1-1-2014

Self-Construal Moderates Testosterone Reactivity To Competitive Outcomes

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SELF-CONSTRUAL MODERATES TESTOSTERONE REACTIVITY TO COMPETITIVE OUTCOMES

by

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DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2014

MAJOR: PSYCHOLOGY (Social)

Approved by:

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Advisor Date

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ACKNOWLEDGEMENTS

I would like to express my gratitude to my advisor, Dr. Richard Slatcher, for his guidance, patience, and immense support throughout graduate school, and for providing an excellent, creative environment to let my curiosity and productivity flourish. I also owe uncountable thanks to Dr. Justin Carré as well for taking me into his lab and developing my skills in social neuroendocrinology, providing excellent feedback and direction in my research. I also thank Dr. Carré for being exceptionally supportive of me and generous in sharing his time to collaborate. I additionally would like to thank Dr. Larry Williams, Dr. Boris Baltes, Dr. Rusty McIntyre, Dr. Antonia Abbey, and Dr. Patricia Siple for their support and instruction in statistics, social cognition, cognitive psychology, and social relationships. Many thanks are also due to Dr. Pranjal Mehta, Dr. Elizabeth Page-Gould, Dr. June Gruber, Dr. Craig Neumann, Dr. Shinobu Kitayama, Dr. Arthur Aron, Craig Anderson, John Blanchar, Dr. Amber Vesotski, and Dr. Baldwin Way for being such excellent collaborators to work with from afar.

I also wish to thank Dr. Phoebe Lin, Dr. David Oberleitner, Stefan Goetz, Rhiana Wegner, Ledina Imami, Lynzey Baker, Erin Tobin, Jennifer Pierce, Sheri Pegram, Daniel Saleh, and Jana Ranson, who have provided me with much support during graduate school, along being great people to chat about ideas with. I also thank my parents, Scott and Cathy Welker, for their constant support, best wishes, and encouragement.

I owe countless thanks to the research assistants that have helped me throughout the years in conducting my research and collecting data: Elianna Lozoya, Shyneth Galicia, Jordan Liphardt, Brian Tyminsky, Alexandra Padilla, Samantha Cain, Jocelyn Campbell, Nicholas Jones, Hannah Holmes, Balbir Singh Khalsa, Stephanie Loomis, Jason Strnad, Joanna Cooper, Shaunna Donajkowski, Dylan Sydam, Kurt Omadlao, Kevin Keuhn, Danya Alawie, Nisha Kuruvadi, David Trombly, Jaclyn Stapleton, Donald States, Angy Hanna, Segilola Ayeni, Fairouz Shoubah, Robert Miller, Kellen Mrkva, and Deborah Latsch.

Finally, I thank my partner, James Witman. Thank you for being supportive of my ideas, always being there to cheer me up, and standing by me through everything.

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CHAPTER 1

Theoretical Background

José Mujica, the president of Uruguay (2010-present), lives an unusual life for a world leader. Discarding the grandiose standards of living many other world leaders take advantage of, Mujica resides in a run-down farmhouse on the outskirts of Montevideo. He is guarded by two police officers and a three-legged dog named Mañuela. Described as the "world's poorest president," Mujica donates 90% of his income to charity, living off the Uruguayan equivalent of 775 U.S. dollars per month. On top of that, he drives a 1987 Volkswagen Beetle, and never wears a tie (Hernandez, 2012). Across the border from Uraguay, Christina Fernández de Kirchner, the current president of Argentina, lives a drastically different lifestyle. According to media reports, de Kirchner obtained 20 new pairs of Christian Louboutin shoes for approximately $110,000 on a trip to Paris in 2011 and owned 27 houses, apartments, stores, and hotels worth over $18 million in 2010 (Mount, Calafate, & Sherwell, 2012). When considering the lavish lifestyles and displays of power many world leaders adopt compared to the lifestyle of Mujica, one might question: How can increases in status affect people's behaviors so differently?

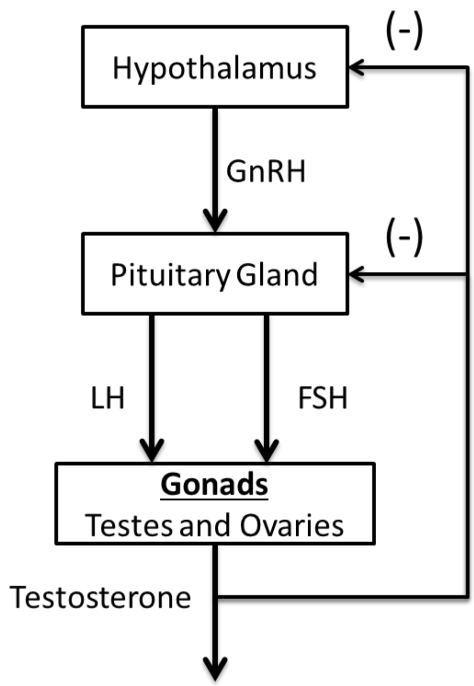
A key factor related to status within a group is dominance. Trait dominance, an individual difference characterized by the motivation to control and influence social situations, events, other people, and relationships (Anderson, & Kilduff, 2009a; Buss & Craik, 1980; Mehrabian, 1996; Wiggins, 1979) is an important predictor of behaving competently around others (Anderson, & Kilduff, 2009a), leadership (Lord, De Vader, & Alliger, 1986), how individuals judge subordinates (Operario & Fiske, 2001), and risk-taking (Demaree, DeDonno, Burns, Feldman, & Everhart, 2009). Researchers have investigated many social psychological predictors of dominance and seeking higher status (See Anderson, & Kilduff, 2009b; Fiske, 2010; Mazur &

Booth, 1998 for reviews) such as gender role stereotypes and prejudice (e.g., Ruble & Ruble, 1982), non-verbal behaviors and postures (e.g., Carney, Cuddy, & Yap, 2010; Renninger, Wade, & Grammer, 2004), being middle-aged (Caspi, Roberts, & Shiner, 2005), extraversion (e.g., McCrae & Costa, 1989), having a genetic predisposition toward verbal aggressiveness (Valencic, Beatty, Rudd, Dobos, & Heisel, 1998), need for power (Winter, 1988), and self-monitoring (Flynn, Reagans, Amanatullah, & Ames, 2006).

Testosterone

In addition to these factors, one important biological predictor of dominance in both humans and nonhuman animals is testosterone. A wide literature in humans and animals suggests that both endogenous and experimentally-altered levels of testosterone are positively related to dominance (Archer, 2006; Archer, Graham-Kevan, & Davies, 2005; Book, Starzyk, & Quinsey, 2001; Wingfield, Hegner, Dufty, & Ball, 1990). Testosterone is an androgen steroid hormone and the end-product of the Hypothalamic-Pituitary-Gonadal (HPG) axis (See Figure 1). It is produced in the adrenal cortex and ovaries in women, but is produced in much greater quantities within the Leydig cells of the testes in men (Nelson, 2005). Testosterone varies as a function of diurnal circadian cycles, with testosterone concentrations at their highest upon waking, slowly decreasing across the day, with more stable levels in the afternoon (Dabbs, 1990). In the context of this circadian cycle, testosterone can be secreted into the bloodstream rapidly, resulting in relative changes in testosterone within a few minutes (Mazur & Booth, 1998).

Figure 1. A conceptual diagram of the production of testosterone by the hypothalamic-pituitary-gonadal (HPG) axis.



Note: The hypothalamus releases gonadotropin-releasing hormone (GnRH), which then stimulates the pituitary gland to release luteinizing hormone (LH) and follicle-stimulating hormone. LH and FSH then stimulate the gonads to produce testosterone. Testosterone also has inhibitory feedback effects on the testosterone induction generated by the hypothalamus and pituitary gland.

Throughout perinatal and pubertal development, testosterone has many organizational effects in humans and animals (See Arnold & Breedlove, 1985; Arnold & Gorski, 1984; Hau, 2007; Liben et al., 2002 for reviews). Within perinatal humans, testosterone shapes the formation of genitalia and the central nervous system (e.g., Arnold & Breedlove, 1985; Arnold & Gorski, 1984; Chura, Lombardo, Ashwin, Auyeung, Chakrabarti, Bullmore, & Baron-Cohen, 2010). Evidence from primate research suggests that testosterone exposure in the later periods of gestation can affect engagement in sex-specific play behavior in youth (Goy, Bercovitch, & McBriar, 1988), and despite methodological limitations, data on perinatal testosterone exposure in humans can be seen as supporting the primate research (Ehrhardt & Meyer-Bahlburg, 1981; Collaer & Hines, 1995). During puberty, testosterone promotes growth of the larynx in males, resulting in deeper voices, promotes muscle growth, body hair, and shapes bone density (Molina, 2013).

However, within adulthood, changes in testosterone are theorized to facilitate social behaviors (Mazur & Booth, 1998; Wingfield et al., 1990). Specifically, the "Challenge Hypothesis" (Wingfield et al., 1990) holds that testosterone fluctuations in birds vary as a function of mating system, rising during breeding seasons to facilitate spermatogenesis, reproductive behavior, and expressing male secondary sex characteristics (Molina, 2013; Porterfield, 2001; Zitzmann & Nieschlag, 2001). Although originally intended to explain the link between testosterone variation in social behavior in birds, the challenge hypothesis (Wingfield et al., 1990) holds that testosterone increases in monogamous males during socially unstable times and these changes in testosterone facilitate aggressive behavior between males. This work is supported by recent evidence in animal research showing that social challenges elevate testosterone in males, and these changes in testosterone are related to aggressive behavior (McGlothlin, Jawor, & Ketterson, 2007). Similarly, the biosocial model of status (Mazur, 1985; Mazur & Booth, 1998) holds that testosterone functions to signal dominance and aggression in adult humans and nonhuman animals.

Baseline Testosterone and Dominance

Baseline testosterone has been found to robustly predict aggression and dominance in animals, particularly in the presence of unstable status hierarchies (e.g., Giammanco et al. 2005; Collias et al. 2002; Ruiz-de-la-Torre & Manteca, 1999; Oliveira, Almada, & Canario, 1996; Sapolsky, 1991; Wingfield et al. 1990). In humans, there are a few studies suggesting that baseline testosterone predicts threat vigilance, dominance, and aggression (e.g., Cashdan, 1995; Grant and France, 2001; Mehta & Beer, 2010; Mehta et al., 2008; Sellers, Mehl, & Josephs, 2007; Slatcher, Mehta, & Josephs, 2011), while other work has not found this relationship (e.g., Josephs, Sellers, Newman, & Mehta, 2006). Meta-analytic evidence suggests only a weak positive relationship between baseline testosterone and aggression in humans (Archer, et al., 2005). Work by Mehta and Josephs (2006) suggests that testosterone concentrations are a better indicator of dominance than self-report measures.

Testosterone Reactivity and Dominance

Other work has suggested that acute fluctuations in testosterone may be more strongly linked to dominance behaviors like aggression than basal testosterone concentrations (Archer, 2006; Carré, McCormick, & Hariri, 2011). A growing body of recent empirical work suggests that testosterone reactivity to social events is a robust predictor of aggressive behavior (Carré, Campbell, Lozoya, Goetz, & Welker, 2013; Carré, Gilchrist, Morissey, & McCormick, 2010; Carré, Putnam, & McCormick, 2009; Geniole, Carré, & McCormick, 2011; Hermans et al., 2008; Ross et al., 2004). This concept is further supported by the fact that androgen receptors are densely located in regions of the brain known to mediate aggression behavior (Abdelgadir, Roselli, Choate, & Resko, 1999; Finley & Kritzer, 1999; Kritzer, 2004; Sarkey, Azcoitia, Garcia-Segura, Garcia-Ovejero, & DonCarlos, 2008; Simon & Lu, 2006).

Aside from predicting dominance, testosterone also changes in response to social situations. For instance, testosterone rises in response to competition (Archer, 2006; Mazur & Booth, 1998), including vicarious experiences of competitions (e.g., Bernhardt, Dabbs, Fielden, & Lutter, 1998; Stanton, Beehner, Saini, Kuhn, & LaBar, 2009), remaining elevated in winners and decreasing in losers (see Archer, 2006 for a meta-analysis; Carré et al., 2013; van Anders &

Watson, 2007). Testosterone in men has also been found to be altered by good individual athletic performances and social connectedness with team mates (Edwards, Wetzel, & Wyner, 2006), adopting dominant vs. submissive postures (Carney et al., 2010) watching a competitive interaction end in victory or defeat (Bernhardt, Dabbs, Fielden, & Lutter, 1998), interacting with weapons (Klinesmith, Kasser, & McAndrew, 2006), viewing aggressive media (Cook & Crewther, 2012), interacting with attractive females (Roney, Lukaszewski, & Simmons, 2003; Roney, Mahler, & Maestripieri, 2007), and sexual arousal (Archer, 2006).

These fluctuations in testosterone in response to social events have been proposed to predict later behaviors, including aggression (Carré, McCormick, & Hariri, 2011; Mazur & Booth, 1998; Mazur, 1985; Wingfield et al., 1990). Indeed, empirical work has found that changes in testosterone in response to competitive outcomes (Carré et al., 2013) and interacting with weapons (Klinesmith et al., 2006) mediate the effects of these testosterone-modulating social events on subsequent aggressive behavior.

Although testosterone reactivity has been found to predict aggressive behavior, testosterone reactivity may predict other behaviors, such as risk taking. Like aggression, risk taking has been positively associated with increased basal testosterone in males (Apicella, Dreber, Campbell, Gray, Hoffman, & Little, 2008; Booth, Johnson, & Granger, 1999; Stanton, Liening, & Schultheiss, 2011; Vermeesch, T'Sjoen, Kaufman, & Vincke, 2008; White, Thornhill, & Hampson, 2007; but see Sapienza, Zingales, & Maestrini, 2009). Specifically, Van Honk and colleagues (Van Honk, Schutter, Hermans, Putman, Tuiten, & Koppeschaar, 2004) report that pharmacological administrations of testosterone in women increase risky decision making on the Iowa gambling task (Bechara, Damasio, Tranel, & Damasio, 1997). Although most of this work suggests that baseline testosterone predicts risk taking, recent reports suggest that testosterone reactivity can predict risk taking in men. Men's fluctuations in testosterone while performing in front of an attractive female predict risk-taking behavior, in the form of a decreased likelihood to abort potentially dangerous skateboarding tricks (Ronay & von Hippel, 2010). Additionally, testosterone reactivity following victory and defeat predicts financial risk taking (Apicella, Dreber, Mollerstrom, 2014), although Apicella and colleagues did not examine whether testosterone reactivity mediated the effects of victory and defeat on risk taking. Due to these extensive parallels between the testosterone-aggression relation and the testosterone-risk taking relation, testosterone reactivity to competitive outcomes may also mediate the effects of competitive outcomes on risk taking.

Moderators of testosterone reactivity to competition

Despite findings that competitive outcomes and other types of interactions affect testosterone reactivity in men, some studies have failed to find differences in testosterone reactivity between winners and losers (e.g., Mazur, Susman, & Edelbrock, 1997; Schultheiss, Campbell, & McClelland, 1999; Schultheiss & Rohde, 2002).[1] One suggested reason for this inconsistency has been the presence of individual differences that may moderate the impact of competitive outcomes on testosterone reactivity (Salvador, 2005). So far, research has established two individual difference moderators of testosterone reactivity to competition: power motive and anxiety.[2] Indeed, research has suggested that both implicit power motive (Schultheiss, Campbell, & McClelland, 1999; Schultheiss & Rhode, 2002) and trait anxiety (e.g. Maner, Miller, Schmidt, & Eckel, 2008; Welker & Carre, 2013) moderate testosterone reactivity

[1] Although these cited articles do not show main effects of competitive outcomes on testosterone reactivity, Schultheiss, Campbell, and McClelland (1999) and Schultheiss and Rohde (2002) find that these effects are moderated by implicit power motive.
[2] Though not a psychological construct, recent work has also revealed that facial structure moderates testosterone responses to competition (Pound, Penton-Voak, Surridge, 2009). Specifically, masculine facial structure in men was related to increased testosterone following winning a competition.

to competition. Individuals motivated to obtain personalized power by asserting dominance over others showed testosterone reactivity to competition, while individuals motivated to obtain power through prosocial means did not show this same effect (Schultheiss, Campbell, & McClelland, 1999). Additionally, individuals with low impulse control and high power motive showed testosterone reactivity to winning or losing a competitive task (Schultheiss & Rhode, 2002). Other recent work has also found that social anxiety moderates testosterone reactivity to winning or losing competition (Maner, Miller, Schmidt, & Eckel, 2008; Welker & Carre, 2013). This works extends animal research showing that only rats bred to have low anxiety show testosterone reactivity to competitions, relative to high anxiety bred rats (Veenema, Torner, Blkume, Beiderbeck, & Neumann, 2007). Preliminary work in humans suggests that testosterone decreases in response to losing a competition only in high anxiety men (Maner et al., 2008). However, research with larger samples suggests that reactivity to competitive outcomes occurs in only low anxiety men (Welker & Carré, 2013).

The potential moderating role of self-construal

One additional moderator of testosterone reactivity to competition could be self-construal. Self-construal, or how individuals mentally represent the self in relation to others (Cross, Hardin, Gercerk-Swing, 2011; Markus & Kitayama, 1991a), was initially coined to describe differences between how individuals in individualistic (e.g., United States of America) and collectivistic cultures (e.g., Japan) define and mentally represent the self (Markus & Kitayama, 1991a). Self-construals can vary between having independent or interdependent self-construals. Individuals with an independent self-construal view the self as being unique and independent of others, defining the self in terms of internal attributes, such as attitudes, abilities, and personality traits. Accordingly, an independent individual would experience increases in self-esteem when experiencing positive events that distinguish his or her self from others. On the other hand, individuals with an interdependent self-construal view themselves collectively as being connected to others, defining the self in terms of external, situational factors (e.g., group membership, relationships, communities). Thus, interdependent individuals would experience increases in perceived status and self-esteem when experiencing positive events that enable them to fit in and belong with others. Self-construal is also culturally-variant, with individuals from western cultures such as the United States generally holding independent self-construals, and individuals from eastern, collectivistic cultures such as China and Japan generally holding interdependent self-construals (Markus & Kitayama, 1991b).

Despite these cultural differences in self-construal, individual can also vary in self-construal *within* cultures. Indeed, multiple theorists have maintained that although cultural contexts often promote individuals adopt and develop one self-construal over the other, all individuals have a construal that is both, to a varying extent, independent and interdependent (Markus & Kitayama, 1991a; Singelis, 1994; Triandis, 1995). For instance, despite living in a western culture, a husband devoted to his family, relatives, a bowling team, or the culture of his workplace is likely to hold a more interdependent self-construal than a brash, single entrepreneur on an effort to climb his way to the top and achieve a personal victory. Indeed, research with U.S. samples has shown that self-construal is linked to how individuals implicitly organize information relating the self to others (Cross, Morris, & Gore, 2002). Additionally, priming different self-construals within individualistic and collectivities cultures can lead individuals to show greater preferences toward corresponding collectivistic and individualistic values (Gardner, Gabriel, & Lee, 1999).

Why might self-construal moderate the links between testosterone reactivity, behavior, and competitive outcomes? The following discussion highlights three ways in which self-construal may moderate reactivity to competitive outcomes: 1) How the competitive outcomes impact the self differently for independent and interdependent individuals, 2) Differences in competitiveness and teamwork preferences between independent and interdependent people, and 3) Differences in attributions of the competitive outcome between independent and interdependent individuals.

Impact on perceptions of self-status. One reason for why self-construal may moderate testosterone reactivity to competition lies in how individuals define the self. Because individuals with interdependent self-construals define the self in terms of groups and social identities they belong to, the perceived status of interdependent individuals may be less affected by the outcomes of individualistic competitions than independent individuals. Accordingly, independent and individualistic individuals seek to distinguish themselves in how they compare to other individuals in status, while interdependent and collectivistic individuals do not share this motivation (Heine, Lehman, Markus, & Kitayama, 1999; Lalwani & Shavitt, 2009).

Individuals with independent self-construals may experience changes in dominance in response to the outcomes of individualized competitions, since these outcomes would allow an individual to feel they have achieved (or failed to achieve) the outcome on their own. On the other hand, if a victory is achieved as part of a group, the increased status will reflect the status of the group as a whole, not the individual. Thus, the independent individual would not experience an increase in perceived status, and consequently, testosterone.

If an interdependent individual wins an individualized competition, however, the elevated status from winning a personal competition may not make them feel dominant, since interdependent people are motivated to fit in with others. When competing as a group, however, interdependent individuals may experience an increase or decrease in testosterone from winning or losing, respectively, because the status of the group will more accurately represent an interdependent individual's status than the status of an individual. However, it is also possible that competition with a group, regardless of winning or losing, will increase testosterone, since participating as a group and cooperating with others, regardless of the outcome, would increase an interdependent individual's sense of status.

Competitiveness and preference for teamwork. Individuals with independent construals may seek to win tasks individually because they seek to be singled out for success, rewards, and a sense of accomplishment. Accordingly, research suggests that independent individuals may be more competitive than interdependent individuals, making independent individuals more engaged by competitions, and subsequently, by their outcomes. Having an independent self-construal leads individuals to cooperate less with others (Utz, 2004). Additionally, American participants (who have more independent self-construals) are more likely to compete in a social dilemma than Vietnamese participants (who have more interdependent self-construals; Parks & Vu, 1994). On the other hand, interdependent individuals are concerned with functioning in harmony with others in an intergroup setting (Heine et al., 1999). Thus, although it may be that individuals with independent self-construals enjoy competition more, it also may be that interdependent individuals enjoy collaborating with others as a team due to their motivation to fit in with others.

Attributions. A third possibility for how self-construal may moderate reactivity to competitive outcomes involves the causal attributions individuals make for their wins and losses. Attribution theory (Heider, 1944, 1958; Jones & Davis, 1965; Kelley, 1967) differentiates between situational, external attributions—explanations of the causes of events as originating from forces *outside* an individual (e.g., environment, culture)—and dispositional, internal attributions—explanations of the causes of events as originating from forces within an individual (e.g., motivations, dispositions). Collectivism, and accordingly, having an interdependent self-construal, is associated with a cognitive bias toward committing external, situational attributions, while individualism is associated with a likelihood of committing internal, dispositional attributions (Al-Zahrani & Kaplowitz, 1993; Carpenter, 2000; Duff & Newman, 1997; Morris, & Peng, 1994). Therefore, when experiencing a win or loss, interdependent individuals may view the causes of the outcome as external, and therefore not effective at changing their sense of status (e.g., "I had a lot of help from others," "The task was extremely difficult,"). On the other hand, independent people may view their wins and losses as a function of internal characteristics (e.g., "I am worthless," "I am talented and intelligent") and use these attributions to inform their sense of status.

Beyond these moderation effects, interdependent individuals may also experience increased testosterone reactivity to team competitions, regardless of the competitive outcome. This possibility is supported by a report that social interconnectedness increases mens' testosterone reactivity after a competition, regardless of competitive outcome (Edward et al., 2006). Given that having an interdependent self-construal is related to feeling more connected with social milieus (Markus & Kitayama, 1991b), and that individuals with interdependent self-construals are motivated toward interpersonal closeness (Holland, Roeder, van Baaren, Brandt, & Hanover, 2004), interdependent individuals may also experience greater testosterone reactivity after team competitions, regardless of the competitive outcome.

Hypotheses and Research Questions

For the reasons described above, it is proposed that self-construal moderates neuroendocrine reactivity to competitive outcomes. Based on this rationale, the current research examines how self-construal and competitive outcomes affect testosterone reactivity to competition. Hypotheses 1a, 1b, and 1c are concerned with if and when a competitive outcomes produce testosterone reactivity. As previously discussed, because a growing body of research suggests that testosterone reactivity mediates the effects of social events on behaviors, such as aggression (Carré et al., 2013) and risk taking (e.g., Ronay & von Hippel, 2010), the current research also tests whether these fluctuations in testosterone will map on to aggression and risk-taking behavior. Therefore, hypotheses 2a, 2b, and 2c are concerned with whether testosterone reactivity affects risk-taking behavior and aggressive behavior, and if these relations are moderated by self-construal. Specifically, the following hypotheses and research questions were proposed:

Research Questions:

1. Will group competitions increase testosterone reactivity in men with independent self-construals?
2. Will testosterone mediate the effects of testosterone reactivity on risk taking only when independent individuals win or lose individualized competitions and only when interdependent individual win or lose team competitions?
3. Will differences in external and internal attributions of success and loss, increased competitiveness in independent individuals, and desire for teamwork in interdependent individuals mediate the moderating effects of self-construal on testosterone reactivity to competition?

Hypotheses:

1a) Competitive outcome will influence testosterone reactivity in men, whereby male winners increase in testosterone and male losers decrease in testosterone.

1b) Self-construal will moderate the effects of individualized competitive outcomes on testosterone reactivity. Specifically, individual competitions will produce testosterone reactivity in independent men in the direction hypothesized in hypothesis 1a.

1c) Self-construal will also moderate the effects of group competitive outcomes on testosterone reactivity, but in a different direction than hypothesized in hypothesis 1b. Group competitions will produce testosterone reactivity in interdependent men in the direction of hypothesis 1a.

2a) Testosterone reactivity to competitive outcomes will be positively associated with aggressive and risk-taking behavior.

2b) Testosterone reactivity will mediate the effect of competitive outcomes on risk taking and aggression.

2c) Self-Construal will moderate the mediating effect of testosterone reactivity to individualized competitive outcomes specified in hypothesis 2b, such that the relationship specified in hypothesis 2b will be specific to independent men.

Overview of Research

The above research questions and hypotheses were tested with data from two studies. In Study 1, men and women completed a self-construal measure and were randomly assigned to win or lose an individualized competitive outcome, providing saliva samples before and after the game to assess testosterone reactivity. Participants then completed self-report questionnaires of perceptions of the game and a well-validated measure of aggressive behavior. By assessing testosterone reactivity to an experimental manipulation of victory and defeat in the context of an individualized competition, this experimental design tests whether individualized competitive outcomes influence testosterone reactivity (Hypothesis 1a) and if self-construal moderates these effects (Hypothesis 1b). For Hypothesis 1b, it was hypothesized that there would be a significant self-construal X competitive outcome interaction on testosterone reactivity. Additionally, is was hypothesized that testosterone would only mediate the effects of competitive outcomes on aggression when men had an independent self-construal. The inclusion of a behavioral aggression task allowed the researchers to test whether testosterone reactivity predicted aggressive behavior (Hypothesis 2a), if testosterone reactivity mediated the effects of competitive outcome (Hypothesis 2b), and if this mediation relationship was specific to men with independent self-construals (Hypothesis 2c).

In Study 2, after completing self-report measures of self-construal, competitiveness, and teamwork preferences, men were randomly assigned to a 2 (competition outcome: win vs. lose) x 2 (team vs. individual competition) factorial experimental design, providing salivary testosterone samples before and after the competition. After the competition, participants completed self-report measures of perceptions of the game, measures of attributions of the competitive outcome, and a widely used behavioral assessment of risk taking behavior. Study 2 was capable of testing all hypotheses and replicating the hypothesis tests included in study 1 (Hypotheses 1a, 1b, 2a, 2b, and 2c) using a behavioral measure of risk taking instead of aggression. However, the inclusion of the group competition in addition to an individualized competition allowed for examining whether self-construal moderates testosterone reactivity to group competitive outcomes (Hypothesis 1c), whether group competitions affected testosterone reactivity in men with independent self-construals (Research Question 1), and if men with independent self-construals only show testosterone reactivity to individualized competitive outcomes, whereas men with interdependent self-construals only show testosterone reactivity to group competitive outcomes (Research Question 2). Based on these hypotheses and research questions, it was expected that there would be a significant 3-way self-construal X competitive outcome X team condition interaction predicting testosterone reactivity to the competitive task. The inclusion of measures of competitiveness, desire for teamwork, and attributions of competitive outcome allowed for the testing of several plausible mechanisms for how self-construal moderates testosterone reactivity to victories and defeat (Research Question 3).

CHAPTER 2

Study 1

Study 1 investigated whether self-construal moderated the effects of competitive outcomes on testosterone reactivity and aggression in men. Men and women completed the self-construal scale (Singelis, 1994) and were assigned to either win or lose a video game competition, with salivary testosterone and cortisol measured before and after the game. Following this task, participants completed a well-validated task measuring costly reactive aggression. This data set was previously collected, with results appearing in work by Carré and colleagues (2013), Welker and colleagues (Welker, Lozoya, Campbell, Carré, & Neumann; 2014), and Goetz and colleagues (Goetz, Shattuck, Miller, Campbell, Lozoya, Weisfeld, & Carré, in press, Study 1). To determine if this dataset was adequately powered, power analyses were conducted using G*power 3.1.5 (Faul, Erdfelder, Lang, & Buchner, 2007). Using a two-tailed alpha of .05 and the effect size metric of Pearson's *r*, this sample size of 237 provides substantial power for detecting large effect sizes ($|r| = .50$, power > .99), substantial power for detecting medium effect sizes ($|r| = .30$, power > .99), and low power for detecting small effect sizes ($|r| = .10$, power = .34).

Methods

Participants

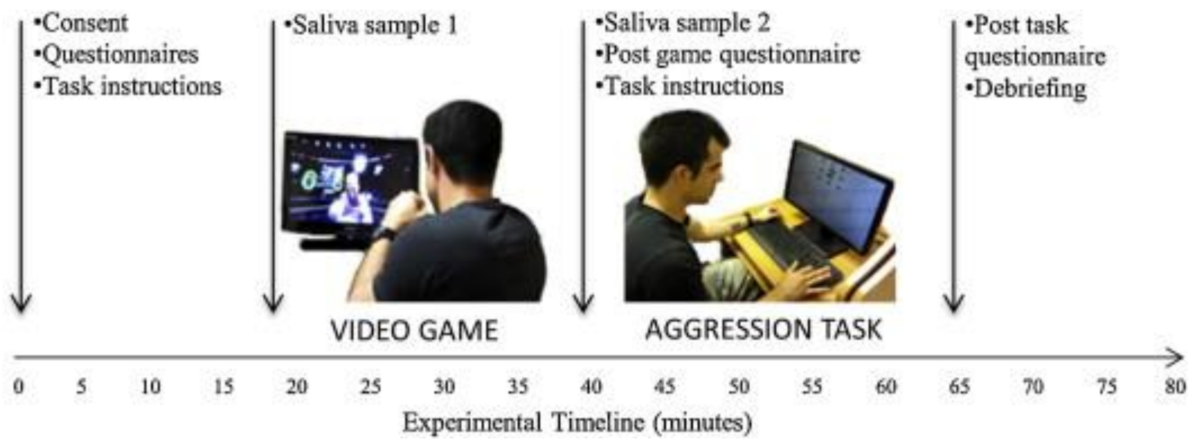
237 undergraduate students (114 men, 123 women; $M_{age} = 21.73$, $SD = 4.66$) were recruited from the Wayne State University Psychology subject participation pool and participated for an honorarium of partial course credit and 10 dollars. The sample was diverse (46% Caucasian, 19% African American, 15.2% Asian, .4% Native American, 3.8% Bi-racial, 13.9% Other, and 1.7% did not report race). Participants were randomly assigned to either play a

competitive game of volleyball or boxing and to win or lose this competition in a 2 x 2 factorial design. To reduce the effects of diurnal variation in testosterone (Liening, Stanton, Saini, & Schultheiss, 2010; Schultheiss & Stanton, 2009), all saliva samples were collected between 11:00 AM and 5:00 PM.

Materials and Procedure

An overview of Study 1 is presented in Figure 2. Participants arrived in the lab and completed the informed consent procedure. Then participants completed a personality and demographics questionnaire containing a measure of self-construal. 95.4% of the experimental sessions were conducted by female researchers, 3.8% were conducted with both a female and male experimenter present, while .8% were conducted with exclusively male experimenters.

Figure 2. Experimental timeline of Study 1.



Self Construal Scale. Self-Construal was measured using the self-construal scale (Singelis, 1994) to measure independent and interdependent self-construals (See Appendix A). Participants were asked to rate the extent to which they agreed with 24 items using a 7-point Likert type scale (1 = Strongly Disagree, 7 = Strongly Agree). Sample items included “I enjoy being unique and different from others in many respects” (Independent Dimension), “My happiness depends on the happiness of those around me (Interdependent Dimension), and “My personal identity, independent of others, is very important to me" (Independent Dimension). Both independent and interdependent factors showed acceptable internal consistency (Cronbach's *α*s = .61 and .66, respectively) and had only a small, marginally significant correlation with each other (r = .12, p = .076). Similar to other researchers (e.g., Aaker, & Williams, 1998; Zhang, Feick, & Price, 2006), the interdependent dimension items were reversed-coded and all items were averaged, creating a scale where high values indicated a more independent self-construal, and low values represented a more interdependent self-construal.

Video Game Competition and saliva samples. Participants were randomly assigned to play either boxing or volleyball on the XBOX 360 gaming console with a Kinect motion-sensing input device. The motion-sensing properties of the Kinect device allowed participants to control the game with physical movements, similar to a real volleyball game. The participants were unknowingly randomly assigned to either win or lose the game. This manipulation was facilitated such that the game was preprogrammed to be set to either the easiest or most difficult difficulty setting prior to participants beginning the game. Participants played the game for multiple rounds for 15 minutes. No participants in the loss condition won any of the rounds, and all participants in the win condition won at least one round. To measure baseline and reactive salivary hormones, participants provided saliva samples via unstimulated passive drool before and after the game.

Post Game Questionnaire. Participants then completed a short questionnaire assessing their perceptions of the video game (See Appendix B). Participants were asked to rate the game using 7-point Likert type scales on the extent to which they found the game to be exciting (1 = not exciting, 7 = exciting), frustrating (1 = not frustrating, 7 = frustrating), difficult (1 = easy, 7 =

difficult), enjoyable (1 = not enjoyable, 7 = enjoyable), and fast (1 = slow action, 7 = hectic action).

These game perceptions were subjected to a principle components analysis using a varimax rotation (See Table 1). This analysis found two primary components cumulative explaining 77.75% of the total variance that were labeled as enjoyableness (with loadings ≥ .60 on enjoyable, exciting, fast) and difficulty (loadings ≥ .48 on difficulty, frustrating, fast). These factor scores were extracted using the regression method for analyses.

Table 1. Principal components analysis of video game perceptions (Study 1).

	Component	
	Game Enjoyableness	Game Difficulty
% of variance (Rotation SS Loadings)	39.41%	38.34%
Items and Factor Loadings		
How difficult was the game?	-.03	**.92**
How frustrating was the game?	-.07	**.89**
How fast was the action of the game?	**.60**	**.48**
How enjoyable was the game?	**.87**	-.22
How exciting was the game?	**.92**	-.01

Point Subtraction Aggression Paradigm. To measure aggressive behavior, participants then played the point subtraction aggression paradigm (PSAP; Cherek, Tcheremissine, & Lane, 2006), a well-validated behavioral measure of reactive aggression. Participants were told that they were playing a game with another participant (actually a computer) and the object of the game was to win as many points as possible, and these points could later be exchanged for money. Participants were given three response options of buttons to press during the game: pressing button 1 would earn participants a point after 100 consecutive presses (reward button), pressing button 2 would steal a point from the other player after 10 consecutive presses (aggressive button), and pressing button 3 after ten presses would protect points from being stolen by the other player for a temporary period (protection button). During the task, points were randomly stolen from participants, and this was attributed to the other player who got to keep the stolen points. Participants were told that although they could press button 2 to steal points from the other player, they were in the condition in which they do not get to keep the stolen points for themselves. Thus, pressing button 2 to take points from the other players was a costly act of aggression. The PSAP consisted of three 7-minute blocks.

Since the outcome of interest was aggressive behavior, aggressive behavior was computed by regressing the number of aggressive button presses on participants' reward and protection button presses and saving the unstandardized residuals. This procedure removed the variance in aggressive button presses explained by reward and protection button presses, allowing analyses to examine the unique variance in aggression not explained by other behaviors during the game. Following the PSAP, participants were debriefed and dismissed.

Salivary Hormone Analysis

Saliva samples were collected and stored in polystyrene tubes, frozen at -20°C until assayed. Saliva samples were assayed in duplicate using immunoassay kits from DRG International. The intra-assay coefficients of variation were adequate (9.30% in male samples and 12.47% in female samples). Testosterone reactivity was computed by regressing time 2 concentrations on time 1 concentrations and saving the unstandardized residuals (e.g., Mehta & Josephs, 2006; Carré et al., 2009; Schultheiss et al., 1999). Testosterone reactivity scores were assessed through computing percent change scores $((\{T2 - T1\}/T1)*100)$ to support these analyses. Unless otherwise noted, neither index of testosterone change used altered the significance of the reported affects. To attenuate outliers, testosterone reactivity concentrations and aggression scores were Winsorized to ±3 SDs.

Statistical Analyses

Moderation Analysis

Moderated regression analysis was used to test interactions. Interactions were calculated as the product of mean-centered predictors. Simple slopes analyses were conducted using PROCESS (Hayes, 2013), an SPSS utility designed for testing mediation and moderation analyses. This utility interprets interactions in the manner recommended by Aiken and West (1991) and West, Aiken, and Krull (1996) by computing the simple slopes at conditional values of the predictors (e.g., effect coded values for categorical variables, ±1 SDs for continuous variables).

Mediation Analysis

The significance of conditional indirect effects were tested with bootstrapping (Shrout & Bolger, 2002). Bootstrapping, a nonparametric resampling procedure, is recommended for testing mediation analysis in smaller sample sizes or where distributions are skewed or unknown (Shrout & Bolger, 2002). PROCESS (Hayes, 2013) was also used to compute bias-corrected 95% confidence intervals for indirect effects using 5000 resamples. Significant indirect effects are indicated by confidence intervals that do not include 0.

Moderated Mediation

Because it was hypothesized that testosterone reactivity would mediate the effects of competitive outcome on aggression in men with independent self-construals, moderated mediation (Muller, Judd, & Yzerbt, 2005) was also tested. Specifically, this analysis tested whether self-construal moderates the effects of competitive outcome on testosterone reactivity in men, and consequently, whether self-construal moderated the mediating effect of testosterone reactivity between competitive outcome and aggression. This specific moderated mediation was tested using Model 7 in PROCESS, which tests whether the conditional indirect effect of testosterone reactivity was moderated by self-construal. This test was supported by the use of the moderated mediation index (Hayes, 2013), which is the slope of the line relating the indirect effect and moderator. Bootstrapping also was used to test whether this index was significantly different from 0. Because it is possible that self-construal can also moderate the effects of outcome on competition and testosterone reactivity on aggression, exploratory moderated regression analysis also tested whether self-construal moderated these effects.

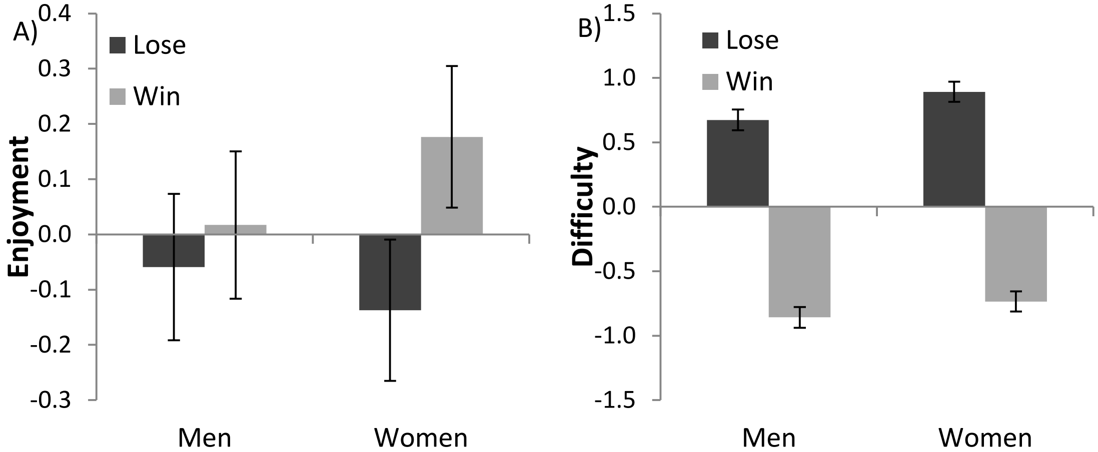
Results

Game perceptions.

Two 2-way (gender X outcome) ANOVAs were conducted on the perceptions of game enjoyment and difficulty (See Figure 3). For enjoyment, there were no main effects of gender (F(1, 231) = 1.00, p = .755) or competitive outcome (F(1, 231) = 2.234, p = .136), and the gender X outcome interaction was nonsignificant (F(1, 231) = .83, p = .364). For difficulty, there was a significant main effect of outcome on difficulty (F(1, 231) = 395.85, p < .001), with losers perceiving the game as more difficult (M = .78, SE = .06) than winners (M = -.80, SE = .06). For difficulty, there was also a main effect of gender (F(1, 231) = 4.65, p = .032), whereby women found the game to be more difficult (M = .08, SE = .08) than men (M = -.89, SE = .08). This difference in perceived difficulty may be due to the fact that men tend to play video games more than women and thus have more experience (e.g., Lucas & Sherry, 2004). Outcome and Gender did not significantly interact to predict perceived difficulty (F(1, 231) = .36, p = .550).

Moderated regression analyses with self-construal added as a predictor to the above models found that self-construal had no significant three way interactions (ps ≥ .279) or two-way interactions (ps ≥ .245) with the above effects. In our following analyses, we tested the robustness of our effects by adding difficulty and enjoyment as covariates.

Figure 3. Video game enjoyment and perceived difficulty as function of outcome and gender.



Note: Error bars represent standard errors of the mean.

Effects of Baseline Testosterone

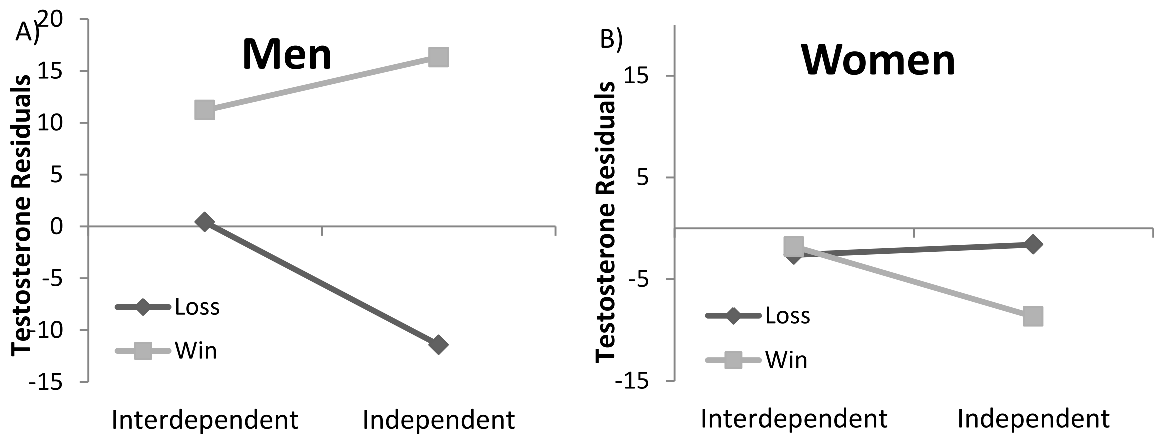
Baseline testosterone was not associated with aggressive behavior in men (*r* = .01 ,*p* = .909) or women (*r* = -.01, *p* = .944). This association was not moderated by self-construal or competitive outcome in either men or women (*p*s ≥ .290).

Moderation Analysis: Outcome Effects on Testosterone Reactivity

Moderated regression analysis was conducted with testosterone reactivity (residualized) regressed on self-construal, outcome, gender, and all possible cross-products. The results of this analysis are presented in Table 2. There was a significant three-way outcome X gender X self-construal interaction effect (*b* = 26.87, *se* = 10.72, *t*(220) = -2.51, *p* = .013). This three-way interaction also remained significant after controlling for game enjoyment and difficulty (*b* = -27.09, *se* = 10.73, *t*(217) = -2.53, *p* = .012). Simple slopes analysis indicated that this interaction occurred because there was a significant conditional outcome X self-construal interaction that occurred in men (*b* = 18.32, *se* = 8.30, *t*(220) = 2.21, *p* = .028), but not women (*b* = 8.54, *se* = 6.79, *t*(220) = -1.26, *p* = .209).

The simple slopes of this 3-way interaction are presented in Figure 4. Within men, competitive outcomes (scored 0 = lose, 1 = win) affected testosterone concentrations most robustly in individuals with independent self construals, with winners having elevated testosterone compared to losers ($b = 27.73$, $se = 2.18$, $t(220) = 5.35$, $p < .001$). Although this conditional effect still occurred in those with interdependent self-construals, the magnitude was weaker ($b = 10.81$, $se = 5.15$, $t(220) = 2.10$, $p = .370$). For women, competitive outcome was not significantly associated with testosterone reactivity for those with interdependent ($b = .80$, $se = 4.62$, $t(220) = .17$, $p = .863$) or independent self-construals ($b = -7.09$, $se = 4.53$, $t(220) = -1.56$, $p = .119$).[3]

Figure 4. Moderation of the effects of competitive outcome on testosterone reactivity by self-construal.



Note: Panel A represents the significant conditional competitive outcome X self-construal interaction in men. Panel B represents a nonsignificant statistical interaction in women.

[3] Using percent testosterone reactivity as the outcome of this model resulted in a nonsignificant three-way outcome x gender x self-construal interaction effect ($p = .105$). Despite this, the conditional outcome X self-construal interaction was marginally significant in men ($p = .065$) and nonsignificant within women ($p = .761$). Within men, competitive outcomes affected percent testosterone reactivity in those with independent self-construals ($b = 32.02$, $se = 10.14$, $t(222) = 3.16$, $p = .002$), not interdependent self-construals ($b = 4.19$, $se = 10.11$, $t(222) = .41$, $p = .679$). Thus, using percent testosterone reactivity yielded the same direction of effects within the data.

Table 2. Testosterone Reactivity as a function of competitive outcome, sex and self-construal.

Predictor	*b*	*se*	*t*	*p*
Self-Construal	-3.42	2.66	-1.29	0.200
Outcome	**7.57**	**2.40**	**3.15**	**0.002**
Gender	**-7.70**	**2.41**	**-3.20**	**0.002**
Outcome X Self-Construal	4.30	5.31	0.81	0.420
Outcome X Gender	**-22.41**	**4.81**	**-4.67**	**< .001**
Gender X Self-Construal	0.58	5.37	0.11	0.914
Outcome X Gender X Self-Construal	**26.87**	**10.72**	**-2.51**	**0.013**

Similar to the analyses of Carré and colleagues (2013), there were significant main effects of outcome (p = .002), gender (p = .002), and a significant 2-way Gender X outcome interaction (p < .001). Competitive outcomes, gender, and self-construal did not have a significant three-way interaction when predicting aggressive behavior (b = 12.07, se = 39.93, t(217) = .30, p = .763).

Moderation of relationship with testosterone and aggression

Moderated regression analyses were also used to test the effects of testosterone residuals, self-construal, gender, and all of their possible interactions on aggressive behavior (See Table 3). There was no significant three-way interaction (p = .251), and no other effects were significant. However, there was a marginally significant testosterone reactivity X Gender interaction (p = .073). The simple slopes of this marginally significant interaction indicated that testosterone reactivity predicted aggressive behavior only in men (b = .79, se = .29, t(214) = 2.74, p = .007), not women (b = .03, se = .41, t(214) = 08, p = .933). Furthermore, self-construal did not moderate the relationship between testosterone reactivity and aggression in men or across all participants.

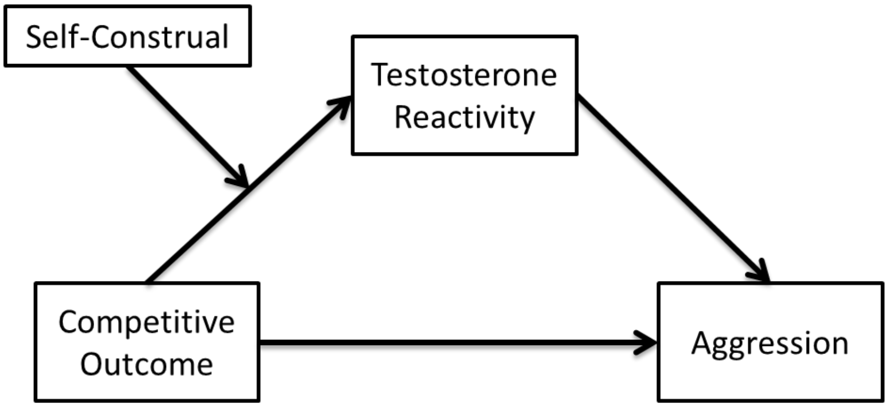
Table 3. Aggressive Behavior as a function of Testosterone Reactivity , sex, and self-construal

Predictor	*b*	*se*	*t*(209)	*p*
Self-Construal	1.97	10.96	0.18	0.858
Testosterone Reactivity	0.30	0.26	1.14	0.256
Gender	-12.07	9.05	-1.33	0.184
ΔT X Self-Construal	0.54	0.61	0.89	0.376
ΔT X Gender	-0.93	0.51	-1.8	0.073
Gender X Self-Construal	-15.67	22.14	-0.71	0.480
ΔT X Gender X Self-Construal	1.38	1.20	1.15	0.251

We then tested whether the mediating effect of testosterone reactivity between competitive outcomes and aggression found by Carré and colleagues (2013) was specific to men with independent construals. Because our previous analyses found that self-construal only moderated the direct effect of competitive outcomes on testosterone reactivity, we specified the moderated mediation model to have self-construal only moderate the indirect effect at this point in the model (Process Model 7, Hayes, 2013; See Figure 5). In this model, bootstrapping indicated that testosterone reactivity mediated the effects of competitive outcome on aggression only in men with independent self-construals (*b* = 21.66, *se* = 9.37, 95% CI: 3.61, 40.28), not interdependent self-construals (*b* = 6.30, *se* = 5.87, 95% CI: -3.06, 20.53). Additionally, the moderated mediation index was significantly different than 0, indicating the presence of moderated mediation (Index = 18.08, 95% CI: 2.72, 45.16). The pattern and significance of the indirect effects in men with interdependent (*b* = 9.08, *se* = 8.68, 95% CI: -4.26, 31.98) and independent (*b* = 25.00, *se* = 11.27, 95% CI: 5.92, 52.11) self-construals remained the same after controlling for game difficulty and enjoyment.[4]

[4] Moderated regression analyses revealed that there was no significant outcome X testosterone reactivity interaction predicting aggression in men (*b* = -.19, *se* = .67, *t*(95) = -.28, *p* = .779). Additionally, there was no significant outcome X testosterone reactivity X self-construal interaction predicting aggression (*b* = -1.65, *se* = 1.87, *t*(95) = -.88, *p* = .379).

Figure 5. Path diagram of moderated mediation relationship of self-construal moderating the mediating effects of testosterone reactivity between competitive outcomes and aggression.



Discussion

The current study found that testosterone reactivity to competitive outcomes only occurred within men that had independent self-construals (supporting Hypotheses 1a and 1b). Furthermore, in men with independent construals, testosterone reactivity mediated the effects of competitive outcomes on aggressive behavior (supporting Hypotheses 2a and 2b). This mediated relationship was moderated by self-construal within men (supporting Hypothesis 2c). Within women, competitive outcomes did not produce changes in testosterone reactivity, testosterone reactivity did not mediate the relationship between competitive outcomes and aggression, and this relationship was not moderated by self-construal. These results suggest that self-construal can alter the function of testosterone as a mediating mechanism of aggressive processes among men.

This work is not without limitations. First, the competition task in this study was an individualized manipulation of competitive outcome. Participants played the game alone, and thus victories and defeats during the game inform their sense of status as an individual competing against a computer—not groups to which participants belong, or participants' sense of achieving teamwork and collaboration with others. Those with independent self-construals may be motivated to achieve status independently from others, while those with more interdependent self-construals may be motivated to achieve status in a cooperative manner. Therefore, in the context of a group competition, interdependent individuals may show testosterone reactivity to competitive outcomes. Furthermore, this testosterone reactivity may also modulate social behavior in interdependent individuals. Thus, it is necessary to test whether competitive outcomes to group competitions can influence testosterone reactivity, and subsequently behaviors in those with interdependent self-construals.

Additionally, the behavioral specificity of these effects within independent individuals was not clear from these results. Study 1 found that self-construal moderated the effects of competitive outcomes and testosterone reactivity on aggressive behavior. However, this effect may generalize to other behaviors, such as risk taking. By nature, aggressive behavior is a specific form of risk taking (e.g., Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996), as there are numerous costs to aggressive behavior, including retaliation, loss of social status, incarceration, and injury or death.

The moderated mediation effect established in Study 1 also needed to be cross-validated in a separate sample. Because a moderated mediation effect is complex, it was important to replicate this effect in a separate, well-powered sample of men. This replication would help support the robustness of the relationships between testosterone reactivity, competition, and aggression occurring only in men with independent self-construals.

CHAPTER 3

Study 2

Study 2 was designed to replicate the moderation effect of self-construal on testosterone reactivity to competition in Study 1 (Hypotheses 1b), while examining several explanatory mechanisms for this effect. In particular, Study 2 additionally investigated whether individuals with independent self-construals would show testosterone reactivity to the outcomes of group competitions (Hypothesis 1c). Study 2 also investigated whether the moderation effect in Hypothesis 1 occurred because of differences in attributions, increased competitiveness in independent individuals, or increased desire for team work in interdependent individuals (Hypothesis 3). Study 2 further investigated whether group competitions affected testosterone reactivity in men with interdependent self-construals (Research question 1). Finally, Study 2 extends the findings of Study 1 by testing whether testosterone reactivity to competitive outcomes can also mediate the effects of winning and losing on a novel behavioral measure of risk taking (Hypotheses 2a and 2b). In line with Research Question 2, Study 2 investigated whether testosterone reactivity to group competitions would mediate the effects of winning and losing on risk taking for individuals with interdependent self-construals.

Study 2 tested these hypotheses and research questions by using a 2 X 2 experimental design. Similar to Study 1, participants were randomly assigned to win or lose a video game task. However, participants were additionally assigned to compete in the game alone or on a team with a confederate who appeared to be another participant in the study. Because existing literature suggests that competition and competitive outcomes do not affect testosterone reactivity as much in women compared to men (e.g., Carré et al., 2009; Carré et al., 2013; Kivlighan, Granger, & Booth, 2005), Study 2 only investigated these effects within a sample of men.

Methods

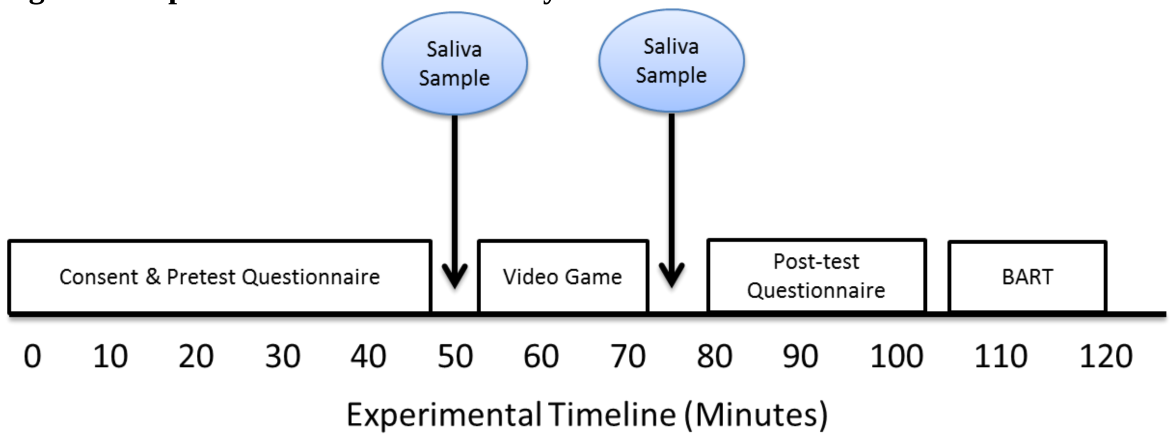
Participants and design

Participants were 165 male university psychology students (M_{age} = 20.64, *SD* = 3.00) that were randomly assigned to a 2 (competitive outcome: win vs. loss) x 2 (playing game alone vs. playing game on a team) design. The sample was diverse (38.2% Caucasian, 19.4% Black, 18.1% Asian, 4.8% Latin America, .6% Native American, and 18.8% Other). Participants were recruited through the online psychology subject pool and all participants were compensated by receiving partial course credit and being entered in a raffle for a 150 dollar gift card. Using a two-tailed alpha of .05, this sample size provides substantial power for detecting large effect sizes ($|r|$ = .50, power > .99), adequate power for detecting medium effect sizes ($|r|$ = .30, power = .98), and low power for detecting small effect sizes ($|r|$ = .10, power = .25).

Materials and Procedure

An overview of the study timeline is presented in Figure 6. In Study 2, participants first completed the consent form and a battery of pretest personality and demographic questionnaires, played a competitive video game with a rigged outcome of victory or defeat, with saliva samples taken pre and post-game, completed a post-task questionnaire, and then completed a risk taking task. 89.5% of the experimental sessions were run by male researchers.

Figure 6. Experimental timeline of Study 2.



Pre-Experimental Questionnaire. First, participants completed a demographic questionnaire assessing their age, gender, and race. Then, participants completed the 30-item self-construal scale (Singelis, 1994, See Appendix A), which consisted of seven-point Likert-type items measuring the extent to which participants hold interdependent and independent construals (1 = Strongly Disagree, 7 = Strongly Agree). The interdependent (Cronbach's $\alpha = .80$) and independent (Cronbach's $\alpha = .78$) dimensions were positively correlated with each other ($r = .35$, $p < .001$), and this measure was scored similarly to the scoring used in Study 1.

Participants then completed two items as a measure of competitiveness, selected from the trait dominance scale provided by the international personality item pool (IPIP; Goldberg, Johnson, Eber, Hogan, Ashton, Cloninger, & Gough, 2006), which is part of a publicly available stand-in version of the Gough California Psychological Inventory (Gough, 1996). Participants indicated how much they agreed with these items ("I try to surpass others' accomplishments" and "I try to outdo others") on a 7-point scale (1 = Disagree Strongly, 7 = Agree Strongly). These two items were highly correlated ($r = .71$, $p < .001$) and showed good internal consistency ($\alpha = .83$).

Preference for teamwork was measured by eight items combined from Kirkman & Shapiro's (2001) Resistance to teams scale and Campion, Medsker, and Higgs' (1993) preference for teamwork scale, using a 7-point scale (1 = Strongly Disagree, 7 = Strongly Agree). Because these scales were designed to measure preferences for working as a team in organizational settings, the items will be reworded to apply to video gameplay (e.g., "I would rather play alone than on a team" [reverse coded], "I am eager to be working with other players in a team"). This scale had excellent internal consistency (α = .92).

Saliva samples. Saliva samples were obtained from participants before and after playing the XBOX 360 Kinect volleyball game. Samples were taken between 11am and 5pm to minimize diurnal variation in testosterone.

Competitive outcome manipulation. Similar to Carré and colleagues (2013), participants played an XBOX 360 Kinect game of volleyball set to either the highest difficulty (loss) or the lowest difficulty (win). Participants played the video game for 15 minutes before being stopped by the researcher to complete the post-task saliva sample, post-experimental questionnaire, and the balloon analog risk task (described below).

Collective and individual competition manipulations. Participants in the team condition were paired with a male confederate, who appeared to be another participant scheduled for the study. The confederate and participant were told by the experimenter that they were part of a team and the goal of this task is to work together to collectively win the video game. When playing as a team, the Kinect sensor read both of the participants' movements as they stood next to each other and played the game on the same television screen.

Post-Experimental Questionnaire. Similar to Study 1, participants completed a short questionnaire assessing their perceptions of the video game (See Appendix C). This questionnaire contained the same 5 items as the post-game questionnaire in Study 1, but also included the items "How fun was the game?," "How hard was the game to win?," and "How hard did you try to win in the game?" (1 = not very, 7 = very). Similar to Study 1, a principle components analysis using a varimax rotation extracted two components (Game Difficulty and Enjoyment) that explained 74.44% of the variance in these items. The results of this analysis are presented in Table 4. Using the regression method, these factor scores were saved as indices of perceived difficulty and enjoyment.

Table 4. Principal components analysis of video game perceptions (Study 2).

	Component	
	Game Difficulty	Game Enjoyment
% of variance (Rotation SS Loadings)	39.65%	34.79%
Items and Factor Loadings		
How difficult was the game?	**.88**	-.12
How frustrating was the game?	**.83**	-.07
How hard was the game to win?	**.91**	-.06
How fast was the action of the game?	**.70**	.30
How hard did you try to win the game?	**.60**	.42
How enjoyable was the game?	-.05	**.94**
How fun was the game?	-.07	**.95**
How exciting was the game?	.16	**.84**

Although not initially implemented at the beginning of the study, a portion of the later participants (N = 38) completed an additional manipulation check of the team condition by responding to an item asking them how much they felt like they "belonged to a team" (1 = not very, 7 = very).

To measure attributions of the performance outcome, participants completed two measures. The first measure was a two-item self-report measure asking participants to indicate how much they were "responsible for the outcome of the game (e.g., winning or losing)" and how much their "behavior determined the outcome of the game" (1 = not at all, 7 = very much). These two items showed adequate reliability (Cronbach's α = .61) and were averaged into one index.

The second measure required participants to list 7 reasons for why they either won or lost the game. Three blind coders classified each attribution as either external (e.g., “The game was easy,” “The computer cheated”), internal (e.g., “I’m a volleyball God,” “I have good reaction time”). Responses that were not a legitimate reason or attribution (e.g., “All your base are belong to us,” blank responses) were not coded. The number of each type of attribution was summed and divided by the total number of scored reasons listed, resulting in percentages of external and internal attributions made from each participant. Interrater consistencies for the external (ICC = .625) and internal (ICC = .788) attributions percentages were acceptable and good, respectively. These percentages were averaged into two single indices of participants’ external and internal attributions of the game outcome.

Balloon Risk Analog Task. Participants then completed a widely used measure of risk taking, the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). The BART has been used by a wide variety of researchers to predict how performance on the task is linked to dispositional anxiety (Maner et al., 2007), smoking (Lejuez et al., 2003), and risk taking behaviors in adolescents (Lejuez, Aklin, Daughters, Zvolensky, Kahler, & Gwadz, 2007). In this version of the task, participants accumulated money points by pumping up 30 virtual balloons. Each balloon pump earned participants $.05, and for every $.10 earned, participants earned a raffle ticket for a 150 dollar gift card. Each balloon had a maximum threshold of pumps it could reach before it exploded, ranging between 1 to 30 pumps. If a balloon exploded, all points were lost from that specific balloon. Participants also had an option to save the points from a balloon, provided that the balloon has not yet exploded, and move on to pumping the next balloon in the sequence. Altogether, when performing this task, participants must make a decision to engage in risky behavior with each button press, as the balloon has a chance to explode with each press.

Consistent with previous work (Maner et al., 2007), the average number of pumps from unexploded balloons served as participants' index of risky behavior.

Salivary Hormone Analyses

Saliva samples were collected and stored in polystyrene tubes and frozen at -20°C until assayed. Additionally, saliva samples were assayed for testosterone in duplicate using immunoassay kits from DRG International. The intra-assay coefficients of variation were adequate (6.16). Similar to Study 1, testosterone reactivity was calculated residualized change, and results were also confirmed using percent change. Unless otherwise noted, the significance of reported effects did not differ depending on which index of testosterone reactivity was used. Testosterone reactivity values were Winsorized to ±3 SDs.

Statistical Analyses

Similar to the previous study, moderated regression analyses and mediation analyses were used to assess the hypotheses using PROCESS (Hayes, 2013). All data were inspected for outliers and distributional anomalies. Similar to what was tested in Study 1, the role of self-construal moderating the mediating relationship of testosterone reactivity between competitive outcome and aggression was tested. However, it was hypothesized that competitiveness, attributions of competitive outcomes, and preferences for teamwork would mediate the effect of self-construal on this moderation effect. Thus, we also examined these mediated moderation effects as well. Because there are several moderation effects we aimed to test, these 2-way and 3-way interaction effects were first tested before moderated mediation was modeled in the analyses.

Results

Manipulation Checks, Intercorrelations, Descriptive Statistics, and Game Perceptions

One participant refused to play the game due to arthritis, another four participants failed to win any of the rounds in the win condition, and another participant discovered a glitch that allowed him to win all of the rounds played on the lose condition. These participants (N = 6) were removed from the analyses. Unless otherwise noted, excluding these participants did not change the significance of any reported findings.

Intercorrelations and descriptive statistics of all study variables are presented in Table 5. Notably, across all participants, no predictors in the dataset where associated with risk taking behavior (all $|r|$s $\leq .08$)., including testosterone reactivity. However, it is possible that the effects of testosterone reactivity were specific to, or moderated by, the experimental conditions.

To examine participants' perceptions of the experimental conditions, 2-way (win vs. loss X team vs. individual) ANOVAs were conducted on participants' sense of being on a team, perceptions of game difficulty and enjoyment, and self-reported and listed attributions of the game outcome. The results of these analyses are presented in Figure 7.

Being part of a team. For being part of a team, it is important to note that only 38 participants were able to complete this measure, which limited the statistical power in analyses. There was no significant team condition X outcome interaction ($F(1,34) = .35$, $p = .558$) or main effect of competitive outcome ($F(1,34) = .95$, $p = .338$). Although the main effect of team competition was nonsignificant ($F(1,34) = 1.44$, $p = .238$), the direction of the effect was as expected: Participants in the team condition tended to feel as though they were part of a team ($M = 5.38$, $SE = .52$) compared to those in the alone condition ($M = 4.59$, $SE = .40$). Though not

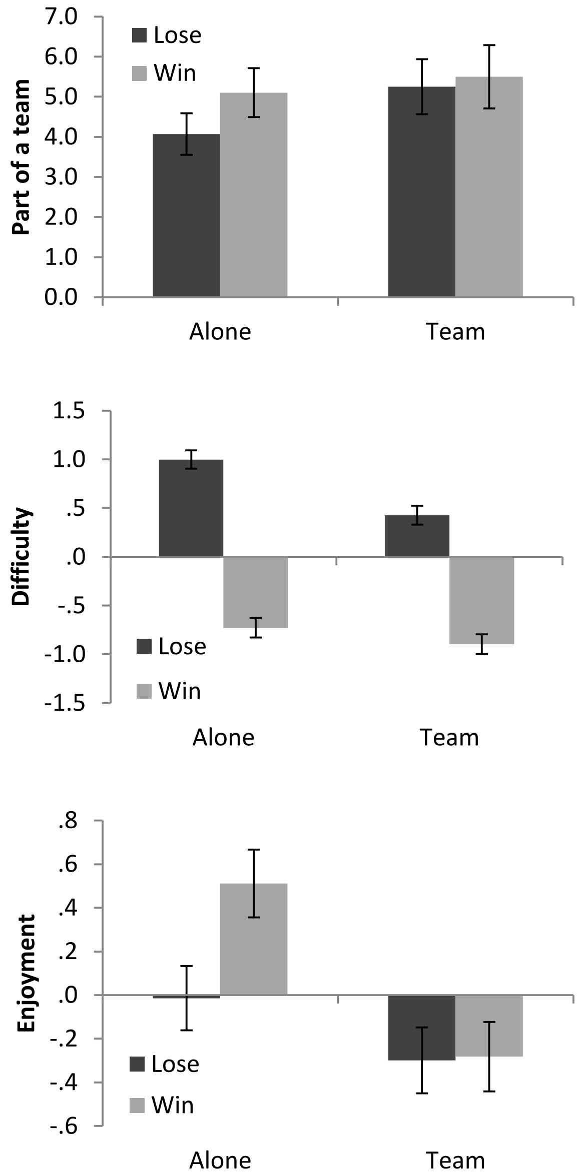
Table 5. Correlations and Descriptive Statistics for Study 2 Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. T1	--												
2. T2	.83***	--											
3. Residualized T Change	-.01	.54***	--										
4. Percent T Change	-.27***	.26**	.88***	--									
5. Self Report Attributions	-.01	-.05	-.08	-.05	--								
6. Game Difficulty	-.10	-.02	.11	.07	.03	--							
7. Game Enjoyment	-.06	-.05	-.03	.07	.27***	-.00	--						
8. Listed Attributions (Internal)	.00	-.07	-.14†	-.16*	.18*	-.13†	.02	--					
9. Listed Attributions (External)	-.08	-.12	-.12	-.11	.03	-.02	-.05	.73***	--				
10. Competitiveness	-.09	-.09	-.02	-.03	.09	-.04	-.07	.09	.10	--			
11. Self Construal	.05	.01	-.05	-.03	.10	.09	.00	.02	.07	.10	--		
12. Teamwork preferences	-.11	-.09	-.00	.05	.17*	.02	.27***	-.04	-.07	.10	-.16†	--	
13. Risk Taking	.00	.02	.07	.04	.07	-.07	.08	.01	-.02	.04	.01	-.01	--
M	104.52	98.31	.17	-4.14	5.02	-.01	-.02	.50	.41	5.28	4.18	4.72	9.80
SD	43.27	40.20	21.68	24.07	1.28	1.00	1.00	.09	.07	1.43	.43	1.42	3.24

Note: ***$p < .001$, ** $p < .01$. *$p < .05$, †$p < .10$

significant, this difference was of a moderate effect size (Cohen's *d* = -.47) by the standards of Cohen (1988).

Figure 7. Feeling like part of a team, difficulty, and enjoyment as a function of gender and competitive outcome.



Note: Error bars represent standard errors of the mean.

Game Difficulty. A similar 2-way ANOVA conducted on the game difficulty factor scores revealed significant main effects of team condition ($F(1,152) = 14.22$, $p < .001$) and competitive outcome ($F(1,152) = 241.61$, $p < .001$). Specifically, losers found the game more difficult (*M* = .71, *SE* = .07) than winners (*M* = -.81, SE = .07) and participants in the alone condition found the game more difficult (*M* = .13, *SE* = .07) than those in the team condition (*M* = -.24, *SE* = .07). There was also a significant team condition X outcome interaction ($F(1,152) = 4.18$, $p = .043$).[5] Simple effects tests revealed that losers in the alone condition found the game more difficult (*M* = 1.00, *SE* = .09) than losers in the team condition (*M* = .73, *SE* = .10; $F(1,152) = 17.82$, $p < .001$). However, there was no difference in difficulty by team condition among participants that won ($F(1,152) = 1.42$, $p = .236$).

Game enjoyment. Another 2-way ANOVA analyzing game enjoyment found a significant main effect of team condition ($F(1,152) = 12.35$, $p = .001$), with those playing as a team enjoying the game more (*M* = .25, *SE* = .11) than those playing it alone (*M* = -.29, *SE* = .11). There was a marginally significant effect of competition outcome on game enjoyment ($F(1,152) = 2.86$, $p = .079$), with participants that won the game tending to enjoying it more (*M* = .115, *SE* = .11) than those that lost (*M* = -.16, *SE* = .11). Although the team condition X outcome interaction was nonsignificant ($F(1,152) = 2.74$, $p = .100$), simple effects showed a significant difference between team conditions in winners ($F(1,152) = 12.71$, $p < .001$), but not losers ($F(1,152) = 1.82$, $p = .179$).

[5] When excluded participants were used in the data analysis, this interaction was marginally significant ($p = .089$).

Attributions

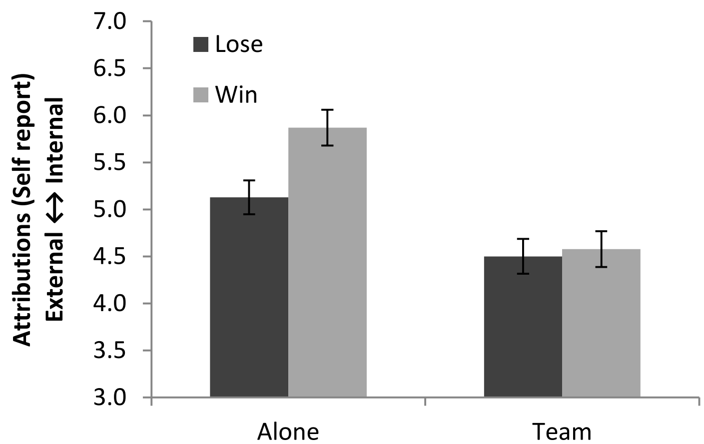
The 2-item self-report attribution scale, while having adequate internal consistency (α = .61), was not well-correlated with participants percentages of listed internal (*r* = .18, *p* = .028) and external attributions (*r* = .03, *p* = .75). On the other hand, the percentage of listed external and internal attributions were strongly correlated (*r* = .73, *p* < .001). Given that the tendencies to make external versus internal attributions are theoretically opponent processes, this high association between these measures, as well as the lack of strong association with the self-report measure, may indicate that the reason-listing is not the best assessment of attributions.

Effects of condition on self-reported attributions. Did competitive outcomes and playing as a team affect the attributions participants made of the outcome of the game? A 2-way (team vs. individual X competition outcome) ANOVA was conducted on self-reported attributions (See Figure 8). There was a significant main effect of team condition (*F*(1,155) = 26.44, *p* < .001), with those in the alone condition making more internal attributions (*M* = 5.50, *SE* = .13) of the game outcome than those in the team condition (*M* = 4.54, *SE* = .13). There was also main effect of outcome (*F*(1,155) = 4.83, *p* = .029), with winners making more internal attributions of the outcome (*M* = 5.22, *SE* = .14) than losers (*M* = 4.81, *SE* = .13). This result is consistent with previous work suggesting that individuals maintain positive self-views by making external attributions of failures and internal attributions of successes (e.g., Brown & Rogers, 1991; Grove, Hanrahan, & McInman, 1991). The team condition X outcome interaction was marginally significant (*F*(1,155) = 3.15, *p* = .078)[6], marked by a conditional effect of competitive outcome on attributions occurring in those playing alone (*F*(1,155) = 8.03, *p* = .005), not as a team (*F*(1,155) = .09, *p* = .767).

[6] This interaction was statistically significant when participants that were excluded were included in the analyses (*p* = .039).

Effects of conditions on listed attributions. For listed internal attributions, another 2-way team condition X competitive outcome ANOVA revealed no main effects or interaction (all Fs(1,155) $\leq$ 1.67, ps $\geq$ .198). Similarly, no main effects and interactions of experimental condition were significant (all Fs(1,155) $\leq$ .37, ps $\geq$ .545). Given the very low correlations between these indices and self-reported attributions, these may not be the best index of self-reported attributions.

Figure 8. Self-reported attributions as a function of experimental condition.



Note: Error bars represent standard errors of the mean.

Effects of baseline testosterone.

We then examined the relationship between baseline testosterone and risk taking. Baseline testosterone concentrations were unrelated to risk taking (r = .00, p = .992). Exploratory moderated regression analyses did not find the relationship between baseline testosterone and risk taking to be moderated by competitive outcomes (b = .00, se = .01, t(153) = .45, p = .650), team condition (b = -.00, se = .01, t(153) = -.48, p = .635), or self-construal (b = -.02, se = .01, t(153) = -1.34, p = .181).

Replication of Study 1: The Mediating effects of testosterone

The next analyses aimed to replicate the moderated mediation effect found in Study 1. Did testosterone mediate the relationship between competitive outcomes and risk taking? Another 2 x 2 (competition outcome X team) ANOVA on residualized testosterone reactivity revealed—in contrast to Study 1—a marginally significant main effect of competition outcome ($F(1,152) = 3.20$, $p = .076$) whereby winners had marginally decreased testosterone ($M = -3.04$, $SE = 2.50$) compared to losers, who experienced relatively increased testosterone ($M = 3.16$, $SE = 2.40$). The main effect of team condition ($F(1,152) = .06$, $p = .809$) and the team condition X outcome interaction ($F(1,152) = .40$, $p = .528$) were nonsignificant. Using percent testosterone reactivity as the index of testosterone did not alter the significance of these effects, with the exception that the main effect of competitive outcome became nonsignificant ($p = .123$). Overall, risk taking behavior was not related to residualized testosterone reactivity ($r = .07$, $p = .370$) or percent testosterone reactivity ($r = .04$, $p = .648$).

Neither residualized testosterone reactivity (95% CI = -.18, .02) nor percent testosterone reactivity (95% CI = -.13, .03) mediated the relationship between competitive outcomes and risk behavior. This is not surprising given the absence of the expected indirect effects illustrated in previous analyses. This mediation did not occur when analyses were restricted to only those that competed individually or as a team (95% CIs included 0). Furthermore, self-construal did not significantly moderate the mediating effects of residualized testosterone reactivity across all participants (95% CI for the index of moderated mediation: -.05, .31), or within those competing alone (95% CI = -.26, .16) or as a team (95% CI = -.15, .54). Thus, Study 2 did not successfully replicate the findings of Study 1.

Moderation by Self-Construal

Despite the fact that the moderated mediation found in Study 1 was not replicated in Study 2, it was still important to examine if competition outcomes, team condition, testosterone reactivity, and self-construal impacted risk taking behavior in a different pattern. Thus, in the next analyses, other multivariate associations between these variables.

Moderated regression analyses (See Table 6) were used to test whether self-construal moderated the effects of competitive outcome and team condition on testosterone reactivity (Model 1) and risk taking behavior (Model 2), along with whether self-construal moderated the effects of testosterone reactivity, team condition, and competitive outcomes on risk taking behavior (Models 3 and 4). All predictors were mean-centered prior to calculating interactions.

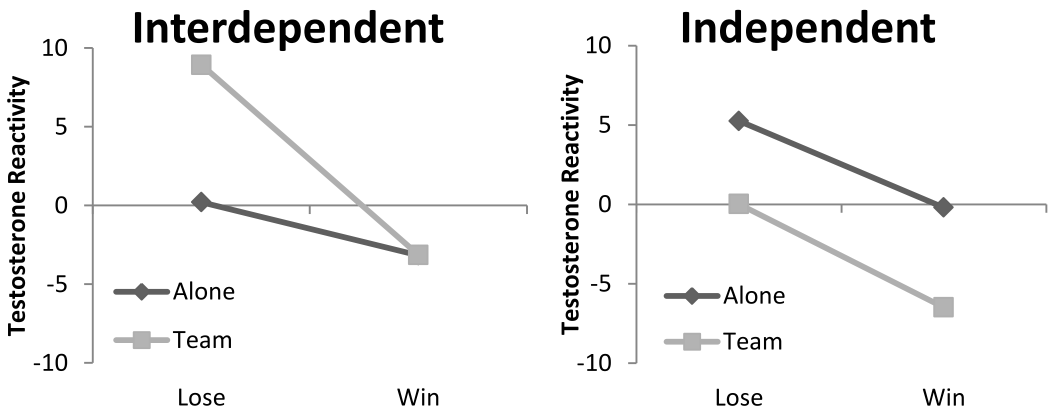
Model 1. In model 1, residualized testosterone reactivity was regressed on self-construal, competitive outcome, team condition, and all possible cross-products of these variables. These analyses revealed only a marginally significant effect of competitive outcome (b = -3.42, se = 1.75, $t(148)$ = -1.95, p = .053), revealing the trend that individuals that lost the competition experienced increased testosterone reactivity compared to those that lost, which is consistent with previous analyses. All other main effects and interactions were nonsignificant (all ps $\geq$ .158), including the hypothesized self-construal X outcome interaction (p = .811) and the self-construal X outcome X team condition interaction (p = .600).

Table 6. Moderated Regression Analyses from Study 2.

Model	DV	Predictors	*b*	*se*	*t*	*p*
Model 1	$F(7,148) = .54$, $p = .805$, $R^2 = .02$					
	ΔT	SC	-1.27	4.17	-.30	.761
		Outcome	-3.42	1.75	-1.95	.053
		Team	-.30	1.75	-.17	.865
		SC X Outcome	1.00	4.19	.24	.811
		Outcome X Team	-1.22	1.75	-.69	.488
		SC X Team	-5.93	4.17	-1.42	.158
		Team X Outcome X SC	2.21	4.19	.53	.600
Model 2	$F(7,151) = 1.05$, $p = .401$, $R^2 = .05$					
	Risk Taking	SC	.40	.62	.63	.532
		Outcome	.22	.26	.83	.407
		Team	.37	.26	1.44	.152
		SC X Outcome	.30	.62	.48	.634
		Outcome X Team	-.07	.26	-.25	.801
		SC X Team	-.86	.62	-1.38	.168
		Team X Outcome X SC	.71	.62	1.14	.257
Model 3	$F(7,148) = .76$, $p = .624$, $R^2 = .03$					
	Risk Taking	SC	.18	.63	.29	.775
		ΔT	.01	.01	.89	.374
		Team	.34	.26	1.30	.196
		SC X ΔT	.02	.03	.47	.639
		ΔT X Team	.01	.01	.81	.419
		SC X Team	-.95	.63	-1.51	.134
		Team X ΔT X SC	.00	.03	.05	.964
Model 4	$F(7,148) = 1.91$, $p = .071$, $R^2 = .05$					
	Risk Taking	SC	.39	.62	.64	.524
		ΔT	.01	.01	.59	.555
		Outcome	.28	.26	1.09	.275
		SC X ΔT	.02	.03	.57	.572
		ΔT X Outcome	**.03**	**.01**	**2.59**	**.011**
		SC X Outcome	.42	.62	.68	.499
		Outcome X ΔT X SC	**.07**	**.03**	**2.29**	**.024**

The simple slopes of this model are presented in Figure 9. The only conditional simple slope of competitive outcome that neared statistical significance occurred in participants with interdependent self-construals that played in the team condition (b = -6.03, se = 3.38, t(148) = -1.79, p = .076). However, the absence of significant interaction effects indicates that the simple slopes did not significantly differ from each other. Controlling for game difficulty and enjoyment, as well as using the percent change index of testosterone reactivity, did not change the significance of any effects in model 1, with the exception that the previously reported marginally significant effect of competitive outcome became nonsignificant (p = .408 with covariates, p = .165 using percent testosterone reactivity). Controlling for these two covariates and using the percent change index of testosterone reactivity did not alter the findings of subsequent models, unless otherwise specified.

Figure 9. Testosterone reactivity as a function of experimental conditions and self-construal.



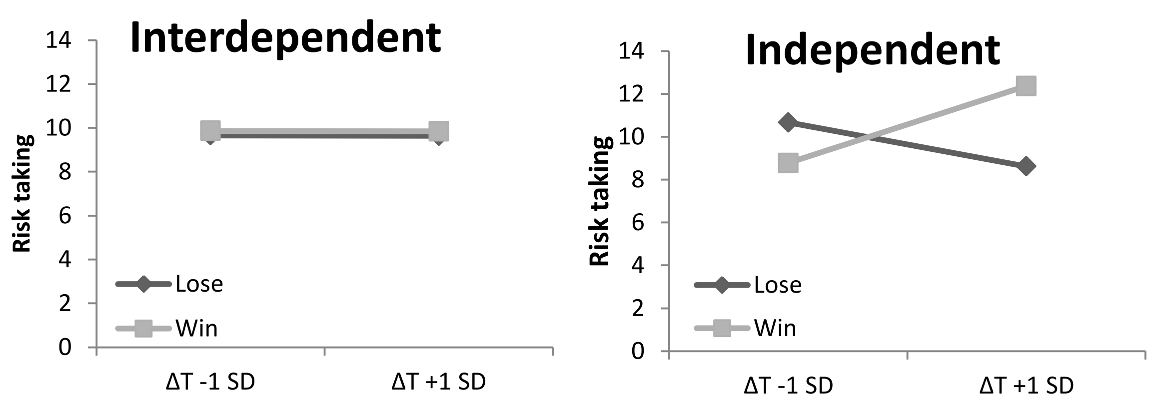
Model 2. Similar to model 1, there were no significant main effects or interactions (*p*s ≥ .152) emerging when risk taking behavior was regressed on self-construal, competitive outcome, team condition, and all possible cross-products. Thus, self-construal and the experimental conditions did not affect risk taking.

Model 3. Model 3, which consisted of risk taking behavior being regressed on self-construal, testosterone reactivity, team condition, and all possible interactions, also did not reveal any significant effects (*p*s ≥ .134).

Model 4. Self-construal did not moderate the effects of competitive outcomes and competing as a team on testosterone reactivity and risk taking. In the absence of these effects, we explored whether competitive outcomes and self-construal moderated the relationships between testosterone reactivity and risk taking. Indeed, some researchers have found that changes in testosterone only predict aggression within male losers of competitions (Carré, Putnam, & McCormick, 2009). Thus, in the absence of the mediating effects of testosterone reactivity that occur in Study 1, it is important to examine if the effects of testosterone reactivity on risk taking are moderated by self-construal and competitive outcomes.

Thus, in Model 4, risk taking behavior was regressed on self-construal, competitive outcome, testosterone reactivity, and all possible three way interactions. This model revealed a significant 3-way outcome X testosterone reactivity X self-construal interaction (*b* = .07, *se* = .03, *t*(148) = 2.29, *p* = .024). The simple slopes of this model are presented in Figure 10. This interaction occurred because there was a conditional outcome X self-construal interaction that occurred in those with independent self-construals (*b* = .07, *se* = .02, *t*(148) = 3.27, *p* = .001), not interdependent self-construals (*b* = .00, *se* = .02, *t*(148) = .00, *p* = .998). Simple slopes analysis revealed that when self-construal was independent, testosterone reactivity was positively associated with risk taking in winners (*b* = .09, *se* = .03, *t*(148) = 2.84, *p* = .005) but marginally associated, in a negative direction, with risk taking in losers (*b* = -.05, *se* = .03, *t*(148) = -1.75, *p* = .083). Within interdependent individuals, testosterone reactivity was not significantly associated with risk taking in winners (*b* = -.00, *se* = .03, *t*(148) = -.01, *p* = .989) or losers (*b* = -.00, *se* = .02, *t*(148) = -.03, *p* = .977).[7]

Figure 10. Risk taking as a function of self-construal, testosterone reactivity, and competitive outcome.



[7] This model also featured a significant 2-way outcome X testosterone reactivity (*p* = .011), whereby changes in testosterone positively predicted risk taking in winners (*b* = .04, *se* = .02, *t*(152) = 2.41, *p* = .017), but not losers (*b* = -.01, *se* = .02, *t*(152) = -.72, *p* = .472). However, as indicated by the previous analyses, this interaction was further moderated by self-construal. Additionally, the 3-way outcome X testosterone reactivity X self-construal interaction was marginally significant when using percent change as an index of change (*p* = .066). However, the conditional competitive outcome X testosterone reactivity interaction was significant in those with independent self-construals (*p* = .013), but not those with interdependent self-construals (*p* = .962).

Controlling for game enjoyability and difficulty did not change the significance of the 3-way outcome X testosterone reactivity X self-construal interaction (p = .026). However, using percent change as an index of testosterone reactivity resulted in a marginally significant outcome X testosterone reactivity X self-construal interaction (p = .066). Despite this difference in significance, the conditional outcome X testosterone reactivity interaction was still significant only when individuals had an independent self-construal (p = .013), not an interdependent self-construal (p =.962).

We then conducted additional analyses to demonstrate that the outcome X testosterone reactivity X self-construal interaction did not vary as a function of team of condition. The team condition did not moderate the 3-way interaction (p = .234). The 3-way interaction was significant when examining only those that competed as individuals (p = .007). Although the 3-way interaction was nonsignificant within those in the team condition (p = .218), the conditional outcome X testosterone reactivity interaction was significant only in those with independent self-construals (p = .021) and not those with interdependent self-construals (p = .641). Thus, the pattern of the interaction was similar across both team conditions.

Exploratory analyses of potential mechanisms related to self-construal

Because self-construal did not moderate the mediating effects of testosterone between competitive outcomes and risk taking, the roles of attributions, team-work preferences, and competitiveness were not examined as moderators of this mediated relationship. Instead, we examined whether these three factors also moderated the interaction between competition and testosterone reactivity on risk taking. Additionally, we investigated whether these factors were associated with self-construal. Notably, listed internal (r = .02, p = .812) and external (r = .07, p = .403) attributions, self-reported attributions (r = .10, p = .198), and competitiveness (r = .10, p

= .206) were not related to self-construal. However, there was a marginally significant association between teamwork preferences and self-construal (*r* = -.155, *p* = .051)[8], suggesting that increased desire to work as a team may be associated with increased interdependence. This association is consistent with research suggesting that having an interdependent self-construal is associated with increased cooperativeness compared to having an independent self-construal (Heine et al., 1999; Parks & Vu, 1994; Utz, 2004).

Moderated regression analyses were conducted with risk-taking regressed on testosterone reactivity (residualized), competitive outcome, teamwork preferences, and all possible interactions. Similar to previous analyses, the two-way testosterone reactivity X competition outcome interaction was significant (*b* = .03, *se* = .01, *t*(148) = 2.32, *p* = .022), while the testosterone reactivity X teamwork preferences and outcome X teamwork preferences interactions were nonsignificant (*p*s ≥ .547). Although the 3-way testosterone reactivity X outcome X teamwork preferences interaction was nonsignficant (*b* = -.01, *se* = .01, *t*(148) = -1.61, *p* =.110), the conditional testosterone reactivity X outcome interaction was only significant when individuals had low teamwork preferences (i.e. did not like to work as a team), *b* = .05, *se* = .02, *t*(148) = 2.62, *p* = .010, not high teamwork preferences (i.e. enjoyed working as a team), *b* = .01, *se* = .02, *t*(148) = .55, *p* = .585.

The conditional testosterone reactivity X outcome interaction predicting risk taking was not further moderated by listed internal attributions (*b* = -.19, *se* = .16, *t*(148) = -1.17, *p* = .243), listed external attributions (*b* = -.19, *se* = .22, *t*(148) = -.86, *p* = .390), self-reported attributions (*b* = -.01, *se* = .01, *t*(148) = -.63, *p* = .186), or competitiveness (*b* = -.00, *se* = .01, *t*(148) = -.45, *p* = .655). However, the conditional testosterone reactivity X outcome interaction on risk taking

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[8] When excluded participants were used to calculate the correlation between self-construal and teamwork preferences, the association was statistically significant but the effect size remained the same (*r* = -.16, *p* = .045)

was most pronounced when listed internal attributions were low (b = .05, se = .02, $t(148)$ = 2.28, p = .024), listed external attributions were low (b = .04, se = .02, $t(148)$ = 2.15, p = .033), self-reported attributions were external (b = .04, se = .02, $t(148)$ = 2.15, p = .033), and competitiveness was low (b = .03, se = .02, $t(148)$ = 1.76, p = .081). However, the condition conditional testosterone reactivity X outcome interactions were nonsignificant at the opposite ends of these dimensions (ps $\geq$ .252). However, given the weak association between self-construal and teamwork preferences (r = -.16) and the other potential mechanisms examined ($|r\text{s}|$ $\leq$ .10), it is unlikely that these are the mechanisms in which self-construal modulates the behavioral effects of testosterone reactivity.

Discussion

Study 2 found that competitive outcomes and testosterone reactivity jointly interacted to predict risk taking behavior, but only in men with independent self-construals. Specifically, in men with independent self-construals, rises in testosterone within winners of the competition was associated with increased risk taking behavior. The conditional relationship between testosterone and competition in Study 2 was of a moderated nature, rather than a mediated relationship in Study 1. Thus, hypotheses 1a, 1b, 1c, 2b, and 2c were not supported. Despite this difference in results, Study 1 and Study 2 support the conclusion that testosterone and competition jointly modulate behavior only in individuals in independent self-construals. Although risk taking was not associated as a main effect with testosterone reactivity (hypothesis 2a was not supported), the effects of testosterone reactivity on risk taking were moderated by competitive outcomes.

There are multiple strengths to Study 2. First, Study 2 attempted to replicate the moderated mediation effect of Study 1 with a large sample. Although this effect did not replicate, Study 2 did rule out several mediating mechanisms and did provide some evidence for why testosterone did not respond to competitive outcomes in the same fashion as Study 1. Study 2 also examined if the pattern of results in Study 1 generalized to a novel behavioral measure of risk taking, and when individuals competed as a team.

Study 2 also found that teamwork preferences modulated the interactive effects of outcome and testosterone reactivity on risk taking, such that these effects only occurred when individuals disliked teamwork. Although teamwork preferences were predicted to be related to self-construal, and also a possible mechanism of these effects, the small association between these constructs (r = -.16) does not suggest that teamwork preferences are the mechanism behind why self-construal modulates the behavioral effects of testosterone reactivity to competition.

Rather, this small association between self-construal and teamwork preferences suggests that teamwork preferences are an independent process outside of self-construal that also modulates how testosterone and competitions predict behavior.

The current study also found that competing alone or as part of a team did not alter how self-construal modulated the effects of testosterone reactivity (Research question 1). Rather, the effects of testosterone reactivity and competition on risk-taking behavior occurred in those with independent self-construals when individuals competed alone or as part of a team. This finding does not support the possibility that interdependent individuals would show testosterone reactivity, and furthermore, risk taking behavior, in a team context (Research questions 1 and 2).

This study also did not support the notion that attributions and competitiveness would explain the modulating effects of self-construal (Research Question 3). Attributions and competitiveness were not related to self-construal, and thus could not serve as a mechanism of these effects. Although Study 2 did not lend support to a mechanism for why self-construal modulates the effects of testosterone reactivity on behavior, it does eliminate three mechanisms that seemed likely to explain this moderation effect.

There are multiple strengths to Study 2. First, using a relatively well-powered sample, Study 2 expanded upon the work in Study 1 by examining the whether the moderation effect would remain constant in both individualized and team-based competitive contexts. Study 2 also sought to unveiled mechanisms for why self-construal moderated these effects. Limitations and future directions for the current research are discussed below in the general discussion.

CHAPTER 4

General Discussion

Collectively, these two studies suggest that self-construal alters whether testosterone reactivity and competition affect behaviors. Study 1 found that testosterone reactivity mediated the effects of competitive outcomes on aggressive behavior, and that these findings occurred in men with independent self-construals. Specifically, in men with independent self-construals, testosterone increased winners and decreased in losers. In turn, these changes in testosterone predicted aggressive behavior.

Study 2 did not show a similar mediation effect to that of Study 1 when predicting risk taking behaviors. Instead, testosterone reactivity and competitive outcome interacted to predict risk taking. However, similar to Study 1, these effects only occurred in men with independent self-construals, not men with interdependent self-construals. These effects did not vary depending on whether individuals competed individually or as a team. Additionally, Study 2 did not find evidence for psychological mechanisms of the moderating effect of self-construal. In summary, although the relationships between testosterone reactivity, competitive outcomes, and behavior vary across both studies, these effects were specific to men with independent self-construals.

Broadly, the current research suggests that self-construal is an important moderator of the behavioral functions of testosterone. Testosterone has been widely thought to be linked to aggression, dominance, and antisocial behavior (See Mazur & Booth, 1998; Carré et al., 2011; Mehta, Goetz, & Carré, in press for reviews). However, this research suggests these effects are specific to individuals that view their self as independent from others. The cultural variability of these differences in self-construct (Markus & Kitayama, 1991) suggests that cultural contexts may alter the link between testosterone, aggression, and risk taking. This finding is in keeping with emerging research in cultural neuroscience and immunology suggesting that culture can alter the links between the psychological and physiological (See Kitayama & Park, 2010 for a review).

The current research also adds to emerging findings suggesting that individual differences can alter testosterone reactivity patterns to competition. Researchers have found several individual difference moderators of testosterone's effects on social behavior and whether testosterone responses to competitive outcomes, including anxiety (Veenema et al., 2007, Maner et al., 2007), power motive (Schultheiss et al., 1999; Schultheiss & Rohde, 2002), and dominance (Slatcher, Mehta, & Josephs, 2011). Taking the current research in context with these findings, the role of testosterone in human social behavior is more complex than originally specified by previous researchers (e.g., Mazur & Booth, 1998; Wingfield et al., 1990). Moreover, the role of testosterone in responding to social situations and predicting social behaviors varies greatly as a function of individual differences, personality, and potentially, culture.

The present research did not identify any specific mechanisms that aid in explaining how self-construal alters the joint effects of competitive outcomes and testosterone dynamics on social behavior. In Study 2, the interaction between testosterone dynamics and competitive outcomes predicting risk taking behavior were strongest in individuals that did not prefer working in teams, that made low amounts of listed internal and external attributions, that had more internal self-reported attributions, and were low in competitiveness. However, none of these variables significantly moderated this competitive outcome X testosterone reactivity moderation effect, and these factors only had nonsignificant associations with self-construal that were small in magnitude. The current research did, however, suggests that these three mechanisms are not responsible for the moderating effect of self-construal.

There are other possible mechanisms that may explain the moderating effect of self-construal that were unexplored by the current research. One possibility involves how individuals are motivated to dominate others. Researchers have distinguished between different ways of how individuals are motivated to achieve power and dominance over others (McClelland, Davis, Kalin, & Wanner, 1972; McClelland, 1975; Schultheiss et al., 1999; Schultheiss & Rhode, 2002; Smith, 1992; Winter, 1973). Powerful and dominant individuals can dominate others prosocially or through assertive means. The former of these means, referred to by previous researchers as socialized power (S power; McClelland et al., 1972; Winter, 1973) involves dominating others through benevolent means (e.g., obtaining influence by helping others, providing advice, providing time and resources, protecting others). The latter, however, referred to as personalized power (P power) by previous researchers (McClelland et al., 1972; Winter, 1973), entails achieving power through assertiveness and power (e.g., aggression, threatening others, coercion). Because those with interdependent self-construals are motivated to fit in with others and to achieve status through social harmony and belongingness to groups (Markus & Kitayama, 1991), interdependent individuals might show increased effects of testosterone reactivity and competition in situations involving succeeding at achieving dominance through socialized means. In turn, these testosterone responses might predict prosocial dominance behaviors, such as generosity (Flynn et al., 2006), donations in a public goods game (e.g., Andreoni, 1988) or providing help to a stranger (DeWall, Baumester, Gailliot, & Maner, 2008). However, for those with independent self-construals, prosocial collaboration with others may not be a principal motivation. Thus, aggression and antisocial acts of dominance may be observed more in independent individuals. Because the current research investigated these effects within a competitive context, this may explain the absence of the relationship between testosterone reactivity, changes in status, and social behavior in interdependence that did not emerge in these two studies. This possibility may also help further explain recent findings showing that testosterone promotes prosocial behavior in the absence of competition (Boksem et al., 2013).

Another possible explanation of the moderating effects of self-construal found in the current research is that independent individuals are more likely to derogate competitors. Previous work suggests that Japanese students (who tend to have more interdependent self-construals) have greater identification with their teams and the outcomes of team competitions relative to European American students (who have a more independent self-construal; Snibbe, Kitayama, Markus, Suzuki, 2003). However, Japanese participants did not express intergroup bias toward their opponent teams, which was found in European Americans. Testosterone increases in response to perceiving one's status as being challenged by another and facilitates increased aggression toward challengers (e.g., Archer, 2006; Wingfield et al., 1990). Because of this lack of negative evaluations toward competitors within individuals with interdependent self-construals, opponent derogation may be an important factor to consider in future research. Further, this lack of derogation of competitors may explain the lack of increases in testosterone and inability of these changes in testosterone to predict post-competition behavior in men with interdependent self-construals.

A third mechanism that could be at work is the perception of status instability. Work in non-human animals suggests that testosterone predicts aggressive behavior most strongly when status hierarchies are unstable (e.g., Wingfield et al., 1990). Do interdependent individuals perceive status hierarchies as more stable than independent individuals? Collectivistic cultures—

which contain individuals with more interdependent self-construals—generally contain more rigid status hierarchies (See Ravlin & Thomas, 2005 for a review). For example, Polynesian workers (more interdependent and collectivistic) are less accepting of younger supervisors than Anglo-European workers (more independent and individualistic; Ah Chong & Thomas, 1997). Additionally, those with independent construals also perceive themselves as having more personal influence over situations than those with interdependent self-construals (Hernandez & Iyengar, 2001). The tendency for interdependent, collectivistic individuals to focus on the effects of the situation, rather than the individual (Choi, Nisbett, & Norenzayan, 1999; Masuda & Nisbett, 2001) may lead interdependent individuals to be more aware of the contextual influence of the existing status hierarchy on outcomes, and thus perceive status hierarchies as more stable. Future research is needed to determine if perceived status instability is responsible for the moderating effects of self-construal found in the current research.

The current research operationalized self-construal as an individual difference. However, interdependence is not only a dispositional characteristic, but context-specific to relationships. Both relational models of interdependence (Agnew & Etcheverry, 2006; Slotter & Gardner, 2009) and self-expansion theory (Aron & Aron, 1986; Aron & Aron, 1996; Aron, Aron, & Norman, 2004) hold that individuals in close relationships share a self-concept overlap between the self and close others. In the context of those close relationships, the interdependence may explain why individuals might be less likely to aggress toward close others. Additionally, the findings of this research may explain emerging research suggesting that individuals will only show testosterone reactivity when competing with outgroup members, not ingroup members (Flinn, Ponzi, & Muehlenbein, 2012). Because individuals share overlap with their self-concept and ingroup members (Cialdini, Brown, Lewis, Luce, & Neuberg, 1997), this interdependence may be a mediating factor in explaining variability in testosterone reactivity to outgroup and ingroup competitions.

Study 1 demonstrated that testosterone mediated the effects of competitive outcomes on aggressive behavior in men with independent self-construals. However, Study 2 showed a moderation effect of self-construal for testosterone reactivity to competitive outcomes. The difference in the nature of these effects between these two studies is surprising given the methodological similarity. However, it is important to note retrospectively that Study 1 was conducted primarily by female research assistants, whereas Study 2 was conducted mostly by male research assistants. The gender of the research assistants may have influenced the difference in these two results. The presence of an attractive female can elevate testosterone concentrations in men (e.g., Ronay & von Hippel, 2012), and evolutionary psychology holds that males are often motivated to compete to win the attraction of females (e.g., Buss, 1988). Additionally, men high in mating motivation are more likely to engage in risk taking (Baker & Maner, 2008). Thus, in the presence of a female, men may show pronounced testosterone reactivity to competitions, as well as increased risk taking. However, while in the presence of another male, testosterone reactivity may influence men's behavior within those that experience changes in status, similar to the findings of others (Carré et al., 2010; Geniole et al., 2011). Future research is needed to determine whether the presence of a male or female alters the relationships between testosterone reactivity, competitive outcomes, and social behavior. This possibility may explain why some studies fail to find main effects of competitive outcomes on testosterone reactivity (e.g., Schultheiss et al., 1999; Welker & Carré, in press).

Differences in the nature of the risk taking task from Study 2 with those used by Ronay and von Hippel (2010) may also explain why there was not a direct, main effect relationship between testosterone reactivity and risk taking in Study 2. In the study by Ronay and Von Hippel, participants engaged in risk taking in the presence of an attractive female. However, in Study 2 of the current research, participants engaged risk taking behavior while alone. It is possible that the relationship between testosterone reactivity and risk taking varies depending on the presence of an attractive female.

This study adds to a growing literature showing that testosterone dynamics can have impacts on social behavior, particularly aggression and risk taking (e.g., Apicella et al., 2014; Carré et al., 2009, 2010, 2011, 2013; Geniole et al., 2011; Hermans et al., 2008; Ross et al., 2004; Klinesmith et al., 2006; Ronay & von Hippel, 2010). Because testosterone reactivity predicts both aggression and risk taking within the context of competition, it is possible that there is a unitary psychological mechanism behind both of these effects. Indeed, aggression itself is often a risk-taking behavior, as behaving aggressively toward others can result in retaliation, punishment, or harm to oneself. Thus, risk taking itself may be the mechanism explaining the relationship between testosterone reactivity and aggression. However, other mechanisms involved could be impulsivity, which is predictive both of impulsive aggression (e.g., Carré et al., 2009, 2010, 2011, 2013; Geniole et al., 2011; Klinesmith et al., 2006) and risk taking behaviors (e.g., Apicella et al., 2014; Ronay & von Hippel, 2010). Future research is needed to examine whether the relationship between testosterone reactivity and aggression are mediated by risk taking, and potentially impulsivity.

The present research did not find that whether individuals competed as a group or individually interacted with self-construal to alter the relationship between testosterone and behavior. However, it is important to note that the groups in this study were dyads. Due to the small size of these groups, participants in the study may have felt more like they were part of a team if they participated in larger groups of three or more individuals. This size of group would be more difficult to implement in an experimental study, given the larger number of researchers needed to function as confederates in the groups. However, it would provide a more robust manipulation of whether participants perceived themselves as part of a group. Because of this limitation, the current study does not offer substantial evidence that whether a competition takes a social or individualized context does not alter the moderating effects of self-construal, or the relationships between competition, testosterone dynamics, and behavior.

An additional limitation of the present research is the lack of experimental manipulations of testosterone and self-construal. First, both studies measure, rather than experimentally manipulate, self-construal. Causal evidence for the moderating effect of self-construal can be further supported by a research design using experimental manipulations of self-construal. Several experimental manipulations of self-construal exist in the literature (e.g., Brewer & Gardner, 1996; Lee, Aaker, Gardner, 2000; Gardner, Gabriel, & Lee, 1999). Future research would benefit from replicating the present research with an experimental manipulation of self-construal. Additionally, it is important to verify the findings of the present research with experimental manipulations of testosterone. Researchers are increasingly using pharmacological manipulations of testosterone to show causal evidence for the effects of testosterone on behavior (e.g., Boksem et al., 2013; Goetz, Tang, Thomason, Diamond, Hariri, & Carré, in press; Hermans et al., 2008). Using these pharmacological manipulations of testosterone and experimental manipulations of self-construal would demonstrate greater causal evidence for the roles of these two variables in predicting aggression and risk taking.

Although the current research included a manipulation of team condition in Study 2, it is possible that this manipulation of teamwork could have been more salient to participants. Future research may benefit from examining team competitions between strangers by making the strangers feel an increased sense of solidarity between each other. Researchers have developed several research paradigms to get individuals to feel closer to each other in the laboratory (e.g., Aron, Melinat, Aron, Vallone, & Bator, 1997) and have a shared, common identity (See Gaertner & Dovidio, 2000 for a review) that could be used in this experimental context.

Future research will also benefit from extending the current findings into a cross cultural context to see if the effects of self-construal also extend cross-culturally. For instance, researchers could manipulate competitive outcomes in the United States of America and Japan, measuring testosterone reactivity, aggression, and risk taking. In conjunction with experimental manipulations of self-construal and self-reported individual differences in self-construal, this research could help show converging evidence that interdependence, on the levels of culture, personality, and interpersonal relationships can alter the role of testosterone in influencing social behavior.

Conclusion

The present research is impactful on broad theory in the social neuroendocrinology of aggression and risk taking. These findings suggest for the first time that the social neuroendocrinology of competition and antisocial behavior is variant depending on how individuals mentally represent their relation to others. Additionally, the implications of the current research may lead researchers to investigate culturally variability in social neuroendocrinology. Broadly, this research, along with the findings of others (See Chiao, 2009; Chiao, Cheon, Mrazek, & Blizinsky, 2013; Han & Northoff, 2009; Kitayama & Park, 2010), suggests that culture and self-construct can alter the links between physiology, behavior, and psychology. However, future work is needed to investigate the mechanisms by which self-construal moderates testosterone responses to competition, along with moderating the relationship between testosterone function and social behavior.

APPENDIX A: SELF-CONSTRUAL SCALE

Please use the scale to select how well you agree with each statement.

1	2	3	4	5	6	7
Disagree Strongly	Disagree Moderately	Disagree A little	Neither Agree Nor Disagree	Agree A little	Agree Moderately	Agree Strongly

1. ____I enjoy being unique and different from others in many respects.
2. ____I can talk openly with a person who I meet for the first time, even when this person is much older than I am.
3. ____Even when I strongly disagree with group members, I avoid an argument.
4. ____I have respect for the authority figures with whom I interact.
5. ____I do my own thing, regardless of what others think.
6. ____I respect people who are modest about themselves.
7. ____I feel it is important for me to act as an independent person.
8. ____I will sacrifice my self-interest for the benefit of the group I am in.
9. ____I'd rather say "No directly, than risk being misunderstood.
10. ____Having a lively imagination is important to me.
11. ____I should take into consideration my parents' advice when making education/career plans.
12. ____I feel my fate is intertwined with the fate of those around me.
13. ____I prefer to be direct and forthright when dealing with people I've just met.
14. ____I feel good when I cooperate with others.
15. ____I am comfortable with being singled out for praise or rewards.
16. ____If my brother or sister fails, I feel responsible.
17. ____I often have the feeling that my relationships with others are more important than my own accomplishments.
18. ____Speaking up during a class (or meeting) is not a problem for me.
19. ____I would offer my seat in a bus to my professor (or my boss).
20. ____I act the same way no matter who I am with.
21. ____My happiness depends on the happiness of those around me.
22. ____I value being in good health above everything.
23. ____I will stay in a group if they need me, even when I am not happy with the group.
24. ____I try to do what is best for me, even when I am not happy with the group.
25. ____Being able to take care of myself is a primary concern for me.
26. ____It is important to me to respect decisions made by the group.
27. ____My personal identity, independent of others, is very important to me.
28. ____It is important for me to maintain harmony within my group.
29. ____I act the same way at home that I do at school.
30. ____I usually go along with what others want to do, even when I would rather do something different.

APPENDIX B: VIDEO GAME PERCEPTION QUESTIONNAIRES (STUDY 1)

For each question, please choose the response number that most accurately fits your experience of the game you just played.

1. How difficult was the game?

1	2	3	4	5	6	7
Easy						Difficult

2. How enjoyable was the game?

1	2	3	4	5	6	7
Not Enjoyable						Enjoyable

3. How frustrating was the game?

1	2	3	4	5	6	7
Not Frustrating						Frustrating

4. How exciting was the game?

1	2	3	4	5	6	7
Not Exciting						Exciting

5. How fast was the action of the game?

1	2	3	4	5	6	7
Slow Action						Hectic Action

APPENDIX C: VIDEO GAME PERCEPTION QUESTIONNAIRES (STUDY 1)

For each question, please choose the response number that most accurately fits your experience of the game you just played.

For each question, please choose the response number that most accurately fits your experience of the game you just played.

1	2	3	4	5	6	7
Not Very						Very

1. _____How difficult was the game?
2. _____How enjoyable was the game?
3. _____How fun was the game?
4. _____How frustrating was the game?
5. _____How exciting was the game?
6. _____How hard was the game to win?
7. _____How fast was the action of the game?
8. _____How hard did you try to win in the game?

How many games did you play? __________

Out of the games you played, how many games did you win? __________

Video Game Attribution Listing Form

List 7 reasons why you think you won (won 2 out of 3 games) or lost (lost all games or won only once) the series of games.

1.____

2.____

3.____

4.____

5.____

6.____

7.____

APPENDIX C: VIDEO GAME PERCEPTION QUESTIONNAIRES (STUDY 1)

Video Game Attribution Listing Scale

1. How much were you personally responsible for the outcome of the game (e.g. winning or losing)? – please circle.

1	2	3	4	5	6	7
Not at all responsible						Very Responsible

2. How much did your own behavior determine the outcome of the game?

1	2	3	4	5	6	7
Not at all						Very Much

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ABSTRACT

SELF-CONSTRUAL MODERATES TESTOSTERONE REACTIVITY TO COMPETITIVE OUTCOMES

by

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August 2014

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Major: Psychology (Social)

Degree: Doctor of Philosophy

Previous research shows that testosterone reactivity to competitive outcomes predicts aggressive behavior in men. However, some studies have failed to find these effects, and it has been suggested that individual differences moderate the relationships between competitive outcomes, testosterone fluctuations, and aggressive behavior. The current research examined whether one individual difference—self-construal—would moderate these effects. In Study 1, participants were assigned to win or lose a competitive video game and engaged in a reactive aggression task. Results indicated that increases in testosterone in response to winning and decreases in response to losing occurred in men with independent, not interdependent, self-construals. These changes in testosterone mediated the effects of winning and losing on aggressive behavior only in independent men. In Study 2, participants were assigned to win or lose a competition as an individual or part of a team, and completed a novel measure of risk taking. Although analyses found that, unlike Study1, testosterone and competitive outcomes interacted to predict risk taking. However, these effects were again specific to men with independent self-construals. These results suggest for the first time that testosterone's association with antisocial behaviors is a function of how individuals think of the self in relation to others.

AUTOBIOGRAPHICAL STATEMENT

Keith Welker graduated from Grand Valley State University in 2008 with a Bachelor of Science in Psychology. He completed a Master of Arts degree in Psychology in 2012, with a minor in quantitative psychology. His research background is in the social neuroendocrinology of dominance, aggression, and relationships. He has experience in examining salivary hormones, individual differences, and advanced statistical techniques such as multilevel modeling, structural equation modeling, and dyadic analysis from a variety of statistical packages. His recent work examining how couple friendships can increase passionate love has been covered by many media outlets, including Time, USA Today, Science Daily, and The Telegraph. He has also spent over a year serving as a statistical consultant at Wayne State University, helping individuals from many different disciplines analyze their data, prepare grants, and write manuscripts. Recently, he accepted a postdoctoral position in the Department of Psychology and Neuroscience at the University of Colorado Boulder under the supervision of Dr. June Gruber.