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Losing the battle but winning the war: Uncertain outcomes reverse the usual effect of winning on testosterone

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ABSTRACT

The biosocial model of status predicts a competition effect (or winner–loser effect), whereby winning a competition should cause a rise in testosterone relative to losing. However, its applicability to women and the role of contextual factors, such as a decisive versus close match, have been overlooked. In two studies of female competition, we tested whether the winner–loser effect generalizes to dominance contests that model unstable social hierarchies, namely in close competitions wherein the winner–loser distinction is unsettled (Study 1) and in competitions in which the outcome is uncertain (Study 2). In both studies we found evidence for a *reverse* winner–loser effect whereby losers experienced a net increase in testosterone compared to winners. Moreover, the rise in testosterone was stronger in those competitors who reported being more surprised by the loss (Study 2). These results represent some of the first empirical evidence for the reverse effect of what is predicted by the biosocial model of status. We interpret these findings in terms of the dominance motivation that testosterone might subserve within unstable status hierarchies.

1. Introduction

In women's tennis history one of the most famous rivalries took place between Steffi Graf and Arantxa Sanchez Vicario, who between January 1994 and July 1996 faced each other for no less than six Grand Slam finals. At the 1996 Wimbledon final, Graf dominated the entire match and won; Vicario later acknowledged the clear superiority of her opponent. A more memorable match, however, took place at the French Open final of the same year. Again, Graf emerged as victorious, but only after a riveting, back-and-forth final round that was one of the longest ever. Remarking on her narrow victory after the final game, Graf predicted victory for her rival on their next meeting; and apparently feeling poised to win, Vicario challenged Graf to a rematch. In short, it had become unclear which player was dominant. The underlying psychological and biological processes in close and uncertain competitions like the classic Graf–Vicario rivalry – in contrast to the unambiguous win–lose scenarios typically employed in studies of the "Competition Effect" – is the topic of the present research.

More than a century of research suggests that the steroid hormone testosterone regulates competitive and socially dominant behaviors across the animal kingdom, behaviors that are implicated in the pursuit of status within social hierarchies. One of the most influential theories of testosterone and social behavior – the biosocial model of status (BMS) – posits a dynamic, bidirectional relationship between testosterone and status (Mazur & Booth, 1998). According to the model, not only does testosterone encourage status-seeking behaviors, but changes in status should in turn alter testosterone concentrations. Specifically, the BMS predicts that winning a competition should cause a rise in testosterone relative to losing, and these testosterone changes should in turn guide individuals toward or away from future attempts at gaining status (Mazur & Booth, 1998). This model has garnered empirical support in many species ranging from mice to nonhuman primates and humans (for example, Bernstein, Rose, & Gordon, 1974; Lloyd, 1971; Zilioli & Watson, 2012). Most human studies have used sports competitions – such as soccer (Oliveira, Gouveia, & Oliveira, 2009), tennis (Mazur & Lamb, 1980), and volleyball (Edwards & Kurlander, 2010) – to model status dynamics and testosterone changes. Consistent with the predictions of the BMS, many of these studies show a *competition effect* (or winner–loser effect) whereby winners show

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an increase in testosterone for a few hours following the competition, while losers show a decrease in testosterone. Such effects are seen in competitors not only following their contests, but also when reviewing previous contests on video; in one example, hockey team members showed an increase in salivary testosterone after viewing a previous game that they had won (Carré & Putnam, 2010). Impressively, even purely vicarious competition effects have been observed, in the testosterone responses of sports fans witnessing wins or losses of their favorite teams. For example, in a study of soccer fans watching a World Cup match, fans that rooted for the winning team showed an increase in testosterone after the match relative to fans who rooted for the losing team (Bernhardt, Dabbs, Fielden, & Lutter, 1998). Similarly, on the night of the 2008 US presidential election, people who supported the losing candidate (McCain) dropped in testosterone relative to people who supported the winning candidate (Obama) (Stanton, Beehner, Saini, Kuhn, & LaBar, 2009). Together, these results support the BMS, showing that a rise in social status (victory) increases testosterone concentrations and a drop in social status (defeat) causes testosterone suppression.

Despite the broad appeal of the BMS, there are two important limitations in this area of research that have not been adequately addressed. First, the model has been tested primarily in men. Much more data in women are needed to determine the extent to which the model does or does not apply to female status dynamics. And second, although there are now many positive reports, the predicted winner–loser effect is not universally replicated (Gonzalez-Bono, Salvador, Ricarte, Serrano, & Arnedo, 2000; Suay et al., 1999), suggesting that unknown psychological and contextual factors besides competition outcome may affect testosterone responses (Bateup, Booth, Shirtcliff, & Granger, 2002; van Anders & Watson, 2007). Although researchers have recently begun to investigate some psychological factors such as personality traits (Schultheiss & Rohde, 2002) and cognitive appraisals (Gonzalez-Bono et al., 2000), the role of contextual factors in regulating testosterone responses to competition has been overlooked.

One contextual factor that may affect testosterone responses is whether a competition results in a clear, decisive victory or a close one, or even an uncertain one. Decisive victories model stable hierarchies where the winner clearly dominates the loser, and testosterone may rise or fall in alignment with the new hierarchy as the BMS predicts. In contrast, competitions in which the outcome is close or uncertain cause the status hierarchy to become unpredictable and unstable, and this instability may induce testosterone response profiles that diverge from the predictions of the BMS. This possibility is implied by animal and human research demonstrating different behavioral consequences of status in stable versus unstable hierarchies (Ellemers & Basrreto, 2000; Gust, Gordon, Hambright, & Wilson, 1993; Higham & Maestripieri, 2010; Magee & Galinsky, 2008; Nadler & Halabi, 2006; Sapolsky, 2005; Tauber & van Leeuwen, 2012). In stable hierarchies, high status is associated with more socially dominant, approach-oriented behaviors compared to low status. But in unstable hierarchies, these effects often reverse. Low status individuals in unstable hierarchies–seeing an opportunity to improve their status – show heightened dominance and approach behaviors compared to high status individuals. For example, subordinate male rhesus macaques form revolutionary coalitions and fight over dominance during period of rank instability (Higham & Maestripieri, 2010). Likewise, Gust et al. (1993) found that, compared to periods of stability, female rhesus monkeys displayed more physical aggression when the social rank was unstable. Interestingly, post-aggression reconciliatory behaviors also increased in this context. These active coping strategies are in sharp contrast with the inhibited ways low-status primates tend to respond when in stable social hierarchies (Sapolsky, 2005). In line with these observations, tennis player Arantxa Sanchez Vicario expressed enhanced status-seeking motivation after she barely lost to Graf in the 1996 French Open final, publicly challenging Graf to a rematch. Given testosterone's role in encouraging status-seeking behaviors, it is plausible that testosterone response profiles may show similar patterns to these prior behavioral findings in unstable hierarchies. Whereas the BMS predicts that attaining high status (victory) should increase testosterone relative to attaining low status (defeat) regardless of the nature of the hierarchy, an alternative *status instability hypothesis* predicts that possession of an unstable low status position (e.g., defeat in a close match) should enhance testosterone so as to encourage status-seeking behaviors in that opportunity-rich environment. Conversely, attainment of an unstable high status position (e.g., winning a close victory) might be associated with avoidance of further contests. Therefore, to return to our example, the status instability hypothesis predicts that after their close match Sanchez Vicario may have experienced elevated testosterone compared to Graf, not the other way around as the BMS predicts. The primary goal of the present research was to contrast these two opposing predictions – the predictions of the BMS versus the predictions of the status instability hypothesis, using laboratory competitions designed to model unstable, uncertain status hierarchies in females.

A second goal of our research was to explore the extent to which psychological states, such as mood, explain post-competition testosterone responses in unstable hierarchies. Theoretical models of testosterone fluctuations in response to social competition have proposed mood as a principal modulator (Chichinadze, Lazarashvili, Chichinadze, & Gachechiladze, 2012; Salvador & Costa, 2009), but empirical results have been inconclusive. Indeed, many studies show no associations between mood and testosterone fluctuations in competition (e.g., Gladue, Boechler, & McCaul, 1989; Mazur, Susman, & Edelbrock, 1997; Mehta & Josephs, 2006; but see, McCaul, Gladue, & Joppa, 1992). One possible explanation is that researchers have focused only on higher-order constructs such as global positive and negative mood and have neglected more specific aspects of mood that may be more closely associated with endocrine function in status hierarchies (for an example, see Zilioli & Watson, 2013). Thus, in addition to measuring global positive and negative affect in line with previous studies, the present research added a previously unstudied affective state relevant to unstable hierarchies: surprise. Unstable hierarchies are characterized by high uncertainty (Sapolsky, 2005), and therefore surprise may play a role in modulating biological processes in these contexts. We measured global positive mood, negative mood, and surprise in our studies and examined their relationships with testosterone changes. Given the mixed findings on mood and hormone changes in previous research, we did not make any specific predictions for these analyses.

Lastly, because testosterone secretion in women is equally split between the ovaries and the adrenal cortex (Burger, 2002), in both studies cortisol was also measured. This allowed us to understand the implication of the hypothalamic–pituitary–adrenal (HPA) axis in the anticipated androgenic response to a potentially stressful event such as social defeat.

2. Study 1

In Study 1, undergraduate women engaged in a competition with a female confederate. The contest was manipulated so that the competitors were always tied going into the final round (seven rounds in total). In each preceding round participants always just barely won or barely lost. We measured levels of testosterone before and after the manipulation. Surprise, positive affect and negative affect were assessed at the end of the competition.