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Going on Stage: Testosterone in Greetings and Meetings

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This research explored the relation of endogenous testosterone levels to behavior in brief social encounters. In four studies, 358 college students whose testosterone levels were known entered a room and (1) stood and spoke to a video camera, (2) stood and talked with an experimenter, (3) sat and talked with an interviewer, or (4) sat and talked with a peer. High-testosterone students entered more quickly, focused more directly on their targets, and displayed a more forward and independent manner. Results were similar for men and women. Correlates of testosterone are visible in thin slices of everyday behavior lasting only a few seconds. The effect of this behavior on a social interaction partner remains to be determined. © 2001 Academic Press

Key Words: testosterone; nonverbal behavior; self-presentation; dominance.

The present article deals with testosterone in day-to-day social life. Most prior research has examined testosterone in the long sweep of behavior, such as in its relation to marriage and divorce (Booth & Dabbs, 1993); occupation (Dabbs, 1992); or aggression, delinquency, and criminal violence (Archer, Birring, & Wu, 1998; Banks & Dabbs, 1996; Dabbs, Carr, Frady, & Riad,

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1995). Prior research has also dealt with competition, finding that testosterone levels are high before an important contest and that they increase in the winner and decrease in the loser following the contest (Bernhardt, Dabbs, Fielden, & Lutter, 1998; Booth, Shelley, Mazur, Tharp, & Kittok, 1989). One general theme that emerges from prior research is that testosterone is associated with dominance in face-to-face encounters (cf. Mazur, 1985). Another theme is that testosterone is associated with persistence and focused attention (Andrew, 1978). Attempts to uncover more links between this biological characteristic and meaningful behavior trends seem warranted.

Any effects of testosterone on short-term social interaction are likely mediated by relatively simple changes in thought and behavior, perhaps even in a person's own nonverbal expressive style (cf. DePaulo, 1992). Prior research suggests testosterone increases energy, focus of attention, and a task (vs social) orientation. Testosterone injections increase activity levels (McAdoo, Doering, Dessert, Brodie, & Hamburg, 1978), and high-testosterone individuals are more restless and oriented toward action than low-testosterone individuals (Dabbs, Strong, & Milun, 1997). Testosterone injections have been found to decrease fearfulness in animals (Boissy & Bouissou, 1994). High-testosterone men and women smile less than low-testosterone men and women (Cashdan, 1995; Dabbs, 1997), suggesting they are either less happy or less concerned with being friendly. Such simple affects and actions are plausible pathways whereby testosterone might contribute to interpersonal dominance.

Individual differences in testosterone, if reflected in expressive behavior, may set the social and emotional tone when individuals meet and form impressions of each other. Expressive behavior of the type likely related to testosterone has been shown to be extremely predictive of other professional and interpersonal outcomes (Ambady & Rosenthal, 1992). Ambady and Rosenthal (1993) found that 30 s of a teacher's expressive behavior while lecturing predicted half the variance in student ratings at the end of a course. Individual differences in expressive style can color the first impression formed within social and professional introductions, which may then drive final social attributions and professional evaluations (Prickett, Bernieri, & Gada, 2000). For example, naïve observer judgments of a job applicant's intelligence, politeness, competence, and hireability that were based on a 20-s video clip of the target meeting and being greeted by the interviewer significantly predicted trained interviewers' final evaluations of that interviewee following their 20-min structured interview (Prickett, Gada-Jain, & Bernieri, 2000).

More recently, Ambady, Hallahan, and Conner (1999) found that naïve observers could assess the sexual orientation of targets at a level above chance from a few seconds of silent videotape. They concluded that the information was conveyed through gross gestural information by replicating the

accuracy finding when the video stimulus was transformed into a white outlined figure against a black background via a special-effects generator. Accuracy of perception was not found with still photographs, which suggests this interpersonal information was encoded in the targets' *movement* style and not in their appearance (Ambady et al., 1999). Insofar as testosterone influences interpersonal orientation and expressive behavior, it may affect the manner and outcome of any face-to-face interaction.

In the studies described below, we sought to determine the correlates of testosterone in everyday behavior that might contribute to interpersonal dominance. We observed subjects as they walked alone into a room and performed a social task. The episodes were brief, but they had elements in common with many everyday social encounters. They involved behavior that is important in the early stage of meetings, when the parties know little about each other. Understanding the role of testosterone at such moments may help us understand its role across the longer span of a person's life.

The Nature of Judgment Studies

Judgment studies may employ a variety of metrics, from physical units of measurement (e.g., the movement of the corner of someone's mouth measured in millimeters) to psychological units of measurement. For example, observer judgments of happiness may be given on a 5-point scale that ranges from *not at all happy* to *very happy* (Rosenthal, 1982). Judgments based on physical units are often more reliable than judgments based on psychological units of measurement, but in some instances the validity of the latter approach may be higher (Ambady, Bernieri, & Richeson, 2000; Rosenthal, 1966). This may be because of a combination of the molecular-level cues having a lower degree of inherent social meaning (Rosenthal, 1982) while at the same time being multiply determined by a potentially large number of idiosyncratic situational and environmental factors. Ambady et al. (2000) have reviewed an extensive literature on the measurement of molar constructs from thin slices of the behavioral stream, concluding that the predictive validity from this methodology is much higher than some might have anticipated.

As mentioned above, two general psychological constructs can be derived from the literature as being associated with chronic levels of testosterone: interpersonal dominance and a focus of attention or perseverance (e.g., lack of distractability). The main objective of this series of studies was to determine whether these constructs, as manifested in targets' self-presentational behavior, could be related to their testosterone levels, assessed in saliva samples. The behavioral metrics employed ranged from the molecular to the molar and were selected on the basis of (a) their relevance to one of the two psychological constructs involved and (b) the unique environmental and physical constraints within the observed contexts. It is important to keep in mind that the purpose of this study is not to demonstrate that individuals

high in testosterone exhibit a specific nonverbal gesture across all contexts—or even within a specific context. We did not believe that any specific concordance between a specific molecular behavior (e.g., head turn to the left) and testosterone level would necessarily replicate across the population of interpersonal contexts and environments. Instead, our objective was to learn whether testosterone is associated with behaviors that in the precise contexts we observed reflected the psychological constructs of dominance and focus that have been associated with this male hormone.

GENERAL METHOD

We measured subjects' testosterone levels and observed their behavior in four studies. Subjects were 122 male and 236 female undergraduate students participating as part of a course requirement. They reported to a social psychology laboratory, where they learned about the procedure and signed consent forms. We then videotaped them walking into a room and speaking to a camera, meeting an experimenter, being interviewed, or talking with a peer.

We measured testosterone from a single saliva sample from each subject. Salivary and serum testosterone levels correlate about $r = .85$ (Campbell, Udry, & Halpern, 1992), and a single serum measurement correlates about $r = .85$ with the mean of seven measurements taken over the course of a year (Vermeulen & Verdonck, 1992). All samples were collected midmorning to control for diurnal variations in testosterone. Each subject chewed a stick of sugarfree gum and deposited 3 ml of saliva into a 20-m polyethylene vial. We stored the samples frozen and assayed them in duplicate using a radioimmunoassay with ether extraction,^{125}I-labeled testosterone tracer, and charcoal separation (Dabbs, 1990, 1991). The mean coefficient of variation (CV) between assay duplicates was less than 10%. We included control samples from high- and low-testosterone saliva pools in each assay, and we adjusted for variation between assays by multiplying each subject's testosterone score by the ratio of the mean value of the control samples across all assays to the value of the control samples in the subject's assay. Mean testosterone scores across the four studies were 1.78 ng/dl ($SD = 0.62$) for women and 9.92 ng/dl (*SD* 3.06) for men. We standardized scores within each sex to remove the sex difference in testosterone, and we dropped three scores that were more than 3 SD above the standardized mean.

STUDY 1: MEETING A CAMERA

In Study 1, we examined a rudimentary social setting. Ninety-nine subjects entered a room one at a time and described themselves to a video camera. We asked them to spend about 45 s before the camera. We filmed them entering the room, approaching the camera, and speaking. The task called upon subjects' characteristic manner of self-presentation, but it was not affected by the presence of a real social partner.

Procedure

Subjects were 40 male and 59 female undergraduate students. After signing a consent form and providing a saliva sample, each subject entered an adjacent room, walked about 15 ft across the room to stand in front of a video camera, spoke a few words of self-description, and left. The camera recorded a full view of the subjects entering the room and a view of the face and upper body of the subjects as they spoke.

We attempted to identify and code expressive behaviors that were relevant to the psychological construct of attentional focus or goal directedness. Preliminary inspection of the videotapes revealed variations in the way they approached the camera. The greatest variations involved the extent to which their gaze locked on to the camera upon entering the room and held it there as opposed to visually scanning the room, particularly the location of the exit. Two coders examined the first few seconds of each session, from the point where subjects entered the room to the point where they had come to a stop before the camera. They recorded the number of times a target appeared to intentionally look at something in the room other than the camera. The correlation between coders' scores is reported along with the Spearman–Brown Effective reliability of the measurements (see Rosenthal & Rosnow, 1991, pp. 51–54, for a discussion of effective reliability) after pooling the data across the two coders ($r = .83$, $R = .91$) for subjects' initial visual scan of the room. Coders also rated the degree to which a target walked in a straight path from the door to where the camera was positioned. This was rated on a simple 3-point scale. Reliability here was a bit higher ($r = .93$, $R = .96$). Coders then were asked to assess whether the vocal tone of each target seemed to rise or fall at the conclusion of each utterance. This was a binary ''decision we labeled declarative tone of voice''. The agreement between coders was slightly lower for this variable ($r = .52$, $R = .69$). Finally, coders rated the general extent to which the target's attention appeared to be focused on the camera (reliability; $r = .63$, $R = .77$). Three other coders examined each session in its entirety. They scored subjects' focus on the camera (intraclass correlation among judges, $r = .51$, $R = .76$), looking down or away while talking ($r = .50$, $R = .75$), apparent nervousness ($r = .56$, $R = .80$), and overall ''dynamism'' (the mean of ratings for cocky, energetic, walking fast, speaking fast, speaking loud, and speaking much; $r = .75$, $R = .90$). The components of this last variable were defined loosely and required more subjective interpretation on the part of the coders.

Results

The results are summarized in Table 1. Low-testosterone subjects looked around more than high-testosterone subjects did in the entry portion of the session (almost always looking left, toward the exit and the area where there was most furniture). High-testosterone subjects focused more on the camera than low-testosterone subjects did in the overall session and showed less nervousness. However, high- and low-testosterone subjects did not differ in directness of their path to the camera, looking away or down while talking, declarative tone of voice, and overall dynamism. In summary, in this rudimentary social setting high-testosterone subjects appeared less circumspect and more focused on the task than did low-testosterone subjects.

STUDY 2: TALKING WITH AN EXPERIMENTER

In Study 2, we added a person to the setting. Seventy-eight subjects met and spoke briefly to a female experimenter rather than to a camera. We filmed

TABLE 1
Correlations of Testosterone with Behavior among Subjects ($N = 99$) Speaking to a Camera

Behavior	Portion of session	
	Entry	Overall
Looking around	−.20*	
Direct walk to camera	−.04	
Declarative tone	−.07	
Focus on camera	.16	.25*
Looking away or down		−.05
Nervousness		−.22*
Overall Dynamism		.08

Note. Blank cells indicate judges did not score the behavior.
* $p < .05$.

subjects entering the room, approaching the experimenter, standing before her, and answering questions about themselves.

Procedure

Subjects were 21 male and 57 female undergraduate students. After signing a consent form and providing a saliva sample, each subject walked down a hallway, knocked on the door of a room, entered, walked about 20 ft across the room to meet an experimenter standing behind a lectern, briefly answered questions from her, and left. The experimenter was a woman older than most of the subjects. She spoke with subjects for about 2 min., asking what they thought about when waiting for someone, what they associated with the words ''success'' and ''danger,'' and how they would describe the essence of themselves. The content of these questions was developed to examine another research question. The content of the responses made by targets was not considered relevant to the objectives of this study and will not be discussed here. A video camera behind and to one side of the experimenter recorded a full view of the subject entering the room and a view of the face and upper body of the subject speaking.

We had 12 raters judge the male subjects and 14 judge the female subjects. Raters assessed each subject on an overall confident vs cautious manner and on one of two sets of three adjectives: cautious, poised, and happy or friendly, aggressive, and charming. Intraclass correlations were computed to determine the effective reliabilities of each rating. The Spearman–Brown effective reliability was relatively low, ranging from $R = .36$ for judgments of poise to $R = .68$ for judgments of friendliness (median effective reliability for the six ratings was $R = .55$).

Two additional coders recorded whether subjects looked back toward the door after entering and whether they spoke before the interviewer spoke. Coders showed near-perfect agreement on these data. Finally, we measured the length of time each subject spent in the room. The constellation of these three measures together constituted a variable we called ''forwardness.'' We wanted to compute a conceptually derived composite variable that included behaviors that appeared to differentiate between targets who entered the room directly and began the task at hand without hesitation and those who seemed less direct. In other words, we wanted a robust measure of the extent to which targets moved through the experimental session with

TABLE 2
Correlations of Testosterone with Behavior among Subjects ($N = 78$) Meeting a Stranger

Behavior	Correlation
Confident vs cautious	.10
Friendly	.05
Aggressive	−.02
Charming	.08
Cautious	.07
Poised	.02
Happy	.05
Overall forwardness	.24*

* $p < .05$.

alacrity. Thus, we created an overall objective forwardness score by summing the three variables after first standardizing them and reversing the signs for looking back and for time spent in the room. The median intercorrelation among these three variables was $r = .16$.

Results

The results are summarized in Table 2. High-testosterone subjects behaved in a significantly more forward manner than low-testosterone subjects, although testosterone was not related to the other more subjective ratings. In summary, higher testosterone subjects displayed a more forward, business-like, get-it-done manner, although we could not attach more specific labels to their behavior.

STUDY 3: BEING INTERVIEWED

In Study 3, we examined a more relaxed setting. One hundred forty-five subjects sat and talked with a female interviewer for 5–10 min. We filmed subjects entering a room, approaching a table where the interviewer sat, sitting down across from her, and talking about themselves. Once again we assessed the overall alacrity with which subjects entered the room and began to engage, or allow themselves to be engaged by, the experimenter.

Procedure

Subjects were 45 male and 100 female undergraduate students. Five subjects had missing data and were not included in the analysis. After signing a consent form and providing a saliva sample, each subject walked down a hallway, knocked on the door of a room, entered, and walked about 10 ft into the room to join an interviewer seated at a table. The interviewer was a female student of about the same age as the subjects. She introduced herself and asked questions for 5–10 min about the subject's background, worry and stress, extraversion or introversion, dominance toward others, religion, and the subject's description of himself or herself. A video camera behind and to one side of the interviewer recorded a full view of the

subject entering the room and a view of the face and upper body of the subject seated at the table. After the interview, the subject returned to a waiting room and completed the NEO-PI-R personality inventory (Costa & McCrae, 1992). There were no significant effects related to this inventory.

We imported the videotape recordings into a computer, reducing the frame rate from 30 to 1 fps to conserve space. We deleted all but the first 30 s. of each session, which left enough time for each subject to become completely seated at the table with the interviewer. We inserted a title before each subject and reassembled the material into a movie. Two judges counted the number of frames (equivalent to the number of seconds) each subject spent at the door (before releasing the door and walking on in), walking toward the table, standing beside the table, and getting seated at the table. We summed these four scores to produce a total entry time for each subject.

Results

High testosterone subjects moved more quickly than low-testosterone subjects to the point of being seated at the table with the interviewer. Mean total entry time was 11.1 s. ($SD = 2.7$), and the correlation between testosterone and entry time was $r = -.29$, ($df = 138$, $p < 05$). For the four components of overall entry time, testosterone was correlated $r = -.24$ ($p < .01$) with time spent in the doorway, $r = -.13$ (*ns*) with time walking across the room, $r = -.16$ ($p = .05$) with time standing beside the table, and $r = .01$ (*ns*) with time getting seated. High-testosterone subjects approached the interviewer more quickly than low testosterone subjects, especially in the initial moments of entering the room.

STUDY 4: TALKING WITH A PEER

In Study 4, we examined conversations among pairs that contained one high- and one low-testosterone subject. Eighteen unacquainted pairs of same-sex subjects each sat at a table and talked for 5 min. We filmed each pair entering the room, sitting down, and talking.

Procedure and Results

Subjects were 18 pairs of undergraduate students, 8 male and 10 female. We initially had 27 pairs, 7 with prior testosterone measurements from participation in other studies and 20 with no prior measurements. In order to ensure sizeable testosterone differences between subjects within each pair, we dropped 9 of the 27 pairs in which the testosterone CV was less than 20%.

After signing a consent form, providing a saliva sample, and being instructed to converse briefly and get to know each other, the subjects in each pair entered an adjacent room and seated themselves across a small table from each other. No one else was present. A video camera further back in the room recorded a full view of subjects entering the room and a profile view of their faces and upper bodies after they were seated.

As in Study 1, subjects appeared to differ most when they first entered, approached the table, sat down, and started to talk before settling into the

routine give-and-take of conversation. We imported the videotape record into a computer, reducing the frame rate from 30 to 1 fps to conserve space. We deleted all but the first 15 s of each session, inserted titles showing a pair number before each pair, and reassembled the material into a movie. We used a software horizontal flip filter in Adobe Premiere to make two versions of the movie, one with the high-testosterone subjects always seated on the left side of the table and the other with the high-testosterone subjects always seated on the right side.

We recruited 13 undergraduate judges who did not know that the study involved testosterone. We told them that subjects on the two sides of the table represented two different groups, and we asked them to figure out what the difference was between the groups. Seven judges viewed the version that showed all high-testosterone subjects seated on the left, and six viewed the version that showed all high-testosterone subjects seated on the right. Each judge worked alone, viewing the movie twice and writing a few sentences saying how he or she thought the left and right groups differed. After judges formed their impressions, we explained that one group was more ''independent,'' which we defined as confident, relaxed, and at ease, and the other was more ''responsive,'' which we defined as attentive, friendly, fidgety, and sometimes tense or nervous. Preliminary examination of the films led us to believe that high-testosterone subjects were more confident, relaxed, or at ease and low-testosterone subjects were more attentive, friendly, fidgety, tense, or nervous. We chose ''independent'' and ''responsive'' as labels, therefore, for these opposing descriptions. We then asked judges which side of the table represented the independent group and which side represented the responsive group.

Of the 13 judges, 10 identified subjects on the high-testosterone side of the table as belonging to the independent group and subjects on the low-testosterone side as belonging to the responsive group, $p < .05$ by sign test.[1]

DISCUSSION

The findings suggest that testosterone in both men and women is associated with a focused and perhaps confident manner of meeting and dealing with strangers. This effect was visible in thin slices of behavior lasting 30 s or less (cf. Ambady et al., 2000). Other researchers have found testosterone related to forward and assertive behavior. Udry, Morris, and Kovenock (1995) reported women's testosterone levels accounting for 10% of the variance in how others rate them on masculinity–femininity. High-testosterone children, some as young as 3 years of age, are strikingly independent in their playground behavior (Schaal, Tremblay, Soussignan, & Susman, 1996;

[1] Thanks to a suggestion made by an anonymous reviewer we also computed a chi-square for this effect [$X^2(1) = 3.77$, $p < .06$, $\Phi = .54$].

Strong & Dabbs, 2000). High-testosterone college students contacted at random moments report being involved in action more often than low-testosterone students (Dabbs et al., 1997). Cows injected with testosterone display less fear when exposed to unfamiliar environments or novel objects (Boissy & Bouissou, 1994), and they are more dominant in relationships with other cows (Bouissou, 1978).

Other observations support the notion that a confident manner is important in social interaction. Criminals reportedly identify persons with uncoordinated and awkward gaits as being easy targets for assault (Grayson & Stein, 1981). Stephen Potter (1970) underscored the importance of looking relaxed in competition in *The Complete Upmanship*, where he gave the rule that ''the first muscle tensed is the first point scored.'' Confidence can make the opposition cautious, hesitant, and uneasy. Sumo wrestlers, like bears and other animals, approach opponents with threatening postures and gestures. The outcome of a dominance contest is often foreshadowed by action before the contest begins, as athletes stare down opponents, lawyers intimidate witnesses, and actors strut onto a scene. Confidence may come from age, experience, social status, or conscious strategy. The present findings suggest it also may come from high levels of testosterone, which can be more important than traditional personality characteristics in contributing to an individual's style and manner of approach.

We did not find all the effects we expected. For example, in the dyadic conversations we expected judges to describe higher testosterone subjects as more ''dominant'' (Mazur, 1985). They did not do so, even though they rated high-testosterone subjects as more confident, relaxed, and at ease and low-testosterone subjects as more attentive, friendly, fidgety, and tense or nervous. We conclude that the concept of dominance is broader than often indicated in psychological writing, where it is associated with force and hostile action. Especially in non-threatening or friendly settings, one may achieve dominance simply by being engaging and attractive. To be dominant it is often sufficient simply to have ''presence,'' a quality of implied power that elicits cautious respect from others. A person with presence does not have to perform any particular act to seize dominance, because others automatically behave in a deferential fashion (Dabbs, 1998). Elements of energy, confidence, and focus associated with testosterone may contribute to dominance by eliciting deference from others.

The present findings suggest testosterone is related to expressive behavior in the early moments of a social encounter. Studies cited in the introduction show testosterone is related to long-term patterns of crime, delinquency, and occupational choice. In brief encounters and long-term behavior, testosterone appears associated with a straightforward roughness that guides an individual along general paths of thought and behavior. Early moments of social encounters can be more revealing than later moments because other forces

come into play in later moments, as happens when testosterone predicts dominance in a fight between two unacquainted monkeys but not in the established hierarchy of a monkey group (Bernstein, Gordon, & Rose, 1983). Testosterone appears to affect expressive behavior. Although these effects are subtle and brief, they can have profound impacts on how people are perceived and judged by others (Ambady et al., 2000), thereby setting the initial tone of an encounter or a relationship. The initial tone establishes expectancies that guide the subsequent flow of behaviors and attributions about these behaviors.

In the study of conversing pairs, we found it easier to detect characteristics associated with testosterone differences when judging sets of high- or low-testosterone individuals grouped together than when judging individuals one at a time. Sets of individuals together may be more revealing because expressions and actions not noticed in isolation take on significance when viewed together. This has been noticed before, where it proved easier to detect facial expressions associated with high- or low-testosterone levels in judging whole sets of photographs of high- or low-testosterone subjects together than it is in judging individual photographs of high or low testosterone subjects alone (Dabbs, 1997).

Readers might question whether the effect sizes reported here are even worthy of note. Aside from the relatively large effect size reported in Study 4 (see footnote) the testosterone effects in terms of r ranged between .20 and .25. Of what impact is testosterone if it is contributing a mere 4% of the observable variance in behavior? Two points need to be made. First, unlike many social psychological experiments that attempt to explain or influence some critical and singular decision, behavioral event, or unidimensional judgment, the present investigation was studying nonverbal self-presentational behavior (DePaulo, 1992). This was not a study of what precisely people do at critical, theoretically derived moments but an attempt to reveal individual differences in expressive style, movement through space, and interpersonal orientation. The main point was not the identification of universal one-to-one relationships between testosterone level and subjects' tendency to ''look left'' within our very idiosyncratic social/environmental context. Rather, our point was that testosterone has some effect on operant, free-flowing behavior, the kind of behavior that might otherwise be considered ''error variance'' in typical investigations of social interaction.

The second point, made by Rosenthal and colleagues (1995; Rosenthal & Rubin, 1982) is that many consumers of social science research severely underestimate the practical impact of effect sizes, especially when they are discussed in terms of ''percentage of variance accounted for.'' Table 3 presents our generic finding (testosterone effect $r > .20$) in terms of a Binomial Effect Size Display (BESD; Rosenthal & Rubin, 1982). This display is a way of showing the practical importance of any effect indexed by a correlation

TABLE 3
Binomial Effect Size Display (BESD) Illustrating the Effect of Testosterone on Expressive Behavior Where the Effect Size $r = .20$

	High testosterone	Low testosterone	Total
Forward and direct expressive style	60	40	100
Nondirect expressive style	40	60	100
Total	100	100	200

coefficient. The correlation is shown to be the simple difference in hypothetical rates of a ''forward and direct expressive style'' between those with high levels of testosterone and those with low levels. The table has been standardized such that column and row totals are fixed equal at 100. A count of 50 in each of the four cells represents a null effect of testosterone on observable behavior. As is evident in Table 3, the effects we report in this study are comparable to increasing the presence of a direct expressive style from 40% of the low-testosterone sample to 60% of the high-testosterone sample. This increase of 20 percentage points effectively increases the prevalence of this behavioral style by 50% (i.e., the increase from 40 to 60). Illustrated this way the reader can see that the effects reported here are far from trivial.

The present findings are correlational ones. There are many differences between high- and low-testosterone individuals, and we cannot know the particular importance of testosterone until we manipulate it in social settings. There are testosterone receptors in brain centers associated with motivation and emotion, including the hypothalamus, amygdala, and preoptic areas (Michael, Rees, & Bonsall, 1989). There are also receptors in the cortex (Sarrieau, Mitchell, Lal, Olivier, Quirion, & Meaney, 1990), but relatively little is known about the action of testosterone in the cortex. A better understanding of brain receptors and mechanisms will clarify the pathways whereby testosterone might affect both brief encounters and long-term patterns of social behavior.

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