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TESTOSTERONE AND THE BIOLOGY OF POLITICS

Experimental Evidence from the 2008 Presidential Election

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Although scholars have long recognized the central role politics plays in our lives they have only recently begun to study the biology underlying political behavior. Hormones have been implicated in a number of social behaviors, and behavioral endocrinology, a relatively new subfield of biology, seeks to understand the reciprocal relationship between hormones and behavior. In this chapter, we focus on testosterone (T), a 19-carbon steroid hormone best known for its role in the development and maintenance of masculine features. The intent of this chapter is to provide a basic framework for understanding testosterone action and its influence on behavior in the political domain.

We will also include an illustration of how the field of endocrinology can be used to inform political science by describing a study we conducted during the 2008 U.S. presidential election where we examine changes in testosterone levels of male participants with varying levels of partisan identification as they watched the election unfold. This chapter is meant to go beyond describing the mechanisms and channels by which T affects behavior by also addressing the reciprocal nature between testosterone and behavior. We also attempt to ground our understanding of this relationship within an evolutionary framework. Toward this end, we can ask: Does testosterone affect political behavior? Does political behavior affect testosterone? And if there is a relationship between testosterone and political behavior, what, if any, is the adaptive significance of such a relationship?

A Primer on Testosterone

As we learned in the previous chapter, the endocrine system is a system of cellular communication where information about an individual's physical and social world is transduced in an integrative fashion with the genome, through its regulation of gene expression, and the nervous system. Given the highly integrative and reciprocal manner by which the endocrine system operates, the scientific study of the interrelationships between hormones and behaviors is a complex one.

Testosterone is a steroid hormone in the family of androgens because it has 19 carbons. All steroids begin as a progestin with 21 carbons. Progestins are precursors for androgens, which in turn, are precursors for estrogens, which only have 18 carbons. The significance of this is that women first make androgens that are aromatized into estrogens. Similarly, men aromatize androgens into estrogens but in relatively smaller quantities. Thus it is the relative amounts of hormones synthesized by each sex that vary. The largest amounts of testosterone are produced by the leydig cells of the testes in men and to a lesser extent by the adrenal gland. Women synthesize about one-eighth of the amount of testosterone as men and this is done so in roughly equal quantities in both the ovaries and the adrenal gland. Finally, T displays a diurnal rhythm in both sexes where the highest and most variable amounts are in the morning.

Due to the development of radioimmunoassay, behavioral endocrinological research has flourished in the past 50 years. Before this, measurement of endogenous T was difficult because it circulates in the bloodstream in very minute quantities. Often testosterone will be measured in nanograms (ng, 10^{-9} g) and will be reported as a percentage relative to 100 ml of blood plasma. Typical levels for men are around 10ng/ml. Today it is also possible to measure free T (e.g., the biologically active or "unbound" testosterone) in saliva. This sampling method is often more practical for behavioral researchers than blood plasma measurement as it is less invasive and samples often do not require immediate refrigeration or freezing. While T is secreted into the bloodstream in spurts, so that levels change considerably within minutes, salivary measurement is able to pick up moment to moment changes.

Many behavioral endocrinologists rely on observational (i.e., nonexperimental) studies as an initial approach for documenting relationships between T and behavior. Though such observational studies are a useful first step, interpreting correlations derived from observational data is complicated. One complication arises because of reciprocal causality; T might be causing behavior and behavior might be affecting T levels. Without carefully controlled experiments, in which hormones or social/behavioral contexts are manipulated, it is difficult to establish causality.

Adding to the complexity is the fact that T also has two different processes by which it exerts its influence. That is, it has both organizational and activational effects. In mammals, T exerts organizational effects on the brain early in ontogeny during sexual differentiation and again during puberty. These organizational effects are more permanent and affect male behavior in the long term by programming how individuals respond to current levels of T or what we call the activational or nonpermanent effects of T. Teasing apart organizational from activational effects is difficult because the organizational effect of T may not be related to current levels (Wallen and Hassett 2009). Thus, consideration of exposure during these critical periods of development, as well as current circulating levels of T, is essential to fully understand the role T has in influencing behavior (Apicella et al. 2008).

The last 20 years has witnessed a surge in studies that attempt to identify relationships between circulating T and social behavior. Testosterone has been associated with increased aggression (Archer 2006), sensation seeking (see, e.g., Roberti 2004 for a review), hostility (Hartgens and Kuipers 2004), mate-seeking (Roney, Mahler, and Maestripieri 2003), food acquisition (Worthman and Konner 1987), dominance (Mazur and Booth 1998), and, more recently, financial risk-taking (Apicella et al. 2008).

Testosterone is found to rise in men in response to challenges and winners of competitive interactions often experience a relative increase in T compared to losers (Wingfield et al. 1990; Mazur and Booth 1998). This differential T response has been found for physical competitions, for example, wrestling (Elias 1981) and tennis (Booth et al. 1989) and even noncognitive chance-based competitions such as coin tosses (McCaul, Gladue, and Joppa 1992). Interestingly, fans of sports teams also experience a similar pattern of response though they themselves are not participants in the competition (Kemper 1990). Since political elections are also a form of competition we decided to examine whether this differential response in T also holds in the political domain. The study described below uses the 2008 presidential election as a natural experiment to examine T responses in men to the election outcome.

A Natural Experiment: Testosterone Response Following the 2008 U.S. Presidential Election

Rationale

Males of many primate species devote considerable effort to gaining status and dominance since it often confers a reproductive advantage (Wrangham, "Evolution" 1999). Competitions are important not only in determining status hierarchies within groups but also for establishing dominance over other groups. Hierarchies are often established through direct physical fighting, but in humans status contests are also resolved through complex social and political arrangements, for example, large-scale elections.

It has been suggested that political participation, which at the individual level can be costly, occurs not only out of self-interest but also out of concern for members of one's in-group (Fowler and Kam 2007). Individuals tend to organize their world into cultural groups formed on the basis of kin, shared values, and norms, and at times subtle and even arbitrary symbolic differences (Tajfel et al. 1971; Efferson, Lalive, and Fehr 2008). In-group favoritism, where reward allocation is biased toward members of one's own group, has been demonstrated in a number of domains (Yamagishi, Jin, and Kiyonari 1999), including politics. Not surprisingly, both Republicans and Democrats are more charitable to members of their own party than to members of the opposing party (Fowler and Kam 2007). Despite the potential importance of group membership, little work has been conducted on hormonal responses to group competitions, with the literature on sport teams being an important exception (Bernhardt et al. 1998), which finds that spectator T responses parallel those of participants in sports event, though not always as strongly.

As mentioned earlier, T levels respond differently to winning and losing, with members of losing teams experiencing a relative decline. Here we wanted to examine whether this finding also holds for political competitions. To do this, we examined T responses in men with varying levels of partisan identification by election outcome. We hypothesized that strength of partisan identification would be associated with the T response so that a stronger attachment to the losing party will be correlated with a stronger relative decline in T.

This T response may have an adaptive function. Elevated T levels in winners of competitions may serve to reinforce the successful behavior and encourage further dominance-seeking behaviors (Wingfield et al. 1987; Mazur 1985). Overconfidence, believed to be mediated in part by T, has been postulated as a source of intergroup conflict and war (Johnson et al. 2006). Conversely, the decline in T exhibited after losses may serve to inhibit behaviors that escalate conflict. Therefore, we were also interested in examining whether political wins and losses, along with their associated T responses, affect individuals' levels of investment and commitment to their political group. To do this, we measured generosity toward an individual's political party using a standard dictator game (Forsythe et al. 1994), both before and after the election. Participants were given five dollars (USD), of which any amount could be anonymously donated to their political party. Thus supporting one's political in-group requires individuals to incur a small pecuniary cost and can be thought of as a measure of both support and affirming commitment (Fowler and Kam 2007). We hypothesized that loss should be associated with a relative decline in group support.

Methods

Twenty-four male participants were recruited via e-mail lists of political organizations or clubs at colleges in the greater Boston area. The sample included men between the ages of 18 and 32 (mean 22.70, S.D. 4.00) who were not taking psychotropic or hormonal medication. Based on self-report, the sample was 50% White, 25% Asian, 21% Hispanic, and 4% Other. Of the nine Republicans who participated, four were strong Republicans, two were moderate Republicans, and three were weak Republicans. Of the thirteen Democrats, five self-identified as strong Democrats, seven as moderate, and one as weak. Two subjects reported being politically Independent. The study was approved by the Harvard University's Committee on the Use of Human Subjects in Research. Participation was anonymous and all subjects gave informed consent to participate.

Subjects were instructed to arrive at 6:45 p.m. to a cinema on the Harvard campus rented solely for the purpose of the study. Subjects were provided with a t-shirt for their candidate and other political paraphernalia. The cinema was decorated with American flags, red and blue balloons, and streamers. On the cinema screen, we projected the election coverage of CNN. Subjects remained at the study site throughout the evening. Three subjects, however, were recruited from a nearby campus common area that was also broadcasting CNN's election coverage. These subjects were also given political paraphernalia in support of their candidate, were in the presence of a research assistant, and did not differ systematically from the primary sample in their T levels and pattern of change.

Three unstimulated saliva samples via passive drool were provided throughout the course of the evening for salivary T measurement. Upon arrival, the first sample was collected from participants. Participants were asked to spit through a straw into a small polystyrene tube. Subjects also filled out a short questionnaire to gauge political preferences. Basic demographic information was also collected. Finally, subjects were given an envelope containing five one-dollar bills, of which they could anonymously donate any share to the party of their preferred candidate. Subjects were required to submit an envelope to the experimenters even if they decided not to make a donation.

A second saliva sample was provided at 8:40 p.m., just as CNN projected an Obama win in Pennsylvania. Several crucial swing states, including Colorado, Indiana, Florida, Missouri, North Carolina, Ohio, and Virginia, had not yet been called. A third saliva sample was collected at 11:15 p.m., approximately fifteen minutes after CNN, and all other major networks, called the election to Obama. At this point, a second envelope with five one-dollar bills was distributed and subjects could make an anonymous donation to their party of up to five dollars.

Results

Each subject reported the strength of their partisan identification on a seven-point scale with categories Strong Democrat (assigned the value −3) Moderate Democrat (−2), Weak Democrat (−1), Independents (0) and so on up to Strong Republicans (3). Summary statistics are reported in table 9.1, disaggregated by party affiliation.

TABLE 9.1. Summary statistics. Testosterone is measured in pg/ml from saliva samples obtained at approximately 7.00 pm (Testosterone 1), 8.30 (Testosterone 2) and 11.00 (Testosterone 3). Donations were solicited at approximately 7pm (Donation Amount 1) and 11 pm (Donation Amount 2). The "Total" column includes two subjects who reported being politically independent.

	Democrats (n=13)		Republicans (n=9)		Total (n=24)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Testosterone 1	42.15	16.79	53.28	20.81	49.33	21.62
Testosterone 2	33.28	10.28	37.07	20.69	36.38	20.20
Testosterone 3	39.16	14.43	35.02	11.28	36.21	13.39
Donation 1 (USD)	1.92	2.18	2.89	2.52	2.32	2.32
Donation 2 (USD)	1.46	2.30	.56	1.67	1.09	2.07
Age (in years)	23.07	3.75	21.69	3.37	22.78	4.00
Race (1 if white)	.46	.52	.56	.53	0.50	0.51

Since the data were collected over a period of 4 hours, there was an average decline of T of 13.12 pg/mL over the course of the evening (paired t-test; two-sided, $t = 2.62$, $p = 0.015$, two-sided, $n = 24$). This decline is consistent with the natural diurnal pattern of T (Dai et al. 1981). There was also a decline in the average donation amount, from $2.13 on average before the election to $1.00 after the election result. This decline was statistically significant (paired t-test; $t = 2.45$, $p = 0.022$, two-sided, $n = 24$) and discernible in both Democrats and Republicans. The differences between Republicans and Democrats in donations and testosterone levels at arrival were not significant at the 5% level and we are hence reluctant to attach too much significance to them.

Our primary hypothesis was that the T response to the electoral outcome would be a function of the strength of partisan identification. We defined the T response as the difference between T measured at the beginning of the evening, before any results had been announced, and the end of the evening, shortly after Wolf Blitzer announced on CNN that Barack Obama had won the election.

Regressing the T response on partisan identification, the coefficient on partisan identification is quantitatively large and statistically significant (linear regression; $\beta = -4.53$, $p = 0.045$, two-sided, $n = 24$). This coefficient suggests that moving one integer up the partisan scale, for example going from being a Weak Democrat to a Moderate Democrat, is associated with experiencing a 4.53 pg/mL smaller T decline, on average, during the course of the evening. The relationship retains significance if the two Independent observations are not included (linear regression; $\beta = -4.17$, $p = 0.027$, two-sided, $n = 22$). The correlation between the T response and partisan identification is illustrated graphically in the first panel of figure 9.1.

A second hypothesis concerned the effect of the electoral outcome on the willingness to donate to one's in-group. We find some evidence in support of the proposition that defeat depresses the willingness to donate to one's in-group. Regressing the difference in donation on partisan identification, the coefficient on partisan identification is just shy of significant (linear regression; $\beta = -.41$, $p = 0.055$, two-sided, $n = 22$). This result excludes the two Independents, who were both offered the opportunity to donate money to the party of either candidate but declined to do so. Including the Independents does not appreciably change the result (linear regression; $\beta = -0.40$, $p = 0.054$, two-sided, $n = 24$). Finally, exploratory analyses reveal that the change in testosterone is associated with the change in donations within partisans (linear regression; $\beta = 4.71$, $p = 0.012$, two-sided, $n = 22$), but the statistical

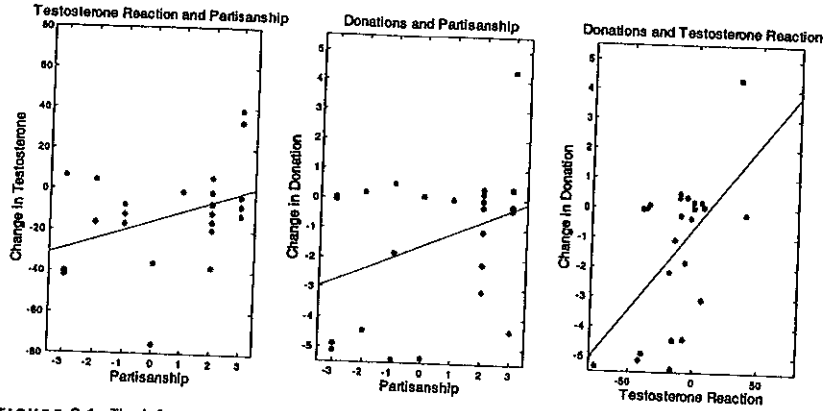

FIGURE 9.1. The left panel is a scatterplot of the change in testosterone pg/mL (third sample minus first sample) against the partisan identification, where −3 is Strong Democrat, −2 is Moderate Democrat, −1 is Weak Democrat, 0 is Independent, and so on up to 3 for Strong Republicans. The middle panel is a scatterplot of the change in donation (donation after the Democratic win minus the donation before the Democratic victory) against partisan identification. The unit is $USD. For expositional clarity (several points in the original dataset were overlapping) the donation change has been jittered. The right-hand panel plots the testosterone change against the donation change. A blue star denotes a Democratic individual, a red star denotes a Republican individual, and a black star denotes an Independent individual.

significance vanishes when the Independents are included (linear regression; $\beta = 3.70$, $p = 0.105$, two-sided, $n = 24$).

Conclusions

Recent research in political science has sought to uncover specific biological substrates that underlie variation in political traits including ideology and behavior. Studies of twins have shown that much individual variation in both political attitudes and behaviors can ultimately be traced to genes (Fowler, Baker, and Dawes 2008; Martin et al. 1986; Alford, Funk, and Hibbing 2005). Scholars have also taken tentative steps toward understanding how specific genes, often interacting with the environment, influence complex traits such as voting (Fowler and Dawes 2008) and strength of partisanship (Hatemi et al. 2008). Other lines of work ask how neuroscience can inform political science (McDermott 2004) and how individual differences in physiological reactions to fearful stimuli can predict political views (Oxley et al. 2008). This study was meant to be used as an example of how the field of behavioral endocrinology can be used to understand political behavior.

The results reported here provide a demonstration of a differential hormonal reaction in partisan supporters of an election. The stronger a subject

was attached to the party of the losing candidate, the greater his relative testosterone decline. The relative decline in testosterone in losers may serve to appropriately calibrate, or adjust, confidence to realistic levels and promote withdrawal behavior from contests that are likely to result in further harm, while an increase in testosterone in winners may prime the winner for subsequent competition and further status elevation, possibly through its effects on confidence (Wrangham, "Is military incompetence" 1999; Johnson 2004). In this way, testosterone serves as a biological reinforcer of behavior (Wingfield et al. 1987; Mazur 1985). Consistent with this hypothesis, Mehta and Josephs (2006) reported that following defeat, losers who experienced an increase in testosterone were more likely to enter anew into competition compared to losers who did not experience such an increase.

In line with the hypothesis that decreased testosterone may result in the withdrawal of investment we found that partisan identification was associated with a decline in generosity, as measured by anonymous donations made before and after the electoral outcome was announced. In addition, within partisan subjects, the decline in generosity was predicted by the decline in testosterone. These results are not inconsistent with conventional wisdom that higher testosterone overall should be associated with less prosociality and decreased investment (Harris et al. 1996), as there is some evidence of the testosterone response being correlated with change in donations. Here we did not, however, find a relationship between overall testosterone levels and donation amount.

Although wide-scale elections are evolutionarily novel, coalition building and dominance seeking likely played a crucial role in human evolution. Men are concerned with gaining dominance as the spoils of increased status often include increased resources and access to mates (Wrangham, "Is military incompetence" 1999; Chagnon 1968). While most animals compete in dyads, humans frequently compete in groups. In addition, dominance contests in animals are mostly physical, while human contests are often socially determined (Boehm 1999).

In light of the small sample size, it is important to be modest about these findings. Yet many studies that have examined changes in testosterone by competition outcome have used comparable samples sizes (van Anders 2007). We also emphasize that these results were obtained under far from ideal conditions. It is likely that the testosterone response is muted when a defeat or victory is expected. The implied probability of an Obama win, as inferred from the prices on the online betting markets, was approximately 90% the day before the election. This figure probably masks much heterogeneity in

beliefs, but suggests that an Obama victory was widely anticipated though not certain. The fact that we still find a large, but imprecisely estimated, differential testosterone response suggests the election was deemed to be of sufficient significance to generate a hormonal reaction.

We suggest that future work examine hormonal changes in the context of political competitions using larger and more diverse samples. In summary, we report novel data suggesting that the "winner-loser effect" also holds true in the political arena. We suggest that findings such as these, if successfully incorporated into models of political behavior, might ultimately lead to a more comprehensive political science.

Note

Samples were frozen by midnight and stored at −20°C. Samples were packed in dry ice and shipped via FedEx overnight delivery to Salimetrics of State College, Pennsylvania. Samples were assayed for salivary T in duplicate using a highly sensitive enzyme immunoassay (Cat. No. 1-2402, Salimetrics LLC, State College). The test used 25 µl of saliva per determination, has a lower limit of sensitivity of 1.0 pg/mL, standard curve range from 6.1 pg/mL to 600 pg/mL, an average intra-assay coefficient of variation of 4.6% and an average inter-assay coefficient of variation of 8.25%. Method accuracy determined by spike recovery averaged 104.4% and linearity determined by serial dilution averaged 99.9%.

References

Alford, J. R., C. L. Funk, and J. R. Hibbing. 2005. Are political orientations genetically transmitted? *American Political Science Review* 99 (2): 153–67.

Apicella, C. L., A. Dreber, B. Campbell, P. B. Gray, M. Hoffman, and A. C. Little. 2008. Testosterone and financial risk preferences. *Evolution and Human Behavior* 29:384–90.

Archer, J. 2006. Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neuroscience and Biobehavioral Review* 30:319–45.

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

Boehm, C. 1999. *Hierarchy in the forest: The evolution of egalitarian behavior*. Cambridge: Harvard University Press.

Booth, A., G. Shelley, A. Mazur, G. Tharp, and R. Kittock. 1989. Testosterone and winning and losing in human competition. *Hormones and Behavior* 23:556–71.

Chagnon, N. A. 1968. *Yanomamo, the fierce people*. New York: Rinehart and Winston.

Dai, W., L. Kuller, R. LaPorte, J. Gutai, L. Falma, and A. Gagguela. 1981. Epidemiology of plasma T levels in middle-age men. *American Journal of Epidemiology* 114:804–16.

Efferson, C., R. Lalive, and E. Fehr. 2008. The coevolution of cultural groups and in-group favoritism. *Science* 321:1844–49.

Elias, M. 1981. Serum cortisol, testosterone, and testosterone-binding globulin responses to competitive fighting in human males. *Aggressive Behavior* 7:215–24.

Forsythe, R., J. L. Horowitz, N. E. Savin, and M. Sefton. 1994. Fairness in simple bargaining experiments. *Games and Economic Behavior* 6:347–69.

Fowler, J. H., L. A. Baker, and C. T. Dawes. 2008. Genetic variation in political participation. *American Political Science Review* 102:233–48.

Fowler, J. H., and C. T. Dawes. 2008. Two genes predict voter turnout. *Journal of Politics* 70 (3): 579–94.

Fowler, J. H., and C. D. Kam. 2007. Beyond the self: Altruism, social identity, and political participation. *Journal of Politics* 69:811–25.

Harris, J. A., J. P. Rushton, E. Hampson, and D. N. Jackson. 1996. Salivary testosterone and self-report aggressive and pro-social personality characteristics in men and women. *Aggressive Behavior* 22:321–31.

Hartgens, F., and H. Kuipers. 2004. Effects of androgenic-anabolic steroids in athletes. *Sports Medicine* 34: 513–54.

Hatemi, P. K., J. R. Alford, J. R. Hibbing, N. G. Martin, and L. Eaves. 2008. Is there a "party" in your genes? *Political Research Quarterly*: doi:10.1177/1065912908327606.

Johnson, D. 2004. *Overconfidence and war*. Cambridge: Harvard University Press.

Johnson, D.D.P., R. McDermott, E. S. Barrett, J. Cowden, R. Wrangham, M. H. McIntyre, and S. P. Rosen. 2006. Overconfidence in wargames: Experimental evidence on expectations, aggression, gender and testosterone. *Proceedings of the Royal Society of London B-Biological Sciences* 273 (1600): 2513–20.

Kemper, T. D. 1990. *Social structure and testosterone*. New Brunswick, N.J.: Rutgers University Press.

Martin, N. G., L. J. Eaves, A. C. Heath, R. Jardine, L. M. Feingold, and H. J. Eysenck. 1986. Transmission of social attitudes. *Proceedings of the National Academy of Sciences* 83:4364–68.

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

Mazur, A., and A. Booth. 1998. Testosterone and dominance in men. *Behavior and Brain Sciences* 21:353–63.

McCaul, K. D., B. A. Gladue, and M. Joppa. 1992. Winning, losing, mood, and testosterone. *Hormones and Behavior* 26:486–504.

McDermott, R. 2004. The feeling of rationality: The meaning of neuroscientific advances for political science. *Perspectives on Politics* 2:691–706.

Mehta, P. H., and R. A. Josephs. 2006. Testosterone change after losing predicts the decision to compete again. *Hormones and Behavior* 50:684–92.

Oxley, D. R., K. B. Smith, M. W. Hibbing, J. L. Miller, J. R. Alford, P. K. Hatemi, and J. R. Hibbing. 2008. Political attitudes vary with physiological traits. *Science* 321 (5896): 1667–70.

Roberti, J. W. 2004. A review of behavioral and biological correlates of sensation seeking. *Journal of Research in Personality* 38:256–79.

Roney, J. R., S. V. Mahler, and D. Maestripieri. 2003. Behavioral and hormonal responses of men to brief interactions with women. *Evolution and Human Behavior* 24:365–75.

Tajfel, H., M. G. Billig, R. P. Bundy, and C. Flament. 1971. Social categorization and intergroup behavior. *European Journal of Social Psychology* 1:149–78.

Wallen, K., and J. Hassett. 2009. Neuroendocrine mechanisms underlying social relationships. In *Endocrinology of social relationships*, ed. P. T. Ellison and P. B. Gray, 32–54. Cambridge: Harvard University Press.

Wingfield, J. C., G. F. Ball, A. M. Dufty Jr., R. E. Hegner, and M. Ramenofsky. 1987. Testosterone and aggression in birds. *American Scientist* 75:602–8.

Wingfield, J. C., R. E. Hegner. A. M. Dufty Jr., and G. F. Ball. 1990. The "Challenge Hypothesis": Theoretical implications for patterns of testosterone secretion, mating systems, and breeding strategies. *American Nature* 136:829–46.

Worthman, C. M., and M. J. Konner. 1987. Testosterone levels change with subsistence hunting effort in !Kung San men. *Psychoneuroendocrinology* 12:449–58.

Wrangham, R. 1999. Is military incompetence adaptive? *Evolution and Human Behavior* 20:3–17.

———. 1999. Evolution of coalitionary killing. *Yearbook of Physical Anthropology* 42:1–30.

Yamagishi, T., N. Jin, and T. Kiyonari. 1999. Bounded generalized reciprocity: In-group boasting and in-group favoritism. *Advances in Group Processes* 16:161–97.