



## Comparison of clear and narrow outcomes on testosterone levels in social competition<sup>☆</sup>



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### ABSTRACT

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Social competition is associated with marked emotional, behavioral and hormonal responses, including changes in testosterone levels. The strength and direction of these responses is often modulated by levels of other hormones (e.g. cortisol) and depends on psychological factors – classically, the objective outcome of a competition (win vs. loss) but also, hypothetically, the closeness of that outcome (e.g. decisive victory vs. close victory). We manipulated these two aspects of a social contest among male participants (N = 166), to investigate how testosterone and affect fluctuated as a function of clear vs. narrow wins and clear vs. narrow losses. We found that losing a competition by a small margin (a narrow loss) was experienced as more pleasant than a clear loss. Among individuals with higher levels of basal cortisol, winning the competition by a narrow margin was associated with a *decrease* in testosterone levels. These findings are discussed within the framework of the status instability hypothesis and the growing literature on how situational and physiological factors modulate testosterone reactivity to social contests.

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### 1. Introduction

Competition is the prevailing mean for determining status within both human and non-human social hierarchies (Magee and Galinsky, 2008; Sapolsky, 2004). Acquisition of status can lead to remarkable emotional responses to competitive outcomes, such as joy after a victory (a gain of status) and frustration after a defeat (and loss of status). Social contests are also associated with hormonal fluctuations, primarily with regard to testosterone levels. According to the Challenge Hypothesis (Archer, 2006), testosterone levels rise during periods when competitive and aggressive behaviors are common, and drop during periods of social stability. These fluctuations depend further on the outcome of social contests, such that winners tend to experience an increase in testosterone compared to losers. This observation has been labelled the “winner–loser effect” and is central to the Biosocial Model of Status

(BMS) (Mazur, 1985; Mazur and Booth, 1998), which highlights the adaptive consequences of outcome-related testosterone change. According to the BMS, winning a competition is associated with a rise in social status, and testosterone increases may serve to promote competitive and aggressive behavior aimed at defending and maintaining one's new position. On the other hand, losing a contest may lower social status, and testosterone decreases may promote submissive behaviors that serve to avoid further loss of status or physical harm.

While these basic tenets of the BMS have been replicated numerous times (for a review, see Carré and Olmstead, 2015; Hamilton et al., 2015), an increasing number of experiments indicate that a more nuanced account is required, to explain various situational and psychological variables that can give rise to not only null results but even a full inversion of the classic winner effect. During competitions characterized by close outcomes (e.g. barely winning or barely losing), the winner–loser effect has been seen to reverse, such that losers showed *increased* testosterone relative to winners (Zilioli et al., 2014). Zilioli and colleagues argue that testosterone increases after unstable losses and decreases after unstable wins, a phenomenon termed the *status instability hypothesis* and corroborated by other data (Oliveira et al., 2013, 2014). By this account, close or uncertain outcomes render the status hierarchy unstable and in such circumstances, status-seeking

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behaviors mediated by increased testosterone could enable lower status individuals to grasp an opportunity to enhance their status. Conversely, reduced testosterone after a close victory may promote the avoidance of further contests as a strategy to protect one's vulnerable high-status position from being lost in the unstable environment. While appealing, the earlier experiment by Zilioli et al. (2014) only compared close contests, and did not use a fully-factorial design comparing close wins and losses against decisive wins and losses. Zilioli et al. (2014) also tested female samples exclusively, and hence it is unclear if these findings generalize to the larger literature on male competition.

The aim of the present study was to investigate testosterone responses to winning and losing, where the closeness between winners and losers was manipulated. We predicted that the outcome of the competition (win vs. loss) would interact with the closeness of the outcome (narrow vs. clear) in determining the change in testosterone levels. Specifically, the status instability hypothesis predicts that testosterone levels would increase in clear winners and narrow losers, and decrease in clear losers and narrow winners (Zilioli et al., 2014). In light of recent studies showing how testosterone responses to competition outcomes can further depend on basal cortisol levels, we also obtained pre-competition salivary cortisol samples (Edwards and Casto, 2015; Zilioli and Watson, 2012). Pre-competition cortisol levels were found to be negatively associated with testosterone change in both winners and losers, following a laboratory competition procedure (Mehta and Josephs, 2006), and similar findings have been shown in field observations of athletic competitions (Edwards and Casto, 2015).

We also obtained subjective ratings of affect and motivation, to extend a further line of research showing that a narrow loss can elicit a stronger subjective motivation to play than categorical victories (Clark et al., 2009). For example, in professional basketball games, teams that were slightly behind at halftime were more likely to win the match than the teams that were slightly ahead (Berger and Pope, 2011). Similar effects are well established in gambling behavior, in which “near-miss” outcomes that just fall short of a significant payout are associated with increased motivation to play and more persistent gambling (Clark et al., 2009; Cote et al., 2003). These results indicate that emotional responses to social contests do not scale with outcome in a simple monotonic fashion (whereby losers would always feel more negative than winners). We predicted that narrow losses would increase subjective ratings of the desire to play the game again, a measure of motivation.

Our social competition task was a modified version of the 2-player Tetris competition developed by Zilioli and Watson (2012, 2014) and Zilioli et al. (2014). Pairs of undergraduate male participants played against one another in a 15 minute contest, using two computer terminals in adjacent testing rooms. The competitor who scored higher (by completing the most lines) was designated the winner and received an additional prize. In reality, game outcomes were pre-determined such that participants were randomly assigned to the four conditions, to enable testosterone changes to be disambiguated from differences in effort or true performance. We modified the original procedure to experimentally manipulate the closeness of the victory or defeat, such that in some pairs, one player would experience a resounding victory by a large points distance – henceforth a *clear win*, contrasting with their opponent sustaining a *clear loss*. In other pairs, the scores were extremely close, representing a *narrow win* and *narrow loss*.<sup>1</sup> This mimics many real-world competitions that involve a continuous dimension of “distance” between competitors. We reinforced our four outcome types by presenting verbal feedback to participants *during* the Tetris game, in the form of a series of on-screen SMS messages from the experimenter (e.g. for narrow losers “Keep going, you are slightly behind!”). Prior to the experiment reported here sampling testosterone levels, we piloted

the modified Tetris game in 87 participants to confirm differential effects of outcome closeness on subjective ratings (i.e. affect following the outcome, and motivation to play, see Supplementary material). In the present study, we tested male participants exclusively, as previous research on the winner-loser effect has shown stronger effect sizes for testosterone change in males than females (Carré and Olmstead, 2015; Carré et al., 2013).

## 2. Methods

### 2.1. Participants

One hundred and sixty-six male volunteers (mean age = 23.2, SD = 3.27; age range = 19–33) were recruited using advertisements around the university. Seventy percent identified as White/Caucasian, 22% as Asian, 8% as ‘Other’. Volunteers attended a single testing session, where they completed the Tetris game (15 min), post-experiment questionnaires, and provided two saliva samples. Participants attended test sessions in pairs, after selecting a test slot via the laboratory website. Thus generally, participants did not know each other prior to arrival, as this was discouraged on the website. The opponents met each other upon arrival at the lab, to reinforce the competitive element. The study was conducted in accordance with the Declaration of Helsinki and was approved by University of Cambridge Human Biology Research Ethics Committee. Written informed consent was obtained from all participants. Participants were reimbursed £12 (~US\$18) for participation.

### 2.2. Two-player Tetris game

The competitive task was adapted from the Tetris game previously used by Zilioli and Watson (2012, 2014). Tetris is a speeded puzzle game in which different two-dimensional shapes drop down the screen, and must be rotated and fitted together into rows. If a player “fills” an entire line with no spaces, that line disappears to create more space for the falling blocks. As the game unfolds, the speed at which the blocks drop increases, resulting in steadily increasing difficulty and cognitive effort by the player. Each participant was led to believe that he was competing against the other participant via two linked computers. Unbeknownst to the participants, the outcome of the task was manipulated, such that winning and losing conditions were pre-assigned rather than determined by performance. An important feature of this variant of Tetris was that if the screen filled with blocks, the game did not terminate (as in the classic game) but rather the screen would shift the blocks down, allowing all participants to continue for the required 15 minute period, regardless of their prior experience level or ability. After 15 min of play, the message “you win!” on a colorful background was displayed on the winner's screen, while the loser's screen displayed “you lose!” on a drab background.

We manipulated the closeness of scores between winners and losers by imposing two features. First, immediately following the outcome display (i.e. the “you win!”/“you lose!” message), both the participant's and opponent's scores were presented. The participant's score was necessarily veridical, but the opponent's score was manipulated in order to pre-configure the four outcome types. In the clear win condition, the opponent scored 30% of the participant's score (e.g. participant vs. opponent: 1436 vs. 431). In the clear loss condition, the opponent scored 1.7 times of the participant's point (e.g. 1436 vs. 2441). In the narrow win condition, the opponent scored 11 points less than the participant (e.g. 1436 vs. 1425). In the narrow loss condition, the opponent scored 11 points more than the participant (e.g. 1436 vs. 1447). Second, throughout the competition, participants were presented with scripted messages in the upper right corner of the Tetris display (for 5 second duration). During the initial 12 min of the competition, five “neutral” messages (e.g. “Do your best”, “Go, go, go”) were presented (every 2 min). These messages were identical across conditions and did not imply relative performance of the two competitors. During the final

<sup>1</sup> In a competition with a binary outcome (i.e. win vs. loss), a “narrow win” could alternatively be termed a “near loss”. Conversely a “narrow loss” could alternatively be termed a “near win”. For ease of clarity in labelling the cells of our 2 × 2 design, “narrow” vs. “clear” were used here.

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