A Biobehavioral Model of Implicit Power Motivation

Arousal, Reward and Frustration

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1. Power motivation: Definition, measurement, and validity

Like members of many other social species, humans show marked individual differences in how much they seek and enjoy power. Some people are driven to become socially visible and dominate their fellow human beings, while others do not seem to care much for any kind of self-assertion and feel comfortable keeping a low social profile. Such individual differences in the drive for power have been conceptualized and studied over the past 50 years through the prism of the power motive construct. The power motive (also sometimes labeled need Power, or n Power) represents an enduring affective preference for having impact on other people or the world at large (Winter, 1973). Individuals with a strong power motive experience the consummation of the impact incentive as pleasurable and rewarding, whereas individuals with a weak power motive do not derive much pleasure from having impact. Accordingly, the former are more motivated than the latter to seek out opportunities to have impact on others.

From the start, research on the power motive was guided by the notion that introspective access to motivational states and traits is limited and that motives should therefore be assessed indirectly – hence the attribute implicit (McClelland, 1984). In their groundbreaking research on the achievement motive, David McClelland and John Atkinson had shown that experimentally aroused motivational states alter the content of stories that individuals write about picture cues in specific ways that can be codified into reliable scoring systems (McClelland, Atkinson, Clark, & Lowell, 1953). The McClelland-Atkinson approach was first applied towards the development of a measure of implicit power motivation by Veroff (1957), who compared the stories written by candidates in student elections with stories written by students not running for office, and later by Uleman (1972), who devised a scoring system by comparing stories written by students who acted as powerful experimenters with those written by students assigned to the less powerful role of research participant. Winter (1973) conducted additional studies employing experimental arousal of power motivation and cross-validated and combined the content coding categories he had derived in his research with those identified earlier by Veroff and Uleman. According to Winter's integrated scoring system, power imagery is scored whenever a story character expresses a power concern through strong forceful actions, provides unsolicited help, support or advice, tries to control or regulate others' behavior, tries to influence, persuade, bribe, or argue with another person, tries to impress another person or the world at large, arouses strong, non-reciprocal emotions in others, or is concerned with reputation and prestige.

The scoring system is applied to imaginative stories that participants write in response to 4 to 6 picture cues showing people in everyday situations slightly suggestive of themes of power and dominance (e.g., a captain talking to a passenger; two women working in a laboratory; a couple in a nightclub; see Smith, 1992, for reproductions of these and other commonly used pictures). This procedure of collecting imaginative stories for scoring is called the Picture Story Exercise (PSE) and derived from Morgan and Murray's (1935) Thematic Apperception Test. Before scorers can code PSE stories for motivational content, they are required to achieve > 85% reliability on scoring materials prescored by an expert (Smith, 1992). This rigorous criterion ensures high inter-rater reliability: in studies in which two scorers coded the same PSE independently for motivational imagery, inter-rater agreement is usually 80% to 100%. Stability of power motive scores across assessments is substantial, too (see Schultheiss & Pang, in press, for an overview of research on the reliability of implicit motive scores). For instance, Winter and Stewart (1977) reported a retest correlation of .61 for a 1-week interval, and Lundy, and Koestner, Franz, and Hellmann (1991; cited in Smith, 1992) obtained a retest correlation of .55 for an 8-month interval.

A large body of literature supports the validity of Winter's power motive measure (reviewed in McClelland, 1987; Winter, 1996). For instance, consistent with the notion that power motivation should promote social success and visibility, power-motivated individuals have been found to draw others’ attention through risky choices and behaviors (e.g., McClelland & Watson, 1973), to be more likely to ascend to higher levels of management in large corporations (e.g., McClelland & Boyatzis, 1982), to pursue more successful careers (McClelland & Franz, 1992) and to be more sexually active than individuals low in power motivation (e.g., Schultheiss, Dargel, Rohde, 2003 a). The darker side of power motivation is represented by findings involving this need in alcohol abuse, relationship violence, and political radicalism (Lichter & Rothman, 1981; Mason & Blankenship, 1987; McClelland, Kalin, Davis, & Wanner, 1972). Strong evidence for the validity of the power motive measure also comes from research on political behavior and between-group processes. Adapting his power motive scoring system for use with any kind of running text, Winter (1991) found that US presidents whose inaugural speeches were more saturated with power motivation imagery were more likely to wage war, to be assassinated, and to be rated as great by historians than US presidents with fewer power images in their inaugural speeches. Increases and decreases of power motivation assessed in political documents have also been shown to be associated with peaceful and violent outcomes of international crises (Winter, 1987; see also Winter, 1993).

Importantly, the power motive and other implicit motives, such as the needs for affiliation and achievement, are more likely to become aroused by and respond to <u>nonverbal cues</u> than to verbal stimuli (Schultheiss, 2001). Klinger (1967) showed that individuals respond with increases in affiliation or achievement motivation expressed in PSE stories to watching an affiliation-oriented or achievement-oriented experimenter, even if they can not hear his verbal instructions. In a similar vein, Schultheiss and Brunstein (1999; 2002) demonstrated that experimenters who assigned and described a power-related goal verbally to their participants failed to arouse participants’ power motive. Only after participants had an opportunity to translate the verbally assigned goal into an experiential format through a goal imagery exercise did their power motive predict goal commitment and task performance. Recent research indicates that facial expressions of emotion are particularly salient nonverbal cues for the power motive. Power-motivated individuals attend to and condition well in response to expressions signaling another person's low dominance and submission (e.g., surprise) and attend away from and show poor conditioning in response to expressions signaling another person's high dominance (e.g., anger, but also a smiling face) (Schultheiss & Hale, 2005; Schultheiss, Pang, Torges, Wirth, & Treynor, 2005).

Consistent with their nonverbal-processing bias, implicit motives are particularly likely to show an effect on behavior if non-declarative measures (e.g., measures of behaviors and processes that are not controlled by a person's view of herself or himself or the person's explicit intentions) are employed, but have very limited or no effects on declarative measures of motivation (i.e., measures that tap into a person's conscious sense of self and the beliefs, judgements, decisions, and attitudes associated with it). The differential effect of motives on declarative and non-declarative measures was first observed by deCharms, Morrison, Reitman and McClelland (1955), who found that the PSE measure of achievement motivation predicted performance on a scrambled-word test (a non-declarative measure), but not participants' attribution of achievement-related traits to themselves or others (declarative measures of motivation). Later, Biernat (1989) showed that the PSE achievement motive measure predicted performance on a math task (a non-declarative measure of motivation), but not subjects' decision to serve as a group leader on another task (a declarative measure of motivation). In a similar vein, Brunstein and Hoyer (2002) found that high-achievement individuals showed superior performance on a vigilance task (non-declarative measure), but were not more likely than low-achievement individuals to continue on the task if given the choice (declarative measure). Lastly, Schultheiss and Brunstein (2002) found that the PSE power motivation measure predicts nonverbal (e.g., gesturing, facial expressions) and paraverbal (e.g., speech fluency) behaviors on a persuasion task, but not the actual content of the arguments presented, which can be conceived of as a declarative measure.

To summarize, implicit power motivation is assessed through content coding of picture stories and other kinds of verbal material. Motive scores derived in this manner provide an objective, reliable, and valid measure of an individual's need to have impact on others or the world at large. Consistent with the nonconscious, implicit nature of motives assessed per content coding, the power motive is particularly responsive to nonverbal cues, but not verbal-symbolic stimuli, and more likely to influence non-declarative indicators of motivation than declarative ones. There is also considerable evidence for a biological root of implicit power motivation, to which I will turn next.

2. Endocrine and learning correlates of power motivation

Power motivation arousal and sympathetic catecholamines

Initial evidence for a link between implicit power motivation and individual differences in physiological responses to social stimuli came from a study conducted by Steele (1973; see McClelland, 1987, for further details of this research). Steele compared participants whose power motive had been aroused through the presentation of inspirational speeches (e.g., Winston Churchill's speech at Dunkirk) with participants from a control condition who had listened to travel tapes and participants who had listened to an achievement-arousing tape. His dependent variables were changes on the PSE measure of power motivation and urinary metabolites of epinephrine (E) and norepinephrine (NE), two catecholamines that are released by the sympathetic nervous system (SNS) under conditions of acute stress. Steele found that participants in the power-arousal condition had not only significantly higher post-arousal power motive scores than control-group and achievement-arousal participants; post-arousal power motive scores were also correlated .71 with increases in E and .66 with increases in NE in this group. In contrast, catecholamine changes from before to after the experimental manipulation were not significantly associated with power motive scores in control-group and achievement-arousal participants. These findings suggested that power motivation arousal is uniquely associated with an enhanced response of the SNS, as reflected in sympathetic catecholamine increases.

Further support for a link between power motivation and SNS activation came from a study by McClelland, Floor, Davidson, and Saron (1980). They found that power-motivated male students who experienced frequent power challenges in their daily lives (e.g., being physically threatened or encountering difficulties when dealing with the college administration) and who were unable to spontaneously express power-related impulses (as reflected in high activity inhibition scores on the PSE; cf. Schultheiss & Brunstein, 2002) had significantly higher urinary E levels than all other participants.

In another study, McClelland, Ross, and Patel (1985) assessed salivary NE in students immediately and 105 min after an important midterm examination to measure their acute stress response and also took a baseline measure of salivary NE several days after the exam. The midterm exam was considered to be a challenge for power-motivated individuals, because students' status and prestige in college are associated with their academic standing and hence how well they do on examinations. Students whose power motive was stronger than their affiliation motive showed a strong and sustained increase in NE after the exam, whereas students whose affiliation motive was stronger than their power motive showed only a slight NE post-exam increase relative to baseline levels. These findings provide further evidence for the notion that implicit power motivation, in interaction with specific power-arousing situations and cues, predicts SNS activation and catecholamine release.

McClelland (1987 b) speculated that NE, which is released both peripherally and centrally in response to situational challenges, is associated with the experience of having impact and thus represents a biological basis of power motivation reward. A role of NE as the reward substrate of power motivation is unlikely for three reasons, though: First, despite initial speculations about a rewarding role of NE (e.g., Stein, 1975), depriving the brain of NE, either by lesion or chemical depletion, does not impair animals’ capacity for intra-cranial self stimulation, a classical measure of reward and reinforcement (see Rolls, 1999, for a summary). Second, NE is released not only in the context of power-related challenges, but also other acute stressors (such as jumping from an airplane or escaping a predator), which makes a specific role of NE in power motivation reward even less likely. Third, the studies on power motivation and catecholamine release conducted by McClelland and colleagues were not designed to actually reward or frustrate power-motivated individuals’ need for impact and thus to examine what happens upon incentive consummation. Rather, they can be viewed as evidence for a role of NE (and E) in power motivation arousal and thus heightened sensitivity for cues predicting, and energization of behavior directed towards attainment of, the impact incentive.

Testosterone’s role in power motivation reward

A hormone with a stronger claim to a specific role in power motivation is the gonadal steroid testosterone (T). In animals and humans, high levels of T have been found to be associated with dominance, social success, enhanced libido, and assertive and violent behavior (e.g., Albert, Jonik, & Walsh, 1992; Carter, 1992; Mazur & Booth, 1998; Monaghan & Glickman, 1992). In many primates, dominant males show transient T increases in response to dominance challenges (Bernstein, Gordon, & Rose, 1983; Mazur, 1985; Sapolsky, 1987). Human males respond with T increases to winning, and with T decreases to losing, dominance contests such as tennis matches, chess tournaments, or even games of chance against another person (reviewed in Mazur & Booth, 1998). The relationship between dominance and T is less well documented for women (Mazur & Booth, 1998), whose free T levels are about 1/4th to 1/6th of those usually observed in healthy men. However, consistent with the notion that T is crucial for female dominance, too, some research shows that elevated T levels in women lead to enhanced physiological and attentional responses to angry faces (van Honk et al., 1999, 2001), that high-T women occupy higher occupational positions than low-T women in various social hierarchies (e.g., Dabbs, Alford, & Fielden, 1998; Purifoy & Koopmans, 1979), and that female prisoners who are ranking high in the prison hierarchy or have a history of showing unprovoked aggression are characterized by high T levels (Dabbs & Hargrove, 1997; Dabbs, Ruback, Frady, Hopper, & Sgoutas, 1988).

Subjectively, high T levels are associated with feelings of vigor and activation (Dabbs, Strong, & Milun, 1997; Sherwin, 1988). T is an effective anti-depressant in clinical populations with very low or absent endogenous T production (e.g., Rabkin, Wagner, & Rabkin, 1996), but, at supraphysiological doses, can also lead to addiction (Pope & Katz, 1994). Consistent with T's addictive properties, animal studies show that T has reinforcing effects. Systemically or locally administered T increases dopamine transmission in the nucleus accumbens (e.g., Packard, Schroeder, & Alexander, 1998), which is at the heart of the brain's incentive motivation system (Cardinal, Parkinson, Hall, & Everitt, 2002). Administration of T has also been shown to reinforce behavior in conditioned place preference paradigms (Alexander, Packard, & Hines, 1994; Wood, Johnson, Chu, Schad, & Self, 2004). T-induced conditioned place preference can be abolished by the concomitant administration of dopamine antagonists (Packard et al, 1998; Schroeder & Packard, 2000). Accumbens-mediated reinforcing effects of T are particularly pronounced after T has been metabolized to 3α-androstanediol (Frye, Rhodes, Rosellini, & Svare, 2002).

Over the past several years, my laboratory has been dedicated to exploring the link between implicit power motivation and T. In several studies, we have found a slight positive association between basal T levels and the implicit power motive (Schultheiss, Campbell, & McClelland, 1999; Schultheiss, Dargel, & Rohde, 2003 b; Schultheiss, Wirth, Torges, Pang, Villacorta, & Welsh, 2005). However, this association emerges more clearly for men than for women (cf., Schultheiss et al., 2003 b). In a study using an experimental arousal design similar to Steele's (1973), we found that relative to a motivationally neutral documentary film, a movie depicting the aggressive pursuit of dominance (The Godfather II) elicited increases in power motivation on the PSE in both men and women, but T increases only in men with high basal T levels and not in women (Schultheiss, Wirth, & Stanton, 2004). Moreover, in power-arousal-group participants T changes from before to immediately after the movie correlated substantially with changes in PSE power motive scores among men (bipartial $\underline{r} = .86$; $\underline{p} = .001$), whereas T and power motive changes were not significantly associated among women (bipartial $\underline{r} = -.13$; $\underline{ns}$). While these findings may suggest that the power motive and power motivation arousal are not specifically associated with T in women, it is also conceivable that the relatively higher measurement error for the comparatively low female T levels and the smaller magnitude of situation-induced T changes in women may mask a more substantial positive association between T and power motivation in women.

Going beyond correlational links between T and power motivation or power motivation arousal, my colleagues and I have also explored how the power motive influences individuals' T responses and instrumental learning in response to experimentally varied victory and defeat in dominance contests. In our dominance-contest studies, same-sex dyads competed on several rounds of an implicit-learning task which required participants to repeatedly execute a complex visuomotor pattern. The outcome of this contest was varied such that the designated “winner” won most rounds and the designated “loser”accordingly lost most of the time. Participants' motivational dispositions and personality were assessed with a PSE and questionnaires at the beginning of the study; their salivary T levels and their mood were assessed several times before and after the contest; instrumental learning was assessed by determining their learning gains on the implicit-learning task after the contest. Notably, participants had no conscious intention to acquire the visuomotor pattern featured on the implicit learning task, nor did they become aware of the fact that they had learned anything in the first place. Thus, learning was implicit in the sense that it happened automatically and was not mediated by declarative processes (e.g., through explicit memory and self-instruction).

Across three studies conducted with young male adults in the US and Germany, we consistently found that, 15 to 20 min post-contest, power motivation predicted T increases after a victory and T decreases after a defeat (Schultheiss et al., 1999; Schultheiss & Rohde, 2002; Schultheiss, Wirth et al., 2005). However, when we examined the effect of power motivation on women's T responses to the contest outcome, we found a very different pattern of results. In women, power motivation predicted a general sustained post-contest T increase (averaged across assessments at 0, 15 and 30 min after the contest; semipartial $\underline{r} = .29$, $\underline{p} = .01$), regardless of contest outcome. This increase was particularly strong in power-motivated losers immediately after the contest, whereas power-motivated winners showed only a very slight and non-significant T increase at this time.

In contrast to these sex differences in hormonal responses to social victory and defeat, implicit power motivation predicted contest-outcome effects on instrumental learning (sequence execution accuracy) in exactly the same way and magnitude in men and women. In both genders, power motivation was associated with enhanced instrumental learning among winners and impaired instrumental learning among losers. These findings represent a replication of similar results obtained by Schultheiss and Rohde (2002) in a male German sample. Together with that earlier study, they provide straightforward evidence for a moderating role of the implicit power motive in instrumental learning of behavior that has impact on others (i.e., beating one's opponent on the contest) and the inhibition of behavior that led to the frustration of the need for impact (i.e., being beaten by one's opponent).

Consistent with the reinforcing effects of T documented in animal experiments, we also found that men's T changes 15 to 20 min post-contest were associated with instrumental learning and statistically mediated the effect of power motivation on learning. Schultheiss and Rohde (2002) reported that among power-motivated winners, T increases transmitted the boosting effect of power motivation on implicit learning among winners, and Schultheiss, Wirth, et al (2005) found that high-power losers' T decreases translated into impaired implicit learning. (That neither study found the mediation effect in both winners and losers can probably be explained by the fact that the effect of power motivation and T changes was smaller among losers than among winners in Schultheiss and Rohde's study and vice versa in Schultheiss, Wirth et al's (2005) study.) While Schultheiss and Rohde's (2002) and Schultheiss, Wirth, et al's (2005) findings can not conclusively establish a causal reinforcing role of T in instrumental learning, such a causal effect could, in principle, be documented by administering androgen receptor antagonists like flutamide to participants before they enter a dominance contest and thus preventing T and its metabolites from boosting dopamine transmission in the brain's reinforcement circuits.

Paralleling the absence of reports on reinforcing effects of T on behavior in female animals, Schultheiss, Wirth et al (2005) did not find any evidence for a reinforcing effect of T on implicit learning in women. In fact, higher post-contest T levels even showed a negative association with one aspect of implicit learning (speed of visuomotor pattern execution), which is inconsistent with a role of T in reinforcement. The lack of evidence for a reinforcing effect of T on instrumental learning in females does not rule out priming effects of T on power-motivated behaviors. Animal studies show that T lowers the threshold for aggressive behavior in males and females (Albert et al., 1992), and the above-cited research on the effects of T on women's emotional responding to social threats and challenges suggests a priming role of T on female assertiveness in humans, too. Consistent with the hypothesis that T primes self-assertion in women, we found that female losers, who had the strongest T increases immediately after the contest, also showed the greatest increase in power imagery in response to a post-contest PSE picture suggesting aggression (a woman with an angry face and bared teeth; bipartial $r = .34$, $p < .05$), but not to non-aggressive PSE pictures (female judges; women playing basketball; bipartial r = .11, ns). Thus, while elevated T levels after a social defeat do not reinforce instrumental behavior in women, they are associated with what seems to be a compensatory need to assert oneself forcefully.

Finally, our studies also provide pervasive evidence for a dissociation between declarative and non-declarative measures of motivation and motivational outcomes. Declarative measures of power motivation (such as the dominance and aggression scales of Jackson’s, 1985, Personality Research Form [PRF] or the social potency and aggression scales of Tellegen’s, 1982, Multidimensional Personality Questionnaire) did not show consistent or substantial correlation with the non-declarative PSE measure of power motivation or predict, conjointly with contest outcome, T changes and instrumental learning in a consistent or meaningful way in any of our studies. For instance, in the male sample studied by Schultheiss, Wirth, et al (2005), self-reported dominance motivation (PRF) correlated .07 (ns) with implicit power motivation. The correlation between self-reported dominance motivation and T changes 15 min post-contest was -.05 among losers and -.11 among winners (semipartial rs, ps > .10). Likewise, the correlation between self-reported dominance motivation and implicit learning was -.15 among both losers and winners (ps > .10). Conversely, while the implicit power motive, in combination with contest outcome, significantly predicted both T changes and instrumental learning (non-declarative criterion measures), it failed to predict participants’ self-reported affective responses (a declarative criterion measure) to the contest outcome in the Schultheiss and Rohde (2002, unpublished data) and Schultheiss, Wirth, et al (2005) studies. The sole strong predictor of participants’ post-contest mood in all of these studies was the contest outcome, with winners reporting to feel happy and strong and losers reporting to feel sad and weak after the contest. Notably, self-reported affect after the contest also did not significantly correlate with either T changes or implicit learning gains in any study. This pattern of results led Schultheiss, Wirth, et al (2005) to conclude that “conscious experience of pleasure or displeasure is not a necessary corollary of reward and reinforcement" (p. 186).

Frustrated power motivation and cortisol changes

While T appears to scale the reward value of outcomes of dominance-related social interactions in men and may subserve a general power-motivation-enhancing function in women, recent evidence points to a role of cortisol in frustrated power motivation in both genders. Wirth, Welsh, and Schultheiss (in press) analyzed saliva samples collected in Schultheiss and Rohde's (2002) study and in a dominance-contest study conducted with male and female US college students for cortisol (C) levels. C is released by the adrenals under stress, particularly if the stress is uncontrollable, and induces the body to shunt available energy into coping with the stressor. While C is not consistently related to declarative measures of negative affect and stress, it increases reliably in stress-induction paradigms (Dickerson & Kemeney, 2004) and is chronically elevated in depressed individuals (Rothschild, 2003). Wirth et al (2004) found that across both the German and the US samples, implicit power motivation predicted increased C after the contest in losers and decreased C after the contest in winners. According to this finding, a social defeat was particularly stressful for high-power individuals, but not for low-power individuals (who may actually have been comfortable with the defeat; see Schultheiss, Wirth, et al, 2005, for a discussion of this issue).

3. Towards a biobehavioral model of power motivation

So far, I have reviewed evidence implicating the sympathetic catecholamines in power motivation arousal, the gonadal steroid testosterone in male power motivation reward and power-motivated women's response to dominance challenges in general, and the adrenal steroid cortisol in frustrated or stressed power motivation. In the remainder of this chapter, I will review research that suggests that the observed hormonal changes are not independent of each other but represent a coherent, integrated endocrine response to dominance challenges, and I will sketch out how power motivation interacts with situational cues and outcomes to affect hormonal changes and behavior in men and women.

Male power motivation

In men, the major source of androgens (including T) are the testes, with androgen release being driven by pulses of luteinizing hormone (LH) from the pituitary. These LH pulses, and their decline over the course of the day, account for the wave-like release of T, with T peaks occurring every one to three hours, and the typical circadian profile of T, with high levels in the morning and low levels in the evening, but they are in all likelihood too slow to account for the rapid T changes Schultheiss and Rohde (2002) and Schultheiss, Wirth, et al (2005) observed post-contest in men. However, Sapolsky (1986, 1987) has demonstrated in his research on social status and reproductive physiology in baboons that other mechanisms are involved in T secretion besides the LH pathway. He found that the sympathetic catecholamines E and NE have a stimulatory effect on testicular T secretion within minutes, whereas cortisol released from the adrenals inhibits T secretion just as quickly. Thus, the balance between sympathetic catecholamines and cortisol determines whether T release is transiently increased or decreased. Sapolsky observed that dominant baboons showed a comparatively strong catecholamine response and weak cortisol response to stress, leading to a T increase within 30 min (the same time window in which Schultheiss and Rohde, 2002, and Schultheiss, Wirth, et al, 2005, observed transient T peaks in power-motivated winners), whereas low-ranking animals showed a comparatively weak catecholamine response and strong cortisol response to stress, leading to a rapid decline of T.

Research on the relationship between stress hormones and T in humans provides results that are consistent with Sapolsky’s stress-hormone-balance model of T release. For instance, Gerra et al (1996) reported a correlation of .62 for plasma T and NE levels in young male adults, which suggests that these hormones, although released by different glands, are functionally related in humans, too. Eubank, Collins, Lovell, Dorling and Talbot (1997) measured stress hormones and T in marathon canoeists before an important competition and split their subjects into two groups: facilitators, who viewed the competition as a positive challenge, and debilitators, who felt distressed in the face of the contest. In the group of facilitators, T and plasma E and NE increased before the competition, whereas C remained low. In contrast, debilitators showed decreased T and catecholamine levels, but increased C levels immediately before the competition. Finally, the combined T and C data collected from the same sample of German males by Schultheiss and Rohde (2002) and Wirth et al (in press; Study 1) reveal that an inhibitory effect of C on T may only emerge after a defeat: C increases 20 min post-contest were associated with T decreases in losers (bipartial $\underline{r} = -.33$, $\underline{p} = .06$), whereas a positive relationship between changes in both hormones was obtained in winners (bipartial $\underline{r} = .35$, $\underline{p} = .05$). Consistent with Sapolsky's balance model, the lack of an inhibiting effect of C on T increases in winners may have been due to an increased release of catecholamines (not assessed), whose stimulatory effect on T release outweighed the inhibitory effect of C.

Sapolsky's stress-hormone-balance model of T release, in conjunction with the previously reviewed literature on the rewarding properties of T, provide a framework for integrating the endocrine and behavioral changes associated with power motivation arousal and satisfaction/frustration in men. According to the model outlined in Figure 1, in individuals high in power motivation, power-related situational cues and contexts elicit a specific increase in sympathetic catecholamines (as observed by McClelland et al., 1980, 1985), which prime the individual for asserting himself against others. Physiologically, the increasing levels of sympathetic catecholamines result in increases in cardiovascular tone, oxygen uptake, and availability of energy in the form of glucose and fatty acids (Kaplan, 2000). Psychologically, increased levels of sympathetic catecholamines are associated with enhanced sensory signal-to-noise ratio and vigilance (Robbins, 1997). The overall result of these changes make the power-motivated person more physiologically, psychologically, and behaviorally prepared for dealing with a dominance challenge or for taking advantage of an opportunity to have impact on others.

The described sympathetic nervous system changes occur on the order of seconds and minutes. To the extent that they persist, fanned by feedback from the environment signaling to the individual that the challenge can be effectively countered and controlled (Henry, 1992), they have a stimulatory effect on the testicles, thus inducing the release of T observed in power-motivated contest winners 15 to 20 min post-contest in Schultheiss and Rohde's (2002) and Schultheiss, Wirth, et al's (2005) studies and the transient T increase observed in dominant primates when their dominance is challenged (Bernstein et al., 1983; Sapolsky, 1987). In males, this T increase has two short-term effects: First, it temporarily lowers the threshold for aggression, thus making the individual more pugnacious and willing to defend or assert his dominance over others (Albert et al., 1992; Sapolsky, 1987). Second, through its anabolic effects, increased T helps to increase muscle strength within minutes to hours, which would provide physiological backup for the individual's increased proneness to engage in dominance conflicts with others (Tsai & Sapolsky, 1996). Victory-induced T increases also have a long-term effect on behavior by their effects on dopamine transmission in the striatum, which accentuate learning of the behaviors that ultimately led to victory (cf. Frye et al., 2003; Packard et al., 1998).

To the extent that a power-motivated individual loses control over the outcome of a contest, however, the stress-hormone balance tilts the other way, towards a net increase of C over sympathetic catecholamines (note that catecholamines may increase under these conditions, too; however, their effect is likely to be offset by the strong C increases). The net effect of this shift in stress hormones is an increased inhibitory action of C on testicular T release that outweighs the stimulatory effect on catecholamines and results in the stagnating or decreasing T levels observed in power-motivated losers by Schultheiss and Rohde (2002), Schultheiss et al (1999) and Schultheiss, Wirth, et al (2005). The increased C levels may reflect a switch from dealing with a challenge that can be met to adjusting to an uncontrollable stressor, consistent with fact that the individual has lost dominance and thus control over his opponent. Psychologically, decreased C levels raise the aggression threshold for the individual through removing inhibition on T release. Thus, it will take a stronger stimulus to make him engage in another dominance encounter than previously, and this may protect the individual from further costly defeats (cf. Mazur, 1985). Reduced T may also be causally involved in impaired learning of behavior that was “instrumental” for the defeat by attenuating striatal dopamine transmission and thus the “glue” that would help consolidate goal-directed behavior. However, it is also conceivable that reduced C has a direct attenuating effect on reinforcement through its inhibiting effects on dopamine synthesis and turnover (cf. Pacak et al., 2002). Whatever the precise mechanism, its outcome ensures that behavior that was counterproductive to the power-motivated individual’s goal of having impact will not make it into the individual’s repertoire of power-related skills.

Female power motivation

My tentative biobehavioral model of female power motivation is similar to the male model in most respects (see Figure 2). Thus, based on the research reviewed previously, it is clear that situations and contexts that arouse or challenge a woman’s power motivation stimulate the release of sympathetic catecholamines, which induce physiological and psychological changes conducive to active coping with the task at hand. Likewise, in the studies reported by Schultheiss, Wirth, et al (2005), power-motivated women do not differ from power-motivated men in their learning responses to the contest outcome: winners show enhanced, losers show impaired instrumental learning. Finally, power-motivated women, like power-motivated men, respond with a C increase to a social defeat (Wirth et al., in press).

The model of female power motivation differs from the male model in two crucial respects, though. First, there is no evidence that T increases are associated with instrumental learning and reinforcement in women. Schultheiss, Wirth, et al (2005) failed to find significant positive correlations between women's post-contest T increases and indicators of instrumental learning of behavior that had been involved in winning or losing the contest. As mentioned previously, this finding is in agreement with the animal literature on the reinforcing properties of T, which so far have been documented for male mammals only. Note, however, that this lack of a role of T in reinforcement in females does not preclude such a role for other gonadal steroids such as estradiol or T precursors and metabolites. Also, because there is considerable evidence for a role of elevated T in female dominance and aggression (see above), the absence of reinforcing effects of T in women does not seem to diminish T's role as a facilitator of power-motivated behavior.

Second, there is little evidence that Sapolsky's stress-hormone balance model of T release and inhibition applies for females in the same way that it applies for males. In contrast to their pronounced stimulatory effect on the testes, sympathetic catecholamines do not seem to be capable by themselves to stimulate androgen release from the female ovaries (Dyer & Erickson, 1985). Moreover, whatever stimulatory or inhibitory effects stress hormones may exert on T release from the ovaries would not have a strong influence on circulating levels of T in women, because the relative contribution of the gonads to overall T levels is comparatively much smaller in women than in men – hence the substantially lower total T levels in women. In contrast, the adrenal glands represent a more significant source of circulating androgens in women than in men (Ojeda, 2000). Schultheiss, Wirth, et al (2005) therefore proposed that the rise in T observed in power-motivated women (and particularly in losers) after a contest may be the result of increased androgen release from the adrenal cortex, possibly triggered by increased stress axis activation. Because women may be more sensitive to even slight changes in T (Sherwin, 1988), the T-increasing effect of (lost) dominance challenges may make power-motivated women more likely to seek and engage in further opportunities to assert themselves.

Clearly, the biobehavioral model of female power motivation is much more speculative and in need of empirical corroboration than the model of male power motivation, for which numerous converging lines of evidence exist in the animal and human literature. It is notable that the lack of research in the hormonal correlates and mechanisms of female dominance behavior, deplored by Sapolsky in 1987, persisted more than ten years later, when Mazur and Booth (1998) concluded that the empirical literature on the role of T in female dominance is scant and disparate, and continues until this day. To the extent that the unequal allocation of research efforts to the endocrine correlates of dominance in men and women is due to researchers' implicit or explicit assumption that issues of dominance are more salient or important among men, consultation of the literature on implicit power motivation may provide a healthy corrective. In their review of gender differences in implicit motives, Stewart and Chester (1982) concluded that women and men do not substantially differ in their average level of power motivation, in the cues and stimuli that arouse their need for power, or in the behaviors that they employ to have impact on others (see also Pang & Schultheiss, in press; Schultheiss & Brunstein, 2001; Schultheiss, Wirth, & Stanton, 2004). Given the strong links between implicit power motivation and physiological processes, the power motive construct may therefore represent a particularly suitable vantage point from which to study the hormonal correlates of dominance and self-assertion in women.

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Acknowledgements

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Figure captions

Figure 1. Biobehavioral model of male power motivation arousal and reward/frustration.

Figure 2. Biobehavioral model of female power motivation arousal and reward/frustration. The bold arrow reflects Schultheiss, Wirth, et al’s (2005) finding that for power-motivated women, a social defeat transiently raises testosterone more than a victory.

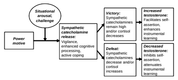
Situational arousal, challenge
Power motive
Sympathetic catecholamine release: Vigilance, enhanced cognitive processing, active coping
Victory: Sympathetic catecholamines remain high and/or cortisol decreases
Defeat: Sympathetic catecholamines decrease and/or cortisol increases
Increased testosterone: Facilitates self-assertion, enhances instrumental learning
Decreased testosterone: Inhibits self-assertion, attenuates instrumental learning

Figure 1.

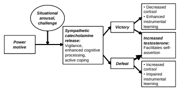
Situational arousal, challenge
Power motive
Sympathetic catecholamine release: Vigilance, enhanced cognitive processing, active coping
Victory
Defeat
• Decreased cortisol • Enhanced instrumental learning
Increased testosterone: Facilitates self-assertion
• Increased cortisol • Impaired instrumental learning

Figure 2.