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Differences in cortisol responding and post-stress affiliation among women who are naturally cycling, using oral contraceptives, and using IUDs☆

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ABSTRACT

Despite the pervasiveness of women's use of hormonal contraceptives, surprisingly little is known about the influence of HCs on psychological processes under stress. We examined how hormonal contraceptive use, including use of oral contraceptives and hormonal intrauterine devices (IUDs), relates to physiological and affiliative responses under stress. Women (N=190) underwent the Trier Social Stress Test (TSST), provided saliva samples for assays of free cortisol and progesterone, and completed three measures of affiliation. Women using both oral contraceptives and hormonal IUDs showed blunted cortisol responses to the TSST relative to naturally cycling women. Although there were no group differences in women's self-reported extraversion at baseline (prior to the TSST), women using oral contraceptives, compared to the other three groups, showed less social affiliative behavior following the TSST across two dependent measures. There were no differences in affiliation between naturally cycling women in their follicular or luteal phase, failing to replicate past research. Importantly, differences in affiliation were unrelated to differences in cortisol responses. Results suggest that hormonal contraceptives may subtly alter multiple stress-responsive processes via independent mechanisms, and in ways that are consistent with past research demonstrating that some women who use hormonal contraceptives experience heightened risk of negative stress-related outcomes.

1. Introduction

The same stressor does not induce the same stress in everyone (Fink, 2016). Indeed, individual differences in the link between stressor and stress response are theoretically important contributors to stress-related negative health outcomes (Garfin et al., 2018; O'Connor et al., 2021; Shields and Slavich, 2017). At a psychological level, there is perhaps no better buffer of stress than social support and affiliation (Häusser et al., 2012; Schmiedl et al., 2022). Notably, seeking social support during stress may be an especially important strategy for women (Copeland and Hess, 1995; McDonald and Korabik, 1991; Ogus et al., 1990). At a physiological level, factors such as basal hormone levels can alter the biological stress response (e.g., Cooper et al., 2021; Quinn and Shields, 2023). Despite the theoretical importance of these dynamics to health, little work has examined how women's use of common medications that alter basal sex hormone levels—namely, oral contraceptives (OCs) and hormonal intrauterine devices (IUDs)—might influence their social-affiliative behavior and related biological stress responses. This study aims to address that gap.

1.1. Buffering Stress by Social Support and Affiliation

Women's use of affiliation as a predominant coping strategy can be understood from the perspective of the "tend-and-befriend" theory (Taylor et al., 2000). According to this theory, when women undergo stress, they may affiliate with close others to mitigate their stress. Women may engage in affiliative behavior in the face of a stressor because fight-or-flight strategies may have been less adaptive for women

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in the evolutionary past (Taylor et al., 2000). Affiliative tactics may thus help women to mitigate or survive stressors most effectively (Nickels et al., 2017; Taylor et al., 2006; Turton and Campbell, 2005).

Although the tend-and-befriend theory has largely focused on oxytocinergic and dopaminergic processes (Taylor, 2006), other hormones (e.g., cortisol, progesterone) have also been implicated in affiliative behaviors (Wirth and Schultheiss, 2006; cf. Pekarek et al., 2025). For example, social rejection induces cortisol responses (e.g., Blackhart et al., 2007; Stroud et al., 2017; Stroud et al., 2002), whereas social affiliation attenuates cortisol responses to social stressors (Berger et al., 2016). Similarly, sex hormone fluctuations are associated with women's cortisol responses (Kirschbaum et al., 1999) and their affiliative motives (Makhanova et al., 2025; Maner and Miller, 2014; Schultheiss et al., 2003; Van Wingen et al., 2008). Further, progesterone administration increases amygdala reactivity to angry and fearful faces (Van Wingen et al., 2008), suggesting that progesterone could increase sensitivity to situations that may benefit from affiliative behaviors. Thus, cortisol and progesterone responses may contribute to affiliative behavior under stress.

1.2. Hormonal Contraceptive Use and Stress Responses

Many women use hormonal contraceptives (HCs) to prevent unwanted pregnancy or alleviate symptoms related to their menstrual cycles. In addition to such intended effects, HCs also appear to have unintended effects. For example, compared to naturally cycling women, women using OCs demonstrate blunted stress-induced cortisol responses (Aleknaviciute et al., 2017; Hertel et al., 2017; Kirschbaum et al., 1995; Kirschbaum et al., 1999), and blunted cortisol and progesterone responses in competitive settings (Casto et al., 2023). Additionally, compared to naturally cycling women, women using OCs produce up to 170% more corticosteroid-binding globulin (CBG; Wiegratz et al., 1995). This increased CBG production may be an attempt to neutralize excess cortisol (Hertel et al., 2017), as CBG inactivates bound cortisol. Whatever the reason for this increased production, it may be one possible mechanism contributing to HC-related blunting of stress responses: CBG binds excess cortisol (e.g., from a stress response), and high CBG makes assays of free (i.e., unbound) cortisol responses appear blunted (Roche et al., 2013). Notably, there may be other causes of such response blunting (e.g., changes in receptor densities or sensitivities; Rohleder et al., 2003).

Due to these nuances, most acute stress studies exclude women using OCs (Gervasio et al., 2022). Consequently, little is known about how women's stress responses—including affiliative behavior—differ by OC use. Even less is known about how different types of HCs relate to stress responses. To our knowledge, only three studies have examined stress responses among women using hormonal IUDs, and their results are inconsistent: In response to acute stress and comparing women using hormonal IUDs to naturally cycling women, Aleknaviciute and colleagues (2017) found heightened cortisol responses (n_{IUD}=15), Bürger and colleagues (2025) found no difference in responses (n_{IUD}=27; though each woman completed the stress protocol twice), and Casto and colleagues (2025) found blunted cortisol responses (n_{IUD}=29). Moreover, to our knowledge, no study has examined how use of any HCs relates to differences in affiliative or social behavior under stress in humans (for studies addressing similar questions in rodents, see Lacasse et al., 2025; Santoru et al., 2014).

1.3. Current Research

The current study addressed the gaps described above by examining differences in hormonal and social responses to an acute stressor among women who were naturally cycling (follicular vs. luteal), using OCs, or using hormonal IUDs. Participants underwent the Trier Social Stress Test (TSST) and provided saliva samples, which were assayed for cortisol and progesterone. We assessed women's affiliation via three measures: an implicit motives task, a self-report questionnaire, and a behavioral task. We hypothesized that women using OCs would show blunted cortisol and affiliative responses relative to naturally cycling women. Because of mixed results in the prior studies (Aleknaviciute et al., 2017; Bürger et al., 2025; Casto et al., 2025), we did not have strong predictions for women using hormonal IUDs. Finally, we explored whether group differences in women's affiliation under stress and would be partially mediated by cortisol and progesterone reactivity.

Our focus on women's social responses under stress is also situated within the social psychology literature showing that stressors can increase affiliation, especially toward others experiencing the same stressor (Gump and Kulik, 1997). Moreover, the social reconnection hypothesis contends that social exclusion can activate people's affiliative motives and prompt them to seek social contact with new and accepting people (Maner et al., 2007). The context of the TSST, a socially evaluative stressor, is thus ideal for examining whether HC use dysregulates women's affiliation.

2. Method

2.1. Participants

Women were recruited via convenience sampling from the broader campus community of a public university in the Midwestern United States. Participants were compensated with a $25 Amazon gift card or credits toward their psychology course.

All interested participants (N = 1236) first completed an eligibility screening survey. Exclusion criteria were: (1) not being assigned female at birth and not identifying as women, (2) being under 18 or over 35, (3) being pregnant or nursing within the last 6 months, (4) having chronic health conditions that impact endocrine functioning (e.g. polycystic ovary syndrome, diabetes, hypothyroidism/hyperthyroidism), (5), taking medications that could impact endocrine functioning (e.g. corticosteroids, beta-blockers, anxiolytics, spironolactone), (6) having a BMI under 18.5 or over 30, and (7) having a recent history of drinking in excess. As is recommended for studies on acute stress and related biomarkers (e.g., Shields, 2020; O'Connor et al., 2009), we also excluded smokers due to effects of smoking on cortisol, sex hormones, and similar analytes (Tweed et al., 2012). Naturally cycling women had an additional inclusion criterion of having regular menstrual cycles (i.e. cycles were regularly occurring and lasting 21–35 days) (Creinin et al., 2004). Women using HCs had an additional inclusion criterion of using either a hormonal IUD or a combined, monophasic oral contraceptive (i.e., one that included both a progestin and ethinyl estradiol, with the same dosage of both synthetic hormones across all active pills).[1] Women who met all initial inclusion and exclusion criteria (n=425) were invited to participate in the study; 211 women participated in the study between February 2022 and May 2023.

Scheduling procedures for eligible participants differed based on the quasi-experimental group membership (i.e. women using OCs, women using hormonal IUDs, naturally cycling women). See Supplemental Materials for full scheduling and group assignment details. Primary analyses included 190 participants who had data for at least one key dependent measure: women using OCs (n = 52), women using IUDs (n = 53), naturally cycling-follicular phase (n = 43), and naturally

[1] The additional inclusion criterion for oral contraceptive-using women was intended to reduce pharmacological heterogeneity within the sample. We focused on monophasic, combined oral contraceptives because they are the most commonly prescribed category of oral contraceptives in the United States (Brynhildsen, 2014; Teal and Edelman, 2021). Unfortunately, we did not ask participants to report the time of their last pill ingestion or about the specific oral contraceptive prescription they were taking. However, based on other our studies conducted in this community, we would expect the majority OCs to contain norgestimate or norethindrone/norethindrone acetate.

cycling-luteal phase ($n = 42$). See Table 1.

2.2. Materials

To gain a comprehensive understanding of women's affiliative motives following stress, the three measures varied in type: an implicit motives task (the Functional Projection of Emotion Task), a self-report questionnaire (the State-Adapted Fundamental Social Motives Scale), and a behavioral task (the Card Game Task).[2] The implicit motives task and questionnaire were counterbalanced; participants began these tasks immediately after providing the second saliva sample (approximately 20 min after the offset of the stressor). Participants completed the behavioral task at the end of the laboratory session, approximately 40 min after the offset of the stressor and after providing the last saliva sample.

2.2.1. Functional projection task

To assess women's implicit social motives, we used the Functional Projection Task (Maner et al., 2005). Past research using this task has documented that, when motivational states become activated, people are more likely to perceive goal-relevant emotions in the faces of neutral social targets (Kawada et al., 2004; Krems et al., 2015; Niedenthal et al., 2000).[3] Participants were given the same instructions as in prior research (Maner et al., 2005). Participants were told that they would see several faces of people with neutral facial expressions. Ostensibly, these people thought about an emotional event and subsequently covered their emotions with the neutral facial expression before being photographed. Participants were asked to give a "gut" rating to guess what emotion each person was feeling prior to putting on the neutral expression. Participants rated each target on three focal motivational states ("stressed" or "rejected" or "social") and several foil motivational states (e.g. "angry" or "sexually aroused") using a scale of 1 (*Not at all*) to 9 (*Very much*). We averaged the ratings of all 16 male and female targets (presented in random order). Two participants had missing data for this variable. We hypothesized that increased affiliative desire may be indexed by perceiving the neutral faces as feeling more social, as well as less stressed and rejected.

2.2.2. State-adapted fundamental social motives scale

We modified the Fundamental Social Motives Scale (Neel et al., 2016) to capture state motives (the modified scale is available in the Supplemental Materials). Participants indicated their agreement with how much each statement represented how they felt "right now" on a 7-point scale from 1 (*Strongly disagree)* to 7 (*Strongly agree*). Each motive was measured with a 6-item subscale; we focused on the three subscales related to affiliation: affiliation motives within a group (e.g. "Right now, it is important that I am a part of a group," Cronbach's α=.93, M=4.69, SD=1.13), exclusion concern motives (e.g. "Right now, I would be extremely hurt if a friend excluded me," Cronbach's α=.88, M=3.78, SD=1.47), independence motives (e.g. "Right now, I want to be by myself," Cronbach's α=.86, M=3.75, SD=1.35). Cronbach's α was calculated from responses of all women who participated in the study. Of participants who were included in our final sample, one had missing data for this measure.

2.2.3. Card Game Task

Participants were told that they would be playing a card game with another woman who was also participating in the study but in another room down the hall. This cover story created a context in which affiliation should appear likely, given past research has shown social exclusion to increase affiliation for anticipated interactions with novel social partners (Maner et al., 2007) and stress to increase affiliation with targets who purportedly went through the same stressful experience (Gump and Kulik, 1997). The card questions for the game were chosen from an existing experimental paradigm that consists of high versus low self-disclosure questions (Aron et al., 1997); high self-disclosure questions are important for generating feelings of interpersonal closeness (Aron et al., 1997). Self-disclosure is critical for developing close relationships; people like others who self-disclose to them and like others to whom they self-disclose (Collins and Miller, 1994). Thus, selecting higher self-disclosure cards (and thus deciding to share high-disclosure information with a novel social partner) for the ostensible game can indicate greater desire for social closeness.[4]

We provided the participants with 10 cards that were pre-rated by an independent group of undergraduate students to ensure (a) their applicability to the student population and (b) that half would require high self-disclosure (e.g. "What is your most treasured memory?") and half would require low self-disclosure (e.g. "How did you celebrate last Halloween?"). Participants were instructed to select five cards. Notably, participants never interacted with another person; the study ended after they chose their five cards. The number of high self-disclosure questions chosen were therefore the behavioral measure of affiliation. Because of issues with session timing (e.g., if a participant came late), 22 participants had missing data for this measure.

2.2.4. Additional self-report measures

Participants completed several measures that we used to verify that baseline differences in sociality and emotional state were not driving subsequent effects of group membership on primary dependent measures. With the exception of women in the luteal phase reporting higher fear of negative evaluation than both groups of women using HCs, there were no group differences in neuroticism, extraversion, or other variables at baseline. See Supplemental Materials for full method and results, as well as models examining the primary dependent measures with the additional covariate of fear of negative evaluations.

At each saliva sample timepoint, participants also completed a subjective measure of stress. There were no group differences at any time points, in change in subjective stress from baseline to post-stressor, or in the full trajectory of subjective stress change. See Supplemental Materials for full method and results.

2.3. Procedure

All lab sessions occurred between 12 pm and 5 pm to account for diurnal fluctuations in cortisol (e.g., Ljubijankīć et al., 2008). Upon arriving in the lab, all participants provided written informed consent. Then, participants completed general personality questionnaires in a private room for 10 min to allow them to become habituated to the lab environment. Participants provided the first (i.e., baseline) saliva sample via passive drool after this acclimation period. The sample was always collected 10 min after arrival. If participants were not done with the questionnaires, they were interrupted to provide the sample. Conversely, if participants were done with the questionnaires before 10 min were up, they were instructed to wait quietly until the next portion of the study could begin. Importantly, throughout the entire study, participants were not allowed to drink water or use their phones and were instructed to leave them placed in their backpacks outside of their reach.

Next, participants completed the Trier Social Stress Test (TSST; Kirschbaum et al., 1993) to induce social stress. Participants were given five minutes to prepare a speech for their dream job, but were not allowed to write it down. After the preparation period, they presented their speech to two stoic female judges (confederates) in a room, with

[2] See Supplemental Materials for zero-order correlations between measures.

[3] See Supplemental Materials for additional details about how this task has been used in prior research.

[4] See Supplemental Materials for additional details about how we adapted this task based on prior research on affiliation and self-disclosure.

Table 1
Participant Demographics by Group.

Demographic Variable	Oral Contraceptives(n= 52)	Hormonal IUD (n= 53)	Follicular Phase (n= 43)	Luteal Phase (n= 42)	Whole Sample (n= 190)
Age: *M*(*SD*)	20.52(3.57)	22.17(4.17)	21.21(4.50)	20.90(3.81)	21.22(3.88)
Race: % White/Caucasian	86.54%	92.45%	70.27%	75.68%	82.68%
Ethnicity: % Non-Hispanic	86.54%	88.68%	83.78%	89.19%	87.15%
Relationship Status: % Single	55.77%	64.15%	56.76%	43.24%	55.87%
Sexual Orientation: % Only Heterosexual	82.69%	62.26%	81.08%	72.97%	74.30%
Political Orientation: *M*(*SD*)	4.87(2.43)	3.81(2.15)	4.48(2.75)	5.14(2.35)	4.54(2.45)
Religiosity: *M*(*SD*)	5.73 (2.84)	4.34(3.01)	7.69 (2.64)	6.48 (2.87)	5.94 (3.08)

Note. Participants reported their political orientation using a scale of 1 (*Very liberal*) to 10 (*Very conservative*), and their religious orientation using a scale of 1 (*Not religious at all*) to 10 (*Very religious*).

the speech supposedly recording for nonverbal analysis. If they finished before five-minutes were up, the judges instructed them to continue. Then, participants completed a five-minute oral arithmetic task, counting backwards by 13 from 1022. Mistakes required them to start over from 1022.

After this task, participants returned to the private room for a 15-minute waiting period to allow time for cortisol responses to become expressed in saliva (Shirtcliff et al., 2015). Participants were provided with coloring books and markers while they waited. The amount of time participants spent coloring did not significantly differ across groups, $F(3, 129) = 0.35$, $p = .789$. After the waiting period, participants provided the second saliva sample (i.e., +15 min post-stressor offset). After providing the second sample, participants completed two of the key dependent measures of affiliation (i.e., functional projection task and fundamental motives questionnaire, presented in random order). Next, participants completed other tasks and questionnaires that were beyond the scope of the current research. During the questionnaire block, participants were interrupted at + 25 and + 35 min post-stressor offset to provide their third and fourth saliva sample, respectively. At the end of the study, and after the fourth saliva sample, participants completed the final measure of affiliation (i.e., card game task). We placed this measure at the end because of the specific deception it involved (i.e., participants believing that they would be interacting with another participant for the next task). Immediately after making their card selection, participants were debriefed, compensated, and dismissed. [5]

2.4. Saliva Sample Collection

Although participants did not receive instructions to avoid drinking or eating before the session, they were instructed to put away their water bottles and refrain from eating or drinking during the session. The four saliva samples (baseline, +15, +25, and +35) were each provided directly (i.e., without a straw) via passive drool into individual 15 mL sterile conical tubes (VWR International; 89039–666). All saliva samples were frozen at −20°C at the end of the session.

2.5. Cortisol assays

Saliva samples were assayed in duplicate using an expanded range high-sensitivity salivary cortisol enzyme immunoassay kit purchased from Salimetrics (State College, PA; catalog number 1–3002). The sensitivity of the assay was < 0.007 μg/dL; the standard curve ranged from 0.012 to 3.000 μg/dL. The inter-assay CV was 16.85% (10.38% for high controls, 23.31% for low controls). Given the inter-assay variability was higher than typical benchmarks, we undertook additional steps to clean the data to make sure analyses were not conducted on unreliable hormone data. Cortisol analyses included 171 participants (39 follicular, 40 luteal, 45 OC, and 47 IUD) for whom we had complete, reliable data. See Supplemental Materials for additional information on the assay kits and data cleaning. The intra-assay CV for samples included in analyses was 8.65%.

2.6. Progesterone assays

Saliva samples were assayed in duplicates using a salivary progesterone enzyme immunoassay kit purchased from Salimetrics (State College, PA; catalog number 1–1502). The sensitivity of the assay was 0.5 pg/mL; the standard curve ranged from 10 pg/ML to 2430 pg/mL. The inter-assay CV was 9.33% (5.06% for high controls, 13.59% for low controls). The intra-assay CV was 16.88%. Because we were focused on progesterone reactivity, only the first and second saliva samples were assayed for progesterone.

2.7. Data reduction and statistical analysis

Data and syntax are available on OSF: https://osf.io/cjk3s/overview?view_only=e37d4c3d397540e3aac3981c6ffa5149.

Analyses for cortisol and progesterone were conducted in R v. 4.5.1 with packages afex (1.5–0) and emmeans (1.11.2–8). To examine whether cortisol responses differed as a function of group, we first conducted a Type III SS ANOVA. Models included a between-subject group factor (follicular, luteal, OC, and IUD), a within-subject time factor (baseline, +15, +25, and +35), and a group x time interaction. Sphericity correction via Greenhouse-Geisser was applied by default per afex's settings; this entails that the analyses' degrees of freedom are attenuated according to the correction. The same model was used for the ancillary area under the curve relative to increase (i.e., AUCi) analysis (presented in the Supplemental Materials).

To determine how cortisol responses differed among the four groups, we conducted a hierarchical Bayesian analysis using Turing within Julia. This approach is more comprehensive than simple post-hoc comparisons because it allows us to isolate whether differences at any post-stressor timepoint are driven by a latent difference in basal cortisol, reactivity, or recovery. We modeled participants' cortisol at each timepoint within a model estimating simultaneous group- and participant-level deviations from population baseline (*int.*), reactivity (*lin.*), and recovery (*qua.*) means within a hierarchical quadratic Bayesian growth curve model (see Fig. 2). We sampled the posterior via four chains with 5000 iterations each following 1000 burn-in iterations. Rhat values indicated chain convergence for each parameter (Rhats<1.01), as did Gelman and Geweke diagnostic tests. Our primary tests were related to group differences in deviation of reactivity (i.e., linear increases). To facilitate interpretations, we added the sampled population value on each iteration to each group deviation.

Analyses testing differences in the affiliation measures among the four groups of women were conducted in SPSS v. 29. For each outcome measure, we first conducted a one-way ANOVA to examine differences among the four groups. Missingness was deleted listwise per analysis;

[5] Due to time constraints, some participants did not complete the card selection task.

there were no outliers. We used $p < .05$ as our threshold for statistical significance. We then conducted several robustness analyses. Specifically, because women in the quasi-experimental groups differed on age, religiosity, and political orientation (see Supplemental Materials), we controlled for these demographic variables in ancillary analyses reported in the main text. Furthermore, because naturally cycling women in the luteal phase reported higher baseline levels of fear of negative evaluations, we conducted additional models controlling for fear of negative evaluations. These latter models are reported in the Supplemental Materials; controlling for fear of negative evaluation did not change the pattern of results reported in the main text. Fig. 1 was created using ggplot2 within R. Fig. 2 was created using PowerPoint. Fig. 3 was created using Plots and StatsPlots within Julia. Figs. 4 and 5 were created using Excel.

3. Results

3.1. Cortisol and Progesterone Responses by Group

3.1.1. Cortisol

We found a main effect of Time ($p < .001$), no main effect of Group ($p = .105$), and a significant Time × Group interaction, $F(4.83, 269.0) = 2.32$, $p = .046$, $\eta_p^2 = .04$. See Fig. 1.

Notably, although multiple significant group differences emerged in follow-up analyses (e.g., at T3, Follicular – IUD, $p = .006$), inferring the mechanisms underlying this time-dependent change is difficult without more formal modeling. Thus, we conducted a hierarchical quadratic Bayesian growth curve model (see Fig. 2).

At baseline, the groups did not differ in cortisol levels ($\mu^{int}_{follicular}$=6.27, μ^{int}_{luteal}=5.66, $\mu^{int}_{OC.}$=6.11, μ^{int}_{IUD}=5.84): All group mean contrasts included 0 within their 89% highest density intervals (HDIs), and 1-p_{dir} values (analogous to Bayesian one-tailed p value, albeit s with an upper bound of.50) indicated no group differences, 1-p_{dir}s > .157.

In contrast, there were a number of differences between groups in cortisol reactivity to the stressor. In particular, although there were no differences between naturally cycling women in the follicular phase ($\mu^{lin}_{follicular}$=2.85, 89% HDI: [1.93, 3.76]) and those in their luteal phase (μ^{lin}_{luteal}=2.42, 89% HDI: [1.57, 3.22]), 89% HDI_{diff}: [-0.56, 1.51], 1-p_{dir}= .248, and although there were no differences between women taking OCs (μ^{lin}_{OC}=1.65, 89% HDI: [0.87, 2.41]) and women with hormonal IUDs (μ^{lin}_{IUD}=0.94, 89% HDI: [0.09, 1.84]), 89% HDI_{diff}: [-0.34, 1.67], 1-p_{dir}= .124, both naturally cycling groups showed greater reactivity than women with hormonal IUDs, lower bounds of HDI_{diff}s > 0.21, 1-p_{dir}s < .019, Moreover, there was a tendency for naturally cycling women to show greater reactivity than women using OCs (follicular – OC: 1-p_{dir}=.039; luteal – OC: 1-p_{dir}=.126). Combining the groups four groups into two (i.e., naturally cycling or women using HCs) and contrasting their average linear increases showed a robust difference in cortisol reactivity, μ^{lin}_{diff}= 1.34, HDI_{diff}: [0.25, 2.30], 1-p_{dir}= .006. Because the μ^{lin}_{diff} parameter has a standard deviation of one, this result can also be interpreted as an effect size on the order of 1.34 nmol/L for the difference in cortisol response for women using HCs (compared to naturally cycling women). Fig. 3 illustrates these results. In short, naturally cycling women showed greater increases in free cortisol than women HCs, with no differences between women using OCs versus hormonal IUDs.

To supplement the above results, we conducted a sensitivity analysis using the area under the curve relative to increase (i.e., AUCi). See Supplemental Materials.

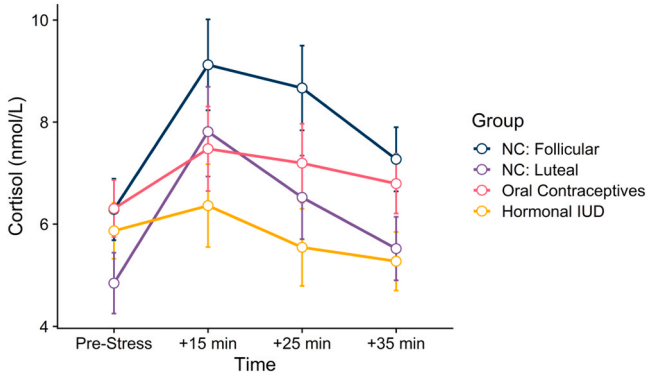

Fig. 1. *Cortisol Responses by Group. Note.* NC=naturally cycling, IUD=intrauterine device, min=minutes. Listed timepoints are given relative to stress offset. Error bars depict the standard error of the mean. Sample sizes per group were 39 follicular, 40 luteal, 45 oral contraceptives, and 47 IUD.

3.1.2. Progesterone

We found no main effect of Time ($p = .131$), a main effect of Group ($p < .001$), but no Time × Group interaction, $F(3, 164) = 1.11$, $p = .346$, $\eta_p^2 = .02$. Analyses of the Group effect showed that progesterone was significantly greater in the luteal group than any other group ($ps < .001$), and that none of the other groups differed from each other ($ps > .231$). Exploratory analyses also showed a significant increase in progesterone from T1 to T2 in the luteal phase group ($p = .024$) without any increase in progesterone in any other group ($ps > .717$). However, the change in the luteal group was not significantly different from the change in any other group ($ps > .102$). Bayesian analyses did not indicate any group differences in progesterone responses (1-p_{dir}s > .138).

3.2. Social affiliation

3.2.1. Functional projection task

Turning to post-stress affiliative behavior, we first examined whether the four groups of women differed in their projection of emotions of stress, rejection, and sociality (see Fig. 4). For projection of stress onto neutral faces, there were significant differences between groups, $F(3, 184) = 3.46$, $p = .018$, partial $\eta^2 = .05$. Women using OCs projected more stress compared to naturally cycling women in the luteal phase ($p = .028$; d=.46), and women using the hormonal IUD ($p = .002$; d=.61). However, this effect was only marginal when compared to naturally cycling women in the follicular phase ($p = .084$; d=.36). No other pairwise comparisons were significant ($ps \geq .231$). In ancillary analyses that controlled for age, political orientation, and religious ideology the overall difference between the groups remained significant, $F(3, 177) = 3.26$, $p = .023$, partial $\eta^2 = .05$, and the same pattern of pairwise comparisons emerged.

For projection of rejection, differences between groups were only marginal, $F(3, 184) = 2.64$, $p = .051$, partial $\eta^2 = .04$. We nevertheless conducted post-hoc comparisons between groups. We found that women using OCs projected more rejection onto neutral targets compared to naturally cycling women in the luteal phase ($p = .020$; d=0.49), and women using the hormonal IUD ($p = .014$; d=0.49), but not naturally cycling women in the follicular phase ($p = .119$; d=0.44). No other pairwise comparisons were significant (all $ps \geq .442$). Notably, the overall difference between the groups became significant in ancillary analyses that controlled for age, political orientation, and religious ideology, $F(3, 180) = 2.9$, $p = .038$, partial $\eta^2 = .05$. A similar pattern of pairwise comparisons emerged with one difference: women using OCs also projected more rejection than naturally cycling women in the follicular phase ($p = .048$; d=0.44).

For projection of sociality onto the neutral faces, however, there were no significant differences between groups, $F(3, 184) = 1.67$, $p = .176$, partial $\eta^2 = .03$. For analytical consistency, ancillary analyses controlled for age, political orientation, and religious ideology, confirming there were no significant differences between groups, $F(3, 180) = 1.86$, $p = .139$, partial $\eta^2 = .03$.

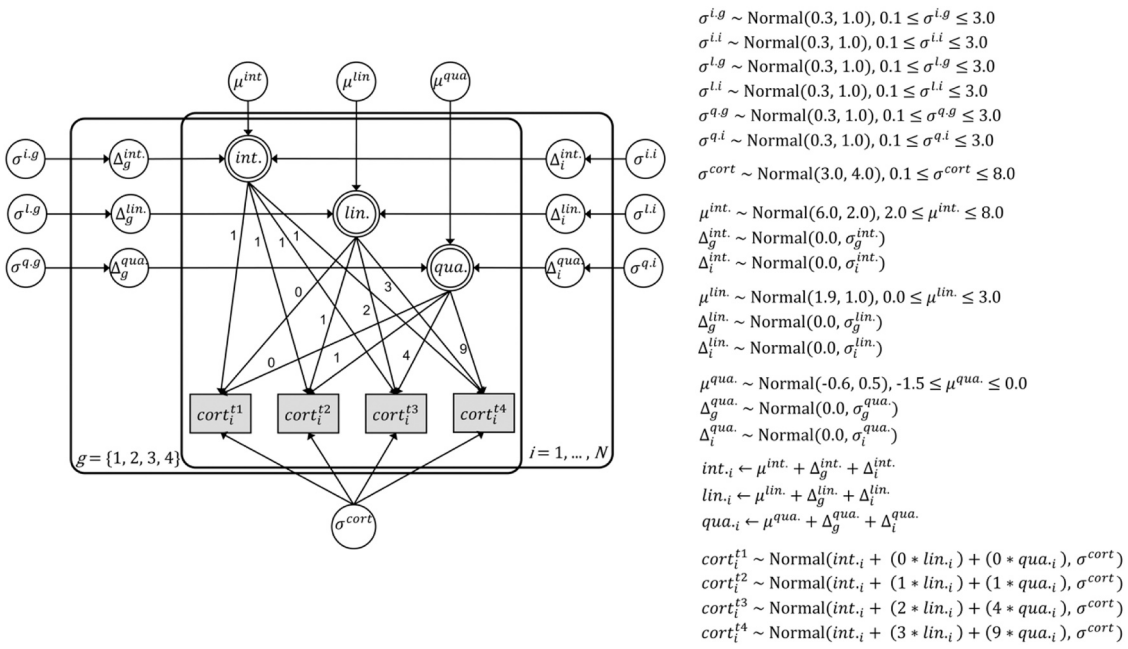

Fig. 2. *Hierarchical Bayesian Model Used for Cortisol Analyses. Note*. Population estimates were combined with group- and participant-level deviations for each group *g* and participant *i* to produce expected values for each observation within the depicted growth curve model. Population priors were drawn from sample data. Intercept, linear, and quadratic coefficients are constrained to these forms in the same way as is typical for a quadratic latent growth curve model with four timepoints; equations are shown to the right of the graphical model. The model is illustrated using graphical hierarchical Bayesian modeling nomenclature and guidelines given in Farell & Lewandowsky (2018; see also Shields et al., 2025). In brief, variables within circles are estimated, variables within two circles are computed from estimated variables, variables in gray rectangles are observed variables, and parameters that differ by group (*g*) and participant (*i*) are shown within the respective labeled enclosure.

3.2.2. Fundamental social motives

Next, we examined whether women in the four groups differed in their self-reported state-adapted fundamental social motives. There were no significant differences in any of the three subscales: affiliation motives within a group, exclusion concern motives, or independence motives ($ps > .112$).

3.2.3. Card game task

For the final task, we examined differences in the likelihood of asking high self-disclosure questions as a behavioral measure of desire for social closeness among the four groups of women using a one-way ANOVA. There were significant differences between groups, $F(3, 164) = 3.79$, $p = .012$, partial $\eta^2 = .07$. Women using OCs were less likely to ask high self-disclosure questions compared to naturally cycling women in the follicular ($p = .008$; d=0.59) and luteal phases ($p = .004$; d=0.64), as well as women using the hormonal IUD ($p = .020$; d=0.42). No other pairwise comparisons were significant ($ps \geq .497$). See Fig. 5. Notably, the overall difference between the groups remained significant in ancillary analyses that controlled for age, political orientation, and religious ideology, $F(3, 160) = 2.95$, $p = .034$, partial $\eta^2 = .05$. A similar pattern of pairwise comparisons emerged with one difference: women using OCs were only marginally less likely to ask high self-disclosure questions than IUD using women ($p = .050$; d=0.42).

3.3. Exploration of mediations

Finally, we explored whether cortisol responses mediated any associations between group and affiliative outcomes. We did not explore progesterone as a potential mediator due to a lack of group differences in progesterone reactivity. To assess for possible mediation, we examined the group Δ_g^{lin} parameter (i.e., the group deviations around the population linear increase in cortisol) within the Bayesian model, extended to each of the outcomes with significant group differences. We found no evidence for mediations by cortisol responses (1-p_{dir}s $> .244$).

4. Discussion

Despite the commonality of HC use, relatively little is known about how different forms of these medications influence or relate to various stress responses. We examined differences in affiliative and physiological stress responses among women who are naturally cycling, using OCs, and using hormonal IUDs. Consistent with work on OCs and one of the three prior studies on hormonal IUDs, we found a blunting of cortisol responses under stress across both HC groups, with women using hormonal IUDs showing the weakest cortisol response. We found no significant group differences in progesterone responses under stress. Interestingly, we found a distinct difference in affiliative behavior in women using OCs alone: Women using OCs were more likely to project stress and rejection onto a neutral face than women in any of the other three groups, and they were also less likely to choose high-disclosure topics to discuss with a putative conversation partner. These affiliative differences, however, were not statistically mediated by underlying differences in cortisol responses. In short, these findings suggest that HC use may be a subtle but noteworthy factor associated with the disruption of affiliative behavior and cortisol reactivity under stress. Furthermore, these findings may contribute to understanding why, for some women, HC use is associated with an increased risk for negative stress-related outcomes like depression (Mengelkoch et al., 2025; Skovlund et al., 2016).

At a theoretical level, our results are only partially consistent with theories suggesting that cortisol and/or progesterone may increase affiliative behavior (e.g., Wirth and Schultheiss, 2006; Duffy et al., 2017; though see Pekarek et al., 2025, for work challenging the link between progesterone and affiliative behavior). In particular, although we found differences in affiliative behavior by HC use—which alters the endogenous dynamics of both cortisol and progesterone—these differences were restricted to women using OCs alone, and they were not mediated by either progesterone or cortisol responses under stress. This does not rule out acute effects of progesterone or cortisol; stress influences a host

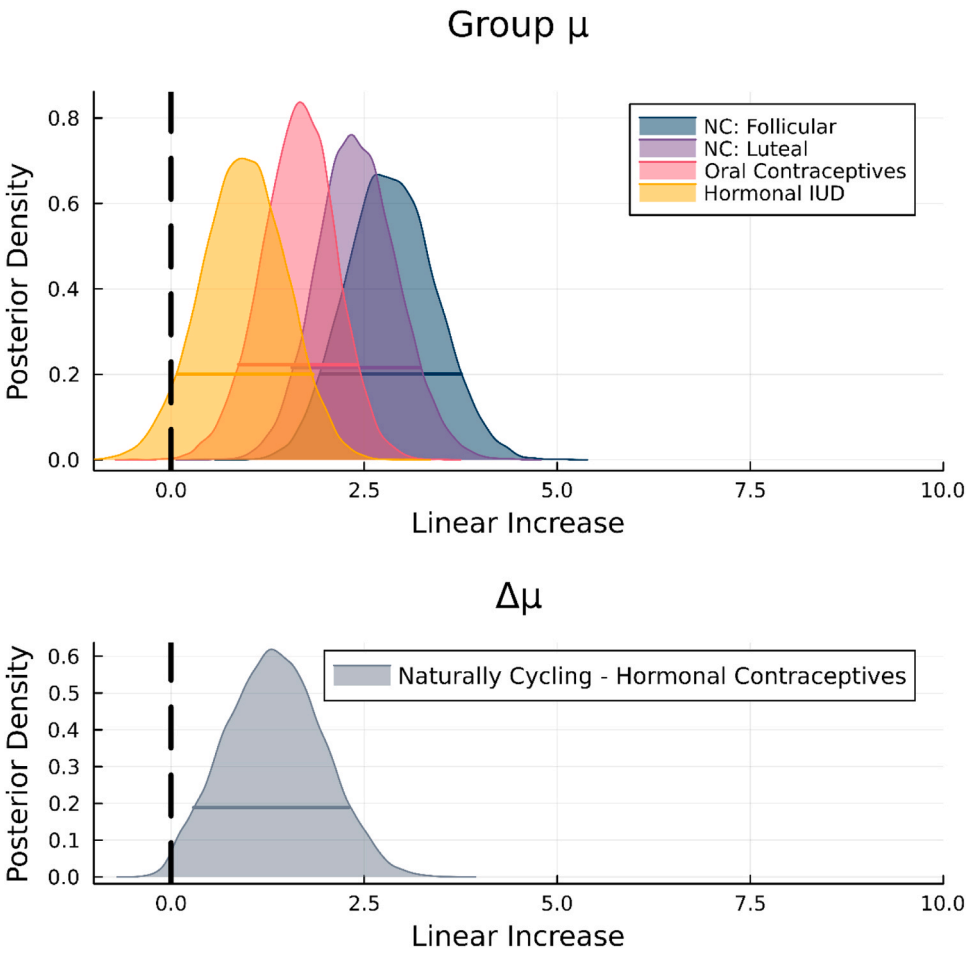

Fig. 3. *Hierarchical Bayesian Estimates of Cortisol Increases. Note:* Each estimate's 89% highest density interval (HDI) is indicated by a solid line within each parameter's posterior density. Bayesian analyses revealed that the naturally cycling women had larger cortisol responses than women using hormonal contraceptives, which is illustrated in the lower panel. In particular, the difference between the group-level coefficients indicating linear cortisol increases differed between these two group classes—namely, the group-level coefficient contrast [((follicular + luteal)/2) – ((OC + IUD)/2)] was positive and the contrast's 89% HDI (and 95% HDI) did not include zero.

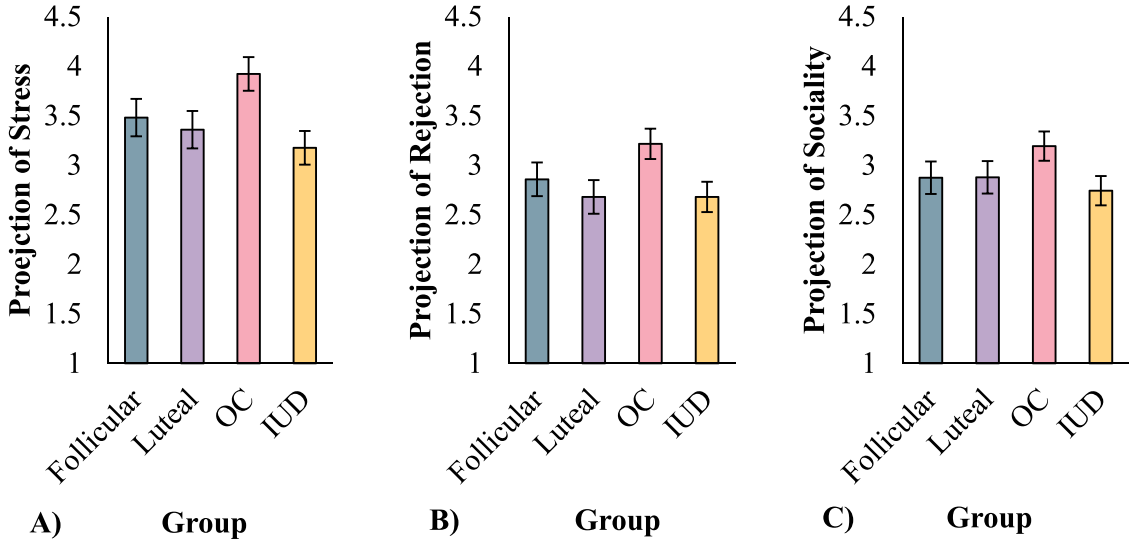

Fig. 4. *Group Differences in Functional Projection of Emotion. Note:* Stress (Panel A), Rejection (Panel B), and Sociality (Panel C). *OC=oral contraceptives, IUD=intrauterine device.* Error bars depict the standard error of the mean. Sample sizes per group were 42 follicular, 42 luteal, 52 OC, and 52 IUD.

of physiological processes, and it is possible that these other processes may interact with progesterone or cortisol to influence affiliative

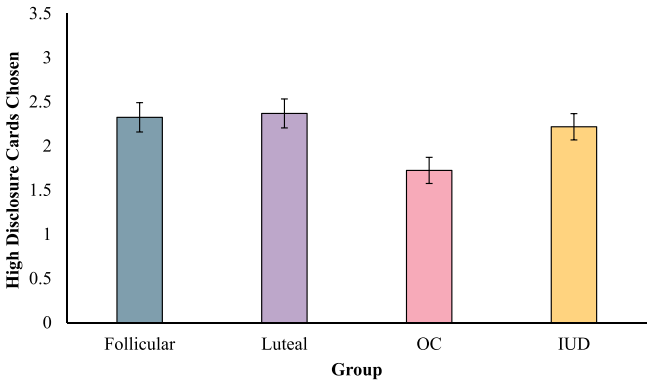

Fig. 5. Group Differences in Selection of High-Disclosure Questions in the Card Game Task. Note: OC=oral contraceptives, IUD=intrauterine device. Error bars depict the standard error of the mean. Sample sizes per group were 37 follicular, 38 luteal, 47 OC, and 46 IUD. For this task, women chose 5 out of 10 possible cards (5 high self-disclosure, 5 low self-disclosure), entailing that the maximum score possible is 5.0 (i.e., all five cards were high self-disclosure). Higher values on this graph reflect more high self-disclosure (or fewer low self-disclosure) cards being chosen, while lower values reflect fewer high self-disclosure (or more low self-disclosure) cards being chosen.

behavior. It is also likely that chronic HC use alters receptors for or sensitivity to glucocorticoids and sex hormones (e.g., Silverman and Sternberg, 2012), which could alter how acute changes in progesterone or cortisol relate to affiliative behavior. Overall, although we found no mediation of group differences in affiliation by group differences in cortisol or progesterone responses in this study, these hormones may nevertheless contribute to the difference we observed in affiliation by women using OCs. However, any mechanistic account of this difference would need to be able to explain why this difference in affiliative behavior was not observed in women using hormonal IUDs.

We found that women using hormonal IUDs showed the weakest cortisol response under stress of any of the four groups. As described above, only three studies to our knowledge had previously examined differences in biological stress responses among women using hormonal IUDs (Aleknaviciute et al., 2017; Bürger et al., 2025; Casto et al., 2025), and each found different patterns of results. Notably, our findings for a blunted cortisol response are consistent with those of Casto and colleagues (2025). This pattern is not consistent with the findings of the other two studies. Aleknaviciute and colleagues (2017) found that women using hormonal IUDs showed a heightened cortisol response to the TSST, which is opposite of what we found in this study. Although we cannot say for certain why our results differed, we can speculate. First, there are three primary doses for levonorgestrel IUDs, and it is possible that the relative use of the three doses differed between our study and that of Aleknaviciute and colleagues. If levonorgestrel exerts quadratic effects on cortisol responses as a function of its dose, that could account for these between-study differences. Second, with only 15 women using hormonal IUDs in their study, the heightened response observation may have been driven by one or two outliers. This idea is supported by their second study, which found that women using hormonal IUDs showed the same blunted cortisol response to adrenocorticotropic hormone (ACTH) stimulation that women using OCs did relative to naturally cycling women.

Also different from the pattern of results in our study, Bürger and colleagues (2025) found no differences in cortisol responses under stress between the IUD using women and naturally cycling women. This study assessed women's cortisol responses to the Maastricht Acute Stress Test (MAST) at two laboratory visits that were scheduled four months apart and recruited 27 women using hormonal IUDs. Although there were two assessments for each participant's cortisol response under stress, there were no differences in women's cortisol responses between the sessions. Besides issues of sample size, another possible reason for differences in our findings is due to the method of stress induction; the MAST and the TSST vary in methodologies and their ability to evoke cortisol responses and negative affect (Shields et al., 2017; Smeets et al., 2012). Future research should continue to examine how women using hormonal IUDs respond under instances of acute stress, and whether there are moderating factors related to methodology or women's individual differences, including medical histories.

We also found no significant progesterone response under stress, which stands in contrast to most prior work (e.g., Herrera et al., 2016; Shields et al., 2019), though—given our sample—not all prior work (Herrera et al., 2019). The progesterone response under acute stress tends to be weaker than the cortisol response (Herrera et al., 2016; Shields et al., 2019), and contraceptive use blunts the progesterone response to stress (Herrera et al., 2019). It is thus possible that we failed to observe a difference in progesterone over time within this study because of power issues. The increase we observed *post hoc* in luteal-phase women supports this idea.

This study failed to replicate differences in affiliation between naturally cycling women during different phases of the menstrual cycle (Makhanova et al., 2025; Maner and Miller, 2014). Past research found that women in the luteal (vs. follicular) phase are more socially attuned and report greater desire to affiliate. One possible explanation for our failure to replicate this finding could be that affiliative motives are more closely linked to each woman's own hormonal fluctuations than to cycle phase alone. In the current study, women were not compared to themselves but were collapsed into groups. Methodological and experimental design differences could thus explain our failure to replicate. Another possible explanation for the absence of differences in affiliation between the follicular and luteal phases is that our study examined affiliation after a socioevaluative stressor, whereas prior research demonstrating cycle changes in affiliation has primarily assessed baseline affiliative motives. Notably, consistent with prior literature and this explanation, we observed higher baseline fear of negative evaluation among women in the luteal phase. Controlling for these baseline differences, however, did not affect the reported pattern of results (see Supplemental Materials).

Although we interpreted women using OCs selecting more shallow disclosure questions for the ostensible card game as indicating lower desire for affiliation, an alternative explanation for our finding is that women using OCs may have been more sensitive to social risk. Because self-disclosure is inherently risky (Laurenceau et al., 1998; Taylor and Altman, 1975), especially with strangers, it may be that women using OCs were more sensitive to these risks. That is, the reduced selection of high self-disclosure questions may not have been due to perceiving social closeness as less rewarding, but due to perceiving self-disclosure as riskier. Indeed, women using OCs did project more feelings of rejection onto the neutral faces, which could be an indicator of greater felt rejection. If participants feel rejected or fear negative evaluations, their reduction in affiliation would also be consistent with the social reconnection hypothesis (Maner et al., 2007). Though at baseline, women using OCs did not report higher trait fear of negative evaluation, they nevertheless could have been experiencing higher state fears of negative evaluation or general aversion to social risk. Future research would benefit from directly assessing whether HC use may affect women's post-stress affiliation through decreasing the rewarding aspects of social interaction, increasing the perceptions of social risks, or both.

This study has multiple strengths, including a large sample size, incorporation of distinct phases for naturally cycling women (i.e., follicular, luteal), within-study replication of affiliative behavior results in two tasks, hierarchical Bayesian modeling, and use of the gold-standard acute stress induction. Despite its strengths, it has some limitations. First, we used a quasi-experimental design and recruited women who were already using OCs or hormonal IUDs. Thus, we cannot make any causal claims about effects of HCs or particular HC types on cortisol or affiliative responses under stress, because any group differences observed in the study are confounded by self-selection and potential pre-

existing differences. Similarly, because the present study did not include a non-stressed control condition, we cannot make causal claims that OC use affects women's affiliative behavior under stress. However, it is worth noting that we did not observe any group differences in extraversion at baseline (see Supplemental Materials). Second, there are numerous types of OCs, and they differ in the extent to which they influence progesterone and/or estrogen directly, as well as other processes (e.g., androgenicity) which may influence social behavior (Beltz, 2024; Hill, 2019; Mitchell and Welling, 2020). As recommended by Beltz (2024), future research should collect detailed information about the type of progestin, dosages of progestins and ethinyl estradiol, and require that pill packs be uploaded and confirmed by a researcher, as self-report is often unreliable. Unfortunately, we were unable to differentiate between oral contraceptive type, and it is possible that some pills (e.g., progestin-only pills) may differ in their effects on stress responses from other pills (e.g., combined oral contraceptive pills). Furthermore, progestin dosage, generation, half-life, time of ingestion, as well as progestational, estrogenic, and androgenic properties may all be important factors that influence women's cortisol and/or affiliative responses under stress. Future studies should additionally ask women which hormonal IUD they are using, as the different types have different dosages of levonorgestrel.

Third, acute stress inductions can differ in their effects on behavioral and physiological outcomes (Shields et al., 2017). We used the TSST, which is a social stressor. A social stressor has strong face validity with respect to potentially influencing social affiliative behavior. However, it is also possible that a social stressor might produce more demand characteristics on this behavior than a pain-based stressor like the MAST used by Bürger and colleagues (2025). Such demand characteristics could alter observable group differences in social affiliative behavior under stress if HC use alters sensitivity to a study's demand characteristics. Fourth, we were unable to determine mechanisms underlying women using OCs differences in social affiliative behavior. Future work could address these limitations by replicating and extending the work with assays of other hormones, use of additional stressor types, and sufficient power to examine distinct forms of oral contraception individually.

4.1. Conclusion

The potential influences of HCs are arguably vastly understudied relative to their usage commonality. Relative to naturally cycling women (assessed in distinct follicular and luteal phases), both women using OCs and hormonal IUDs showed blunted cortisol responses under acute stress. Moreover, women using OCs showed less affiliative behavior under stress than the other groups. Our findings thus demonstrate that women's "befriend" response under stress (Taylor et al., 2000; Taylor, 2006) may be blunted by OC use. Overall, these results support the idea that HC use may subtly alter stress-responsive behavior and physiology.

CRediT authorship contribution statement

Grant Shields: Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Mikayla Joslin:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Anastasia Makhanova:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Abby Sibson:** Writing – review & editing, Investigation, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.psyneuen.2026.107875.

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