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The implications of changing hormonal contraceptive use after relationship formation

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ABSTRACT

Modern-day environments differ drastically from those in which humans evolved, which likely has important implications for human mating psychology. Particularly notable is the modern advancement of hormonal contraceptives (HCs), which alter the natural hormones of the many women who use them. According to the HC congruency hypothesis, HCs alter sex hormones and brain processes that are linked to numerous relationship preferences. In light of work suggesting such preferences play an important role in relationship evaluations, changing HC use during a long-term relationship (relative to use at relationship formation) should impact women's relationships. We used data from two independent longitudinal studies of 203 newlywed couples to address this possibility. Results demonstrated that wives reported lower sexual satisfaction (but not marital satisfaction) when their HC use was incongruent (versus congruent) with their use at relationship formation. These findings provide preliminary support for the HC congruency hypothesis, though we also broaden our theoretical framework to offer methodological recommendations for future research.

1. Introduction

Modern-day humans live in an environment that vastly differs from the one in which they evolved. According to the evolutionary mismatch hypothesis (Li, van Vugt, & Colarelli, 2018), such environmental changes have outpaced the time needed for humans' psychological mechanisms to adapt, and this mismatch has important implications for a wide range of human emotions, cognitions, and behaviors (Buss, 2000; Maner & Kenrick, 2010; Tooby & Cosmides, 1990). For example, despite the greater nutritional value of fruit versus refined sugar and even artificial sweeteners, people frequently prefer candy to fruit.

Given the crucial role of reproduction and pair bonding throughout human evolution, selection pressures have weighed particularly heavily on human mating. Thus, environmental mismatch may have important implications for human mating psychology (see Li et al., 2018). Modern humans struggle to maintain their long-term relationships (Finkel, Hui, Carswell, & Larson, 2014), evidenced by the fact that on average relationship satisfaction declines over time (see Meltzer, McNulty, Jackson, & Karney, 2014b) and marital dissolution rates in industrialized countries hover between 30% and 50% (Amato & James, 2010). Mismatches between our evolved and modern environments may partially account for such relationship difficulties.

1.1. Considering the role of hormonal contraceptives for modern Women's romantic relationships

Particularly notable in regard to long-term romantic relationship success is the modern advancement of hormonal contraceptives (HCs), which approximately 140 million women worldwide use (Mørch et al., 2017). HCs secrete synthetic progestin (and, for some, ethyl estradiol), suppressing natural production of estrogen and progesterone in women who use (versus do not use) HCs. Consequently, HC-using women do not experience natural cyclical variations in estrogen and progesterone [i.e., spikes in estrogen that facilitate ovulation, spikes in progesterone following ovulation; Fleischman, Navarrete, & Fessler, 2010; though see Grøntvedt, Grebe, Kennair, & Gangestad, 2017 for evidence of continued progestogenic effects]. Likewise, recent evidence suggests HCs alter women's brain structures such that women who use (versus do not use) HCs have more grey matter in their prefrontal cortices, pre- and postcentral gyri, and inferior parietal lobules (Pletzer et al., 2010). Due, at least in part, to these physiological changes, HCs have been implicated in a wide variety of psychological processes and outcomes, including but not limited to depression (Skovlund, Mørch, Kessing, & Lidegaard, 2016; Young, Midgley, Carlson, & Brown, 2000), reward processing (Scheele, Plota, Stoffel-Wagner, Maier, & Hurlemann, 2015), and emotion recognition (Hamstra, De Rover, De Rijk, & Van der Does, 2014; Radke & Derntl, 2016).

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With respect to their romantic relationships, many women begin or discontinue using HCs numerous times after meeting their partner, thereby regularly altering their natural hormonal profiles and brain structures from those that evolved to those dictated by modern medicine. And there is reason to believe such changes negatively impact women's long-term relationship outcomes (for a similar argument, see Roberts, Cobey, Klapilová, & Havlíček, 2013; Roberts et al., 2014; Russell, McNulty, Baker, & Meltzer, 2014). Drawing from interdependence theory (Kelley & Thibaut, 1978), which is the predominant relationship-science perspective on how people evaluate their relationships, people's satisfaction depends on the extent to which their relationship experiences and outcomes meet their relationship preferences, or their relationship standards. Some evidence suggests women's sex hormones are associated with their sexual preferences such as heightened desires for sex (Gangestad & Thornhill, 2008; Grøntvedt et al., 2017; Roney, 2018; Roney & Simmons, 2013; also see Jones et al., 2018) as well as their partner preferences such as heightened desires for masculine or symmetrical partners (Meltzer, 2017; Pisanski et al., 2014; Thornhill, Chapman, & Gangestad, 2013; for review, see Alvergne & Lummaa, 2010; for an example of a study that did not detect an association between sex hormones and partner preferences, see Jones, Hahn, & DeBruine, 2019). Thus, beginning or discontinuing HCs after relationship formation may alter women's sexual and relationship preferences. To the extent that women's sexual preferences change when they begin or discontinue using HCs (relative to use at relationship formation) and thus their sexual relationships no longer meet these altered preferences (because they presumably meet their pre-altered preferences), we might expect such women to experience declines in sexual satisfaction. Likewise, to the extent that women's partner and relationship preferences change when they begin or discontinue using HCs (relative to use at relationship formation) and thus their partners and relationships no longer meet these altered preferences, we might expect such women to experience declines in relationship satisfaction.

Consistent with this rationale, the HC congruency hypothesis (Roberts et al., 2013) posits that changes in women's HC use relative to relationship formation can negatively impact their subsequent sexual and relationship satisfaction (see Roberts et al., 2014; Russell et al., 2014). The core tenet underlying this hypothesis is that a partnered woman should be less satisfied at times when her HC use is incongruent with her HC use at relationship formation relative to times when her *own* HC use is congruent with her HC use at relationship formation. That is, HC incongruency versus congruency is inherently a within-person process. Accordingly, one of the strongest tests of the HC congruency hypothesis would utilize a longitudinal design that repeatedly assesses women's HC use and their relationship outcomes. Such a longitudinal design would (a) allow the crucial within-person variance in HC incongruency that is likely associated with changes in women's sexual and relationship satisfaction to be statistically isolated from the between-person variance in HC incongruency in order to demonstrate that any associations are indeed driven by within- versus between-person variance, (b) increase power, and (c) help rule out between-person confounds.

Although some recent empirical work has provided preliminary support for the HC congruency hypothesis (Roberts et al., 2014; Russell et al., 2014; c.f. Jern et al., 2018), none of this work utilized a longitudinal design to statistically isolate the within-person variability in women's HC incongruency. Indeed, three independent studies published in two independent articles (Roberts et al., 2014; Russell et al., 2014) demonstrated that those women whose current HC use was incongruent with their use at relationship formation reported lower sexual satisfaction than those women whose current HC use was congruent with their use at relationship formation [although Russell et al., 2014 used a longitudinal design, their analyses collapsed across within- and between-person variance]. Two of these three studies additionally demonstrated that HC incongruency was associated with lower relationship satisfaction—but only among women whose partners had relatively less attractive faces (Russell et al., 2014). Given the self-selective nature of HC use, however, it is possible that these previously demonstrated effects were due to unmeasured or unknown between-person differences among HC-incongruent versus HC-congruent women rather than within-person changes in HC incongruency. For example, less (versus more) educated women change their HC use more frequently (Frost, Singh, & Finer, 2007) and thus prior HC-incongruency effects could alternatively be attributed to greater financial stress—a correlate of relatively lower education (Dakin & Wampler, 2008). As noted, utilizing a longitudinal design that isolates the within-person variance from the between-person variance would help to rule out such unmeasured or unknown between-person differences. Thus, the primary aim of the current study was to use data drawn from two independent longitudinal studies to examine the association between within-person variance in women's HC incongruency and their sexual and relationship satisfaction, controlling for the between-person variance in HC incongruency.

1.2. Exploring whether partner facial attractiveness moderates these associations

As previously noted, interdependence theory (Kelley & Thibaut, 1978) posits that women will be most relationally satisfied to the extent that their partners meet their preferences. Given some work suggests women's partner preferences may be linked to their sex hormones and brain structures (e.g., Cooper, Dunne, Furey, & O'Doherty, 2012; Meltzer, 2017; Pisanski et al., 2014; Thornhill et al., 2013; for a review, see Alvergne & Lummaa, 2010; c.f. Jones et al., 2019), we might expect any corresponding changes in relationship evaluations to depend on the extent to which their partners continue to meet their preferences. Although prior research in this area has explored moderation by partner facial attractiveness, theory and supporting evidence regarding the role of partner facial attractiveness provide competing predictions. On the one hand, partner attractiveness serves as a cue of genetic fitness and thus women should benefit (and be satisfied) to the extent that their partners are physically attractive—regardless of changes in their preferences for partner attractiveness. Consistent with this rationale, women value partner attractiveness (Eastwick & Finkel, 2008; Fletcher, Simpson, Thomas, & Giles, 1999). We thus might expect that women with particularly attractive partners are less susceptible to declines in satisfaction following changes in their HC use; data from two independent studies are consistent with this idea (see Russell et al., 2014). On the other hand, however, other research demonstrates partner attractiveness is unassociated or even negatively associated with women's satisfaction—at least in long-term relationships (French, Altgelt, & Meltzer, 2019; Meltzer et al., 2014b), and another line of research suggests partner preferences for attractiveness are not linked to women's sex hormones (Jones et al., 2019). We thus might alternatively expect partner facial attractiveness to play an insignificant role in the association between within-person changes in HC use (relative to use at relationship formation) and women's relationship evaluations. In light of these competing predictions, we did not make clear a priori predictions regarding the role of partner attractiveness. Nevertheless, we had the data available and thus, as a secondary aim, explored whether the associations between women's HC incongruency and their sexual and relationship satisfaction depended on their partners' facial attractiveness.

1.3. Exploring whether the direction of HC incongruency matters

According to the HC congruency hypothesis, women are more likely to experience poorer relationship outcomes at times when their HC use is incongruent (versus congruent) with their use at relationship formation—regardless of the direction of such incongruency (i.e., beginning versus discontinuing HCs). Whereas some of the preliminary work testing this hypothesis supports the notion that the direction of HC

incongruency is inconsequential (Roberts et al., 2014), other work has demonstrated that women who form their relationships while using (versus not using) HCs are most at risk for declines in satisfaction (Russell et al., 2014). As others have argued (Jern et al., 2018), these studies may have produced inconsistent or even spurious results when testing such directional effects because they were comprised of disproportionately sized comparison groups (i.e., HC-incongruent women who began versus discontinued using HCs). To the extent that the current study has more balanced groups, we additionally sought to explore whether the associations between women's HC incongruency and their sexual and relationship satisfaction depend on whether women began versus discontinued using HCs. Given the prior mixed evidence, we did not make a priori directional predictions.

1.4. Overview of the current study

We used two independent, longitudinal studies of newlywed couples and multilevel modeling to provide what we believe is the strongest test to date of the HC congruency hypothesis. In both studies, we assessed wives' HC incongruency, sexual satisfaction, and marital satisfaction as well as husbands' objective facial attractiveness within the first few months of marriage. We then reassessed wives' HC incongruency, sexual satisfaction, and marital satisfaction every few months across the early years of marriage. We predicted that within-person variance in wives' HC incongruency would be negatively associated with their sexual and marital satisfaction such that a given wife would be less satisfied when her HC use was incongruent (versus congruent) with her use at relationship formation. As previously noted, altered partner preferences may be one mechanism through which HC incongruency might impact relationship outcomes (also see Russell et al., 2014); we thus additionally explored this possibility. Moreover, we additionally explored whether the direction of HC incongruency mattered. Given the parallel designs of both studies, we describe them simultaneously and analyze them together to increase power, though we controlled for idiosyncratic differences across studies.

2. Method

2.1. Participants

The participants in Study 1 were 109 heterosexual women drawn from a broader 4-year longitudinal study of 113 newlywed couples in Dallas, Texas, U.S.A (four women failed to indicate their HC use at relationship formation and thus could not be included in the primary analyses). The participants in Study 2 were 94 heterosexual women drawn from a broader 2-year longitudinal study of 104 newlywed couples in Tallahassee, Florida, U.S.A. (we a priori excluded five same-sex female couples based on the notion that such women are less likely to use and thus change HCs over time, four additional women who had experienced menopause prior to study enrollment, and one additional woman who failed to indicate her HC use at relationship formation). Thus, the present analyses are based on a final sample of 203 newlywed wives.[1] A sensitivity analysis that accounted for repeated assessments [for sexual satisfaction, Intraclass Correlation Coefficient (ICC) = .38; for marital satisfaction, ICC = .55; see Snijders & Bosker, 2011], indicated our effective sample size of 401 for sexual satisfaction and 320 for marital satisfaction allowed us to detect an effect as small as effect-size r = .14 for sexual satisfaction and effect-size r = .16 for marital satisfaction with power = .80.

We recruited couples by sending invitations to couples in the area who had recently applied for marriage licenses in the county of the study location (Study 1) and via flyers and Facebook advertisements (Study 2). As part of the broader goals of the studies, eligibility required that all participants (a) had been married fewer than four months in Study 1 and three months in Study 2, (b) were at least 18 years of age, and (c) spoke English (to ensure questionnaire comprehension). Given broader aims of Study 1, that study included the additional criterion that both couple members were not previously married.

At baseline in Study 1, these wives were 26.74 (SD = 4.75) years of age and had completed 15.78 (SD = 2.79) years of education. Fifty-two percent of these wives were employed full time and 13% were full-time students. These wives' mean reported income was US$33.14 k ($SD$ = $35.96 k) per year. The sample was diverse; 49% self-identified as Caucasian, 26% self-identified as African American, 16% self-identified as Latina, 5% self-identified as Asian, and 4% self-identified as another race/ethnicity.

At baseline in Study 2, these wives were 28.87 (SD = 6.63) years of age and had completed 16.14 (SD = 2.53) years of education. Fifty-six percent of these wives were employed full time and 22% were full-time students. These wives' mean reported income was US$26.53 k ($SD$ = $17.14 k) per year. The majority (75%) self-identified as Caucasian.

2.2. Procedure and measures

Following recruitment, couples in both studies completed a survey electronically through Qualtrics.com or through the mail. These surveys included a consent form, a battery of questionnaires including our key measures (i.e., wives' HC incongruency, sexual satisfaction, marital satisfaction, covariates) and additional measures beyond the scope of the current analyses, as well as instructions asking spouses to complete the questionnaires independently. During a corresponding laboratory session, we obtained objective measures of husbands' physical attractiveness. Couples received US$100 for completing this baseline assessment.

We then re-contacted couples every four (Study 2) to six (Study 1) months during the first two (Study 2) to four years (Study 1) of marriage to reassess our key measures as well as additional measures beyond the scope of the current analyses. The primary analyses are thus based on eight assessments in Study 1 and up to seven assessments in Study 2. Couples received US$30 (Study 1) or US$25 (Study 2) for completing each follow-up assessment.

2.2.1. Wives' HC incongruency

At baseline in both studies, wives indicated whether they were "using a form of hormonal birth control when [they] began dating [their] husband." In total, 86 wives indicated using HCs at relationship formation. At all assessments in both studies, wives additionally indicated whether they were "currently taking any form of hormonal birth control." We used these responses to form an index of HC incongruency such that *0* = "HC congruent" [i.e., wives who were (a) not using HCs at relationship formation and not using HCs at a given assessment or (b) using HCs at relationship formation and using HCs at a given assessment] and *1* = "HC incongruent" [i.e., wives who indicated that they were (a) not using HCs at relationship formation but using HCs at a given assessment or (b) using HCs at relationship formation but not using HCs at a given assessment]. Notably, given that wives completed up to eight assessments in Study 1 and up to seven assessments in Study 2, there was adequate opportunity for within-person variability in HC incongruency (indeed, the average within-person SD = 0.20). For our primary analyses that statistically isolated within- and between-person variance, we person-centered this dummy-coded variable so that it estimated within-person HC incongruency and averaged each woman's mean response on this dummy-coded variable across all assessments so that it estimated between-person HC incongruency (see Curran & Bauer, 2011; Raudenbush & Bryk, 2002). Thus,

[1] These data are independent of those reported in Russell et al. (2014). Although portions of these data have been used in other published reports (e.g., French et al., 2019; French, Meltzer, & Maner, 2017; Meltzer, 2020), none of those articles reported the associations described in this manuscript.

higher scores on our within-person HC incongruency variable indicate HC incongruency whereas higher scores on our between-person HC incongruency variable represent the proportion of assessments that a given wife was incongruent (.00 = wife was incongruent for 0% of her completed assessments; .50 = wife was incongruent for 50% of her completed assessments; 1.00 = wife was incongruent for 100% of her completed assessments).

2.2.2. Partner physical attractiveness

Similar to Russell et al. (2014), groups of trained research assistants (Study 1, $N = 5$; Study 2, $N = 5$) used the photographs taken at the baseline laboratory session to rate each husband's facial attractiveness on a 10-point scale (*1* = "Not at all attractive;" *10* = "Highly attractive"). Consistent with findings that people within and across cultures show very high agreement regarding who is attractive (Langlois et al., 2000), our coders demonstrated adequate agreement (Study 1: ICC = .81; Study 2: ICC = .87).

2.2.3. Sexual satisfaction

At all assessments in both studies, we assessed both couple members' sexual satisfaction using the Index of Sexual Satisfaction (Hudson, Harrison, & Crosscup, 1981); notably, this was the same measure used by Russell et al. (2014). Specifically, wives indicated the extent to which 25 statements describe their current sexual relationship with their husbands (e.g., "I think that our sex is wonderful") on a 7-point scale (*1* = "None of the time;" *7* = "All of the time"). We reverse coded necessary items and averaged intimates' responses across all items to form an index of sexual satisfaction at each assessment; higher scores reflect higher sexual satisfaction. Internal consistency was high (for both couple members across all assessments in both studies, $\alpha \geq .91$). Although we were primarily interested in wives' sexual satisfaction (as a dependent variable), we accounted for the dyadic influence (Kelley & Thibaut, 1978) of husbands' sexual satisfaction by including it as a covariate in supplemental robustness analyses (see Kenny & Cook, 1999).

2.2.4. Marital satisfaction

At all assessments in both studies, we assessed both couple members' global marital satisfaction using the Quality Marriage Index (Norton, 1983); notably this was the same measure used by Russell et al. (2014). Specifically, intimates indicated the extent to which they agreed or disagreed with six general statements about their marriage (e.g., "My relationship with my partner makes me happy"). Five items utilize a 7-point scale, whereas one item utilizes a 10-point scale, yielding scores ranging from 6 to 45. Higher scores reflect greater satisfaction with the marriage. Internal consistency was high (for both couple members across all assessments in both studies, $\alpha \geq .88$). Although we were primarily interested in wives' marital satisfaction (as a dependent variable), we accounted for the dyadic influence (Kelley & Thibaut, 1978) of husbands' marital satisfaction by including it as a covariate in supplemental robustness analyses (see Kenny & Cook, 1999).

2.2.5. Covariates

To ensure that any association between women's HC incongruency, sexual satisfaction, and marital satisfaction was not due to (a) pregnancy or (b) the couples' attempts to conceive, wives in both studies additionally indicated at each assessment whether they were "currently pregnant" and whether they were "trying to get pregnant." We dummy coded their responses (*0* = "No;" *1* = "Yes") and controlled for both covariates in supplemental robustness analyses. Eight women failed to respond to both items at all assessments.

3. Results

3.1. Descriptive statistics and preliminary analyses

Across both studies, 36.0% ($n = 73$) of wives became HC incongruent at some point during the study (40 of these wives were not using HCs at relationship formation whereas 33 of these wives were using HCs at relationship formation); of the 64.0% ($n = 130$) of wives who remained HC congruent, 40 wives were consistent HC users (i.e., they reported using HCs at relationship formation and at each assessment) whereas 90 wives were consistent non-HC users (i.e., they reported not using HCs at relationship formation and at each assessment).

Additional descriptive statistics for and bivariate correlations among all variables and covariates are presented in Table 1. A few of these are worth highlighting. First, in contrast to preliminary work in support of the HC congruency hypothesis (Roberts et al., 2014; Russell et al., 2014), we did not detect a significant correlation between wives' HC incongruency and their sexual satisfaction or marital satisfaction. Notably, however, these bivariate correlations collapse across within- and between-person variance in wives' HC incongruency, and the key aim of the current study involves isolating such variance. Moreover, it is unclear from these bivariate correlations whether husbands' facial attractiveness moderates these associations. Second, wives' sexual and

Table 1
Descriptive statistics for and correlations among all primary variables and covariates.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	Currently Pregnant	–							
(2)	Attempting to Conceive	−.12***	–						
(3)	Partner Sexual Satisfaction	.01	−.03	–					
(4)	Partner Marital Satisfaction	.05	−.01	.47***	–				
(5)	HC Incongruency	.02	−.02	−.04	−.02	–			
(6)	Partner Facial Attractiveness	.01	−.04	.05	.06†	.12***	–		
(7)	Sexual Satisfaction	.06†	.01	.55***	.32***	−.02	.12***	–	
(8)	Marital Satisfaction	.08*	.04	.22***	.48***	−.01	.05†	.51***	–
M		.10	.12	5.64	40.29	.38	4.72	5.64	39.69
SD		.30	.32	.91	5.93	.49	1.28	.91	7.14

Note. Currently Pregnant, Attempting to Conceive, and HC Incongruency are dummy-coded variables. All variables are time-varying variables, except for Partner Facial Attractiveness, which was only assessed at baseline. Reported correlations collapse across all assessments but account for nonindependence.

† $p < .10$. * $p < .05$. *** $p < .001$.

marital satisfaction were strongly associated with their husbands' sexual and marital satisfaction, respectively, highlighting our a priori decision to control for husbands' satisfaction in supplemental robustness analyses (as did Russell et al., 2014). Not surprisingly, these newlywed wives and husbands reported relatively high sexual and marital satisfaction on average across the course of the study, though there was substantial variability in these reports.

3.2. Examining the cross-sectional associations between Wives' HC incongruency and their sexual and marital satisfaction

As noted, the preliminary evidence in support of the HC congruency hypothesis compared HC-incongruent women with HC-congruent women—that is, prior studies collapsed within- and between-person variance in HC incongruency. In an effort to replicate this cross-sectional approach, which allows us to additionally determine whether such results differ from our primary, longitudinal approach, we first conducted two sets of cross-sectional analyses: one examining wives' sexual satisfaction and one examining wives' marital satisfaction.

3.2.1. Sexual satisfaction

In the first set of analyses, we first regressed wives' baseline sexual satisfaction[2] onto their baseline HC incongruency, controlling for idiosyncratic differences across studies (coded such that −1 = "Study 1" and 1 = "Study 2"). Results demonstrated that between-person differences in wives' HC incongruency at baseline were not significantly associated with their sexual satisfaction at baseline, b = −0.08, $CI_{95\%}$ [−0.32: 0.16], $t(199) = -0.69$, $p = .491$. A supplemental robustness analysis demonstrated this association remained nonsignificant when we additionally controlled for the dyadic influence of their partners' baseline sexual satisfaction,[3] whether wives were pregnant, and whether couples were attempting to conceive (as did Russell et al., 2014), b = −0.07, $CI_{95\%}$ [−0.28: 0.14], $t(195) = -0.69$, $p = .494$.

Prior work in support of the HC congruency hypothesis suggests partners' objective facial attractiveness does not further moderate this association (Russell et al., 2014); nevertheless, we explored this possibility. Thus, we re-estimated the previous model but additionally included husbands' facial attractiveness (standardized) and the HC Incongruency × Husbands' Facial Attractiveness interaction as predictors. In this analysis, we did not detect an association between the HC Incongruency × Husbands' Facial Attractiveness interaction and wives' sexual satisfaction at baseline, b = 0.10, $CI_{95\%}$ [−0.14: 0.34], $t(197) = 0.83$, $p = .406$, nor did we detect an association of the simple effect of wives' HC incongruency at baseline and their sexual satisfaction at baseline, b = −0.10, $CI_{95\%}$ [−0.34: 0.14], $t(197) = -0.84$, $p = .402$. A supplemental robustness analysis demonstrated this interaction remained nonsignificant when we additionally controlled for husbands' sexual satisfaction, whether wives were pregnant, and whether couples were attempting to conceive, b = 0.14, $CI_{95\%}$ [−0.06: 0.35], $t(193) = 1.36$, $p = .177$.

3.2.2. Marital satisfaction

In the second set of analyses, we re-estimated our first analysis but replaced wives' sexual satisfaction with wives' marital satisfaction. Again, results demonstrated that between-person differences in wives' HC incongruency at baseline were not significantly associated with their marital satisfaction at baseline, b = 0.75, $CI_{95\%}$ [−0.62: 2.12], $t(200) = 1.08$, $p = .284$. A supplemental robustness analysis demonstrated this effect remained nonsignificant when we additionally controlled for husbands' marital satisfaction, whether wives were pregnant, and whether couples were attempting to conceive, b = 0.50, $CI_{95\%}$ [−0.78: 1.78], $t(197) = 0.77$, $p = .443$.

[2] One wife failed to complete her baseline measure of sexual satisfaction.

[3] One husband failed to complete his baseline measure of sexual satisfaction.

To examine whether husbands' facial attractiveness moderated this null association (as it did in prior work, Russell et al., 2014), we re-estimated the previous model but additionally included husbands' facial attractiveness (standardized) and the HC Incongruency × Husbands' Facial Attractiveness interaction as predictors. In this analysis, we did not detect an association between the HC Incongruency × Husbands' Facial Attractiveness interaction and wives' marital satisfaction at baseline, b = −0.21, $CI_{95\%}$ [−1.58: 1.16], $t(198) = -0.30$, $p = .764$, nor did we detect an association of the simple effect of wives' HC congruency at baseline and their marital satisfaction at baseline, b = 0.75, $CI_{95\%}$ [−0.63: 2.13], $t(198) = 1.07$, $p = .284$. A supplemental robustness analysis demonstrated this interaction remained nonsignificant when we additionally controlled for husbands' marital satisfaction, whether wives were pregnant, and whether couples were attempting to conceive, b = −0.40, $CI_{95\%}$ [−1.68: 0.88], $t(195) = -0.61$, $p = .540$.

3.3. Examining the associations between within-person variance in Wives' HC incongruency and their sexual and marital satisfaction

Given that the HC congruency hypothesis is based on the notion that the *within-person variance* in a given woman's HC incongruency should be negatively associated with her relationship evaluations, our next set of analyses (i.e., our primary set of analyses) used repeated assessments within person (i.e., longitudinal data) to statistically isolate within- and between-person variance in HC incongruency. Specifically, we estimated the associations between wives' within-person variance in HC incongruency and their sexual and marital satisfaction, controlling for their between-person variance in HC incongruency. As a reminder, the estimate of between-person HC incongruency in these analyses represents the proportion of total assessments that each wife was HC incongruent (formed by estimating each woman's average congruency score) and thus differs from the between-person estimates used in prior research (e.g., Roberts et al., 2014). We again conducted two sets of analyses: one examining wives' sexual satisfaction and one examining wives' marital satisfaction.

3.3.1. Sexual satisfaction

We first tested whether wives' within-person variance in HC incongruency was associated with their sexual satisfaction, controlling for their between-person variance in HC incongruency. Specifically, we used the MIXED procedure in SPSS 23 (to account for the nested nature of these data) to estimate the following multilevel model:

$$\begin{aligned} Y_{ti}\,(\text{Wives' Sexual Satisfaction}) = {} & \pi_{0ti}(\text{Intercept}) + b_{1i}(\text{Study}) + \pi_{2ti}(\text{Time}) \\ & + b^{B}{}_{3i}(\text{Between-Person HC Incongruency}) \\ & + \pi^{W}{}_{4ti}(\text{Within-Person HC Incongruency}) + e_{ti} + r_i \end{aligned} \quad (1)$$

where we (a) controlled for Time (coded as the number of months elapsed since baseline, which was coded 0; standardized) to account for temporal changes (Bolger, Davis, & Rafaeli, 2003), (b) controlled for Study to account for idiosyncratic differences across studies, (c) specified the maximal random effects structure by allowing all time-varying estimates (Intercept, Time, Within-Person HC Congruency) to vary randomly across wives [following Matuschek, Kliegl, Vasishth, Baayen, and Bates's (2017) recommendations for selecting random effects, we confirmed that this was the best model; also see Barr, Levy, Scheepers, & Tily, 2013], and (d) specified an unrestricted covariance structure. In addition to this primary model, we conducted a supplemental robustness analysis that additionally controlled for theoretically relevant covariates that we selected a priori—i.e., husbands' sexual satisfaction, whether couples were attempting to conceive, and whether wives were pregnant (none of which were allowed to vary across wives; see Barr et al., 2013).

Results of both analyses are reported in the top half of Table 2. As

Table 2
Associations Between Wives' HC Incongruency (HCI) for their sexual and marital satisfaction.

	Uncontrolled Model				Controlled Model			
	b	$CI_{95\%}$	*df*	*r*	*b*	$CI_{95\%}$	*df*	*r*
Wives' Sexual Satisfaction								
Intercept	5.56***	[5.41: 5.71]	216.96	–	5.57***	[5.45: 5.70]	214.47	–
Study	−0.02	[−0.12: 0.08]	188.94	.03	−0.02	[−0.11: 0.06]	182.87	.04
Time	−0.19***	[−0.24: −0.14]	111.82	.57	−0.12***	[−0.16: −0.07]	97.17	.44
Between-Person HCI	0.07	[−0.19: 0.34]	201.26	.04	0.09	[−0.13: 0.31]	195.55	.06
Within-Person HCI	−0.18*	[−0.32: −0.03]	76.24	.26	−0.20**	[−0.37: −0.03]	67.01	.28
Husbands' Sexual Satisfaction	–	–	–	–	0.37***	[0.32: 0.43]	831.87	.42
Pregnant	–	–	–	–	0.13*	[0.00: 0.25]	692.94	.08
Attempting to Conceive	–	–	–	–	0.10	[−0.04: 0.25]	865.10	.05
Wives' Marital Satisfaction								
Intercept	38.28***	[37.11: 39.46]	207.45	–	38.90***	[37.97: 39.83]	192.19	–
Study	−0.34	[−1.01: 0.34]	199.45	.07	−0.28	[−0.84: 0.29]	188.90	.07
Time	−1.60***	[−2.23: −0.97]	96.88	.46	−0.82**	−1.33: −0.31]	74.64	.35
Between-Person HCI	0.72	[−0.96: 2.39]	200.71	.06	0.65	[−0.77: 2.06]	190.59	.07
Within-Person HCI	−0.01	[−1.06: 1.03]	774.61	.00	−0.46	[−1.44: 0.52]	707.04	.03
Husbands' Marital Satisfaction	–	–	–	–	2.54***	[2.16: 2.93]	846.27	.41
Pregnant	–	–	–	–	1.12*	[0.14: 2.10]	784.60	.08
Attempting to Conceive	–	–	–	–	2.04***	[0.91: 3.18]	901.32	.12

Note. HCI = Hormonal Contraceptive Incongruency. Effect-size *r* is reported. Within-Person HCI is coded such that *0* = current HC use is congruent with use at relationship formation and *1* = current HC use is incongruent with use at relationship formation; Between-Person HCI is each person's mean HC incongruency across all assessments and thus ranges from 0 to 1. The estimates in both controlled models exclude random effects for all covariates (see Barr et al., 2013); supplemental robustness analyses that modeled maximal random variation revealed that interpretations of the Within-Person HCI estimate remained unchanged (for sexual satisfaction, $p = .002$; for marital satisfaction, $p = .778$).

Effect-sizer = $\sqrt{\frac{t^2}{t^2 + df}}$.

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

can be seen, consistent with the within-person phenomenon purported by the HC congruency hypothesis, wives' within-person HC incongruency (but not between-person HC incongruency) was negatively associated with their sexual satisfaction in both models. That is, a given wife reported lower sexual satisfaction at times when her current HC use was incongruent (versus congruent) with her HC use at relationship formation, and this association emerged independent of husbands' sexual satisfaction, whether wives were pregnant, and whether wives were attempting to conceive. Given that wives' sexual satisfaction was associated with their marital satisfaction (see Table 1), we additionally explored the extent to which these effects emerged independent of wives' marital satisfaction, providing a more sensitive test of our key effect. These exploratory results revealed the association between wives' within-person HC incongruency and their sexual satisfaction was somewhat attenuated but trended toward traditional significance (uncontrolled model: b = −0.14, $CI_{90\%}$ [−0.26: −0.02], t(70.41) = −1.93, p = .058, effect-size r = .22; controlled model: b = −0.14, $CI_{90\%}$ [−0.27: −0.01], t(65.07) = −1.81, p = .075, effect-size r = .22).

To explore whether husbands' facial attractiveness moderated the association between wives' within-person HC incongruency and their sexual satisfaction, we re-estimated Eq. 1 but additionally included husbands' facial attractiveness (standardized) and the Within-Person HC Incongruency × Husbands' Facial Attractiveness interaction as predictors, controlling for the Between-Person HC Incongruency × Husbands' Facial Attractiveness interaction. Results of this exploratory analysis demonstrated that husbands' facial attractiveness did not significantly moderate the association between wives' within-person HC incongruency and their sexual satisfaction, b = 0.08, $CI_{95\%}$ [−0.08: 0.24], t(76.32) = 0.99, p = .323. Notably, this association remained nonsignificant when we additionally controlled for husbands' sexual satisfaction, whether wives were pregnant, and whether wives were attempting to conceive, b = 0.13, $CI_{95\%}$ [−0.05: 0.31], t(64.37) = 1.41, p = .165.

Finally, we explored whether the association between wives' within-person HC incongruency and their sexual satisfaction depended on whether wives did versus did not use HCs at relationship formation (i.e., the direction of incongruency). Specifically, we again re-estimated Eq. 1 but additionally included wives' HC use at relationship formation (−1 = "No HC use at relationship formation;" 1 = "HC use at relationship formation") and the Within-Person HC Incongruency × HC Use at Relationship Formation interaction as predictors, and we additionally controlled for the Between-Person HC Incongruency × HC Use at Relationship Formation interaction. Notably, these interactions can alternatively be interpreted as the effect of wives' within- and between-person HC use at any given assessment, respectively. Results of this exploratory analysis demonstrated that the Within-Person HC Incongruency × HC Use at Relationship Formation interaction trended toward significance, b = 0.13, $CI_{90\%}$ [0.01: 0.25], t(72.77) = 1.77, p = .080, effect-size r = .20,[4] and the simple main effect of Within-Person HC Incongruency continued to emerge as significant, b = −0.16, $CI_{95\%}$ [−0.30: −0.02], t(72.81) = −2.20, p = .031, effect-size r = .25. Nevertheless, given that (a) this interaction did not reach traditional significance, (b) it no longer trended toward significance when we additionally controlled for husbands' sexual satisfaction, whether wives were pregnant, and whether couples were attempting to conceive, b = 0.10, $CI_{95\%}$ [−0.08: 0.28], t(76.72) = 1.14, p = .259, and (c) we did not predict it a priori, we hesitate to interpret this finding until future research can replicate it.

3.3.2. Marital satisfaction

To examine the associations between wives' HC incongruency and their marital satisfaction, we again statistically isolated within- and between-person variability by re-estimating Eq. 1 but replacing Wives' Sexual Satisfaction with Wives' Marital Satisfaction. In this model, we allowed the Intercept and Time estimates to vary randomly across wives but not the Within-Person HC Incongruency estimate given that the model would not converge when we estimated a random effect for this parameter.[5] In addition to this primary model, we again conducted a supplemental robustness analysis that additionally controlled for husbands' marital satisfaction, whether wives were attempting to conceive, and whether wives were pregnant (none of which were allowed to vary across wives).

Results of both analyses are reported in the bottom half of Table 2. As can be seen, we did not detect an association between wives' within-person HC incongruency and their marital satisfaction, and this association remained nonsignificant when we controlled for husbands' marital satisfaction, whether wives attempting to conceive, and whether wives were pregnant. Given that wives' sexual satisfaction was associated with their marital satisfaction (see Table 1), we additionally explored the extent to which these effects emerged independent of wives' sexual satisfaction. These exploratory analyses similarly failed to detect an association between wives' within-person HC incongruency and their marital satisfaction (uncontrolled model: b = 0.49, $CI_{95\%}$ [−0.47: 1.45], t(783.35) = 1.00, p = .318; controlled model: b = −0.02, $CI_{95\%}$ [−0.93: 0.89], t(702.97) = −0.03, p = .973).

Although we planned a priori to explore the extent to which (a) husbands' objective facial attractiveness and (b) the direction of incongruency moderated the association between wives' HC incongruency and their marital satisfaction (Russell et al., 2014), the lack of between-person variability in this association (as suggested by the fact that the model would not converge when we included a random effect for the within-person HC incongruency estimate) unfortunately rendered such tests of moderation conceptually unsound.[6]

4. Discussion

4.1. Study rationale and summary of results

Given the evolutionary importance of reproduction and pair bonding throughout human history, the mismatch between evolved and modern environments may have important implications for human mating psychology (Li et al., 2018). Relevant to the current study, the modern advancement of HCs may help explain, at least in part, modern relationship difficulties (see Finkel et al., 2014) such as reduced sexual and relationship satisfaction when women's current HC use is incongruent with their use at relationship formation. Although prior research has provided preliminary empirical support for this possibility (Roberts et al., 2014; Russell et al., 2014), such work has not directly tested the within-person nature of the phenomenon. That is, to our knowledge, no

[4] This result alternatively suggests that wives trended toward reporting lower sexual satisfaction when they were using (versus not using) HCs.

[5] The fact that the model would not converge when we included a random effect for the association between wives' Within-Person HC Incongruency and marital satisfaction suggests this association does not differ across the wives in our sample. Indeed, the variability estimate was not large enough to detect against the residual variance (see Barr et al., 2013), r = 2.81, SE = 0.00, and direct tests confirmed this was the most parsimonious model (see Matuschek et al., 2017).

[6] For interested readers, an exploratory analysis that excluded this random effect revealed partner facial attractiveness did not significantly moderate this association, b = 0.61, $CI_{95\%}$ [−0.57: 1.80], t(772.12) = 1.02, p = .308; although this result differs from past research (e.g., Russell et al., 2014), readers should exercise extreme caution when interpreting this null result given the lack of significant variance in the association. Likewise, a second exploratory analyses revealed the direction of incongruency did not significantly moderate this association, b = 0.81, $CI_{95\%}$ [−0.24: 1.86], t(777.84) = 1.51, p = .131. Again, readers should exercise extreme caution when interpreting this null result.

research to date has examined the association between the within-person variance in partnered women's HC incongruency and their sexual and relationship satisfaction.

We thus pooled the data from two independent, longitudinal studies of newlywed couples to test these associations. Consistent with the HC congruency hypothesis (Roberts et al., 2013), wives were less sexually satisfied when their current HC use was incongruent (versus congruent) with their HC use at relationship formation. Inconsistent with the HC congruency hypothesis, however, we did not detect an association between wives' marital satisfaction and their within-person changes in HC congruency. Given that there was not sufficient between-person variability in this association—at least in the current data, we were limited in our ability to test the extent to which this null main effect was qualified by the extent to which those wives have physically attractive partners (see Russell et al., 2014).[6] Exploratory analyses further revealed that (a) husbands' facial attractiveness did not significantly moderate the association between within-person changes in wives' HC congruency and their sexual satisfaction and (b) the direction of HC incongruency (or alternatively, wives' HC use at a given assessment) for wives' sexual satisfaction trended toward mattering. This latter finding, however, was not robust to the inclusion of covariates and thus we are hesitant to make strong conclusions regarding it.

4.2. Theoretical implications

These results have several important theoretical implications. First, and perhaps most notably, this research (a) provides the strongest test to date of the HC congruency hypothesis (Roberts et al., 2013) and (b) adds to the growing body of literature supporting the evolutionary mismatch hypothesis (Li et al., 2018). Indeed, married women reported lower levels of sexual satisfaction when their HC use was incongruent (versus congruent) with their use at relationship formation. Given that women's sexual-frequency preferences are associated with their sex hormones (e.g., Gangestad & Thornhill, 2008; Grøntvedt et al., 2017; Roney, 2018; Roney & Simmons, 2013; also see Jones et al., 2018), changes in such preferences—as a result of changes in their HC use—presumably accounted for (at least some of) the declines in sexual satisfaction demonstrated here. We unfortunately did not have an adequate measure of wives' sexual-frequency preferences in the current study and were thus unable to explore this possibility. Future research may benefit from directly examining the extent to which changes in women's sexual preferences that correspond with changes in their HC use account for their declines in sexual satisfaction.

It is of course worth noting that Roberts et al. (2013) did not highlight the role of *sexual* preferences in their original conceptualization of the HC congruency hypothesis, which exclusively highlighted the role of partner preferences (particularly preferences for partner physical attractiveness; also see Russell et al., 2014). Nevertheless, recent work demonstrates women's sex hormones and brain structures are associated with numerous relationship preferences, including but not limited to sexual frequency (Gangestad & Thornhill, 2008; Grøntvedt et al., 2017; Roney, 2018; Roney & Simmons, 2013), sexual desire (Jones et al., 2019; Roney, 2018), partner bonding (Gangestad & Grebe, 2017), and partner personality (Cooper et al., 2012). Given such recent work, and given that the association between HC incongruency and women's sexual satisfaction did not depend on their partners' facial attractiveness in the current study, we suggest the HC congruency hypothesis be theoretically expanded to encompass the complexities inherent to formulating relationship evaluations. Indeed, changes in any relationship preferences as a result of beginning or discontinuing HCs (relative to use at relationship formation) may threaten the delicate balance of relationship rewards versus costs that underlie intimates' relationship outcomes (Rusbult & Buunk, 1993).

Second, the current research highlights the importance of examining psychological phenomena in the contexts in which they are most likely to occur. Given that HC incongruency theoretically impacts women over time during the course of their long-term relationships, it should be tested in such a context. By repeatedly assessing partnered women's HC incongruency and relationship outcomes over time in the current research, we were able to statistically isolate the within- from the between-person variance in women's HC incongruency, which allowed us to rule out key between-person differences (e.g., education, income) that may have accounted for effects in prior research (Roberts et al., 2014; Russell et al., 2014). Nevertheless, there are potential confounds—specifically, within-person confounds—that we were unable to account for in the current study. Women may begin or discontinue using HCs throughout the course of their relationship for multiple reasons; although we ruled out some of these reasons (e.g., pregnancy, attempting to conceive), we were unable to rule out other possibilities that might be associated with women's relationship outcomes (e.g., weight gain caused by HCs, mood changes). Only a true experiment can rule out all potential confounds.

4.3. Additional considerations and future directions

We would be remiss if we failed to acknowledge a recent study (Jern et al., 2018) that used a large sample of women to test the HC congruency hypothesis and failed to find empirical support for it. Indeed, Jern and colleagues failed to detect an association between partnered women's HC incongruency and their sexual satisfaction; likewise, they failed to detect a moderating effect of partner facial attractiveness for those women's relationship satisfaction. Nevertheless, similar to Roberts et al. (2014), Jern and colleagues used a cross-sectional design that prohibited examination of HC incongruency within women. In light of the fact that the between-person variance in women's HC incongruency was unassociated with women's sexual satisfaction in the current study, such between-person variance may have suppressed (see Sharpe & Roberts, 1997) the HC-congruency effect in prior cross-sectional research such as Jern et al., making it difficult to consistently detect it.

It is also worth noting that Jern et al. (2018) used women's own reports of their partners' attractiveness, which may have further precluded their ability to detect the extent to which partner facial attractiveness moderates the association between HC incongruency and women's relationship satisfaction. According to evolutionary perspectives, men's facial features serve as an objective indicator of their genetic quality (Thornhill & Gangestad, 1999; cf. Scott et al., 2014), but women's subjective reports of their partners' attractiveness are biased by various relationship goals and motives (Boyes & Fletcher, 2007; Meltzer, McNulty, Jackson, & Karney, 2014a). In one study, for example, women misidentified photographs of close others that had been attractively enhanced as those close others' actual photographs (Epley & Whitchurch, 2008). Accordingly, the differences in results obtained by Russell et al. (2014) versus those reported by Jern et al. (2018) could potentially be explained by the use of objective versus subjective ratings of partner attractiveness. As noted, wives in the current sample did not differ in the extent to which their within-person HC incongruency was associated with their marital satisfaction, prohibiting us from testing moderators (e.g., partner attractiveness) of this association. Future research may thus benefit from obtaining samples exhibiting greater variability in this association to allow for such exploration.

Finally, future research may also benefit from examining the generalizability of the results presented and discussed here. The homogenous nature of our newlywed samples aided in our ability to detect implications of HC incongruency for women's sexual satisfaction, but it remains to be seen whether similar associations emerge among women involved in different types of long-term relationships. Although we do not have theoretical reason to expect these associations to differ among some other types of long-term relationships such as domestic partnerships, non-newlywed married couples, or consensually non-monogamous couples, HC incongruency may function differently among same-sex female couples. Although women in same-sex relationships

are less likely to use HCs (in the current study, such excluded women did not report using HCs at any assessments), they may begin or discontinue using HCs for purposes other than contraception, and the effects of any changes in HC use relative to use at relationship formation may also depend on their female partners' HC incongruency.

5. Conclusion

Across the course of their long-term romantic relationships, women begin and discontinue using HCs numerous times, thereby regularly altering their hormonal profiles and brain structures from those that evolved to those dictated by modern medicine. As the current research highlights, such changes may be detrimental for women's relationships—particularly for their sexual relationships. Given the importance of long-term romantic relationships to women's overall psychological and physical well-being (Finkel et al., 2014; Robles, Slatcher, Trombello, & McGinn, 2014), the functional perspective offered by the HC congruency hypothesis and the evolutionary mismatch hypothesis may provide novel insights into ways to improve relationship well-being.

Data availability

The data associated with this research are available at https://osf.io/v2dqc/.

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Declaration of Competing Interest

None.

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