



# Adaptive Calibration of Dyadic Sexual Desire Is Sex Differentiated and Disrupted by Hormonal Contraceptives

Juliana E. French<sup>1</sup> · Anastasia Makhanova<sup>2</sup> · Andrea L. Meltzer<sup>3</sup>

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## Abstract

Adaptive calibration models suggest that features of people's childhood ecologies can shape their reproductive outcomes in adulthood. Given the importance of dyadic sexual desire (i.e., desire for sex with a partner) for relationships and reproduction, we examined the extent to which people's childhood ecologies—especially the unpredictability of those ecologies—adaptively calibrate such desire. Nevertheless, because female (versus male) sexual desire is presumed to be more sensitive to situational factors, and because hormonal contraceptives alter myriad aspects of female physiology that influence female sexual desire, we predicted that adaptive calibration of dyadic sexual desire would emerge more strongly for naturally cycling females (versus females who use hormonal contraceptives and versus males). In Study 1, a total of 630 participants (159 males, 203 naturally cycling females, and 268 females using hormonal contraceptives) completed questionnaires assessing the harshness and unpredictability of their childhood ecologies as well as their sexual desire. Consistent with predictions, childhood unpredictability (but not harshness) was positively associated with dyadic (but not solitary) sexual desire among naturally cycling females (but not among females using hormonal contraceptives nor among males). Study 2, which consisted of 736 females (307 naturally cycling females, 429 females using hormonal contraceptives), replicated this pattern of results for females. These findings add to a growing literature suggesting that the instability of people's early childhood ecologies can adaptively calibrate their adult reproductive motivations and behaviors, including their dyadic sexual desire. Not only is the current finding among the first to show that some adaptive calibration processes may be sex differentiated, it further highlights that hormonal contraceptives, which alter the evolved reproductive physiology of females, may disrupt adaptive calibration processes (though such disruption may not be inherently negative).

**Keywords** Sexual desire · Adaptive calibration · Sex differences · Hormonal contraceptives · Evolutionary mismatch

## Introduction

Dyadic sexual desire (i.e., desire for sex with a partner) is a distinguishing feature of romantic relationships that plays a crucial role in relationship outcomes (see Birnbaum et al., 2021; Birnbaum & Finkel, 2015). Indeed, low dyadic sexual desire is associated with relationship dissatisfaction (Day et al., 2015; McNulty et al., 2019; Risch et al., 2003), which

itself predicts relationship dissolution (French et al., 2019; Karney & Bradbury, 1995). Given these implications, it is important to understand the factors underlying individual differences in such desire. In the current work, we examined one potentially important predictor of individual differences in dyadic sexual desire—the quality of people's childhood ecologies.

## Childhood Ecology and Sexuality

Inspired by theoretical insights from evolutionary biology (Chisholm, 1993), recent models of adaptive calibration suggest people's early childhood ecologies facilitate development and behaviors that may be adaptive for navigating a similar environment in adulthood (Belsky et al., 1991; Ellis et al., 2009). Such models further posit that ecological conditions that increase the risk of early mortality may

✉ Juliana E. French  
juliana.french@okstate.edu

<sup>1</sup> Department of Psychology, Oklahoma State University, 116 Psychology Building, Stillwater, OK 74078, USA

<sup>2</sup> Department of Psychological Sciences, University of Arkansas, Fayetteville, AR, USA

<sup>3</sup> Department of Psychology, Florida State University, Tallahassee, FL, USA

be especially influential. First, ecological harshness is one condition that increases mortality and thus shortens life expectancy. Because resource scarcity is a common feature of ecological harshness in modern-day, Western societies (Belsky et al., 2012), life-history theorists have often operationalized childhood harshness as relatively low family socioeconomic status (e.g., see Belsky et al., 2012; French et al., 2020; Griskevicius et al., 2011; Maner et al., 2017; Simpson et al., 2012; Szepeswol et al., 2015). Second, to the extent that ecological conditions are stable, people can potentially learn to forecast outcomes and enact strategies to navigate those conditions effectively; this is not the case when conditions are unpredictable. Childhood unpredictability is thus a second such ecological feature, distinct from childhood harshness (Belsky et al., 2012), that is often indexed by instability in familial life and parental behavior (e.g., see Belsky et al., 2012; French et al., 2020; Maner et al., 2017; Simpson et al., 2012; Szepeswol et al., 2015; Zhao et al., 2022).

According to life history theory, these features of people's childhood ecologies may calibrate their physiological development and adult sexual behavior. More specifically, people reared in relatively harsh and/or unpredictable ecologies often develop earlier and engage in behaviors that facilitate earlier reproduction (e.g., Belsky et al., 1991, 2012; Griskevicius et al., 2011; Hartman et al., 2018; Simpson et al., 2012; Tan et al., 2022), presumably because high early mortality in such environments demands relatively faster reproduction (i.e., “fast” life history strategies). Indeed, such people tend to reach sexual maturity at a younger age, engage in more frequent sexual behavior, have a greater number of sexual partners, and report fewer intentions to use protection against pregnancy during sexual intercourse (Belsky et al., 2010; Dunkel et al., 2015; French et al., 2020; Simpson et al., 2012). Together, this work suggests myriad aspects of adult sexuality are calibrated to people's childhood ecologies in ways that may functionally increase the probability of reproductive success (cf. Dinh et al., 2022).

Importantly, the harshness and unpredictability of people's childhood ecologies are thought to operate and be independently associated with outcomes. Whereas childhood harshness may specifically calibrate development toward early reproduction through, for example, early pubertal timing, childhood unpredictability may specifically calibrate later adult reproductive cognitions and behaviors, such as number of sexual partners (e.g., Ellis et al., 2009; Belsky et al., 2012; for a recent discussion of this issue, see Alley & Diamond, 2021). Consistent with this perspective, recent work has commonly revealed associations between early ecological unpredictability, but not harshness, and adult reproductive cognitions and behaviors (French et al., 2020; Maner et al., 2017).

Surprisingly, dyadic sexual desire has historically received little attention in this literature, despite early research

suggesting that such desire functions to facilitate reproduction (see Schmitt, 2001). Given myriad aspects of adult sexuality are indeed calibrated to childhood ecology in a manner that may enhance adult reproductive success, it seems reasonable to expect that people's early ecologies—especially the unpredictability of those ecologies—also calibrate their dyadic sexual desire. Nevertheless, we are not aware of any research that has directly examined such adaptive calibration of dyadic sexual desire. Although one recent paper (Sýkorová & Flegr, 2021) demonstrated some preliminary support for this notion by demonstrating that “fast” life history strategies (but not features of people's childhood ecologies per se) were associated with increased desires for uncommitted sex, it remains unclear the extent to which (1) such associations are driven by features of people's childhood ecologies and (2) adaptive calibration of sexual desire generalizes to partnered sex broadly rather than uncommitted sex specifically.

### Considering Sex Differences

Although theory and prior research on adaptive calibration suggest dyadic sexual desire may be upregulated for all people reared in unpredictable childhood ecologies, there are at least two theoretical reasons to expect that any such associations may be stronger among females compared to males.<sup>1</sup> First, mammalian sex and reproduction have asymmetric costs for females versus males (Trivers, 1972) such that females incur relatively greater levels of obligatory parental investment that, at a minimum, requires nine months gestation. In contrast, the minimum level of investment for males is the time it takes to contribute male gametes (e.g., sperm), which—compared to female gametes (e.g., ovum)—are plentiful and nearly immediately replenishable. To the extent that one function of dyadic sexual desire is to facilitate reproduction, the reproductive payoff for having generally high levels of dyadic sexual desire is thus likely to be greater for males (versus females).

Second, likely because male (versus female) reproductive success may hinge to a greater extent on high sexual desire, males tend to show consistently high levels of dyadic sexual desire (i.e., a ceiling effect), whereas female dyadic sexual desire exhibits relatively more flexibility (Baumeister, 2000; for preliminary evidence, see McNulty et al., 2019) that depends on context, including changes in life experiences, cultural influences, and fecundity. For example, although major life events such as marriage and the transition to

<sup>1</sup> Given (1) these predictions are based on theory rooted in biological sex differences and (2) we measured participants' sex (rather than gender identity), we refer to “male” and “female” throughout for clarity and consistency. Nevertheless, we acknowledge that sexual desire is influenced by myriad factors other than biological sex (e.g., cultural norms, etc.).

parenthood impact both male and female sexual functioning, including sexual desire (e.g., Dawson et al., 2021; Rosen et al., 2021), some work (e.g., McNulty et al., 2019) suggests some such major events impact only female sexual desire. Likewise, females (but not males) exhibit significant monthly intraindividual variability in sexual desire that tracks their cyclical monthly fluctuations in key sex-steroid hormones (e.g., estradiol, testosterone, progesterone); specifically, female sexual desire peaks mid-cycle, during ovulation in the few days after estradiol has peaked, ovarian testosterone has spiked, and progesterone is beginning to rise (e.g., Jones et al., 2018; Roney & Simmons, 2013).

### **Hormonal Contraceptives: An Evolutionary Mismatch**

Further complicating the theorized association between childhood ecologies and female dyadic sexual desire, there is reason to expect that hormonal contraceptives may disrupt this association. According to the evolutionary mismatch perspective (Li et al., 2018), evolutionarily novel features of our modern environment that are mismatched to the ancestral environments in which our psychological mechanisms evolved may alter or attenuate the functioning of evolved mechanisms. Hormonal contraceptives are likely to be one such source of evolutionary mismatch because they prevent pregnancy by pharmacologically altering female sex hormones through the administration of synthetic versions of progesterone (i.e., progestin) and, sometimes, estradiol. Given the importance of these hormones for female sexuality, hormonal contraceptives may thus have downstream consequences for female sexuality (e.g., Alvergne & Lummaa, 2010; Burrows et al., 2012; French et al., 2020), including their sexual desire.

How might hormonal contraceptives impact female sexual desire? Although existing literature on this issue has historically been mixed (for reviews, see Burrows et al., 2012; Davis & Castaño, 2004; Schaffir, 2006), recent accounts suggest most commonly prescribed hormonal contraceptives might elevate female sexual desire. Indeed, an unintended effect of the progestins contained in many hormonal contraceptives is that they bind with androgen receptors that normally bind testosterone (Darney, 1995), and testosterone is associated with higher female sexual desire (e.g., Corona et al., 2016; French et al., 2022; but see van Anders, 2012). Consequently, we might expect females using hormonal contraceptives (versus naturally cycling females) to display comparatively higher sexual desire that is less variable, limiting our ability to observe any potential associations between childhood unpredictability and their sexual desire. That is, we might expect an association between childhood unpredictability and dyadic sexual desire to emerge among females who are naturally cycling but be attenuated

(or completely suppressed) among females using hormonal contraceptives.

### **Study Overview**

In the present work, we used data from two independent studies to examine the extent to which people's childhood ecologies adaptively calibrate their adult dyadic sexual desire. In Study 1, we sought to test the extent to which such adaptive calibration emerges among naturally cycling females but not among females using hormonal contraceptives or males. In Study 2, we used previously collected data to conduct a partial replication that sought to replicate the extent to which females' hormonal contraceptive use moderated adaptive calibration of their adult dyadic sexual desire; given Study 2's broader goals, there were no male participants.

As has become common in this literature, in both studies, we partitioned people's childhood ecologies into both harshness and unpredictability, and we examined the extent to which childhood harshness and childhood unpredictability are independently associated with dyadic sexual desire. Nevertheless, given recent related work (e.g., French et al., 2020; Maner et al., 2017), we predicted that childhood unpredictability (but not harshness) would be positively associated with dyadic sexual desire. Furthermore, given (1) female (versus male) sexual desire is typically more sensitive to contextual influences and (2) hormonal contraceptives interrupt the link between ovulatory hormones and female dyadic sexual desire, we predicted a priori that an association between childhood unpredictability and dyadic sexual desire would emerge most strongly among naturally cycling females. In contrast, we expected the association to be attenuated or completely suppressed among females using hormonal contraceptives, and we expected males in Study 1 to demonstrate consistently high dyadic sexual desire regardless of the unpredictability of their childhood ecologies. Finally, in both studies, we examined the specificity of these effects for dyadic sexual desire by conducting parallel analyses with solitary sexual desire (i.e., the desire to engage in sexual activities alone). Given the importance of partnered sex for reproductive success, adaptive calibration of sexual desire should uniquely emerge for dyadic sexual desire but not for solitary sexual desire. Of course, to the extent that solitary sexual desire facilitates subsequent dyadic sexual desire, enjoyment of partnered sex, and improved sexual functioning, it remains possible that adaptive calibration of sexual desire may be generalized and not specific to dyadic desire. We thus explored these possibilities.

## Study 1

### Method

#### Participants and Materials

A total of 695 undergraduate students from the subject pool at a large Southeastern university in the U.S. participated in an online survey study. Of these, we a priori excluded 65 participants: 57 who failed an attention-check item, one who self-identified as asexual, one who self-identified as transgender, one who did not report their sex, one who did not complete both measures of childhood ecology, three who did not complete the measure of sexual desire, and one female who did not report their hormonal contraceptive use. Thus, our final sample was comprised of 630 individuals (471 females). Although we did not pre-register our analyses, we did not conduct any analyses until data collection was complete. Our sample size was determined by the number of participants we could recruit during two academic semesters. A power sensitivity analysis determined that this sample allowed us to detect a small effect ( $r=0.12$ ) with 80% power. Of note, oversampling females enabled us to effectively examine variability in associations with dyadic sexual desire as a function of their hormonal contraceptive use—among the females in our sample, 268 (57%) reported using hormonal contraceptives.

Participants ranged in age from 18 to 29 years ( $M=19.18$ ,  $SD=1.42$ ). The sample self-identified as predominantly White/Caucasian (83%); 9% of participants self-identified as Black/African American, 3% self-identified as Asian, 1% self-identified as American Indian/Alaska Native, 1% self-identified as ‘Other,’ and 3% self-identified as Multiracial; additionally, 22% of these participants self-identified as Hispanic or Latinx. Most participants (62%) reported being single whereas the remaining participants reported they were currently in a romantic relationship.

#### Measures

After providing informed consent, participants completed online demographic questionnaires that included a measure of their sex and measures assessing (1) the harshness and unpredictability of their childhood ecologies, (2) dyadic and solitary sexual desire, (3) hormonal contraceptive use (females only), (4) relationship status, which we used as a covariate in supplemental analyses (see below), and (5) other measures beyond the scope of the current analyses (e.g., eating behaviors, exercise behaviors, stress, time spent with friends, self-perceived desirability as a mate). Participants received partial course credit as compensation.

**Childhood Harshness** Similar to prior work (e.g., Belsky et al., 2012; French et al., 2020; Griskevicius et al., 2011; Maner et al., 2017; Simpson et al., 2012; Szepeswol et al., 2015, 2017; Zhao et al., 2022), we assessed childhood harshness by measuring participants’ relative family socioeconomic status in childhood. Specifically, we utilized three items from a previously validated measure of childhood SES (Griskevicius et al., 2011) that asked participants to indicate their agreement with the following statements using a 7-point scale ( $1=$  Strongly disagree;  $7=$  Strongly agree): (1) “My family usually had enough money for things when I was growing up,” (2) “I grew up in a relatively wealthy neighborhood,” and (3) “I felt relatively wealthy compared to the other kids in my school.” We reverse scored each item such that higher values represent greater childhood harshness; we then averaged across all items to create an index of childhood harshness ( $\alpha=0.87$ ).

**Childhood Unpredictability** Similar to prior research (e.g., Maner et al., 2017; Simpson et al., 2012; Szepeswol et al., 2015; Zhao et al., 2022), we assessed childhood unpredictability using a previously validated four-item measure (Simpson et al., 2012) that indexes familial changes and day-to-day inconsistencies in childhood. Specifically, participants used a 5-point scale ( $1=$  Never;  $5=$  Many times) to indicate the frequency with which the following familial changes and daily inconsistencies occurred in their early childhood: (1) “did your parents or legal guardians change jobs or occupational status?,” (2) “were there changes to your place of residence?,” (3) “were there changes to your familial circumstances (divorce or separation of parents, parents starting new romantic relationships, parents leaving the home, etc.)?,” and (4) “was your family life inconsistent and unpredictable from day to day?” We averaged across all items to create an index of childhood unpredictability ( $\alpha=0.73$ ), where higher values represent greater childhood unpredictability.

**Dyadic Sexual Desire** We assessed dyadic sexual desire with four items from the Sexual Desire Inventory (SDI; Spector et al., 1996). Although participants completed the full SDI, we selected these four items a priori given that most closely tapped interest in engaging in sexual activities with a partner. All items used an 8-point scale, but the scale anchors varied per item. One item asked: “During the last month, how often would you have liked to engage in sexual activity with a partner (for example, touching each other’s genitals, giving or receiving oral stimulation, intercourse, etc.)?” ( $1=$  Not at all;  $8=$  More than once a day). Two items assessed the strength of participants’ dyadic sexual desire by asking: “How strong is your desire to engage in sexual activity with a partner?” and “When you have sexual thoughts, how strong is your desire to engage in sexual behavior with a partner?” ( $1=$  No desire;  $8=$  Strong desire). The fourth item asked: “Compared



**Table 1** Study 1: Descriptive statistics for and bivariate correlations among all key variables

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Childhood harshness	–					
(2) Childhood unpredictability	.33***	–				
(3) Dyadic sexual desire	–.02	.12**	–			
(4) Solitary sexual desire	.09*	.10*	.37***	–		
(5) Participant sex	–.02	–.04	–.18***	–.40***	–	
(6) Hormonal contraceptive use ( <i>females only</i> )	–.11*	–.12*	.20***	–.03	–	–
<i>M</i>	2.92	2.07	5.23	3.05	–	–
<i>SD</i>	1.47	0.93	1.52	1.89	–	–

Participant sex is coded such that 1=Males and 2=Females. Hormonal contraceptive use is coded such that 1=Naturally cycling females and 2=Hormonal contraceptive using females

\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$

to other people of your age and sex, how would you rate your desire to behave sexually with a partner?" ( $I$  = Much less desire; 8 = Much more desire). We averaged across all items to create an index of sexual desire ( $\alpha = 0.85$ ) such that higher values represent greater dyadic sexual desire.

Although we selected these four items a priori because they appeared to best assess our construct of interest, readers may wonder how our 4-item measure compares to traditional scoring methods of the SDI (Moyano et al., 2017; Spector, 1996). A confirmatory factor analysis using Mplus 8.0 and maximum likelihood estimation revealed that our 4-item dyadic sexual desire subscale fit the data well (CFI = 0.99, TLI = 0.99, SRMR = 0.02, RMSEA = 0.08) whereas the original (Spector et al., 1996) and updated (Moyano et al., 2017) scoring methods yielded poor fit indices that fell outside of their acceptable ranges (for Spector et al.: CFI = 0.76, TLI = 0.66, SRMR = 0.10, RMSEA = 0.23; for Moyano et al.: CFI = 0.88, TLI = 0.82, SRMR = 0.06, RMSEA = 0.18). Crucially, our 4-item model (AIC = 8968.52) fit the data better than did the Spector et al., (1996; AIC = 18273.81) and Moyano et al. (2017; AIC = 15584.00) models.<sup>2</sup>

**Solitary Sexual Desire** We used the three solitary desire items from the SDI that paralleled those we used for our dyadic measure: (1) "During the last month, how often would you have liked to behave sexually by yourself (for example, masturbating, touching your genitals, etc.)?" ( $I$  = Not at all; 8 = More than once a day), (2) "How strong is your desire to engage in sexual activity by yourself?" ( $I$  = No desire; 8 = Strong desire), and (3) "Compared to other people of your age and sex, how would you rate your desire to behave

sexually by yourself?" ( $I$  = Much less desire; 8 = Much more desire). We averaged across all items to create an index of solitary desire ( $\alpha = 0.93$ ) such that higher values represent greater solitary sexual desire. Similar to our measure of dyadic sexual desire, a confirmatory factor analysis revealed that our 3-item solitary sexual desire subscale fit the data (AIC = 6483.08) better than did the Spector et al., (1996; AIC = 6492.12) and Moyano et al. (2017; AIC = 8156.37) models.

**Hormonal Contraceptive Use** To assess hormonal contraceptive use, females responded either "No" or "Yes" to the following question: "Are you currently using hormonal contraceptives (examples include birth control pill, patch, shots, or hormonal IUD)?" We coded this item such that  $I$  = No ( $n = 203$ ) and  $I$  = Yes ( $n = 268$ ).

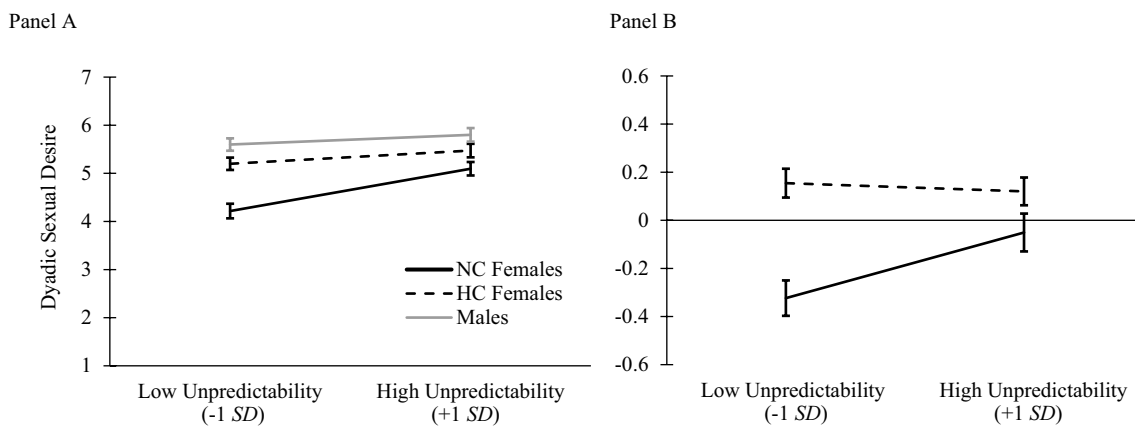
**Covariate** We assessed participants' relationship status, which we used as a covariate in supplemental robustness analyses, for two reasons. First, compared to single people, people in relationships may be more likely to experience dyadic sexual desire. Second, females who are in romantic relationships (versus single females) may be more likely to use hormonal contraceptives. We thus asked participants to respond to the following item: "Are you currently in a romantic relationship?," using a "Yes" or "No" response format.

## Results

### Preliminary Analyses

The descriptive statistics for and bivariate correlations among variables are reported in Table 1. A few preliminary results are worth highlighting. First and most relevant to our predictions, childhood unpredictability was positively associated with dyadic sexual desire, whereas childhood harshness was not significantly associated with dyadic

<sup>2</sup> We followed the recommendations of others (e.g., Kline, 2005; Schreiber et al., 2006) to compare the AICs across models given they involved different variables and somewhat varied samples because some participants skipped some items. Lower AICs indicate better fitting models.



**Fig. 1** Associations between childhood unpredictability and dyadic sexual desire for naturally cycling (NC) females, hormonal contraceptive (HC) using females, and (for Study 1) males. *Note* Results from Study 1 are depicted in Panel A; results from Study 2 are depicted

in Panel B. Dyadic sexual desire in Study 2 is standardized such that 0 represents average desire, negative values represent below-average desire, and positive values indicate above-average desire

sexual desire; interestingly, both early ecological factors were positively associated with solitary sexual desire. Second, sex was associated with dyadic and solitary sexual desire such that male (dyadic:  $M = 5.70$ ,  $SD = 1.41$ ; solitary:  $M = 4.35$ ,  $SD = 1.62$ ) sexual desire was higher than female (dyadic:  $M = 5.07$ ,  $SD = 1.54$ ; solitary:  $M = 2.61$ ,  $SD = 1.77$ ) sexual desire [dyadic:  $t(628) = 4.60$ ,  $p < 0.001$ ; solitary:  $t(627) = 10.96$ ,  $p < 0.001$ ]. It is worth noting that, despite these mean-level sex differences, males and females shared overlapping distributions, and both reported relatively high dyadic sexual desire that was above the midpoint (4.5) of the scale [for males,  $t(158) = 10.81$ ,  $p < 0.001$ ; for females,  $t(471) = 5.07$ ,  $p < 0.001$ ], underscoring the idea that within-sex variability is often greater than significant between-sex variability. For solitary sexual desire, males' desire was near the scale's midpoint,  $t(158) = -1.15$ ,  $p = 0.253$ , whereas females' desire was significantly lower than the scale's midpoint,  $t(469) = -23.16$ ,  $p < 0.001$ . Third, hormonal contraceptive use was positively associated with dyadic (but not solitary) sexual desire such that females who used hormonal contraceptives reported greater dyadic sexual desire ( $M = 5.34$ ,  $SD = 1.34$ ) than did naturally cycling females ( $M = 4.71$ ,  $SD = 1.70$ ),  $t(469) = -4.50$ ,  $p < 0.001$ . Moreover, both childhood harshness and unpredictability were negatively associated with female hormonal contraceptive use, suggesting that, consistent with other research (e.g., French et al., 2020), females reared in harsh or unpredictable childhood ecologies are less likely to use protection against pregnancy.

### Is Dyadic Sexual Desire Calibrated to Childhood Ecology and Does the Association Depend on Sex and Female Hormonal Contraceptive Use?

To examine the extent to which childhood harshness and childhood unpredictability are uniquely associated with dyadic sexual desire, we regressed dyadic sexual desire onto childhood harshness and unpredictability (both standardized). Results demonstrated that, consistent with predictions, childhood unpredictability (but not harshness) was positively associated with dyadic sexual desire,  $b = 0.22$ ,  $CI_{95\%} [0.09, 0.34]$ ,  $t(627) = 3.38$ ,  $p = 0.001$ , effect-size  $r = 0.13$ , providing evidence that dyadic sexual desire may be adaptively calibrated to the unpredictability of people's childhood ecologies. Of note, a supplemental analysis revealed that this association remained significant when we included relationship status as a covariate,  $b = 0.24$ ,  $CI_{95\%} [0.12, 0.36]$ ,  $t(626) = 3.91$ ,  $p < 0.001$ , effect-size  $r = 0.15$ .

To examine whether the association between childhood unpredictability and dyadic sexual desire differed across naturally cycling females versus females who used hormonal contraceptives and males, we regressed dyadic sexual desire onto (1) participants' group membership (i.e., naturally cycling female, female using a hormonal contraceptive, or male), which we specified as a fixed factor, (2) participants' childhood harshness and unpredictability (both standardized), (3) the Group  $\times$  Childhood Harshness interaction, and (4) the Group  $\times$  Childhood Unpredictability interaction. According to this analysis, the Group  $\times$  Childhood Harshness interaction did not emerge as significant,  $F(2, 621) = 1.35$ ,  $p = 0.261$ , whereas the Group  $\times$  Childhood Unpredictability interaction

emerged as significant,  $F(2, 621) = 3.06, p = 0.048$ . Simple effects analyses of the latter interaction (depicted in Panel A of Fig. 1) revealed that childhood unpredictability was positively associated with dyadic sexual desire among naturally cycling females,  $b = 0.44, t(621) = 4.26, p < 0.001$ , effect-size  $r = 0.17$ , but not among females using hormonal contraceptives ( $p = 0.172$ ) nor among males ( $p = 0.405$ ); crucially, this significant, positive association statistically differed from the two null associations (both  $ps \leq 0.036$ ). One supplemental robustness analysis revealed that results emerged similarly when we additionally controlled for participants' relationship status [the Group  $\times$  Childhood Unpredictability interaction:  $F(2, 620) = 2.81, p = 0.061$ ; the simple effect of childhood unpredictability for naturally cycling females:  $p < 0.001$ ; the simple effect of childhood unpredictability for females using hormonal contraceptives:  $p = 0.112$ ; the simple effect of childhood unpredictability for males:  $p = 0.207$ ]. Two additional supplemental robustness analyses demonstrated the Group  $\times$  Childhood Unpredictability interaction trended toward significance when we replaced our dyadic sexual desire measure with those used by Spector et al. (1996) and Moyano et al. (2017), both  $ps \leq 0.083$ .

### Are These Associations Specific to Dyadic Sexual Desire?

To examine the extent to which the associations between childhood unpredictability and sexual desire are unique to dyadic versus solitary sexual desire, we repeated the above analyses but replaced dyadic sexual desire with solitary sexual desire. Results demonstrated that, although both childhood harshness and unpredictability trended toward being positively associated with solitary sexual desire (for harshness,  $p = 0.122$ ; for unpredictability,  $p = 0.073$ ), the key Group  $\times$  Childhood Unpredictability interaction emerged as non-significant ( $p = 0.214$ ). This result remained unchanged when we (1) additionally controlled for participants' relationship status ( $p = 0.204$ ), and (2) replaced our solitary sexual desire measure with those used by Spector et al. (1996) and Moyano et al. (2017), all  $ps \leq 0.207$ .

## Discussion

Study 1 provided initial evidence demonstrating that childhood unpredictability (but not childhood harshness) calibrates adult dyadic sexual desire among naturally cycling females but not among females using hormonal contraceptive or males. Furthermore, supporting the possibility that such adaptive calibration may be particularly important for female reproductive success, these results uniquely emerged for dyadic sexual desire and did not extend to solitary sexual desire.

## Study 2

In Study 2, we used existing data to replicate the observed, positive association between childhood unpredictability and dyadic sexual desire among naturally cycling females but not among females using hormonal contraceptives. As noted, given the broader goals of this study, we did not recruit males, and thus, our analyses were limited to females only.

## Method

### Participants

Participants in this study were 736 females attending the University of Arkansas who (1) participated through the Psychology subject pool in exchange for partial course credit or (2) responded to flyers posted on campus and participated in exchange for entry into a gift-card raffle, and (3) completed the measure of dyadic and solitary sexual desire. A power sensitivity analysis determined that this sample allowed us to detect a small effect ( $r = 0.10$ ) with 80% power.

These participants ranged in age from 18 to 39 ( $M = 20.04, SD = 3.56$ ). Additionally, 307 (42%) participants were naturally cycling whereas the remaining used a hormonal contraceptive. Approximately half (52%) of participants reported being single whereas the remaining participants reported they were currently in a romantic relationship (44%) or were unsure (4%). The sample self-identified as predominantly White/Caucasian (84%); 4% of participants self-identified as Black/African American, 2% self-identified as Asian, 2% self-identified as American Indian/Alaska Native, 1% self-identified as "Other," 4% self-identified as Multiracial, and 1% selected "Unknown/Do not wish to report"; additionally, 9% of these participants self-identified as Hispanic or Latinx.

### Measures

After providing informed consent, participants completed online measures assessing (1) the harshness and unpredictability of their childhood ecologies, (2) dyadic and solitary sexual desire, (3) hormonal contraceptive use, (4) relationship status, and (5) other measures beyond the scope of the current analyses. As compensation, participants recruited through the Psychology subject pool received partial course credit whereas all other participants received entry into a gift-card raffle.

**Childhood Ecology** We used the same measures described in Study 1 to assess childhood harshness and childhood unpredictability. Consistent with Study 1, the reliability for the

**Table 2** Study 2: Descriptive statistics for and bivariate correlations among all key variables

	(1)	(2)	(3)	(4)	(5)
(1) Childhood harshness	–				
(2) Childhood unpredictability	.36***	–			
(3) Dyadic sexual desire	.13**	.09*	–		
(4) Solitary sexual desire	.17***	.15***	.41***	–	
(5) Hormonal contraceptive use	–.03	.03	.18***	.02	–
<i>M</i>	3.25	2.18	–0.00	0.00	–
<i>SD</i>	1.50	1.00	0.88	0.95	–

The composites for dyadic and solitary desire were created with items that were first standardized across the entire sample. Hormonal contraceptive use is coded such that 1=Naturally cycling females and 2=Hormonal contraceptive using females

\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$

measure assessing childhood harshness was high ( $\alpha = 0.87$ ), whereas the reliability for the measure assessing childhood unpredictability was sufficient ( $\alpha = 0.74$ ).

**Dyadic and Solitary Sexual Desire** We assessed dyadic and solitary desire using the same items from the SDI (Spector et al., 1996) that we used in Study 1 with one exception: due to a technical error, one item from the dyadic subscale was excluded (specifically, “When you have sexual thoughts, how strong is your desire to engage in sexual behavior with a partner?”). Furthermore, the response format across items differed such that some were assessed on a 7-point scale whereas others were assessed on a 9-point scale; for this reason, we first standardized each item across the sample before computing a composite for each subscale. The reliability for each sexual desire subscale was high (for dyadic sexual desire,  $\alpha = 0.85$ ; for solitary sexual desire,  $\alpha = 0.95$ ).

**Hormonal Contraceptive Use** We assessed whether participants were currently using a form of hormonal birth control, with “Yes” or “No” as response options.

**Covariate** We assessed participants’ relationship status by asking participants to respond to the following item: “Are you currently in a romantic relationship?” with “Yes,” “No,” and “Unsure” as response options.

## Results

### Preliminary Analyses

The descriptive statistics for and bivariate correlations among variables are reported in Table 2. First, unlike in Study 1, both childhood unpredictability and childhood harshness

were significantly positively associated with dyadic sexual desire, though these bivariate correlations do not account for the unique influence of each childhood ecology variable. Second, consistent with Study 1, hormonal contraceptive use was positively associated with dyadic (but not solitary) sexual desire such that females who used hormonal contraceptives reported greater dyadic sexual desire ( $M = 0.13$ ,  $SD = 0.85$ ) than naturally cycling females ( $M = -0.19$ ,  $SD = 0.89$ ),  $t(734) = -4.99$ ,  $p < 0.001$ . Finally, unlike in Study 1, neither childhood harshness nor unpredictability were significantly associated with female hormonal contraceptive use.

### Replicating Hormonal Contraceptives as a Boundary Condition for Adaptive Calibration of Female Dyadic Sexual Desire

We first sought to replicate the finding that hormonal contraceptive use moderates the association between childhood unpredictability and female dyadic sexual desire. In doing so, we regressed dyadic sexual desire (standardized) onto (a) hormonal contraceptive use (dummy coded such that Naturally Cycling = 0 and Hormonal Contraceptive Use = 1), (b) both parameters of childhood ecology (i.e., harshness and unpredictability, each standardized), and (c) their interactions. Replicating the pattern that emerged in Study 1, the Hormonal Contraceptives  $\times$  Childhood Unpredictability interaction emerged as significant,  $b = 0.15$ ,  $t(730) = 2.14$ ,  $p = 0.033$ , effect-size  $r = 0.08$ , whereas the Hormonal Contraceptives  $\times$  Childhood Harshness interaction did not ( $p = 0.683$ ). Simple-effects analyses for the former interaction (depicted in Panel B of Fig. 1) revealed that childhood unpredictability was significantly positively associated with dyadic sexual desire among naturally cycling females,  $b = 0.14$ ,  $t(730) = 2.34$ ,  $p = 0.020$ , effect-size  $r = 0.09$ , but not among females using hormonal contraceptives ( $p = 0.682$ ). Results emerged similarly in a supplemental analysis that included relationship status (dummy-coded) as a covariate [Group  $\times$  Childhood Unpredictability:  $b = 0.14$ ,  $t(728) = 1.93$ ,  $p = 0.054$ ; simple effect of childhood unpredictability for naturally cycling females:  $b = 0.12$ ,  $t(728) = 2.18$ ,  $p = 0.030$ ; simple effect of childhood unpredictability for females using hormonal contraceptives:  $p = 0.782$ ].

### Replicating the Specificity of Adaptive Calibration of Female Dyadic Sexual Desire

To test whether these associations extend to female solitary sexual desire, we repeated our primary analysis but replaced Dyadic Sexual Desire with Solitary Sexual Desire. Replicating results reported in Study 1 and in contrast to the results observed for dyadic sexual desire, female hormonal contraceptive use did not interact with childhood unpredictability



( $p = 0.534$ ) nor harshness ( $p = 0.189$ ) to predict solitary sexual desire.

## Discussion

Study 2 replicated results from Study 1, demonstrating that childhood unpredictability (but not childhood harshness) calibrates adult dyadic sexual desire among naturally cycling females but not among females using hormonal contraceptives. Furthermore, Study 2 again demonstrated these associations uniquely emerged for dyadic sexual desire and did not extend to solitary sexual desire. Of note, given broader study goals, these analyses were limited to females, and thus, we could not replicate the null association (from Study 1) for such adaptive calibration of dyadic sexual desire among males.

## General Discussion

Adaptive calibration models posit that features of people's early childhood ecologies—especially the unpredictability of those ecologies—facultatively shape later reproductive drives and behaviors (Belsky et al., 1991, 2010; Chisholm, 1993). Nevertheless, theory and recent research offer reason to expect such adaptive calibration to sometimes be sex differentiated (e.g., Baumeister, 2000) and sensitive to context (Li et al., 2018). The current studies provide, to our knowledge, the first evidence in support of the idea that dyadic (but not solitary) sexual desire is adaptively calibrated to the unpredictability (but not harshness) of naturally cycling females' childhood ecologies such that those reared in relatively unpredictable (versus predictable) childhood ecologies reported greater dyadic sexual desire. Hormonal contraceptives, which are evolutionarily novel and alter myriad aspects of female sexuality by changing their reproductive physiology, appeared to attenuate this association for those who use them. Study 1 additionally demonstrated that this association did not emerge for males, who demonstrated relatively high dyadic and solitary sexual desire regardless of their early childhood ecologies.

These findings add to a growing literature on adaptive calibration of psychological traits (e.g., Brumbach et al., 2009; French et al., 2020; Griskevicius et al., 2011) by highlighting the importance of early ecologies in shaping individual differences in adult reproductive motivations and behaviors. Importantly, this work reveals theoretically important boundary conditions that may be inherent to such adaptive calibration: the predicted association emerged among naturally cycling females but not among females using hormonal contraceptives nor among males (in Study 1). It is worth noting that females who experience higher (versus lower) levels of dyadic sexual desire may be more inclined to use hormonal

contraceptives, which may explain the positive association between hormonal contraceptive use and female dyadic sexual desire; nevertheless, the blunted association between their childhood ecology and reported levels of dyadic sexual desire suggests that hormonal contraceptives may suppress adaptive calibration of female sexuality. These (and other) boundary conditions for adaptive-calibration processes that have been previously overlooked could help explain some recent inconsistencies in this literature (see Dinh et al., 2022). Future research may thus benefit from considering the extent to which other adaptive-calibration processes—particularly those that function to calibrate people's sexuality—may be sex differentiated and/or altered by female hormonal contraceptive use (or other relevant factors).

More broadly, this research underscores the utility of considering how evolutionarily novel features of the modern environment, such as hormonal contraceptives, may disrupt evolved psychological processes (Li et al., 2018). The present findings contribute additional evidence that hormonal contraceptives alter psychological processes important to close relationships (see French et al., 2017; French & Meltzer, 2020; Goetz et al., 2019; Russell et al., 2014). Although hormonal contraceptives afford many benefits to those who use them (e.g., protection against unintended pregnancy, reduced menstrual pain and flow), accumulating research reveals myriad psychological consequences of hormonal contraceptive use (Alvergne & Lummaa, 2010; for an extensive review, see Hill, 2019). Of note, the current data reveal that females who use hormonal contraceptives report *higher* dyadic sexual desire, on average, than naturally cycling females. Of course, a causal association should not be determined from these cross-sectional data; moreover, other work reveals mixed findings on how hormonal contraceptives impact female sexual desire (see Burrows et al., 2012). More research is needed to determine how hormonal contraceptives may causally affect women's sexual desire and, importantly, carefully delineate potential moderating factors such as the type of progestins contained in them (Hill & Mengelkoch, 2023). Nevertheless, when considered alongside other work demonstrating that high female dyadic sexual desire can benefit female's close relationships (e.g., McNulty et al., 2019), the present work suggests that, if some hormonal contraceptives increase female dyadic sexual desire, this could potentially benefit relationships to the extent that sex promotes pair bonding and sustained relationship satisfaction (Meltzer et al., 2017). Given recent estimates suggest that approximately 140 million females worldwide use hormonal contraceptives (Mørch et al., 2017), ongoing research efforts examining the myriad ways in which hormonal contraceptives impact female psychology and their relationships is paramount.

## Strengths and Limitations

This work had several strengths worth noting. First, our samples were sufficiently powered to detect the small effects that we observed here. Although the key effects of interest are indeed small, this is to be expected given that many factors are likely to underlie people's dyadic sexual desire, including stress, ovulatory cycle phase (for females), and health. Nevertheless, sexual desire is a defining feature of romantic relationships that has important consequences for relationship outcomes (e.g., Birnbaum & Finkel, 2015; Dillon et al., 2015; McNulty et al., 2019) and, as such, even small effects can contribute meaningfully toward advancing relationship science. Second, by demonstrating similar findings across two independent studies, we can feel more confident that our results do not reflect a Type I error. Third, this work highlights the utility of integrating multiple theoretical perspectives. By integrating insights from evolutionary biology (e.g., Chisholm, 1993; Trivers, 1972) and evolutionary psychology (e.g., Li et al., 2018) with classic social psychological perspectives (e.g., Baumeister, 2000), we were able to generate the novel hypotheses tested here. Future work in this area may continue to benefit from further integration of disparate theoretical perspectives.

Despite these strengths, several factors limit interpretations of these findings until they can be further replicated and extended, though they also suggest important avenues for future research. First, the homogeneity of our college–student samples poses the problem of a restricted range of childhood ecologies. Although such restricted range did not undermine our ability to detect an association, future research may benefit from examining the associations demonstrated here in more variable samples and even cross-culturally. Further, examining adaptive calibration of dyadic sexual desire in non-college samples would additionally clarify whether the associations demonstrated here are generalizable. Future research may also benefit from including non-survey measures of sexual desire (e.g., implicit measures, measures of physiological arousal), which are less susceptible to self-presentational biases (Dawson & Chivers, 2014). Finally, these data are cross-sectional and thus cannot support causal conclusions. Although prior longitudinal demonstrations of adaptive calibration of sexual processes (e.g., Simpson et al., 2012) bolster confidence in the interpretation of the findings reported here, future research should consider longitudinal and/or experimental examination of adaptive calibration of dyadic sexual desire.

## Conclusion

Dyadic sexual desire is central to reproduction and important for relationship functioning. The current research demonstrates support for the notion that people's childhood

ecologies adaptively calibrate their dyadic sexual desire in adulthood, but such adaptive calibration appears to occur exclusively for naturally cycling females (not females using hormonal contraceptives nor males). This work contributes to a growing body of knowledge on adaptive calibration processes, sex differences, and how hormonal contraceptives may be a source of evolutionary mismatch that can alter people's evolved psychology.

**Author's Contributions** AM designed and performed the research study; JEF and ALM analyzed the data; and JEF and AM wrote the paper with input from ALM.

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**Data Availability** All materials are described in full. Upon publication, data will be made available on OSF.

**Code Availability** Upon publication, syntax for all key analyses will be made available on OSF.

## Declarations

**Conflict of interest** Not applicable; the authors have no relevant financial or non-financial interests to disclose.

**Ethics Approval** Approval was obtained from the institutional review board of Florida State University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

**Informed Consent** Informed consent was obtained from all participants.

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