

## Sociosexuality moderates the association between testosterone and relationship status in men and women

Robin S. Edelman\*, William J. Chopik, Emily L. Kean

Department of Psychology, University of Michigan, Ann Arbor, 530 Church Street, Ann Arbor, MI 49109, USA

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### ABSTRACT

Single individuals typically have higher testosterone compared to those who are partnered, suggesting that individual differences in testosterone are associated with mating effort, or people's motivation to find a sexual partner. However, there is less consistent evidence for links between testosterone and sociosexuality, or people's orientation toward uncommitted sexual activity. Based on Penke and Asendorpf's (2008) conceptualization, we propose that a more nuanced measure of sociosexuality may reveal more robust associations with testosterone. In the current study, we assessed relations between three components of sociosexuality—desire, behavior, and attitudes—and endogenous testosterone levels in men and women. We found that partnered status was indeed associated with lower testosterone in both men and women, but only among those who reported more restricted sociosexuality. Partnered men who reported greater *desire* for uncommitted sexual activity had testosterone levels that were comparable to those of single men; partnered women who reported more frequent uncommitted sexual *behavior* had testosterone levels that were comparable to those of single women. These findings provide new evidence that people's orientations toward sexual relationships, in combination with their relationship status, are associated with individual differences in testosterone. The current results are also among the first to demonstrate sociosexuality–testosterone associations in both men and women, and they reveal that the nature of these associations varies by gender. Together, these findings highlight the utility of a multifaceted conceptualization of sociosexuality and the implications of this conceptualization for neuroendocrine processes.

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### Introduction

Testosterone is thought to play an important role in the initiation and establishment of sexual relationships (Ellison, 2001). In humans, single individuals tend to have higher levels of testosterone compared to those who are in committed, monogamous relationships (e.g., Booth and Dabbs, 1993; Burnham et al., 2003; van Anders and Siciliano, 2010). Such findings appear to be more robust among men, but there is also evidence that single women have higher testosterone compared to those who are partnered (Kuzawa et al., 2010; van Anders and Watson, 2006b). Moreover, longitudinal research suggests that men's testosterone levels increase prior to divorce and decrease with remarriage (Mazur and Michalek, 1998), suggesting that testosterone facilitates mating effort, or an individual's effort to secure a sexual partner.

Other research suggests that, rather than relationship status per se, differences in testosterone may be associated with an individual's orientation toward relationships and/or their propensity to have sex

outside of a relationship with one primary partner (van Anders and Siciliano, 2010; van Anders et al., 2007). For instance, men with multiple partners (i.e., polyamorous or polygamous men) have higher testosterone than men with one partner and, in some cases, higher testosterone than single men (Alvergne et al., 2009; Gray et al., 2007; van Anders et al., 2007). Polyamorous women also have higher testosterone than both single and singly partnered women (van Anders et al., 2007). These findings suggest that partnered individuals who maintain interest in extra-pair sexual activity may not necessarily show lower testosterone compared to single individuals.<sup>1</sup>

There is relatively little evidence for direct links between testosterone and measures of relationship orientation, however. In particular, several studies have examined individual differences in *sociosexuality*, or a person's orientation toward uncommitted sexual activity (Gangestad and Simpson, 1990). Pioneering work by Kinsey and colleagues revealed that there are large individual differences in

\* Corresponding author at: Department of Psychology, University of Michigan, 530 Church Street, Ann Arbor, MI 48109, USA. Fax: +1 734 647 9440.

E-mail addresses: [redelste@umich.edu](mailto:redelste@umich.edu) (R.S. Edelman), [chopik@umich.edu](mailto:chopik@umich.edu) (W.J. Chopik), [emship@umich.edu](mailto:emship@umich.edu) (E.L. Kean).

<sup>1</sup> Testosterone decreases with age in both men and women (e.g., Zumoff et al., 1995), leading to the possibility that age-related differences in testosterone contribute to relationship-status effects observed in prior research. However, in studies that have statistically controlled for age, partnering remains associated with lower testosterone among both men and women (e.g., Mazur and Michalek, 1998; van Anders and Watson, 2006b).

people's attitudes toward uncommitted sexual activity and the extent to which they engage in such activity (e.g., Kinsey et al., 1948). Based in part on this work, Simpson and Gangestad (1991) developed a brief self-report measure of sociosexual orientation, the Sociosexual Orientation Inventory (SOI). The SOI assesses individual differences in sexual behavior, fantasies about uncommitted sexual activity, and attitudes toward casual sex. People who report a greater number of past and expected future sexual partners, more frequent fantasies about uncommitted sexual activity, and more permissive attitudes toward casual sex are considered to have a more *unrestricted* (vs. *restricted*) sociosexual orientation. Subsequent research using the SOI demonstrates that individual differences in sociosexuality have important implications for relationship outcomes. For example, men and women with an unrestricted sociosexual orientation engage in sexual activity more quickly, are more likely to be unfaithful in romantic relationships, and are less invested in those relationships compared to those with a more restricted sociosexual orientation (see Simpson et al., 2004, for a review).

Given that mating effort has been linked with testosterone (e.g., Wingfield et al., 1990), it is reasonable to expect that individual differences in sociosexuality would vary as a function of testosterone levels. Indeed, McIntyre et al. (2006) found that men's unrestricted sociosexuality (measured with the SOI) was positively associated with testosterone levels among partnered men; there was no association between sociosexuality and testosterone among single men. In other words, partnered men who retained interest in uncommitted sexual activity did not show lower testosterone levels compared to single men. However, other studies have not found associations between SOI scores and testosterone in men (Charles and Alexander, 2011), including as a function of partnered status (e.g., van Anders et al., 2007). In addition, although very few studies on this topic have included female participants, those that have similarly suggest that women's SOI scores are not significantly correlated with their testosterone levels (Charles and Alexander, 2011; van Anders et al., 2007).

Although extant research paints an inconsistent picture of the relation between sociosexuality and testosterone, it is important to note that the SOI, the measure used in prior studies, may not have captured the multifaceted nature of sociosexuality. Penke and Asendorpf (2008) advocate for distinguishing among sociosexual desire, behavior, and attitudes, rather than aggregating these components into a global measure of sociosexuality, as is done with the SOI. Penke and Asendorpf define sociosexual *desire* as interest in uncommitted sexual activity; sociosexual *behavior* as the extent to which an individual has engaged in or expects to engage in uncommitted sexual activity; and sociosexual *attitudes* as an individual's feelings about uncommitted sexual activity. These different components of sociosexuality generally map onto tripartite models of evaluative judgment that have been influential in the field of social psychology (e.g., Rosenberg and Hovland, 1960; Zanna and Rempel, 1988). Such models contend that people's evaluations in a particular domain can be characterized by three related, yet distinct, components: cognition (i.e., attitudes), emotion (i.e., desire), and behavior. According to this theoretical framework, different evaluative components may predominate in different contexts, and the associations among the various components can differ across individuals and domains. For instance, consistency between attitudes and behavior may be stronger for some domains and among some individuals (Kraus, 1995). These distinctions may be particularly important in the domain of sociosexuality, where there are potentially large intra-individual differences between people's desires to engage in casual sex, their beliefs about doing so, and their tendency to engage in such behavior.

In two studies, Penke and Asendorpf (2008) demonstrated that, despite moderate intercorrelations among sociosexual desire, behavior, and attitudes, each showed a different pattern of associations with sexual and relationship outcomes. For instance, longitudinal analyses

indicated that sociosexual desire was the strongest predictor of relationship dissolution and that sociosexual behavior was the strongest predictor of number of future sexual partners. Although sociosexual attitudes showed consistent associations with other personality constructs (e.g., shyness), this component of sociosexuality did not show any unique associations with sexual or relationship outcomes. Based on these findings, Penke and Asendorpf speculate that sociosexual attitudes may be more strongly influenced by self-presentational goals and perceptions of cultural norms than the other two sociosexuality components.

Penke and Asendorpf's (2008) findings also revealed important gender differences in the various components of sociosexuality, many of which may have implications for individual differences in testosterone. Specifically, men reported considerably higher levels of unrestricted sociosexual desire compared to women; gender differences in sociosexual attitudes were in the same direction but were much smaller in magnitude, and there were no significant gender differences in sociosexual behavior. These findings suggest that (on average) men's desire for uncommitted sexual activity exceeds their tendency or ability to engage in it, most likely because women are less inclined toward casual sex. Thus, for men, measures of sociosexual desire may be more closely associated than measures of sociosexual behavior to their motivation to have uncommitted sex and, by extension, to their testosterone levels. Consistent with this idea, Penke and Asendorpf found that men's sociosexual desire scores uniquely predicted their flirting behavior with a female confederate in the laboratory.

Women's sexuality, on the other hand, is thought to be more fluid than men's (Diamond, 2003), and there is evidence that sexual behavior and sexual desire are less closely associated among women than men (Baumeister, 2000). That is, women may be less likely to act on their sexual desires and/or more likely to engage in sexual behavior that is inconsistent with their desires. Baumeister (2000) also argues that sexual desire should be less stable over time for women than for men, a hypothesis that was supported by Penke and Asendorpf's (2008) data on sociosexual desire. Taken together, these findings lead to the hypothesis that measures of sociosexual behavior may be more closely associated than measures of sociosexual desire to women's motivation to have uncommitted sex and, by extension, to their testosterone levels. Along these lines, Penke and Asendorpf (2008) found that, for women, sociosexual behavior (rather than sociosexual desire) scores uniquely predicted laboratory flirting behavior. Further, van Anders and Watson (2007) and van Anders and Siciliano (2010) propose that, because of differences in fluidity, women's testosterone levels may be more sensitive to state-like cues associated with sexual behavior.

The few studies that have assessed different aspects of sexuality in relation to testosterone generally support these claims. For instance, testosterone has been associated with interest in extra-pair sexual activity among partnered men (McIntyre et al., 2006, Study 2). van Anders and Siciliano (2010) similarly found that men's (but not women's) desires to date were positively associated with their testosterone levels (van Anders and Siciliano, 2010). In another study, women's (but not men's) number of past and expected future sexual partners was positively associated with testosterone (van Anders et al., 2007; see also Cashdan, 1995). Because different aspects of sociosexuality may be associated with testosterone for men and women, as these findings suggest, important gender differences may have been obscured in prior research using global measures of sociosexuality (e.g., Charles and Alexander, 2011) or in studies that assessed only certain aspects of this multifaceted construct (e.g., van Anders et al., 2007).

To our knowledge, there has been no comprehensive investigation of links between these different components of sociosexuality and testosterone. The current study was therefore designed to examine: a) the extent to which sociosexual desire, behavior, and attitudes are

associated with testosterone levels, b) whether these associations differ according to partnered status, and c) whether the nature of these associations varies by gender. Based on prior research (e.g., Burnham et al., 2003; van Anders and Watson, 2007), we expected that partnered men and women would have lower testosterone compared to those who were single. In addition, given theory and research on gender differences in sexuality (e.g., Baumeister, 2000; van Anders and Siciliano, 2010), we expected that men's scores on the sociosexual *desire* subscale would be positively related to testosterone and that women's scores on the sociosexual *behavior* subscale would be associated with higher testosterone levels. Based on the findings of McIntyre et al. (2006), we further expected that these components of sociosexuality would moderate the effects of relationship status, such that partnered men who reported unrestricted (i.e., high levels of) sociosexual desire would show testosterone levels comparable to single men, and partnered women who reported unrestricted sociosexual behavior would show testosterone levels comparable to single women. Finally, because Penke and Asendorpf (2008) found that sociosexual attitudes did not uniquely predict sexual and relationship outcomes, and past research does not reveal a coherent relation between sexual attitudes and testosterone (e.g., Bancroft et al., 1991), we did not anticipate unique relations between the attitudes subscale and testosterone levels in our study.

## Methods

### Participants and procedure

Participants were 260 undergraduate students (52% men), ranging in age from 18 to 37 ( $M = 19.71$ ,  $SD = 2.56$ ), who received course credit or monetary compensation for their participation. Participants were drawn from a larger study of neuroendocrine responses to video stimuli; only baseline data (i.e., pre-video exposure) are included in the current report. Thirty-seven percent of men and forty percent of women reported that they were currently involved in a romantic relationship. The ethnic composition of the sample was 64% Caucasian, 18% Asian-American, 7% African-American, and 11% of mixed or other ethnicities. Female participants were tested during all phases of their menstrual cycles.<sup>2</sup> Thirteen additional participants were tested but were missing data on either the sociosexuality measure (due to computer malfunctions) or testosterone (due to insufficient saliva) and are therefore not included in the present analyses. In addition, because testosterone levels typically decline with age (e.g., Taylor et al., 2007) and are lower among women using hormonal contraceptives (e.g., Liening et al., 2010), one 68-year-old female participant and 31 female participants taking hormonal contraceptives were excluded from the present analyses. (Results covarying contraceptive use, rather than excluding women on hormonal contraceptives, were virtually identical to those reported here.)

All procedures were approved by the University of Michigan Institutional Review Board. Participants were asked to refrain from eating, drinking, smoking, or brushing their teeth for one hour prior to the beginning of the experimental session. Participants were tested between the hours of 10:00 and 19:00 h, but most participants (91%) were tested between 12:00 and 18:00 h to control for circadian changes in testosterone. (We also included time of day as a covariate in our analyses.) During individual testing sessions, informed consent was obtained, after which participants provided a saliva sample that

was used to assess testosterone levels. Participants then completed demographic questionnaires and a measure of sociosexual orientation.

### Materials

*Sociosexual orientation* was assessed with the revised Sociosexual Orientation Inventory (SOI-R; Penke and Asendorpf, 2008), a 9-item self-report measure. The SOI-R includes three subscales corresponding to the desire, behavior, and attitude facets of sociosexual orientation. The sociosexual *desire* subscale (SOI-Desire,  $\alpha = .88$ ) reflects an individual's interest in uncommitted sex (e.g., "How often do you experience sexual arousal when you are in contact with someone with whom you do not have a committed romantic relationship?"); the sociosexual *behavior* subscale (SOI-Behavior,  $\alpha = .86$ ) reflects an individual's past uncommitted sexual activity (e.g., "With how many different partners have you had sexual intercourse on one and only one occasion?"); the sociosexual *attitudes* subscale (SOI-Attitudes,  $\alpha = .89$ ) reflects an individual's beliefs about uncommitted sexual activity (e.g., "I can imagine myself being comfortable and enjoying 'casual' sex with different partners"). A global sociosexual orientation score (SOI-Total,  $\alpha = .88$ ) can also be obtained by computing the mean of all nine items. Participants are asked to respond to each item using a 9-point Likert scale (ranging from 1 to 9), with higher numbers indicating a more unrestricted sociosexual orientation (e.g., more often experiencing sexual arousal outside of a committed relationship, greater number of casual sexual partners).

### Salivary testosterone: collection and assessment

Participants used a stick of sugar-free chewing gum to collect up to 7.5 mL saliva in a sterile polypropylene vial and then discarded the chewing gum. The vials were placed in frozen storage immediately after the experimental session was complete. Samples were freed from mucopolysaccharides and other residuals by three freeze–thaw cycles followed by centrifugation. Salivary testosterone was assessed with a solid phase 125I radioimmunoassay (TKTT1, Diagnostic Productis Corporation, Los Angeles) at the University of Michigan Core Assay Facility. All samples were assayed in duplicate. Analytical sensitivity of the assay ( $B_0 - 2 SD$ ) was .02 pg/mL. The mean inter- and intra-assay coefficients of variation were 9.6% and 5.5%, respectively.

### Statistical analyses

Two participants (one male, one female) with testosterone levels greater than four standard deviations above the mean for their gender were excluded from subsequent analyses. The remaining testosterone distributions were inspected for normality within gender; all skewness and kurtosis values were less than an absolute value of 1, indicating acceptable levels of normality (Bulmer, 1979). (Analyses using square-root transformed testosterone values yielded virtually identical results.) Three participants (two male, one female) declined to answer any of the items on the SOI-Behavior subscale and are therefore missing data for this particular subscale. Data were also excluded for one additional female participant whose SOI-Behavior score was larger than six standard deviations above the mean for women, but her scores on the other two subscales were retained, leaving 254 participants (132 male, 122 female) for multivariate analyses.<sup>3</sup>

<sup>2</sup> Dabbs and de La Rue (1991) demonstrated that menstrual cycle effects on testosterone are relatively small, particularly in comparison to individual differences in testosterone between women, and argue that menstrual cycle phase does not need to be covaried in studies linking individual differences in testosterone to psychological variables.

<sup>3</sup> Sixteen participants reported recent gum bleeding and/or oral lacerations/infections, which can alter hormone concentrations due to blood contamination (Schultheiss and Stanton, 2009). However, testosterone levels did not differ in men or women reporting these conditions,  $t's < -|1.60|$ ,  $p's > .55$ , and results excluding these participants were virtually identical to those presented here.



Salivary testosterone was the dependent variable for subsequent analyses. Gender, relationship status, and the three sociosexual dimensions—desire, behavior, and attitudes—served as the independent variables. Time of day was included as a covariate in multivariate analyses. The Statistical Package for the Social Sciences (SPSS, version 17) was used to conduct all analyses. Mean differences were assessed using independent samples *t*-tests (two-tailed) and associations were assessed using correlations and hierarchical multiple regressions. Because of large gender differences in testosterone, analyses involving testosterone were conducted separately by gender.

## Results

### Preliminary analyses

Descriptive statistics and correlations among the primary study variables are presented by gender in Table 1. As expected, testosterone levels were significantly higher among men compared to women,  $t(256) = 25.69, p < .001, d = 3.21$ . Also as expected, single male participants had higher testosterone levels,  $M = 96.67 \text{ pg/mL}, SD = 31.95$ , than partnered male participants,  $M = 85.67 \text{ pg/mL}, SD = 27.40, t(132) = 2.03, p < .05, d = .37$ . This difference was in the same direction for women but was not statistically significant,  $t(122) = .51, p = .61, d = .09$ . As shown in Table 1, men's testosterone levels were positively associated with their scores on the SOI-Desire and SOI-Attitudes subscales.

In addition, men reported higher levels of sociosexual desire, behavior, and attitudes compared to women,  $t$ 's (252–256) > 3.76,  $p$ 's < .01,  $d$ 's > .54. For both men and women, partnered status was associated with higher SOI-Behavior scores (reflecting greater past unrestricted sexual behavior); among women, partnered status was additionally associated with lower SOI-Desire scores (see Table 1). It is also worth noting that the three sociosexuality subscales were significantly intercorrelated for both men and women, but only moderately so, consistent with results reported by Penke and Asendorpf (2008).

Participant age was not significantly related to testosterone levels for men,  $r(134) = -.07, p = .44$ , or for women,  $r(124) = .07, p = .43$ , so age was not included in subsequent analyses. However, time of day was significantly negatively correlated with testosterone for both men,  $r(134) = -.24, p < .01$  and women,  $r(124) = -.35, p < .001$ , indicating an expected circadian decrease in testosterone levels (Schultheiss and Stanton, 2009). Time of day was therefore included as a covariate in subsequent analyses.

### Multivariate analyses

Next, we conducted hierarchical regression analyses to examine the unique and interactive influences of relationship status and the sociosexuality subscales on testosterone levels. Because of the intercorrelations among relationship status and the sociosexuality subscales, they were included together on the first step, along with time of

day. The two-way interactions between relationship status and the sociosexuality subscales were entered on the second step. Relationship status was contrast-coded ( $-1 = \text{single}, 1 = \text{in a relationship}$ ) and, to reduce multicollinearity resulting from the inclusion of interaction terms in the regression equations, all continuous variables were centered prior to analysis (see Aiken and West, 1991).

Results from these regression analyses are presented in Table 2. For men, only the main effect of time was significant on the first step. On the second step, as hypothesized, SOI-Desire scores were positively associated with testosterone levels, and this effect was qualified by a significant interaction between SOI-Desire and relationship status. As a group, the addition of the interactions between relationship status and the sociosexuality subscales approached significance,  $p = .08$ . Decomposing the relationship status  $\times$  SOI-Desire interaction revealed that SOI-Desire was positively associated with testosterone among partnered men,  $\beta = .54, p < .01$ , but this relation was not significant among single men,  $\beta = .01, p = .95$  (see Fig. 1). We also tested whether the effects of partnered status differed according to men's level of sociosexual desire (not pictured). Tests of the simple slopes (at one standard deviation above and below the means of sociosexual desire, see Aiken and West, 1991) revealed that partnered status was associated with lower testosterone among men reporting low levels of sociosexual desire,  $\beta = -.37, p < .05$ ; however, partnered status was not significantly associated with testosterone among men reporting high levels of sociosexual desire,  $\beta = .09, p = .51$ .<sup>4</sup>

For women, only the main effect of time was significant on the first step. On the second step, the interaction between relationship status and SOI-Behavior was significant, although as a group, the addition of the interactions between relationship status and the sociosexuality subscales was not statistically significant,  $p = .13$ . Decomposing the relationship status  $\times$  SOI-Behavior interaction revealed that higher SOI-Behavior scores were associated with higher testosterone levels among partnered women,  $\beta = .41, p < .01$ , but this relation was not significant among single women,  $\beta = -.11, p = .40$  (see Fig. 2). We also tested whether the effects of partnered status differed according to women's level of sociosexual behavior (not pictured). Tests of the simple slopes (at one standard deviation above and below the means of sociosexual behavior, see Aiken and West, 1991) revealed that partnered status was associated with lower testosterone among women reporting low levels of sociosexual behavior,  $\beta = -.40, p < .01$ ; however, partnered status was not significantly associated with testosterone among women reporting high levels of sociosexual behavior,  $\beta = .11, p = .41$ .<sup>5</sup>

Finally, because the few prior studies of sociosexuality and testosterone used a global measure of sociosexuality (e.g., McIntyre et al., 2006), we also investigated whether a similar pattern of findings would emerge in our data with the SOI-Total score. When we re-conducted our regression analyses, replacing the three sociosexuality subscales with the SOI-Total score, there was a significant positive

**Table 1**  
Descriptive statistics and correlations among primary study variables.

	1	2	3	4	5	M	SD
Testosterone (pg/mL)		-.05	.12	-.06	-.05	19.88	7.38
SOI-Desire	.17*		.12	.34**	-.20*	3.05	1.68
SOI-Behavior	.06	.35**		.38**	.22**	1.50	.85
SOI-Attitudes	.20*	.45**	.42**		-.05	3.06	2.12
Relationship status	-.17*	-.01	.29**	.07			
M	92.57	5.17	2.10	5.37			
SD	30.69	2.03	1.53	2.37			

Note. Descriptive statistics and correlations are presented below the diagonal for men ( $n = 134$ ) and above the diagonal for women ( $n = 124$ ); relationship status:  $-1 = \text{single}, 1 = \text{in a relationship}$ .

\*  $p \leq .05$ .

\*\*  $p < .01$ .

<sup>4</sup> van Anders and Siciliano (2010) found that, in men, dating desires mediated the association between relationship status and testosterone. Therefore, we examined whether the sociosexuality subscales mediated (as well as moderated) the effect of relationship status on men's testosterone levels. The magnitude of the association between relationship status and testosterone was unchanged when the sociosexuality subscales were included in the regression equation, indicating that the sociosexuality variables did not mediate the association between relationship status and testosterone in men. (We did not test for mediation in women because there was not a significant main effect of relationship status among women.)

<sup>5</sup> We also conducted three separate regression analyses (per gender) predicting testosterone from each SOI subscale and its interaction with relationship status. Results from those analyses were very similar to those reported earlier: For men, the main effect of SOI-Desire was significant,  $\beta = .20, p < .05$ , and the main effect of relationship status was significant across analyses,  $p$ 's < .05. The relationship status  $\times$  SOI-Desire interaction was in the same direction but did not reach statistical significance,  $\beta = .12, p = .16$ . The main effect of SOI-Attitudes was also significant,  $\beta = .19, p < .05$ , consistent with zero-order correlations. For women, the relationship status  $\times$  SOI-Behavior interaction was statistically significant,  $\beta = .19, p < .05$ .

**Table 2**  
Summary of hierarchical regression analyses predicting testosterone levels.

	Men (n = 132)						Women (n = 122)					
	Step 1			Step 2			Step 1			Step 2		
	B	SE (B)	$\beta$	B	SE (B)	$\beta$	B	SE (B)	$\beta$	B	SE (B)	$\beta$
Relationship status	–4.73	2.74	–.15	–4.12	2.71	–.13	–.94	.68	–.13	–.96	.68	–.13
Time of day	–3.36	1.11	–.26**	–3.81	1.11	–.29**	–1.03	.30	–.31**	–1.08	.31	–.32**
SOI-Desire	2.42	1.47	.16	3.33	1.49	.22*	–.13	.41	–.03	–.32	.45	–.07
SOI-Behavior	–1.02	1.96	–.05	–1.37	1.99	–.07	1.15	.85	.13	.78	.88	.09
SOI-Attitudes	1.87	1.28	.14	1.45	1.46	.11	–.42	.35	–.12	–.36	.36	–.10
SOI-D $\times$ rel. status				3.21	1.49	.21*				–.06	.45	–.01
SOI-B $\times$ rel. status				–3.66	1.97	–.18				2.04	.85	.23*
SOI-A $\times$ rel. status				–.88	1.46	–.07				–.36	.36	–.10
R <sup>2</sup>			.14			.19			.14			.18
F			4.23**			3.59**			3.66**			3.06**
$\Delta$ R <sup>2</sup>						.05						.04
$\Delta$ F						2.30						1.92

Note. Relationship status: –1 = single, 1 = in a relationship.

\*\*  $p < .01$ .

\*  $p < .05$ .

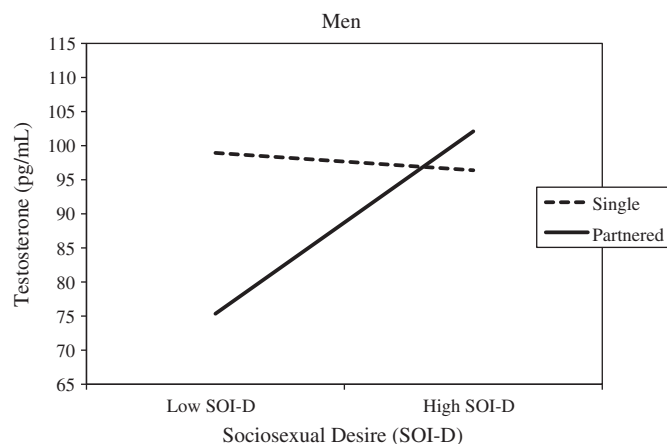
association between the SOI-Total score and men's testosterone levels,  $\beta = .21$ ,  $p < .05$ , but the interaction between SOI-Total scores and relationship status was not significant,  $\beta = -.04$ ,  $p = .67$ . (There was also a main effect of relationship status,  $\beta = -.19$ ,  $p < .05$ .) No significant effects or interactions involving the SOI-T variable or relationship status emerged for women, all  $p$ 's  $> .21$ . In other words, although SOI-Total scores were associated with men's testosterone levels, there was no evidence that this pattern differed for partnered versus single men, and there were no significant testosterone–sociosexuality associations in women. These findings suggest that the individual SOI-R subscales have unique and important implications for neuroendocrine processes, which might not be apparent if only global measures of sociosexuality are used.

## Discussion

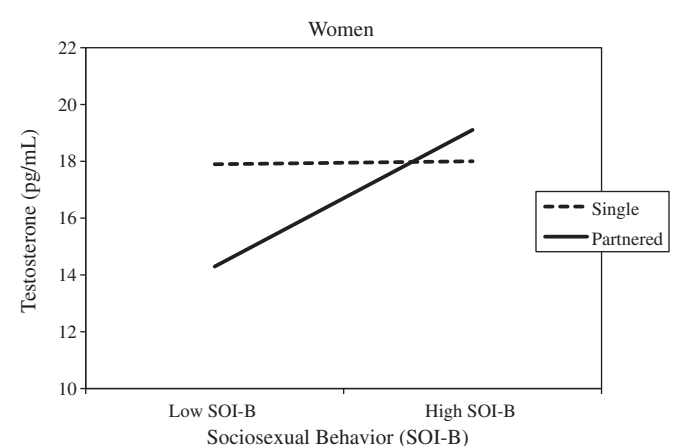
Findings from the current study advance our understanding of links between testosterone and relationship processes in several important ways. First, despite consistent evidence that testosterone levels differ by partnered status (van Anders and Watson, 2006a), much less attention has been paid to the boundary conditions of this effect. Our findings reveal that partnering is related to testosterone only among participants reporting more restricted sociosexual desire

(for men) or sociosexual behavior (for women). In other words, insofar as partnered individuals retain interest or engage in sexual activity outside of a committed relationship, their testosterone levels are indistinguishable from those of single individuals. Second, our findings demonstrate that testosterone is associated with at least one aspect of people's orientation toward romantic or sexual relationships. Testosterone has been linked with other personality constructs, such as social dominance and sensation-seeking, but there is much less evidence for associations with constructs that have direct relevance for romantic relationships (Booth et al., 2006). Thus, the current findings highlight the contributions of both dispositional and contextual factors to neuroendocrine processes.

The current study is also among the relatively few to examine associations between testosterone and relationship processes in women (Booth et al., 2006; van Anders and Watson, 2006a). Our findings support the idea that although (or perhaps because) women's testosterone levels are considerably lower than men's, small differences in testosterone can have important implications for women (Sherwin, 1988). At the same time, the current findings reveal provocative gender differences among partnered individuals, in that testosterone was associated with men's sociosexual desire and with women's sociosexual behavior. It is noteworthy that Penke and Asendorpf (2008) found that a similar pattern of associations



**Fig. 1.** Men's testosterone levels as a function of sociosexual desire (SOI-D) and relationship status. Following procedures recommended by Aiken and West (1991) for depicting interactions involving continuous variables, simple slopes are plotted separately for single versus partnered men at one standard deviation above and below the means of SOI-D.



**Fig. 2.** Women's testosterone levels as a function of sociosexual behavior (SOI-B) and relationship status. Following procedures recommended by Aiken and West (1991) for depicting interactions involving continuous variables, simple slopes are plotted separately for single versus partnered women at one standard deviation above and below the means of SOI-B.

predicted behavior with an opposite-sex confederate in the laboratory: Flirting behavior was most strongly associated with sociosexual desire for men and with sociosexual behavior for women. The association between men's sociosexual desire and flirting behavior was partly mediated by direct gaze toward the confederate, a sign of dominance that is correlated with testosterone (Booth et al., 2006). The association between women's sociosexual behavior and flirting was mediated by the amount of smiling and laughing women engaged in during the interactions. Such behavior could be interpreted as reflecting submission rather than dominance (Eibl-Eibesfeldt, 1989), but it may nevertheless be effective in signaling sexual interest to men (Moore, 1985). Taken together, these findings suggest that individual differences in testosterone might contribute to gender differences in the associations between flirting behavior and various components of sociosexuality.

Although the precise reasons for these gender differences await further investigation, one possibility stems from the differences observed for sociosexuality. Consistent with prior research (Penke and Asendorpf, 2008), men in our study reported considerably higher sociosexual desire compared to women; gender differences in sociosexual behavior were in the same direction, but were much smaller. These findings suggest that men's tendency or ability to engage in uncommitted sexual activity may be limited by women's inclination (or lack thereof) to do so (Buss and Schmitt, 1993). Given these restrictions, men's motivation to engage in casual sex (and therefore their testosterone levels) may be more closely tied to their levels of sociosexual desire than to their actual sociosexual behavior. Women's sociosexual behavior, in contrast, should be less constrained than men's by the availability of willing sexual partners, so their motivation to engage in casual sex (and thus their testosterone levels) may be more closely tied to their actual sociosexual behavior than to their levels of sociosexual desire. A complementary possibility stems from gender differences in sexual fluidity: van Anders and Watson (2007) and van Anders and Siciliano (2010) propose that, because women's sexuality tends to be more fluid than men's (e.g., Diamond, 2003), women's testosterone levels should be more sensitive to state-like fluctuations in relationship cues, for instance those related to sexual behavior. According to this perspective, men's testosterone levels should more closely correspond to trait-like orientations toward relationships, such as desire for uncommitted sexual activity.

Findings from the current study also make several important contributions to research on sociosexuality. First, our findings highlight the utility of conceptualizing sociosexuality as a multidimensional rather than a unitary construct. Penke and Asendorpf (2008) propose that, despite intercorrelations among the various components of sociosexuality, each should show some distinct associations with other variables in the nomological network of sexuality and interpersonal relationships. Their research supported this idea by demonstrating that each component of sociosexuality had a unique pattern of associations with relationship processes and outcomes. Our findings dovetail with theirs by revealing that different components of sociosexuality show distinct associations with testosterone, a biological marker with important implications for sexuality and close relationships. Moreover, as just described, these associations differed by gender in ways that are theoretically meaningful in the context of sexuality and sexual fluidity more generally.

Second, it is worth noting that, among men, testosterone was also positively correlated with sociosexual attitudes, indicating that men who view unrestricted sexual activity favorably had higher testosterone levels. However, sociosexual desire and attitudes were positively correlated with one another in both men and women and, in multivariate analyses, the effect of sociosexual attitudes on men's testosterone levels became nonsignificant. Thus, the association between sociosexual attitudes and testosterone in men may be largely a function of the fact that people who desire to have uncommitted sex also tend to view such behavior favorably. Penke and Asendorpf (2008) similarly found that sociosexual attitudes

were positively correlated with sociosexual desire and behavior in both men and women, but that sociosexual attitudes were typically the weakest predictor of future sexual behavior and relationship outcomes when the three subscales were considered together. Moreover, sociosexual attitudes were associated with other personality constructs and with religiosity, leading Penke and Asendorpf to speculate that this aspect of sociosexuality may be more susceptible to social and cultural influences. Findings from the current study lend further support to the idea that sociosexual attitudes (while certainly important from an intrapersonal perspective) may have little predictive validity with respect to sexual and relationship outcomes in general and sexual behavior more specifically.

Third, our ancillary analyses using total sociosexuality scores, rather than the individual components, support the idea that critical information can be lost when only global measures of sociosexuality are used. When we included participants' total sociosexual orientation scores in multivariate analyses, there was no evidence for an interaction between total scores and relationship status for men, and there were no significant associations or interactions between total scores and testosterone for women. Thus, the multidimensional measure of sociosexuality revealed unique associations that were not apparent when the total score was used, reinforcing the importance of the individual subcomponents. These results also allude to the possibility that a reliance on global measures of sociosexuality may have contributed to null associations with testosterone in prior work (e.g., Charles and Alexander, 2011).

More generally, the current findings contribute to knowledge about the biological bases of sociosexuality. In a recent review of research on sociosexuality and romantic relationships, Simpson et al. (2004) advocate for a deeper understanding of the role that testosterone may play in promoting unrestricted sexual behavior. Although there is considerable evidence that testosterone is associated with sexual behavior and mating effort in animals, including birds (Wingfield et al., 1990), rodents (Taylor et al., 2007), and nonhuman primates (Muller and Wrangham, 2004), relatively few studies have focused on the biological correlates of sociosexuality in humans. Moreover, Taylor et al. (2007) argue that there is little evidence (in any species) that individual differences in endogenous testosterone levels are associated with differences in sexual behavior. Our findings extend prior work on this topic by demonstrating that individual differences in testosterone indeed have important implications for sociosexuality in both men and women, but that the nature of this association varies according to the particular aspect of sociosexuality under investigation and according to participants' relationship status.

Of course, as with any correlational study, we cannot answer questions about causality based on our findings alone. Variations in sociosexuality could result from endogenous changes in testosterone levels (Taylor et al., 2007), but social context can also modulate hormones (van Anders and Watson, 2006a), perhaps increasing testosterone over time for those who engage in (or desire to engage in) uncommitted sexual activity. Longitudinal research provides evidence for both of these pathways with respect to sexuality and partnering more generally. For instance, increases in testosterone predict the onset of sexual behavior among adolescent girls (Halpern et al., 1997) and baseline testosterone predicts changes in relationship status in men (van Anders and Watson, 2006b). Changes in men's relationship status also prospectively predict changes in testosterone levels (Mazur and Michalek, 1998). The current findings additionally link testosterone with sociosexuality, which has been shown to predict changes in relationship status (Penke and Asendorpf, 2008); perhaps individual differences in sociosexuality contribute to some of the longitudinal findings just described. Future research could begin to address these issues by assessing longitudinal changes in sociosexuality and the extent to which such changes are associated with changes in testosterone (and vice versa).

Individual differences in one's ability to attract uncommitted sexual partners (in addition to their inclination toward casual sex) may also contribute to the testosterone–sociosexuality associations

that we observed. For instance, men with higher levels of testosterone may be perceived by women as more attractive, particularly for short-term relationships (e.g., Roney et al., 2006), which could increase high-testosterone men's desire for uncommitted sexual activity. This explanation may be less likely for women, in that female physical features associated with high testosterone (e.g., prominent brow ridges) may be perceived as less attractive by men (Campbell et al., 2009). However, women reporting unrestricted sociosexual orientations may be perceived as more attractive by men (Boothroyd et al., 2011), which could increase their likelihood of uncommitted sexual behavior. Thus, relations between sociosexuality and testosterone may at least partially reflect the associations of these variables with perceived attractiveness to potential mates. Unfortunately, we did not assess such perceptions in the current study, so it remains for future research to determine their role in the associations that we uncovered.

It is also important to acknowledge several aspects of our research design that may limit the generalizability of our findings. First, our measure of relationship status simply asked participants whether they were currently in a romantic relationship, rather than the extent to which they were committed to that relationship. van Anders and Siciliano (2010) found that women in casual relationships had lower testosterone than single women, but did not differ in their testosterone levels from women in long-term relationships, suggesting that degree of commitment may not be the key determinant of differences in testosterone for women. Men in casual relationships, however, did not differ in testosterone from single men, and both groups had higher levels of testosterone compared to men in long-term relationships, suggesting that degree of commitment may in fact be important for men. In the current study, we cannot know how participants in casual relationships conceptualized their relationship status, and it is possible that men and women in casual relationships selected different options when asked to choose between "single" and "in a relationship". Future studies should explore whether the differences that we found extend to casual relationships, and whether such findings vary by gender.

Second, we did not measure relationship duration. At least among men, testosterone levels may remain relatively high in the beginning stages of a romantic relationship (e.g., before six months, Gray et al., 2004). Gray and colleagues argue that the early stages of a romantic relationship are characterized by a courtship period, and that relatively high levels of testosterone during this period may reflect effort invested in securing a sexual partner. Once the relationship becomes more established and committed, testosterone levels would be expected to decrease. It would be particularly interesting to assess whether changes in testosterone that occur as relationships develop over time are also associated with changes in sociosexual orientation.

Third, we did not assess participants' sexual orientation. Many studies of relationship status–testosterone links exclude non-heterosexual men (e.g., McIntyre et al., 2006; van Anders and Siciliano, 2010), based in part on findings that relationship status effects are not observed among gay or bisexual men (van Anders and Watson, 2006b). Although few studies have included non-heterosexual women, there is evidence for relationship status effects in this population as well (van Anders and Siciliano, 2010). Of course, the fact that we could not exclude non-heterosexual participants, distinguish those in casual relationships, or control for the effects of relationship duration should have made it more difficult for us to detect statistically significant associations between relationship status and testosterone. Thus, our analyses may underestimate the strength of the associations among these variables, and future studies may benefit from using more precise measures.

Finally, because the majority of our participants were college students, future research should explore whether our findings generalize to older, non-college student samples. On the one hand, college students may be an ideal sample in which to study relationship dynamics and sociosexuality, because this is a period when young adults

are beginning to form stable romantic relationships (Arnett, 2000). Moreover, the college culture has been characterized as promoting uncommitted sexual activity, which may render this setting particularly relevant for studying individual differences in sociosexuality (Bogle, 2008). On the other hand, young adult samples that are not drawn from a college population could yield different findings, insofar as unrestricted sexuality is less common or is viewed less favorably in other populations. In addition, beyond young adulthood, romantic relationships tend to become increasingly stable (Arnett, 2000), so it is possible that the strength of associations between relationship status and neuroendocrine processes would increase with age.

Despite these limitations, findings from the current study demonstrate meaningful associations among endogenous testosterone levels, relationship status, and individual differences in sociosexual orientation. We found that partnered status was associated with lower testosterone levels, in both men and women, but only among individuals who reported more restricted sociosexuality. Moreover, different facets of sociosexuality were associated with testosterone for men and women, with sociosexual desire predicting testosterone for partnered men and sociosexual behavior predicting testosterone for partnered women. These novel findings advance our understanding of the biological correlates of personality and social behavior in humans, highlight the importance of distinguishing among different aspects of sociosexuality, and suggest many potentially fruitful avenues for future research.

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