study, they should not (a) eat dairy products or anything containing live bacterial cultures (e.g., yogurt), (b) consume caffeine or alcohol, (c) smoke cigarettes, (d) exercise, or (e) brush their teeth. While completing various questionnaires and tasks, each participant provided two 1.5-mL saliva samples via passive drool. To minimize diurnal variation, the first sample was collected at approximately 3:30 p.m.; the second at approximately 4:00 p.m. Samples were stored at −25 °C and then shipped to Salimetrics (State College, Pennsylvania) for immunoassay (for testosterone, intraassay coefficient of variation, CV = 4.6%, interassay CV = 9.8%; for cortisol, intraassay CV = 3.5%, interassay CV = 5.1%). Testosterone and cortisol values were log-transformed, which successfully reduced skewness (for cortisol, skewness was reduced from 3.47 and 3.05 for the two samples to .88 and .59, respectively; for testosterone, skewness reduced from 1.69 and 1.28 to .39 and −.07, respectively).

For each hormone, the final measure was the average of the two samples (α values = .84 and .82, for testosterone and cortisol, respectively, confirming high cross-sample consistency). Outliers—values equal to or greater than three standard deviations above or below the mean—were excluded. One participant was excluded on the basis of this criterion. Results were virtually unchanged if this outlier was included. We chose to average across the two saliva samples in order to increase the reliability of our measurement of endogenous hormone levels. It is possible, however, that the second sample, which occurred toward the end of the experimental session, may have been influenced by the various tasks and questionnaires (unrelated to the current hypothesis) that participants completed in the interim. In addition to several questionnaires, there were two tasks that contained a between-subjects experimental manipulation: (a) a decision-making task that either contained a sunk cost or not, and (b) an ostracism manipulation, in which participants played a computerized ball-tossing game (Cyberball; Williams & Jarvis, 2006) and were either excluded or included by the other participants. Importantly, both manipulations were designed to test completely separate research questions, which did not involve hormone levels. Additionally, the second saliva sample was collected immediately after the ostracism manipulation, which was likely insufficient time for manipulation-related changes in testosterone or cortisol to enter saliva (Schultheiss et al., 2012). Indeed, testing each hormone as a function of time of collection (Time 1 vs. Time 2) and experimental condition, revealed no significant Time × Condition interactions (p values > .12) for either experimental manipulation. In short, the two unrelated manipulations did not significantly affect hormone levels. Furthermore, when repeating our main analyses using only Time 1 hormone levels, which were collected prior to any experimental manipulations, the critical interaction (Testosterone × Cortisol) remains statistically significant.

[2] This focus on objective status attainment highlights a critical distinction between the present research and previous research on power and stress among executives (Sherman et al., 2012). Whereas previous work focused conceptually on stress as the outcome of interest and incorporated a hormonal measure (cortisol) as one indicator of stress, the present work focuses on attained status, not stress, as the outcome of interest.

Number of subordinates. Participants answered the following two questions: "How many people do you, yourself, manage?" and "How many people are subordinate to you within your line of management (i.e., direct and indirect reports)?" Because these variables were positively skewed (skewness values of 4.21 and 2.43, respectively), responses were log-transformed, *z* scored, and then averaged ($\alpha = .62$; skewness = 1.39).

Control Measures

Socioeconomic status. Participants indicated their level of education (1 = *high school,* 2 = *some college,* 3 = *2-year degree,* 4 = *4-year degree,* 5 = *postgraduate/professional degree,* or *other*) and family income (1 = *$0–$24,999*, 2 = *$25,000–$49,999*, 3 = *$50,000–$74,999*, 4 = *$75,000–$99,999*, 5 = *$100,000–$149,999*, 6 = *$150,000–$249,999*, 7 = *$250,000–$499,999*, 8 = *$500,000+*).

Awakening time. Because hormone levels can be influenced by the time one awakens on the day of testing (Edwards, Evans, Hucklebridge, & Clow, 2001), participants indicated the time they awoke that morning, which we converted to number of hours after midnight.

Health. Participants indicated—yes or no—whether they exercised at least once per week (82.2%), whether they used tobacco products (6.8%), whether they drank caffeinated beverages (98.6%), and whether they suffered from any of the following conditions: diabetes (2.7%), asthma (1.4%), a heart condition (6.9%), or a neurological disorder (1.4%).

Managerial experience. To test whether managerial experience might explain any observed relationship between number of subordinates and hormones, participants indicated how many years they had served in a management role ($M = 17.22$, $SD = 6.65$).

Results

Preliminary Analyses

We first examined simple relationships among the independent variables. As others have found (e.g., Mehta & Josephs, 2010), testosterone and cortisol levels were positively correlated ($r = .49$, $p < .001$; see Table 1 for correlations and descriptive statistics for all variables).

Primary Analyses

We tested our primary hypothesis in a multiple linear regression model, predicting the number of subordinates from testosterone, cortisol, and their interaction. Predictors were centered (*z* scored, prior to computing the interaction term), an approach that is recommended in order to reduce nonessential multicollinearity between the interaction term and main effects (Cohen, Cohen, West, & Aiken, 2013). Given the different units for testosterone and cortisol, we chose *z* scoring as our centering method. By putting the predictors into standardized units, this approach makes the regression coefficients—for the main regression and the follow-up simple slopes analysis—more interpretable. To account for age-related differences in hormone levels and number of subordinates, age was added as a covariate.[3] In Step 1, we tested the main effects of testosterone and cortisol (as well as age, the covariate); in Step 2, we added the interaction term.

As predicted, there were no main effects of testosterone ($\beta = .20$, $p = .16$) or cortisol ($\beta = .06$, $p = .69$) but a significant Testosterone × Cortisol interaction, $\beta = -.35$, $p = .005$, $\Delta R^2 = .11$ (see Figure 1). This interaction remained statistically significant when adding any of the following variables as covariates in Step 1: (a) awakening time, (b) managerial experience, or (c) the health indicators. We decomposed the interaction using simple slopes analysis (Aiken & West, 1991), testing the effect of testosterone at high and low cortisol (the mean ±1 *SD*). Testosterone was a significant, positive predictor of number of subordinates for low-cortisol individuals ($\beta = .67$, $p = .002$) but not for high-cortisol individuals ($\beta = -.09$, $p = .59$).[4]

To assess specificity, we tested whether the Testosterone × Cortisol interaction predicted either of the two primary facets of socioeconomic status (income and education). This analysis yielded no significant effects (*t* values < 1.67, *p* values > .10); that the dual-hormone pattern predicted only number of subordinates supports the specificity of the dual-hormone pattern in explaining attained status.

Secondary Analyses

We conducted secondary analyses to check robustness, assessing whether the findings were sensitive to the particular specifications of the model. First, our results did not depend on the inclusion of age: The Testosterone × Cortisol interaction remained statistically significant if age was removed from the model ($\beta = -.32$, $p = .008$). Second, when we analyzed separately the two items comprising the *number of subordinates* measure (total subordinates and direct reports, i.e., the number of people the executive directly supervises), the Testosterone × Cortisol interaction was statistically significant for both ($\beta = -.33$, $p = .007$, for total subordinates; $\beta = -.28$, $p = .03$, for direct reports).[5] Third, because status-concerned executives may have been tempted to inflate their number of subordinates, we sought a way to assess attained status that was less vulnerable to intentional inflation. For this purpose, we created a derived, binary variable reflecting whether or not the executive had indirect reports, that is, employees within his line of management who did not report directly to him but instead reported to one of his subordinates. An

[3] We also tested whether one's ratio of testosterone to cortisol was associated with the number of subordinates. Although this measure was predictive of certain outcomes in prior research (e.g., Terburg, Morgan, & van Honk, 2009), it was unrelated to number of subordinates, $t < 1$.

[4] We ran our primary regression model separately for the two most common sectors: government ($n = 38$) and defense (military, defense, and law enforcement; $n = 21$). The Testosterone × Cortisol interaction was statistically significant for both, helping to rule out sector as a potential third variable.

[5] Recognizing that an executive's number of subordinates may fluctuate over a career, and that such fluctuation is not necessarily an indicator of attainment, we also analyzed the number of subordinates participants had at their career peak. Specifically, participants were asked, "Across your career, what is the maximum number of people that you, yourself, have managed?" and "Across your career, what is the maximum number of people that have been subordinate to you within your line of management (i.e., direct and indirect reports)?" Looking at these peak levels instead of current level, the Testosterone × Cortisol interaction remained statistically significant.

Table 1
Correlations Among Study Variables

	Testosterone	Cortisol	Number of subordinates	Age	Education	Family income	Awakening time
Testosterone	93.26 (32.11)						
Cortisol	.49**	.10 (.05)					
Number of subordinates	.22	.15	182.22 (362.01)				
Age	−.08	.02	.05	48.68 (5.94)			
Education	−.04	−.07	−.16	.07	4.78 (.65)		
Family income	−.13	−.22	.06	.07	.19	5.85 (.64)	
Awakening time	−.13	−.18	−.12	−.28*	.09	−.15	5.96 (.64)

Note. Means (*SD*) are presented on the diagonal. All means are based on raw, untransformed variables. The units of measurement are pg/mL for testosterone, μg/dL for cortisol, and hours since midnight for awakening time. The mean of .10 μg/dL for cortisol is lower than means reported in some previous research (e.g. Mehta & Josephs, 2010; Zilioli & Watson, 2012). This discrepancy may be due to our late afternoon collection time (3:30 p.m.–4:00 p.m.), an interpretation that is consistent with time of day effects reported previously (Saxbe, Repetti, & Nishina, 2008).
* $p < .05$. ** $p < .01$.

executive with indirect reports is high enough up in the organizational hierarchy that his or her subordinates have subordinates. If an executive's answer to the question "How many people are subordinate to you within your line of management (i.e., direct and indirect reports)?" was greater than his answer to the question, "How many people do you, yourself, manage?" this signifies that he had indirect reports. Sixty-five percent of the executives reported a larger number to the former question than to the latter question and were dummy coded as "1" for the purpose of this analysis (all others were coded as "0," indicating that they did not have indirect reports). Knowing whether an executive is high enough up in the organizational structure to have indirect reports reveals something about his status. This variable distinguishes lower-level managers from higher-level managers, but since it is a derived, nonquantitative estimate, it may be less vulnerable to intentional inflation by executives looking to overstate their status. A logistic regression model predicting this outcome (dummy coded: 0 = no, 1 = yes) revealed a marginally significant Testosterone × Cortisol interaction (B = −.56, *SE* = .33, *p* = .08, Odds Ratio (OR) = .56). Although this interaction failed to reach statistical significance, it was in the same direction as the primary analyses. For that reason, we conducted follow-up simple slopes analysis. The pattern was similar to what was observed for the quantitative status variables: For those with high cortisol (1 *SD* above the mean), executives' testosterone levels were unrelated to whether or not they had indirect reports (B = −.01, *SE* = .39, *p* = .99, OR = .99). However, for those with low cortisol (1 *SD* below the mean), testosterone was a significant positive predictor (B = 1.16, *SE* = .54, *p* = .03, OR = 3.20). As the OR of 3.20 indicates, the odds that an executive had indirect reports more than tripled with a 1 *SD* increase in testosterone. Although the interaction was only marginally significant, this pattern is broadly consistent with our hypothesis using a measure of attained status that is cruder but less vulnerable to intentional inflation.[6]

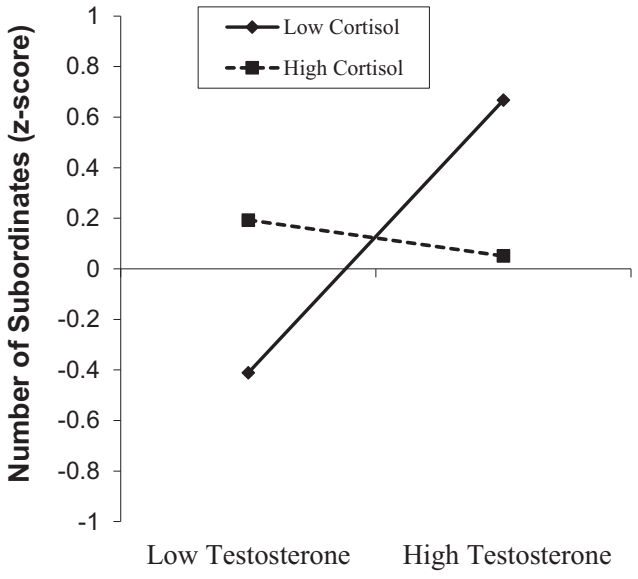

Figure 1. Number of subordinates as a function of testosterone and cortisol. Lines are regression slopes from simple slopes analysis (low = 1 *SD* below the mean, high = 1 *SD* above the mean).

Finally, because our outcome variable was a composite of two skewed count variables, we sought to confirm our primary results using negative binomial regression, which is designed to handle overdispersed count data (Gardner, Mulvey, & Shaw, 1995). We conducted two separate negative binomial regressions, each predicting one of the individual raw count variables (number of total subordinates and number of direct reports). For each model, we predicted the number of subordinates outcome, specifying testosterone, cortisol, and their interaction as predictors. Because the results were similar whether age was included as a covariate or not, age was not included in the models. Whether predicting number of subordinates directly managed (i.e., direct reports) or total number of subordinates, we observed a statistically significant Testosterone × Cortisol interaction (for direct reports, *B* = −.94, *SE* = .13, Wald Chi-Square = 54.00, *p* < .001; for total subordinates, *B* = −1.04, *SE* = .15, Wald chi-square = 49.81, *p* < .001), indicating that the relationship between attained status and testosterone was more positive with lower levels of cortisol. Thus, the

[6] We also repeated the analyses using the leadership level measure used by Sherman et al. (2012). This measure was a composite of three submeasures: number of subordinates, number of direct reports, and self-reported authority. When using this measure, the primary results (significant Testosterone × Cortisol interaction and significant simple slope for low-cortisol individuals) were unchanged.

critical dual hormone pattern was observed whether we tested the model using ordinary least squares regression (on the transformed variables) or negative binomial regression (on the raw, untransformed variables).

Discussion

Many factors determine whether someone is promoted to increasing authority in an organization. In this study, we examined a relatively unexplored factor: hormone levels. As predicted, testosterone was positively associated with attained status—the number of subordinates over which an executive has authority—but only for low-cortisol executives. More specifically, high-testosterone, low-cortisol executives were particularly likely to occupy high-status positions whereas low-testosterone, low-cortisol executives were particularly likely to occupy lower status positions. Notably, these relationships were specific to organizational status: they did not hold when predicting income or education. It has been argued that high testosterone coupled with low cortisol may be a hallmark of powerful individuals (Carney, Cuddy, & Yap, 2010); by looking at the hormone levels of executives in real-world organizational hierarchies, we show this to be true, at least for men.

These findings also support the recent claim that testosterone's link to status and social dominance is conditioned by other factors, especially cortisol (Josephs, Mehta, & Carré, 2011). This causal interpretation, which is consistent with the known inhibitory effect of cortisol on androgen receptors (Chen et al., 1997; Viau, 2002) but not directly addressed by our data, suggests that cortisol may silence status processes. This silencing would presumably occur at both ends of the testosterone spectrum, impeding the status-enhancing effects of high testosterone as well as the status-diminishing effects of low testosterone. The affected psychological processes may include any testosterone-influenced process or behavior that reliably shapes who seeks out, and successfully attains (and retains) high-status roles. Candidate psychological processes include known testosterone-linked processes, such as power motives (Schultheiss et al., 2003), tolerance of risk (Stanton et al., 2011; Sapienza et al., 2009), reduced fear (Hermans et al., 2006), utilitarian decision-making (Carney & Mason, 2010), and aggressive behavior (Ehrenkranz et al., 1974). For example, perhaps low-cortisol, high-testosterone individuals are prone to proactive, bold actions, which depend on some inclination toward risk and aggressiveness. Because these behaviors are a core component of the leader stereotype (Eagly & Karau, 2002), those who display them may seem "leader-like" to others in the organization, thereby facilitating promotion to powerful managerial positions. In contrast, low-cortisol, low-testosterone individuals may be unlikely to display these putative leadership behaviors and may, therefore, struggle to capture the attention of organizational decision-makers seeking to identify future leaders.

Whichever processes prove most important, these findings cast cortisol as an equalizer between high- and low-testosterone individuals. When cortisol is low, low-testosterone individuals are particularly likely to hold lower-ranking positions and high-testosterone individuals to hold higher-ranking positions. However, when cortisol is high, low- and high-testosterone individuals possess similar levels of organizational status. If high cortisol silences testosterone and testosterone-driven processes, it may open up the door for other processes to play a more prominent role in advancement. If dominance and dominance-related factors (such as testosterone) become less important when cortisol is high, other dimensions, such as social competence and leadership abilities (e.g., the ability to effectively manage a team) may exert greater influence. If so, then high-cortisol individuals are not necessarily destined to low (or moderate) levels of organizational status; rather their advancement may simply hinge on traits and behaviors besides testosterone and testosterone-fueled behavior.

If chronically elevated cortisol can silence status processes, then it is important to consider the conditions that chronically elevate cortisol. In addition to trait-like variability in baseline levels (Liening et al., 2010; Sellers et al., 2007), certain contextual factors may trigger episodic shifts. A recent meta-analysis (Miller, Chen, & Zhou, 2007) found that chronic psychological stressors reliably elevate cortisol levels, but only if they are uncontrollable events (i.e., the person experiencing the stressor cannot end it), such as combat, bullying, and abuse. Potentially controllable stressors, such as certain cases of job loss or caregiving experiences, did not reliably increase afternoon/evening cortisol levels or total daily output. Thus, uncontrollable chronic stressors may produce the kind of sustained elevations in cortisol that have the potential to silence status processes. The literature has, by and large, treated stress as a consequence of low status (e.g., Marmot, Shipley, & Rose, 1984). The current findings suggest that stress may also have an additional role as a gatekeeper of the various psychological and physiological processes that determine status. This potential effect of stress is particularly relevant if the mechanism of the observed relationships is the direct inhibitory action of cortisol on testosterone. Nevertheless, even if elevated endogenous cortisol is a distal indicator of some more proximal mechanism (e.g., heightened biological and psychological responses to stress), factors that chronically elevated cortisol may still be influential if they are the initial link in a causal chain that ultimately silences status processes.

In addition to their novel theoretical contributions, the current findings lend support for the external validity of previous laboratory experiments showing that the dual-hormone pattern predicts status-related behaviors (e.g., Mehta & Josephs, 2010). This is important because the question of whether laboratory findings are reproducible and generalizable to externally valid, real-world contexts is central to recent critiques of psychology (Makel, Plucker, & Hegarty, 2012; Mitchell, 2012). Laboratory research takes advantage of the benefits of experimental design but typically relies on contrived and often minor inductions. Although this methodology is often an appropriate and integral first step, laboratory findings can only be validated by careful replication using natural variation on the dimension of interest (e.g., status). The value of these complementary approaches was illustrated by Anderson and Bushman's (1997) meta-analysis, which used real-world measures of aggression to affirm the results of various experimental inductions of aggression. In a similar way, the current findings affirm the external validity of laboratory studies of the dual-hormone hypothesis and status-related behaviors (e.g., Mehta & Josephs, 2010).

Limitations and Future Directions

Although these findings are a promising first step in clarifying the role of hormonal factors in status attainment, conclusive answers must await important follow-up work. Indeed, some of the value of the current research lies in the interesting and important

questions that it raises. For example, the findings raise the possibility that endogenous hormone concentrations may have predictive power: high endogenous testosterone, in conjunction with low cortisol, may predispose individuals to powerful positions that afford social status and may be a reliable way to identify potential leaders *before* they emerge. Previous work showing that undergraduate students with low cortisol and high testosterone were particularly likely to act dominantly in a laboratory task (Mehta & Josephs, 2010, Study 1) suggests that hormone levels may be antecedents of status attainment. Future leaders may have high testosterone and low cortisol before they enter organizations and ascend the organizational ranks. For those with low cortisol, higher levels of circulating testosterone may trigger various status-promoting changes: fear reduction (Hermans et al., 2006), risk seeking (Sapienza et al., 2009), social approach (Montoya et al., 2012), and status strivings (Josephs et al., 2006). Because testosterone and cortisol show stability across time (Dabbs, 1991; Granger et al., 2004; Liening et al., 2010; Sellers et al., 2007), these hormone-linked characteristics may persist and facilitate advancement within hierarchies. Longitudinal studies that track individuals both before and after they enter organizations will be critical in testing these possibilities directly.

Consideration of the present findings alongside those of Sherman et al. (2012), which found that those occupying high-status positions have an elevated sense of control over their lives and lower levels of stress, raises another interesting possibility. If gains in power and status buffer stress, keeping cortisol levels low, then testosterone may be free to drive further status pursuits. In this way, initial status gains may beget further ones, creating an upward spiral of status attainment.[7] The potential for complex interactions suggests that although the current analyses focus on one causal direction (baseline hormone levels causing changes in status, in keeping with past research on the dual-hormone hypothesis), other causal pathways (e.g., status changes causing hormone changes) may be important as well. Further, the possibility that multiple causal pathways act in a complex, potentially reciprocal, pattern suggests exciting avenues for future research, such as prospective, longitudinal studies that track hormone levels, stressors, and sense of control at multiple points before and after individuals enter and advance within social hierarchies.

The executives in our sample came from various kinds of public-sector organizations, including those with a strict meritocracy (i.e., the military) and those with looser guidelines for promotion (i.e., government agencies). We also had representation from organizations both inside and outside the United States. By studying these executives, we captured the phenomenon of interest among individuals with significant real-world influence. Unfortunately, studying executives provides a single snapshot, one that necessarily comes after status attainment. Because we did not collect hormone data prior to our participants' rise in status, we must exercise caution in inferring a causal link between hormones and status attainment. In future research, longitudinal and experimental designs will be particularly useful in testing this possibility.

Our sample was composed of public sector executives and may not be representative of executives in general. Whether the dual-hormone pattern emerges among other types of executives, such as those in the private sector, or among female executives, must await future research. Although evidence for the dual-hormone hypothesis has come primarily from studies of men (Dabbs et al., 1991; Denson et al., 2013; Mehta & Josephs, 2010, Study 2; Pfattheicher et al., 2014; Popma et al., 2007; van den Bos et al., 2013; Zilioli & Watson, 2012), there is evidence supporting the dual-hormone hypothesis in women (Edwards & Casto, 2013; Mehta & Josephs, 2010, Study 1; Tackett et al., 2014).

Conclusion

Despite a recent movement toward restructuring organizations to create "flattened" hierarchies that minimize power asymmetries (Littler & Innes, 2004), there remains no shortage of organizational positions that afford status and power. The present findings, which derive from examining hormonal variations among individuals embedded within actual social hierarchies, reveal that two important biological regulators of social behavior—testosterone and cortisol—may silently work in concert to facilitate the attainment of these powerful roles.

[7] The current findings build on Sherman et al. (2012) in another way: They reveal an additional complexity in the relationship between leadership and cortisol. The significant testosterone-by-cortisol interaction in the current study indicates that the negative cortisol-leadership relationship emerged for a specific subset of participants: men with high levels of testosterone. Regions-of-significance analysis revealed that the relationship between cortisol and number of subordinates became statistically significant (in the negative direction) at a testosterone value of 1.21 *SD*s above the mean. This analysis supports an inverse relationship between cortisol and leadership for a theoretically sensible subsample: high-testosterone men. According to the literature, these are the individuals who should benefit most from gains in power and status (Josephs et al., 2006; Mehta, Wuehrmann, & Josephs, 2009; Zyphur et al., 2009) and thus should experience the greatest reduction in stress.

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