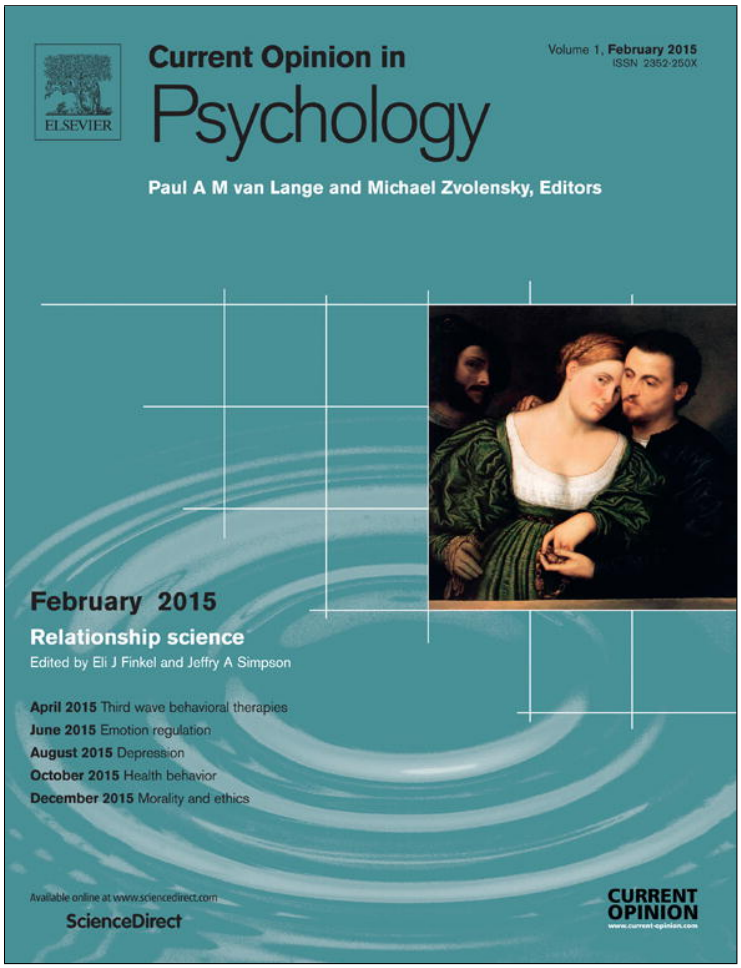

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Current Opinion in Psychology

The role of testosterone in human romantic relationships

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Testosterone may play important signaling roles in human romantic relationship dynamics. Testosterone appears to promote pursuit of mates and may therefore increase the odds of relationship entry. Because competitive pursuit of mates may interfere with stable pair bonds and effective parenting, however, entry into nurturant relationships may have a negative feedback effect on testosterone production and mating effort. In this article, we summarize evidence for testosterone acting as a signal that promotes mate pursuit at various timescales, and synthesize a range of recent findings into a heuristic model ('The Testosterone-Relationship Cycle') depicting the role of this hormone in the initiation, maintenance, and functioning of human mating relationships.

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Introduction: the biological functions of testosterone

The role of testosterone in human relationship dynamics may derive from more basic biological functions of this hormone. A primary function of testosterone appears to be the regulation of energy distribution to alternative parts of the organism. Theorists have proposed that testosterone promotes investment in ''mating effort'': the growth of secondary sex traits that facilitate mate pursuit (e.g., ornaments in some species, muscle mass in humans), physiological outcomes such as sperm production, and behavioral proclivities toward competition with same-sex rivals and the display of courtship behaviors [1]. Because energy is finite, however, these physical and behavioral investments are funded via inhibitory effects of testosterone on outcomes such as fat storage and immune function [2].

The energy distribution model suggests that testosterone should drop when not necessary for mate competition in order to achieve time and energy savings. Consistent with this, in seasonally breeding species, testosterone often drops to very low levels during the nonbreeding season [3]. In species that form pair bonds, such as socially monogamous birds, testosterone tends to be elevated during courtship and mate choice, but then falls during provisioning of newly produced offspring [4,5]. Testosterone has been causally implicated in this behavioral transition from mating to parenting effort, as experimental administration of testosterone has been shown to prolong courtship behaviors at the expense of parenting behaviors, leading to increases in offspring mortality [6].

In sum, testosterone appears to act as a signal that coordinates physical and behavioral investment in mate pursuit at the expense of investment in other priorities. Application of this idea to human romantic relationships produces the model proposed in the next section.

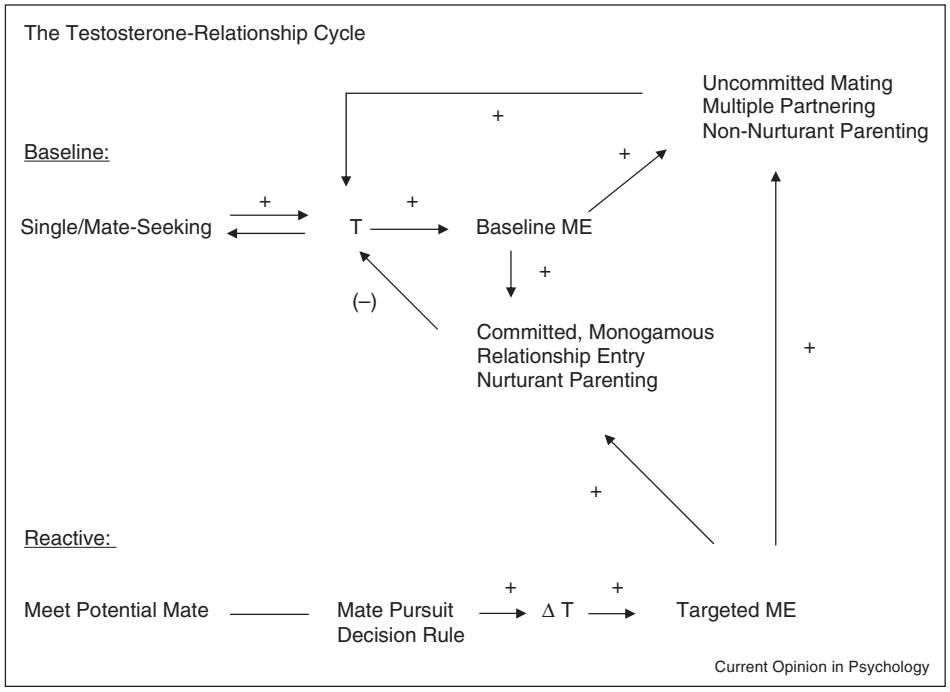
The testosterone-relationship cycle: a theoretical model

Figure 1 presents a model for the role of testosterone in human romantic relationship dynamics. The top half of the figure refers to baseline testosterone concentrations at longer time-scales (i.e. typical hormone values over weeks or months), whereas the bottom half of the figure refers to transient increases in testosterone above baseline within 15–60 min after encounters with potential mates. A unifying hypothesis across both time-scales is that testosterone acts as a signal that calibrates physical and psychological mechanisms toward the goal of mate pursuit.

The baseline portion of the model posits bi-directional relationships between mate-seeking proclivities and testosterone. On the left side of the figure, being unpartnered is predicted to produce a motivational state directed toward mate seeking that in turn promotes higher testosterone production. Greater baseline testosterone concentrations should in turn promote physical (e.g., greater muscle mass) and behavioral investments in mating effort. Behavioral investments could include both competing for resources that facilitate mate acquisition, such as social status, or more direct behaviors such as social approach of potential mates.

The baseline model bifurcates with respect to the outcomes of successful mating efforts. Entry into satisfying, committed, monogamous relationships (downward arrow in Fig. 1) may lead to reduced testosterone (and hence less mate-seeking) as a means of protecting a successful

Figure 1



A theoretical model relating human mating relationships to production of the hormone testosterone. T — testosterone; ΔT — reactive changes in testosterone above baseline minutes after interacting with a potential mate; ME – mating effort, broadly defined.

relationship and to achieve energy and time savings absent mate competition. Uncommitted, short-term sexual encounters or multiple partnering (upward arrow in Fig. 1) may often entail a psychological state in which individuals are still seeking additional partners, however, and this mate-seeking state may be associated with elevated testosterone. If a psychological orientation toward mate seeking is the key variable, furthermore, then even within monogamous relationships the level of interest in other partners may predict testosterone concentrations, which may in turn predict the odds of future relationship dissolution.

The reactive portion of the model proposes that an acute testosterone increase in reaction to a potential mate serves as an internal signal that broadcasts a positive decision regarding pursuit of a specific mating opportunity. This signal is then hypothesized to coordinate the calibration of both physiological and psychological mechanisms toward immediate mate pursuit. The function of this calibration is the promotion of successful mate acquisition, thereby linking the reactive and baseline portions of the model in Fig. 1.

Evidence for the model

Baseline

The strongest support for the baseline portion of Fig. 1 comes from the association between relationship status and testosterone. Cross-sectionally, single men generally have higher testosterone than their monogamously partnered counterparts [7–9], with more mixed evidence among women [8,10,11]. Given the theorized function of testosterone in promoting mating effort, higher baseline testosterone should predict subsequent mating success. In a longitudinal confirmation of this idea, Gettler *et al.* [12] showed that 21.5 year old, single non-fathers with high testosterone were more likely to be partnered fathers by age 26, compared to men with low testosterone. This supports links in the model from heightened testosterone to entry into monogamous relationships (see pathway from T to committed relationship entry in Fig. 1). Heightened testosterone may also facilitate short-term as opposed to committed mating behavior (see pathway from T to uncommitted mating in Fig. 1), and consistent with this are positive correlations between testosterone and lifetime number of sexual partners [13,14]. These links between testosterone and mating success are presumably mediated in part by hormonal influences on behavioral components of mating effort (see arrow from T to baseline ME in Fig. 1), and indeed baseline testosterone has been shown to predict outcomes such as dominance-related behaviors during mate competitions that in turn led to heightened attractiveness perceptions by potential mates [15].

Although elevated testosterone may promote successful attainment of various types of mating relationships

(especially in men), only committed, monogamous relationships generally appear to predict declines in men's testosterone. In cross-sectional samples, degree of relationship seriousness (e.g., casual dating versus cohabiting versus married) negatively predicted men's testosterone [8], although similar measures of seriousness have not typically predicted women's testosterone [8,11]. Longitudinal investigations have likewise demonstrated drops in men's testosterone after marriage [12,16]. Uncommitted or multiple partnering has not been similarly associated with reduced testosterone, however, as polygynously married men in some societies have testosterone at least as high as single men (17; cf. 18), and polyamorous Canadian men and women were also shown to have higher testosterone than other categories of individuals [19].

As mentioned above, a motivational state directed toward pursuit of new mating partners might be an important predictor of testosterone production. Consistent with this, a sample of partnered men with more unrestricted sociosexual orientations (i.e. openness to uncommitted sex [20]) maintained the elevated testosterone characteristic of single men [21], although not all studies replicated this effect using total scores on SOI (sociosexual orientation inventory) scales [19]. Edelstein *et al.* [22], however, argued that total SOI scores might imperfectly capture desires for additional mating, since they may be affected by opportunities for sex or cultural attitudes toward promiscuity. In their sample, men in relationships who scored higher specifically on a sociosexual desires subscale of a revised SOI measure had testosterone as high as single men, whereas partnered women who reported more unrestricted sociosexual behaviors likewise had testosterone as high as single women (and higher than partnered women with low sociosexual behaviors) [22]. Although these findings have yet to be replicated outside of North America, they support desire for new partners as a predictor of testosterone (see also 11), and may help explain why, on average, monogamous relationships predict reduced testosterone but uncommitted or multiple partnering relationships do not.

The hypothesis that testosterone both responds to mate-seeking desires and promotes behavioral investment in mating effort carries implications for the role of this hormone in romantic relationship functioning. Reduced testosterone may help protect investments in successful relationships (see also 23 (this issue)), whereas negative relationship outcomes may cause up-regulation of testosterone as a prelude toward relationship cessation and mate-switching. A recent study by Edelstein *et al.* [24••] supports such conjectures: a dyadic analysis of 39 couples found that both actor and partner testosterone negatively predicted actors' ratings of relationship satisfaction and commitment, with these associations found for both men and women. That higher testosterone may actually preface relationship dissolution is supported by longitudinal data showing that men's testosterone concentrations positively predicted their future probability of divorce in a sample of army veterans [25].

The results of the Edelstein *et al.* [24••] study on relationship quality suggest natural points of contact between the socioendocrinology literature and the literature applying interdependence theory [26] to the study of human relationships. Variables that predict relationship persistence — such as the maintenance of positive illusions regarding relationship quality [27] — may predict testosterone concentrations as well, if in fact testosterone acts in part as an internal signal of interest in alternative partners. Incorporation of testosterone measures into research studying the predictors of relationship quality may therefore lead to the development of an interesting biomarker of specific relationship dynamics, and also promote the integration of social and biopsychological perspectives on human social interactions.

Finally, nurturant parenting is another relationship variable that predicts reduced testosterone (see 28). Fatherhood appears to have effects that are additive to the declines associated with men's monogamous partnering [7,12], and motherhood has likewise been associated with reduced testosterone in two recent studies that examined women [29,30•]. Merely being a father does not seem sufficient for this effect, however, as fathers and non-fathers did not differ in testosterone in a pastoralist society in which men were not involved in direct child care [31]; likewise, across diverse cultural contexts, fathers who are more involved in day-to-day childcare have lower testosterone than fathers who perform less care [32,33••,34]. These patterns provide further support for testosterone tracking investment in mate pursuit versus competing priorities, since those individuals committing the most time and other resources specifically to parenting effort also exhibit the lowest testosterone concentrations.

Reactive

The reactive portion of the model in Fig. 1 addresses rapid testosterone responses to social interactions with potential mates. The research in question zooms in on endocrine events in the early stages of courtship that in turn lead to relationship initiation. Unlike the research examining relationships and baseline testosterone values — which is exclusively correlational — this research is experimental and can thus directly demonstrate that mating-relevant stimuli cause increases in testosterone. The proposed function of rapid testosterone responses is the priming of organism-wide calibrations of mechanisms toward the goal of mate pursuit.

Males of many nonhuman vertebrate species exhibit rapid (within 15–45 min.) increases in testosterone after

non-tactile exposure to conspecific females, with such responses absent after comparable exposure to other males (reviewed in [35•]). Given phylogenetic conservation of the brain mechanisms that regulate these effects [36], Roney and colleagues hypothesized similar hormonal responses in humans. A series of laboratory experiments have in fact supported rapid testosterone increases in young men after brief social interactions with young women, with such effects not found after interactions with other men [37–40]. A number of field studies have likewise supported reactive testosterone increases after men interact with women in more natural environments [41–43,44•]. Although female hormone responses to interactions with potential mates have generally gone untested in nonhuman species, Lopez *et al.* [45] demonstrated that young women showed reactive increases in testosterone after viewing a movie clip depicting a highly attractive man courting a young woman, whereas such responses were absent among women who viewed various types of control videos.

As depicted in the bottom section of Fig. 1, reactive testosterone increases are hypothesized to index a positive internal decision regarding mate pursuit. In nonhuman species, male responses to females are absent in various circumstances: during the nonbreeding season in seasonally breeding species [46], after males reach a state of sexual satiation via frequent ejaculation [47], when subordinate monkeys are in the presence of a dominant male who could thwart mating attempts [48], and when marmoset males are actively caring for offspring [49]. As these are all circumstances in which males do not pursue females for clear functional reasons, these patterns suggest a rule in which testosterone responses are present only when mate pursuit is likely to occur.

Testosterone responses may likewise index a positive decision rule for mate pursuit in humans. Flinn *et al.* [44•], for example, demonstrated that testosterone was higher among men in a Dominican village in time periods after interactions with women, except when the women were mates of the men's friends, which is likely a circumstance in which mate pursuit is typically inhibited. Likewise, in laboratory experiments, ratings of men's courtship-like efforts during conversations with women confederates have sometimes positively predicted testosterone responses measured 15–45 min after the conversations [37,38], suggesting larger hormone responses given behavioral evidence of mate pursuit.

Finally, reactive testosterone increases are hypothesized to broadcast an internal signal that prepares the organism for mate pursuit in the immediate hours and days after meeting a potential partner. Because hormones are released into the general circulation, they are efficient signals for simultaneously coordinating mechanism settings distributed across the brain and the rest of the body. Roney [35•] reviews evidence that reactive testosterone increases may have a suite of effects that would logically facilitate mate acquisition efforts, such as transient increases in physical strength, reduced fear responses and increased risk-taking, and increased probability of approaching potential mates. By hypothesis, these effects should increase the probability of entering into either committed or uncommitted mating relationships — thus linking the reactive and baseline portions of the model in Fig. 1 — although direct evidence for this awaits future research.

Conclusion

Across many species, testosterone is known to increase time and energy allocated to mating effort, leading to trade-offs with other costly priorities, such as immune function or investments in partnering-parenting. The evidence reviewed here supports a similar role for testosterone in humans. The best-supported elements of the Testosterone-Relationship Cycle model (Fig. 1) include negative associations between baseline testosterone concentrations and participation in nurturant romantic or parenting relationships, as well as the ability of social interactions with attractive potential mates to trigger rapid increases in testosterone. Future research could provide many refinements of the model. Little is known regarding possible interactions between the baseline and reactive portions of the model, and one might logically hypothesize, for instance, that nurturant parenting should affect mate pursuit decision rules in such a way as to inhibit testosterone responses to potential mates. In addition, the findings reviewed here suggest that researchers studying social relations might profitably employ testosterone as a biomarker that both predicts and responds to variables that determine the quality and persistence of human romantic relationships.

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