Quantifying the Sexual Afterglow: The Lingering Benefits of Sex and Their Implications for Pair-Bonded Relationships

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Abstract

Sex presumably facilitates pair bonding, but how do partners remain pair-bonded between sexual acts? Evolutionary perspectives suggest that sexual afterglow serves this purpose. We explored how long sexual satisfaction would remain elevated following sex and predicted that stronger sexual afterglow would characterize more satisfying partnerships. We pooled the data from two independent, longitudinal studies of newlywed couples to examine these issues. Spouses reported their daily sexual activity and sexual satisfaction for 14 days and their marital satisfaction at baseline and 4 or 6 months later. Results demonstrated that sexual satisfaction remained elevated approximately 48 hr after sex, and spouses experiencing a stronger afterglow reported higher levels of marital satisfaction both at baseline and over time. We interpret these findings as evidence that sexual afterglow is a proximal cognitive mechanism through which sex promotes pair bonding.

Sex is a defining feature of romantic relationships. From an evolutionary perspective, the ultimate value of sex in relationships is obvious: Sex leads to reproduction and gene propagation (Alexander & Noonan, 1979). But some researchers have proposed that sex has a secondary function in humans and other animals that require biparental care: It facilitates pair bonding (Birnbaum & Finkel, 2015; Meston & Buss, 2007; Young & Wang, 2004). Research on monogamous prairie voles has directly linked sex to pair bonding by indicating that sex activates dopamine and neuropeptide (e.g., oxytocin, vasopressin) receptors in the brain's reward circuitry that function to condition attachments to sexual partners (Young & Wang, 2004). In humans, these same neural pathways have been linked to sexual arousal and sexual satisfaction (Bartels & Zeki, 2000; Carmichael et al., 1987), which have been directly linked to the maintenance of relationship satisfaction over time (McNulty, Wenner, & Fisher, 2016; Yeh, Lorenz, Wickrama, Conger, & Elder, 2006).

Yet, despite the apparent benefits of sex for long-term relationship stability, there are significant costs to having constant or uninterrupted sex (Daly, 1978; Lehtonen, Jennions, & Kokko, 2012). First, sex requires resources, such as time and energy. Throughout humans' evolutionary history, time and effort spent on mating depleted finite resources otherwise available for hunting, gathering, and self-protection (Daly, 1978). Second, men's sperm concentration decreases with successive ejaculations, and thus the likelihood of conception decreases as

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sexual frequency increases (Carlsen, Petersen, Andersson, & Skakkebaek, 2004; Sauer, Zeffer, Buster, & Sokol, 1988). Peak sperm concentration appears to be restored after approximately 1 to 3 days of abstinence (Carlsen et al., 2004; Levin, 2009; Sauer et al., 1988). Finally, because of the anatomical structure of the human penis, men risk displacing their own sperm during successive copulations (Gallup et al., 2003). The probability of conception is maximized approximately 2 days after sex (Wilcox, Weinberg, & Baird, 1995). Taken together, these findings suggest that remaining abstinent for several days after engaging in sex could have provided a reproductive advantage. It is thus not surprising that young married people (a) engage in sex approximately once every 2 to 4 days (Call, Sprecher, & Schwartz, 1995; McNulty et al., 2016; Meltzer & McNulty, 2016), (b) demonstrate reduced benefits of particularly frequent sex (Muise, Schimmack, & Impett, 2016), and even (c) report reduced happiness when instructed to increase their frequency of sex as part of their participation in experimental research (Loewenstein, Krishnamurti, Kopsic, & McDonald, 2015).

Given the crucial role of sex in pair bonding, how might humans remain pair-bonded while engaging in sex only intermittently? One possibility is that intimates experience enhanced sexual satisfaction that lingers following sexual activity (i.e., a sexual afterglow) and that this lingering sexual satisfaction functions to sustain the pair bond. This possibility makes sense given that sexual satisfaction consistently predicts global reports of relationship satisfaction, whereas specific acts of sex do not (Hicks, McNulty, Meltzer, & Olson, 2016; McNulty et al., 2016; Yeh et al., 2006; but see Brody & Costa, 2009). Nevertheless, this possibility raises two questions. First, if couples do experience a sexual afterglow, how long does it last? Given that (a) peak sperm concentrations are restored, (b) the likelihood of conception is maximized, and (c) committed partners engage in sex approximately 24 to 72 hr after a previous act of sex (Carlsen et al., 2004; Levin, 2009; McNulty et al., 2016; Meltzer & McNulty, 2016; Wilcox et al., 1995), sexual afterglow may last a similar duration. The first aim of the current research was to examine the duration of intimates' elevated sexual satisfaction following a single act of sex. Second, if couples experience a sexual afterglow, does it predict relationship outcomes over time? If afterglow functions to facilitate pair bonding, intimates with a stronger afterglow (i.e., stronger association between sex and lingering sexual satisfaction) may remain more satisfied with their relationships over time. The second aim of the current research was to examine the association between intimates' sexual afterglow and their prospective relationship satisfaction. We pooled the data from two independent, longitudinal studies of newlywed couples to pursue both aims.

Method

Participants

Participants in Study 1 were 186 members of 96 couples who completed at least three consecutive days of a 14-day diary component of a broader longitudinal study of 113 newlywed couples in northern Texas (21 husbands and 19 wives did not complete at least three consecutive days of the daily diary). Participants in Study 2 were 230 members of 118 couples (1 lesbian couple) who completed at least three consecutive days of a 14-day diary component of a broader longitudinal study of 120 newlywed couples in northern Florida (7 husbands and 3 wives did not complete at least three consecutive days of the daily diary). In each study, data collection was initially planned for 12 months but was extended for 1 additional month to increase sample size.

Participants in both studies were recruited via letters sent to couples who had recently applied for marriage licenses. In the area targeted in Study 1, a large number of couples registered for marriage licenses each month, so we sent letters to 700 randomly selected couples. In the area targeted in Study 2, we were able to receive only names (not addresses) through the county clerk, so we sent letters only to those couples for whom we could find local addresses online. To compensate for this limitation in Study 2, we additionally recruited couples using fliers and Facebook advertising. Of the 82 couples for whom recruitment data were available, 40% were recruited via letters, 45% were recruited via Facebook advertising, 12% were recruited via fliers, and 23% were recruited via word of mouth. These percentages do not sum to 100% because these categories are not mutually exclusive (i.e., some couples learned about the study in multiple ways).

Given the broader goals of the studies, all couples in Study 1 were required to have been married for fewer than 4 months, and all couples in Study 2 were required to have been married for fewer than 3 months. Additionally, both members of the couples in both studies were required to be at least 18 years of age and to speak English (to ensure comprehension of the self-report questionnaires). An additional criterion in Study 1 was that both members of the couples had to be in their first marriage.

At baseline, the husbands in Study 1 were 27.73 (SD = 4.40) years of age and had completed 15.54 (SD = 2.67) years of education. Seventy-five percent were employed full time, and 13% were full-time students. The mean income reported by these husbands was $41,014 ($SD$ = $32,817) per year. The wives in Study 1 were 26.66 (SD = 4.42) years of age and had completed 16.21 (SD = 2.81) years of education. Fifty-four percent were employed full time, and 13% were full-time students. The mean income reported by these wives was $32,476 ($SD$ = $31,636) per

year. The sample was diverse; 50% of husbands and 52% of wives self-identified as Caucasian, 22% of husbands and 22% of wives self-identified as Black or African American, 19% of husbands and 15% of wives self-identified as Hispanic or Latino, 3% of husbands and 5% of wives self-identified as Asian, and 6% of husbands and 6% of wives self-identified as another race or ethnicity. The couples had been together an average of 38.92 (*SD* = 33.34) months prior to marriage, and 20% of the couples had children.

At baseline, the husbands in Study 2 were 31.69 (*SD* = 9.58) years of age and had completed 15.94 (*SD* = 2.52) years of education. Seventy-one percent were employed full time, and 21% were full-time students. The mean income reported by these husbands was $29,440 (*SD* = $24,582) per year. Twenty-six percent of the husbands had been married at least once before their current relationship. The wives in Study 2 were 29.75 (*SD* = 7.97) years of age and had completed 16.29 (*SD* = 2.44) years of education. Sixty-two percent were employed full time, and 21% were full-time students. The mean income reported by these wives was $29,642 (*SD* = $50,237) per year. Twenty-two percent of the wives had been married at least once before their current relationship. This sample was also relatively diverse; 79% percent of husbands and 76% of wives self-identified as Caucasian, 12% of husbands and 12% of wives self-identified as Black or African American, 3% of husbands and 5% of wives self-identified as Hispanic or Latino, 1% of husbands and 1% of wives self-identified as Asian, and 5% of husbands and 6% of wives self-identified as another race or ethnicity. The couples had been together an average of 43.39 (*SD* = 31.90) months prior to marriage, and 29% of the couples had children.

Procedure

After enrolling in one of the studies, participants were either mailed a packet of surveys to complete at home and bring with them to a laboratory session or e-mailed a link to Qualtrics.com, where they completed the surveys online prior to their laboratory session. These surveys included three self-report measures of global marital satisfaction, self-report measures of several covariates (sexual frequency, demographic information, Big Five personality traits, self-esteem, depression, and attachment in security), and additional self-report measures beyond the scope of the analyses reported here. In addition, the packet of surveys included a consent form approved by the local human-subjects review board and a letter instructing participants to complete their questionnaires independently of their partners. At their laboratory session, participants completed a variety of tasks beyond the scope of the current analyses. We compensated all couples $100 for completing the surveys and session.

Before leaving the lab, each participant was invited to complete a daily survey before going to bed on each of the subsequent 14 nights. All the couples were given the option of completing these surveys online or through the mail, and the large majority chose to complete them online. The daily survey included items assessing various daily activities, including whether participants had engaged in sex with their partners that day and, regardless of whether they had engaged in sex, their sexual satisfaction that day. In both studies, the couples were paid $35 for completing all 28 diaries, or $1.00 per diary if they failed to complete all 28. After the 14th day, we mailed the couples a check for participating. In Study 1, the wives completed diaries on an average of 12.73 (*SD* = 2.32) days, and the husbands completed diaries on an average of 12.75 (*SD* = 1.99) days; in Study 2, the wives completed diaries on an average of 12.67 (*SD* = 2.44) days, and the husbands completed diaries on an average of 12.39 (*SD* = 2.68) days. In total, analyses testing for a sexual afterglow were based on 5,252 diary reports from 412 individuals.

Approximately 6 months (Study 1) or 4 months (Study 2) after their initial laboratory session, the couples were recontacted by phone or e-mail and were sent (via mail or e-mail) a packet that contained the same three measures of global marital satisfaction, along with a letter of instruction reminding participants to complete the forms independently of their partners. Across both studies, 177 (76% of the broader sample) husbands and 185 (79% of the broader sample) wives (of 189 couples) completed this follow-up assessment. Thus, analyses testing the implications of afterglow for marital-satisfaction trajectories were based on the responses of a total of 362 individuals. The participants who did not complete this follow-up assessment did not differ in age, income, or baseline marital satisfaction from those who did complete it (all *p*s > .371). The participants who did not complete this follow-up assessment, however, had completed fewer years of formal education, *t*(413) = 3.85, *p* < .001, and were less likely to self-identify as Caucasian, χ^2(1, *N* = 415) = 8.80, *p* = .003, than the participants who had completed it. Thus, we controlled for these variables in supplemental analyses predicting changes in marital satisfaction. All couples received a check ($30 in Study 1; $25 in Study 2) for completing this follow-up assessment.

Measures

Sex. Before going to bed each of the 14 nights of the diary phase, participants were asked to independently respond to the question: "Did you have sex with your partner today?" Other researchers have documented (e.g., Jacobson & Moore, 1981) that partners do not always report the same daily behaviors, including sexual behavior, and indeed, across both studies, the correlation

between partners' reports was .84. We relied on individuals' reports of sex by forming a dummy code for sex that was coded 0 if the participant reported not having had sex with his or her partner that day and 1 if the participant reported having had sex with his or her partner that day. The Supplemental Material available online reports analyses suggesting that most sex was positive.

Daily sexual satisfaction. As part of the same diary assessment, regardless of whether participants indicated that they had engaged in sex with their partner that day, they were asked to respond to the question: "How satisfied were you with your sex life today?" The response scale ranged from 1, *not at all satisfied*, to 7, *extremely satisfied*.

Daily marital satisfaction. Also as part of the same diary assessment, and also regardless of whether participants indicated that they had engaged in sex with their partner that day, they were asked to respond to the following three questions: "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 for these questions ranged from 1, *not at all satisfied*, to 7 *extremely satisfied* (see Schumm et al., 1986). We summed these responses to form a measure of daily marital satisfaction (all coefficient αs > .90).

Global marital satisfaction. The participants completed three measures of global marital satisfaction at baseline and at the follow-up assessment. One measure was the Quality Marriage Index (Norton, 1983), which contains six items asking respondents to indicate the extent of their agreement with general statements regarding the quality of their marriage. The second measure was a version of the semantic differential (Osgood, Suci, & Tannenbaum, 1957); the participants were asked to rate their perceptions of their marriage on fifteen 7-point scales anchored by opposing adjectives (e.g., *dissatisfied-satisfied*). The third measure was the Kansas Marital Satisfaction Scale (Schumm et al., 1986), which asks respondents to indicate the extent of their agreement with three general statements regarding the quality of their marriage. Internal consistency of all three measures was high (across both assessments in both studies, all coefficient αs for husbands and wives ≥ .90). So that our results would not be specific to one measure, we created an index of global marital satisfaction for each participant by averaging the three measures after standardizing each one across assessments. This decision to create a composite score was supported by the fact that the three scales were highly correlated at each assessment (all *r*s ≥ .74).

Covariates. We assessed and controlled for several potential confounds. We assessed sexual frequency by asking each participant to provide a numerical estimate of the number of times the couple had engaged in sex during the prior 4 (Study 2) or 6 (Study 1) months. We assessed participants' Big Five personality traits using the International Personality Item Pool (Goldberg, 1999). In Study 1, we used the 60-item subscales for neuroticism and conscientiousness and the 10-item subscales for extraversion, agreeableness, and openness; in Study 2, we assessed all five traits using the 60-item subscales. Differences in the number of items used within and across studies were due to the goals of the broader studies and attempts to minimize the burden on participants. We assessed participants' depressive symptoms using the 20-item Center for Epidemiologic Studies Depression Scale (Radloff, 1977), and we assessed participants' self-esteem using the 10-item Rosenberg (1965) Self-Esteem Scale. Finally, we assessed participants' attachment insecurity using the 36-item Experiences in Close Relationships Scale (Brennan, Clark, & Shaver, 1998). Internal consistency was strong for all the covariates (αs = .83–.96, median = .92). Fifty-nine participants did not complete the sexual-frequency measure, and 16 did not complete at least one of the other measures. To minimize loss of power due to these missing data, we conducted separate supplemental analyses that controlled for frequency of sex and for the remaining covariates (specifically, participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage).

Results

Descriptive statistics and preliminary analyses

Given that the procedures of the two studies were similar, we pooled their data. Effects were not moderated by study and, as detailed in the Supplemental Material, were generally replicated when we analyzed the data from each study separately. Participants reported that they engaged in sex on approximately 4 of the 14 days of the diary (*M* = 3.94), though there was substantial between-person variability in these reports (*SD* = 2.83, range = 0–14). Notably, this frequency is similar to what has been observed in other samples of newlywed couples using different methods of assessment (e.g., Call et al., 1995; McNulty et al., 2016; Meltzer & McNulty, 2016). This provides some confidence that our diary assessment did indeed capture instances of sex when they occurred. Sexual-satisfaction ratings were just above the midpoint of the scale and normally distributed (*M* = 4.83, *SD* = 1.98,

Table 1. Results of Models Testing the Effects of Sexual Intercourse on Immediate and Lingering Sexual Satisfaction

Predictor	Same-day effect			24-hr effect			48-hr effect			72-hr effect		
	β	SE	r	β	SE	r	β	SE	r	β	SE	r
Intercept	4.34	0.08		4.22	0.09		4.21	0.09		4.21	0.10	
Study	−0.04	0.04	.05	−0.04	0.04	.05	−0.05	0.05	.07	−0.05	0.05	.08
Day of diary entry	0.00	0.01	.03	0.01	0.01	.06	−0.00	0.01	.00	−0.00	0.01	.01
Sex the same day	**1.89**	**0.08**	**.84****	1.93	0.05	.85**	1.90	0.09	.83**	1.93	0.09	.82**
Sex 1 day prior				**0.41**	**0.05**	**.51****	0.42	0.05	.50**	0.39	0.05	.46**
Sex 2 days prior							**0.12**	**0.04**	**.19***	0.13	0.05	.18*
Sex 3 days prior										**0.01**	**0.05**	**.02**

Note: Across all models, *df* = 212 for the intercept and study estimates, and *df* = 213 for all other estimates; we included a grand-mean-centered dummy code for study. For the sake of clarity, the key effects in each model are in boldface. Effect-size *r* is reported.
*p < .01. ***p* < .001.

skewness = −0.54, kurtosis = −0.80), and husbands and wives did not differ in these ratings, $t(414) = -0.65, p = .518$.

Do intimates experience a sexual afterglow?

Given the nested nature of the data (repeated daily assessments were nested within individuals, and individuals were nested within dyads), we examined whether sex has immediate benefits for sexual satisfaction using multilevel modeling with HLM 7.01 (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011). We estimated the following Level 1 equation in a three-level model:

$$Y_{ti} = \pi_{0i} + \pi_{1i}(\text{day of diary entry}) + \pi_{2i}(\text{sex the same day}) + e_{ti}, \quad (1)$$

where Y_{ti} refers to individual i's sexual satisfaction at time t, the day of the diary entry, and π_{0i} is the intercept. Day of diary entry (a covariate) was grand-mean-centered, and sex the same day was uncentered. A grand-mean-centered dummy code for study was included on the Level 3 intercept, all Level 2 estimates were allowed to vary across individuals, and the shared variance between husbands' and wives' data was controlled in Level 3; all Level 3 estimates were allowed to vary randomly across couples. Results from this analysis are presented in the first column of Table 1.

Not surprisingly, sex on a given day was strongly positively associated with sexual satisfaction on that same day. Notably, supplemental analyses demonstrated that this effect was not moderated by study, $\beta = -0.05, SE = 0.08, t(212) = -0.57, p > .250$; by participants' sex (coded 0 for husbands and 1 for wives), $\beta = -0.11, SE = 0.12, t(213) = -0.91, p > .250$; or by participants' age, $\beta = -0.01, SE = 0.01, t(213) = -1.63, p = .105$. Supplemental analyses also demonstrated that the effect held when we controlled for baseline reports of sexual frequency, $\beta = 1.89, SE = 0.09$,

$t(202) = 20.73, p < .001$, 95% confidence interval (CI) = [1.71, 2.07], effect-size $r = .82$, and when we controlled for participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage, $\beta = 1.89, SE = 0.08, t(212) = 23.05, p < .001$, 95% CI = [1.73, 2.05], effect-size $r = .85$.

How long does sexual afterglow last?

Next, we estimated a series of models that examined the length of sexual afterglow. Specifically, we estimated three different models to examine the extent to which sex on a given day predicted sexual satisfaction (a) on the following day (i.e., 24 hr later), (b) 2 days later (i.e., 48 hr later), and (c) 3 days later (i.e., 72 hr later). First, we examined the extent to which sex on a given day predicted sexual satisfaction 24 hr later by estimating the following lagged Level 1 equation in a three-level model with the same specifications as Equation 1:

$$Y_{ti} = \pi_{0i} + \pi_{1i}(\text{day of diary entry}) + \pi_{2i}(\text{sex 1 day prior}) + \pi_{3i}(\text{sex the same day}) + e_{ti}, \quad (2)$$

where Y_{ti} refers to individual i's sexual satisfaction at time t, the day of the diary entry, and π_{0i} is the intercept. Results from this analysis are presented in the second column of Table 1. As shown, sexual satisfaction on a given day was positively associated with engaging in sex the previous day, controlling for whether the couple also engaged in sex on that same day. Notably, supplemental analyses demonstrated that this 24-hr effect was not moderated by study, $\beta = 0.07, SE = 0.09, t(212) = 0.85, p > .250$; by participants' sex, $\beta = 0.01, SE = 0.08, t(213) = 0.17, p > .250$; or by participants' age, $\beta = 0.01, SE = 0.01, t(213) = 1.19, p = .237$. Supplemental analyses also demonstrated that this effect held when we controlled for baseline reports of sexual frequency, $\beta = 0.40, SE = 0.05$,

$t(202) = 7.77$, $p < .001$, 95% CI = [0.30, 0.50], effect-size $r = .48$, and when we controlled for participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage, $\beta = 0.43$, $SE = 0.05$, $t(212) = 9.02$, $p < .001$, 95% CI = [0.33, 0.53], effect-size $r = .53$. These findings indicate that sexual afterglow lasts at least 24 hr.

In the second of the three models, we examined the extent to which sex on a given day predicted sexual satisfaction 48 hr later by estimating the following lagged Level 1 equation in a three-level model with the same specifications as Equation 1:

$$Y_{ti} = \pi_{0i} + \pi_{1i}(\text{day of diary entry}) + \\ \pi_{2i}(\text{sex 2 days prior}) + \pi_{3i}(\text{sex 1 day prior}) + \quad (3) \\ \pi_{4i}(\text{sex the same day}) + e_{ti},$$

where Y_{ti} refers to individual i's sexual satisfaction at time t, the day of the diary entry, and π_{0i} is the intercept. Results from this analysis are presented in the third column of Table 1. As shown, sexual satisfaction on a given day was positively associated with engaging in sex 2 days prior, controlling for whether the couple also engaged in sex 1 day prior or on that same day. Notably, supplemental analyses demonstrated that this 48-hr effect was not moderated by study, $\beta = -0.03$, $SE = 0.09$, $t(212) = -0.36$, $p > .250$; by participants' sex, $\beta = 0.05$, $SE = 0.08$, $t(213) = 0.55$, $p > .250$; or by participants' age, $\beta = 0.01$, $SE = 0.01$, $t(213) = 1.54$, $p = .125$. Supplemental analyses also demonstrated that this 48-hr effect was marginally significant when we controlled for baseline reports of sexual frequency, $\beta = 0.09$, $SE = 0.05$, $t(202) = 1.83$, $p = .068$, 95% CI = [−0.01, 0.19], effect-size $r = .13$, and was significant when we controlled for participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage, $\beta = 0.14$, $SE = 0.05$, $t(212) = 2.99$, $p = .003$, 95% CI = [0.04, 0.24], effect-size $r = .20$. These findings indicate that sexual afterglow lasts at least 48 hr.

In the third of the three models, we examined the extent to which sex on a given day predicted sexual satisfaction 72 hr later by estimating the following lagged Level 1 equation in a three-level model with the same specifications as Equation 1:

$$Y_{ti} = \pi_{0i} + \pi_{1i}(\text{day of diary entry}) + \\ \pi_{2i}(\text{sex 3 days prior}) + \pi_{3i}(\text{sex 2 days prior}) + \quad (4) \\ \pi_{4i}(\text{sex 1 day prior}) + \pi_{5i}(\text{sex the same day}) + e_{ti},$$

where Y_{ti} refers to individual i's sexual satisfaction at time t, the day of the diary entry, and π_{0i} is the intercept. Results from this analysis are presented in the final column of Table 1. As shown, sexual satisfaction on a given day was not associated with engaging in sex 3 days prior, controlling for whether the couple additionally engaged in sex 2 days prior, 1 day prior, or on that same day. Notably, supplemental analyses demonstrated that this nonsignificant 72-hr effect was not moderated by study, $\beta = -0.13$, $SE = 0.09$, $t(212) = -1.47$, $p = .144$; by participants' sex, $\beta = -0.02$, $SE = 0.09$, $t(213) = -0.18$, $p > .250$; or by participants' age, $\beta = -0.00$, $SE = 0.01$, $t(213) = -0.66$, $p > .250$. Supplemental analyses also demonstrated that the 72-hr effect continued to be nonsignificant when we controlled for baseline reports of sexual frequency, $\beta = -0.02$, $SE = 0.05$, $t(202) = -0.33$, $p > .250$, and when we controlled for participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage, $\beta = 0.00$, $SE = 0.05$, $t(212) = 0.01$, $p > .250$. Taken together, the results of these analyses indicate that sexual afterglow lasts 48 hr, but not 72 hr.

By what process does sex lead to enhanced sexual satisfaction 48 hr later?

Our conceptual model is based on the idea that a single act of sex promotes biological changes (as demonstrated in other research; see Bartels & Zeki, 2000; Carmichael et al., 1987) that are decoded as sexual satisfaction. We contend that sexual afterglow emerges because these biological changes remain and continue to be decoded as sexual satisfaction for an extended period of time after the act of sex. Accordingly, sexual satisfaction immediately after sex (i.e., sexual satisfaction the same day) should explain elevated sexual satisfaction 48 hr later (i.e., sexual afterglow). Thus, we examined whether the sexual satisfaction observed 48 hr after sex could be traced to the sexual satisfaction observed immediately after sex through the intervening level of sexual satisfaction. In other words, we examined whether sexual satisfaction 2 days prior and sexual satisfaction 1 day prior, respectively, mediated the association between sex 2 days prior and sexual satisfaction on a given day (see Fig. 1).

We estimated two mediated paths. First, we examined whether sexual satisfaction on the same day that sex occurred mediated the effect of sex that day on sexual satisfaction the next day, using the procedures outlined by Tofighi and MacKinnon (2011). This indirect effect, $\beta = 0.42$, $SE = 0.04$, was significant, 95% CI = [0.34, 0.51], $p < .001$. Thus, sexual satisfaction on the same day that sex occurred mediated the effect of that day's sex on sexual satisfaction the next day. Second, we examined whether sexual satisfaction on the day after sex occurred mediated the effect of sexual satisfaction the previous day (i.e., the day that sex occurred) on sexual satisfaction 2 days after sex, using the same procedures. This indirect
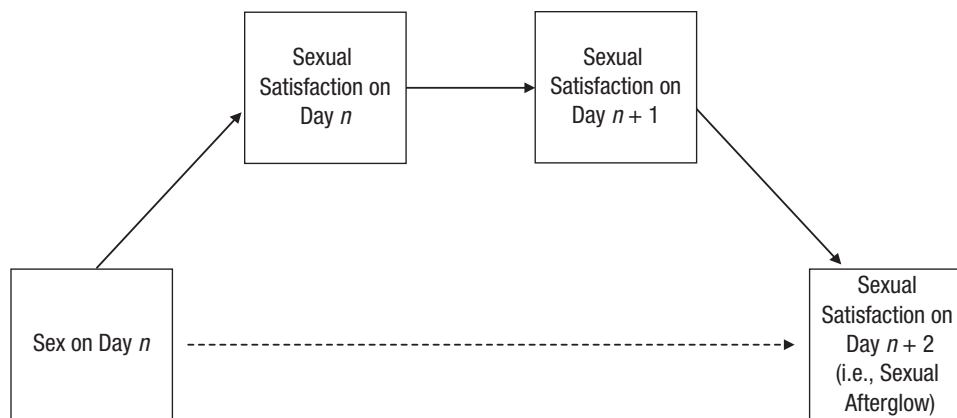
Fig. 1. Conceptual model of sexual afterglow. According to this model, the effect that sex on a given day has on sexual satisfaction 2 days later (direct effect; dashed line) may be mediated by sexual satisfaction the same day and 1 day later (indirect effects; solid lines).

effect, $\beta = 0.04$, $SE = 0.00$, was also significant, 95% CI = [0.04, 0.05], $p < .001$. Thus, sexual satisfaction the day after sex mediated the effect of immediate sexual satisfaction on sexual satisfaction 2 days after sex. Notably, once we controlled for sexual satisfaction on the day of sex and sexual satisfaction 1 day following sex, sex on any given day was no longer associated with sexual satisfaction 2 days later, $\beta = -0.04$, $SE = 0.05$, $t(213) = -0.90$, $p = .371$. This suggests that the 48-hr afterglow effect can be traced indirectly to the sexual satisfaction that occurs immediately after sex.

Is intimates' sexual afterglow associated with the trajectory of their marital satisfaction?

Finally, we examined whether sexual afterglow functions to maintain the pair bond by testing whether between-person differences in the strength of the 48-hr sexual afterglow predicted the trajectory of participants' marital satisfaction. Before addressing this question, however, we estimated the trajectories of participants' global marital satisfaction over the first few months of marriage across the two studies by computing a three-level growth-curve model. Specifically, at Level 1, we regressed each participant's marital satisfaction on the time of assessment, which was coded as the month of assessment; baseline was coded as 0, and follow-up was coded as 4 (in Study 2) or 6 (in Study 1). The autocorrelation from repeated assessments was controlled in Level 2, the shared variance between husbands' and wives' data was controlled in Level 3, idiosyncratic differences between studies were controlled by including a grand-mean-centered dummy code on the Level 3 intercept, and the Level 2 and Level 3 intercepts were allowed to vary randomly. Given that we modeled marital satisfaction using only

two time points, slopes were fixed across individuals and couples. We used restricted maximum likelihood estimation and placed no restrictions on the autoregressive error structures. According to this analysis, husbands and wives experienced declines in global marital satisfaction across the first 4 to 6 months of marriage, $\beta = -0.07$, $SE = 0.01$, $t(147) = -5.61$, $p < .001$, 95% CI = $[-0.09, -0.05]$, effect-size $r = .42$. Notably, a supplemental analysis demonstrated that this effect was not moderated by participants' sex, $\beta = 0.01$, $SE = 0.01$, $t(146) = 0.45$, $p > .250$.

To examine the extent to which participants' 48-hr sexual afterglow was associated with the two components of this trajectory (the intercept representing initial marital satisfaction and the slope representing decline in marital satisfaction across the first several months of marriage), we regressed both these parameters as estimated at Level 1 on between-person differences in the 48-hr afterglow effect at Level 2 of a three-level model. The afterglow effect was operationalized as the empirical Bayes estimate of the within-person association between sexual satisfaction on a given day and sex 2 days prior, which we obtained from the residual files formed by estimating the 48-hr effect (the second of our three sexual-afterglow models described earlier). The autocorrelation from repeated assessments was controlled in Level 2, the shared variance between husbands' and wives' data was controlled in Level 3, and the Level 2 and Level 3 intercepts were allowed to vary randomly.

The results are presented in Table 2. As the table shows, the strength of participants' 48-hr sexual afterglow was positively associated with both initial marital satisfaction and changes in marital satisfaction over time.

Figure 2 presents trajectories of marital satisfaction for participants whose 48-hr sexual afterglow was 1 *SD* below and 1 *SD* above the sample mean. As the figure reveals, participants who reported relatively high levels

Table 2. The Effects of Participants' 48-Hr Sexual Afterglow on the Trajectory of Their Marital Satisfaction

	Initial marital satisfaction				Change in marital satisfaction			
Predictor	β	SE	df	r	β	SE	df	r
Study	0.01	0.10	212	.01				
48-hr afterglow	0.07	0.02	201	.19*	0.03	0.01	146	.22*

Note: We included a grand-mean-centered dummy code for study. Effect-size *r* is reported.
*$p < .01$.

of sexual afterglow 48 hr after engaging in sex also reported relatively high levels of marital satisfaction at the time of marriage and remained more satisfied over the subsequent months of marriage compared with participants who reported relatively low levels of sexual afterglow 48 hr after engaging in sex. Notably, a supplemental analysis demonstrated that neither effect was moderated by study—initial marital satisfaction: $\beta = 0.06$, $SE = 0.05$, $t(200) = 1.19$, $p = .237$; change in marital satisfaction: $\beta = 0.02$, $SE = 0.02$, $t(144) = 0.74$, $p > .250$. Further, a supplemental analysis demonstrated that neither effect was moderated by participants' sex—initial marital satisfaction: $\beta = 0.10$, $SE = 0.07$, $t(199) = 1.45$, $p = .147$; change in marital satisfaction: $\beta = -0.01$, $SE = 0.03$, $t(144) = -0.39$, $p > .250$. Also, neither effect was moderated by participants' age—initial marital satisfaction: $\beta = -0.01$, $SE = 0.01$, $t(197) = -0.94$, $p > .250$; change in marital satisfaction: $\beta = -0.00$, $SE = 0.01$, $t(142) = -0.39$, $p > .250$. A supplemental analysis also demonstrated that both effects

held when we controlled for baseline reports of sexual frequency—initial marital satisfaction: $\beta = 0.07$, $SE = 0.03$, $t(152) = 2.49$, $p = .014$, 95% CI = [0.01, 0.13], effect-size $r = .20$; change in marital satisfaction, $\beta = 0.03$, $SE = 0.01$, $t(99) = 3.01$, $p = .004$, 95% CI = [0.01, 0.06], effect-size $r = .29$. Finally, a supplemental analysis also demonstrated that the intercept effect was marginally significant and the slope effect was significant when we controlled for participants' age, education, race-ethnicity, Big Five traits, depression, self-esteem, and insecure attachment, as well as the length of couples' relationships prior to marriage—initial marital satisfaction: $\beta = 0.05$, $SE = 0.03$, $t(173) = 1.93$, $p = .055$, 95% CI = [−0.01, 0.11], effect-size $r = .14$; change in marital satisfaction: $\beta = 0.03$, $SE = 0.01$, $t(132) = 2.97$, $p = .004$, 95% CI = [0.01, 0.05], effect-size $r = .25$.

Are these effects unique to sexual afterglow?

Although our conceptual model stemmed from questions about the existence and function of sexual afterglow, it is also possible that sex provides an immediate benefit to global relationship satisfaction that functions to promote long-term pair bonding. If so, and if these two measures of afterglow are correlated, it may be this relational afterglow, rather than sexual afterglow, that accounts for the trajectory of marital satisfaction. To find out, we reestimated Equation 3, substituting daily marital satisfaction for daily sexual satisfaction, and we used the strength of this relational afterglow to predict the trajectory of marital satisfaction. Sex was marginally positively associated with marital satisfaction 48 hr after sex, $\beta = 0.07$, $SE = 0.04$, $t(213) = 1.93$, $p = .055$, 95% CI = [−0.01, 0.15], effect-size $r = .13$. However, that association was no longer significant when we controlled for sexual satisfaction 48 hr after sex, $\beta = 0.02$, $SE = 0.03$, $t(213) = 0.74$, $p > .250$. In contrast, the association between sex on a given day and sexual satisfaction 48 hr later remained significant when we controlled for marital satisfaction 48 hr after sex, $\beta = 0.11$, $SE = 0.04$, $t(213) = 2.80$, $p = .006$, 95% CI = [0.03, 0.19], effect-size $r = .19$.

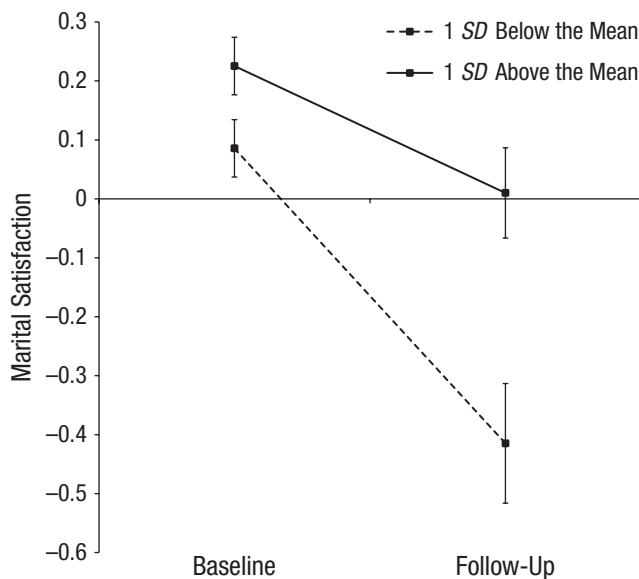Moreover, and crucially, when both forms of afterglow were used to predict the trajectory of marital satisfaction

Fig. 2. Implications of sexual afterglow for the trajectory of marital satisfaction: marital satisfaction at baseline and at the follow-up assessment for participants whose 48-hr sexual afterglow was 1 *SD* below and 1 *SD* above the sample mean. Error bars represent ±1 *SE*.

over time, sexual afterglow continued to positively predict both components of the trajectory of marital satisfaction—initial marital satisfaction: β = 0.06, *SE* = 0.03, *t*(197) = 2.21, *p* = .028, 95% CI = [0.00, 0.12], effect-size *r* = .16; change in marital satisfaction: β = 0.03, *SE* = 0.01, *t*(142) = 2.65, *p* = .009, 95% CI = [0.01, 0.05], effect-size *r* = .22—whereas relational afterglow did not. In fact, relational afterglow was negatively associated with marital satisfaction both when we controlled for sexual afterglow—initial marital satisfaction: β = −0.14, *SE* = 0.03, *t*(197) = −4.53, *p* < .001, 95% CI = [0.08, 0.20], effect-size *r* = .31; change in marital satisfaction: β = −0.02, *SE* = 0.01, *t*(142) = −2.08, *p* = .040, 95% CI = [−0.04, 0.00], effect-size *r* = .17—and when we did not control for sexual afterglow—initial marital satisfaction: β = −0.14, *SE* = 0.03, *t*(198) = −4.72, *p* < .001, 95% CI = [−0.20, −0.08], effect-size *r* = .32; change in marital satisfaction: β = −0.03, *SE* = 0.01, *t*(143) = −2.46, *p* = .015, 95% CI = [−0.05, −0.01], effect-size *r* = .20. In other words, lingering sexual satisfaction appears to serve a unique function for relationships by proximally linking immediate sexual experiences with more distal and general relationship evaluations.

Discussion

Sex is a defining feature of romantic relationships assumed not only to promote successful reproduction but also to facilitate pair bonding (Birnbaum & Finkel, 2015; Meston & Buss, 2007). There are, however, significant costs to having constant or uninterrupted sex (Carlsen et al., 2004; Daly, 1978; Gallup et al., 2003; Lehtonen et al., 2012; Sauer et al., 1988; Wilcox et al., 1995). We pooled data from two independent, longitudinal studies of newlywed couples and obtained support for the idea that couples experience a sexual afterglow (i.e., lingering sexual satisfaction following sexual activity) that functions to sustain the pair bond between acts of sex. Following a single occurrence of sex, participants reported enhanced sexual satisfaction that lasted 48 hr but not 72 hr. Further, participants who reported relatively high levels of this sexual afterglow 48 hr after engaging in sex also reported relatively high levels of marital satisfaction at the time of marriage and remained more satisfied over the subsequent months of marriage compared with participants who reported relatively low levels of sexual afterglow 48 hr after engaging in sex.

Several strengths of this research enhance our confidence in these conclusions. First, the current work drew from two independent studies of marriage, which allowed for increased power, and the fact that the results did not vary between the studies demonstrates replicability. Second, rather than using data from people in newly formed relationships or asking single people to imagine they are involved in relationships, we used data from young,

married couples for whom the measured outcomes were real and consequential. Third, analyses controlled for numerous potential confounds, which decreased the possibility that the results were spurious because of associations between those variables and our key variables. Finally, because all the participants were newlyweds, our results are unlikely to be the product of unmeasured differences in marital duration.

Several limitations of this research should also be considered until the findings can be replicated and extended. First, the self-report measures of sexual afterglow and marital satisfaction may have been biased by participants' perceptions or motivations to appear positive. Moreover, given its links to biological processes, part of the afterglow process may escape conscious awareness, and thus future research may benefit from using implicit measurements (see Hicks et al., 2016; McNulty & Olson, 2015). Second, although we instructed participants to complete their daily diaries each night before falling asleep, and although participants reported engaging in sex as frequently as has been observed in other samples using different measurement techniques (e.g., Call et al., 1995; McNulty et al., 2016; Meltzer & McNulty, 2016), it is possible that we failed to capture some of the days' activities (e.g., sex). Nevertheless, any such unmeasured occurrences of sex likely varied randomly (rather than systematically) with the other variables examined and thus likely added measurement error that made our tests more conservative rather than biased in favor of our predictions. Third, although participants reported being very satisfied, on average, with the sex they reported (see the Supplemental Material), some sex may have been unwanted, unpleasant, or coercive. Any such undesired sexual activity would have likely undermined our ability to detect effects as well, and future research may benefit from exploring the extent to which the effects of sexual afterglow depend on whether sex is desired or positive. Fourth, whereas the relative homogeneity of the two samples enhances our confidence in the pattern of associations that emerged, this lack of variability limits our ability to generalize these findings to other samples. Indeed, it is unclear if similar patterns would emerge among older or nonheterosexual couples. Finally, our follow-up assessments occurred 4 to 6 months after the daily-diary assessment, and it is unclear whether the strength of sexual afterglow continues to predict intimates' marital satisfaction over a longer period of time. Future research may benefit from examining the stability of sexual afterglow and whether its benefits span longer durations.

These limitations notwithstanding, these findings have important implications for theory and future research. First, as far as we are aware, this is the first research to quantify the length of sexual afterglow and to examine its

benefits. Not only does it join others in demonstrating the role of sex in promoting human pair bonding (Birnbaum & Finkel, 2015; McNulty et al., 2016; Meston & Buss, 2007; Yeh et al., 2006), but it offers evidence for a novel cognitive mechanism through which such links emerge. Specifically, despite occurring intermittently, sex promotes pair bonding by creating a lasting sexual afterglow. This functional role is consistent with the finding that sexual afterglow appears to last approximately the same length of time (a) that it takes for peak sperm concentrations to be restored (Carlsen et al., 2004; Levin, 2009), (b) that sperm remain maximally viable in the female reproductive tract (Wilcox et al., 1995), and (c) that elapses between acts of sex among newlyweds (McNulty et al., 2016; Meltzer & McNulty, 2016). The fact that sex did not have lingering effects on daily relationship satisfaction is consistent with the idea that people may not consciously consider sex when evaluating their relationships (Hicks et al., 2016). Instead, the link between sex and explicit relationship satisfaction may emerge over time through automatic processes, such as sexual afterglow (see McNulty & Olson, 2015; McNulty, Olson, Meltzer, & Shaffer, 2013).

Second, the current findings also suggest several novel directions for future research. For example, given that we drew from neurobiological research on sex (Bartels & Zeki, 2000; Carmichael et al., 1987; Young & Wang, 2004), future research may benefit from examining the role of neuropeptides and other neurochemicals in accounting for the length and implications of afterglow; intimates' neurochemical concentrations may remain elevated for the same length of time as daily sexual satisfaction, and between-person differences in extended elevated concentrations may predict aspects of pair bonding. Additionally, although experiencing a lengthy afterglow may be functional in the context of reproductively viable long-term relationships, such as the new marriages examined here, future research may benefit from examining whether people in other types of relationships experience a longer or shorter afterglow. For example, older individuals in more established relationships for whom reproduction is less important may experience a longer afterglow, whereas individuals in short-term relationships (Buss & Schmitt, 1993) or individuals with a more short-term sexual orientation (Simpson & Gangestad, 1992) may experience a shorter afterglow. Studies consistent with these possibilities have found that sexual desire and frequency decrease over the course of relationships (Baumeister & Bratslavsky, 1999; McNulty et al., 2016). Future research may also benefit from examining the extent to which sexual afterglow predicts other indicators of pair-bonding strength, such as decreased infidelity, the conversion of short-term relationships to long-term relationships, and the decision to marry. In sum, afterglow may be a critical and thus far unexamined predictor or indicator of specific interpersonal processes that ultimately affect relationship satisfaction.

Finally, at a broader level, these findings highlight the importance of the duration of interpersonal experiences for interpersonal well-being. To date, most research on human social relationships has examined the immediate and long-term implications of discrete psychological experiences. For example, rejection (Maner, DeWall, Baumeister, & Schaller, 2007), praise (Flora & Segrin, 2000), forgiveness (McNulty, 2008), and apology (Luchies, Finkel, McNulty, & Kumashiro, 2010) all have measurable effects on relationships, but the current work suggests that the duration of such experiences—that is, the length of their aftermath—is an additional factor worth examining in its own right; how long people remain happy following a compliment, angry following a fight, or motivated following a setback likely has important implications for interpersonal well-being that have been largely unexplored to date.

In sum, the current research suggests that sexual satisfaction remains elevated for 48 hr after sex, on average, and that this sexual afterglow functions to promote long-term pair bonding. Future research may benefit from examining predictors, moderators, and other implications of sexual afterglow.

Action Editor

D. Stephen Lindsay served as action editor for this article.

Author Contributions

A. L. Meltzer, J. K. McNulty, and T. N. Bradbury developed the study concept. A. L. Meltzer and J. K. McNulty were responsible for the study design and oversaw data collection. A. L. Meltzer, A. Makhanova, and J. K. McNulty performed the data analyses and interpretation. A. L. Meltzer, A. Makhanova, L. L. Hicks, and J. E. French drafted the manuscript, and J. K. McNulty and T. N. Bradbury provided critical revisions. All the authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

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Open Practices

As noted by Finkel, Eastwick, and Reis (2015), publicly sharing data from studies of romantic couples risks violating participants' confidentiality, as one spouse may identify his or her partner's data using knowledge or reasonable guesses about that partner's

responses to certain questions. For this reason, the authors chose not to apply for the Open Data badge. All materials have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/4e7j8/. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617691361. This article has received the badge for Open Materials. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

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