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Intrasexual competition mediates the relationship between men's testosterone and mate retention behavior

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ABSTRACT

Previous research has established a link between testosterone concentrations in males and their mating effort as it relates to their *mate seeking behaviors*. However, very little research has analyzed how variability in basal testosterone concentration of males affects their mating effort once they have secured a romantic partner. In a sample of undergraduate men, the relationship between testosterone, intrasexual competitiveness, and mate retention behavior was examined. Results showed that higher basal testosterone predicted more self-reported mate retention effort. This relationship was mediated by intrasexual competitiveness, such that high T men reported more intrasexual competitiveness, which when included in the model predicted mate retention, and reduced the initial T – mate retention relationship to statistical non-significance. When examined separately, this mediation effect applied specifically to cost-inflicting, rather than benefit-provisioning, mate retention behavior. These are the first findings to link T to mate retention effort and to identify intrasexual competitiveness as a mechanism which might account for this relationship.

1. Introduction

A growing body of research has demonstrated that testosterone plays an important role in encouraging male intrasexual competition and *mate-seeking* behavior across a variety of sexually-reproducing species, including humans [34,35,39,42,52,59]. Previous work indicates that men demonstrate relatively rapid increases in T during competition (see [20] for meta-analysis) and when interacting with attractive females (e.g., [47–49]). Such acute changes in T may serve to promote mate-acquisition and/or retention behavior. Recent work indicates that elevated T after competition positively predicts subsequent mate seeking behavior [57]. However, humans are also unique from many mammalian species in that *long-term* heterosexual pair bonding is the most common form of mating [7]. Yet, little is known about whether testosterone also predicts effort aimed at *retaining* a long-term mate.

Individuals often engage in behavior meant to prevent their partners' infidelity or defection from the romantic relationship, and to dissuade intrasexual rivals from mating with their partner (see [1] for review). Collectively, these actions are referred to as mate retention behavior. Ancestrally, successful implementation of mate retention behavior would have had important consequences for reproductive fitness, including providing males with preferential sexual access and greater paternity certainty. Such reproductive benefits should conceivably have selected for underlying psychological and biological mechanisms that serve to motivate mate retention effort [31]. The goal of the present study was to determine whether endogenous testosterone predicts mate retention behavior, and whether trait intrasexual competitiveness mediated this relationship.

1.1. Testosterone and mate retention

Testosterone has been linked to male mate guarding in some non-human species. For example, male White-Crowned Sparrows (*Zonotrichia leucophrys*) with higher testosterone exhibit more territorial mate guarding when their mates are sexually receptive [38]. Elevated testosterone levels have also been found during periods of mate guarding in primates including wild male long-tailed macaques (*Macaca fascicularis*; [21]) and savanna baboons (*Papio cynocephalus*; [43]), particularly with respect to instances of agonistic intrasexual competition (see [22,39]).

Nevertheless, in human males, there is a lack of research examining testosterone, intrasexual competitiveness, and mate retention effort. However, some circumstantial evidence points to a potential relationship between these variables. Fales et al. [17] exposed male participants to profiles of other males who were purportedly attending the

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same university, which participants were told would also be rated for attractiveness by their female romantic partners. Results demonstrated an increase in male testosterone levels following exposure to the profiles that was significantly greater when their partner was in the fertile versus infertile phase of her menstrual cycle. Other research has focused on sexual jealousy, which is correlated with human mate-retention behavior (e.g., [6]), in relation to putative markers of prenatal testosterone. Fussell et al. [19] found that a low (i.e., more masculinized) 2D:4D ratio predicted greater distress over a partner's hypothetical sexual infidelity in a sample of men and women. More specific to self-report mate retention effort, in a sample of Iranian men Pazhoohi et al. [44] found that the use of mate retention tactics declined with age. Conversely, female partner age and fertility status did not relate to male mate retention behavior. Atari et al. [3] also found a negative relationship between men's age and their mate retention behavior. In both of these studies, the authors interpreted this link as being ostensibly due to declining testosterone levels with age, although individual differences in testosterone were not examined. In the present study, it was hypothesized that men's testosterone levels would predict more mate retention behavior.

1.2. Cost-inflicting versus benefit-provisioning mate retention

This relationship was expected to exist across the two broad categories of human mate retention: cost inflicting and benefit provisioning strategies. Cost-inflicting mate retention behaviors are those that involve direct guarding (e.g., concealing one's mate) or negative intersexual or intrasexual inducements (threats or acts of violence against a partner or same-sex conspecific). Cost-inflicting behavior directed toward rivals may deter mate-poaching attempts, harm, or eliminate competitors, whereas cost-inflicting behavior directed toward the partner may reduce the risk of partner infidelity or defection by causing one's partner to feel fearful or undeserving of the current relationship [37]. According to the challenge hypothesis, testosterone plays an important role in such cost-inflicting actions by encouraging aggression when it may be beneficial for reproduction, including for the purpose of mate retention [7,59]. There is evidence that testosterone predicts aggression broadly within the context of intrasexual competition (see [4,12] for review). Specific to mate retention, some studies have linked testosterone to various acts of intimate partner violence [5,53], which as a constellation of aggressive behavior directed toward one's romantic partner, has been considered as an extreme form of mate retention by some evolutionary psychologists [27].

There is also preliminary evidence that testosterone may predict benefit provisioning acts of mate retention, which can include resource displays, sexual inducements, and acts of love and care. Benefit-provisioning behaviors reduce the risk of partner infidelity or defection by increasing their satisfaction with the relationship [37]. Men with masculinized (low) 2D:4D ratios, a putative marker of prenatal androgen exposure, exhibit more interest in gift giving (flowers, chocolates/candies, and love letters) within their romantic relationships [40]. Moreover, men's masculinized digit ratios have also been linked to increased erotic gift giving to romantic partners, but only among those high in mating confidence [41]. Conversely, women with more feminized digit ratios were associated with romantic gift giving [40]. Research has, however, also demonstrated negative links between testosterone and relationship commitment among men, but not women. Higher testosterone has been linked to lower relationship commitment in pair-bonded men (e.g., [25]). To the extent that relationship commitment has previously been linked to other benefit-provisioning acts such as resource display, appearance enhancement, and love [36], it is presently unclear how testosterone might relate to benefit provisioning mate retention.

1.3. Individual differences in intrasexual competition

Thornhill and Alcock [54] noted that mate retention serves as an important intrasexually-competitive strategy. Successfully implemented, mate retention can allow one individual to maintain access to a preferred mate to the exclusion of same-sex rivals vying for that same partner. In humans, mate retention has similarly been considered as a component of intrasexual competition (e.g., [15,18]). Yet individual differences exist in the degree to which individuals view confrontation with intrasexual conspecifics in competitive terms, particularly within the context of mating [9]. Higher levels of self-report intrasexual competitiveness have previously been shown to relate broadly with increased effort in the domains of mate *acquisition/attraction* in both males [10] and females (e.g., [56]), as well as with increased willingness to aggressively *guard* a mate from a same-sex mate-poacher [2]. Moreover, intrasexually-competitive orientation is sensitive to reproductive pressures such as the perceived scarcity of mating opportunities [2]. This suggests that self-reported intrasexually competitive orientation provides impetus for competitive mating behavior. Thus, in the present study it was further predicted that an intrasexually-competitive orientation would mediate the testosterone – mate retention relationship (Fig. 1).

2. Method

2.1. Participants

108 male undergraduates were recruited as part of a larger study from a university and college in Northern Ontario, Canada, using the campus online research participation system and recruitment stations in common areas. Given that the hypotheses being tested in this study applied to mating dynamics in sexual relationships (as a proxy for ancestral reproductive behavior; [46]), and because some of the items on the mate-retention inventory are inherently conflated with having had sexual intercourse (e.g., items assessing sexual inducements) participants who had never engaged in consensual sexual activity (defined as penile vaginal penetration) were excluded from analyses. Additionally, participants that did not fully complete the self-report measures of interest regarding relationship status, intrasexual competitiveness, or mate retention were excluded. Therefore, the final sample in which the mediation model was tested comprised 92 men between the ages of 17 and 29 (M = 20.72, SD = 2.41). Prior to testing, all participants reported being free of medications affecting hormone concentrations and having no history or diagnosis of a psychiatric illness or drug dependency.

2.2. Materials and procedure

Participants were led to a private and quiet testing room. As part of

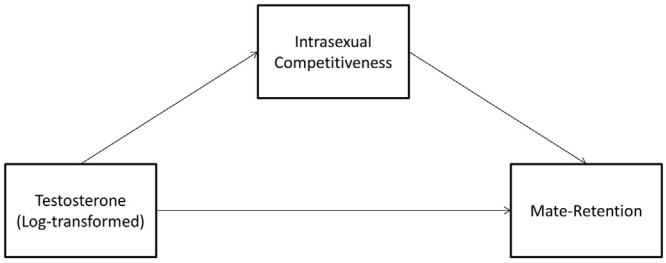

Fig. 1. Predicted model whereby intrasexual competitive orientation mediates the relationship between testosterone and mate-retention behavior.

a larger study on mating behavior, they provided a saliva sample via passive drool into a transparent 5 ml polystyrene culture tube, and completed a self-report paper and pencil questionnaire. Participants were remunerated with research credit or $5CAD.

2.2.1. Testosterone concentrations

For testosterone, samples were assayed in duplicate using commercially available enzyme immunoassay kits (DRG International, NJ, USA). The average of the duplicates (log transformed) was used for all statistical analyses. Average intra- and inter-assay coefficients of variation were below 11%. Sample provision time ranged from late morning to late afternoon. Testosterone was modestly correlated with sample provision time ($r = -0.19$, $p = 0.06$). Therefore, time of sample provision was entered as a covariate in all analyses. Consistent with previous findings (e.g., [34]), men who were currently in committed romantic relationships ($n = 52$) had modestly lower testosterone levels ($M = 1.61$, $SD = 0.17$) relative to men who were single ($n = 40$) at the time of data collection ($M = 1.68$, $SD = 0.24$), $t(90) = 1.70$, $p = 0.09$, Cohen's $d = 0.34$. Accordingly, we also controlled for romantic relationship status in all subsequent analyses.

2.2.2. Intrasexual competitiveness

Participants next completed the Intrasexual Competition Scale which assessed the degree to which an individual is motivated to compete with members of the same sex [9]. Previous research has found the Intrasexual Competition Scale to be a valid and reliable tool for measuring attitude toward intrasexual competition [2,9]. The measure consists of 12 items rated on a seven-point Likert-type scale ranging from 1 = "*not at all applicable*" to 7 = "*completely applicable.*" Example items include: "I would not hire a competent man as a colleague," "I can't stand it when I meet another man who is more attractive than I am," "When I'm at a party, I enjoy it when women pay more attention to me than other men," "I wouldn't hire a very ambitious man as a colleague," and I always want to beat other men." In the present study, the measure showed good internal consistency ($\alpha = 0.87$).

2.2.3. Mate retention

Mate retention behavior was measured using the Mate Retention Inventory-Short Form (MRI-SF; [8]). The MRI-SF contains 38 items along which respondents indicate how often they have performed the target behavior in the past year, using a Likert-type scale ranging from 0 = "*Never*" to 3 = "*Often*". Items correspond to five mate retention strategies (i.e., positive inducements, public signals of possession, direct guarding, intersexual negative inducements, and intrasexual negative inducements) loading onto two distinct higher-order factors: *benefit-provisioning* behavior such as "Bought my partner an expensive gift", and *cost-inflicting* behavior such as "Insisted that my partner spend all their free time with me". Following recent published research (e.g., [13]), including studies focused on hormones (e.g., [16,58]) and other biological factors associated with human reproduction in relation to mate retention (e.g., ejaculate quality; [30]), mean scores for all MRI-SF items were considered as an overall index of mate retention. However, given that research has also identified potential links between testosterone and specific cost-inflicting and benefit provisioning acts of mate retention, these two constructs were also examined separately in subsequent exploratory analyses. In the present study, the overall measure showed good internal consistency ($\alpha = 87$), as did the cost inflicting ($\alpha = 84$) and benefit provisioning ($\alpha = 84$) subscales.

2.3. Analytic approach

We examined the relationship between testosterone and mate retention effort (first overall mate retention, then cost inflicting and benefit provisioning mate retention specifically), controlling for saliva sample provision time of day and current romantic relationship status.[1] Bootstrapping procedures, as outlined by MacKinnon et al. [32], were used to examine the role of intrasexual competition in mediating this relationship. For each analysis, 1000 bootstrapping samples were derived. Unstandardized regression coefficients are reported.

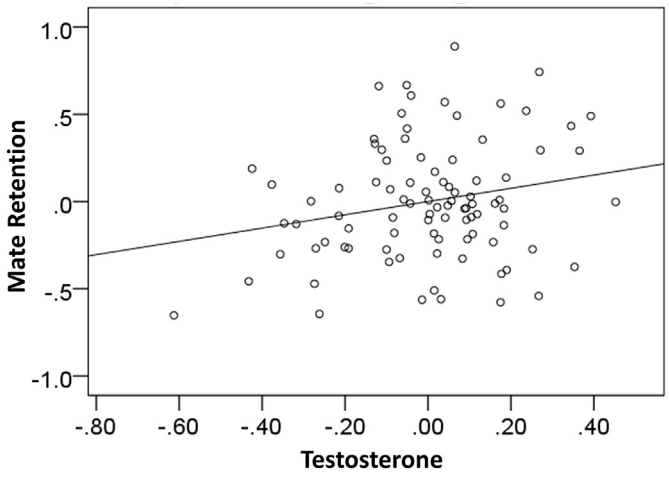

Fig. 2. Scatterplot demonstrating partial relationship between Log-transformed testosterone and mate-retention behavior. Note that analyses were conducted both with and without windsorizing the lowest basal T value which was > 3 SD below the mean.

3. Results

We first examined whether testosterone predicted mate retention behavior. Testosterone had a total (c-path) effect on mate retention effort, $b = 0.39$, $SE = 0.17$, $t = 2.24$ $p = 0.027$, such that men higher in testosterone reported engaging in more mate-retention effort (Fig. 2). Results also demonstrated that men's testosterone predicted more intrasexual competitiveness, $b = 0.10$, $SE = 0.48$, $t = 2.19$ $p = 0.05$.

With intrasexual competitiveness included in the model, the direct (c' path) effect of testosterone on mate retention was reduced to statistical non-significance, $b = 0.28$, $SE = 0.17$, $t = 1.69$ $p = 0.10$. Intrasexual competitiveness had a direct (b path) effect on mate retention, $b = 0.11$, $SE = 0.04$, $t = 3.14$ $p = 0.002$, such that more intrasexually competitive men engaged in more mate retention (Fig. 3). Intrasexual competition mediated the link between testosterone and mate retention (bootstrapping: 95% LL = 0.015, 95% UL = 0.25). The mediation model contributed 11% ($R^2adj = 0.113$) toward explained variance in men's mate retention. Neither saliva provision time or relationship status predicted past engagement in mate retention. Results did not meaningfully change when excluding the control variables from the model. This mediation model also remained statistically-significant when the single lowest data point for basal T (> 3 SD below mean) was windsorized in post-hoc analyses.

The model was then re-examined in order to explore whether this mediated effect was being driven by either cost inflicting or benefit provisioning mate retention strategies. Results showed that testosterone predicted cost-inflicting mate retention, $b = 0.35$, $SE = 0.17$, $t = 2.01$ $p = 0.048$. Intrasexual competitiveness, when entered into the model,

[1] We also examined whether the sexual history variables (1) relationship length (anchored at 1 = "less than two months" to 5 = "more than two years") or (2) lifetime number of dating partners correlated with any study variables. Relationship length (among those currently in relationships) did not correlate with with testosterone, intrasexual competitiveness, current relationship status, and overall mate-retention, cost-inflicting or benefit provisioning mate-retention, thus we did not limit our sample to those currently in romantic relationships. Lifetime dating partners (among the entire sample) did not correlate with testosterone, intrasexual competitiveness, current relationship status, and overall mate-retention, cost-inflicting or benefit provisioning mate-retention. Moreover, adding lifetime dating partners as a covariate did not meaningfully alter the results of the mediation models presented herein.

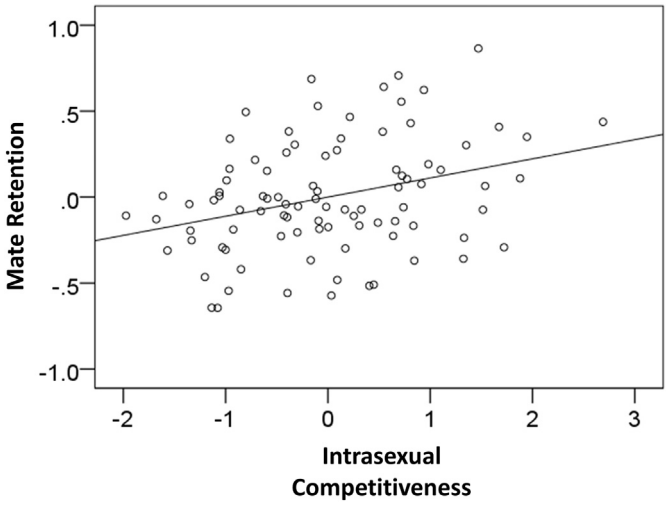

Fig. 3. Scatterplot demonstrating partial relationship between intrasexual competitive and mate retention behavior.

Table 1
Correlations between testosterone, intrasexual competitiveness, and components of benefit-provisioning mate-retention among men.

	1	2	3	4	5	6
1. Testosterone	–					
2. Intrasexual competition	0.23*	–				
3. Resource display	0.18†	0.03	–			
4. Sexual inducement	0.14	0.22*	0.49***	–		
5. appearance enhancement	0.29**	0.26*	0.33**	0.43***	–	
6. Love and care	0.09	−0.01	0.33**	0.42***	0.55***	–
7. Submission	0.09	0.16	0.23*	0.45***	0.40***	0.33**

† $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$ (two-tailed).

predicted cost inflicting mate retention, $b = 0.14$, $SE = 0.03$, $t = 4.16$ $p = 0.0001$, whereas testosterone did not, $b = 0.21$, $SE = 0.16$, $t = 1.28$ $p = 0.20$. Intrasexual competition mediated the link between testosterone and cost inflicting mate retention (bootstrapping: 95% LL = 0.0002, 95% UL = 0.296). The mediation model contributed 17% ($R^2adj = 0.171$) toward explained variance in men's cost inflicting mate retention. Neither saliva provision time or relationship status predicted past engagement in mate retention. Results did not meaningfully change with the exclusion of the control variables from the model, or when the lowest basal T value (> 3 SD below mean) was windsorized in post-hoc analyses.

Testosterone also modestly related to men's benefit-provisioning mate retention, $b = 0.44$, $SE = 0.23$, $t = 1.90$ $p = 0.061$. This relationship was reduced upon inclusion of intrasexual competitiveness into the model, $b = 0.37$, $SE = 0.24$, $t = 1.58$ $p = 0.12$; however, intrasexual competitiveness was unrelated to benefit provisioning mate retention, $b = 0.07$, $SE = 0.05$, $t = 1.34$ $p = 0.18$ (bootstrapping: 95% LL = −0.012, 95% UL = 0.241), and this accounted for < 2% of explained variance ($R^2adj = 0.016$). Neither saliva provision time or relationship status predicted past engagement in mate retention. Results did not meaningfully change with the exclusion of the control variables from the model. Because past research has found differential links between testosterone and resource provisioning (positive) versus commitment provisioning (negative) within relationships, we also ran a post-hoc correlation analysis between testosterone, intrasexual competition, and each component of the benefit provisioning subscale. Results demonstrate some evidence of links between testosterone and provision of resources (enhanced physical appearance, displaying resources), but not for commitment (i.e., love and care) (Table 1).

4. Discussion

Studies have previously linked testosterone to men's mating effort – primarily within the context of mate-seeking behavior. For example, high testosterone men engage in more intrasexual dominance within the context of competing for the favor of a woman. Additionally, research has demonstrated that unmated men have higher testosterone than pair-bonded men ([5,33,55]; but see [29]). Among men who are in committed romantic relationships, individual differences in testosterone are also positively correlated with men's dominance displays toward an intra-sexual competitor during a mating competition [52]. However, we are unaware of any research that has extended the testosterone – mating effort hypothesis to one of the most common and important facets of mating effort in humans - that of retaining a mating partner. This is an important gap in the literature given that the formation and maintenance of long-term heterosexual relationships is a fundamental strategy in human reproduction [7], and may lead to the best reproductive outcomes [26,28]. Results of the present study found that men's endogenous testosterone predicted increased mate retention behavior, and that this relationship was mediated by intrasexual competitiveness. To our knowledge, this is the first study to demonstrate a potential, albeit indirect, relationship between individuals' endogenous testosterone and their mate retention behavior. These findings support previous indirect findings of Pazhoohi et al. [44] and Atari et al. [3] who demonstrated that the frequency with which men engage in mate retention behaviors declines as they age, which is possibly mediated by declining levels of testosterone.

In the present study, the relationship between testosterone and mate-retention was largely driven by the predictive relationship between testosterone, intrasexual competitiveness, and *cost-inflicting* (as opposed to benefit-provisioning) mate retention. Our results corroborate more circumstantial findings surrounding T and cost-inflicting mate retention, including those of Cousins et al. [14] who demonstrated that men with a lower 2D:4D ratio, a putative indicator of higher prenatal androgen exposure, were more likely to threaten male competitors (a form of intrasexual negative inducement) and to physically aggress against their partner (a form of intersexual negative inducement). However, in contrast to the findings of Nepomuceno et al. [40,41], we did not demonstrate a relationship between testosterone and their benefit provisioning mate retention behaviors. This could be due in part to differential effects of testosterone upon various types of benefit-provisioning. Correlation analysis showed some bivariate links between testosterone and resource display and appearance enhancement, which may corroborate the provision of more tangible benefits as opposed to relational commitment (which has previously been linked to reduced testosterone). Moreover, although Miguel and Buss [36] found links between self-report relationship commitment and scores on the love/commitment (e.g., “displayed greater affection toward my partner”) and submission/debasement (e.g., “gave in to my partner's every wish”) mate retention scales, it is possible for one to engage in such commitment-oriented actions and to simultaneously be relatively non-committal to the relationship. Future research should re-examine links between testosterone and a broader array of both self-reported commitment and infidelity scales, alongside benefit provisioning mate-retention within relationships, perhaps including partner reports of men's behavior in order to augment self-report responses.

Based on the current investigation, it seems that endogenous testosterone could influence men's mate retention behavior as a form of intrasexual competition, and therefore may be partially responsible for the variation in the types of mate retention tactics men use and the frequency with which they engage in these tactics. However, in order to build upon the current study, future investigations should have men complete the MR-SF and provide saliva samples at multiple time points

in order to test if endogenous testosterone is indeed a predictor of men's subsequent use, rather than cross-sectional reporting of, mate retention tactics.

The present study has several limitations which suggest fruitful avenues for future investigations. To begin, we only analyzed basal levels of a single steroid hormone, testosterone, at a single time point. Moreover, our sample consisted of men who were both single and men who were in romantic relationships at the time of data collection. Although this is consistent with some previous use of the mate-retention inventory, and although we did not find differences among study variables (except a modest difference among T) between single and pair-bonded men, future studies investigating the relationships between testosterone and mate retention behaviors would nevertheless benefit from testing testosterone in relation to in-vivo mate retention activity (necessitating a sample comprised of only pair-bonded men), as well as testing participants' testosterone reactivity in relation to their mate-retention efforts. It could be that men's increases in testosterone in response to a challenge serves as a better predictor of their subsequent mate retention behavior than does their basal testosterone levels (see [11,12]). In support of this supposition, men partnered to ovulating women experienced rises in testosterone after exposure to facial photographs of dominant men, who their partner would also be viewing, suggesting that men's rise in testosterone is facultative and may motivate them to engage in mate retention behaviors when they encounter a relationship threat [17].

The current investigation relied on a young WEIRD sample (Western, educated, industrialized, rich and democratic) population [24]. Romantic relationships among western undergraduate students may not be representative of relationships between individuals in other age groups or living in other societies. To begin, undergraduate students are younger than the average adult and therefore have had fewer romantic partners than adults from the broader population [23,50]. As a result, they may have less experience implementing mate retention tactics. Similarly, because many undergraduates are still in the process of finding and securing a long-term partner, they may be less committed to their current partner and engage in mate retention behaviors less frequently than adults who are more invested in their relationships [50]. Therefore, future investigations should include a sample of older reproductive-age adults who are more likely to be in committed romantic relationships.

We did not account for the mate value of the participants' partners. Several studies have highlighted that mate value discrepancy is a key factor that affects individuals' experience of jealousy and motivates their mate retention behaviors (e.g., [45,51]). Specifically, individuals who perceive themselves to have significantly lower mate value than their partner are more sensitive to relationship threat and are more forgiving of partner transgressions [45,51]. The willingness of individuals with relatively lower mate value to forgive their high mate value partner's relationship transgressions (i.e., infidelity) represents a mate retention tactic in which the low mate value partner tolerates relationship transgressions by the high mate value partner as a means to reduce conflict and maintain the relationship [51]. Future studies investigating the relationship between individuals' testosterone concentrations and their propensity to engage in mate retention should account for mate value discrepancy.

Here we report what is to our knowledge the first evidence of a relationship between men's endogenous testosterone concentrations and the extent to which they engage in mate retention behavior. Although previous investigations have demonstrated that higher testosterone concentrations promote mate seeking behavior in unmated men, our study is the first to demonstrate that the difference in mated men's testosterone concentrations is related to mate retention behaviors. Specifically, men with higher testosterone engage in more cost inflicting mate retention behaviors. However, this relationship appears to be indirect in nature, such that it was mediated by their intrasexual competitiveness. Therefore, testosterone may function to incite mating effort behaviors in mated men as well as unmated men by promoting mate retention behaviors in the former and mate seeking behaviors in the later.

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