Hormones and Behavior **36,** 234–241 (1999)
Article ID hbeh.1999.1542, available online at http://www.idealibrary.com on IDEAL®

Implicit Power Motivation Moderates Men's Testosterone Responses to Imagined and Real Dominance Success

Oliver C. Schultheiss,*[,1] Kenneth L. Campbell,‡ and David C. McClelland†[,]§

*Department of Psychology, Harvard University, William James Hall 1518, 33 Kirkland Street, Cambridge, Massachusetts 02138; ‡Department of Biology, University of Massachusetts at Boston, 100 Morrissey Boulevard, Boston, Massachusetts 02125-3393; and §Department of Psychology, Boston University, 64 Cummington Street, Boston, Massachusetts 02215

Received February 16, 1999; revised May 3, 1999; accepted June 9, 1999

This study tested the hypothesis that implicit power motivation moderates individuals' testosterone responses to the anticipated success in and actual outcome of a dominance contest. Salivary testosterone levels were assessed in 42 male students at the beginning of the study, after they had imagined a success in an ensuing power contest, and immediately after the contest had taken place. Contest outcome (winning or losing against a competitor on a speed-based task) was varied experimentally. Participants' power motive was assessed with a picture-story exercise, in which an assertive, personalized (p Power) component was distinguished from an altruistic, socialized (s Power) component. In contrast to all other participants, individuals high only in p Power (a) had elevated testosterone after imagining a success in a subsequent dominance contest and (b) continued to have high testosterone levels after actually winning, but not after losing, the contest. © 1999 Academic Press

Key Words: **testosterone; implicit power motivation; dominance contest; goal imagery.**

There is ample evidence from studies on primates and humans to suggest a link between dominant or aggressive behavior on the one hand and the gonadal steroid hormone testosterone on the other (Mazur and Booth, 1998; Bernstein, Gordon, and Rose, 1983). Specifically, a number of field and laboratory studies with adult male participants of tennis matches (e.g., Booth, Shelley, Mazur, Tharp, and Kittok, 1989), chess tournaments (Mazur, Booth, and Dabbs, 1992), or contests in which the outcome was varied experimentally (Gladue, Boechler, and McCaul, 1989; McCaul, Gladue, and Joppa, 1992) revealed (a) a rise in testosterone before dominance-related contests that has been interpreted as an anticipation effect (see also Kemper, 1990) and (b) elevated testosterone levels in winners and depressed testosterone levels in losers for some minutes to several hours after the contest. Similar testosterone changes have also been observed in the case of vicarious dominance successes or failures (Bernhardt, Dabbs, Fielden, and Lutter, 1998).

Other researchers have failed to find postcontest testosterone differences between winners and losers in field and laboratory studies (Gonzalez-Bono, Salvador, Serrano, and Ricarte, 1999; Mazur, Susman, and Edelbrock, 1997; Salvador, Simon, Suay, and Llorens, 1987), which casts some doubt on the general efficacy of situational factors such as contest outcome to influence testosterone levels. It would seem reasonable to assume that personality factors may moderate individuals' testosterone responses to succeeding or failing at a dominance contest. Specifically, the strength of an individual's need for dominance or status may play a crucial role in how the individual responds hormonally to dominance outcomes. Accordingly, only individuals high in this need should show differential patterns of testosterone after winning or losing, whereas testosterone levels of individuals low in this

[1] To whom correspondence should be addressed at present address: Department of Psychology, University of Potsdam, P. O. Box 601553, D-14415 Potsdam, Germany. Fax: +49 331 977 2829. E-mail: oschultheiss@yahoo.com.

† Deceased on March 27, 1998.

0018-506X/99 $30.00

need should remain largely unaffected by contest outcome.

Attempts to pinpoint such a personality disposition, though, have met with little success in studies employing a wide variety of paper-and-pencil measures of dominance and other personality traits (e.g., Archer, Birring, and Wu, 1998; Dabbs, Hopper, and Jurkovic, 1990). Archer (1991) and Mazur and Booth (1998) have therefore questioned the relevance of such self-report measures to predict hormones and behaviors associated with dominance. In a similar vein, studies on motivational processes in humans have shown that questionnaire measures of self-attributed motives (e.g., the self-attributed needs for dominance, achievement, or affiliation) tap individuals' cognition-based self-concept rather than their emotional–motivational dispositions and thus frequently fail to predict affect-driven behavior (Biernat, 1989; deCharms, Morrison, Reitman, and McClelland, 1955; McClelland, 1987; McClelland, Koestner, and Weinberger, 1989).

Hence, in the present study we employed a measure of affect-based power motivation to predict adult human males' testosterone changes in response to winning or losing a dominance contest against another person. The power motive can be defined as the capacity of obtaining emotional satisfaction from having impact on others (Winter, 1973, 1996). An individual's power motive is aroused by learned stimuli that signal the availability of the impact incentive in a given situation. The individual then engages in behavior that, if it is instrumental in obtaining the incentive, leads to a rewarding affective state and thus becomes reinforced (see McClelland, 1987; Weinberger and McClelland, 1990; Winter, 1996).

The power motive is implicit in the sense that it functions outside of a person's conscious awareness and is not correlated with questionnaire-based measures of self-attributed dominance, aggression, or assertiveness (King, 1995; McClelland, 1980). However, it can shape an individual's fantasies and behavior if aroused by power-relevant stimuli in the individual's environment. Therefore, the strength of a person's power motive can be determined by analyzing the content of fantasies he or she reports in response to picture cues thematically related to power and dominance. The Picture Story Exercise (PSE) technique developed by McClelland and his colleagues for the assessment of implicit motives is typically used for this purpose (see Smith, 1992). The PSE measure of implicit power motivation has been shown to predict a wide variety of dominance-related behaviors and life outcomes and to be closely associated with sympathetic arousal, immune system functioning, and substance abuse (for reviews, see Jemmott, 1987; McClelland, 1987, 1989; Winter, 1996).

In the present research, we proceeded on the assumption that in dominance-related contexts, individuals with a strong power motive should show high levels of testosterone after winning a dominance contest against another person. In contrast, losing the contest should lead to stable or reduced testosterone levels in high- and low-power individuals alike. Because high-power individuals may greatly differ in the means through which they have learned to have impact on others, we differentiated between a personalized (p Power) and a socialized (s Power) component of the power motive. As previous research has shown, individuals high in p Power satisfy their need for impact in assertive ways, and it was this variant of power motivation to which the incentive of winning a contest and thus beating an opponent was tailored. Individuals high in s Power, on the other hand, typically try to have impact through prosocial behavior, and a strong socialized power motive acts as a check on personalized power concerns (McClelland, Davis, Kalin, and Wanner, 1972; Winter, 1973). Thus, we expected that it would be only those individuals who were high solely in p Power for whom winning the contest would be rewarding and who would therefore register the largest gains in testosterone. In contrast, winners high in s Power or low in both kinds of power motivation as well as losers in general should not respond with a testosterone increase to the contest outcome.

We tested these hypotheses in a sample of male students because (a) testosterone levels are about 3- to 10-fold higher, and thus easier to measure, in adult men than in adult women (Read, 1993) and (b) findings regarding the relationship between testosterone and dominance in women have been somewhat inconclusive so far (Dabbs, 1992; Mazur and Booth, 1998). To assess changes in hormone concentrations, we measured participants' salivary testosterone levels several times before and after the contest. Finally, by having individuals anticipate a successful outcome of the contest imaginatively before actually entering it, we both ascertained that individuals' power motive would be adequately engaged in the contest task (see Schultheiss and Brunstein, 1999) and tested whether the anticipatory precontest rise in testosterone reported in earlier studies would be moderated by participants' implicit power motive.

METHOD

Participants. Forty-two male Harvard University undergraduate and graduate students, age 20.26 ± 0.44 years, who had fasted and refrained from oral hygiene for 1 h before arriving at the laboratory, participated pairwise in the study for a remuneration of $20. Smokers and psychology students were excluded. Differences in participants' testosterone levels due to circadian variations were minimized by holding sessions only at 1:45 PM and 4:00 PM.

Design and procedure. The study was based on an Experimental Condition × p Power × s Power design. Experimental condition was varied by having one participant in each dyad win ($N = 21$) and the other lose ($N = 21$) a dominance contest. Participants' p and s Power levels were assessed with a PSE.

Upon arriving at the laboratory, participants provided a first saliva sample (T1). The male experimenter then administered a PSE and had them work on a task unrelated to the present report for 15 min. Next, he explained that participants would now compete against each other on a speed-based paper-and-pencil task. Before participants entered the contest, they listened to a tape-recorded imagery exercise vividly describing the course of the ensuing contest from the winner's perspective for 10 min (cf. Schultheiss and Brunstein, 1999) and then provided a second saliva sample (T2). Immediately upon finishing the actual dominance contest, which had lasted 10 min, participants collected saliva for a third time (T3). Finally, they were fully debriefed about the design and purpose of the study.

Experimental condition. The task participants competed on during the contest required them to connect a sequence of consecutive ascending numbers (1-2-3-4-. . .), which were surrounded by distractor numbers and arranged in a matrix, as fast as possible with a pen until they reached a highlighted number (e.g., "67") representing the stop mark. Each pair of participants worked on 10 different forms during the contest. The participant finishing first on a given trial said "Done!" and the other participant had to stop immediately. Thus, each participant had the opportunity to have impact on the other participant by completing a sequence first and thus to stop and hence frustrate his competitor. Undetectable for the participants, the number sequences of the 10 parallel forms presented during the contest differed in length such that the designated winner won 8 of 10 times while the designated loser accordingly won only 2 times.

Implicit power motivation. The PSE was administered to participants using standard instructions described in Smith (1992) and consisted of six picture cues that have been widely used in earlier research on power motivation (McClelland, 1975; Smith, 1992; Winter, 1973). Participants had 5 min per picture to write down a story. Two trained scorers later independently coded these stories for p Power and s Power. The scoring manual, which was adapted from the scoring system developed by McClelland *et al.* (1972), scored p Power whenever someone shows a concern for increasing her or his dominance over others in assertive or powerful ways. Whenever someone having power resources at his or her command uses his or her power to give unsolicited help, advice, or protection, s Power was scored. Percentage agreement between scorers across all stories, conservatively estimated by the index of concordance (see Martin and Bateson, 1993; Winter, 1991), was satisfactory with 73%. Scoring disagreements were resolved by discussion, and scores from these joint sessions were used as participants' final scores. Summed across six stories, participants had a p Power score of 3.17 ± 0.42 and an s Power score of 0.88 ± 0.16. Because s Power imagery was absent in the stories of 19 participants and present once or more often in the stories of 23 participants, a dummy variable was created by assigning a "0" to the former group of participants and a "1" to the latter. For maximum test power, p Power remained a quantitative variable in all further analyses (cf. Cohen and Cohen, 1983).

Salivary testosterone assay. Sample collections took about 5 min each and were done at times >10 min apart, ample time for salivary testosterone levels to approach equilibrium with free testosterone levels in serum (Ellison, 1993; Read, 1993). At each sampling point, participants used a fresh sugar-free chewing gum to collect 3.5 to 7 ml saliva in a sterile cryogenic vial and then removed the chewing gum (Dabbs, 1991). Vials were closed and frozen immediately after collection. For accurate pipetting, samples were freed from mucopolysaccarides by several freeze–thaw cycles with subsequent centrifugation. Salivary testosterone levels were determined by a solid-phase ^{125}I radioimmunoassay (Coat-A-Count, Diagnostic Products Corp., Los Angeles, CA), using the modified protocol described in Campbell, Schultheiss, and McClelland (1999). Intra-assay CV for duplicates was 12% (averaged across three assays) and sensitivity was at 16 pg/ml.

Statistical procedures. Data were analyzed using the regression procedure of SYSTAT 7.0. Experimental

condition was coded 1 for winners and −1 for losers. When higher-order effects were tested for significance, lower-order effects were always controlled for first. To determine whether independent variables had an effect on a testosterone measurement above and beyond their influence on a preceding measurement, we also tested for significant changes in testosterone accounted for by the independent variables by covarying out the preceding measurement. Descriptive data are expressed as mean ± SEM. An α level of 5% (two-tailed) was employed in all analyses.

RESULTS

For T1 through T3, participants' salivary testosterone concentrations were 104 ± 10, 108 ± 8, and 125 ± 9 pg/ml and did not differ significantly across the three measurements, $P > 0.05$. Although correlations between measurements were of only moderate magnitude ($r = 0.37$ for T1/T2, $r = 0.37$ for T1/T3, and $r = 0.44$ for T2/T3, Ps < 0.02), they were comparable to those obtained in other studies (e.g., Booth *et al.*, 1989).

At T1, only the correlation between testosterone and p Power approached significance ($r = 0.29$, $P < 0.07$). Thus, individuals high in p Power tended to have higher testosterone levels (e.g., a predicted value of 122 pg/ml for individuals 1 SD above the p Power sample mean) than those low in p Power (e.g., a predicted value of 87 pg/ml for individuals 1 SD below the p Power sample mean).

At T2, p Power was accounted for by a highly significant p Power × s Power interaction ($B = -21.04$, $SE = 4.81$, $\Delta R^2 = 0.260$, $\Delta F(1, 38) = 19.11$, $P < 0.0001$). The full regression model accounted for 48.35% of variance in testosterone at T2 ($F(3, 38) = 11.86$, $P < 0.00005$). As Fig. 1 illustrates, this interaction was based on a strong positive association between p Power and testosterone in the absence of s Power ($r = 0.77$, $P = 0.0001$) that did not occur in the presence of s Power ($r = 0.09$, $P > 0.05$). Notably, the interaction remained highly significant even when we reran the full regression analysis while holding testosterone at T1 constant, thus testing for changes in testosterone from T1 to T2 ($B = -19.04$, $SE = 4.85$, $\Delta R^2 = 0.129$, $\Delta F(1, 37) = 15.41$, $P < 0.0005$).

At T3, testosterone levels of winners (133 ± 14 pg/ml) did not differ from those of losers (117 ± 11 pg/ml), $P > 0.05$. However, postcontest testosterone was predicted by a significant Experimental Condition × p Power × s Power interaction ($B = -16.95$, $SE = 7.47$, $\Delta R^2 = 0.082$, $\Delta F(1, 34) = 5.15$, $P < 0.05$),

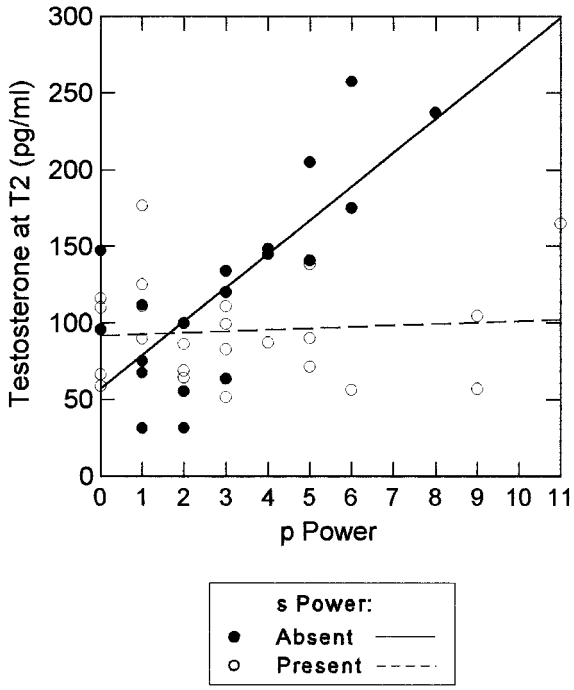

FIG. 1. The effect of p Power on testosterone (T2) after the goal imagery exercise. Regression lines were plotted separately for participants with s Power either absent (filled circles, solid line) or present (empty circles, dotted line).

which survived covarying out testosterone at T2 ($B = -15.45$, $SE = 7.84$, $\Delta R^2 = 0.063$, $\Delta F(1, 33) = 3.87$, $P = 0.05$). Without the covariate, the full regression model including all predictors and their interaction terms accounted for 46.01% of variance in testosterone at T3 ($F(7, 34) = 4.14$, $P < 0.005$).

The three-way interaction was based on a highly significant p Power × s Power effect among winners ($B = -51.86$, $SE = 12.41$, $\Delta R^2 = 0.432$, $\Delta F(1, 17) = 17.47$, $P < 0.001$), which also held when testosterone at T2 was partialled out first ($B = -45.92$, $SE = 17.27$, $\Delta R^2 = 0.269$, $\Delta F(1, 16) = 7.07$, $P < 0.02$). Thus, among winners, the pattern of results at T3 significantly differed from that obtained at T2. Further analyses revealed that in this group, p Power was positively associated with testosterone in the absence of s Power ($r = 0.88$, $P = 0.01$) and negatively in the presence of s Power ($r = -0.62$, $P = 0.01$). As Fig. 2 illustrates, winners high in p Power but lacking s Power had higher testosterone at T3 than all other winners or losers in general, whereas s Power-present winners high in p Power had lower postcontest testosterone than most other participants.

A significant p Power × s Power interaction also emerged for losers ($B = -17.97$, $SE = 7.78$, $\Delta R^2 =$

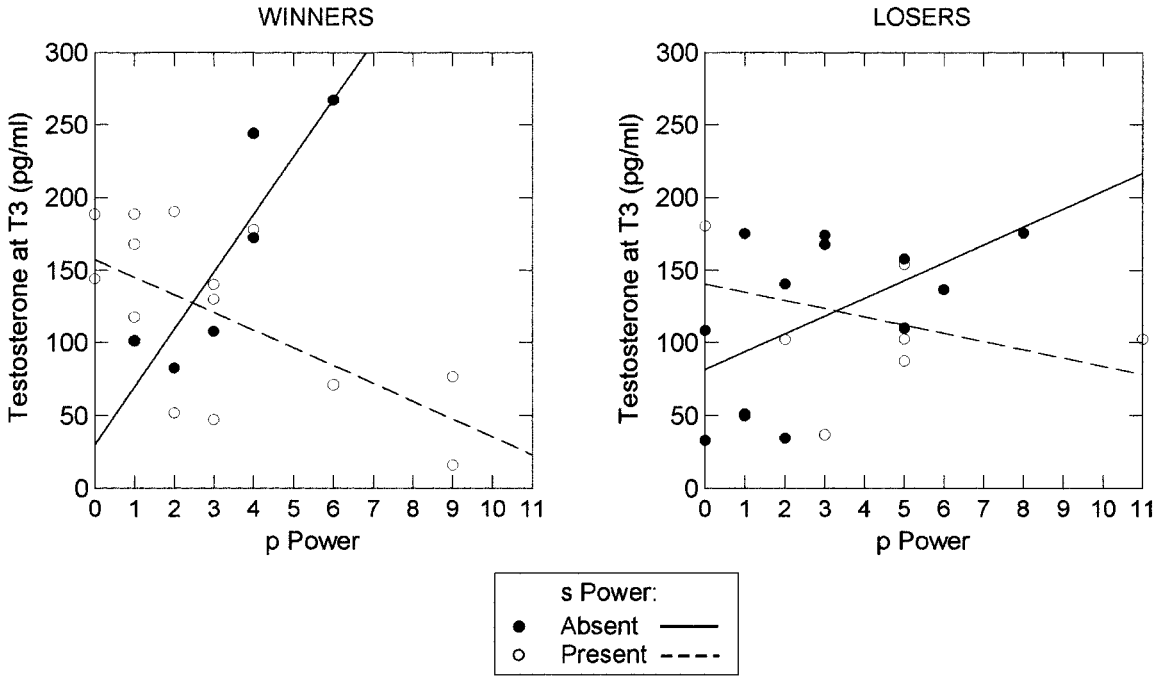

FIG. 2. The effect of p Power on testosterone (T3) after the contest. Regression lines were plotted separately for winners (left) and losers (right) with s Power either absent (filled circles, solid lines) or present (empty circles, dotted lines).

0.234, $\Delta F(1, 17) = 5.33$, $P < 0.05$); however, it did not survive partialling for testosterone at T2 ($P > 0.05$) and therefore could not be differentiated from the pattern of results obtained at T2. Additional analyses indicated that although correlations between p Power and testosterone were sizable both in the presence ($r = -0.41$) and in the absence ($r = 0.54$) of s Power in this group, they did not become significant, Ps > 0.05. Notably, in contrast to their winning counterparts, none of the losers high in p Power but lacking s Power had testosterone values greater than 175 pg/ml or exceeding those of s Power-present losers.

DISCUSSION

The present findings provide strong support for the notion that in human males, individual differences in two components of implicit power motivation moderate testosterone responses to both an imagined and a real success in a dominance-related contest. First, we found that implicit power motivation predicted individuals' hormonal responses to anticipating a dominance success imaginatively. Postimagery testosterone levels were about twice as high in individuals high only in p Power, that is, with a strong need to have impact on others exclusively through assertive means, compared to all other participants. We were thus able to capture a testosterone-stimulating effect of dominance fantasies that has been postulated on the basis of elevated precontest testosterone levels observed in some studies (cf. Kemper, 1990; Mazur and Booth, 1998) but never directly tested.

Second, we found that after participants had actually won a subsequent dominance contest, implicit power motivation in combination with contest outcome predicted postcontest testosterone above and beyond the effects observed after the imagery exercise preceding the contest. Specifically, among winners without s Power, postcontest testosterone levels remained positively related to p Power, and those with the highest levels of p Power had the highest testosterone levels of all participants. Moreover, in accordance with the hypothesis that s Power acts as a check on assertive motivational impulses, we found that among winners with a socialized power motive higher p Power was now associated with lower postcontest testosterone. By comparison, postcontest testosterone remained largely unchanged relative to precontest levels in losers, and high-p Power losers lacking s Power did not show the elevated testosterone levels we observed in their winning counterparts.

Notably, imagining a success or actually winning or losing the contest did not in and of itself account for differences in individuals' postimagery or postcontest testosterone levels, thus reinforcing our notion that in order to fully understand testosterone changes in dominance-related contexts, it is necessary to look at characteristics of both the situation (i.e., an anticipated or actual dominance success) and the person (i.e., interindividual variations in the *affective capacity* to experience having impact as rewarding, which are reflected by differences in the implicit power motive). Hence, previous failures to find clear-cut testosterone differences between winners and losers of dominance contests may have been due to wide variations in participants' implicit power motivation, among other potential reasons.

What is the possible role of testosterone in implicit power motivation? As Mazur (1985) and Kemper (1990) have theorized, elevated testosterone levels following a dominance success may serve to reinforce assertive behavior, whereas depressed testosterone levels after losing a dominance contest should work the opposite way. A reinforcing function of testosterone has been documented in animal studies in which testosterone administration was effective in increasing the intensity of behavior preceding the hormone treatment (e.g., Alexander, Packard, and Hines, 1994; Packard, Cornell, and Alexander, 1997) and is also suggested by the interaction of sex steroids with brain reward structures subserving incentive motivation (e.g., Alderson and Baum, 1981; Packard, Schroeder, and Alexander, 1998). Although we are not aware of any studies in which the reinforcing role of testosterone has been tested directly in human subjects, we would argue on the basis of our present findings that if testosterone increases following a dominance success indeed strengthen behavior that was instrumental in achieving that success, we would expect to observe the strongest learning effects in individuals high in implicit power motivation, because they also show the most pronounced testosterone responses to dominance-relevant outcomes. Hence, within dominance-related contexts, it seems possible that testosterone's capacity to reinforce behavior may be specific to the implicit power motive.

Underscoring the advantage of implicit over self-report measures of dominance, the magnitude of the effects resulting from the prediction of testosterone with a combination of implicit power motivation and situational factors by far exceeded those obtained in similar experimental studies using questionnaire measures of dominance to predict hormonal responses. In contrast to the lack of substantial associations between testosterone and self-report measures in many cross-sectional studies, we also observed that high-p Power individuals tended to start out with higher testosterone levels than other participants. This finding may either reflect a lasting up-regulation of testicular function in high-p Power individuals, presumably due to a training effect of frequent dominance successes over a prolonged period of time, or a more momentary carryover of a recent testosterone surge they may have obtained by successfully asserting themselves outside the laboratory.

In addition to replicating the present results in other and larger male samples than the one studied in the present research, future studies should employ sufficiently sensitive testosterone assays (see Campbell *et al.*, 1999) and possibly also estrogen assays (see Cashdan, 1995) to determine whether the pattern of results we obtained in this study will also hold for women's hormonal responses to winning or losing a dominance contest. Second, the interplay between implicit power motivation and power-related fantasies on testosterone changes should be studied in greater detail than was possible in the present study. Specifically, the content of individuals' fantasies could be varied experimentally by, for instance, having some participants imagine a success, some a failure, and others something unrelated to having impact. Third, we would expect testosterone to be closely associated with components of implicit power motivation other than p Power. Thus, it may seem worthwhile to create situations in which socialized power motivation (or a combination of p Power and s Power) is first aroused and then fulfilled or frustrated by, for instance, having individuals fantasize about a success or actually succeed or fail at teaching others in order to study their hormonal responses to such imagined or real power-relevant outcomes. Fourth, some studies indicate that the Type A behavior pattern, which is characterized by high competitiveness, hostility, and an enhanced sense of time urgency, is associated with increased daytime testosterone levels (Zumoff, Rosenfeld, Friedman, Byers, Rosenman, and Hellman, 1984) and testosterone increases in response to provocation (Berman, Gladue, and Taylor, 1993) or challenging tasks (Williams, Lane, Kuhn, Melosh, White, and Schanberg, 1982). However, despite parallels in the behavior profiles of Type A and high-power individuals, there is little empirical overlap between the two constructs (Matthews and Saal, 1978). Nevertheless, it might seem worthwhile to explore the cojoint effects of implicit power motivation and the Type A behavior pat-

tern on testosterone responses to dominance contests in future studies.

Finally, in light of the well-documented link between testosterone and aggressive behavior on the one hand and the frequent failure to predict either with questionnaire measures of dominance or aggression on the other, we believe that the implicit power motive has suffered undue neglect in past research on testosterone and aggression. By considering the extensive body of literature that already exists on this approach, affect-based dispositions can help illuminate why some individuals frequently resort to violent ways of dealing with their social environment.

ACKNOWLEDGMENTS

We thank Erin Lehman for her help in developing the materials used in this study, Katharina Thiele for coding the stories, and Joachim Brunstein, Michael Baum, and three anonymous reviewers for helpful comments on earlier drafts of this article. This work was supported by a Deutsche Forschungsgemeinschaft research stipend to Oliver C. Schultheiss (SCHU 1210/1-1, 1-2, 1-3) and a research grant of McBer & Co., Boston, to David C. McClelland. This article is dedicated to the memory of David C. McClelland.

REFERENCES

Alderson, L. M., and Baum, M. J. (1981). Differential effects of gonadal steroids on dopamine metabolism in mesolimbic and nigro-striatal pathways of male rat brain. *Brain Res.* **218,** 189–206.

Alexander, G. M., Packard, M. G., and Hines, M. (1994). Testosterone has rewarding affective properties in male rats: Implications for the biological basis of sexual motivation. *Behav. Neurosci.* **108,** 424–428.

Archer, J. (1991). The influence of testosterone on human aggression. *Brit. J. Psychol.* **82,** 1–28.

Archer, J., Birring, S. S., and Wu, F. C. W. (1998). The association between testosterone and aggression among young men: Empirical findings and a meta-analysis. *Aggress. Behav.* **24,** 411–420.

Berman, M., Gladue, B., and Taylor, S. (1993). The effects of hormones, Type A behavior pattern, and provocation on aggression in men. *Motiv. Emot.* **17,** 125–138.

Bernhardt, P. C., Dabbs, J. M., Jr., Fielden, J. A., and Lutter, C. D. (1998). Testosterone changes during vicarious experiences of winning and losing among fans at sporting events. *Phys. Behav.* **65,** 59–62.

Bernstein, I. S., Gordon, T. P., and Rose, R. M. (1983). The interaction of hormones, behavior, and social context in nonhuman primates. *In* B. B. Svare (Ed.), *Hormones and Aggressive Behavior,* pp. 535–561. Plenum, New York.

Biernat, M. (1989). Motives and values to achieve: Different constructs with different effects. *J. Pers.* **57,** 69–95.

Booth, A., Shelley, G., Mazur, A., Tharp, G., and Kittok, R. (1989). Testosterone, and winning and losing in human competition. *Horm. Behav.* **23,** 556–571.

Campbell, K. L., Schultheiss, O. C., and McClelland, D. C. (1999). A necessary adjustment of protocol for use of DPC Coat-A-Count total testosterone assay with saliva. *Clin. Biochem.* **32,** 83–85.

Cashdan, E. (1995). Hormones, sex, and status in women. *Horm. Behav.* **29,** 354–366.

Cohen, J., and Cohen, P. (1983). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences.* Erlbaum, Hillsdale, NJ.

Dabbs, J. M. (1991). Salivary testosterone measurements: Collecting, storing, and mailing saliva samples. *Phys. Behav.* **49,** 815–817.

Dabbs, J. M. (1992). Testosterone measurements in social and clinical psychology. *J. Soc. Clin. Psychol.* **11,** 302–321.

Dabbs, J. M., Hopper, C. H., and Jurkovic, G. J. (1990). Testosterone and personality among college students and military veterans. *Pers. Indiv. Diff.* **11,** 1263–1269.

deCharms, R., Morrison, H. W., Reitman, W., and McClelland, D. C. (1955). Behavioral correlates of directly and indirectly measured achievement motivation. *In* D. C. McClelland (Ed.), *Studies in Motivation,* pp. 414–423. Appleton-Century-Crofts, New York.

Ellison, P. T. (1993). Measurements of salivary progesterone. *Ann. N. Y. Acad. Sci.* **694,** 161–176.

Gladue, B. A., Boechler, M., and McCaul, K. D. (1989). Hormonal response to competition in human males. *Aggress. Behav.* **15,** 409–422.

Gonzalez-Bono, E., Salvador, A., Serrano, M. A., and Ricarte, J. (1999). Testosterone, cortisol, and mood in a sports team competition. *Horm. Behav.* **35,** 55–62.

Jemmott, J. B. (1987). Social motives and susceptibility to disease: Stalking individual differences in health risks. *J. Pers.* **55,** 267–298.

Kemper, T. D. (1990). *Social Structure and Testosterone: Explorations of the Socio-bio-social Chain.* Rutgers Univ. Press, New Brunswick.

King, L. A. (1995). Wishes, motives, goals, and personal memories: Relations of measures of human motivation. *J. Pers.* **63,** 985–1007.

Martin, P., and Bateson, P. (1993). *Measuring Behaviour: An Introductory Guide.* Cambridge Univ. Press, New York.

Matthews, K. A., and Saal, F. E. (1978). Relationship of the Type A coronary-prone behavior pattern to achievement, power, and affiliation motives. *Psychosom. Med.* **40,** 630–636.

Mazur, A. (1985). A biosocial model of status in face-to-face primate groups. *Soc. Forces* **64,** 377–402.

Mazur, A., and Booth, A. (1998). Testosterone and dominance in men. *Behav. Brain Sci.* **21,** 353–397.

Mazur, A., Booth, A., and Dabbs, J. M. (1992). Testosterone and chess competition. *Soc. Psych. Quart.* **55,** 70–77.

Mazur, A., Susman, E. J., and Edelbrock, S. (1997). Sex differences in testosterone response to a video game contest. *Evol. Hum. Behav.* **18,** 317–326.

McCaul, K. D., Gladue, B. A., and Joppa, M. (1992). Winning, losing, mood, and testosterone. *Horm. Behav.* **26,** 486–504.

McClelland, D. C. (1975). *Power: The Inner Experience.* Irvington, New York.

McClelland, D. C. (1980). Motive dispositions. The merits of operant and respondent measures. *In* L. Wheeler (Ed.), *Review of Personality and Social Psychology,* Vol. 1, pp. 10–41. Sage, Beverly Hills.

McClelland, D. C. (1987). *Human Motivation.* Cambridge Univ. Press, New York.

McClelland, D. C. (1989). Motivational factors in health and disease. *Am. Psychol.* **44,** 675–683.

McClelland, D. C., Davis, W. N., Kalin, R., and Wanner, E. (1972). *The Drinking Man.* Free Press, New York.

McClelland, D. C., Koestner, R., and Weinberger, J. (1989). How do self-attributed and implicit motives differ? *Psychol. Rev.* **96,** 690–702.

Packard, M. G., Cornell, A. H., and Alexander, G. M. (1997). Rewarding affective properties of intra-nucleus accumbens injections of testosterone. *Behav. Neurosci.* **111,** 219–224.

Packard, M. G., Schroeder, J. P., and Alexander, G. M. (1998). Expression of testosterone conditioned place preference is blocked by peripheral or intra-accumbens injection of alpha-flupenthixol. *Horm. Behav.* **34,** 39–47.

Read, G. F. (1993). Status report on measurement of salivary estrogens and androgens. *Ann. N. Y. Acad. Sci.* **694,** 146–160.

Salvador, A., Simon, V., Suay, F., and Llorens, L. (1987). Testosterone and cortisol responses to competitive fighting in human males: A pilot study. *Aggress. Behav.* **13,** 9–13.

Schultheiss, O. C., and Brunstein, J. C. (1999). Goal imagery: Bridging the gap between implicit motives and explicit goals. *J. Pers.* **67,** 1–38.

Smith, C. P. (Ed.) (1992). *Motivation and Personality: Handbook of Thematic Content Analysis.* Cambridge Univ. Press, New York.

Weinberger, J., and McClelland, D. C. (1990). Cognitive versus traditional motivational models: Irreconcilable or complementary? *In* E. T. Higgins and R. M. Sorrentino (Eds.), *Handbook of Motivation and Cognition: Foundations of Social Behavior,* Vol. 2, pp. 562–597. Guilford, New York.

Williams, R. B., Lane, J. D., Kuhn, C. M., Melosh, W., White, A. D., and Schanberg, S. M. (1982). Type A behavior and elevated physiological and neuroendrocrine responses to cognitive tasks. *Science* **218,** 483–485.

Winter, D. G. (1973). *The Power Motive.* Free Press, New York.

Winter, D. G. (1991). Measuring personality at a distance: Development of an integrated system for scoring motives in running text. *In* D. J. Ozer, J. M. Healy, and A. J. Stewart (Eds.), *Perspectives in Personality,* Vol. 3, pp. 59–89. Jessica Kingsley, London.

Winter, D. G. (1996). *Personality: Analysis and Interpretation of Lives.* McGraw-Hill, New York.

Zumoff, B., Rosenfeld, R. S., Friedman, M., Byers, S. O., Rosenman, R. H., and Hellman, L. (1984). Elevated daytime urinary excretion of testosterone glucuronide in men with Type A behavior pattern. *Psychosom. Med.* **46,** 223–225.