9

Social Endocrinology
Hormones and Social Motivation

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Psychologists have long understood that research on the biological systems of social behavior is critical to our understanding of human social functioning. In his 1967 book titled *The Biological Basis of Personality*, for example, Hans Eysenck reviewed the extant research on personality and physiology and called for continued research on the topic. Despite the importance that Eysenck placed on biology, biological processes were largely ignored by social and personality psychologists in the following several decades. In recent years, however, psychologists have begun to examine links between biology, personality, and social behavior. As a result, new discoveries about personality and social processes are emerging that could not have emerged with traditional social psychology methods alone. Along with advances in molecular genetics, social neuroscience, and behavioral endocrinology, the potential contributions of biological research to social psychology are greater than they've ever been.

Social endocrinology is an emerging interdisciplinary field that bridges behavioral endocrinology (the study of the interaction between hormones and behavior) with social and personality psychology. Over a century of animal research has shown that variation in hormone levels influences a variety of social behaviors. For example, testosterone increases aggression and dominance behavior in many species (Giammanco, Tabacchi, Giammanco, Di Majo, & La Guardia, 2005). Testosterone levels also rise during periods of high competition such as the mating season (Wingfield, Hegner, Dufty, & Ball, 1990), and these testosterone rises promote further dominance (Trainor, Bird, & Marler, 2004). Other animal studies show that oxytocin and progesterone promote affiliative behavior, such as parental care, social bonding, and monogamy (Bartz & Hollander, 2006). It has also been well established that glucocorticoids increase during periods of physical and

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psychological stress, which prepares the animal to deal with the stressor (Tsigos & Chrousos, 2002).

Although animal studies have contributed greatly to the field of behavioral endocrinology, only recently have researchers begun to examine the relationships between hormones and social behavior in humans. The past five years in particular have shown incredible growth in social endocrinology research, as more social-personality psychologists incorporate endogenous hormone measurement or exogenous hormone administration into their experiments. This new wave of research in social endocrinology has yielded unique insights into a broad array of social psychological processes, including the neuroendocrine systems that regulate social motivation and the effects of hormone–environment interactions on social behavior.

This chapter provides an overview of recent social endocrinology research on the role of hormones in human social motivation. We focus on findings from our laboratory on naturally occurring testosterone and cortisol, but we touch on research from other labs as well, including studies of oxytocin and progesterone. We start by discussing research on testosterone and status-seeking motivation. Next, we highlight recent findings on the roles of oxytocin, progesterone, and testosterone in affiliation and cooperation motivation. Third, we review studies on cortisol and social approach/inhibition. Finally, we discuss recent findings on hormone–hormone interactions and social behavior.

TESTOSTERONE AND STATUS-SEEKING MOTIVATION

Testosterone (T) is a steroid hormone derived from cholesterol. It is produced and released primarily by the testes in men and by the ovaries and adrenal cortex in women. T belongs to a class of hormones called androgens, which are those hormones that are responsible for the development and maintenance of masculine characteristics. In addition to supporting basic physical development, T is also critically involved in regulating social behavior. For example, a large amount of animal literature indicates that T levels are associated with dominance—behavior intended to gain or maintain high status (Mazur & Booth, 1998). Both naturally occurring and experimentally elevated levels of T are positively associated with social rank and dominant behaviors in a variety of species (lemurs, Cavigelli & Pereira, 2000; squirrel monkeys, Coe, Mendoza, & Levine, 1979; sifakas, Kraus, Heistermann, & Kappeler, 1999; chimpanzees, Anestis, 2006; Muller & Wrangham, 2004; baboons, Sapolsky, 1991; birds, Collias, Barfield, & Tarvyd, 2002; fish, Oliveira, Almada, & Canario, 1996; lambs, Ruiz-de-la-Torre & Manteca, 1999). This relationship between T and dominance tends to emerge most strongly during periods of social instability. Sapolsky (1991), in his research on wild baboons, for example, demonstrated that T predicted status-related behaviors when the status hierarchy was unstable (after the alpha male was crippled in fighting and social competition broke out). When the hierarchy was stable, however, T and behavior were unrelated. This basic pattern of results has been found in several other species (fish, Oliveira et al., 1996; lambs, Ruiz-de-la-Torre & Manteca, 1999; birds, Wingfield et al., 1990). Taken together, the animal literature suggests that when social status is uncertain, high T levels motivate individuals to seek out higher status.

The association between higher T and dominance has also been extended to humans. For instance, people high in basal T tend to be more aggressive and more socially dominant than individuals low in basal T (Archer, 2006; Archer, Birring, & Wu, 1998; Cashdan, 1995; Grant & France, 2001; Jones & Josephs, 2006; Josephs, Newman, Brown, & Beer, 2003; Josephs, Sellers, Newman, & Mehta, 2006; Mazur & Booth, 1998; Newman, Sellers, & Josephs, 2005; Sellers, Mehl, & Josephs, 2007; Tremblay et al., 1998). T also increases vigilance toward dominance cues such as angry, threatening faces (van Honk et al., 1999; Wirth & Schultheiss, 2007) and decreases vigilance toward submissive cues such as fearful faces (van Honk, Peper, & Schutter, 2005). These effects of T on attention seem to be strongest when dominance–submission cues are presented outside conscious awareness (e.g., van Honk et al., 2005; Wirth & Schultheiss, 2007), suggesting that the relationship between T and dominant behaviors may be mediated, at least in part, by subconscious motivational and attentional processes.

The Basal Testosterone × Status Interaction

The findings reviewed above are consistent with the hypothesis that T levels influence status-seeking motivation. However, to provide more direct tests of this hypothesis, we conducted several studies in which we experimentally manipulated social status (Jones & Josephs, 2006; Josephs et al., 2003, 2006; Mehta, Jones, & Josephs, 2008; Newman et al., 2005). In eight different studies, we measured basal T in saliva before a status manipulation, and we measured various affective, cognitive, physiological, and behavioral outcomes after the manipulation. The designs of these studies and a summary of the results are presented in Table 9.1. Figure 9.1 depicts results from Study 1 of Josephs et al. (2006). In all of the studies, the interaction between basal T and status predicted the outcomes under investigation. For example, Josephs et al. (2006) found that high T individuals paid more attention to status cues, became dysphoric, and performed poorly on complex cognitive tasks after losing status, but paid less attention to status cues, showed no evidence of dysphoria, and performed well on complex cognitive tasks after gaining status. Mehta et al. (2008) further showed that high T individuals rose in cortisol (a physiological marker of psychological stress) after losing status, but dropped in cortisol (a physiological marker of psychological relaxation) after gaining status. Taken together, this literature suggests that high T individuals are driven to rise in status; when they achieve high status, high T individuals experience relaxation (e.g., drop in cortisol, low negative affect) and adaptive functioning (e.g., good cognitive performance), but when they fail to achieve high status, high T individuals experience psychological distress (e.g., negative affect, rise in cortisol) and maladaptive functioning (e.g., poor cognitive performance).

Across these same studies, low T individuals reacted very differently to changes in status. In some of the studies, low T individuals' reactions to high and low status were similar to those in control conditions (Josephs et al., 2003; Newman et al., 2005), suggesting that low T individuals do not have the same strong drive for status that high T individuals have. However, in other studies low T individuals reacted more negatively to high status than to low status. Specifically, low T

TABLE 9.1 Studies Demonstrating a Basal Testosterone × Status Interaction

Study	Status Manipulation	Dependent Variable(s)	Participant Sample	Primary Results
Josephs et al., 2003, Study 1	Negative stereotype prime (stereotype threat)	Math performance	Women	High T women performed poorly after negative stereotype prime.
Josephs et al., 2003, Study 2	Positive stereotype prime (stereotype lift)	Math performance	Men	High T men excelled in performance after positive stereotype prime.
Newman et al., 2005	Leader/ follower	Mental rotation performance Verbal performance Cardiovascular arousal	Men and women	High T participants performed poorly in a low-status position. High T participants dropped in diastolic blood pressure in a high-status position.
Josephs et al., 2006, Study 1	Competitive victory/defeat	Analytical performance Positive and negative affect Implicit attention to status	Men and women	High T participants performed poorly, had higher negative affect, and were more attentive to status cues after losing status. Low T participants showed this pattern after gaining status.
Josephs et al., 2006, Study 2	Skilled versus unskilled opponent	Math performance Cardiovascular arousal	Men and women	High T participants performed poorly and had higher heart rate in a low-status position. Low T participants showed this pattern in a high-status position.
Jones & Josephs, 2006	Competitive victory/defeat	Affiliative behavior Aggressive behavior	Men	High T men were less affiliative and more aggressive after losing status.
Mehta et al., 2008, Study 1	Competitive victory/defeat	Change in cortisol	Men	High T men rose in cortisol after losing status but dropped in cortisol after gaining status.
Mehta et al., 2008, Study 2	Competitive victory/defeat	Change in cortisol Approach-avoidance behavior	Women	High T women rose in cortisol and showed avoidant behavior after losing status. High T women dropped in cortisol and showed approach behavior after gaining status.

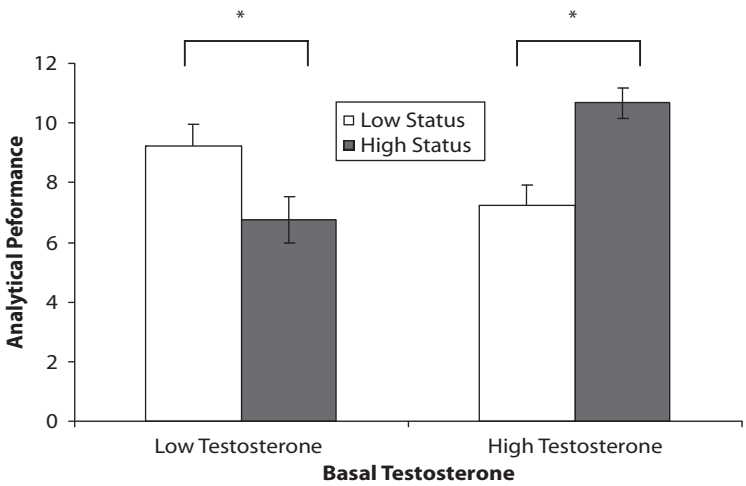

Figure 9.1 Mean Graduate Record Exam (GRE)–Analytical performance (number of items correct out of 20 questions) as a function of basal testosterone and social status. Low testosterone = men and women in bottom third of basal testosterone distribution relative to other individuals of the same sex. High testosterone = top third of basal testosterone distribution relative to other individuals of the same sex. Error bars represent 1 standard error. *$p < .01$. (Adapted from Josephs, R. A., Sellers, J. G., Newman, M. L., & Mehta, P. H., The mismatch effect: When testosterone and status are at odds. *Journal of Personality and Social Psychology*, *90*(6), 2006, Study 1.)

participants were hypervigilant to status cues, showed elevated cardiovascular arousal, and performed poorly on complex cognitive tasks in a high-status position but not in a low-status position (Josephs et al., 2006; see Figure 9.1). These latter findings suggest that low T individuals might actually prefer low status and actively avoid high status. As Josephs and colleagues (2006) argued, low T individuals "might shun high status positions … because they lack a strong power motive … they lack a dominating, aggressive personality … and they may not believe they have what it takes physically to maintain such positions" (p. 1001). Thus, when low T individuals are thrust into a high-status position, they may experience arousal and maladaptive functioning out of a desire to return to a more comfortable and safer position of low status.

There were no sex differences in the predictive power of basal T on reactions to changes in status. Men and women high in T relative to other individuals of the same sex reacted negatively to a drop in status (Josephs et al., 2003, 2006; Mehta et al., 2008; Newman et al., 2005). Men and women low in T relative to other individuals of the same sex showed neutral (Josephs et al., 2003; Mehta et al., 2008; Newman et al., 2005) or negative reactions (Josephs et al., 2006) to a rise in status. These findings suggest that basal T is a biological marker of chronic status-seeking motivation in both men and women.

Testosterone Fluctuations and Status-Seeking Motivation

The studies reported above examined basal T as a stable trait and implied that T levels directly influence social motivation and behavior. However, not only does T influence behavior, but behavior and the social environment also influence T levels. Specifically, it seems that T levels fluctuate around basal levels in status-relevant social settings. According to the reciprocal model of T and status (Mazur & Booth, 1998), T levels should decrease when status drops but increase when status rises. These changes in T levels are expected to produce a reciprocal effect by influencing subsequent status-seeking behaviors. Specifically, there has been speculation that T increases may encourage further attempts at gaining status, whereas T decreases may lead individuals to flee the situation to avoid any further loss of status.

Empirical support for this reciprocal model comes from research in real-world sports competitions and rigged laboratory competitions. Several studies have shown that winners increase in T relative to losers for a few hours following a competition (Elias, 1981; Gladue, Boechler, & McCaul, 1989; Mazur, Booth, & Dabbs, 1992; Mazur & Lamb, 1980; McCaul, Gladue, & Joppa, 1992). However, other studies have not found this overall win–lose effect (Gonzalez-Bono, Salvador, Serrano, & Ricarte, 1999; Mazur, Susman, & Edelbrock, 1997; Schultheiss et al., 2005) but instead shown that T changes after changes in status depend on psychological factors, such as personality. For example, Schultheiss et al. (2005) found that individual differences in implicit power motive moderated the effects of victory and defeat on T changes. Specifically, high-power individuals rose in T after victory, but these same individuals dropped in T after defeat. Low-power individuals showed the opposite pattern of T changes. Jones and Josephs (2006) showed that basal T was also a moderator of the effects of victory and defeat on changes in T. High T individuals also rose in T after victory and dropped in T after defeat. Low T individuals showed the opposite pattern. Presumably, people high in power motive or high in basal T are chronically motivated to gain status. Thus, when their status drops, these individuals react strongly by dropping in T. However, when their status rises, they react strongly by rising in T.

Although this literature has uncovered several important variables that predict T changes after changes in status, researchers have simply assumed that status-induced changes in T influence subsequent status-seeking behaviors. We conducted the first study in humans that examined the relationship between postcompetition fluctuations in T and subsequent social behavior (Mehta & Josephs, 2006). We experimentally manipulated status with a rigged competition and collected saliva samples before and after the competition to measure changes in T (Mehta & Josephs, 2006). After participants provided the second saliva sample, they chose whether they wanted to (a) rechallenge their opponent to a second competition or (b) complete an alternative noncompetitive task. The results showed that changes in T after losing predicted who wanted to compete again in a second competition. Losers who rose in T were more likely to choose to rechallenge their opponent (73%) than losers who dropped in T (22%). These findings are consistent with the reciprocal model and suggest that a rise in T after a drop in status motivates

further attempts at gaining status, whereas a drop in T after a drop in status motivates individuals to avoid any further loss of status.

Taken together, research on T and status suggests that basal T taps into a person's chronic status-seeking motivation, analogous to a personality trait, whereas short-term changes in T tap into a person's status-seeking motivation, analogous to mood (cf. Mehta et al., 2008).

THE SOCIAL ENDOCRINOLOGY OF AFFILIATION AND COOPERATION MOTIVATION

Research on the social endocrinology of affiliation and cooperation motivation in humans has concentrated on the roles of oxytocin and, to a lesser extent, progesterone. However, recent research implicates testosterone in social cooperation as well. In this section, we review some recent findings from these literatures.

Oxytocin and Affiliation/Cooperation Motivation

Oxytocin is a peptide hormone that is released in the brain and acts like a neurotransmitter. Oxytocin has been studied extensively across mammalian species and is critically involved in the regulation of maternal behavior and social bonding (Campbell, 2008). The animal and human literatures on oxytocin and social motivation are discussed in depth in a recent review article (Campbell, 2008). Here we highlight some recent human studies from this extensive literature.

Human studies show that oxytocin regulates affiliation and social bonding in males and females. For example, Kosfeld, Heinrichs, Zak, Fischbacher, and Fehr (2005) found that intranasal administration of oxytocin in men increased trust behavior in an economic investment game. A recent comprehensive study of pregnant mothers showed that plasma levels of oxytocin in mothers during pregnancy and in the postpartum period were positively associated thoughts, feelings, and behaviors related to mother–infant bonding (Feldman, Weller, Zagoory-Sharon, & Levine, 2007). These findings suggest that oxytocin increases affiliation motivation, which may promote maternal care during and immediately after pregnancy. Another study showed that oxytocin interacts with social support to influence affective and neuroendocrine responses to social stress (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). In this study, male participants were randomly given social support (the presence of a best friend) or no support and were administrated either intranasal oxytocin or a placebo. All participants were exposed to a standardized laboratory psychosocial stressor (Trier Social Stress Test), and neuroendocrine and affective responses to the stressor were measured (Heinrichs et al., 2003). The social support and oxytocin manipulations showed an interactive effect such that a combination of social support and oxytocin treatment resulted in a blunted stress response. These findings suggest that the effect of social support on the stress response depends on oxytocin (Heinrichs et al., 2003). The results of this study are generally consistent with the "tend-and-befriend" theory, which

suggests that stress promotes affiliation and social contact, particularly in women, via regulation of peptide hormones such as oxytocin (Taylor, 2006).

One mechanism by which oxytocin may promote affiliation and social cooperation is through an increased ability to recognize emotions and infer mental states in others. Consistent with this idea, Domes and colleagues (Domes, Heinrichs, Michel et al., 2007) demonstrated that oxytocin administration increased emotion recognition ability as indicated by better performance on the Reading the Mind in the Eyes Test. This test was designed to measure people's ability to infer mental states from the eye region, an area of the face important for emotional detection and social communication. Another study showed that oxytocin administration increased attention to the eye region in neutral faces (Guastella, Mitchell, & Dadds, 2008), suggesting that the positive effect of oxytocin on emotion recognition may be mediated by increased attention to the eyes.

Another mechanism by which oxytocin may promote affiliation is by making positive social cues more memorable. A recent study provided support for this hypothesis by showing that oxytocin administration improved memory for happy faces but not for angry or neutral faces (Guastella, Mitchell, & Mathews, 2008).

Other research shows that oxytocin influences neural reactivity to emotional stimuli, regardless of the valence of the stimuli. Specifically, oxytocin administration reduced amygdala reactivity to happy, angry, and fearful faces (Domes, Heinrichs, Gläscher, et al., 2007). On the basis of these findings, the authors speculated that oxytocin may reduce uncertainty about the predictive value of positive and negative social stimuli, leading to social approach and affiliation behavior.

Progesterone and Affiliation Motivation

Progesterone is a steroid hormone released primarily by the ovaries in women and by the adrenal glands in men. It plays an important role in the female menstrual cycle and pregnancy. Animal research suggests that progesterone levels during female pregnancy are involved in the regulation of maternal behavior (e.g., Pryce, Dobeli, & Martin, 1993; Rosenblatt, 2002). Some recent studies have shown that progesterone levels are also associated with affiliation motivation in humans. Schultheiss, Dargel, and Rohde (2003) demonstrated that progesterone levels were positively associated with implicit affiliation motivation in normally cycling women but not in women taking oral contraceptives.

Additional experimental studies showed that arousing affiliation motivation through movie clips led to changes in progesterone levels (Schultheiss, Wirth, & Stanton, 2004; Wirth & Schultheiss, 2006). In one study, male and female participants were shown a 30-minute clip from the film *Bridges of Madison County* depicting scenes of affiliation and intimacy. Progesterone increased from before to after the film clip. In a second study, participants were shown a 30-minute clip from the film *A.I.* depicting scenes with social rejection and maternal separation themes. Progesterone and cortisol levels increased from before to after the film clip in men and women. On the basis of these latter findings, the authors speculated that increased progesterone during social stress may facilitate social bonding with other conspecifics. This interpretation is consistent with the tend-and-befriend

theory (Taylor, 2006), which posits that oxytocin release during social stress promotes social contact, especially in women.

Testosterone and Affiliation/Cooperation Motivation

Animal evidence suggests that T suppresses affiliation and social bonding (Wingfield et al., 1990). A growing human literature also demonstrates that T is negatively associated with affiliation. Across several studies, it has been shown that social bonding is inversely related to T levels. For example, correlational studies show that married men have lower T levels than unmarried men (e.g., Gray et al., 2004), and unmarried men in committed romantic relationships have lower T levels than single men (Burnham et al., 2003). McIntyre and colleagues (2006) further showed that the association between relationship status and T levels is moderated by extrapair sexual interest; extrapair sexual interest was positively associated with T in paired men but not in single men. Additional studies show that T levels are lower in men who have recently become fathers (e.g., Berg & Wynne-Edwards, 2001). In a longitudinal study, Mazur and Michalek (1998) found that men who were divorced dropped in T if they remarried, suggesting that social bonding leads to T suppression. Other studies have extended the relationship between social bonding and T to women, showing that partnered women have lower T levels than single women (van Anders & Watson, 2007) and that polygamous women have higher T levels than single and partnered women (van Anders, Hamilton, & Watson, 2007). Overall, then, these data support the hypothesis that social bonding causes T levels to drop, which in turn leads to further bonding and social cooperation. Alternatively, perhaps individuals low in basal T are more likely to enter and remain in committed, romantic relationships than individuals high in basal T. Additional longitudinal studies are needed to test between these two hypotheses.

We recently conducted a study to examine the relationship between basal T and cooperation motivation (Mehta, Wuehrmann, & Josephs, 2009). In this study, same-sex participants reported to the lab and provided a saliva sample, which was later analyzed for basal T levels. Participants were then brought into the same room and told that the study was investigating analytic reasoning and that they would be completing a test of analytic reasoning. After that, participants were randomly assigned to a competitive or cooperative social environment. In the competition condition, participants were told, "As an incentive, we've decided to take the higher scoring person of the two of you and enter you into a drawing for a prize: $25 cash. So if you do better (score higher) than the other person does, you'll be entered into the drawing." But in the cooperation condition, participants were told, "As an incentive, we've decided to add your scores together, and if you score higher than the next group that comes in, you'll both be entered into a drawing for $25 cash for each of you." Participants then completed 15 questions from the former Graduate Record Exam (GRE)–Analytical subsection. The questions selected were of medium difficulty. Participants worked independently on the problems and were not able to communicate with each other. The participants had 20 minutes to complete as many of the questions as possible.

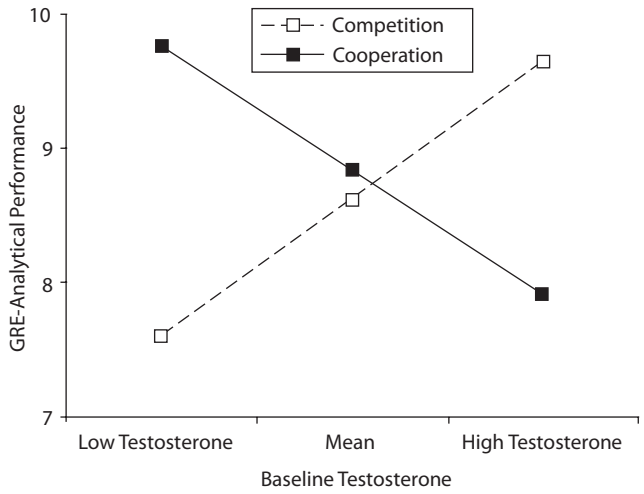

Figure 9.2 Graduate Record Exam (GRE)–Analytical performance (number of items correct out of 15) as a function of competition/cooperation condition and testosterone level (log transformed and standardized within sex). Low testosterone = 1 standard deviation below mean, high testosterone = 1 standard deviation above mean. Standardized betas: competition, $\beta = .37$; $p < .05$; cooperation, $\beta = -.48$, $p < .01$. (Adapted from Mehta, P. H., Wuehrmann, E. V., & Josephs, R. A., "When Are Low Testosterone Levels Advantageous? The Moderating Role of Individual Versus Intergroup Competition." *Hormones and Behavior*, vol. 56, pp. 158–162. Published 2009 by Elsevier. Adapted with permission.)

Results from this study are shown in Figure 9.2. Basal T moderated the effect of the social environment on performance. Specifically, basal T was positively related to performance in the competitive environment, but basal T was negatively related to performance in the cooperative environment. The positive relationship between basal T and performance in competition is consistent with previous research on basal T and status-seeking motivation. Presumably, high T individuals performed well when competing out of a strong desire to gain high status, but low T individuals performed poorly when competing out of a desire to avoid high status. This interpretation is consistent with past research demonstrating the differential effects of high and low status on high and low T individuals (Josephs et al., 2003, 2006; Mehta et al., 2008; Newman et al., 2005).

The results from the cooperation condition suggest that basal T is negatively associated with cooperation motivation. Presumably, low T individuals performed well in a cooperation setting because these individuals were motivated to affiliate and bond with others. In contrast, high T individuals may have performed poorly in the cooperation condition because T may suppress cooperation motivation. This interpretation is consistent with animal research linking high T to suppressed social bonding and high levels of social competition (Wingfield et al., 1990). The results of this study, combined with previous research linking lower T to social bonding, suggest that T, in addition to regulating status-seeking motivation, also plays an important role in influencing affiliation/cooperation motivation.

Studies in which T levels are exogenously administrated provide additional evidence that T suppresses affiliation motivation. For example, one study showed that sublingual T administration in women impaired performance on an emotion recognition task (van Honk, 2008). Because inferring mental states and emotions in others is important for facilitating social bonding, an impaired ability to recognize emotions in others suggests that T may suppress the motivation to affiliate with others. An additional study showed that T administration led to lower rates of cooperation than placebo treatment in a cooperative social setting. The T administration group did not show behavioral differences from placebo administration in a competitive social setting (van Honk, 2008). Together, these studies implicate a causal role of T in suppressing affiliation/cooperation motivation.

Cortisol and Social Approach/Inhibition

Glucocorticoids are a class of hormones that are released by the adrenal glands during physical and psychological stress. The primary glucocorticoid in humans is cortisol. Most research on cortisol has focused on the dispositional and situational variables that cause acute changes in cortisol (e.g., Dickerson & Kemeny, 2004), but some research implicates cortisol in social approach/inhibition motivation. For example, animal studies show that elevated glucocorticoids during stress are associated with freezing behaviors (rats, Nunez, Ferre, Escorihuela, Tobena, & Fernandez-Teruel, 1996; primates, Kalin, Shelton, Rickman, & Davidson, 1998), a response style that is thought to be an extreme form of behavioral inhibition. Additional studies in humans demonstrate that elevated cortisol is associated with social avoidance and inhibition, including anxiety and defensiveness (Brown et al., 1996) and social inhibition and internalizing behaviors (Kagan, Reznick, & Snidman, 1987; Smider et al., 2002). Conversely, low basal cortisol has linked to social approach and aggression (Shoal, Giancola, & Kirillova, 2003; Virgin & Sapolsky, 1997). In one longitudinal study of 314 boys, low basal cortisol levels during preadolescence (age 10 to 12 years) predicted low harm avoidance, low self-control, and more aggressive behaviors 5 years later (Shoal et al., 2003). Further analyses suggested that low self-control mediated the relationship between low cortisol and aggression. Other studies show that basal cortisol is negatively correlated with extraversion (Mehta, 2007) and memory for happy faces (van Honk et al., 2003). Overall, the research suggests that high cortisol is associated with social inhibition and avoidance, whereas low cortisol is associated with social approach.

HORMONE–HORMONE INTERACTIONS AND SOCIAL BEHAVIOR

Social endocrinology research typically examines independent effects of hormones on behavior. In most of the studies reported above, a single hormone was manipulated or measured and its effects on behavior were observed. This approach has certainly been useful in identifying several important relationships between hormones and social behavior. At the same time, many studies using this approach

have failed to demonstrate consistent hormone-behavior associations. For example, findings linking testosterone to aggression in humans are mixed, with many studies showing null effects (Archer et al., 1998). One explanation for such inconsistencies is that hormones may not independently channel social behavior as has been previously assumed. Instead, multiple hormones may work together to channel social behavior.

The possibility that hormone–hormone interactions may drive behavior is supported by studies demonstrating powerful interactions between androgens and glucocorticoids on neuroendocrine and neural responses to threat (Hermans, Ramsey, & van Honk, 2008; Viau, 2002). These findings suggest that androgens and glucocorticoids may also interact to influence social behavior. Consistent with this idea, two studies found that the interaction between testosterone and cortisol was associated with aggression. In one study of male delinquent adolescents (age 12 to 14 years), testosterone was positively related to overt aggression among individuals low in basal cortisol, but testosterone and overt aggression were unrelated among individuals high in basal cortisol (Popma et al., 2007). This study conceptually replicated a previous study of 17- to 18-year-old male offenders (Dabbs, Jurkovic, & Frady, 1991), which also found that high testosterone coupled with low cortisol was predictive of aggressive behaviors. These findings suggest that neuroendocrine systems associated with status-seeking motivation (testosterone) and social approach avoidance (cortisol) interact to influence the expression of aggressive behavior.

In a recent study, we tested the hypothesis that testosterone and cortisol would jointly channel fight-or-flight behavioral responses to social threat in males (Mehta & Josephs, 2010). We studied 64 men who participated in a one-on-one dominance contest in which social defeat and victory were experimentally manipulated. Before the competition, basal testosterone and basal cortisol were measured in saliva. After the competition, the men decided whether to rechallenge their opponent to a second competition (*fight*) or avoid a second competition (*flight*). Neither testosterone nor cortisol alone predicted the behavioral response to social defeat, but the testosterone–cortisol interaction did (see Figure 9.3). High testosterone + low cortisol men chose to fight (rechallenge their opponent) after defeat, whereas high testosterone + high cortisol men chose to flee (avoid a second competition). Testosterone and cortisol were unrelated to fight-or-flight behavior after victory. These findings suggest that when social status is threatened, cortisol modulates the behavioral expression of status-seeking motivation. When cortisol is low, status-seeking motivation—as indicated by high testosterone—is expressed in the form of behavioral approach, or a *fight* response. However, when cortisol is high, status-seeking motivation is expressed in the form of behavioral avoidance, or a *flight* response. This interpretation is consistent with previous research demonstrating that testosterone regulates the drive for status, whereas cortisol regulates social approach avoidance.

In another study, we examined whether the interaction between testosterone and cortisol would predict leadership behavior (Mehta & Josephs, 2010). Same-sex pairs reported to the lab and provided a saliva sample, which was analyzed for basal T and cortisol levels. Participants were randomly assigned to the

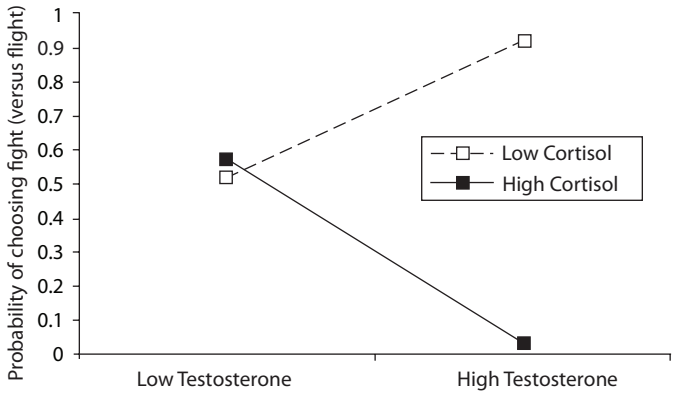

Figure 9.3 Fight-or-flight behavior following social defeat as a function of testosterone and cortisol levels. Low and high values indicate 1 standard deviation above and below the means, respectively, on the testosterone and cortisol distributions. (Adapted from Mehta, P. H., & Josephs, R. A., *Dual-Hormone Regulation of Dominance Behavior*, manuscript submitted for publication, 2010.)

role of leader or follower. Each leader–follower dyad completed a cognitive task together. Then, the participants switched leader–follower roles and completed another version of the cognitive task. The leader–follower interactions were videotaped. Seven judges later watched the videotapes and rated the leaders on 19 different social behaviors (e.g., engaged, gave clear instructions, directive, leader-like, confident, nervous, uncomfortable). All 19 behaviors loaded on to a single factor, and thus, an overall leadership score was created for each participant. There were no main effects of basal T or basal cortisol on leadership, but there was a statistically significant T × Cortisol interaction (Mehta, 2007). Figure 9.4 depicts the pattern of the interaction. Consistent with the results of the studies reported above (e.g., Mehta & Josephs, 2010), high T + low cortisol individuals showed higher leadership scores than did high T + high cortisol individuals. These findings suggest that a pattern of high status-seeking motivation (high T) and social approach (low cortisol) leads to good leadership, whereas a pattern of high status-seeking motivation (high T) and social inhibition (high cortisol) leads to poorer leadership.

Although these findings clearly demonstrate interactions between testosterone and cortisol on aggression, fight-or-flight behavior, and leadership, additional research that incorporates affective, cognitive measures and other physiological measures (e.g., neural activity, hormone fluctuations) into social endocrinology studies will help clarify the mechanisms that underlie these interactions. Preliminary evidence suggests that high testosterone + high cortisol individuals respond to social stress with a short-term drop in testosterone (a marker of social submission) and an increase in negative affect compared to high testosterone + low cortisol individuals. Thus, it seems that high testosterone + high cortisol individuals may experience a social stressor as a threat, whereas high testosterone + low cortisol

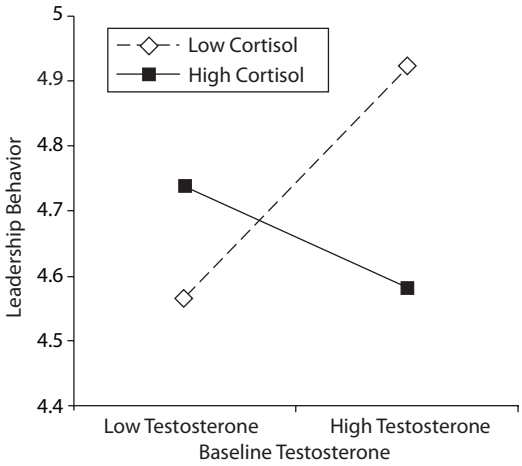

Figure 9.4 Leadership behavior as a function of basal testosterone and basal cortisol. Low testosterone = 1 standard deviation below mean on basal testosterone distribution standardized within sex, high testosterone = 1 standard deviation above mean of basal testosterone distribution standardized within sex, low cortisol = 1 standard deviation below mean, high cortisol = 1 standard deviation above mean. (Adapted from Mehta, P. H., *"Dual-Hormone Regulation of Dominance Behavior,"* manuscript submitted for publication.)

individuals may experience the same stressor as a challenge. These findings are preliminary, and more evidence is needed to support this line of reasoning.

CONCLUSIONS

Despite several decades in which the study of biology was largely ignored by social and personality psychology, biological research in the study of personality and social behavior is now on the comeback. Social endocrinology research in particular has grown tremendously in recent years, as researchers capitalize on its advantages for addressing questions in social psychology that are difficult or impossible to address with traditional self-report and behavioral methods alone. This chapter highlights the contribution of social endocrinology to research on social motivation. However, we anticipate that in the coming years, social endocrinology will make substantial contributions to many areas of social psychology, ranging from the study of emotion, social perception, and stereotyping/prejudice to culture, political psychology, and judgment and decision making.

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