Relationships are More Than Skin Deep: Associations Between Testosterone, Relationship Quality, and Prosocial Behavior

by

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Dedication

This dissertation is dedicated to my grandparents: Allan Chin, Nora Chin, Billy Li, and Mary Li.

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Abstract

Testosterone is a steroid hormone that is important for close relationship processes (Edelstein & Chin, 2018). For instance, people who are single tend to have higher levels of testosterone compared to people who are in committed relationships (Mazur & Michalek, 1998), suggesting that testosterone lowers once one is in a relationship. Furthermore, lower testosterone might be functional for maintaining relationships: Both men and women who have lower testosterone report higher relationship quality (e.g., Edelstein, van Anders, Chopik, Goldey, & Wardecker, 2014). However, only a few studies have examined associations between testosterone and relationship quality in individuals, let alone in a sample of couples, and studies that include couples tend to have relatively small, homogeneous samples. Thus it is not yet clear whether similar testosterone-relationship quality links and any dyadic associations between partners would be found in other samples. The first goal of this study was to examine whether people reported higher relationship quality when they or their partners have lower testosterone. I also examined how people with lower testosterone behaved towards their partners. Given that lower testosterone is thought to be associated with nurturance and caregiving (van Anders, Goldey, & Kuo, 2011), the second goal of this study was to examine whether people with lower testosterone would be more likely to behave in more nurturant (i.e., prosocial) ways towards their partner. Finally, the third goal was to test prosocial behavior as a potential mechanism underlying testosterone-relationship quality links. To address these questions, I analyzed data from 595 heterosexual couples drawn from three samples (college-aged couples, couples with children, and newlywed couples) that included baseline measures of salivary testosterone, self-reports of

relationship quality, and partner interactions that were coded for prosocial behavior. I found that, in the college-aged couples and couples with children, women who had lower testosterone indeed reported higher relationship quality and showed more prosocial behavior. In contrast to expectations, men in the newlywed sample who had lower testosterone reported *lower* relationship quality and engaged in less prosocial behavior. I also found dyadic associations: In the college-aged couples and couples with children, women who had lower testosterone had *partners* who reported higher relationship quality; in the newlywed sample, women who had lower testosterone had partners who reported *lower* relationship quality. I did not find that prosocial behavior accounted for any testosterone-relationship quality links, suggesting that people with lower testosterone felt better about their relationships, but not necessarily because they or their partners were more behaving in more prosocial ways. I discuss potential explanations for discrepant findings across samples: The newlywed couples knew prior to their lab session that they would be discussing a disagreement, which could have caused anticipatory increases in testosterone. This study advances social neuroendocrinology work by assessing the extent to which previous testosterone-relationship quality findings replicate in larger samples of couples and contributes important new information about the associations between testosterone and prosocial behavior.

Chapter 1 Introduction

Testosterone is a steroid hormone that is important for both men and women and is centrally involved in many close relationship processes (Edelstein & Chin, 2018). In general, higher levels of testosterone are thought to be associated with competition and sexuality (van Anders et al., 2011; Wingfield, Hegner, Dufty, & Ball, 1990). For instance, during competitive interactions with other men for a woman's attention, men with higher levels of testosterone tend to show more dominant behaviors compared to men with lower levels of testosterone (Slatcher, Mehta, & Josephs, 2011). In addition, women tend to be more attracted (i.e., report that they "clicked" more) to men with higher testosterone compared to men with lower testosterone (Slatcher et al., 2011). Testosterone is also thought to support the initiation of sexual relationships: People with higher levels of testosterone tend to report a greater desire for uncommitted sexual activity and more frequent uncommitted sexual behavior (Edelstein, Chopik, & Kean, 2011). Therefore, although testosterone appears to promote mate-seeking behaviors, attraction to potential partners, and sexual intimacy, higher levels of testosterone may be associated with poorer functioning for people in established relationships.

Consistent with the idea that lower testosterone is associated with more established relationships, men and women in committed relationships tend to have lower levels of testosterone compared to people who are single (e.g., Edelstein et al., 2011; van Anders & Goldey, 2010), which might suggest that testosterone lowers as a function of being in a relationship. In fact, lower levels of testosterone tend to be associated with better relationship

functioning: Among partnered men, those with lower levels of testosterone are less likely to get divorced and tend to report higher marital satisfaction (Booth & Dabbs Jr, 1993; Mazur & Michalek, 1998). Relatively few studies on testosterone include women, but in one study that included both couple members, both men and women with lower testosterone tended to report higher romantic relationship satisfaction and commitment (Edelstein et al., 2014). Thus, these studies suggest that lower levels of testosterone are associated with higher romantic relationship quality. However, the majority of research on testosterone is conducted on samples of men, and the few studies that include both men and women or couples have relatively small, homogeneous samples (e.g., college-aged couples), which limits our understanding of whether we would see these testosterone-relationship quality links in women and among more established couples (e.g., couples with children).

In addition to self-reports of relationship functioning, how might people with lower testosterone behave towards their partner? In general, lower levels of testosterone are thought to be associated with greater nurturance and caregiving (van Anders et al., 2011; Wingfield et al., 1990). For instance, women with lower testosterone are more likely to report that they are more kind, caring, and helpful (Harris, Rushton, Hampson, & Jackson, 1996). Although researchers have not explicitly examined testosterone and nurturance in romantic partners, other research suggests that men with lower testosterone show greater parental involvement and responsiveness towards their infants (Kuo et al., 2018). Similar to findings from testosterone and parent-child work, perhaps people with lower testosterone behave in more nurturant (i.e., prosocial) ways towards their romantic partners. Furthermore, it is possible that prosocial behavior contributes to (i.e., mediates) the association between testosterone and relationship quality: Perhaps people

with lower testosterone behave in more prosocial ways towards their partners, which consequently results in both partners feeling more positive about their relationships.

Thus, the proposed study will redress critical gaps in the literature by examining associations between testosterone, relationship quality, and prosocial behavior in couples. I expect that (1) men and women with lower testosterone will report higher relationship quality, (2) men and women with lower testosterone will behave in more prosocial ways towards their partner, and (3) prosocial partner behavior will mediate associations between testosterone and relationship quality. Next, I briefly provide an overview of testosterone, testosterone in the context of close relationships, individual and dyadic links between testosterone and relationship quality, and relevant theory and experimental research on testosterone and nurturance that supports these hypotheses.

1.1 Overview: Testosterone and Relationships

Testosterone is a steroid hormone produced in the body and is generally known for its role in the development of secondary sex attributes, such as increased muscle mass, bone mass, and body hair (Freeman, Bloom, & McGuire, 2001). Given these characteristics, people may assume testosterone is a predominately male hormone; however, testosterone is present and important for physical development and behavior in both men and women (Edelstein, 2022). On average, testosterone is indeed higher in men compared to women (e.g., Chin, Reese, Ascigil, Sim, & Edelstein, 2021). Within women, those who use hormonal contraceptives tend to have lower levels of testosterone compared to women who do not take hormonal contraceptives (e.g., Liening, Stanton, Saini, & Schultheiss, 2010). People also tend to show changes reflecting lower levels of testosterone (i.e., declines) as they age, as they become involved in a committed

relationship, and as a function of having children (e.g., Booth & Dabbs Jr, 1993; Gray, Yang, & Pope, 2006; Morley et al., 1997).

In general, testosterone is highest in the morning and declines throughout the day, becoming more stable during the afternoon (Dabbs Jr, 1990). Despite the fact that testosterone declines throughout the day, testosterone levels are relatively stable, particularly when testosterone is collected at the same time over the course of multiple days (Liening et al., 2010). Therefore, baseline measures of testosterone are considered fairly trait-like (Sellers, Mehl, & Josephs, 2007), making it possible to examine associations between testosterone and other constructs such as individual differences in personality and behavior. For example, people with lower levels of testosterone tend to report lower interest in extra-dyadic sex and have a lower likelihood of divorce compared to people with higher levels of testosterone (Edelstein et al., 2011; McIntyre et al., 2006).

There is also research that suggests that people with lower levels of testosterone have higher quality relationships (e.g., Gray, Kahlenberg, Barrett, Lipson, & Ellison, 2002; Julian & McKenry, 1989). For instance, in a sample of middle-aged married men ($N = 37$, $M_{age} = 44.9$), testosterone was negatively associated with relationship satisfaction (Julian & McKenry, 1989). In another study, married men ($N = 14$, $M_{age} = 29.6$) who had lower testosterone also reported greater spousal investment, including making plans for the future, disclosing feelings, and spending time with partners (Gray et al., 2002). In contrast, other work suggests that *higher* testosterone is associated with markers of higher relationship quality, including closeness and self-disclosure (Chin et al., 2021; Edwards, Wetzel, & Wyner, 2006). For instance, in a sample of romantic couples, closeness-inducing partner discussions led to changes reflecting higher testosterone (i.e., increases) in both men and women, and increases were partially explained by

the extent to which people self-disclosed personal and important information to their partner (Chin et al., 2021). These associations also extend to non-romantic relationships, where men who experienced increases in testosterone before playing in a soccer game reported feeling greater closeness and desire for social affiliation with their teammates (Edwards et al., 2006). These findings might suggest that higher testosterone is beneficial for relationship functioning, including maintaining relationships between close others. Overall, these mixed findings suggest that, in general, men who have lower testosterone tend to experience higher relationship quality; however, there are emotionally intimate contexts, such as closeness-inducing discussions, and competitive contexts, such as playing sports, where *higher* levels of testosterone might be associated with markers of higher relationship quality.

Fewer studies on testosterone include women; however, one example of a cross-sectional study that included women ($N = 42$, $M_{age} = 23.6$) found no association between testosterone and women's commitment, whereas men's ($N = 48$, $M_{age} = 23.44$) testosterone was negatively associated with commitment (Hooper, Gangestad, Thompson, & Bryan, 2011). Other relationship functioning-related work suggests that women who have lower testosterone disclose more personal and important information and feel more satisfied with conversations with their partner (Denes, Afifi, & Granger, 2017; Dhillon et al., 2020). These findings suggest that women who have lower levels of testosterone tend to behave in ways that enhance their relationships, and they tend to feel better about their relationship interactions. Future research that examines testosterone and self-reports of relationship quality in larger samples of women is needed to determine whether testosterone-relationship quality links generalize across both men and women.

In addition to the limited number of studies that examine testosterone and relationship quality in samples of individuals, only a handful of studies have examined associations between testosterone and relationship quality in *couples* (Booth, Johnson, & Granger, 2005; Edelstein et al., 2014). This omission is particularly striking given that Interdependence Theory suggests that relationships involve at least two people who interact and influence each other's outcomes (Kelley et al., 2003). Thus, to fully understand relationship functioning, it is essential that we understand the nature of interdependence between couple members, defined as the process by which partners influence one another's experiences (i.e., thoughts, feelings, behaviors, and outcomes). Having larger samples of couples would allow me to examine any links between partners' testosterone and self-reports of relationships quality, and ultimately extend Interdependence Theory by demonstrating psychophysiological associations between couple members. In one of the first studies that measured testosterone and relationship quality in couples (N = 307 parents, $M_{\text{age mothers}}$ = 40.1, $M_{\text{age fathers}}$ = 42.1), Booth et al. (2005) found that men's testosterone was negatively associated with their own and their female partners' marital quality, but only among men who experienced role overload (i.e., the perception of being overwhelmed by multiple commitments and not having enough time to meet them). In contrast, there were no significant associations or interactions between women's testosterone and role overload predicting women's own or their husband's marital quality. These findings provide initial evidence for associations between testosterone and relationship quality, at least among men; however, the data were not analyzed dyadically to account for couple members' interdependence, which complicates the interpretation of any within-couple effects.

Since Booth et al. (2005), our lab has examined within-couple associations between testosterone and relationship quality using analyses that account for both couple members:

Edelstein et al. (2014) found that both men and women who had lower testosterone reported higher relationship satisfaction and commitment. They also found evidence for dyadic associations, such that people who had lower testosterone had *partners* who reported higher relationship satisfaction and commitment, and these partner associations were significantly stronger for men compared to women (i.e., men reported higher relationship quality when their female partners had lower testosterone). There was also a marginal negative association between testosterone and partner investment, such that people with lower testosterone had partners who reported higher relationship investment. These findings demonstrate a consistent negative association between testosterone and indices of relationship quality; however, the sample in this study was relatively small ($N = 39$ couples, $M_{\text{age women}} = 21.31$, $M_{\text{age men}} = 22.18$), and included mainly undergraduate and graduate students, who are typically younger than the general population and who were in relatively shorter relationships (ranging from two months to seven years, $M = 1.60$ years). This sample was also restricted to regularly cycling women, due to effects of hormonal birth control on testosterone levels (Liening et al., 2010). These sample characteristics make it difficult to draw firm conclusions about testosterone-relationship quality links and whether we would see similar associations in more established couples, such as couples who are married or who are transitioning to parenthood.

The negative association between testosterone and relationship quality is also evident in samples of expectant parents (e.g., Chin et al., 2020; Saxbe et al., 2017). In expectant heterosexual parents ($N = 29$ couples, $M_{\text{age mothers}} = 29.19$, $M_{\text{age fathers}} = 30.33$), for instance, fathers with lower average testosterone reported higher relationship satisfaction, investment, and commitment (Saxbe et al., 2017). I also found similar associations in a sample of expectant lesbian parents ($N = 25$ couples, $M_{\text{age birth mothers}} = 31.58$, $M_{\text{age non-birth mothers}} = 32.24$): Birth and

non-birth mothers who had lower average testosterone reported higher relationship satisfaction, commitment, and investment (Chin et al., 2020). These associations also extended to partners, such that birth and non-birth mothers with lower testosterone had *partners* who reported higher relationship quality (Chin et al., 2020). Together, these findings suggest that lower testosterone is also associated with higher relationship quality for couples during the transition to parenthood, and that such associations also extend to partners. Again, however, these studies are limited by their reliance on relatively small and homogenous samples of couples, highlighting the importance of studying hormone-relationship links in larger samples, including samples of parents with children.

1.2 Testosterone and Prosocial Partner Behavior

In addition to self-reports of relationship functioning, how might people with lower testosterone behave? Lower levels of testosterone are thought to be associated with more nurturant and caregiving social contexts (van Anders et al., 2011; Wingfield et al., 1990). For instance, people who have lower testosterone reported more nurturant caregiving behavior and parental involvement (Edelstein et al., 2017; Kuo et al., 2018). People with lower testosterone are also more understanding and responsive caregivers: Fathers who have lower testosterone reported greater sympathy upon hearing infant cries and experience a greater need to respond to those cries (Fleming, Corter, Stallings, & Steiner, 2002).

Although researchers have not explicitly examined the association between testosterone and nurturant caregiving between romantic partners, I would expect that, similar to parent-child relationships, people with lower testosterone would also provide higher quality nurturance and care (i.e., prosocial behavior) to their partners. Perhaps people with lower testosterone are better able to recognize their partner's distress, put more effort towards listening to their partner, and be

more responsive, understanding, and supportive to their partner. It is also possible that I would see partner effects, such that people who have partners with lower testosterone would be more likely to share personal information and communicate more effectively with their partner. In addition, it is possible that prosocial behavior might contribute to the negative association between testosterone and relationship quality in couples; however, this idea has not yet been empirically tested.

1.3 Dissertation Goals

The first goal of my dissertation was to examine a larger sample of couples and test whether people with lower testosterone reported higher relationship quality. Having a larger sample couples allowed me to examine whether I would see similar testosterone-relationship quality links across couples who differ in relationship stage (e.g., dating couples versus more established couples). Examining couples also allowed me to test whether associations between testosterone and relationship quality were similar across men and women. Booth et al. (2005) found effects only for men's testosterone but used limited statistical analyses. In contrast, Edelstein et al. (2014) found stronger associations between women's (versus men's) testosterone and one's own and partner's relationship quality, but in a much smaller sample of younger couples. In sum, there are few studies on testosterone that include both men and women, and studies that do include both men and women or couples tend to be smaller in size. Thus, including a larger sample size of couples provided me with more power to test testosterone-relationship quality associations in both men and women.

The second goal of my dissertation was to examine whether people with lower testosterone behaved in more prosocial ways towards their partner. The majority of the research on testosterone has focused on men (versus women or couples) in competitive contexts,

measuring behaviors generally associated with higher testosterone, such as dominance or aggression. Thus, examining associations between (lower) testosterone and more positive behavior, such as responsiveness, in a dyadic context would help shed light on how men and women behave when they or their partners have lower levels of testosterone.

Lastly, the third goal of my dissertation was to investigate whether prosocial behavior explained (i.e., mediated) any negative associations between testosterone and relationship quality. Might people who have lower testosterone generally behave in more prosocial (e.g., responsive and supportive) ways towards their partner, which then explains why they feel better about their relationships?

1.4 The Current Study

To examine associations between testosterone and relationship quality across men and women and in couples, I selected three large existing datasets that included heterosexual couples (so I could distinguish couples members by gender): The first sample included 129 college-aged dating couples who were in relatively newer relationships and who had no children, the second sample included 241 couples who already had one child and who were expecting their second, and finally, the third sample included 225 newlywed couples who had no children (see Table 1 for a more detailed comparison of samples).

To address my first goal, I began by examining associations between testosterone and relationship quality within each sample. Based on previous research (e.g., Chin et al., 2020; Edelstein et al., 2014; Saxbe et al., 2017), I expected that people with lower testosterone would report higher relationship quality. I also expected dyadic associations, such that people with lower testosterone would also have partners who would report higher relationship quality.

To address my second goal, I examined whether people with lower testosterone engaged in more prosocial behavior. Because parents who have lower testosterone behave in more nurturant and caregiving ways towards their children (e.g., Kuo et al., 2018; see van Anders et al., 2011), I expected that people who have lower testosterone would also behave in more prosocial ways towards their partners (e.g., show greater support; are more responsive).

Finally, I addressed my third goal by examining whether prosocial behavior accounted for (i.e., mediated) any negative associations between testosterone and relationship quality. Specifically, I expected that people who have lower testosterone would behave in more prosocial ways towards their partners, and consequently, would report higher relationship quality (see Figure 1).

Chapter 2 Method

Descriptive statistics for each of the three samples are presented in Table 1. I also summarize the basic procedure for each study below.

2.1 Sample 1: College-Aged Couples

2.1.1 Participants and Procedure

The first sample included 129 heterosexual couples from Amsterdam, Netherlands. I excluded one additional lesbian couple from subsequent analyses because our dyadic data approach requires that couples be distinguishable on some variable (in our case, participant gender). Couples could participate if they were together for longer than four months and had no children. Laboratory sessions took place between 8:00 AM and 6:00 PM, but testosterone was only measured for participants who were scheduled between 2:00 to 6:00 PM (76 men and 77 women) to control for circadian changes in hormones. The couples attended the intake laboratory session together and were instructed to refrain from eating, drinking anything but water, chewing gum, or brushing teeth for two hours prior to the scheduled session. During the intake laboratory session, participants completed personality and relationship measures (administered in Dutch) separately from one another, which took approximately 30-35 minutes. Next, a research assistant instructed participants to provide a saliva sample by asking participants to passively drool down a straw and into a small plastic vial with their heads tilted forward until the required amount of saliva was collected. The vial was sealed and immediately placed in frozen storage (–20°C) until

assayed. The couples were then videotaped while having a 7-minute discussion about a time when their interests diverged (e.g., one partner wants to go to a party, but the other partner wants to stay in and watch a movie) and provided a second saliva sample after the discussion (which was not considered for the current study). Finally, partners were separated to watch a video recording of their conversation and provided ratings about it. After the intake laboratory session, couples completed an 8-day daily diary (i.e., answered questions about their relationship at the end of each day), an experience sampling procedure each of these days (i.e., provided in-moment responses about their relationship three times throughout the day), and a 1-year follow-up about their relationship, none of which are not considered for the purpose of the current study.

2.1.2 Measures

Relationship quality. Participants completed the Investment Model Scale (Rusbult, Martz, & Agnew, 1998), a widely used measure of relationship quality that assesses relationship satisfaction, interest in alternatives, investment, and commitment. Participants rated the extent to which they agreed with statements from the 4-item *satisfaction* (α = .82, e.g., "Our relationship makes me very happy"), 4-item *investment* (α = .72, e.g., "I have invested a great deal into our relationship that I would lose if the relationship were to end"), 4-item *interest in alternatives* (α = .67, e.g., "Other people besides my partner with whom I might get involved are very enticing"), and 7-item *commitment* (α = .81, e.g., "I want our relationship to last for a very long time") subscales using a 7-point scale ranging from 1 (*totally disagree*) to 9 (*totally agree*). I calculated a mean score for each subscale to use in subsequent analyses.

Participants also completed a measure of closeness using the single-item Inclusion of the Other in the Self Scale (IOS; Aron, Melinat, Aron, Vallone, & Bator, 1997). Participants selected

one out of seven pairs of circles labeled *Self* and *Other* that overlap to various degrees, creating a 7-point interval scale that best described their relationship.

Prosocial Behavior. After the partner interaction, participants watched their 7-minute videotaped partner discussion and provided global ratings of *feeling understood*, *support provided*, *perceived received support from partner*, and *perceived partner responsiveness*, on a 7-point Likert scale, ranging from 0 (*none/neutral*) to 6 (*very high*).

2.1.3 Salivary Testosterone Collection and Assessment

Samples were analyzed by luminescence immunoassay (LUM) using a commercial kit from IBL International. Water-based dilutions of all standards and controls were prepared to determine salivary testosterone concentrations. Samples were assayed in duplicate and mean levels for each sample were utilized for analysis. Controls were used to assess assay reliability. The intra- and inter-assay coefficients of variation (CV) were both less than 12%. All saliva samples were assayed for testosterone in duplicated in Dr. Clemens Kirschbaum's lab.

To maximize the use of all available data, testosterone values that were larger than three standard deviations above or below the mean for each gender were winsorized (i.e., replaced with values corresponding to three standard deviations above or below the mean for that particular variable; Chin et al., 2021). Three men with testosterone levels greater than three standard deviations above the mean for their gender were replaced using this approach. Testosterone was positively skewed, kurtosis = 8.36, skewness = 2.56, so I log-transformed the testosterone variable for subsequent analyses.

2.2 Sample 2: Couples with Children

2.2.1 Participants and Procedure

The second sample included 241 heterosexual couples from Michigan, US. Couples could participate if they were living together, expecting their second child, and if their first child was between one and five years of age. At their first prenatal visit, couples completed questionnaires about their relationship quality and had a 10-minute general discussion about their day (where prosocial behavior was coded). Self-report data were also collected at three postpartum time points (1, 4, and 8 months) after the birth of the couples' second child, but these data are not considered for the purpose of the current study. Finally, testosterone data were available for 167 men and 153 women from a 12-month postpartum follow-up visit scheduled between 1:00 and 6:00 PM to control for circadian changes in hormones. Eleven additional women who reported being pregnant at the time of testosterone collection were removed from additional analyses. Participants were instructed to refrain from eating or drinking anything but water for at least 30 minutes prior to the scheduled session. Prior to any lab session tasks, participants were asked to provide their saliva sample (to assay baseline testosterone) while in the waiting room with their infant (who was being held or who were playing on the floor with toys, etc.). Saliva collection was stimulated via chewing sugar-free Trident Original gum. Although some brands and flavors of gum can affect testosterone assays, this particular kind of gum has been shown to have minimal effects on testosterone compared to other kinds of gum using similar assays (Dabbs Jr, 1991). All samples were frozen (–20°C) until assayed.

2.2.2 Measures

Relationship quality. Participants answered the 3-item Kansas Marital Satisfaction Scale (Schumm et al., 1986). Participants rated their satisfaction with their spouse, marriage, and marital relationship (α = .94, e.g., "How satisfied are you with your marriage?") using a 5-point

scale ranging from 1 (*not at all*) to 5 (*extremely*) and a mean score was calculated for subsequent analyses.

Participants also completed the 25-item Intimate Relations Questionnaire (Braiker & Kelley, 1979), a widely used measure for love, ambivalence, maintenance, and conflict. Participants rated the extent to which they agreed with statements from the 10-item *love* (α = .85, e.g., "To what extent do you have a sense of belonging to your spouse/partner?"), 5-item *maintenance* (α = .73, e.g., "How much do you and your spouse/partner talk about the quality of your relationship?"), 5-item *ambivalence* (α = .72, e.g., "How confused are you about your feelings toward your spouse/partner?"), and the 5-item *conflict* (α = .73, e.g., "How often do you feel angry or resentful toward your partner?") subscales using a 9-point scale ranging from 1 (*not at all/never*) to 9 (*very much/extremely*). I calculated a mean score for each subscale to use in subsequent analyses.

Prosocial Behavior. Trained research assistants coded each 10-minute videotaped partner discussion using the Interactional Dimensions Coding System (Kline et al., 2004). Each interaction was broken down into three equal segments and was rated on a 9-point scale, ranging from 1 (*extremely uncharacteristic*) to 9 (*extremely characteristic*) to assess *supportive validation* (i.e., positive listening and speaking skills that demonstrated support of the partner), *communication skills* (i.e., one's ability to convey thoughts and feelings in a clear, constructive manner), *dominance* (i.e., control that one has over their partner), *conflict* (i.e., expressed struggle between the partners), and *withdrawal* (i.e., avoidance of the interaction). The scores for each of the three equal segments were averaged to calculate a mean behavior rating for subsequent analyses. Intraclass correlation coefficients ranged from .88 to .95 (M = .91) for wives and .78 to .92 (M = .88) for husbands.

2.2.3 Salivary Testosterone Collection and Assessment

Samples were analyzed by radioimmunoassay (RIA) using a commercial kit from Siemens Healthcare that was modified for use with saliva according to published protocol (Campbell, Schultheiss, & McClelland, 1999). Water-based dilutions of all standards and controls were prepared to determine salivary testosterone concentrations. Samples were assayed in duplicate and mean levels for each sample were utilized for analysis. Controls were used to assess assay reliability. Samples from the same participants were processed in the same assay. The intra-assay CV was 10.17% for fathers and 15.25% for mothers; the inter-assay CV was 21.22% for fathers and 20.71% for mothers. Higher CVs suggest greater measurement error in the testosterone estimates; however, it is worth noting that such error does not appear to differ by gender in the sample, suggesting that any gender differences in associations in this sample were not attributable to gender differences in precision of the hormone assays. It is also worth noting that the range of testosterone values in the sample were similar to those reported for samples of similarly aged participants in published reports (Keevil et al., 2017). Using the same procedure as previously published work using this dataset, data for three women and one man with testosterone levels above three standard deviations above the mean for their gender were excluded from further analyses, so no winsorizing or log-transformations were conducted (Edelstein et al., 2019).

2.3 Sample 3: Newlywed Couples

2.3.1 Participants and Procedure

The third sample included 225 heterosexual couples recruited from marriage license records in 2008 in Amherst, Massachusetts, US. All couples could participate if they were

between 18-50 years, in their first marriage, had no children, and were not expecting a child. Participants were instructed to refrain from eating, drinking (except water), chewing gum, or brushing their teeth one hour prior to the scheduled session, which were between 4:00 and 7:00 PM to control for circadian changes in hormones. At the beginning of each session, a trained experimenter described the tasks that participants would perform during the session and gave the participants the opportunity to ask questions. All participants knew that they would be discussing an area of disagreement with their partner that would be videotaped. Throughout the session, participants completed personality and relationship measures separately from one another and were asked not to talk to each other while completing questionnaires. Approximately 30 minutes after arrival, participants were instructed to provide a saliva sample (to assay baseline testosterone). Testosterone data were available for 167 men and 153 women. Saliva samples were collected by asking participants to passively drool down a straw and into a small plastic vial with their heads tilted forward until the required amount of saliva was collected. The vial was sealed and immediately placed in frozen storage (−85°C) until assayed. Participants were then instructed to identify three important and unresolved areas of disagreement in their relationship and rated the intensity of each on a scale of 1 (*not at all intense*) to 7 (*extremely intense*). The research assistant chose a topic that both partners had the highest combined intensity ratings for couples to discuss for 15 minutes. After the conflict discussion, participants separately filled out post-discussion measures, and then had a 5-minute discussion together about what they liked about their partner and relationship (as a positive mood induction before leaving the laboratory). Couples were invited back for a laboratory visit after their second and third year of marriage; these visits are not considered for the purpose of the current study.

2.3.2 Measures

Relationship Quality. Participants completed the Perceived Relationship Quality Component (PRQC) Inventory (Fletcher, Simpson, & Thomas, 2000), which assessed satisfaction, commitment, intimacy, passion, and love. Participants rated the extent to which they agreed with statements from each of the 3-item *satisfaction* (α = .94, e.g., "How happy are you with your relationship"), *commitment* (α = .93, e.g., "How dedicated are you to your relationship?"), *intimacy* (α = .83, e.g., "How close is your relationship?"), *passion* (α = .88, e.g., "How lustful is your relationship?"), and *love* (α = .85, e.g., "How much do you adore your partner?") subscales using a 7-point scale ranging from 1 (*not at all*) to 9 (*extremely*). I calculated a mean score for each subscale to use in subsequent analyses.

Prosocial Behavior. Trained research assistants coded behaviors in the 15-minute conflict discussion using the Secure Base Scoring System (SBSS; Crowell et al., 1998; Crowell et al., 2002). The SBSS assessed both partners' secure-base use (care-seeking) and secure-base support (caregiving) behaviors while they discussed a topic on which they disagreed, which should create a potentially distressing situation that activates the attachment system. For the purpose of this study, I will only be using the caregiving subscales: *interest in partner's distress* (i.e., ability to be a good listener and to encourage the partner to express their thoughts and feelings, *recognition of partner's distress* (i.e., sensitivity and understanding that their partner is distressed), *interpretation of partner's distress* (i.e., understanding the content of their partner's distress), and *responsiveness to distress* (i.e., desire and willingness to help partner, and effectiveness and effort to help partner). All subscales are rated from 1 to 7, with low scores representing poor secure base use or support and high scores representing excellent secure base use or support. The intraclass correlation coefficients (Shrout & Fleiss, 1979) were calculated for each subscale with scores for the 30% of discussions that had been coded by all trained observers

to determine agreement among the observers. The intraclass correlation coefficients were .94 for interest, .87 for recognition, .94 for interpretation, and .92 for responsiveness.

2.3.3 Salivary Testosterone Collection and Assessment

Samples were analyzed by an enzyme immunoassay (EIA) using a commercial kit from Salimetrics Incorporated, which are specially designed for use with saliva according to the manufacturer's recommended protocol (Salimetrics, State College, PA). This assay had a range of sensitivity from 1.5 to 360 pg/mL and an average intra- and interassay coefficients of variation less than 10% and 15%, respectively. All saliva samples were assayed for testosterone in duplicate in Dr. Douglas Granger's lab.

To maximize the use of all available data, testosterone values that were larger than three standard deviations above or below the mean for each gender were winsorized (see Sample 1 testosterone write up). Four women and two men with testosterone levels greater than three standard deviations above the mean for their gender were replaced using this approach. Testosterone was not positively skewed, kurtosis = 2.03, skewness = 1.38, so I did not log-transform the testosterone variable for subsequent analyses.

2.4 Statistical Analysis Plan

I used a conceptual model known as the actor-partner interdependence model (APIM; Kenny, Kashy, & Cook, 2006). The APIM was developed to account for the statistical interdependence of couple members and provides actor (i.e., how one's own predictor variable is associated with their own outcome variable) and partner effects (i.e., how one's own predictor variable is associated with their partner's outcome variable). First, I ran an APIM path model for each sample with each couple members' testosterone as predictors and all relationship quality measures as outcomes in the same model. This analysis provided estimates to examine an actor

effect (i.e., the association between one's testosterone and their own relationship quality) and a partner effect (i.e., the association between one's testosterone and their partner's relationship quality). Second, I ran another APIM path model for each sample with each couple members' testosterone as predictors and all prosocial behavior measures as outcomes in the same model. This analysis provided estimates to examine an actor effect (i.e., the association between one's testosterone and their own prosocial behavior) and the total partner effect (i.e., the association between one's testosterone and their partner's prosocial behavior).

Finally, to test whether any associations between testosterone and relationship quality were mediated by prosocial behavior, I extended the standard APIM by adding a mediator variable (APIMeM; Ledermann, Macho, & Kenny, 2011). Separate APIMeM models with couple members' testosterone as predictors, prosocial behavior as mediators, and relationship quality measures as outcomes were estimated for each sample. This analysis provided estimates for the direct actor effect (i.e., the association between one's testosterone and their own relationship quality after controlling for their prosocial behavior) and the direct partner effect (i.e., the association between one's testosterone and their partner's relationship quality after controlling for prosocial behavior). Further, the APIMeM allows for the assessment of indirect actor effects: actor-actor mediation (the association between one's testosterone and their relationship quality through their own prosocial behavior) and partner-partner mediation (the association between one's testosterone and their relationship quality through their partner's prosocial behavior). APIMeM also allows for indirect partner effects: actor-partner mediation (the association between one's testosterone and their partner's relationship quality through their own prosocial behavior) and partner-actor mediation (the association between one's testosterone and their partner's relationship quality through their partner's prosocial behavior).

To estimate the APIM and APIMeM, I used structural equation modeling (SEM) via the Lavaan package in R. As recommended, mediation effects (i.e., indirect effects) were estimated by bootstrap analyses using 5000 bootstrap samples. I evaluated the fit of the models using the chi-square statistic, the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root-mean-square error of approximation (RMSEA). Values greater than or equal to .95 for CFI and TLI, and less than or equal to .06 for RMSEA suggested a good fit.

I also assessed correlations between testosterone and possible control variables (see Table 3): In the couples with children and the newlywed couples, testosterone was negatively correlated with age and use of hormonal contraceptives (for women). Therefore, I controlled for age by including each couple member's mean-centered age in the models that assessed testosterone and relationship quality and in the models that assessed testosterone and prosocial behavior. I later followed this same procedure when controlling for hormonal contraceptive use by including an effect-coded couple-level hormonal contraceptives variable (-1 = woman in the couple not using hormonal birth control, 1 = woman in the couple using hormonal birth control) in each model. I also included the two-way interactions between each control variable and testosterone to examine moderation; however, model fit became extremely poor and results were uninterpretable, so all two-way interactions were removed.

Chapter 3 Results

3.1 Preliminary Analyses

I report descriptives for men's and women's testosterone in samples 1 through 3 in Table 2. As expected, across college-aged couples, couples with children, and newlywed couples, men had significantly higher testosterone levels than women, $t(142) = 11.94$, $p < .001$, $d = 1.94$; $t(205) = 29.59$, $p < .001$, $d = 3.25$; $t(334) = 12.96$, $p < .001$, $d = 1.26$, respectively. Men's and women's testosterone were significantly positively correlated in the newlywed couples, $r = .64$, $p < .001$, but not significantly correlated in college-aged couples, $r = -.16$, $p = .17$, or couples with children, $r = .08$, $p = .36$ (within-couple correlations control for time of day except for the college-aged couples where a time of day variable was not available). I report correlations between testosterone and potential control variables, including age, relationship length, and hormonal contraceptives usage for each sample in Table 3. I also report correlations between testosterone and relationship quality for each sample in Tables 4-6 and correlations between testosterone and prosocial behavior in Tables 7-9.

3.2 Associations Between Testosterone and Relationship Quality

In the sample of college-aged couples, the fit of the APIM testing associations between testosterone and relationship quality was good, $\chi^2 = 1.00$, CFI = 1.00, TLI = 1.22, RMSEA = .00. As expected, the results suggested that women who had lower levels of testosterone reported higher relationship satisfaction and felt closer to their partners, $b = -1.09$, $p < .05$; $b = -1.93$, $p <$

.01, respectively. The association with closeness also extended to partners, such that women who had lower levels of testosterone had partners who reported higher closeness, $b = -1.11$, $p < .05$.

In the sample of couples with children, the fit of the APIM testing associations between testosterone and relationship quality was good, $\chi^2 = .44$, CFI = 1.00, TLI = 1.03, RMSEA = .00. As expected, women who had lower levels of testosterone reported higher relationship satisfaction, $b = -.02$, $p < .05$. Women with lower testosterone also reported less conflict, $b = .03$, $p < .05$.

In the sample of newlywed couples, the fit of the APIM testing associations between testosterone and relationship quality was good, $\chi^2 = .14$, CFI = 1.00, TLI = .93, RMSEA = .07. In contrast to expectations, and in contrast to the college-aged couples and couples with children, men in the newlywed sample who had lower levels of testosterone reported *lower* relationship satisfaction, intimacy, and love for their partners, $b = .002$, $p < .05$; $b = .003$, $p < .01$; $b = .002$, $p < .01$, respectively.

Finally, given that age and use of hormonal contraceptives were negatively correlated with testosterone (see Table 3), I ran each model described above again and controlled for age and hormonal contraceptive use separately. I began by including mean-centered women's and men's age as control variables in each model. Results for testosterone-relationship quality associations were virtually identical with age included as a control variable. In addition, I found associations between age and relationship quality: Among the college-aged couples, women who were older reported higher commitment compared to women who were younger, $b = .05$, $p < .05$; among the couples with children, women who were older had partners who reported lower satisfaction, maintenance, and love, $b = -.07$, $p < .01$; $b = -.09$, $p < .01$; $b = -.06$, $p < .05$,

respectively; in the newlywed couples, men who were older reported lower love and partners of men who were older reported lower passion, $b = -.02$, $p < .05$; $b = -.06$, $p < .01$.

Next, I included effect-coded couple-level hormonal contraceptive use as a control variable in each model. Hormonal contraceptive use was not significantly associated with any relationship quality measures, and the associations between testosterone and relationship quality reported earlier were virtually identical with hormonal contraceptive use included as a control variable.

In sum, for college-aged couples and couples with children, people who had lower testosterone indeed reported higher relationship quality, including higher relationship satisfaction and closeness and less conflict. I also found that these associations extended to partners in these same samples, such that people who had lower testosterone had *partners* who reported higher relationship quality. In contrast to expectations and in contrast to findings for college-aged couples and couples with children, people in the newlywed couples with lower testosterone reported *lower* relationship quality, including lower relationship satisfaction, intimacy, and love.

3.3 Associations Between Testosterone and Prosocial Behavior

In the sample of college-aged couples, the fit of the APIM testing associations between testosterone and prosocial behavior was good, $\chi^2 = .67$, CFI = 1.00, TLI = 1.06, RMSEA = .00. As hypothesized, the results suggested that women with lower testosterone perceived their partners more responsive towards them, $b = -1.30$, $p < .05$. There was also a partner association, such that men with lower levels of testosterone had partners who perceived that they provided more support, $b = -1.32$, $p < .05$.

In the sample of couples with children, the fit of the APIM testing associations between testosterone and prosocial behavior was good, $\chi^2 = .56$, CFI = 1.00, TLI = 1.07, RMSEA = .00.

As hypothesized, the results suggested that women who had lower levels of testosterone were considered by trained observers to be better at communicating, b = -.02, p < .01.

In the sample of newlywed couples, the fit of the APIM testing associations between testosterone and prosocial behavior was good, χ^2 = .18, CFI = 1.00, TLI = .98, RMSEA = .05. In contrast to hypotheses, and in contrast to college-aged couples and couples with children, men in the newlywed sample who had lower levels of testosterone were considered by trained observers to be *worse* at interpreting their partners' distress, b = .004, p < .01.

I then re-examined these models with potential control variables. I began by including mean-centered age for each couple member in each model. Results for the college-aged couples and couples with children were virtually identical as models reported above without age. However, in the newlywed sample, I found additional significant associations between testosterone and relationship quality when I included age as a control variable: Men who had lower testosterone were less responsive and were worse at recognizing their partner's distress, b = .01, p < .05; b = .003, p < .05. I also found associations between age and prosocial behavior: Men who were older were worse at interpreting their partner's distress compared to men who were younger, b = -.07, p < .001, however, women who were older had partners who were better at interpreting their distress, b = .06, p < .001.

Next, I re-examined these models by including a couple-level effect-coded hormonal contraceptive use variable (-1 = woman in couple not using hormonal contraceptives, 1 = woman in couple using hormonal contraceptives). Results for the college-aged couples and couples with children were virtually identical as models reported above without hormonal contraceptive use. In the newlywed sample, I found additional associations between testosterone and relationship quality when I included hormonal birth contraceptives as a control variable: Men who had lower

testosterone were less responsive and were considered by trained coders to be worse at recognizing their partner's distress, $b = .01$, $p < .05$; $b = .003$, $p < .05$.

In sum, for college-aged couples and couples with children, people with lower testosterone showed more prosocial behavior, including being more responsive, providing greater support, and being better at communicating. I also found that these associations extended to partners in these same samples, such that people who had lower testosterone were more likely to have *partners* who behaved in more prosocial ways. In contrast to expectations and in contrast to findings for college-aged couples and couples with children, people in the newlywed couples with lower testosterone were *less* likely to show prosocial behavior, including being poorer at interpreting their partner's distress.

3.4 Does Prosocial Behavior Mediate Any Testosterone-Relationship Quality Links?

Finally, I assessed whether prosocial behavior accounted for any testosterone and relationship quality associations. To reduce the number of predictors in each model and improve model fit, I only included the measure of prosocial behavior that was most strongly associated with testosterone. Therefore, in the sample of college-aged couples, I included responsiveness as a potential mediator of the association between testosterone and relationship quality measures. The fit of the APIMeM testing associations between testosterone and relationship quality with responsiveness as the mediator was satisfactory, $\chi^2 = .01$, CFI = .97, TLI = .58, RMSEA = .11. In line with the previous corresponding APIM model, the results suggested that women who had lower testosterone reported higher closeness to their partners, $b = -1.72$, $p < .05$. The associations between women's testosterone and their relationship satisfaction and responsiveness, and between women's testosterone and their partner's closeness, were reduced when compared with the corresponding APIM and no longer significant, $b = -.86$, $p = .13$; $b = -1.05$, $p = .26$; $b =$ -

1.09, $p = .09$, respectively. Further, the bootstrap analysis suggested that there were no significant indirect effects of women's testosterone on her closeness through her (i.e., actor-actor mediation; $b = -.18$, $p = .48$) or her partner's (i.e., partner-partner mediation; $b = -.09$, $p = .55$) responsiveness, indicating that women who had lower testosterone felt closer to their partners, but this was not due to the fact that they or their partners were being more responsive.

In the sample of couples with children, I included communication as a potential mediator of the association between testosterone and relationship quality measures. The fit of the APIMeM testing associations between testosterone and relationship quality with communication as the mediator was good, $\chi^2 = .96$, CFI = 1.00, TLI = 1.10, RMSEA = .00. In line with the previous corresponding APIM models, the results suggested that women who had lower testosterone reported higher satisfaction and lower conflict, $b = -.02$, $p < .05$; $b = -.03$, $p < .05$, respectively, and were also better at communicating, $b = -.03$, $p < .001$. However, the bootstrap analysis suggested that there were no significant indirect effects of women's testosterone on her satisfaction through her (i.e., actor-actor mediation; $b = .00$, $p = .36$) or her partner's (i.e., partner-partner mediation; $b = .00$, $p = .40$) communication, and no significant indirect effects of women's testosterone on her conflict through her (i.e., actor-actor mediation; $b = .00$, $p = .95$) or her partner's (i.e., partner-partner mediation; $b = .00$, $p = .91$) communication, indicating that women who had lower testosterone felt more satisfied and experienced less conflict, but this was not due to the fact they or their partners were using more positive communication skills.

In the sample of newlywed couples, I included interpretation of partner's distress as a potential mediator of the association between testosterone and relationship quality measures. The fit of the APIMeM testing associations between testosterone and relationship quality with interpretation as the mediator was good, $\chi^2 = .15$, CFI = 1.00, TLI = .91, RMSEA = .07. In line

with the previous corresponding APIM models, the results suggested that men who have lower testosterone reported lower intimacy and love, $b = .59$, $p < .05$; $b = .35$, $p < .05$, respectively. The association between women's testosterone and their partner's commitment was reduced when compared with the corresponding APIM and no longer significant, $b = .22$, $p = .18$. The bootstrap analysis suggested that there were no significant indirect effects of men's testosterone on his intimacy through his (i.e., actor-actor mediation; $b = .07$, $p = .10$) or his partner's (i.e., actor-partner mediation; $b = -.01$, $p = .87$) interpretation, and no significant indirect effects of men's testosterone on his love through his (i.e., actor-actor mediation; $b = .06$, $p = .20$) or his partner's (i.e., actor-partner mediation; $b = .00$, $p = .92$) interpretation, indicating that men with lower testosterone were more likely to report lower intimacy and love, but this was not due to him or his partner having more positive interpretation behavior.

In sum, across college-aged couples, couples with children, and newlywed couples, I did not find that prosocial behavior helped to explain any associations between testosterone and relationship quality. I consider some potential alternative mediators in the discussion.

Chapter 4 Discussion

Findings from the current study provide novel information about links between testosterone and relationship quality and between testosterone and non-verbal prosocial partner behavior in three large samples of couples. Lower testosterone has been associated with more positive relationship functioning and parenting outcomes in both men and women, such as higher relationship satisfaction and more parenting support (Edelstein et al., 2017; Gettler, McDade, Feranil, & Kuzawa, 2011; Kuo et al., 2018). However, the generalizability of the testosterone-relationship quality work has been limited by a reliance on smaller samples (e.g., N = 25-39) of couples (e.g., Chin et al., 2020; Edelstein et al., 2014). And, although there has been some work examining testosterone and prosocial parenting behavior, we know less about testosterone and prosocial partner behavior and whether more positive partner behavior would help explain why people with lower testosterone tend to report higher relationship quality.

In the sample of college-aged couples and couples with children, and in line with expectations, I found that women who had lower levels of testosterone felt more satisfied and closer to their partners, and also experienced less conflict. This association also extended to partners, such that women who had lower levels of testosterone had partners who felt closer to them. It is interesting that I found associations predominantly for women's testosterone across samples of college-aged couples and couples with children, and that the partner associations were stronger for men (i.e., men reported greater relationship quality when their *female partners* had lower testosterone). My findings are consistent with previously published research that

suggests that the negative associations between testosterone and relationship quality may be stronger for women compared to men (Edelstein et al., 2014). Given that women, on average, have lower levels of testosterone compared to men, it is possible that small differences in women's testosterone are more closely tied to behavioral outcomes (i.e., relationship quality) compared to differences among men (Sherwin, 1988).

Similar to the findings for testosterone and relationship quality, I found that women in the college-aged couples and couples with children who had lower testosterone perceived their partners as more responsive and were considered by trained coders as having better communication skills, respectively. This association also extended to partners, such that men who had lower testosterone had partners who were perceived themselves as more supportive. These findings are in line with the Steroid/Peptide Theory of Social Bonds, which suggests that lower testosterone might be associated with more nurturance, including warm and loving contact (van Anders et al., 2011). Previous research has provided some evidence that lower testosterone is indeed associated with nurturance in parent-child contexts (e.g., Edelstein et al., 2019; van Anders, Tolman, & Volling, 2012). However, to my knowledge, little to no work has examined testosterone and nurturant behavior in romantic couples, which limits our understanding about whether lower testosterone is associated with nurturance in romantic relationship contexts. Thus, the findings from the current study extend the Steroid/Peptide Theory by providing some of the first support for associations between lower testosterone and more nurturant, warm, and loving behavior between partners.

In contrast to expectations, men in the sample of newlywed couples who had lower testosterone reported *lower* intimacy and love. There was also a partner association such that women who had lower levels of testosterone had *partners* who reported *lower* relationship

commitment. Similar to associations between testosterone and relationship quality, men in the sample of newlywed couples who had lower testosterone were also *worse* at interpreting their partner's distress. Put another way, men who had *higher* levels of testosterone reported *higher* relationship quality and engaged in more positive behaviors towards their partners. Why might the findings for the newlywed couples stand in contrast to expectations and in contrast to findings for the college-aged couples and couples with children? One potential explanation for the discrepant findings across samples might be due to the study procedure: The newlywed couples knew that they would be having a disagreement discussion with their partner prior to their scheduled laboratory session. Thus, it is possible that these couples had higher testosterone in anticipation for their disagreement discussion. In line with this, men and women in the sample of newlywed couples showed the highest level of baseline testosterone compared to people in the college-aged couples and couples with children samples (see Table 2).

If both men's and women's testosterone were elevated in the sample of newlywed couples compared to the two other samples, why might there be associations between testosterone and relationship quality and between testosterone and prosocial behavior for men but not for women? Perhaps men, who typically respond to challenges with a "fight-or-flight" response (e.g., Nickels, Kubicki, & Maestripieri, 2017), experienced higher pre-discussion testosterone because they were motivated to resolve any disagreements that might come up (i.e., "fight" for their relationship). In fact, it is possible that men experience higher testosterone during challenges because it helps to facilitate closeness and affiliation between close others (Edwards et al., 2006; Kivlighan, Granger, & Booth, 2005). For instance, men who showed changes reflecting higher testosterone (i.e., increases) during competitive events reported greater closeness and social affiliation to their teammates compared to those who showed changes

reflecting lower testosterone (Edwards et al., 2006; Kivlighan et al., 2005). Thus, future research might examine pre-discussion motivations to resolve conflict and feelings of closeness during the discussion to better understand why men who show higher testosterone might also behave in more prosocial ways towards their partners. In contrast to men's fight-or-flight response, women's response to challenges are generally more affiliative in nature than men's, which is characterized as a "tend-and-befriend" strategy (Taylor et al., 2000). Given that tending is more nurturant in nature, I would expect that women who use a tend-and-befriend strategy would have likely shown lower levels of testosterone and more prosocial behaviors. However, women in the newlywed sample showed higher levels of testosterone in anticipation of their disagreement discussion, which might suggest that they interpreted this context as more competitive in nature (Kivlighan et al., 2005). Future research that measures trait competition or feelings of competitiveness or dominance before a disagreement discussion will help shed light on why women might show higher levels of testosterone and behave in less prosocial ways towards their partners.

It is interesting that I found dyadic associations between testosterone and relationship quality and between testosterone and prosocial behavior across all three samples. These dyadic associations provide support for Interdependence Theory (Kelley & Thibaut, 1978), which describes the ways in which people can affect one another's outcomes during the course of an interaction. For instance, people's thoughts, feelings, and behaviors are influenced by one another during interactive situations. My study's findings provide additional physiological evidence for Interdependence Theory because I found that not only are our self-reports of relationship quality or how we behave towards our partners associated with our own testosterone, but these outcomes are also associated with our *partners*' testosterone. It would be interesting for

future research to examine mutuality of dependence, that is, the extent to which partners are equally affected by each other's testosterone, and whether this is influenced by gender or relationship length.

Although I found associations between testosterone and relationship quality and between testosterone and prosocial behavior across my three samples, I did not find that prosocial behavior explained associations between testosterone and relationship quality. However, it is still important to consider other variables that may contribute to testosterone-relationship quality links. One potential mediator could be prosocial behavior that is more nurturant in nature (van Anders et al., 2011). The partner interactions in the current study were more neutral (i.e., about one's day) or conflictual (i.e., disagreement or divergence of interest), which might lead to benign or competitive behaviors, rather than nurturance. Given that testosterone declines during contexts where one provides nurturance to a distressed infant (Edelstein et al., 2019), might we see more nurturant behaviors when one provides nurturance to a distressed partner? Future research could code nurturance (e.g., soothing, comforting) from one partner towards their stressed partner and examine whether more nurturant behavior contributes to any testosterone-relationship quality associations.

It is also possible that I did not find evidence for mediation because it is not about one's behavior that leads them to feel better about their relationship, but instead, it might be about how one perceives their partner. Given that perceptions of how invested partners are motivates people to commit to their relationships (Joel, Gordon, Impett, MacDonald, & Keltner, 2013), perhaps partner perceptions are more strongly associated with relationship quality outcomes compared to objective behavior (Joel et al., 2020). It would be interesting for future research to measure partner perceptions about relationship commitment and investment to determine whether having

lower testosterone leads one to perceive their partners as more committed to them, which consequently leads to one reporting higher relationship quality themselves.

It is also worth noting that, although I selected three fairly large samples, each sample on its own was not powerful enough to run appropriate moderation analyses. Future studies would benefit from recruiting larger samples that would support the inclusion of additional predictors, such as two-way interactions between testosterone and potential moderators. For example, having a larger sample of newlywed couples would allow me to examine whether differences within the sample, such as age, influences (i.e., moderates) the association between testosterone and relationship quality. In addition, the three samples included in this study were limited in age. Given age-related declines in testosterone (e.g., Ellison et al., 2002; Zumoff, Strain, Miller, & Rosner, 1995), researchers generally recruit participants up to 40 years of age, limiting our understanding of whether associations between testosterone and relationship functioning generalize to older adults. Perhaps older adults would show stronger negative associations between testosterone and relationship quality because they have lower levels of testosterone and might have more time to spend with their partner (i.e., due to retirement), and as a result, they would report higher relationship quality. Future research would benefit from recruiting a more diverse sample in terms of age to assess whether naturally occurring age-related declines in testosterone influence associations between testosterone and relationship functioning.

In addition to building on theory, my work also begins to shed light on physiology and relationship dynamics and provides a fruitful direction for researchers and clinicians. For example, my work suggests that physiological markers, such as testosterone, might be reliable indicators of relationship quality. Thus, researchers and clinicians who conduct intervention

research might measure testosterone, in addition to self-reports of relationship quality, as an objective, physiological indicator of relationship functioning.

In conclusion, my findings demonstrated that, among college-aged couples and couples with children, women who had lower levels of testosterone generally reported higher relationship quality. Further, these associations extended to partners in the college-aged couples and couples with children, such that women who had lower testosterone also had partners who reported higher relationship quality. In contrast, men in newlywed couples who had lower testosterone reported *lower* relationship quality. I also found interesting partner associations in the newlywed couples, such that women who had lower testosterone had partners who reported lower relationship quality. Similar to findings for relationship quality, I found that people in the college-aged and couples with children samples were more likely to behave in prosocial ways when they had lower testosterone, but that men in the newlywed sample were more likely to behave in prosocial ways when they had *higher* testosterone. Across all three samples, I did not find that prosocial behavior explained any testosterone-relationship quality associations. Nonetheless, my findings contribute novel information about associations between testosterone and multiple measures of self-reports of relationship quality and non-verbal prosocial partner behavior. Future research will be necessary to further unpack differences across the different samples of couples, including standardizing procedures across samples and measuring motivations to resolve relationship conflict. To sum, my findings on associations between testosterone, relationship quality, and prosocial behavior advances previous work by replicating extant testosterone-relationship quality findings in larger samples, assessing testosterone-relationship links in both men and women across various relationship stages, and contributing important new information about testosterone and prosocial behavior in couples.

Table 1. Summary of Samples Used in Dissertation

	Sample 1: College-Aged Couples	Sample 2: Couples with Children	Sample 3: Newlywed Couples
Demographics			
N couples	*N* = 129	*N* = 241	*N* = 225
Location	Amsterdam, Netherlands	Ann Arbor, Michigan, US	Amherst, Massachusetts, US
Ages	Women = 22.43(2.85)	Women = 31.60(4.22)	Women = 27.72(4.79)
M(*SD*), years	Men = 24.09(3.80)	Men = 33.20(4.78)	Men = 29.13(5.27)
Ethnicity	94% Dutch	86% Caucasian	93% Caucasian
Education	18% bachelor's+	82% bachelor's+	46% bachelor's+
Live together	34%	100%	100%
Relationship length	2.84(2.43)	5.77(2.74)	4.97(2.92)
M(*SD*), years			
Children	0%	0%	100%
Hormonal contraceptive	40%	15%	47%
use (women only)			

Table 2. Descriptives for Testosterone

	Sample 1: *N* = 129 College-Aged Couples	Sample 2: *N* = 241 Couples with Children	Sample 3: *N* = 225 Newlywed Couples
***M*(*SD*)**			
Women	18.58(14.99)	15.48(6.90)	47.86(30.72)
Men	69.17(52.02)	65.92(20.82)	103.57(54.42)
Range			
Women	1.63-91.60	1.10-36.36	7.71-140.72
Men	4.07-257.36	18.65-124.70	20.75-285.38

Note. Testosterone is measured in pg/mL.

Table 3. Correlations Between Testosterone and Potential Control Variables

	Sample 1: *N* = 129 College-Aged Couples	Sample 2: *N* = 241 Couples with Children	Sample 3: *N* = 225 Newlywed Couples
Relationship Length			
Women	.14	-.12	.02
Men	-.14	.00	-.14
Age			
Women	.07	.03	-.15*
Men	.08	-.09	-.23***
Hormonal Birth Control			
Women	-.12	-.34***	-.13*
Men	n/a	n/a	n/a

Note. Testosterone is measured in pg/mL. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 4. College-Aged Couples: Correlations Between Testosterone and Relationship Quality

	1.	2.	3.	4.	5.	6.	*M*(*SD*)
1. Testosterone	**-.16**	-.19	-.09	.01	.14	-.25*	18.58(16.69)
2. Satisfaction	.00	**.39*** **	.56***	.25**	-.16	.49***	5.97(.08)
3. Commitment	-.19	.56***	**.26** **	.17+	-.23**	.32***	6.60(.56)
4. Investment	-.03	.17*	.27**	**.38*** **	-.19*	.38***	4.42(1.30)
5. Alternatives	.05	-.23**	-.27***	-.27**	**.05**	-.23**	2.81(1.10)
6. Closeness	-.07	.32***	.34***	.43***	-.42***	**.48*** **	5.91(1.17)
M(*SD*)	69.17(52.02)	5.96(.86)	6.34(.86)	4.49(1.08)	3.28(1.17)	5.03(1.07)	

Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL and is winsorized and log-transformed. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 5. Couples with Children: Correlations Between Testosterone and Relationship Quality

	1.	2.	3.	4.	5.	6.	*M*(*SD*)
1. Testosterone	**.08**	-.15	.64	.17*	.15	.02	15.48(6.90)
2. Satisfaction	-.04	**.58*****	.31***	-.60***	-.62***	.74***	4.10(.83)
3. Maintenance	-.06	.30***	**.37*****	.09	-.13	.51***	5.71(1.21)
4. Conflict	-.04	-.48***	.12	**.46*****	.53***	-.43***	4.32(1.26)
5. Ambivalence	.03	-.66***	-.18*	.57***	**.38*****	-.66***	2.32(1.19)
6. Love	-.08	.76***	.40***	-.45***	.70***	**.57*****	7.43(1.02)
M(*SD*)	65.92(20.82)	4.23(.75)	5.55(1.17)	3.73(1.21)	2.55(1.19)	7.37(.98)	

Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL and is not winsorized or log-transformed. *$p < .05$, ***$p < .001$.

Table 6. Newlywed Couples: Correlations Between Testosterone and Relationship Quality

	1.	2.	3.	4.	5.	6.	*M*(*SD*)
1. Testosterone	**.64*** **	.00	-.02	.04	.10	.01	47.86(30.72)
2. Satisfaction	.12	**.40*** **	.50***	.74***	.46***	.46***	6.45(.71)
3. Commitment	.19**	.48***	**.16***	.44***	.13*	.65***	6.85(.40)
4. Intimacy	.19**	.68***	.53***	**.50*** **	.52***	.44***	6.38(.72)
5. Passion	.13	.42***	.26***	.62***	**.49*** **	.24***	5.23(1.20)
6. Love	.20**	.54***	.60***	.54***	.33***	**.32*** **	6.81(.43)
M(*SD*)	103.57(54.42)	6.45(.65)	6.77(.49)	6.22(.77)	5.27(1.17)	6.71(.50)	

Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL and is winsorized. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 7. College-Aged Couples: Correlations Between Testosterone and Prosocial Behavior

	1.	2.	3.	4.	5.	*M*(*SD*)
1. Testosterone	**-.16**	-.18	-.10	-.06	-.22	18.58(16.69)
2. Understood	-.01	**.54*****	.63***	.78***	.72***	4.25(1.30)
3. Support Perceived	.15	.63***	**.31*****	.76***	.56***	4.40(1.57)
4. Support Provided	.11	.78***	.76***	**.42*****	.67***	4.44(1.58)
5. Responsiveness	-.16	.72***	.56***	.67***	**.50*****	5.61(1.10)
M(*SD*)	69.17(52.02)	4.47(1.26)	4.42(1.49)	4.50(1.55)	5.67(1.01)	

Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL and is winsorized and log-transformed. ***$p < .001$.

Table 8. Couples with Children: Correlations Between Testosterone and Prosocial Behavior

	1.	2.	3.	4.	5.	6.	*M*(*SD*)
1. Testosterone	**.08**	.03	-.22**	.08	.09	.13	15.48(6.90)
2. Support	.02	**.21****	.36***	-.31***	-.40***	-.46***	4.98(.95)
3. Communication	-.01	.42***	**-.14****	.12	-.13	-.45***	6.30(.76)
4. Dominance	.04	-.29***	.09	**.19****	.72***	.25**	1.53(.74)
5. Conflict	.05	-.46***	-.07	.69***	**.22****	.40***	1.64(.83)
6. Withdrawal	-.04	-.42***	-.63***	.03	.19*	**.05**	1.61(.78)
M(*SD*)	65.92(20.82)	4.92(1.03)	5.79(.98)	1.40(.67)	1.57(.88)	1.85(.97)	

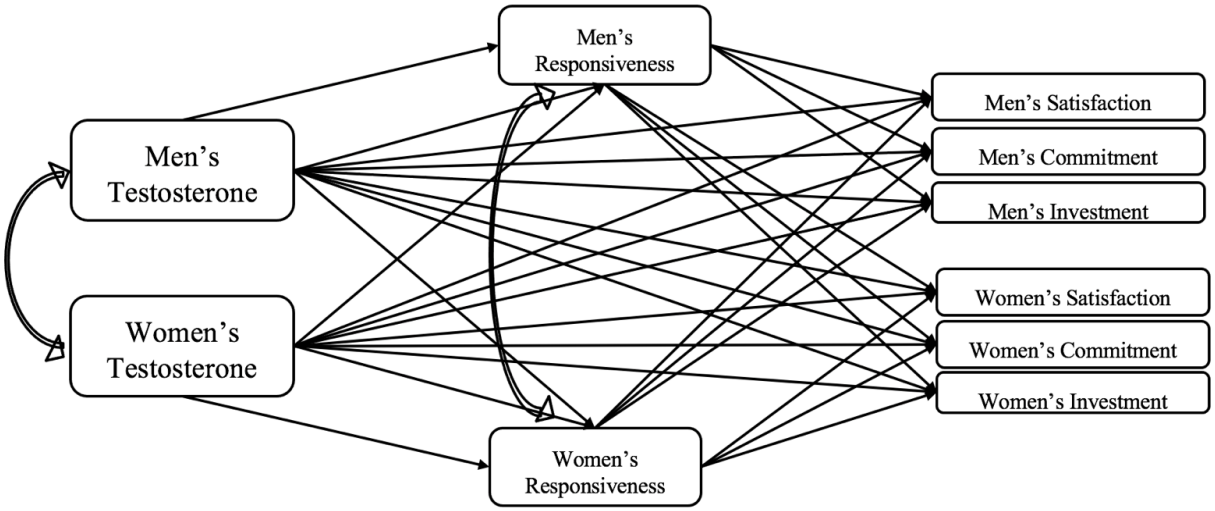
Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 9. Newlywed Couples: Correlations Between Testosterone and Prosocial Behavior

	1.	2.	3.	4.	5.	*M*(*SD*)
1. Testosterone	**.64*** **	.04	.07	.13*	-.01	47.86(30.72)
2. Interest in Partner	.08	**.43*** **	.84***	.54***	.66***	5.83(1.07)
3. Responsiveness	.13	.88***	**.46*** **	.62***	.63***	5.55(1.24)
4. Recognition	.14	.59***	.59***	**.23*** **	.73***	6.59(.79)
5. Interpretation	.15*	.69***	.65***	.66***	**.23*** **	6.30(.92)
M(*SD*)	103.57(54.42)	5.53(1.28)	5.23(1.41)	6.53(.85)	6.07(1.02)	

Note. Women's values are above diagonal, men's values are below diagonal. Within-couple correlations are bolded along diagonal. Testosterone is measured in pg/mL and is winsorized. Recognition = recognition of partner distress; Interpretation = interpretation of partner distress. *$p < .05$, ***$p < .001$.

Figure 1. Example Actor Partner Interdependence Mediation Model (APIMeM)



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