Biological Psychology 174 (2022) 108421

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

An empirical investigation of the roles of biological, relational, cognitive, and emotional factors in explaining sex differences in dyadic sexual desire

Juliana E. French [a,*], James K. McNulty [b], Anastasia Makhanova [c], Jon K. Maner [b], Lisa A. Eckel [b], Larissa Nikonova [b], Andrea L. Meltzer [b]

[a] Oklahoma Center for Evolutionary Analysis, Oklahoma State University, 116 Psychology Building, Stillwater, OK 74078, USA
[b] Florida State University, 1107 W. Call Street, Tallahassee, FL 32306, USA
[c] University of Arkansas, 216 Memorial Hall, Fayetteville, AR 72701, USA

ARTICLE INFO

Keywords:
Dyadic sexual desire
Testosterone
Sex differences
Marriage

ABSTRACT

One challenge many marital couples face is that they experience discrepant levels of sexual desire for one another. Such discrepancies are particularly likely to arise in mixed-sex relationships because, at least in long-term relationships, men tend to have higher levels of sexual desire for their partner than do women. But what underlies this sex difference? We used a dyadic study of 100 mixed-sex community-based newlywed spouses to investigate the role of biological, relational, cognitive, and emotional factors in explaining sex differences in dyadic sexual desire for a long-term partner. Consistent with predictions, wives on average reported lower daily sexual desire for their spouse than did husbands. Moreover, individual differences in men's and women's levels of circulating testosterone explained this sex difference whereas relational (marital satisfaction, commitment), cognitive (sex-role identification, stress, self-esteem), and emotional (mood, depressive symptoms) factors did not. These findings advance our knowledge of factors that influence dyadic sexual desire and may have practical implications for treating relationship distress in mixed-sex marriages.

1. Introduction

Sex is an important component of long-term romantic relationships like marriage. Couples who maintain high levels of sexual satisfaction remain more satisfied over the course of marriage (e.g., French et al., 2019; McNulty et al., 2016; Yeh et al., 2006), and such better marital well-being offers numerous physical and mental health benefits (e.g., Proulx et al., 2007; Robles et al., 2014). One important predictor of sexual satisfaction is the desire to engage in sexual activities with one's current relationship partner (e.g., Muise et al., 2013; Rosen et al., 2018). This form of *dyadic sexual desire* can be contrasted with other forms of dyadic sexual desire, such as the desire to engage in sexual activities with specific individuals who are not one's partner, as well as other forms of sexual desire, such as solitary sexual desire and non-specific forms of sexual desire (see van Anders, 2012).

In contrast to mixed-sex couples in dating relationships (see Mark, 2012), a common challenge faced by mixed-sex couples in more *long-term* relationships is that men sometimes report higher levels of non-specific sexual desire (e.g., Baumeister et al., 2001; Beck et al., 1991; McNulty et al., 2019; Regan & Atkins, 2006) and sexual desire for one's partner specifically (Holmberg & Blair, 2009; McNulty et al., 2019; Muise, Stanton et al., 2016). In two samples of newlywed couples, for example, husbands reported greater general and partner-specific sexual desire than did wives, and wives' relatively lower sexual desire predicted lower marital satisfaction for *both* spouses (McNulty et al., 2019). In the current research, we examined potential explanations for *why* men and women in long-term relationships often experience different levels of dyadic sexual desire for each other. Specifically, we examined the relative roles of biological, relational, cognitive, and emotional variables for explaining sex differences in dyadic sexual desire for one's long-term partner.

1.1. Perspectives on sex differences in sexual desire for one's partner

Women and men can enjoy sex for different reasons and in different ways (e.g., McClelland, 2014), and understanding differences in their sexual desire for a long-term partner is important. Nevertheless, we lack a clear understanding of the extent to which such sex differences in sexual desire for one's partner stem from biological differences between females and males (e.g., differences in sex hormone levels), the

* Corresponding author.
E-mail address: juliana.french@okstate.edu (J.E. French).

https://doi.org/10.1016/j.biopsycho.2022.108421
Received 5 July 2022; Received in revised form 19 August 2022; Accepted 19 August 2022
Available online 27 August 2022

differential influence of relational factors (e.g., relationship satisfaction, commitment), and/or differences in other cognitive and emotional experiences (e.g., sex-role identification, stress, self-esteem, mood, depressive symptoms).

1.2. Biological factors and dyadic sexual desire

With respect to biological factors, evolutionary perspectives suggest sex differences in sexual desire are biologically rooted in the relatively different reproductive challenges men versus women have faced throughout human evolutionary history. In general, men have faced relatively lower *minimum* levels of initial obligatory parental investment than have women (Trivers, 1972) that could have allowed men to gain greater reproductive advantage from having high levels of sexual desire that led to frequent sexual encounters. Successful reproduction for women, in contrast, requires far greater obligatory levels of initial parental investment (nine months gestation, at a minimum), and this may have calibrated women's overall levels of sexual desire to be somewhat lower than men's to deprioritize frequent sex in favor of ensuring adequate investment in offspring (e.g., Buss & Schmitt, 1993). To the extent that these evolutionary forces shape sexual desire for a partner in the context of a long-term relationship, biological differences between men and women could contribute to sex differences in sexual desire for one's long-term partner.

If men and women did evolve to have different levels of dyadic sexual desire, one biological mechanism through which such a sex difference may emerge is differences in levels of circulating testosterone. Testosterone is a sex-steroid androgen hormone that has organizational and activational effects on sexual development and sexual behavior (e.g., Jennings & de Lecea, 2020). Men typically have higher levels of testosterone than do women (Leiblum, 2002; van Anders et al., 2014), and this sex difference in testosterone levels may contribute to men's comparatively higher dyadic sexual desire. Consistent with this possibility, some existing research provides evidence for direct links between testosterone and general sexual desire in both sexes. For example, experimental work has shown that pharmacologically induced hypogonadism, which temporarily suppresses testosterone production, reduces men's sexual interest, and subsequent testosterone administration restores their sexual interest (Schmidt et al., 2004, 2009). Further, whereas subsequent estradiol and progesterone administration does not improve sexual interest in a comparable sample of women (Schmidt et al., 2009), adding testosterone (i.e., combined estrogen-androgen therapy) does increase women's sexual desire (Sarrel et al., 1998). Moreover, higher (versus lower) levels of endogenous testosterone were associated with greater sexual desire among women in other work (e.g., Corona et al., 2016; Gades et al., 2008; Wåhlin-Jacobsen et al., 2015), with androgen deficiencies in women being linked to low sexual desire (Bolour & Braunstein, 2005; Davis & Tran, 2001). Consistent with these findings, exogenous administration of testosterone has been widely used for decades and is a treatment for low sexual desire in both men and women (e.g., Traish et al., 2009; Vignozzi & Reisman, 2020).

Nevertheless, many of these studies linking testosterone to sexual desire have tended to collapse across (a) participants with varying relationship status and (b) various forms of sexual desire. This is noteworthy because some existing theory suggests that testosterone may play a relatively minor role (if any) in accounting for sex differences in sexual desire for a long-term relationship partner, such as a cohabiting partner or spouse, compared to the role it plays in desire for solitary sex, uncommitted sex, and perhaps even sex in casual dating relationships. According to the steroid/peptide theory of social bonds (van Anders et al., 2011), the role of testosterone in sexual desire depends on various contextual factors, including whether sexual desire reflects a desire for pleasure or a desire for intimacy; whereas increased testosterone may predict an increased desire for sexual pleasure, *decreased* testosterone may predict desire for sexual intimacy. Combined with the fact that men and women differ in their goals for sex (e.g., McClelland, 2014), including that women focus more on intimacy versus pleasure (Basson, 2000), this theory suggests that testosterone may be differentially associated with dyadic sexual desire for men and women.

Consistent with this line of theorizing, studies specifically addressing these issues suggest the role of testosterone in dyadic forms of sexual desire is rather complex. For example, several studies have revealed null associations between testosterone and dyadic sexual desire among healthy, non-clinical samples of men (van Anders, 2012; van Anders, Hamilton, & Watson, 2007), though such null associations may reflect ceiling effects (van Anders, 2013). Further, whereas women's solitary sexual desire has been associated with increased testosterone (van Anders, Hamilton & Schmidt, & Watson, 2007), two studies comprised of mostly college participants suggest women's dyadic sexual desire is associated with decreased levels of testosterone (Raisanen et al., 2018; van Anders, 2012). Nevertheless, it is important to note that the participants in these latter two studies varied substantially in their relationship status, with numerous participants being single and/or casually dating; thus, dyadic desire was not necessarily for a long-term partner. Given evidence that associations between testosterone and sexual desire seem to depend, in part, on relationship status and the specific target of desire (e.g., Edelstein et al., 2011; van Anders & Goldey, 2010), it remains unclear whether individual differences in men's versus women's testosterone levels can account for sex differences in sexual desire for a long-term partner.

1.3. Contextual factors and dyadic sexual desire

Much of the theorizing that challenges the role of testosterone in explaining sex differences in dyadic sexual desire focuses on the role of broader contextual factors. Although social context does influence men's sexual functioning (Murray et al., 2017), women's sexual functioning is thought to be more sensitive to social context than is men's (Baumeister, 2000; Baumeister & Bratslavsky, 1999; McNulty & Fisher, 2008; Peplau, 2003), suggesting myriad contextual factors could explain sex differences in sexual desire. For example, dyadic sexual functioning and sexual desire are sensitive to dynamics within people's intimate relationships, such as relationship satisfaction (e.g., McNulty et al., 2016), perceived partner responsiveness (Birnbaum et al., 2016; Birnbaum & Reis, 2012), and novel joint experiences (Muise et al., 2019). Accordingly, sex differences in sexual desire for one's partner could stem from sex differences in perceptions of or reactions to these and other qualities of the relationship (e.g., satisfaction, commitment).

Alternatively, or additionally, there may be contextual factors beyond the relationship itself that account for sex differences in sexual desire for one's partner. For example, gendered social roles often discourage the explicit expression of sexual desire by women (Leiblum, 2002; van Anders, 2013) and encourage inflated reports of sexual desire by men (Murray, 2018); thus, feminine and masculine sex-role identification may lead to differences in how women and men report sexual desire for a long-term partner on self-report measures. Likewise, other cognitive and emotional experiences, such as high stress, low self-esteem, negative mood, and/or depressive symptoms may downregulate sexual desire (Bodenmann et al., 2010). Given these factors are more commonly experienced by women (e.g., Kessler et al., 2005; Meltzer & McNulty, 2010), it is possible that they underlie sex differences in sexual desire for one's partner. Furthermore, given that testosterone may covary with many of these factors (e.g., Booth et al., 1999; van Anders et al., 2015), differences between men's and women's social, cognitive, and emotional experiences may partially or fully explain any apparent links between testosterone and sexual desire for one's partner.

1.4. The current study

We are aware of no work that has examined the relative contributions of testosterone and contextual factors (i.e., relationship dynamics, sex-role identification, and other cognitive and emotional variables) in explaining

sex differences in sexual desire for one's long-term partner. In the current study, we first attempted to replicate prior work showing that, in the context of long-term relationships, men on average report higher levels of sexual desire than their female partners. Second, we examined the extent to which the following variables could account for any such sex differences in husbands' and wives' sexual desire for their spouse: (a) masculine and feminine sex-role identification, (b) relationship quality (e.g., marital satisfaction, commitment), (c) other cognitive and emotional experiences (e.g., stress, self-esteem, mood), and/or (e) individual differences in circulating testosterone.

We relied on existing data from a 14-day diary study of newlywed couples to address these issues. There are several benefits to using diary data from a newlywed sample to examine predictors of spousal dyadic sexual desire. First, married individuals experience enhanced structural commitments relative to dating couples (see Stanley et al., 2010); thus, although long-term committed partnerships can and do exist outside of a marital context, using marriage as a proxy for long-term relationships ensures that such structural long-term commitments are in place. Further, not only does testosterone appear to vary as a function of marriage and commitment (Gettler et al., 2013; Gray et al., 2004), the enhanced interdependence of marriage can also alter how various predictors are associated with sexual outcomes (see Russell et al., 2013). Second, newlywed marriage is a time during which people typically experience high levels of passion and sexual desire for their partners (e.g., Hatfield et al., 2008; McNulty et al., 2019; Mizrahi et al., 2019) as well as considerable with- and between-couple variability (Lavner & Bradbury, 2010), and utilizing daily assessments enabled us to assess spousal dyadic sexual desire as it occurred in people's daily lives, without having to rely on retrospective reports that may be prone to memory-recall biases. Third, using data from both members of the couple in this manner offers a way to hold constant numerous couple-level contextual variables (relationship length, the presence of children) that may differentially affect sexual desire for a long-term partner while directly examining the role of myriad individual-level contextual factors in explaining sex differences in daily reports of sexual desire for such a partner.

2. Materials and methods

2.1. Participants

Participants were 100 members of 50 newlywed mixed-sex couples participating in a broader longitudinal study of marriage. The full sample for the broader study included 120 couples (one couple self-identified as a same-sex female couple), but funding constraints led us to obtain hormonal data from a subset of the sample—the first 51 couples to complete the broader study. One of these couples did not participate in the daily portion of the study, leaving us with our final sample of 100 members of 50 mixed-sex couples. Of these 100 spouses, two husbands did not complete any of the daily surveys that contained our key outcome variable (sexual desire for one's spouse). Thus, our final sample included 98 spouses (48 husbands and 50 wives). Four wives did not provide enough saliva or have detectable levels of testosterone in their saliva samples; consequently, for analyses that included testosterone, this sample was restricted to 94 spouses (48 husbands and 46 wives).[1] The participants in our final sample completed an average of 12 (out of 14) diary entries, yielding 1139 total reports of sexual desire for one's spouse. To provide the most stringent test of power, we computed a power-sensitivity analysis using our smallest sample size (94 spouses). Given their repeated reports, these participants yielded an effective sample size of $N = 197$ (see Snijders & Bosker, 2011), thus offering .80 power to detect an effect-size r as small as .20 in our full model that includes all predictors and covariates.

Participants were recruited from a community in Northern Florida via newspapers, fliers posted in local bridal shops, letters sent to couples in the area that had recently applied for marriage licenses, and Facebook advertising. As part of the broader goals of the study, eligibility required that all participants (a) had been married for less than three months, (b) were at least 18 years of age, and (c) spoke English (to ensure comprehension of the questionnaires). Husbands and wives in our final sample were on average 32.23 ($SD = 8.30$) and 30.46 ($SD = 7.66$) years of age, respectively. Husbands reported on average a personal income of US $36,225 per year whereas wives reported US$43,016 per year. The majority of participants identified as White (81%); 12% identified as Black or African American, 2% identified as Hispanic or Latinx, 4% identified as multiracial, and 1% identified as another, unspecified ethnicity.

2.2. Procedure

The procedure for this study was approved by Florida State University's institutional review board. Participants first completed a battery of questionnaires via Qualtrics.com or through the mail; these questionnaires included (a) a consent form, (b) instructions to complete the questionnaires independently from their spouse, and (c) measures assessing sex-role identification, as well as additional measures beyond the scope of the current analyses. After completing the questionnaires, both members of each couple attended an in-person laboratory session within the first three months following their wedding. During this session, couples provided saliva samples via passive drool and completed several tasks beyond the scope of the current analyses. To address an independent research question (the extent to which the discussions were associated with changes in testosterone; Makhanova et al., 2018), couples provided saliva samples twice during their session—once before and once after a series of marital discussions. We used only those saliva samples collected before their discussions for the current analyses to avoid confounding testosterone with the marital discussions. Because the laboratory sessions occurred several days after most participants completed their baseline questionnaires, it is unlikely that responding to their questionnaires influenced hormone levels in these saliva samples.

Beginning on the day following their lab session and continuing for the subsequent 14 evenings, both couple members completed a daily survey each evening before going to bed; we instructed them to complete these surveys independently from their spouse. In addition to measures beyond the scope of the current analyses, the daily surveys assessed participants' dyadic sexual desire for their spouse, marital satisfaction, commitment, stress, self-esteem, and mood. We paid each couple US$100 for completing the initial questionnaire and attending the lab session, and, after the 14 daily assessments, we mailed each couple who completed all 28 assessments (14 per spouse) a check for an additional US$35 or US$1 per daily assessment if they completed fewer than 28.

3. Measures

3.1. Individual difference variables measured at baseline

3.1.1. Testosterone

As noted by van Anders (2012), prior work has validated the use of a unitary sample to assess individual differences in testosterone. Indeed, although testosterone varies across time and context, the test-re-test reliability of testosterone across multiple days is high (Dabbs, 1990), and others have argued that one sample is sufficient for establishing "trait" levels of testosterone (also see van Anders et al., 2014 for a

[1] Data from the broader study have previously been described in other published reports; although one such report (Makhanova et al., 2018) examined testosterone reactivity from this sub-sample, this published report did not examine associations between testosterone levels and sexual desire or any other of the key variables of interest reported here. Additionally, this sample is completely independent of the samples reported in McNulty et al., 2019.

discussion of this issue). Thus, as has been done in prior work (e.g., Gray et al., 2004; van Anders & Goldey, 2010), we used a unitary measure of testosterone to infer individual differences in levels of circulating testosterone. Although couples provided saliva samples before and after their in-lab discussions, we used only those saliva samples collected before their discussions to avoid confounding testosterone with the marital discussions. Saliva samples collected at baseline were frozen at -–20°C– 20 °C immediately after each session. Before samples were assayed, they were thawed, centrifuged for 15 min at 3000 RPM, and the supernatant was frozen in aliquots. Testosterone was assessed using enzyme-linked immunosorbent assay (ELISA) kits from Salimetrics. Samples were assayed in duplicate. The inter-assay coefficient of variability was 10.65, and the intra-assay coefficient of variability was 3.19.[2] Because testosterone exhibits diurnal variations, typically declining over the course of the day (van Anders et al., 2014), and couples attended their laboratory sessions at different times of the day, we controlled for time of day (operationalized as a linear increase from 7 am) in all analyses that utilized testosterone (e.g., Makhanova et al., 2018) to rule out the possibility that time of day accounted for any effects of testosterone.

3.1.2. Sex-role identification

Participants completed the Bem Sex Role Inventory (BSRI; Bem, 1981), which assesses the extent to which people identify with both traditional masculine and feminine sex roles. People who strongly identify with masculine sex roles tend to endorse a more agentic social identity characterized by assertiveness and competitiveness (formerly labeled as "masculine" traits); in contrast, people who strongly identify with feminine sex roles tend to endorse a more communal identity characterized by warmth and concern for others (formerly labeled "feminine" traits) (Wood & Eagly, 2012). Because people can be high or low on either (or both) masculine and feminine sex-role identification, we used both subscales of the BSRI—one 10-item subscale assesses the extent to which people describe themselves using agentic/masculine adjectives or phrases (e.g., assertive, has leadership abilities), and a second 10-item subscale assesses the extent to which people describe themselves using communal/feminine adjectives or phrases (e.g., affectionate, warm). Participants responded on a scale ranging from *1* ("Not at all") to *9* ("Exactly"). For each subscale, we averaged across all items to compute an average masculine sex-role identification score and average feminine sex-role identification score for all participants (αs = .85 and .91 for masculine and feminine sex-role identification, respectively).

3.2. Daily relational, cognitive, and emotional experiences

Sexual desire and contextual variables can vary substantially from day to day; thus, we assessed them daily using the daily diary portion of the study. Given the broader aim of the longitudinal study of marriage from which these data were derived was to assess a wide range of daily experiences that contribute to marital outcomes, we used single-item measures to minimize participant burden. Indeed, several scholars have advocated for the use of single-item measures when there is a high need to increase efficiency, minimize participant burden, and prevent attrition (Aron et al., 1992; Bergkvist & Rossiter, 2007; Bolger et al., 2003; Milton et al., 2011; Robins et al., 2001), which others have done with considerable success (e.g., Gadassi et al., 2016; Laurenceau et al., 2005; Maxwell & Meltzer, 2020; Pasipanodya et al., 2012; Totenhagen et al., 2016, 2018). Assessing variables on a daily basis allowed us to potentially explain both between and within-person variance in sexual desire using the daily predictor variables. Unfortunately, we did not have the financial resources to assess testosterone at the daily level. Given potential problems with single-item measures (see Moskowitz et al., 2009), we also used trait-level versions of our predictor variables whenever possible; results of these analyses mirror those from the analyses with daily variables and are reported in supplemental materials.

3.3. Daily sexual desire for one's spouse

Participants independently responded to a single item assessing their sexual desire for their spouse ("How much did you want to have sex with your partner today?"). The scale ranged from *1* ("Not at all") to *7* ("Very much"). Reliability for this item across all daily diaries was high, α = .90. The interclass correlation coefficient (ICC) for this variable was .43, suggesting just over half of the variance for daily dyadic sexual desire for one's spouse was within (versus between) individuals.

3.4. Daily marital satisfaction

Participants also completed the three-item Kansas Marital Satisfaction Scale (Schumm et al., 1986), modified to ask about daily marital satisfaction: "How satisfied were you with your partner today?," "How satisfied were you with your relationship today?," and "How satisfied were you with your marriage today?" The response scale ranged from *1* ("Not at all") to *7* ("Extremely"). We averaged across these items to form a composite index of daily marital satisfaction (all αs ≥ .87). Reliability for this composite measure across all daily diaries was moderate, α = .82. The ICC for this variable was .28, suggesting a substantial portion of the variance for daily marital satisfaction was within (versus between) individuals.

3.5. Daily commitment

Participants reported how committed they were to their marriage each day. Specifically, we asked: "How committed to your relationship were you today?" The response scale ranged from *1* ("Not at all") to *7* ("Extremely"). Other work has previously demonstrated meaningful day-to-day variability in relationship commitment using a similar single-item measure of daily commitment (Totenhagen et al., 2016). Reliability for this item across all daily diaries was moderate, α = .88. The ICC for this variable was .38, suggesting a substantial portion of the variance for daily commitment was within (versus between) individuals.

3.6. Daily stress

Participants reported how distressed they were each day ("I felt distressed"), using a response scale ranging from *1* ("Not at all") to *7* ("Extremely), which we used as a proxy for daily stress. Reliability for this item across all daily diaries was moderate, α = .87. The ICC for this variable was .34, suggesting a substantial portion of the variance for daily stress was within (versus between) individuals.

3.7. Daily self-esteem

Participants reported their state self-esteem each day by responding to a single item ("I felt good about myself;" Meltzer, 2020), using a response scale ranging from *1* ("Not at all") to *7* ("Extremely"). Reliability for this item across all daily diaries was high, α = .93. The ICC for this variable was .44, suggesting just over half of the variance for daily self-esteem was within (versus between) individuals.

3.7.1. Daily positive mood

Participants reported their mood each day ("I felt happy"), using a response scale ranging from *1* ("Not at all") to *7* ("Extremely"). Reliability for this item across all daily diaries was high, α = .92. The ICC for this variable was .45, suggesting just over half of the variance for daily mood was within (versus between) individuals.

[2] These coefficients are derived from both saliva samples collected during couples' in-person sessions.

3.7.2. Daily depressed mood

Participants reported on their depressive symptoms each day ("I felt depressed"), using a response scale ranging from *1* ("Not at all") to *7* ("Extremely"). Reliability for this item across all daily diaries was moderate, α = .88. The ICC for this variable was .36, suggesting a substantial portion of the variance for daily depressive symptoms was within (versus between) individuals.

3.8. Access to materials & data

All study materials are either described in full or readily accessible. Data and syntax for primary analyses are available on OSF at the following link: https://osf.io/jmndc/?view_only= 6a75fbce594c48e5b5ad812898543e56.

4. Results

4.1. Preliminary analyses

Descriptive statistics and bivariate correlations appear in Table 1, where daily variables were the average report across days. A few results are worth highlighting. First, consistent with our expectations and previous research, paired samples *t*-tests revealed that, within-dyads, husbands had higher levels of both daily sexual desire for their spouse, $t(47) = 3.50$, $p = .001$, and circulating testosterone, $t(43) = 9.00$, $p < .001$, than their wives; these differences are consistent with the idea that sex differences in testosterone may at least partially account for sex differences in sexual desire for one's spouse. Second, testosterone and sexual desire were modestly positively correlated among wives but not husbands; null associations between testosterone among men have been observed elsewhere (e.g., van Anders, 2012), and, as others have suggested (van Anders, 2013), may be due to a ceiling effect. Nevertheless, given the link between testosterone and daily sexual desire for one's spouse among women, this null bivariate association for men does not preclude a role of testosterone for explaining any sex difference in daily sexual desire for one's spouse because low testosterone may help explain why women's desire is lower than men's. Third, consistent with the possibility that relationship dynamics, cognitive, and emotional experiences may additionally or alternatively explain any sex differences in daily sexual desire for one's spouse, (a) marital satisfaction was positively associated with daily sexual desire for one's spouse among husbands and a similar association trended toward significance among wives and (b) daily positive mood was positively associated with daily sexual desire for one's spouse among both husbands and wives. Fourth, sex-role identification did not appear to be conflated with gender, evidenced by both husbands and wives displaying considerable variability in their masculine and feminine sex-role identification and endorsing relatively high levels of identification with both sex roles; for one-sample *t*-tests comparing husbands' and wives' mean masculine and feminine sex-role identification scores to the mid-point (5) of each subscale, *ps* < 0.001. Finally, expected associations between daily variables offer some evidence for their validity; as just one example, daily commitment was positively associated with daily marital satisfaction.[3]

4.2. Are there sex differences in daily sexual desire for one's spouse?

We first tested whether husbands' and wives' daily sexual desire for each other differed by using the MIXED procedure in SPSS 28 (which accounts for the non-independence of husbands' and wives' data) to estimate the following multilevel model:

$$Y_{ti}(\text{Daily Sexual Desire for One's Spouse}) = \pi_{0ti}(\text{Intercept}) + \pi_{1ti}(\text{Day}) + b_{2i}(\text{Sex}) + e_{ti} + r_i \quad (1)$$

where (a) Day was mean-centered, (b) Sex was coded using weighted effect coding that reflected the number of men and women in the analyses, such that husbands = −0.9583 and wives = 1, and (c) random effects of Intercept and Day were estimated separately for husbands and wives and allowed to covary using an unstructured covariance structure. Conceptually replicating prior work (Holmberg & Blair, 2009; McNulty et al., 2019; Muise, Stanton et al., 2016), husbands experienced significantly greater daily sexual desire for their spouse than did wives across the 14-day daily diary period, $\pi = -0.42$, $t(46.18) = -3.40$, $p = .001$, 95% confidence interval (CI) [− 0.67, − 0.17], effect-size $r = .45$.

4.3. Why do husbands and wives differ in their dyadic sexual desire for each other?

But what is the underlying source of this sex difference in daily sexual desire for one's spouse? Does it reflect relatively low relationship satisfaction or low commitment? Is it due to sex-role identification, or daily cognitive and emotional experiences such as stress, self-esteem, or mood? Do individual differences between men's and women's testosterone levels account for this sex difference? Our next series of analyses examined the extent to which each of these biological, relational, as well as cognitive and emotional experiences might explain differences between husbands' and wives' sexual desire for each other. To do so, we re-estimated Eq. 1 (which estimated the sex difference in daily sexual desire for one's spouse) three times, each time adding additional predictor variables. Of note, we a priori decided upon the order in which to include each of these variables in these models to maximize insights into the relative roles of (a) sex role identification, (b) daily cognitive and emotional experiences, including relational variables, and (c) and testosterone; we then subsequently provide alternative supplemental models. First, given theory suggesting that differences between men's and women's sexuality can be largely explained by sociocultural contexts such as gendered social roles (e.g., Leiblum, 2002; van Anders, 2013), we added both masculine and feminine sex-role identification to examine their associations with daily sexual desire for one's spouse. Second, we added each of the daily cognitive, emotional, and relational experiences that may be implicated in daily sexual desire for one's spouse—daily stress, self-esteem, mood, commitment, and marital satisfaction. Third, we added testosterone, which we log-transformed to correct for skewness and then standardized across the entire sample to facilitate interpretability across models,[4] and we controlled for linear time of testosterone measurement. Adding testosterone to the model last, along with all other predictors that theoretically may account for sex differences in daily sexual desire for one's spouse, provides the strictest test of the hypothesis that testosterone may uniquely account for such sex differences. In each of these models, we standardized all predictors across the entire sample except participant sex (which we coded using weighted effect coding) and day (which we mean-centered). Results are reported in Table 2, where the results from the original model (Eq. 1) appear in column 1 and the key effect of participant sex that represents the sex difference is bolded.

As can be seen in the third column (i.e., Model 3), daily marital satisfaction and daily positive mood were significantly positively associated with daily sexual desire, daily depressed mood trended toward being positively associated with sexual desire, and daily stress trended toward being negatively associated with sexual desire. Nevertheless,

[3] Given these preliminary analyses of the daily variables ignored daily variability, we also conducted a series of multilevel analyses with a single random intercept to examine the validity of these variables by estimating some key associations at the daily level using standardized versions of each variable. These results suggest the daily variables performed as expected; results are reported in supplementary materials.

[4] A non-transformed version of the testosterone variable yielded the same conclusions.

Table 1
Bivariate Correlations and Descriptive Statistics for all Key Variables.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Daily Sexual Desire for Spouse	**[0.16]**	.43**	.03	.28†	.24†	.20	-.16	.26†	.45**	-.21
(2)	Testosterone	.10	**[0.01]**	.07	.15	-.15	-.08	.05	.29†	.36*	-.12
(3)	Masculine Sex Role Identification	.10	-.24†	**[−.00]**	.12	.09	.01	-.07	.09	-.02	.01
(4)	Feminine Sex Role Identification	.08	-.15	.35*	**[.20]**	.26†	.34*	.09	.27†	.25†	.08
(5)	Daily Marital Satisfaction	.39**	.10	-.16	.09	**[0.07]**	.66***	-.31*	.34*	.37**	-.27†
(6)	Daily Commitment	.24	.28†	.02	.33*	.54***	**[.00]**	-.19	.11	.22	-.04
(7)	Daily Stress	-.15	-.22	.26†	-.09	-.46**	-.44**	**[.22]**	-.52***	-.44**	.77***
(8)	Daily Self-esteem	.27†	-.08	.12	.17	.46**	.13	-.14	**[0.09]**	.87***	-.56***
(9)	Daily Positive Mood	.32*	.05	.03	.14	.57***	.34*	-.26†	.85***	**[.11]**	-.57***
(10)	Daily Depressed Mood	-.23	-.23	.16	-.02	-.70***	-.31*	.62***	-.45**	-.49***	**[.20]**
Husbands:	*M*	5.13_{a}	94.41_{a}	6.41	6.84_{a}	6.25	6.55	1.92	5.16	5.13	1.89
	SD	1.22	36.91	1.18	1.22	0.67	0.61	0.95	1.13	1.21	0.94
	n	48	48	48	48	48	48	48	48	48	48
Wives:	*M*	4.35_{b}	40.50_{b}	6.00	7.39_{b}	6.21	6.65	2.19	5.08	5.24	1.99
	SD	1.47	17.49	1.22	1.13	0.61	0.52	1.05	1.05	1.04	0.96
	n	50	46	50	50	50	50	50	50	50	50

Note. Husbands' correlations appear below the diagonal and wives' correlations appear above the diagonal; within-dyad correlations between spouses are presented in bold brackets along the diagonal. For each daily variable, we computed the within-person means across all daily assessments for the purpose of providing bivariate correlations and descriptive statistics. For descriptive statistics, different subscripts in the same column denote within-dyad sex-differentiated means (all $ps \leq 0.021$). $^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

none of the contextual variables fully accounted for the sex difference in daily sexual desire for one's spouse—indeed, the sex difference continued to emerge as significant and equivalent in size in Model 3, 95% CI [− 0.66, − 0.17]. In contrast to the idea that feminine sex-role identification should downregulate dyadic sexual desire, feminine sex-role identification trended toward being *positively* associated with dyadic sexual desire in Model 2, although this association was substantially reduced and no longer trended toward significance in Model 3. As can be seen in the final column of Table 2 (i.e., Model 4), however, testosterone was positively associated with daily sexual desire for one's spouse, 95% CI [0.24, 0.92], and its inclusion in the model reduced the sex difference to near zero and non-significance, 95% CI [− 0.36, 0.33]; a model comparison test confirmed that including testosterone in the model yielded a significant improvement of model fit, $\chi^2(2) = 144.09$, $p < .001$. A supplemental analysis revealed that the association between testosterone and dyadic sexual desire differed for men versus women, b = 0.36, $t(84.42) = 2.11$, $p = .038$, 95% CI [0.02, 0.69], effect-size $r = .22$, such that testosterone was positively associated with daily sexual desire for one's spouse among women, b = 0.89, $t(45.25) = 4.03$, $p < .001$, 95% CI [0.44, 1.33], effect-size $r = .51$, but this positive association did not reach significance among men, b = 0.19, $t(47.08) = 0.74$, $p = .461$, 95% CI [− 0.32, 0.69], effect-size $r = .11$. This latter finding is consistent with other work suggesting a potential ceiling effect in sexual desire among men. A second supplemental robustness analysis that included only sex, testosterone, and time of testosterone measurement as predictors also revealed that testosterone was positively associated with daily sexual desire for one's spouse, b = 0.61, $t(81.62) = 3.29$, $p = .001$, 95% CI [0.24, 0.97], effect-size $r = .34$, and attenuated the sex difference to near zero and non-significance, b = 0.01, $t(68.00) = 0.07$, $p = .946$, 95% CI [− 0.34, 0.37], effect-size $r = .01$.

4.4. Mediation analyses

Finally, we directly tested whether testosterone mediated the association between participant sex and dyadic sexual desire for their spouse. Doing so required first estimating the direct effect of participant sex on circulating testosterone levels (Path A), which we did with the following model using the MIXED procedure in SPSS 28:

$$Y_{ti}(\text{Testosterone}) = \pi_{0ti}(\text{Intercept}) + b_{1i}(\text{Sex}) + b_{2i}(\text{Time of Day}) + e_{ti} + r_i \quad (2)$$

where we again (a) log-transformed and then standardized Testosterone across the entire sample, (b) used weighted effect coding for Sex, (c) controlled for the Time of Day the testosterone sample was collected (standardized), and (d) allowed the Intercept estimate to vary randomly across husbands and wives. Results of this analysis confirmed that participants' sex was associated with their testosterone levels such that husbands had higher testosterone than did wives, b = −0.74, $t(49.88) = -10.20$, $p < .001$, 95% CI [− 0.89, − 0.59], effect-size $r = .82$.

We then used the RMediation package in R (Tofighi & MacKinnon, 2011) to compute the indirect effect and corresponding asymmetric confidence interval based on Path A (the association between participant sex and testosterone; b = −0.74, *SE* = 0.07), and Path B (the association between testosterone and dyadic sexual desire, controlling for participant sex and all contextual variables from Model 4 in Table 2; b = 0.58, *SE* = 0.17). Results of this procedure revealed that the indirect effect (depicted in Fig. 1) was significant, b = −0.43, *SE* = 0.13, 95% CI [− 0.70, − 0.18], consistent with the possibility that levels of circulating testosterone explain, at least in part, differences between husbands' and wives' sexual desire for each other.

5. Discussion

Sex plays an important role in maintaining satisfying, long-term romantic relationships (Maxwell & McNulty, 2019; McNulty et al., 2016; Meltzer et al., 2017; Muise, Kim et al., 2016). Nevertheless, women in mixed-sex long-term relationships such as marriage on average desire sex with their partner less than men do (e.g., Holmberg & Blair, 2009; McNulty et al., 2019; Muise, Stanton, et al., 2016). As far as we are aware, the current research is the first to test the relative roles of biological (e.g., circulating testosterone levels), relational (e.g., marital satisfaction, commitment), and cognitive and emotional factors (e.g., sex-role identification, stress, self-esteem, mood) that might underlie sex differences in sexual desire for one's long-term partner. Results revealed that individual differences in men's and women's testosterone levels explained the observed difference in spousal sexual desire. Marital satisfaction and positive mood emerged as the only other robust predictors of sexual desire for one's spouse, but those variables did not appear to account for the sex difference.

5.1. Theoretical and practical implications

The current work has both theoretical and practical implications. Regarding theory, this work suggests that testosterone plays a role in accounting for sex differences in sexual desire for one's long-term partner, a finding that is consistent with evolutionary perspectives on how evolved reproductive asymmetries between males and females

Table 2
Associations Between Spousal Dyadic Sexual Desire and All Predictor Variables.

	1: Sex Difference			2: Sex-Role Identification			3: All Contextual Factors			4: Testosterone		
	b	*df*	r_{es}	b	*df*	r_{es}	b	*df*	r_{es}	b	*df*	r_{es}
DV = Dyadic Sexual Desire for Spouse												
Intercept	4.72***	48.47	–	4.72***	46.85	–	4.73***	46.30	–	4.72***	46.10	–
Day	-0.01	45.12	.11	-0.01	45.09	.11	-0.00	46.20	.03	-0.00	45.78	.03
Sex	**-0.42****	**46.18**	**.45**	**-0.47*****	**45.88**	**.48**	**-0.42****	**47.32**	**.44**	**-0.01**	**69.77**	**.01**
Masculine SRI				0.03	82.12	.03	0.09	87.02	.08	0.04	76.42	.04
Feminine SRI				0.23†	92.50	.17	0.13	94.73	.10	0.11	82.74	.09
Daily Stress							-0.11†	1097.64	.06	-0.12†	1073.26	.06
Daily Self-esteem							0.09	1063.49	.04	0.11	1049.14	.05
Daily Depressed Mood							0.10†	1079.10	.05	0.11†	1058.57	.05
Daily Positive Mood							0.26***	1067.43	.11	0.23**	1042.88	.10
Daily Commitment							0.01	1019.19	.01	0.01	1017.11	.00
Daily Marital Satisfaction							0.35***	1125.88	.16	0.36***	1101.49	.17
Testosterone (T)										0.58***	82.45	.35
T Time of Day										0.28*	48.14	.30

SRI = Sex-Role Identification. Sex of Spouse is coded using weighted effect coding (Husbands = -0.9583, Wives = 1). For each model, the associations indicating the sex difference in spousal sexual desire are emphasized using bold font. Effect-size *r* (r_{es}) is reported. †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

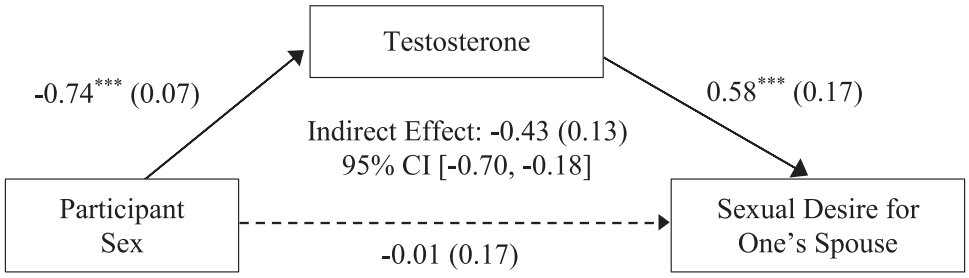

Fig. 1. The indirect association between sex and sexual desire for one's spouse through circulating levels of testosterone. *SEs* are in parentheses. ***$p < .001$.

contribute to sex differences in human sexuality (e.g., Trivers, 1972)—even in the context of established long-term relationships. This is important because the increased commitment and interdependence associated with established relationships can alter levels of testosterone (Gettler et al., 2013; Gray et al., 2004) and the manner in which various factors are associated with sexual outcomes (see Russell et al., 2013).

At the same time, the current work contrasts prior work supporting the steroid/peptide theory of social bonds (van Anders et al., 2011) by showing that testosterone does not underlie sex differences in dyadic sexual desire in samples composed of mostly college students, many of who were single (Raisanen et al., 2018; van Anders, 2012). Nevertheless, the current work does not necessarily undermine that theory. According to the steroid/peptide theory of social bonds (van Anders et al., 2011), high testosterone may be associated with a stronger desire for sexual pleasure whereas low testosterone may be associated with a stronger desire for sexual intimacy. Although women may desire more sexual warmth than men on average (Basson, 2000), these differences are likely to be fairly contextualized. And motivations for sex in the context of a new marriage may be quite different from motivations for sex among single people, dating couples, and couples in more established marriages. Future research may benefit from further examining motivations for sex among different types of relationships of varying lengths, sex differences in those motivations, the extent to which testosterone does or does not account for such differences, and how all of this varies across relationship type and length.

The finding that testosterone, but not relational variables (i.e., marital satisfaction, commitment), seems to drive sex differences in sexual desire for one's long-term partner may also have important practical implications. Practitioners treating couples who present with sexual difficulties in their relationship due to low female dyadic sexual desire can normalize such experiences and help couples understand that low sexual desire for one's partner does not necessarily imply problems with their relationships. Indeed, these insights may help enable couples to make better-informed attributions about underlying sources of relatively lower female dyadic sexual desire, thereby possibly limiting the extent to which couple members blame themselves and their partners for sexual difficulties in their relationships. It is critical to note, however, that couples' sexual functioning is not solely determined by biological factors. Although contextual factors did not explain sex differences in sexual desire, marital satisfaction and mood did predict sexual desire, and we know from other work that the context of the relationship does have implications for sexual functioning more broadly (e.g., Maxwell & McNulty, 2019). For example, being satisfied with a relationship appears to predict sexual satisfaction (French et al., 2019; McNulty et al., 2016; Yeh et al., 2006), engaging in sex with a partner can promote positive relationship outcomes even when it is motivated by factors other than sexual gratification (Impett et al., 2005), and partaking in shared novel activities with one's partner appears to boost sexual desire for women (Raposo et al., 2020). Nevertheless, the current data do speak to the important and perhaps underemphasized role of testosterone for explaining why men may often have higher dyadic sexual desire for their partners than those partners have in return.

These implications are buoyed by several strengths of the research. First, we integrated often disparate literatures from social psychology, evolutionary psychology, behavioral endocrinology, and relationship science to generate the research questions we investigated here. This interdisciplinary, theory-driven approach ensures that this research further advances each of these respective literatures and is of broad theoretical importance. Second, we utilized a longitudinal, dyadic design that allowed us to capture within-person variability in dyadic sexual desire, which increased the power of our analyses. Third, we specifically measured people's daily desire to have sex *with their spouse*, helping to ensure associations were specific to sexual desire directed toward a partner with whom participants are involved in a long-term relationship with, which can have different sources than other forms of sexual desire, such as solitary sexual desire (e.g., van Anders, 2012).

5.2. Limitations and future directions

Despite these strengths, this study's design was also limited in some ways. First, we were only able to obtain a unitary measure of testosterone (at the baseline assessment) and not for each of the daily assessments. Although this enabled us to examine how individual differences in men's versus women's circulating testosterone prospectively predicted dyadic sexual desire for a long-term partner over an extended two-week period, we were unable to examine how within-person variations in circulating testosterone would correspond with daily fluctuations in such desire and any potential bidirectional association between testosterone and sexual desire. Future research may benefit from examining sex differences in spousal dyadic sexual desire using repeated concurrent assessments of levels of circulating testosterone and dyadic sexual desire, ideally with repeated concurrent measures of additional contextual factors likely to influence such sexual desire (e.g., relationship satisfaction, mood). Such research may offer stronger evidence of the direction of the association that emerged here, and shed light on any role of sexual desire in predicting testosterone.

Second, although our analyses were based on a total of 1139 observations of spousal dyadic sexual desire, these observations were derived from a subsample comprised of 94 individuals and thus yielded an effective sample size of 197, which was relatively modest when compared to research based solely on self-report measures. Unfortunately, the cost of obtaining biological and diary data from community samples can prohibit the large samples permitted by other methodologies. Nevertheless, our total number of participants was at least similar to or even larger than other recent studies examining hormonal processes in dyads (e.g., Edelstein et al., 2014; Righetti et al., 2020), and the repeated reports of spousal dyadic sexual desire helped yield an effective sample size that offered ample power.

Third, though it has been recommended by others (e.g., van Anders, 2014), we were unable to account for the possible influence of other hormones including estradiol and progesterone, which have been associated with both testosterone and sexual desire in other work. For example, testosterone appears to be positively associated with both estradiol and progesterone (for estradiol: $r = .35$; for progesterone: $r = .15$; see Roney & Simmons, 2013), and, in other work, (a) within-woman fluctuations in progesterone were negatively associated with general sexual desire, (b) fluctuations in estradiol were positively associated with solitary sexual desire only, and (c) associations between fluctuations in testosterone and sexual desire of any kind failed to emerge (Jones et al., 2018). Nevertheless, this prior work examined within-person associations among women only (Jones et al., 2018; Roney & Simmons, 2013) and thus cannot speak to sex-differentiated associations between hormones and sexual desire. Moreover, although other work (Righetti et al., 2020) suggested that testosterone did not predict sexual desire when controlling estradiol and progesterone, the sample size was even smaller than the current study and, in contrast to other work (see Jones et al., 2018), neither estradiol nor progesterone were associated with sexual desire. Future research would benefit from attempting to replicate the current findings using a larger sample of couples and repeated assessments of testosterone, progesterone, and estradiol.

Fourth, and relatedly, sexual desire appears to vary across women's menstrual cycles, typically peaking mid-cycle around the time of ovulation for women who are in relationships (Pillsworth et al., 2004), whereas men's sexual desire is not subject to such menstrual cycle fluctuations or other known systematically identified fluctuations. Across an extended period of time, such menstrual-cycle variability in women's sexual desire may also help to explain why men, on average, experience greater levels of sexual desire than do women. Similarly, women's tendency to less frequently experience orgasms from sex with their partner compared to men (see Mahar et al., 2020) could play a role in explaining sex differences in sexual desire. Future research may benefit from directly addressing these possibilities as well.

Fifth, due to goals of the broader study of marriage from which the data for the current investigation were derived, we relied on single items to measure most of the daily variables (c.f., marital satisfaction). Although these items are face valid and reliably demonstrate associations with other variables they should theoretically be associated with, it remains possible that these items did not fully capture the constructs of interest and, consequently, may have accounted for little variance in dyadic sexual desire due to measurement error. Readers should therefore exercise caution when interpreting the individual coefficients because the current work may have underestimated the role that these daily experiences may have in accounting for sex differences in sexual desire for a long-term partner. Future research should seek to further delineate the potential influence of these daily relational, cognitive, and emotional experiences.

Finally, it is possible that circulating testosterone levels may be a distal (rather than a direct) predictor of spousal dyadic sexual desire, with some unidentified mediating factor or factors at play. For example, androgen deficiency is associated with a lack of energy (see Bolour & Braunstein, 2005), and people who use testosterone supplements report both an increase in energy and sexual desire (e.g., Straftis & Gray, 2019). In other words, testosterone may not directly impact dyadic sexual desire (as suggested by others; e.g., van Anders, 2012) but may, instead, produce and mobilize energy that then underlies such desire. Future research should examine this and other possible mechanisms. Nevertheless, to the extent that testosterone distally influences sexual desire for one's partner through some mediating factor, this would not mean that testosterone does not play an important role in sexual desire. Indeed, it would suggest that testosterone is an important precursor to, or catalyst, for conditions that must be in place (e.g., energy) for a person to experience dyadic sexual desire for their long-term partner.

6. Conclusion

This research is among the first to simultaneously examine the relative roles of biological, relational, cognitive, and emotional experiences for explaining sex differences in dyadic sexual desire within the context of marriage. Results suggest that circulating testosterone levels (not relational, cognitive, and emotional experiences) help explain why husbands on average exhibit relatively higher spousal dyadic sexual desire than do wives, thereby integrating interdisciplinary perspectives to advance knowledge on the underlying sources of sex differences in dyadic sexual desire.

Acknowledgements

This work was supported by a National Science Foundation grant (BCS-1251520) awarded to James K. McNulty.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.biopsycho.2022.108421.

References

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology, 63* (4), 596.

Basson, R. (2000). The female sexual response: A different model. *Journal of Sex &Marital Therapy, 26*(1), 51–65.

Baumeister, R. F. (2000). Gender differences in erotic plasticity: The female sex drive as socially flexible and responsive. *Psychological Bulletin, 126*(3), 347–374.

Baumeister, R. F., & Bratslavsky, E. (1999). Passion, intimacy, and time: Passionate love as a function of change in intimacy. *Personality and Social Psychology Review, 3*(1), 49–67.

Baumeister, R. F., Cantanese, K. R., & Vohs, K. D. (2001). Is there a gender difference in strength of sex drive? Theoretical views, conceptual distinctions, and a review of relevant evidence. *Personality and Social Psychology Review, 5*, 242–273.

Beck, J. G., Bozman, A. W., & Qualtrough, T. (1991). The experience of sexual desire: Psychological correlates in a college sample. *Journal of Sex Research, 28*(3), 443–456.
Bem, S.L. (1981). Bem Sex Role Inventory: Professional Manual. Consluting Psychologists Press.
Bergkvist, L., & Rossiter, J. R. (2007). The predictive validity of multiple-item versus single-item measures of the same constructs. *Journal of Marketing Research, 44*(2), 175–184.
Birnbaum, G. E., & Reis, H. T. (2012). When does responsiveness pique sexual interest? Attachment and sexual desire in initial acquaintanceships. *Personality and Social Psychology Bulletin, 38*(7), 946–958.
Birnbaum, G. E., Reis, H. T., Mizrahi, M., Kanat-Maymon, Y., Sass, O., & Granovski-Milner, C. (2016). Intimately connected: The importance of partner responsiveness for experiencing sexual desire. *Journal of Personality and Social Psychology, 111*(4), 530–546.
Bodenmann, G., Atkins, D. C., Schär, M., & Poffet, V. (2010). The association between daily stress and sexual activity. *Journal of Family Psychology, 24*(3), 271–279.
Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology, 54*(1), 579–616.
Bolour, S., & Braunstein, G. (2005). Testosterone therapy in women: A review. *International Journal of Impotence Research, 17*(5), 399–408.
Booth, A., Johnson, D. R., & Granger, D. A. (1999). Testosterone and men's depression: The role of social behavior. *Journal of Health and Social Behavior*, 130–140.
Buss, D. M., & Schmitt, D. P. (1993). Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review, 100*(2), 204–232.
Corona, G., Isidori, A. M., Aversa, A., Burnett, A. L., & Maggi, M. (2016). Endocrinologic control of men's sexual desire and arousal/erection. *The Journal of Sexual Medicine, 13*(3), 317–337.
Dabbs, J. M., Jr (1990). Salivary testosterone measurements: Reliability across hours, days, and weeks. *Physiology & Behavior, 48*(1), 83–86.
Davis, S. R., & Tran, J. (2001). Testosterone influences libido and well being in women. *Trends in Endocrinology & Metabolism, 12*(1), 33–37.
Edelstein, R. S., Chopik, W. J., & Kean, E. L. (2011). Sociosexuality moderates the association between testosterone and relationship status in men and women. *Hormones and Behavior, 60*(3), 248–255.
Edelstein, R. S., van Anders, S. M., Chopik, W. J., Goldey, K. L., & Wardecker, B. M. (2014). Dyadic associations between testosterone and relationship quality in couples. *Hormones and Behavior, 65*(4), 401–407.
French, J. E., Altgelt, E. E., & Meltzer, A. L. (2019). The implications of sociosexuality for marital satisfaction and dissolution. *Psychological Science, 30*(10), 1460–1472.
Gadassi, R., Bar-Nahum, L. E., Newhouse, S., Anderson, R., Heiman, J. R., Rafaeli, E., & Janssen, E. (2016). Perceived partner responsiveness mediates the association between sexual and marital satisfaction: A daily diary study in newlywed couples. *Archives of Sexual Behavior, 45*(1), 109–120.
Gades, N. M., Jacobson, D. J., McGree, M. E., Sauver, J. L. S., Lieber, M. M., Nehra, A., Girman, C. J., Klee, G. G., & Jacobsen, S. J. (2008). The associations between serum sex hormones, erectile function, and sex drive: The olmsted county study of urinary symptoms and health status among men. *The Journal of Sexual Medicine, 5*(9), 2209–2220.
Gettler, L. T., McDade, T. W., Agustin, S. S., Feranil, A. B., & Kuzawa, C. W. (2013). Do testosterone declines during the transition to marriage and fatherhood relate to men's sexual behavior? Evidence from the Philippines. *Hormones and Behavior, 64*(5), 755–763.
Gray, P. B., Chapman, J. F., Burnham, T. C., McIntyre, M. H., Lipson, S. F., & Ellison, P. T. (2004). Human male pair bonding and testosterone. *Human Nature, 15*(2), 119–131.
Hatfield, E. C., Pillemer, J. T., O'brien, M. U., & Le, Y. C. L. (2008). The endurance of love: Passionate and companionate love in newlywed and long-term marriages. *Interpersona: An International Journal on Personal Relationships, 2*(1), 35–64.
Holmberg, D., & Blair, K. L. (2009). Sexual desire, communication, satisfaction, and preferences of men and women in same-sex versus mixed-sex relationships. *Journal of Sex Research, 46*(1), 57–66.
Impett, E. A., Peplau, L. A., & Gable, S. L. (2005). Approach and avoidance sexual motives: Implications for personal and interpersonal well-being. *Personal Relationships, 12*(4), 465–482.
Jennings, K. J., & de Lecea, L. (2020). Neural and hormonal control of sexual behavior. *Endocrinology, 161*(10). bqaa150.
Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., & DeBruine, L. M. (2018). General sexual desire, but not desire for uncommitted sexual relationships, tracks changes in women's hormonal status. *Psychoneuroendocrinology, 88*, 153–157.
Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry, 62*(6), 593–602.
Laurenceau, J. P., Barrett, L. F., & Rovine, M. J. (2005). The interpersonal process model of intimacy in marriage: A daily-diary and multilevel modeling approach. *Journal of Family Psychology, 19*(2), 314.
Lavner, J. A., & Bradbury, T. N. (2010). Patterns of change in marital satisfaction over the newlywed years. *Journal of Marriage and Family, 72*(5), 1171–1187.
Leiblum, S. R. (2002). Reconsidering gender differences in sexual desire: An update. *Sexual and Relationship Therapy, 17*(1), 57–68.
Mahar, E. A., Mintz, L. B., & Akers, B. M. (2020). Orgasm equality: Scientific findings and societal implications. *Current Sexual Health Reports, 12*(1), 24–32.
Makhanova, A., McNulty, J. K., Eckel, L. A., Nikonova, L., & Maner, J. K. (2018). Sex differences in testosterone reactivity during marital conflict. *Hormones and Behavior, 105*, 22–27.
Mark, K. P. (2012). The relative impact of individual sexual desire and couple desire discrepancy on satisfaction in heterosexual couples. *Sexual and Relationship Therapy, 27*(2), 133–146.
Maxwell, J. A., & McNulty, J. K. (2019). No longer in a dry spell: The developing understanding of how sex influences romantic relationships. *Current Directions in Psychological Science, 28*(1), 102–107.
Maxwell, J. A., & Meltzer, A. L. (2020). Kiss and makeup? Examining the co-occurrence of conflict and sex. *Archives of Sexual Behavior, 49*(8), 2883–2892.
McClelland, S. I. (2014). "What do you mean when you say that you are sexually satisfied?" A mixed methods study. *Feminism & Psychology, 24*(1), 74–96.
McNulty, J. K., & Fisher, T. D. (2008). Gender differences in response to sexual expectancies and changes in sexual frequency: A short-term longitudinal study of sexual satisfaction in newly married couples. *Archives of Sexual Behavior, 37*(2), 229–240.
McNulty, J. K., Maxwell, J. A., Meltzer, A. L., & Baumeister, R. F. (2019). Sex-Differentiated changes in sexual desire predict marital dissatisfaction. *Archives of Sexual Behavior, 48*(8), 2473–2489.
McNulty, J. K., Wenner, C. A., & Fisher, T. D. (2016). Longitudinal associations among relationship satisfaction, sexual satisfaction, and frequency of sex in early marriage. *Archives of Sexual Behavior, 45*(1), 85–97.
Meltzer, A. L. (2020). Women can benefit from sexual and physical valuation in the context of a romantic relationship. *Personality and Social Psychology Bulletin, 46*(2), 243–257.
Meltzer, A. L., Makhanova, A., Hicks, L. L., French, J., McNulty, J. K., & Bradbury, T. N. (2017). Quantifying the sexual afterglow: The lingering benefits of sex for pair-bonded relationships. *Psychological Science, 28*, 587–598.
Meltzer, A. L., & McNulty, J. K. (2010). Body image and marital satisfaction: Evidence for the mediating role of sexual frequency and sexual satisfaction. *Journal of Family Psychology, 24*(2), 156–164.
Milton, K., Bull, F. C., & Bauman, A. (2011). Reliability and validity testing of a single-item physical activity measure. *British Journal of Sports Medicine, 45*(3), 203–208.
Mizrahi, M., Reis, H. T., Maniaci, M. R., & Birnbaum, G. E. (2019). When insecurity dampens desire: Attachment anxiety in men amplifies the decline in sexual desire during the early years of romantic relationships. *European Journal of Social Psychology, 49*(6), 1223–1236.
Moskowitz, D. S., Russell, J. J., Sadikaj, G., & Sutton, R. (2009). Measuring people intensively. *Canadian Psychology / Psychologie canadienne, 50*(3), 131–140.
Muise, A., Harasymchuk, C., Day, L. C., Bacev-Giles, C., Gere, J., & Impett, E. A. (2019). Broadening your horizons: Self-expanding activities promote desire and satisfaction in established romantic relationships. *Journal of Personality and Social Psychology, 116*(2), 237–258.
Muise, A., Impett, E. A., & Desmarais, S. (2013). Getting it on versus getting it over with: Sexual motivation, desire, and satisfaction in intimate bonds. *Personality and Social Psychology Bulletin, 39*(10), 1320–1332.
Muise, A., Kim, J.J., McNulty, J.K. & Impett, E.A. (2016). The positive implications of sex for relationships. To appear in C. Knee & H. Reis (Eds.), Advances in Personal Relationships, Vol. 1: Positive approaches to optimal relationship development (pp. 124–147). Cambridge University Press.
Muise, A., Stanton, S. C., Kim, J. J., & Impett, E. A. (2016). Not in the mood? Men under-(not over-) perceive their partner's sexual desire in established intimate relationships. *Journal of Personality and Social Psychology, 110*(5), 725.
Murray, S. H. (2018). Heterosexual men's sexual desire: Supported by, or deviating from, traditional masculinity norms and sexual scripts? *Sex Roles, 78*(1), 130–141.
Murray, S. H., Milhausen, R. R., Graham, C. A., & Kuczynski, L. (2017). A qualitative exploration of factors that affect sexual desire among men aged 30 to 65 in long-term relationships. *The Journal of Sex Research, 54*(3), 319–330.
Pasipanodya, E. C., Parrish, B. P., Laurenceau, J. P., Cohen, L. H., Siegel, S. D., Graber, E. C., & Belcher, A. J. (2012). Social constraints on disclosure predict daily well-being in couples coping with early-stage breast cancer. *Journal of Family Psychology, 26*(4), 661.
Peplau, L. A. (2003). Human sexuality: How do men and women differ? *Current Directions in Psychological Science, 12*(2), 37–40.
Pillsworth, E. G., Haselton, M. G., & Buss, D. M. (2004). Ovulatory shifts in female sexual desire. *Journal of Sex Research, 41*(1), 55–65.
Proulx, C. M., Helms, H. M., & Buehler, C. (2007). Marital quality and personal well-being: A meta-analysis. *Journal of Marriage and Family, 69*(3), 576–593.
Raisanen, J. C., Chadwick, S. B., Michalak, N., & van Anders, S. M. (2018). Average associations between sexual desire, testosterone, and stress in women and men over time. *Archives of Sexual Behavior, 47*(6), 1613–1631.
Raposo, S., Rosen, N. O., & Muise, A. (2020). Self-expansion is associated with greater relationship and sexual well-being for couples coping with low sexual desire. *Journal of Social and Personal Relationships, 37*(2), 602–623.
Regan, P. C., & Atkins, L. (2006). Sex differences and similarities in frequency and intensity of sexual desire. *Social Behavior and Personality: An International Journal, 34*(1), 95–102.
Righetti, F., Tybur, J., Van Lange, P., Echelmeyer, L., van Esveld, S., Kroese, J., van Brecht, J., & Gangestad, S. (2020). How reproductive hormonal changes affect relationship dynamics for women and men: A 15-day diary study. *Biological Psychology, 149*, Article 107784.
Robins, R. W., Hendin, H. M., & Trzesniewski, K. H. (2001). Measuring global self-esteem: Construct validation of a single-item measure and the Rosenberg Self-Esteem Scale. *Personality and Social Psychology Bulletin, 27*(2), 151–161.
Robles, T. F., Slatcher, R. B., Trombello, J. M., & McGinn, M. M. (2014). Marital quality and health: A meta-analytic review. *Psychological Bulletin, 140*(1), 140.
Roney, J. R., & Simmons, Z. L. (2013). Hormonal predictors of sexual motivation in natural menstrual cycles. *Hormones and Behavior, 63*(4), 636–645.

Rosen, N. O., Bailey, K., & Muise, A. (2018). Degree and direction of sexual desire discrepancy are linked to sexual and relationship satisfaction in couples transitioning to parenthood. *The Journal of Sex Research, 55*(2), 214–225.
Russell, V. M., Baker, L. R., & McNulty, J. K. (2013). Attachment insecurity and infidelity in marriage: Do studies of dating relationships really inform us about marriage? *Journal of Family Psychology, 27*(2), 242–251.
Sarrel, P., Dobay, B., & Wiita, B. (1998). Estrogen and estrogen-androgen replacement in postmenopausal women dissatisfied with estrogen-only therapy. Sexual behavior and neuroendocrine responses. *The Journal of Reproductive Medicine, 43*(10), 847–856.
Schmidt, P. J., Berlin, K. L., Danaceau, M. A., Neeren, A., Haq, N. A., Roca, C. A., & Rubinow, D. R. (2004). The effects of pharmacologically induced hypogonadism on mood in healthy men. *Archives of General Psychiatry, 61*(10), 997–1004.
Schmidt, P. J., Steinberg, E. M., Negro, P. P., Haq, N., Gibson, C., & Rubinow, D. R. (2009). Pharmacologically induced hypogonadism and sexual function in healthy young women and men. *Neuropsychopharmacology, 34*(3), 565–576.
Schumm, W. R., Paff-Bergen, L. A., Hatch, R. C., Obiorah, F. C., Copeland, J. M., Meens, L. D., & Bugaighis, M. A. (1986). Concurrent and discriminant validity of the Kansas Marital Satisfaction Scale. *Journal of Marriage and the Family*, 381–387.
Snijders, T. A., & Bosker, R. J. (2011). *Multilevel analysis: An introduction to basic and advanced multilevel modeling* (2nd ed.). London, UK: Sage Publications.
Stanley, S. M., Rhoades, G. K., & Whitton, S. W. (2010). Commitment: Functions, formation, and the securing of romantic attachment. *Journal of Family Theory & Review, 2*(4), 243–257.
Straftis, A. A., & Gray, P. B. (2019). Sex, energy, well-being and low testosterone: an exploratory survey of US men's experiences on prescription testosterone. *International Journal of Environmental Research and Public Health, 16*(18), 3261.
Tofighi, D., & MacKinnon, D. P. (2011). RMediation: An R package for mediation analysis confidence intervals. *Behavior Research Methods, 43*(3), 692–700.
Totenhagen, C. J., Butler, E. A., Curran, M. A., & Serido, J. (2016). The calm after the storm: Relationship length as associated with couples' daily variability. *Journal of Social and Personal Relationships, 33*, 768–791.
Totenhagen, C. J., Randall, A. K., & Lloyd, K. (2018). Stress and relationship functioning in same-sex couples: The vulnerabilities of internalized homophobia and outness. *Family Relations, 67*(3), 399–413.
Traish, A. M., Feeley, R. J., & Guay, A. T. (2009). Testosterone therapy in women with gynecological and sexual disorders: A triumph of clinical endocrinology from 1938 to 2008. *The Journal of Sexual Medicine, 6*(2), 334–351.
Trivers, R. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), Sexual selection and the descent of man (pp. 136–179). Aldine-Antherton.
van Anders, S. M. (2012). Testosterone and sexual desire in healthy women and men. *Archives of Sexual Behavior, 41*(6), 1471–1484.
van Anders, S. M. (2013). Beyond masculinity: Testosterone, gender/sex, and human social behavior in a comparative context. *Frontiers in Neuroendocrinology, 34*(3), 198–210.
van Anders, S. M., & Goldey, K. L. (2010). Testosterone and partnering are linked via relationship status for women and 'relationship orientation'for men. *Hormones and Behavior, 58*(5), 820–826.
van Anders, S. M., Goldey, K. L., & Bell, S. N. (2014). Measurement of testosterone in human sexuality research: Methodological considerations. *Archives of Sexual Behavior, 43*(2), 231–250.
van Anders, S. M., Goldey, K. L., & Kuo, P. X. (2011). The steroid/peptide theory of social bonds: Integrating testosterone and peptide responses for classifying social behavioral contexts. *Psychoneuroendocrinology, 36*(9), 1265–1275.
van Anders, S. M., Hamilton, L. D., Schmidt, N., & Watson, N. V. (2007). Associations between testosterone secretion and sexual activity in women. *Hormones and Behavior, 51*(4), 477–482.
van Anders, S. M., Hamilton, L. D., & Watson, N. V. (2007). Multiple partners are associated with higher testosterone in North American men and women. *Hormones and Behavior, 51*(3), 454–459.
van Anders, S. M., Steiger, J., & Goldey, K. L. (2015). Effects of gendered behavior on testosterone in women and men. *Proceedings of the National Academy of Sciences, 112*(45), 13805–13810.
Vignozzi, L., & Reisman, Y. (2020). Testosterone in women: Are we closing the gender gap? *Nature Reviews Urology, 17*(2), 67–68.
Wåhlin-Jacobsen, S., Pedersen, A. T., Kristensen, E., Læssøe, N. C., Lundqvist, M., Cohen, A. S., & Giraldi, A. (2015). Is there a correlation between androgens and sexual desire in women? *The Journal of Sexual Medicine, 12*(2), 358–373.
Wood, W., & Eagly, A. H. (2012). Biosocial construction of sex differences and similarities in behavior. In *Advances in Experimental Social Psychology* (Vol. 46, pp. 55–123). Elsevier.
Yeh, H.-C., Lorenz, F. O., Wickrama, K. A. S., Conger, R. D., & Elder, G. H., Jr. (2006). Relationships among sexual satisfaction, marital quality, and marital instability at midlife. *Journal of Family Psychology, 20*(2), 339–343.