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Endocrinological effects of social exclusion and inclusion: Experimental evidence for adaptive regulation of female fecundity

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ABSTRACT

When current conditions are probabilistically less suitable for successful reproduction than future conditions, females may prevent or delay reproduction until conditions improve. Throughout human evolution, social support was likely crucial to female reproductive success. Women may thus have evolved fertility regulation systems sensitive to cues from the social environment. However, current understanding of how psychological phenomena might affect female ovarian function is limited. In this study, we examined whether cues of reduced social support—social ostracism—impact women's hormone production. Following an in-lab group bonding task, women were randomly assigned to a social exclusion ($n = 88$) or social inclusion ($n = 81$) condition. After social exclusion, women with low background levels of social support experienced a decrease in estradiol relative to progesterone. In contrast, socially-included women with low background social support experienced an increase in estradiol relative to progesterone. Hormonal changes in both conditions occurred specifically when women were in their mid-to-late follicular phase, when baseline estradiol is high and progesterone is low. Follow-up analyses revealed that these changes were primarily driven by changes in progesterone, consistent with existing evidence for disruption of ovarian function following adrenal release of follicular-phase progesterone. Results offer support for a potential mechanism by which fecundity could respond adaptively to the loss or lack of social support.

1. Introduction

In healthy, well-nourished women of reproductive age, there is considerable variation in fecundity that is largely unexplained.[1] In general, approximately one-third of menstrual cycles are nonconceptive (though rates may vary across age groups; Ellison et al., 1987; Hambridge et al., 2013; Prior et al., 2015; Roney and Simmons, 2013). Moreover, between conception and parturition, an estimated 20 to 75% of pregnancies fail (Bulletti et al., 1996; Forbes, 1997; Wasser and Barash, 1983; Zinaman et al., 1996). What explains this variation in female fecundity?

Some instances of reduced reproductive capacity may reflect ancestrally adaptive responses to delay current reproduction when prospects for success are poor. One such response is well established: women experiencing low energy balance or high energetic expenditure produce relatively low levels of ovarian estradiol and progesterone and experience lower rates of ovulation and conception (Ellison, 2003). In addition to high energy demands of pregnancy and lactation, human mothers rely heavily on social support and cooperation for infant survival and success. Therefore, it is possible that women's reproductive

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[1] The usage of the terms, "fecundity" and "fertility," differs across disciplines. In demography, "fecundity" (or "fecundability") refers to the capacity to reproduce, and "fertility" refers to the quantity of offspring. Biologists often reverse these meanings. We employ demographers' usage (see, e.g., Wood, 1989).

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function is also influenced by social cues. Indeed, social factors appear to exert powerful influences on female reproduction in group-living mammals. Field and laboratory studies on a variety of species suggest that female fertility may often be regulated by social cues of an unfavorable reproductive environment, via mechanisms such as inhibition or delay of ovulation, implantation failure, and spontaneous abortion (Beehner and Lu, 2013; Wasser and Barash, 1983).

Social stress appears to play a crucial role in the disruption of female reproductive functioning across a wide range of social mammals, from mice to elephants (Wasser and Barash, 1983). In nonhuman primates, both captive and wild, intimidation and harassment from other female group members are associated with suppressed reproductive hormone levels, ovulation failure, and spontaneous abortion in the targets of aggression (Sapolsky, 2011; Wasser and Barash, 1983; Wasser and Starling, 1988). In the absence of adequate social support or kin presence, social stress is associated with elevated glucocorticoid levels, which exert suppressive impacts on the hypothalamic-pituitary-ovarian (HPO) axis, potentially disrupting reproductive function (Abbott et al., 2003; Bethea et al., 2008; Sapolsky, 2005; Sapolsky et al., 2000). In contrast, when affiliative support is high, social stressors produce less of a response. For example, coalition formation, kin support, social integration, and functional interpersonal support are associated with lower psychological and physiological stress responses during stressful social circumstances (Bales et al., 2005; Beehner et al., 2005; Cohen and Wills, 1985; Crockford et al., 2008; Sapolsky, 2005).

Because humans are a remarkably social, cooperatively breeding species (Hrdy, 2005), women's fertility regulation systems may be especially sensitive to social stress and cues regarding the availability of social support. Assistance from female peers and kin likely played a key role in ancestral women's reproductive success. The availability of social support would have been particularly important during pregnancy, when women's caloric requirements soar, vulnerability to pathogens increases, mobility is impaired, and women are less able to forage for their own food (Dufour and Sauther, 2002; Fessler, 2002). Mothers face high obligate maternal costs of gestation, followed by even higher costs of lactation (Dufour and Sauther, 2002; Jasienska, 2003). Compared to nonhuman primates, human offspring have extended dependent juvenile periods (Kaplan, 1997; Kaplan et al., 2000). Kin and other group members provide resources to mothers and dependent offspring, assist with childcare, and supply social support more generally (Hrdy, 2005; Kaplan et al., 2000; Reiches et al., 2009). Cross-culturally, women receive critical assistance from other women during pregnancy, childbirth, and postpartum (Sosa et al., 1980; Trevathan, 2017). Given the importance of social support to successful childrearing in humans, it could be adaptive to reduce or delay fecundity when such support is unavailable. Lack of support is an important reason why women may choose not to reproduce (Hill and Low, 1992; Hrdy, 1999), but options for behavioral control of fertility would have been limited in the past.

There is little direct evidence that lack of social support causally affects female reproductive functioning, though a number of studies provide preliminary evidence. Women who perceive a lack of social support have poorer reproductive outcomes during stressful life events (Dunkel Schetter, 2011; Hoffman and Hatch, 1996). Lack of social support is associated with poorer fetal growth and increased risk of preterm birth (reviewed in Dunkel Schetter, 2011). Likewise, conflict with family and friends, and lower quality and fewer sources of social support, are correlated with infertility arising from hormonal and menstrual cycle abnormalities (Wasser, 1994; see also Nepomnaschy et al., 2004). In contrast, psychological stressors unrelated to social support, such as studying for exams, may not influence ovarian hormone levels (Ellison et al., 2007).

2. Hormonal mechanisms

Throughout human evolution, social support likely played a key role in women's reproductive success. Studies across nonhuman social mammals, and preliminary evidence in humans, suggest links between social stress, lack of social support, and reduced female fecundity. However, the endocrinological mechanisms underlying these links are not fully understood. Below, we review existing literature on hormonal mechanisms that support fecundity during natural cycles. Disruption of, or variations in, the hormonal mechanisms may be responsible for reproductive suppression. Research on the physiology of reproductive suppression may illuminate how social stress may potentially influence hormone responses that downregulate female fecundity.

2.1. Ovarian function and fecundity

Although complete cessation or delay of reproductive capacity can occur under certain circumstances (e.g., severe nutritional stress or changes in reproductive status; Jasienska, 2003), female fecundity varies along a continuum. Variation in production of ovarian hormones, estradiol and progesterone, predict current or near-future conception probability (Ellison, 2003), partly because these hormones have evolved to coordinate actions that support fecundity.

2.1.1. Estradiol

Both across and within women, higher estradiol levels across the cycle—especially during the mid-follicular phase—covary with conception success (Lipson and Ellison, 1996; Stewart et al., 1993; Venners et al., 2006; see also, Baird et al., 1999; Li et al., 2001). Physiologically, estradiol shifts energy allocations towards readiness for reproduction (Ellison, 2003), including but not limited to fecundity within a cycle. Follicular-phase increases in ovarian estradiol, coordinated by luteinizing hormone and follicle-stimulating hormone, lead to successful release of an egg. Estradiol levels drop under conditions unfavorable to reproduction; this drop is a primary mechanism through which reproductive suppression, via anovulation, is achieved (Ellison, 2003; Jasienska, 2003).

2.1.2. The supportive role of luteal progesterone

During a natural conceptive mammalian reproductive cycle, progesterone levels remain low throughout the follicular phase. Rising estradiol levels during that phase result in release of an egg from an ovarian follicle into the fallopian tubes (Johnson, 2018). During the luteal phase, the follicle becomes the corpus luteum, a temporary endocrine structure that produces progesterone, as well as estradiol, in high quantities. Luteal-phase progesterone functions to prepare the maternal endometrium for successful implantation and maintenance of an embryo, should the egg be fertilized. In women, fecundity is associated with relatively high levels of progesterone during the luteal phase (Ellison, 2003; Vuorento et al., 1990). This association is partly due to the fact that, during anovulatory cycles, the increase in luteal progesterone is greatly blunted.

2.1.3. The disruptive role of follicular-phase progesterone

Progesterone during the follicular phase is mainly produced by the adrenal glands, not the corpus luteum (Johnson, 2018). Heightened levels of follicular-phase progesterone appear to suppress fecundity. Progesterone administration during the follicular phase causes dose-dependent impairment of follicle growth and, in sufficient doses, inhibits ovulation in rhesus monkeys, heifers, and ewes (Adams et al., 1992; Johnson et al., 1996; Skinner et al., 1998; Spies and Niswender, 1972; Ulberg et al., 1951). These effects operate, at least in part, because progesterone inhibits estradiol-induced production of gonadotrophin releasing hormone (GnRH), luteinizing hormone (LH), and follicle-stimulating hormone (FSH) in humans and nonhuman animals (An et al., 2005; Dierschke et al., 1973; Gibson et al., 1991; Harris et al., 1999; Pohl et al., 1982; Richter et al., 2005, 2002; Spies and Niswender, 1972). These hormones are necessary for ovulation. Progesterone's negative feedback effects on GnRH and gonadotrophins are adaptive during the luteal phase, as ovulation has already occurred. During the

follicular, preovulatory phase, progesterone's effects are disruptive. In normally ovulating women, acute administration of progesterone within physiological ranges reduces LH and FSH levels and, during the late follicular phase, results in slower LH pulse frequency and heightened pulse amplitude, resembling patterns during the midluteal phase (Gibson et al., 1991; Soules et al., 1984).

A number of other studies suggest that follicular-phase progesterone may prematurely induce, rather than inhibit, LH secretion. When progesterone is released from the adrenal glands, it prematurely induces LH secretion in humans, rhesus monkeys, rats, hamsters, and rabbits, and this disrupts the physiological cascade necessary for ovulation (Feder and Marrone, 1977; Ferin, 1999; Puder et al., 2000; Xiao et al., 1998; Xiao and Ferin, 1997). Early LH secretion in excess levels also disrupts ovulation and implantation in humans (Homburg et al., 1988; Paulson et al., 1994, 1992; Regan et al., 1990; Stanger and Yovich, 1985; Watson et al., 1993). Although the underlying mechanisms are not understood, the precise timing of follicular-phase progesterone release may determine whether LH production is inhibited or prematurely triggered (Harris et al., 1999; Le et al., 1997; Richter et al., 2002).

Consistent with these effects, correlational evidence supports the idea that elevated follicular-phase progesterone may suppress women's fecundity. A meta-analysis of 63 studies, evaluating over 55,000 fresh in-vitro fertilization (IVF) cycles, concluded that premature progesterone elevation during the late follicular phase, on the day of hCG administration, is associated with decreased probability of pregnancy (Venetis et al., 2013). Prolonged duration of elevated preovulatory progesterone increases the probability of IVF pregnancy failure (reviewed in Sonigo et al., 2014; see also Haouzi et al., 2014; Lawrenz and Fatemi, 2017; Zhu et al., 2015). Even subtle elevation of late follicular-phase progesterone is associated with impaired implantation and lower rates of live birth (Kiliçdag et al., 2010; Lahoud et al., 2012; Ochsenkühn et al., 2012).

In a prospective study of natural conceptions, higher follicular-phase levels of progesterone predicted early pregnancy loss (Vitzthum et al., 2006). Among reproductive-aged women with unexplained infertility, 33% exhibited preovulatory progesterone peaks, over twice the rate in cycles of healthy control women (Vuorento et al., 1990). A prospective study, analyzing daily hormone samples, reported periovulatory progesterone levels that were twice as high in non-conceptive cycles compared to conceptive cycles resulting in live birth (Li et al., 2001). Another longitudinal study, with analysis of almost 600 menstrual cycles from 215 women attempting natural pregnancies, found that non-conceptive cycles were characterized by higher mid-follicular progesterone (Baird et al., 1999).

2.2. Effects of stress on hormones

Ample evidence shows that nutritional and energetic stress are associated with downregulation of ovarian hormones and reduced fecundity (e.g., Ellison, 2003; Jasienska, 2003), but the effects of social and psychological phenomena on the menstrual cycle are much less understood or established. Correlational studies in nonhuman animals find associations between prolonged exposure to social stress and reduced ovarian production of estradiol and progesterone (Sapolsky, 2011). Evidence in humans is scant, but results from a few studies imply potential links between psychosocial stress and estradiol. Women in highly committed relationships have higher estradiol levels (Barrett et al., 2015), and women who are widowed, divorced, or single are more likely to experience early estrogen deficiency (Gökmen et al., 1995). Another study found that psychosocial stress was associated with a same-day decrease in estradiol (Roney and Simmons, 2015). This association was greatest during the mid-to-late follicular phase of the menstrual cycle.

At least during the follicular phase, stress stimulates adrenal production of progesterone in humans and monkeys (Wirth, 2010; Xiao et al., 1998, 1996, 1994; Xiao and Ferin, 1997). Experimental studies show that stress during women's follicular phase elevates progesterone levels (Childs et al., 2010; Herrera et al., 2016). In estradiol-treated postmenopausal women, acute stressors result in adrenal secretion of progesterone, precipitating LH release (which, when poorly timed, is a potential mechanism for reproductive suppression in reproductive-aged women; Puder et al., 2000). Longitudinal evidence in normally ovulating women demonstrates positive associations between cortisol (a stress biomarker) and progesterone levels during the follicular phase, but negative associations during the mid-luteal phase (Nepomnaschy et al., 2004). As reviewed above, elevated progesterone levels during the follicular phase may have suppressive effects on ovarian function. Perhaps for this reason, abrupt changes to the estradiol-to-progesterone ratio inhibit fecundity by disrupting gamete and conceptus transport, leading to reduced likelihood of fertilization and implantation (Johnson, 2018). However, there is a lack of research examining whether social stress impacts adrenal and ovarian hormone production in ways that reduce women's fecundity.

2.2.1. Alternative causal pathways

Although experimental research on some nonhuman species suggests a causal role for progesterone, the association between mid-to-late follicular phase progesterone and reduced fecundity in humans could reflect alternative causal pathways. Cortisol secreted in response to stress can have suppressive effects on the HPO axis (Whirledge and Cidlowski, 2010; Wingfield and Sapolsky, 2003). Moreover, cortisol levels can be positively correlated with progesterone levels due to common pathways during biosynthesis in the adrenal cortex (Conley and Bird, 1997). In a study examining hormonal responses to cold-pressor stress during the follicular phase, resulting cortisol increases appeared to mediate progesterone increases (Herrera et al., 2016). Cortisol could have downstream effects on fecundity, independent of progesterone (see, e.g., Nepomnaschy et al., 2004). High levels of progesterone during the luteal phase suppress cortisol responses to stress and, hence, may also inhibit progesterone responses to stress (see, Bali and Jaggi, 2014; Wirth, 2010).

3. The current study

The current study experimentally tests whether social exclusion, compared to social inclusion, results in hormonal changes potentially associated with reduced fecundity, particularly among women lacking social support in their daily lives. Salivary estradiol, progesterone, and cortisol were collected at baseline and 15 min after the social manipulation. Controlled laboratory conditions and experimental manipulation allow assessment of causal relationships between social exclusion and steroid hormone responses. Cues of social ostracism might indicate reduced future support in the current environment. Whether social stressors are potent enough to disrupt reproductive functioning may depend on whether women have alternative, reliable sources of support. The magnitude of the response may be a function of costs and benefits of current reproduction, and may thus be modulated by existing levels of social support.

3.1. Study history

Because this project began before the practice of preregistration was widespread, in the interests of transparency, we describe the complete history of the project in Supplementary Online Materials (SOM), Section 1. We include synopses of archived fellowship and grant proposals that document our initial plans, and describe how the project evolved during the planning phases.

3.2. Hypothesis

Following social exclusion, women lacking social support will experience hormonal changes associated with reduced fecundity.

3.3. Expected hormonal effects

3.3.1. Cycle phase-specific changes in hormones following social exclusion

Following cues of social exclusion, women in their mid-to-late follicular phase—when estradiol relative to progesterone is high—will experience decreases in estradiol and increases in progesterone, consistent with a potential reduction in fecundity. Socially included women, by contrast, will not experience hormonal responses following the manipulation.

3.3.2. Moderation by background levels of social support

The effect of social exclusion on estradiol and progesterone will be moderated by baseline social support, such that women with low baseline social support will show the largest effects. Women with higher levels of social support will show attenuated hormonal changes.

3.3.3. Potential mediation by cortisol

Changes in estradiol and progesterone may be mediated by changes in cortisol following social exclusion. Women with low social support may be more likely to experience increases in cortisol that mediate hormonal responses during the mid-to-late follicular phase to the experimental manipulation.

4. Methods

4.1. Participants

A total of 253 normally ovulating women between the ages of 18–34 years (mean = 19.54, *SD* = 1.75) completed the study at the University of California, Los Angeles. All participants provided written informed consent to participate in the study. Participation was precluded for individuals who scored above the depression threshold on the Patient Health Questionnaire-2 depression screening (Kroenke et al., 2003); used hormonal contraceptives within the past three months; were currently pregnant; or gave birth or breastfed within the last year.

Saliva samples were collected from all participants. However, some participants (or their saliva samples) did not meet minimum criteria for inclusion. Participants who provided eligible or ineligible samples did not significantly differ in age ($p = .5$), ethnicity (p's $\geq .14$), year in school ($p = .5$), duration of attendance at UCLA ($p = .3$), assignment to experimental condition ($p = .13$), or level of social support ($p = .4$). Specifically, saliva samples were not assayed for the following reasons: three participants reported having an endocrine disorder; two later acknowledged hormonal contraceptive use within the past three months; five were not assigned to an experimental condition due to a computer glitch; four attended a lab session in which fewer participants and confederates were present than the four total required for the partner selection task; fourteen reported disbelief in the manipulation in the open-ended response suspicion probes; thirty-five were unable to provide sufficient amounts of saliva at either baseline or post-manipulation; and twenty-one provided saliva that was discolored or potentially contaminated by blood.[2] In total, salivary hormone samples from 169 women were assayed.

4.2. Study design

Prior to their lab session, participants completed prerequisite online questionnaires screening for eligibility and assessing background social support, loneliness, sensitivity to rejection, and social anxiety. The social background measures were collected in advance to reduce the likelihood of participants becoming aware of the goals of the study and the deception involved in the experimental manipulation. After completing the background questionnaire, participants received an online invitation code to sign up for an available lab session at their convenience. Most participants signed up for a lab session taking place within two weeks of the background assessment (median = 5 days). Sessions started between 12 and 4 p.m. to limit diurnal variation in hormone secretion. Up to five women participated in each session. Whenever fewer than five participants showed up for a given session, female undergraduate research assistants filled in as confederates. At the start of the session, a female experimenter queried whether participants knew each other. Although none did, in three instances, a participant knew an undergraduate confederate; the confederate then publicly volunteered to come back for another session in the future.

At the start of the lab session, participants provided a baseline saliva sample. Participants next completed a version of the Relationship Closeness Induction Task, modified for use in groups of 4–5 (Sedikides et al., 1999). Members of the group took turns orally answering increasingly intimate questions designed to promote social bonding (example items: "What are your hobbies?" "What is one thing happening in your life that makes you stressed out?"). Subsequently, each participant returned to individual computer stations. Computer instructions informed them that an upcoming computer task involves working in smaller groups. Participants were instructed to choose whom they want to work with and were informed that the computers would automatically group participants according to mutual selections. The computer displayed the names of the other participants one at a time with the questions, "Do you want to work with [name]?" and "Why do you (not) want to work with [name]?"

The computer then randomly assigned each participant to a social inclusion or social exclusion condition; in the former, all members of the group ostensibly wished to work with the participant, whereas in the latter, no members of the group wished to do so. The purported stated reasons for why others included or excluded the participant were displayed on the computer. Reasons for inclusion were, "I liked her," "She was friendly," "[Participant name] and I seem to have a lot in common," and "She seems very nice and personable." Reasons for exclusion were derogatory statements designed to evoke social stress, including, "I didn't like her," "She seemed full of herself and annoying," "[Participant name] didn't seem very smart. I don't know how she got into UCLA," and "I liked other people better and would rather work with them." These reasons were pre-rated by female undergraduate research assistants for realism and amount of distress evoked. Ostensibly because it was not possible for the participant to work with everyone/no one, the participant was then instructed to work on computer jigsaw puzzle tasks by herself for 10 min. Participants provided saliva samples 15 min after the manipulation.[3]

Participants completed questionnaires on the computer for the duration of the study while saliva samples were collected. They provided menstrual cycle information, including the onset date of their last menstrual period, their average cycle length, and how sure they were of that date and length.[4] See Table 1 for frequencies of women whose session took place in each forward-count cycle day bin. At the end of the questionnaire, participants completed a suspicion probe (6 open-ended questions) and manipulation check. If participants finished questionnaires early, for the remainder of their session, they watched silent documentaries with subtitles on how erasers are made. At the end of the study, participants were debriefed as a group about the study, and the

[2] For details regarding exclusion on the basis of saliva volume or suspected contamination, see SOM, Section 2.

[3] Saliva samples were also collected at 35- and 60-min post-manipulation. These samples have not been assayed for progesterone or cortisol, and only a subset have been assayed for estradiol (due to budgetary constraints). Therefore, these later time points were not included in analyses.

[4] Only 55% of women from the final sample were very sure or completely sure (and 69% were at least pretty sure) of the date of their last menstrual onset. Only 12% of women were very sure or completely sure (and 35% were at least pretty sure) of their typical cycle length.

Table 1
Number of women from the social exclusion condition, social inclusion condition, and the total sample with assayed hormones in each forward-count cycle day bin. Six women (2 from the social exclusion condition and 4 from the social inclusion condition) did not provide a date of last menses and are not included in the table.

Forward count day	Frequencies			
	Social exclusion	Social inclusion	Total sample	% Total sample
1 to 5	8	13	21	12.9
6 to 10	18	17	35	21.4
11 to 15	14	9	23	14.0
16 to 20	17	11	28	17.3
21 to 25	12	8	20	12.3
26 to 30	11	11	22	13.5
31 to 38	6	8	14	8.5

false nature of the feedback manipulation was revealed.

4.3. Measures

4.3.1. Hormone assays

Salivary estradiol (E), progesterone (P), and cortisol (C) were assayed at baseline and 15 min post-manipulation, following precedent from studies reporting laboratory-induced hormone responses (e.g., Herrera et al., 2016; Lennartsson et al., 2012; Maner et al., 2010). E, P, and C levels are represented in picograms per milliliter (pg/mL).

E and P were analyzed using commercial salivary ELISA kits (Salimetrics, LLC, Carlsbad, CA). C was analyzed using an in-house ELISA with reagents and protocols provided by the University of California at Davis Clinical Endocrinology Laboratory (antibody R4866, sensitivity 300 pg/mL). Interassay CVs for low and high controls were 11.6% and 3.4%, respectively, for P; 6.9% and 11.4% for E; and 9.9% and 7.9% for C. Intraassay CVs, calculated as the mean CV of duplicate determinations, were 5.5% for P, 3.4% for E, and 5.0% for C. For samples with E or P levels below the sensitivity of the curve (E: 30/327 samples, P: 1/338 samples), we substituted a value equivalent to the minimum sensitivity for the assay. No C samples were below sensitivity. Due to a manufacturer error in the calibration of the standard, we had to discard three P assays and repeat with new kits. Three samples had no remaining saliva to repeat the assay, so we used the original assay results and converted them using a regression equation, derived from samples that we were able to run twice ($y = 0.58 + 19.3$, $R^2 = 0.66$, $N = 113$). Exclusion of the three samples does not affect our findings. These three samples did not have enough saliva to run for C.

4.3.2. Experimental condition

Participants were randomly assigned to a social exclusion ($n = 88$) or social inclusion ($n = 81$) condition. For main results reported, condition is effect-coded with social exclusion coded as 1 and social inclusion as −1. For simple effects by social exclusion or inclusion group, condition is dummy-coded with the group of interest coded as the reference group. Although socially included participants are not expected to show changes in estradiol and progesterone, exploratory analyses examined potential effects in this group.

4.3.3. Manipulation check

Manipulation check items included, "I feel accepted by the other participants" (reverse-coded), "I feel as though I have made a 'connection' or bonded with one or more of the participants" (reverse-coded), "I feel like an outsider," "The group decision made me feel good about myself" (reverse-coded), "The group decision hurt my feelings," "I feel good about myself" (reverse-coded), "I feel somewhat inadequate," and "I feel that the other participants failed to perceive me as a worthy and likeable person" (Robertson et al., 2014). Responses were anchored on a 7-point Likert scale, from "strongly disagree" to "strongly agree."

The success of the experimental manipulation requires that participants actually felt rejected (exclusion condition) or accepted (inclusion condition). Moreover, it would be expected that socially excluded women would be more disbelieving of the manipulation than socially included women. Therefore, to derive a manipulation "belief" score, disattenuating for differential validity assumed from between-group relative to within-group variance in item scores, discriminant analyses were performed (SOM, Section 3). A total of 70 participants (80%) from the social exclusion condition and 68 (84%) from the social inclusion condition remained following removal of those whose scores did not reflect adequate belief in the manipulation. Robustness analyses on the full sample, as well as using different cut-off manipulation check values and summed composite scores for selection, yield similar estimates and significance levels. See SOM, Sections 4–5.

4.3.4. Baseline social support

Background levels of social support were assessed using items from the Social Provisions Scale (Cutrona and Russell, 1987; sample items: "There are people I can depend on to help me if I really need it," "I have close relationships that provide me with a sense of emotional security and well-being") and the UCLA Loneliness Scale (Russell et al., 1980; sample items: "There is no one I can turn to," "My social relationships are superficial"). Loneliness scores were reverse-coded when appropriate to positively reflect social support. Items from each scale were averaged to form a composite for Social Provisions ($\alpha = 0.93$) and Lack of Loneliness ($\alpha = 0.93$). The two composites ($r = 0.76$) were standardized and averaged to form a Social Support score. Social Support was standardized prior to data analysis.

4.4. Statistical analyses

Multiple linear regression residualized change models (Castro-Schilo and Grimm, 2018) were estimated using R version 3.6.2. Analyses examined main effects of and interactions between experimental condition, baseline hormone levels, and background social support in predicting post-manipulation hormone levels.

4.4.1. Log-transformation of hormone values

Hormone values were non-normally distributed and thus log-transformed prior to analysis. As Sollberger and Ehlert (2016) argue on statistical and substantive grounds, ratios of hormone levels are best log-transformed prior to use in analyses. Additionally, log-transformation decreases positive skew in hormone distributions and tends to linearize associations between hormone levels and outcomes (Sherry et al., 2014). Results using raw hormone values are similar in pattern and are presented in SOM (Section 6).

4.4.2. Post-manipulation outcome hormone levels

Because fecundity is reflected in levels of both E and P, and both change across the cycle, initial analyses examined the joint additive changes in log-transformed estradiol and log-transformed progesterone, reflected by changes in ln(E/P). The hormone ratio is equivalent to a difference score between log-transformed estradiol and log-transformed progesterone (ln[E] − ln[P]). Decreased levels of ln(E/P) during the mid-to-late follicular phase may suggest possible reductions in fecundity, whereas increased levels may suggest heightened fecundity.

Next, separate regression analyses examine changes in post-manipulation natural-log-transformed estradiol (ln[E]) and progesterone (ln[P]). Decreases in ln(E) and increases in ln(P) during the mid-to-late follicular phase may imply reduced female fecundity, while the reverse is consistent with potentially heightened fecundity.

Follow-up tests analyze post-manipulation logged cortisol as the outcome variable.

4.4.3. Baseline hormone independent variables

For each outcome measure, analyses were conducted using baseline

ln(E/P)—which indexes women's position in their ovulatory cycle—as a predictor. Next, changes in each outcome measure were estimated with baseline ln(E) and ln(P) as separate predictors in the same model. Analyses using ln(E/P) estimate effects of ln(E) and ln(P) constrained to be equal in magnitude but opposite in sign. Analyses entering ln(E) and ln (P) separately allow the unique effects of each to be freely estimated, independent of the other. All results presented are with baseline hormone values mean-centered, except where specified for simple slopes centered at periovulatory phase hormone levels.

4.4.4. Controlling for cortisol

Cortisol and progesterone tend to be positively correlated; increases in progesterone (especially during the follicular phase of a cycle) may be mediated by increased adrenal production of cortisol. To isolate effects on progesterone, analyses control for residualized logged cortisol change scores. Residual scores were derived from regressing post-manipulation natural-log transformed cortisol on baseline natural-log transformed cortisol. Robustness analyses examine effects with cortisol residuals omitted. Overall, robustness and strength of effects are very similar without the control variable (see SOM, Section 7).

4.4.5. Outliers

Hormone distributions were visually inspected for outliers. Data points falling beyond a gap in the continuous distribution of a hormone's values were considered outliers. One outlier met this criterion for post-manipulation logged progesterone (−1.49 SD gap) and one outlier for residualized logged cortisol (+1.05 SD gap). Outlying hormone values were winsorized to the next closest non-outlying value. Whether outliers were retained (not winsorized) or excluded from analyses did not substantively change results (see SOM, Sections 8–9).

4.4.6. Regression models

Models provide tests of primary hypotheses—that social exclusion will result in changes in estradiol and progesterone (described above) that are associated with reduced female fecundity, and that these changes will be moderated by levels of social support available to women. Additionally, models provide examinations of phase-specific changes in estradiol and progesterone, as a function of interactions between experimental condition and social support.

By controlling for main effects of baseline hormone levels, residualized change in hormone levels can be assessed as a function of other predictor variables. Similarly, controlling for residualized cortisol change isolates changes in outcome hormones independent of cortisol change. With baseline hormone levels and social support mean-centered, model results provide tests of main effects of condition, along with tests of phase-nonspecific interactions between condition and social support (i.e., on average across baseline hormone levels). Regression weights of main effects and interactions with condition are reported with condition effect-coded, with social exclusion = 1 and social inclusion = −1. Substituting dummy codes for condition provides estimates of effects for the condition coded 0.

In separate analyses, we examined changes in cortisol levels as a function of social exclusion versus inclusion, moderated by social support and baseline hormones (see Models 4A–B below). Analyses with logged cortisol as the outcome variable test whether the interactions of interest are associated with cortisol change. Estimates allow for investigation of whether estradiol and progesterone responses to the experimental manipulation are related to change in cortisol (e.g., testing for basis for mediation (Mackinnon et al., 2000), comparing direction of effects on cortisol change with that on progesterone change).

Outcome variables and highest-order interaction terms tested are shown below for the regression models analyzed. Corresponding lower-order terms are retained in analyses but are omitted from the model summaries below for brevity.

Model[a]		Dependent Variable	Predictors/ Highest-Order Interaction(s)
1	A	Post-Manipulation ln (E/P)[b]	Baseline ln(E/P) * Condition * Social Support
	B		Baseline ln(E) * Condition * Social Support + Baseline ln(P) * Condition * Social Support
2	A	Post-Manipulation ln (E)[b]	Baseline ln(E/P) * Condition * Social Support
	B		Baseline ln(E) * Condition * Social Support + Baseline ln(P) * Condition * Social Support
3	A	Post-Manipulation ln (P)[b]	Baseline ln(E/P) * Condition * Social Support
	B		Baseline ln(E) * Condition * Social Support + Baseline ln(P) * Condition * Social Support
4	A	Post-Manipulation ln (Cortisol)[c]	Baseline ln(E/P) * Condition * Social Support
	B		Baseline ln(E) * Condition * Social Support + Baseline ln(P) * Condition * Social Support

[a] Linear regression estimates for **Models 1-4 A/B** are displayed in **Tables 2-9**. Baseline and post-manipulation hormone values natural log-transformed. Log of E:P hormone ratio is equivalent to ln(E) – ln (P). **Tables 2-9** show results with baseline hormone values mean-centered and social support scores standardized.

[b] In primary analyses of **Models 1-3 A/B**, presented in **Tables 2-7**, residualized change scores for log-transformed cortisol acts as a control variable to isolate the effects of progesterone that are not mediated by adrenal production of cortisol.

[c] In **Models 4A-4B**, post-manipulation logged cortisol is the outcome variable, with baseline logged cortisol as a control variable for estimations of residualized change in logged cortisol. Results are displayed in **Tables 8-9**.

4.4.7. Power analysis

We estimated statistical power, with $\alpha = 0.05$, to detect a significant 3-way interaction between experimental condition, baseline estradiol/progesterone ratio, and social support in predicting post-manipulation hormone changes. For the full sample of 169, estimated power to detect a small-medium effect size of 0.20 was 73%. For the primary sample of 138, estimated power was 64%. If exclusion of participants who disbelieved the manipulation increases the effect size, power may actually have been higher in the primary sample of 138. Power with $n = 138$ to detect an effect size of 0.25 was 83%.

4.5. Data availability

Data, analysis scripts, and output for this study are posted on Open Science Forum (https://osf.io/69f3x/?view_only=69e5b5566450425080672781b2c91621).

5. Results

5.1. Controlling versus not controlling for cortisol

We conducted analyses on Models 1A–3B, both controlling and not controlling for cortisol change. Results are very similar. Instead of weakening effects, controlling for cortisol actually strengthened effects, suggesting that observed results are not positively confounded or consistently mediated by cortisol release. Because cortisol has associations with ln(E/P) and ln(P), and to isolate changes in outcome hormones, independent of cortisol change, results reported below control for cortisol residuals. For analyses not controlling for cortisol change, see SOM, Section 7.

5.2. Changes in logged estradiol-to-progesterone ratio

5.2.1. Summary of primary models and predicted effects

Initial models tested whether women experience residualized change in ln(E/P) following social exclusion, moderated by social support, and whether these effects vary as a function of baseline ovarian hormone levels. Model 1A (Table 2) tested effects with baseline ln(E/P), and Model 1B (Table 3) followed up with effects of baseline ln(E) and ln(P) estimated separately. Variance inflation factor (VIF) for all predictors in both models did not exceed 2.10, indicating that multicollinearity was not an issue. In both models, logged cortisol residualized change

Table 2
Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor.

	DV: Post-manipulation ln(E/P)											
	Condition effect-coded[a]				Social exclusion condition[b]				Social inclusion condition[c]			
	b	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value
(Intercept)	−4.47	0.03	−151.04	**<.0001**	−4.48	0.04	−107.34	**<.0001**	−4.47	0.04	−105.77	**<.0001**
Baseline ln(E/P)	0.79	0.05	15.31	**<.0001**	0.79	0.06	12.62	**<.0001**	0.79	0.08	9.64	**<.0001**
Ln Cortisol Residual	−0.44	0.09	−5.03	**<.0001**	−0.44	0.09	−5.03	**<.0001**	−0.44	0.09	−5.03	**<.0001**
Condition	−0.01	0.03	−0.17	.865								
Social Support	−0.06	0.03	−1.78	*.077*	0.01	0.04	0.28	.781	−0.13	0.05	−2.71	**.008**
Baseline ln(E/P) * Condition	−0.001	0.05	−0.01	.991								
Baseline ln(E/P) * Social Support	−0.03	0.05	−0.57	.570	0.18	0.07	2.76	**.007**	−0.24	0.08	−2.94	**.004**
*Condition * Social Support*	0.07	0.03	2.18	**.031**								
Baseline ln(E/P) * Condition * Social Support	0.21	0.05	4.03	**<.0001**								

3-Way (Condition × Baseline Hormones × Social Support) interaction of interest is ***bolded and italicized***. Simple **2-way (Baseline Hormones × Social Support) interaction** of interest within condition is **bolded**. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. In analyses with condition dummy-coded, results for main effects of and interactions with condition are redundant and thus excluded from tables.
$p < .05$ **bolded**; $p < .10$ *italicized*.
[a] Results for condition effect-coded, with social exclusion = 1 and social inclusion = −1.
[b] Results for simple effects in the social exclusion condition. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0.
[c] Results for simple effects in the social inclusion condition. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0.

Table 3
Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors.

	DV: Post-manipulation ln(E/P)											
	Condition effect-coded[a]				Social exclusion condition[b]				Social inclusion condition[c]			
	b	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value
(Intercept)	−4.46	0.03	−148.92	**<.0001**	−4.46	0.04	−103.70	**<.0001**	−4.46	0.04	−106.23	**<.0001**
Baseline ln(E)	0.61	0.13	4.70	**<.0001**	0.68	0.19	3.55	**.0006**	0.54	0.17	3.14	**.002**
Baseline ln(P)	−0.77	0.05	−14.18	**<.0001**	−0.77	0.07	−11.03	**<.0001**	−0.77	0.08	−9.32	**<.0001**
Ln Cortisol Residual	−0.44	0.09	−4.90	**<.0001**	−0.44	0.09	−4.90	**<.0001**	−0.44	0.09	−4.90	**<.0001**
Condition	−0.002	0.03	−0.07	.942								
Social Support	−0.05	0.03	−1.69	*.094*	0.02	0.04	0.37	.711	−0.13	0.05	−2.74	**.007**
Baseline ln(E) * Condition	0.07	0.13	0.57	.569								
Baseline ln(E) * Social Support	−0.01	0.13	−0.09	.928	0.39	0.19	2.02	**.045**	−0.42	0.16	−2.53	**.013**
*Condition * Social Support*	0.07	0.03	2.22	**.028**								
Baseline ln(P) * Condition	−0.001	0.05	−0.01	.991								
Baseline ln(P) * Social Support	0.01	0.05	0.17	.864	−0.22	0.07	−2.96	**.004**	0.24	0.08	2.91	**.004**
Baseline ln(E) * Condition * Social Support	0.40	0.13	3.17	**.002**								
Baseline ln(P) * Condition * Social Support	−0.23	0.05	−4.15	**.00006**								

3-Way (Condition × Baseline Hormones × Social Support) interactions of interest are ***bolded and italicized***. Simple **2-way (Baseline Hormones × Social Support) interactions** of interest within condition are **bolded**. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. In analyses with condition dummy-coded, results for main effects of and interactions with condition are redundant and thus excluded from tables.
$p < .05$ **bolded**; $p < .10$ *italicized*.
[a] Results for condition effect-coded, with social exclusion = 1 and social inclusion = −1.
[b] Results for simple effects in the social exclusion condition. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0.
[c] Results for simple effects in the social inclusion condition. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0.

predicted change in post-manipulation ln(E/P), p's $< .0001$. Analyses revealed no main effect of condition, p's $> .85$. Importantly, however, and consistent with predictions, the interaction between condition and social support emerged in both models (Model 1A: $b = 0.07$, $p = .031$; Model 1B: $b = 0.07$, $p = .028$): social support was more positively associated with ln(E/P) in the social exclusion group than the social inclusion group.

5.2.2. Interactions with ln(E/P)

The condition * social support interaction was further qualified by a highly robust positive 3-way interaction with baseline ln(E/P) ($b = 0.21$, $p < .0001$). This interaction was driven by significant 2-way interactions between baseline ln(E/P) and social support, in opposite directions for the social exclusion group ($b = 0.18$, $p = .007$) and social inclusion group ($b = -0.24$, $p = .004$). See Fig. 1. In the social exclusion group, lack of social support was associated with negative changes in ln(E/P) at higher baseline ln(E/P) levels. Socially included women who previously lacked social support, by contrast, showed higher post-inclusion ln(E/P) levels when baseline levels were also high. Social support did not predict changes in ln(E/P) levels for either group when baseline levels were low.

5.2.3. Interactions with ln(E) and ln(P) separately

When allowing effects of baseline ln(E) and ln(P) to be independently estimated, the 3-way interaction with social support by condition was positive in direction for ln(E) ($b = 0.40$, $p = .002$) and negative for ln(P) ($b = -0.23$, $p = .00006$). See Fig. 2. For socially excluded women, social support more positively predicted post-exclusion ln(E/P) when baseline ln(E) levels were high and ln(P) levels were low; ln(E) * social support interaction: $b = 0.39$, $p = .045$; ln(P) * social support interaction: $b = -0.22$, $p = .004$. In contrast, socially included women relatively lacking in social support experienced increased ln(E/P) when baseline ln(E) levels were high and ln(P) levels were low; ln(E) * social support interaction: $b = -0.42$, $p = .013$; ln(P) * social support interaction: $b = 0.24$, $p = .004$. When women had hormone profiles characteristic of the periovulatory phase—with baseline ln(P) at 1 SD below the mean and baseline ln(E) at 1 SD above the mean—social support positively

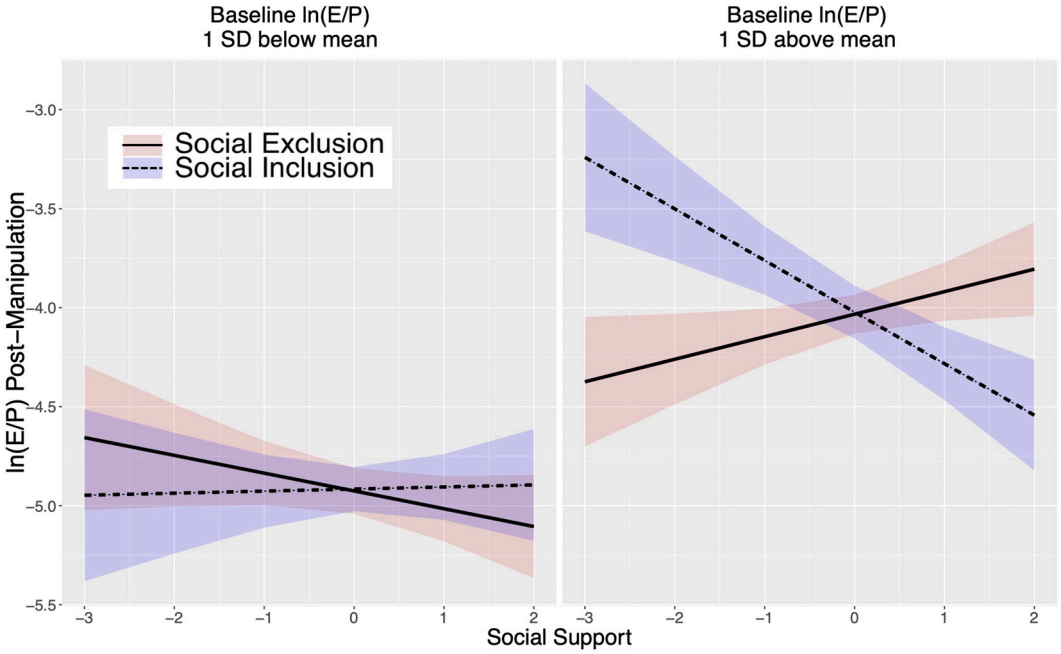

Fig. 1. Model 1A testing the interaction between experimental condition, baseline ln(E/P), and social support in predicting post-manipulation ln(E/P). *Left graph:* baseline ln(E/P) is centered at 1 SD below the mean, a hormone profile characteristic of the luteal phase. *Right graph:* baseline ln(E/P) is centered at 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Shaded areas represent 95% confidence intervals.

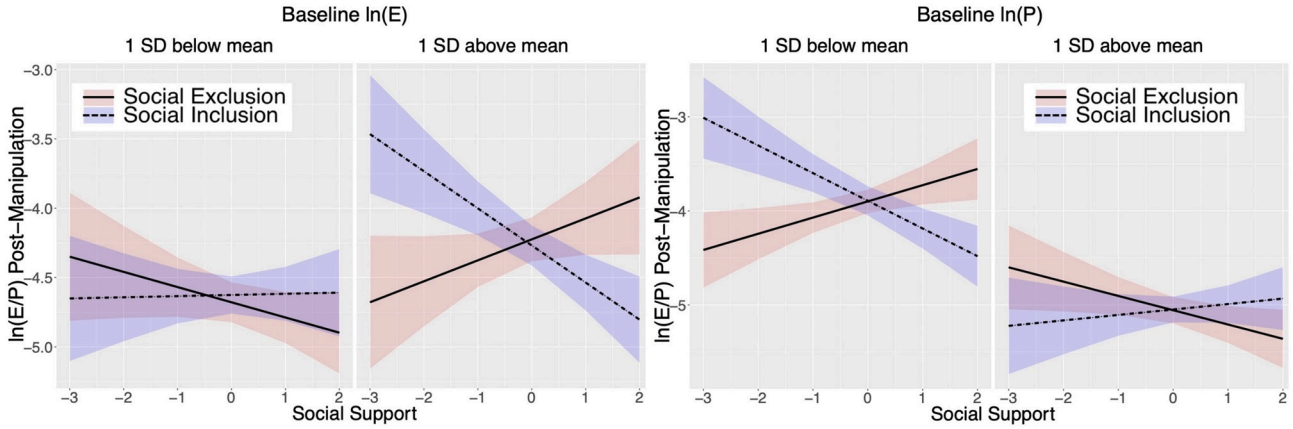

Fig. 2. Results from Model 1B: post-manipulation ln(E/P) regressed on the interaction of experimental condition, social support, and baseline hormones, with effects of baseline *logged estradiol (left two graphs)* and *logged progesterone (right two graphs)* separately estimated. *Left-most graph:* baseline ln(E) centered at 1 SD below the mean represents non-conceptive phases of the cycle. *Right-most graph:* baseline ln(P) centered at 1 SD above the mean characterizes the luteal-phase. *Middle two graphs:* hormone profiles characteristic of the periovulatory phase. Shaded areas represent 95% confidence intervals.

predicted ln(E/P) post-exclusion ($b = 0.31$, $p = .014$) and negatively predicted ln(E/P) post-inclusion ($b = -0.44$, $p = .00006$).

5.2.4. *Marginal effects at high and low levels of social support*

Effects of social exclusion or inclusion differed depending on whether women had high or low levels of social support. Among women with social support 1 SD below the mean, social exclusion, compared to social inclusion, led to greater decreases in post-manipulation ln(E/P) as baseline ln(E/P) increased (ln[E/P] * condition interaction: $b = -0.21$, $p = .004$) or as baseline ln(E) increased and baseline ln(P) decreased (ln [E] * condition: $b = -0.33$, $p = .058$; ln[P] * condition: $b = 0.23$, $p = .003$). In contrast, women with social support 1 SD above the mean showed the reverse pattern: social exclusion, versus social inclusion, was associated with higher expected post-manipulation ln(E/P) as baseline hormone profiles approached periovulatory-phase levels (ln[E/P] * condition: $b = 0.21$, $p = .006$; ln[E] * condition: $b = 0.48$, $p = .012$; ln[P] * condition: $b = -0.23$, $p = .005$).

Results for women with low social support were expected. Results for women with high social support were unexpected and hence contrary to predictions. Ordinary least squares regression constrains effects to be linear across the entire range of the variables examined; if effects are not linear across the full range of social support, marginal effects estimates towards the ends of the continuum can be distorted. In this instance, linearity constrains the rate of change in the exclusion versus inclusion by baseline ln(E/P) interaction to be constant across the social support continuum. If this rate of change is not linear, simple effects estimated at 1 SD above and below the mean on social support may be distorted.

We conducted follow-up exploratory piecewise regression models to examine whether 3-way interaction effects differed for women with social support levels in the upper ranges compared to lower ranges, using three different cut-points: social support levels above versus below the median ($z = 0.13$), above versus below the second tertile ($z = 0.56$),

and above versus below the third quartile ($z = 0.82$). In these analyses, we estimated different slopes for social support groups above and below the cut-point. Results suggested a non-constant rate of change, across social support, in the 2-way exclusion versus inclusion by baseline ln(E/P) interaction. For women with social support levels in the lower ranges, the 3-way interaction of condition, baseline ln(E/P), and social support was highly significant across all analyses (all $p < .001$). In contrast, the 3-way interaction was not consistently detected among women with social support levels in the higher ranges: the interaction was nonsignificant across two analyses (near-zero, $p = .893$, in one instance), and in the reverse direction for the model separating social support at the third quartile ($p = .045$). The difference in the rate of change across social support was significant for piecewise analyses that treated the highest tertile and highest quartile as women with high social support ($p = .028$ and .013, respectively; for the analysis using the median as a cut-off, $p = .091$). See SOM, Section 10, for complete results and model plots.

The primary significance of these findings is that they potentially have implications for the marginal 2-way interactions between the social manipulation and baseline ln(E/P) we reported above. In the piecewise analyses, this interaction was consistently significant for women 1 SD below the mean on social support, matching the results we reported above ($p = .002, .002, .005$). In contrast, the interaction was no longer significant for women 1 SD above the mean on social support in two of three analyses ($p = .013, .074, .077$). (Though these effects were no longer significant, we do not assert the null hypothesis that they do not exist. The strength of evidence for this effect simply weakened.) Given the number of exploratory models conducted (see below also for piecewise analyses on post-manipulation ln[P]), it is possible that some effects are false positives. For instance, the reversal in direction of one 3-way interaction at high levels of social support may reflect Type 1 error, given the inconsistencies in effects across analyses and cut-points (the same interaction was near-zero in another analysis). Effects at lower levels of social support, which were consistent across analyses, may be less likely to reflect false positives.

5.2.5. Summary of results

Among women lacking in social support, social exclusion led to decreases in ln(E/P) whereas social inclusion led to increases in ln(E/P), consistent with potentially reduced and heightened fecundity in each group, respectively. These hormonal changes only occurred when baseline ln(E/P) levels were high, or when baseline ln(E) was high and ln(P) was low in analyses examining separate effects of both hormones. Unexpectedly, changes in ln(E/P) reversed in direction when women had high social support. Simple effects at 1 SD above and below the mean in social support were significantly different between conditions. Follow-up exploratory piecewise models suggested that the effects observed in primary models were present among women with relatively lower levels of social support but were weaker among women with higher levels of social support.

5.3. Changes in estradiol and progesterone

Next, analyses were followed up with examinations of whether the observed effects on post-manipulation ln(E/P) levels can be attributed to changes in ln(E) or ln(P) separately. Diagnostics for possible collinearity effects showed VIF < 2.10 for all predictors.

5.3.1. Changes in logged estradiol

Analysis of regression Model 2A revealed that the interaction between condition, baseline ln(E/P) levels, and social support did not predict post-manipulation ln(E) ($p = .95$; see Table 4). Examination of baseline ln(E) and ln(P) levels separately in the same analysis (Model 2B) also did not reveal significant interactions (p's > .80; see Table 5). There were no interactions between social support and condition, nor main effects of condition, in either model (p's > .25).

Table 4
Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor.

DV: Post-manipulation ln(E)				
	b	SE	*t*-Value	*p*-Value
(Intercept)	0.54	0.03	21.38	**<.0001**
Baseline ln(E/P)	−0.13	0.04	−2.95	**.004**
Ln Cortisol Residual	0.20	0.07	2.65	**.009**
Condition	0.001	0.03	0.05	.961
Social Support	−0.06	0.03	−2.40	**.018**
Baseline ln(E/P) * Condition	−0.02	0.04	−0.49	.627
Baseline ln(E/P) * Social Support	−0.02	0.04	−0.55	.582
*Condition * Social Support*	−0.03	0.03	−1.10	.274
Baseline ln(E/P) * Condition * Social Support	−0.003	0.04	−0.07	.948

3-Way (Condition × Baseline Hormones × Social Support) interaction of interest is ***bolded and italicized***. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.
$p < .05$ **bolded**; $p < .10$ *italicized*.

Table 5
Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors.

DV: Post-manipulation ln(E)				
	b	SE	*t*-Value	*p*-Value
(Intercept)	0.54	0.02	30.30	**<.0001**
Baseline ln(E)	0.66	0.08	8.41	**<.0001**
Baseline ln(P)	0.02	0.03	0.52	.605
Ln Cortisol Residual	0.10	0.05	1.92	*.057*
Condition	0.01	0.02	0.69	.489
Social Support	−0.05	0.02	−2.44	**.016**
Baseline ln(E) * Condition	0.01	0.08	0.14	.887
Baseline ln(E) * Social Support	−0.15	0.08	−2.00	**.048**
*Condition * Social Support*	−0.01	0.02	−0.45	.656
Baseline ln(P) * Condition	−0.01	0.03	−0.30	.766
Baseline ln(P) * Social Support	0.04	0.03	1.11	.270
Baseline ln(E) * Condition * Social Support	0.01	0.08	0.16	.875
Baseline ln(P) * Condition * Social Support	−0.01	0.03	−0.23	.821

3-Way (Condition × Baseline Hormones × Social Support) interactions of interest are ***bolded and italicized***. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.
$p < .05$ **bolded**; $p < .10$ *italicized*.

5.3.2. Changes in logged progesterone

The observed changes in ln(E/P) from baseline may be especially affected by changes in ln(P). Regression Models 3A and 3B next examined changes in post-manipulation ln(P). Cortisol change was significantly associated with ln(P) residualized change (p's < .0001). As before, experimental condition did not have main effects (p's > .65) on ln(P). Changes in ln(P) following social inclusion or exclusion were moderated by background social support in both models (Model 3A: $b = -0.10$, $p = .024$; Model 3B: $b = -0.08$, $p = .035$). Consistent with results on post-manipulation ln(E/P), these effects were qualified by interactions with baseline hormone levels.

5.3.2.1. Interactions with ln(E/P). On average, the experimental task was associated with significant differences in post-manipulation ln(P) levels, as a function of the interaction of condition, baseline ln(E/P), and social support ($b = -0.21$, $p = .003$). See Table 6. As baseline ln(E/P) increased, the association between social support and post-manipulation ln(P) became significantly more negative among socially excluded women ($b = -0.21$, $p = .021$). The interaction between baseline ln(E/P)

Table 6
Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor.

	DV: Post-manipulation ln(P)											
	Condition effect-coded[a]				Social exclusion condition[b]				Social inclusion condition[c]			
	b	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value
(Intercept)	5.01	0.04	124.81	**<.0001**	5.02	0.06	88.30	**<.0001**	5.01	0.06	87.75	**<.0001**
Baseline ln(E/P)	−0.92	0.07	−13.08	**<.0001**	−0.94	0.09	−11.04	**<.0001**	−0.90	0.11	−8.05	**<.0001**
Ln Cortisol Residual	0.64	0.12	5.35	**<.0001**	0.64	0.12	5.35	**<.0001**	0.64	0.12	5.35	**<.0001**
Condition	0.01	0.04	0.14	.891								
Social Support	−0.01	0.04	−0.22	.824	−0.11	0.06	−1.82	*.072*	0.09	0.06	1.41	.162
Baseline ln(E/P) * Condition	−0.02	0.07	−0.30	.765								
Baseline ln(E/P) * Social Support	0.01	0.07	0.08	.938	−0.21	0.09	−2.33	**.021**	0.22	0.11	1.97	*.051*
*Condition * Social Support*	−0.10	0.04	−2.28	**.024**								
Baseline ln(E/P) * Condition * Social Support	−0.21	0.07	−3.00	**.003**								

3-Way (Condition × Baseline Hormones × Social Support) interaction of interest is ***bolded and italicized***. Simple **2-way (Baseline Hormones × Social Support) interaction** of interest within condition is **bolded**. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. In analyses with condition dummy-coded, results for main effects of and interactions with condition are redundant and thus excluded from tables.
$p < .05$ **bolded**; $p < .10$ *italicized*.
[a] Results for condition effect-coded, with social exclusion = 1 and social inclusion = −1.
[b] Results for simple effects in the social exclusion condition. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0.
[c] Results for simple effects in the social inclusion condition. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0.

and social support was positive for socially included women but fell short of statistical significance ($b = 0.22$, $p = .051$). When baseline ln(E/P) was high (1 SD above the mean), but not when it was low (1 SD below the mean), social support was negatively related to post-exclusion ln(P) ($b = -0.22$, $p = .003$) and positively related to post-inclusion ln(P) ($b = 0.21$, $p = .012$). See Fig. 3.

5.3.2.2. Interactions with ln(E) and ln(P) separately. Next, interactions of condition * social support with baseline ln(E) and ln(P) were estimated separately to examine independent associations with post-manipulation ln(P). See Table 7. The interaction of condition * social support with baseline ln(P) was highly significant ($b = 0.22$, $p = .0006$), as was the interaction of condition * social support with baseline ln(E) ($b = -0.40$, $p = .008$).

When socially excluded women had lower baseline ln(P), as is characteristic during the follicular phase, post-exclusion ln(P) was more strongly negatively associated with women's levels of social support (ln[P] * social support interaction: $b = 0.25$, $p = .004$). Among socially included women, the interaction with baseline ln(P) reverses in direction ($b = -0.19$, $p = .039$). As socially excluded women's baseline ln(E) increased, independent of baseline ln(P), their levels of social support more negatively predicted post-manipulation ln(P) residualized change ($b = -0.53$, $p = .018$). The interaction of social support with baseline ln(E) was positive in direction but not statistically significant for socially included women ($b = 0.26$, $p = .174$). When baseline ln(E) was high (1 SD above the mean) and baseline ln(P) was low (1 SD below the mean), social support had opposite effects across experimental conditions (social support * condition interaction: $b = -3.73$, $p = .0001$): lower social support was associated with higher post-*ex*clusion ln(P) ($b = -4.33$, $p = .003$) and lower post-*in*clusion ln(P) ($b = 3.12$, $p = .011$). See Fig. 4.

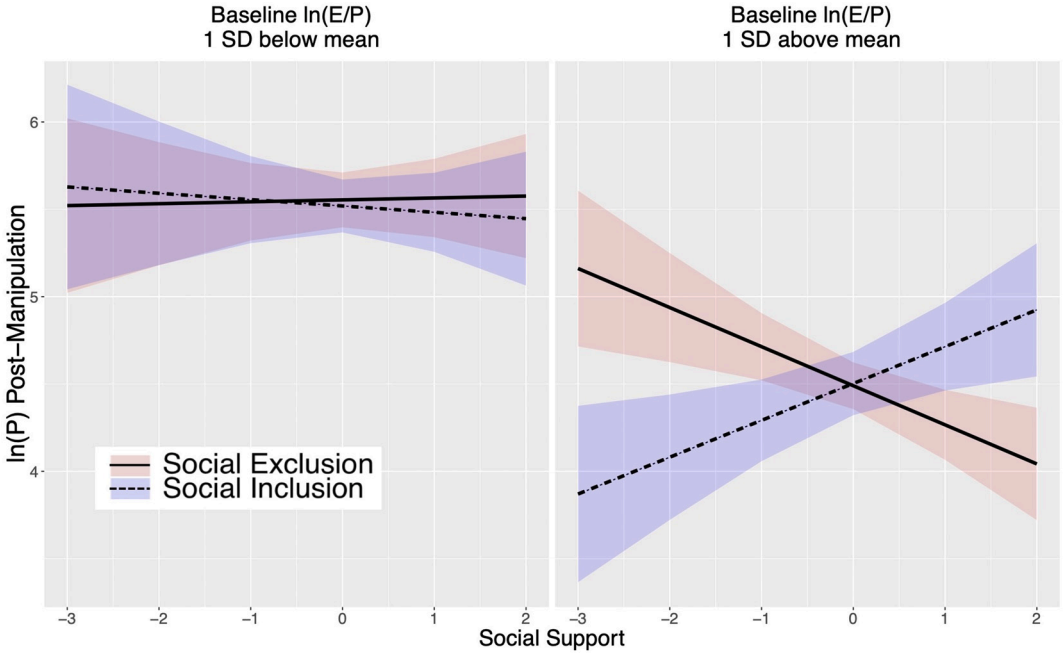

Fig. 3. Model 3A testing the interaction between experimental condition, baseline ln(E/P), and social support in predicting post-manipulation ln(P). *Left graph:* baseline ln(E/P) is centered at 1 SD below the mean, a hormone profile characteristic of the luteal phase. *Right graph:* baseline ln(E/P) is centered at 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Shaded areas represent 95% confidence intervals.

Table 7
Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors.

	DV: Post-manipulation ln(P)											
	Condition effect-coded[a]				Social exclusion condition[b]				Social inclusion condition[c]			
	b	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value	*b*	SE	*t*-Value	*p*-Value
(Intercept)	5.01	0.03	146.74	**<.0001**	5.02	0.05	101.95	**<.0001**	4.99	0.05	104.86	**<.0001**
Baseline ln(E)	0.04	0.15	0.30	.766	−0.02	0.22	−0.07	.942	0.10	0.20	0.54	.594
Baseline ln(P)	0.79	0.06	12.66	**<.0001**	0.78	0.08	9.73	**<.0001**	0.80	0.09	8.43	**<.0001**
Ln Cortisol Residual	0.54	0.10	5.28	**<.0001**	0.54	0.10	5.28	**<.0001**	0.54	0.10	5.28	**<.0001**
Condition	0.01	0.03	0.39	.699								
Social Support	0.01	0.04	0.14	.886	−0.07	0.05	−1.41	.162	0.08	0.05	1.60	.112
Baseline ln(E) * Condition	−0.06	0.15	−0.41	.680								
Baseline ln(E) * Social Support	−0.14	0.15	−0.95	.344	−0.53	0.22	−2.40	**.018**	0.26	0.19	1.37	.174
*Condition * Social Support*	−0.08	0.04	−2.13	**.035**								
Baseline ln(P) * Condition	−0.01	0.06	−0.15	.885								
Baseline ln(P) * Social Support	0.03	0.06	0.42	.677	0.25	0.08	2.93	**.004**	−0.19	0.09	−2.09	**.039**
Baseline ln(E) * Condition * Social Support	−0.40	0.15	−2.71	**.008**								
Baseline ln(P) * Condition * Social Support	0.22	0.06	3.52	**.0006**								

3-Way (Condition × Baseline Hormones × Social Support) interactions of interest are ***bolded and italicized***. Simple **2-way (Baseline Hormones × Social Support) interactions** of interest within condition are **bolded**. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. In analyses with condition dummy-coded, results for main effects of and interactions with condition are redundant and thus excluded from tables.
$p < .05$ **bolded**; $p < .10$ *italicized*.
[a] Results for condition effect-coded, with social exclusion = 1 and social inclusion = −1.
[b] Results for simple effects in the social exclusion condition. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0.
[c] Results for simple effects in the social inclusion condition. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0.

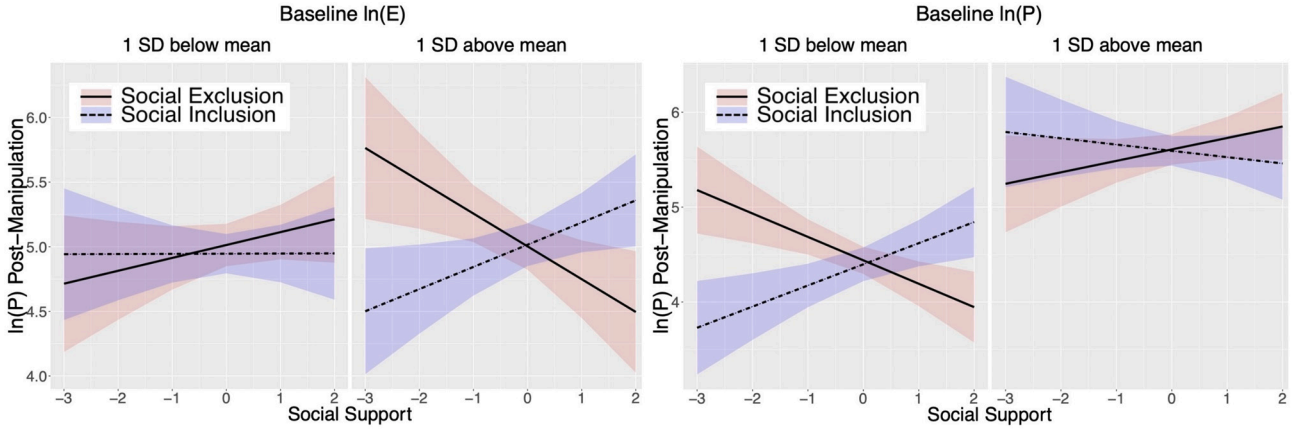

Fig. 4. Results from Model 3B: post-manipulation ln(P) regressed on the interaction of experimental condition, social support, and baseline hormones, with effects of baseline *logged estradiol (left two graphs)* and *logged progesterone (right two graphs)* separately estimated. *Left-most graph:* baseline ln(E) centered at 1 SD below the mean represents non-conceptive phases of the cycle. *Right-most graph:* baseline ln(P) centered at 1 SD above the mean characterizes the luteal-phase. *Middle two graphs:* hormone profiles characteristic of the periovulatory phase. Shaded areas represent 95% confidence intervals.

5.3.2.3. Marginal effects at high and low levels of social support. Models 3A and 3B were next estimated with social support centered at 1 SD above and below the mean. Following social exclusion, compared to social inclusion, women with low levels of social support experienced relatively greater levels of post-manipulation ln(P) as baseline hormones approached periovulatory-phase levels (ln[E/P] * condition: $b = 0.19$, $p = .053$; ln[E] * condition: $b = 0.33$, $p = .093$; ln[P] * condition: $b = -0.23$, $p = .009$). In contrast, among women with high levels of social support, social exclusion compared to social inclusion was associated with lower post-manipulation ln(P) as baseline hormones approached periovulatory-phase levels (ln[E/P] * condition: $b = -0.23$, $p = .023$; ln[E] * condition: $b = -0.46$, $p = .036$; ln[P] * condition: $b = 0.21$, $p = .021$).

Follow-up exploratory piecewise regression analyses suggested that slopes may be nonconstant across different ranges of social support. As before, we conducted three tests to see whether effects differed for women with low social support, compared to high social support (i.e., below versus above the median, second tertile, and third quartile). Results of piecewise analyses on post-manipulation ln(P) were consistent with those on post-manipulation ln(E/P). The interaction between condition, baseline ln(E/P), and social support was significantly different between low versus high social support groups in the analysis that treated the highest quartile as women with high social support ($p = .029$). (For analyses separating women at the median and highest tertile, $p = .135$ and .071, respectively.) Across all analyses, the 3-way interaction was highly significant for women with low social support (all $p < .01$) but was not significant for women with high social support. At 1 SD below the mean in social support, the interaction between experimental condition and baseline ln(E/P) was significant, mirroring the results reported for primary analyses ($p = .028$, .033, .041). At 1 SD above the mean in social support, this interaction was no longer significant in two of the three analyses ($p = .047$, .164, .213). See SOM, Section 11, for tables and figures of piecewise model results.

5.3.3. Summary of results

Analyses examining changes to log-transformed estradiol and

progesterone separately revealed that the effects on post-manipulation ln(E/P) were primarily driven by changes in progesterone. Following the experimental manipulation, women with lower social support exhibited greater changes in progesterone only when baseline ln(E/P) was high—specifically, when baseline ln(E) was high and ln(P) was low. Among these women, social exclusion led to increases and social inclusion led to decreases in progesterone, consistent with potentially reduced and increased fecundity in the respective experimental conditions. In contrast, women with high social support showed progesterone changes in the reverse directions relative to those with low support. Follow-up exploratory piecewise regression analyses suggested that the effects from primary models may be present particularly at lower ranges of social support.

5.4. Cortisol change as the outcome variable

To probe whether the observed changes in ln(E/P) and ln(P) may be mediated or confounded by cortisol release, the same predictors were entered into analyses with post-manipulation logged cortisol as the outcome variable. Baseline logged cortisol (instead of cortisol residuals) was also entered as a predictor, for estimations of residualized change in cortisol. VIF < 2.20 for all predictors. There were no significant main effects of or interactions with experimental condition (p's > .15) in either Model 4A (with baseline ln[E/P] as the hormonal predictor; Table 8) or Model 4B (with effects of baseline ln[E] and ln[P] separately estimated; Table 9). In sum, changes in progesterone do not appear to be driven by changes in cortisol.

6. Discussion

Our results provide experimental support for the hypothesis that cues of social support can influence production of hormones associated with fecundity in cycling women. Cues of social exclusion increased salivary progesterone and reduced the estradiol/progesterone ratio, while cues of inclusion had the opposite effect. These effects were moderated by how much social support participants reported in their everyday lives. Changes were more pronounced among women with low background levels of social support, though associations reversed in direction at high levels of social support. While we initially predicted that the experimental manipulation might change women's estradiol levels, we instead found that changes in the estradiol/progesterone ratio were primarily driven by changes in progesterone.

Hormonal changes following experimental manipulation were more likely to occur among women with high baseline levels of estradiol relative to progesterone, a hormonal profile characteristic of the periovulatory phase. That is, women with higher baseline conception probability were those most affected by the manipulation. Past evidence indicates that psychosocial stress-induced hormonal changes may be especially pronounced during women's periovulatory phase (Roney and Simmons, 2015). Previous literature suggests that even relatively moderate increases in progesterone during the periovulatory phase have the potential to disrupt ovulation or implantation (Adams et al., 1992; Johnson et al., 1996; Kiliçdag et al., 2010; Sonigo et al., 2014; Spies and Niswender, 1972; Venetis et al., 2013). The occurrence of these short-term effects under controlled experimental conditions suggests the possibility that persistent real-world cues of social isolation could significantly inhibit the likelihood of reproduction.

Table 8
Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor.

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-Value	*p*-Value
(Intercept)	8.78	0.03	280.01	**<.0001**
Baseline ln(Cortisol)	0.77	0.07	10.83	**<.0001**
Baseline ln(E/P)	0.07	0.06	1.17	.244
Condition	0.03	0.03	1.11	.270
Social Support	−0.05	0.03	−1.51	.135
Baseline ln(E/P) * Condition	−0.03	0.05	−0.49	.623
Baseline ln(E/P) * Social Support	0.05	0.06	0.98	.328
*Condition * Social Support*	−0.004	0.03	−0.13	.897
Baseline ln(E/P) * Condition * Social Support	0.03	0.06	0.61	.542

3-Way (Condition × Baseline Hormones × Social Support) interaction of interest is ***bolded and italicized***. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.
$p < .05$ **bolded**; $p < .10$ *italicized*.

Table 9
Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors.

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-Value	*p*-Value
(Intercept)	8.79	0.03	276.14	**<.0001**
Baseline ln(Cortisol)	0.75	0.07	10.55	**<.0001**
Baseline ln(E)	0.30	0.14	2.19	**.031**
Baseline ln(P)	−0.10	0.06	−1.70	*.092*
Condition	0.04	0.03	1.40	.164
Social Support	−0.03	0.03	−1.01	.316
Baseline ln(E) * Condition	0.06	0.14	0.45	.651
Baseline ln(E) * Social Support	0.13	0.13	0.98	.330
*Condition * Social Support*	0.01	0.03	0.34	.736
Baseline ln(P) * Condition	0.01	0.06	0.11	.912
Baseline ln(P) * Social Support	−0.08	0.06	−1.30	.197
Baseline ln(E) * Condition * Social Support	0.19	0.14	1.44	.153
Baseline ln(P) * Condition * Social Support	−0.06	0.06	−1.04	.300

3-Way (Condition × Baseline Hormones × Social Support) interactions of interest are ***bolded and italicized***. *Condition × Social Support interaction* at average baseline hormone values is *italicized*. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.
$p < .05$ **bolded**; $p < .10$ *italicized*.

6.1. Hormonal changes following cues of increased social affiliation

We hypothesized that women with higher background levels of social support would experience attenuated, or even no, hormonal changes following social exclusion. Our findings support this prediction. However, we did not predict that socially *included* women would also experience changes in hormones. Among women with lower levels of social support, social inclusion appeared to increase the estradiol/progesterone ratio when baseline levels were high. This result was unpredicted. The possibility that favorable social environments might induce heightened fecundity in women previously lacking social support is not inconsistent with existing research and theory. In humans and nonhuman animals, certain social cues can positively impact female fecundity (e.g., the presence of a potential mate or removal of a dominant female competitor; Beehner and Lu, 2013; Ellis, 2004; French et al., 1984; Machatschke et al., 2006; Sapolsky, 2011; Ziegler et al., 1987).

Plausibly, as humans required social support for reproductive success throughout human evolution (and not merely a male sexual partner), a change in social circumstances predictive of increased affiliative support may likewise increase female fecundity. Women may respond behaviorally and physiologically in ways that function to adaptively regulate fertility in the context of new social relationships (e.g., friendships providing added sources of support or formation of a romantic pair-bond; see Dinh et al., 2017). Among women chronically lacking in social support, it may be important to capitalize on cues of improved conditions. Future research is needed to explore this possibility and further examine the effects of social inclusion.

6.2. Hormonal changes in women with high availability of social support

Unexpectedly, the results of our study also suggested that when women had higher background levels of social support, experimental social exclusion was associated with a higher predicted post-manipulation estradiol/progesterone ratio, and social inclusion was associated with a lower ratio. These results are inconsistent with our hypothesis and are difficult to explain. Follow-up analyses offered suggestive evidence that the effect of social support is non-linear. In particular, the results of primary analyses reflected effects at lower ranges of social support, such that unexpected two-way interactions between the exclusion versus inclusion manipulation and baseline hormone levels were not highly robust at high levels of social support.[5] That said, we recognize that the piecewise regression analyses were exploratory; results could be an artifact of sampling variability and warrant replication. If the unexpected effects at high levels of social support replicate, additional theory is needed to explain them.

6.3. Progesterone as a potential mechanism for fertility regulation

When we conceptualized this study, we hypothesized decreases in estradiol following social exclusion, as estradiol is positively correlated with fecundity when compared across menstrual cycles (Lipson and Ellison, 1996). However, following precedent from the animal literature, we also examined changes in progesterone and the estradiol/progesterone ratio. Despite correlational evidence in humans (Roney and Simmons, 2015) and experimental evidence in nonhuman animals (Galea et al., 1997; Shors et al., 1999; Thorpe et al., 2013; Xiao et al., 1998), we did not find clear evidence for changes in estradiol levels. However, consistent with findings on the effects of stress and research on mechanisms for reproductive suppression, we found changes in women's mid-to-late follicular estradiol/progesterone ratio and progesterone levels.

If humans have mechanisms to perturb fecundity when socially isolated, research suggests that elevations in progesterone would be an effective mechanism to disrupt ongoing follicular activity. The negative impact of follicular-phase progesterone on fecundity can be understood through its inhibitory effects on GnRH, LH, and FSH secretion (Johnson, 2018). While these effects are adaptive post-ovulation, during the luteal phase, they interfere with ovulation during the follicular phase. We speculate that once progesterone evolved to have negative-feedback effects on gonadotropins, natural selection could co-opt stress response systems to adaptively suppress female fecundity—possibly through adrenal production of progesterone to downregulate fecundity following exposure to ancestrally fitness-relevant stressors. We emphasize, however, that the current study cannot directly address whether short-term effects on progesterone levels actually affect reproductive functioning.

Alternatively, post-exclusion changes in follicular-phase progesterone, contingent on low existing social support, could be a side-effect of the manipulation's impacts on cortisol levels. If this were the case, cortisol should mediate the effect of social exclusion on follicular-phase progesterone levels; controlling for cortisol should diminish or eliminate this effect. We tested this possibility and found that controlling for cortisol responses only enhanced social exclusion's impact on follicular-phase progesterone increases. Although these findings suggest that the changes in progesterone levels are not mere side-effects, we cannot completely rule out this possibility due to potential differences in the timing and magnitude of progesterone and cortisol responses following a stressor. Future work should examine whether stress-induced elevations in progesterone during the follicular phase have downstream effects on fecundity, and whether cortisol mediates effects on progesterone.

6.4. Progesterone and motivation for social affiliation

A separate potential explanation for observed changes in progesterone following social exclusion or inclusion involves progesterone's proposed role in motivating social bonding. A number of studies suggest that progesterone release may be associated with increased attention to social cues and motivation for social affiliation. This idea is based on the hypothesis that pregnancy, which is associated with marked increases in progesterone, is a period when the expectant mother would especially benefit from seeking social support; hence, progesterone's effects could have evolved for the additional function of motivating social bonding.

Some studies have found that women's estimated or measured progesterone levels are associated with affiliation motivation, attention to social stimuli, and accuracy at decoding facial expressions (Maner and Miller, 2014; Schultheiss et al., 2003). A number of experimental studies have reported changes in progesterone levels following manipulation of affiliation arousal or social exclusion (Brown et al., 2009; Maner et al., 2010; Schultheiss et al., 2004; Seidel et al., 2013; Wirth and Schultheiss, 2006). However, depending on the study, many reported effects emerged only under varying conditions or with qualifications (e.g., among those with certain psychological attributes or motives, or under specific arousal contexts, and with different context or gender effects across studies). Other studies have failed to find expected progesterone responses or associations (Ball et al., 2014; Gaffey and Wirth, 2014; Wirth and Schultheiss, 2006).

A recent study of particular relevance found that social exclusion was associated with more negative affect when women were in their late follicular phase, compared to their luteal phase (Lobmaier et al., 2019). This study did not measure progesterone responses, but results hint that social exclusion may have more potent psychological effects when fecundity may be most easily disrupted during the menstrual cycle. The finding that social exclusion produces less negative affect when progesterone is high is also inconsistent with the idea that progesterone motivates social bonding. For instance, less of a psychological response may result in reduced likelihood of a behavioral response to seek social affiliation.

In general, effects related to the hypothesized role of progesterone in social affiliation have not consistently replicated. Many published effects have significance levels close to the conventional .05 cut-off, suggesting that the effects may have arisen by chance (reviewed in Gangestad and Grebe, 2017). At present, evidence for progesterone's role in motivating social affiliation is perhaps suggestive but not compelling.

Though our study offers but one additional data point, results are not consistent with progesterone as a facilitator of social bonding. We did not find main effects of experimental condition, nor did we find that progesterone levels rose across both conditions, even after a closeness induction task. These results do not replicate those of past studies manipulating social exclusion or affiliation (Brown et al., 2009; Seidel et al., 2013). We also attempted to conceptually replicate findings that social anxiety or rejection sensitivity moderate the effects of social exclusion, such that highly anxious or rejection-sensitive individuals experience a drop in progesterone in response to exclusion (Duffy et al., 2017; Maner et al., 2010). Because we did not explicitly offer participants a new opportunity to interact following social exclusion (participants worked in separate cubicles for the remainder of the study), our study is conceptually more similar to study 1 from Maner et al. (2010) and to the blocked condition (where the participant and a confederate were separated by a physical barrier) in Duffy et al. (2017). We found that interactions between condition and social anxiety/rejection sensitivity ran in the opposite direction to those previously reported; the interactions were nonsignificant for social anxiety and ranged from significant to nonsignificant for rejection sensitivity, depending on

[5] These results might imply a curvilinear effect of social support. However, we did not find evidence for significant quadratic effects (see SOM, Section 12), though see Simonsohn (2018) on limitations of quadratic effect analysis in examination of non-linearity.

inclusion criteria and whether hormones were log-transformed (see SOM, Sections 13–14). We note that our study differs in important ways from Maner et al. (2010) and Duffy et al. (2017). Instead of using pre-recorded partners or a memory of past social rejection, we had participants interact face-to-face with, and receive (false) feedback from, 3–4 other women. Also, our study is the only one of the three that had participants actually socially affiliate prior to the inclusion/exclusion manipulation; studies 1 and 2 of Maner et al. (2010) did not involve direct social interaction (with study 2 having participants believe that they would interact with another group of people post-manipulation), and Duffy et al. (2017) had participants complete a non-affiliative task with a confederate (taking one-minute turns describing photographs).

In our study, only women in their mid-to-late follicular phase exhibited changes in progesterone, which is not expected if progesterone is associated with affiliation motivation. Women lacking social support showed a decrease in progesterone in response to social inclusion, also contrary to expectations of progesterone acting as a facilitator of social bonding. More plausibly, independent of whether reproductive capacity is suppressed or enhanced, progesterone appears to be released as a stress response. More research is needed to elucidate the nature of progesterone's potential roles in modulating social motives or regulating stress responses.

6.5. Changes in estradiol and lagged effects

When we first hypothesized that social stress and lack of social support might lead to reduced fecundity in women, we predicted that effects would be observed through decreased estradiol levels. They were not, but our study only had the potential to detect relatively rapid hormone responses. Although hormone release by the adrenal glands can happen relatively quickly, the time course of changes in ovarian hormone production is less clear. During the critical periovulatory period, the magnitude of baseline ovarian estradiol production may mask any change in adrenal production. Further complicating matters, even if ovarian hormone production and fecundity are affected soon after the onset of a stressor, not all females may show a significant decrease in estradiol. A study on rhesus monkeys found that stress during the follicular phase acutely increased adrenal progesterone levels and delayed folliculogenesis in all females, but only females with lower pre-stress levels of luteal progesterone experienced decreased estradiol following the stressor (Xiao et al., 1998). In our study, we did not find significant changes in estradiol levels 15 min post-manipulation. It is possible that only a subset of women will experience reduced estradiol following a significant social stressor, and our study was not adequately equipped to detect this response.

Additionally, there may be lagged effects that do not take place until well after the onset of a stressor. Results reported by Roney and Simmons (2015), who found that psychosocial stress was associated with a same-day reduction in estradiol, motivated us to explore whether decreases in estradiol can be observed within a short timeframe. Nonetheless, we acknowledge the possibility that even one hour (the duration of our study after the manipulation) may not be sufficient time to observe changes in ovarian production. More research is needed to examine the time course and possible downstream effects of psychosocial stress-induced hormone responses.

6.6. Limitations and future directions

The results of the current study offer preliminary support for the hypothesis that women's fecundity may be sensitive to cues from the social environment. Results suggest that cues of social inclusion versus ostracism have significant and rapid influences on progesterone levels, particularly during the periovulatory phase of the cycle, which suggests a potential mechanism through which the probability of conception may be enhanced or diminished.

Effects on estradiol, which were small and not statistically reliable, could exist but may not have been detected because of low power. Statistical issues associated with decreased power can result from the reduced sample size (from factors such as the large number of samples with insufficient saliva volume), as well as from noise introduced by individual differences in the efficacy of the manipulation. One limitation that could have compromised power is the smaller number of women whose sessions took place, by chance, during the periovulatory phase. We had decided not to schedule women based on estimated cycle phase due to the logistical challenge of obtaining a large enough sample size, given the need to schedule groups of women to arrive at the same session for the group bonding task. Future studies recruiting larger, more diverse samples of women whose participation is scheduled based on cycle phase would have greater power to detect effects and allow for an examination of the robustness of results across both experimental conditions.

Although our hypotheses focus on potential adaptive mechanisms to regulate fecundity, our results can only directly speak to acute changes in steroid hormone levels. Results for all three assayed hormones (estradiol, progesterone, and cortisol) were obtained only for baseline and 15 min post-manipulation. This precluded analysis of possible effects at later time points, as well as the time course of hormonal changes. Most importantly, we can only infer possible impacts on reproductive outcomes, as we did not directly measure ovulation or conception. Although many features of endocrine and reproductive systems are evolutionarily conserved across taxa, evidence in humans linking stress-induced follicular progesterone increases to reduced fecundity is absent. Future research employing more direct measurements of reproductive suppression is needed.

Our study is the first, to our knowledge, to measure hormone changes as a result of experimentally-manipulated social exclusion versus inclusion from actual peers, based on in-person social interactions. Other studies have used a Cyberball paradigm, recall of rejection, or pre-recorded confederates who purportedly provided feedback on the participant, to elicit experiences of social exclusion. An adequate test of our hypotheses required us to create a more compelling and stressful experience of social exclusion. Yet it is possible the experimental manipulation may still not have sufficiently mirrored real-world situations or provided ancestrally-relevant cues appropriate as inputs to fertility-regulatory adaptations. It is unclear to what extent a transient laboratory induction of social affiliation or ostracism produces effects translatable to real-world, stable cues of social support. However, the paradigm we used led to distinct separation in manipulation check scores (Cohen's $d = 3.97$) and significant differences in hormone outcomes across conditions.

We relied on deception to create a compelling experience of apparent social inclusion/exclusion. Hence, suspicion regarding the manipulation may have occurred. We performed an initial suspicion screening and excluded participants who expressed disbelief in the open-ended suspicion probe; due to budgetary constraints, we did not conduct hormone assays for excluded individuals. It is possible that missing hormone data from participants who voiced suspicion are correlated with some systematic bias in individual-differences variables that might affect outcomes of interest. Although not directly addressing this issue, in our primary analyses, we excluded 16% and 20% of participants in the social inclusion and exclusion groups, respectively, based on scores on manipulation check items. Results are similar on the full sample and when using different manipulation check criteria for selection, suggesting that our failure to assay hormones for overtly suspicious participants did not substantially influence our results.

Additionally, although experimental methods benefit from controlled conditions for examination of causal relationships, they also place limits on generalizability. Future extensions of this research could employ longitudinal studies examining associations between variation in social circumstances and women's hormone levels. However, it would be important to consider whether long-term correlational associations with hormone levels reflect different processes than reactive hormone

responses to the introduction of a stressor.

6.7. Summary and conclusions

The current study provides experimental evidence that cues of increased or reduced social support produce changes in progesterone concentrations and the estradiol-to-progesterone ratio when baseline hormone levels are characteristic of the periovulatory phase. On average, hormonal changes were more pronounced among women lacking social support, while results were less consistent among women with high social support. Under these baseline hormone and low social support profiles, social exclusion by same-sex peers resulted in a decreased ratio of estradiol to progesterone. Social inclusion, by contrast, led to increases in this ratio. These changes were primarily driven by elevated and reduced progesterone concentrations in the respective experimental conditions. Experimental nonhuman animal models and observational research in humans suggest that elevated progesterone during the mid-to-late follicular phase can impair female fecundity. Although the underlying mechanisms for how stress might impact female fecundity are not fully understood, the results of the current study provide evidence in support of possible adaptive fertility regulation in response to the loss or lack of social support in young women.

Declaration of competing interest

None.

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Appendix A. Supplementary online materials

Supplementary online materials for this article can be found online at https://doi.org/10.1016/j.yhbeh.2021.104934.

References

Abbott, D.H., Keverne, E.B., Bercovitch, F.B., Shively, C.A., Mendoza, S.P., Saltzman, W., Snowdon, C.T., Ziegler, T.E., Banjevic, M., Garland, T., Sapolsky, R.M., 2003. Are subordinates always stressed? A comparative analysis of rank differences in cortisol levels among primates. Horm. Behav. 43, 67–82. https://doi.org/10.1016/S0018-506X(02)00037-5.

Adams, G.P., Matteri, R.L., Ginther, O.J., 1992. Effect of progesterone on ovarian follicles, emergence of follicular waves and circulating follicle-stimulating hormone in heifers. J. Reprod. Fertil. 95, 627–640. https://doi.org/10.1530/jrf.0.0960627.

An, B.S., Choi, J.H., Choi, K.C., Leung, P.C.K., 2005. Differential role of progesterone receptor isoforms in the transcriptional regulation of human gonadotropin-releasing hormone I (GnRH I) receptor, GnRH I, and GnRH II. J. Clin. Endocrinol. Metab. 90, 1106–1113. https://doi.org/10.1210/jc.2004-0318.

Baird, D.D., Weinberg, C.R., Zhou, H., Kamel, F., McConnaughey, D.R., Kesner, J.S., Wilcox, A.J., 1999. Preimplantation urinary hormone profiles the probability of conception in healthy women. Fertil. Steril. 71, 40–49. https://doi.org/10.1016/S0015-0282(98)00419-1.

Bales, K.L., French, J.A., Hostetler, C.M., Dietz, J.M., 2005. Social and reproductive factors affecting cortisol levels in wild female golden lion tamarins (Leontopithecus rosalia). Am. J. Primatol. 67, 25–35. https://doi.org/10.1002/ajp.20167.

Bali, A., Jaggi, A.S., 2014. Multifunctional aspects of allopregnanolone in stress and related disorders. Prog. Neuro Psychopharmacol. Biol. Psychiatry 48, 64–78. https://doi.org/10.1016/j.pnpbp.2013.09.005.

Ball, A., Wolf, C.C., Ocklenburg, S., Brüne, M., Wolf, O.T., Güntürkün, O., Pinnow, M., 2014. The type of implicit motive enactment is modulated by sex hormones in naturally cycling women. Physiol. Behav. 123, 119–126. https://doi.org/10.1016/j.physbeh.2013.09.016.

Barrett, E.S., Tran, V., Thurston, S.W., Frydenberg, H., Lipson, S.F., Thune, I., Ellison, P. T., 2015. Women who are married or living as married have higher salivary estradiol and progesterone than unmarried women. Am. J. Hum. Biol. 27, 501–507. https://doi.org/10.1002/ajhb.22676.

Beehner, J.C., Lu, A., 2013. Reproductive suppression in female primates: a review. Evol. Anthropol. 22, 226–238. https://doi.org/10.1002/evan.21369.

Beehner, J.C., Bergman, T.J., Cheney, D.L., Seyfarth, R.M., Whitten, P.L., 2005. The effect of new alpha males on female stress in free-ranging baboons. Anim. Behav. 69, 1211–1221. https://doi.org/10.1016/j.anbehav.2004.08.014.

Bethea, C.L., Centeno, M.L., Cameron, J.L., 2008. Neurobiology of stress-induced reproductive dysfunction in female macaques. Mol. Neurobiol. 38, 199–230. https://doi.org/10.1007/s12035-008-8042-z.

Brown, S.L., Fredrickson, B.L., Wirth, M.M., Poulin, M.J., Meier, E.A., Heaphy, E.D., Cohen, M.D., Schultheiss, O.C., 2009. Social closeness increases salivary progesterone in humans. Horm. Behav. 56, 108–111. https://doi.org/10.1016/j.yhbeh.2009.03.022.

Bulletti, C., Flamigni, C., Giacomucci, E., 1996. Reproductive failure due to spontaneous abortion and recurrent miscarriage. Hum. Reprod. Update 2, 118–136. https://doi.org/10.1093/humupd/2.2.118.

Castro-Schilo, L., Grimm, K.J., 2018. Using residualized change versus difference scores for longitudinal research. J. Soc. Pers. Relat. 35, 32–58. https://doi.org/10.1177/0265407517718387.

Childs, E., Dlugos, A., De Wit, H., 2010. Cardiovascular, hormonal, and emotional responses to the TSST in relation to sex and menstrual cycle phase. Psychophysiology 47, 550–559. https://doi.org/10.1111/j.1469-8986.2009.00961.x.

Cohen, S., Wills, T.A., 1985. Stress, social support, and the buffering hypothesis. Psychol. Bull. 98, 310–357. https://doi.org/10.1037/0033-2909.98.2.310.

Conley, A.J., Bird, I.M., 1997. The role of cytochrome P450 17α-hydroxylase and 31-hydroxysteroid dehydrogenase in the integration of gonadal and adrenal steroidogenesis via the A5 and A4 pathways of steroidogenesis in mammals. Biol. Reprod. 56, 789–799. https://doi.org/10.1095/biolreprod56.4.789.

Crockford, C., Wittig, R.M., Whitten, P.L., Seyfarth, R.M., Cheney, D.L., 2008. Social stressors and coping mechanisms in wild female baboons (Papio hamadryas ursinus). Horm. Behav. 53, 254–265. https://doi.org/10.1016/j.yhbeh.2007.10.007.

Cutrona, C.E., Russell, D., 1987. The provisions of social relationships and adaptation to stress. In: Jones, W.H., Perlman, D. (Eds.), Advances in Personal Relationships. JAI Press, Greenwich, CT, pp. 37–67.

Dierschke, D.J., Yamaji, T., Karsch, F.J., Weick, R.F., Weiss, G., Knobil, E., 1973. Blockade by progesterone of estrogen–induced LH and FSH release in the rhesus monkey. Endocrinology 92, 1496–1501. https://doi.org/10.1210/endo-92-5-1496.

Dinh, T., Pinsof, D., Gangestad, S.W., Haselton, M.G., 2017. Cycling on the fast track: ovulatory shifts in sexual motivation as a proximate mechanism for regulating life history strategies. Evol. Hum. Behav. 38, 685–694. https://doi.org/10.1016/j.evolhumbehav.2017.09.001.

Duffy, K.A., Harris, L.T., Chartrand, T.L., Stanton, S.J., 2017. Women recovering from social rejection: the effect of the person and the situation on a hormonal mechanism of affiliation. Psychoneuroendocrinology 76, 174–182. https://doi.org/10.1016/j.psyneuen.2016.11.017.

Dufour, D.L., Sauther, M.L., 2002. Comparative and evolutionary dimensions of the energetics of human pregnancy and lactation. Am. J. Hum. Biol. 14, 584–602. https://doi.org/10.1002/ajhb.10071.

Dunkel Schetter, C., 2011. Psychological science on pregnancy: stress processes, biopsychosocial models, and emerging research issues. Annu. Rev. Psychol. 62, 531–558. https://doi.org/10.1146/annurev.psych.031809.130727.

Ellis, B.J., 2004. Timing of pubertal maturation in girls: an integrated life history approach. Psychol. Bull. 130, 920–958. https://doi.org/10.1037/0033-2909.130.6.920.

Ellison, P.T., 2003. Energetics and reproductive effort. Am. J. Hum. Biol. 15, 342–351. https://doi.org/10.1002/ajhb.10152.

Ellison, P.T., Lager, C., Calfee, J., 1987. Low profiles of salivary progesterone among college undergraduate women. J. Adolesc. Health Care 8, 204–207. https://doi.org/10.1016/0197-0070(87)90266-X.

Ellison, P.T., Lipson, S.F., Jasienska, G., Ellison, P.L., 2007. Moderate anxiety, whether acute or chronic, is not associated with ovarian suppression in healthy, well-nourished, western women. Am. J. Phys. Anthropol. 134, 513–519. https://doi.org/10.1002/ajpa.20698.

Feder, H.H., Marrone, B.L., 1977. Progesterone: its role in the central nervous system as a facilitator and inhibitor of sexual behavior and gonadotropin release. Ann. N. Y. Acad. Sci. 286, 331–354. https://doi.org/10.1111/j.1749-6632.1977.tb29428.x.

Ferin, M., 1999. Clinical review 105: stress and the reproductive cycle. J. Clin. Endocrinol. Metab. 84, 1768–1774. https://doi.org/10.1210/jcem.84.6.5367.

Fessler, D.M.T., 2002. Reproductive immunosuppression and diet. Curr. Anthropol. 43, 19–61. https://doi.org/10.1086/324128.

Forbes, L.S., 1997. The evolutionary biology of spontaneous abortion in humans. Trends Ecol. Evol. 12, 446–450. https://doi.org/10.1016/S0169-5347(97)01179-8.

French, J.A., Abbott, D.H., Snowdon, C.T., 1984. The effect of social environment on estrogen excretion, scent marking, and sociosexual behavior in tamarins (Saguinus oedipus). Am. J. Primatol. 6, 155–167. https://doi.org/10.1002/ajp.1350060304.

Gaffey, A.E., Wirth, M.M., 2014. Stress, rejection, and hormones: cortisol and progesterone reactivity to laboratory speech and rejection tasks in women and men. F1000Research 3, 1–17. https://doi.org/10.12688/f1000research.5142.1.

Galea, L.A.M., McEwen, B.S., Tanapat, P., Deak, T., Spencer, R.L., Dhabhar, F.S., 1997. Sex differences in dendritic atrophy of CA3 pyramidal neurons in response to chronic restraint stress. Neuroscience 81, 689–697. https://doi.org/10.1016/S0306-4522(97)00233-9.

Gangestad, S.W., Grebe, N.M., 2017. Hormonal systems, human social bonding, and affiliation. Horm. Behav. 91, 122–135. https://doi.org/10.1016/j.yhbeh.2016.08.005.
Gibson, M., Nakajima, S.T., McAuliffe, T.L., 1991. Short-term modulation of gonadotropin secretion by progesterone during the luteal phase. Fertil. Steril. 55, 522–528. https://doi.org/10.1016/S0015-0282(16)54179-X.
Gökmen, O., Seçkin, N.C., Şener, A.B., Özakşit, G., Ekmekçi, S., 1995. A study of premature ovarian failure in Turkish women. Gynecol. Endocrinol. 9, 283–287. https://doi.org/10.3109/09513599509160460.
Hambridge, H.L., Mumford, S.L., Mattison, D.R., Ye, A., Pollack, A.Z., Bloom, M.S., Mendola, P., Lynch, K.L., Wactawski-Wende, J., Schisterman, E.F., 2013. The influence of sporadic anovulation on hormone levels in ovulatory cycles. Hum. Reprod. 28, 1687–1694. https://doi.org/10.1093/humrep/det090.
Haouzi, D., Bissonnette, L., Gala, A., Assou, S., Entezami, F., Perrochia, H., Dechaud, H., Hugues, J.N., Hamamah, S., 2014. Endometrial receptivity profile in patients with premature progesterone elevation on the day of hCG administration. Biomed. Res. Int. 2014, 951937. https://doi.org/10.1155/2014/951937.
Harris, T.G., Sandra, D., Robinson, J.E., Skinner, D.C., Evans, N.P., 1999. Progesterone can block transmission of the estradiol-induced signal for luteinizing hormone surge generation during a specific period of time immediately after activation of the gonadotropin-releasing hormone surge-generating system. Endocrinology 140, 827–834. https://doi.org/10.1210/endo.140.2.6490.
Herrera, A.Y., Nielsen, S.E., Mather, M., 2016. Stress-induced increases in progesterone and cortisol in naturally cycling women. Neurobiol. Stress 3, 96–104. https://doi.org/10.1016/j.ynstr.2016.02.006.
Hill, E.M., Low, B.S., 1992. Contemporary abortion patterns: a life history approach. Ethol. Sociobiol. 13, 35–48. https://doi.org/10.1016/0162-3095(92)90005-O.
Hoffman, S., Hatch, M.C., 1996. Stress, social support and pregnancy outcome: a reassessment based on recent research. Paediatr. Perinat. Epidemiol. 10, 380–405. https://doi.org/10.1111/j.1365-3016.1996.tb00063.x.
Homburg, R., Armar, N.A., Eshel, A., Adams, J., Jacobs, H.S., 1988. Influence of serum luteinising hormone concentrations on ovulation, conception, and early pregnancy loss in polycystic ovary syndrome. Br. Med. J. 297, 1024–1026. https://doi.org/10.1136/bmj.297.6655.1024.
Hrdy, S.B., 1999. Mother Nature: A History of Mothers, Infants, and Natural Selection. Harvard University Press, Cambridge, MA. https://doi.org/10.1086/393476.
Hrdy, S.B., 2005. Evolutionary context of human development: the cooperative breeding model. In: Carter, C., Ahnert, L., Grossmann, K., Hrdy, S.B., Lamb, M., Porges, S., Sachser, N. (Eds.), Attachment and Bonding: A New Synthesis. The MIT Press, Cambridge, MA, pp. 9–32. https://doi.org/10.1093/acprof:oso/9780195320510.003.0003.
Jasienska, G., 2003. Energy metabolism and the evolution of reproductive suppression in the human female. Acta Biotheor. 51, 1–18. https://doi.org/10.1023/A:1023035321162.
Johnson, Martin H., 2018. Essential Reproduction, 8th. John Wiley & Sons, Hoboken, NJ.
Johnson, S.K., Dailey, R.A., Inskeep, E.K., Lewis, P.E., 1996. Effect of peripheral concentrations of progesterone on follicular growth and fertility in ewes. Domest. Anim. Endocrinol. 13, 69–79. https://doi.org/10.1016/0739-7240(95)00045-3.
Kaplan, H.S., 1997. The evolution of the human life course, in: Between Zeus and the Salmon. National Academy Press, Washington, D.C., pp. 175–211
Kaplan, H.S., Hill, K., Lancaster, J., Hurtado, A.M., 2000. A theory of human life history evolution: diet, intelligence, and longevity. Evol. Anthropol. 9, 156–185.
Kiliçdag, E.B., Haydardedeoglu, B., Cok, T., Haciveliogl u, S.O., Bagis, T., 2010. Premature progesterone elevation impairs implantation and live birth rates in GnRH-agonist IVF/ICSI cycles. Arch. Gynecol. Obstet. 281, 747–752. https://doi.org/10.1007/s00404-009-1248-0.
Kroenke, K., Spitzer, R.L., Williams, J.B.W., 2003. The patient health questionnaire-2: validity of a two-item depression screener. Med. Care 41, 1284–1292. https://doi.org/10.1097/01.MLR.0000093487.78664.3C.
Lahoud, R., Kwik, M., Ryan, J., Al-Jefout, M., Foley, J., Illingworth, P., 2012. Elevated progesterone in GnRH agonist down regulated in vitro fertilisation (IVFICSI) cycles reduces live birth rates but not embryo quality. Arch. Gynecol. Obstet. 285, 535–540. https://doi.org/10.1007/s00404-011-2045-0.
Lawrenz, B., Fatemi, H.M., 2017. Effect of progesterone elevation in follicular phase of IVF-cycles on the endometrial receptivity. Reprod. BioMed. Online 34, 422–428. https://doi.org/10.1016/j.rbmo.2017.01.011.
Le, W.W., Attardi, B., Berghorn, K.A., Blaustein, J., Hoffman, G.E., 1997. Progesterone blockade of a luteinizing hormone surge blocks luteinizing hormone-releasing hormone Fos activation and activation of its preoptic area afferents. Brain Res. 778, 272–280. https://doi.org/10.1016/S0006-8993(97)00971-2.
Lennartsson, A.K., Kushnir, M.M., Bergquist, J., Billig, H., Jonsdottir, I.H., 2012. Sex steroid levels temporarily increase in response to acute psychosocial stress in healthy men and women. Int. J. Psychophysiol. 84, 246–253. https://doi.org/10.1016/j.ijpsycho.2012.03.001.
Li, H., Nakajima, S.T., Chen, J., Todd, H.E., Overstreet, J.W., Lasley, B.L., 2001. Differences in hormonal characteristics of conceptive versus nonconceptive menstrual cycles. Fertil. Steril. 75, 549–553. https://doi.org/10.1016/S0015-0282(00)01765-9.
Lipson, S.F., Ellison, P.T., 1996. Comparison of salivary steroid profiles in naturally occurring conception and non-conception cycles. Hum. Reprod. 11, 2090–2096. https://doi.org/10.1093/oxfordjournals.humrep.a019055.
Lobmaier, J.S., Probst, F., Lory, V., Meyer, A.H., Meinlschmidt, G., 2019. Increased sensitivity to social exclusion during the luteal phase: progesterone as resilience factor buffering against ostracism? Psychoneuroendocrinology 107, 217–224. https://doi.org/10.1016/j.psyneuen.2019.05.019.
Machatschke, I.H., Wallner, B., Dittami, J., 2006. Impact of social environment on female chimpanzee reproductive cycles. Horm. Behav. 50, 126–131. https://doi.org/10.1016/j.yhbeh.2006.02.003.
Mackinnon, D.P., Krull, J.L., Lockwood, C.M., 2000. Equivalence of the mediation, confounding and suppression effect. Prev. Sci. 1, 1–9. https://doi.org/10.1023/a:1026595011371.
Maner, J.K., Miller, S.L., 2014. Hormones and social monitoring: menstrual cycle shifts in progesterone underlie women's sensitivity to social information. Evol. Hum. Behav. 35, 9–16. https://doi.org/10.1016/j.evolhumbehav.2013.09.001.
Maner, J.K., Miller, S.L., Schmidt, N.B., Eckel, L.A., 2010. The endocrinology of exclusion: rejection elicits motivationally tuned changes in progesterone. Psychol. Sci. 21, 581–588. https://doi.org/10.1177/0956797610362676.
Nepomnaschy, P.A., Welch, K., McConnell, D., Strassmann, B.I., England, B.G., 2004. Stress and female reproductive function: a study of daily variations in cortisol, gonadotrophins, and gonadal steroids in a rural Mayan population. Am. J. Hum. Biol. 16, 523–532. https://doi.org/10.1002/ajhb.20057.
Ochsenkühn, R., Arzberger, A., Von Schönfeldt, V., Gallwas, J., Rogenhofer, N., Crispin, A., Thaler, C.J., Noss, U., 2012. Subtle progesterone rise on the day of human chorionic gonadotropin administration is associated with lower live birth rates in women undergoing assisted reproductive technology: a retrospective study with 2,555 fresh embryo transfers. Fertil. Steril. 98, 347–354. https://doi.org/10.1016/j.fertnstert.2012.04.041.
Paulson, R.J., Sauer, M.V., Francis, M.M., Macaso, T.M., Lobo, R.A., 1992. In vitro fertilization in unstimulated cycles: the University of Southern California experience. Fertil. Steril. 57, 290–293. https://doi.org/10.1016/S0015-0282(16)54832-8.
Paulson, R.J., Sauer, M.V., Lobo, R.A., 1994. Addition of a gonadotropin releasing hormone (GnRH) antagonist and exogenous gonadotropins to unstimulated in vitro fertilization (IVF) cycles: physiologic observations and preliminary experience. J. Assist. Reprod. Genet. 11, 28–32. https://doi.org/10.1007/BF02213694.
Pohl, C.R., Richardson, D.W., Marshall, G., Knobil, E., 1982. Mode of action of progesterone in the blockade of gonadotropin surges in the rhesus monkey. Endocrinology 110, 1454–1455. https://doi.org/10.1210/endo-110-4-1454.
Prior, J.C., Naess, M., Langhammer, A., Forsmo, S., 2015. Ovulation prevalence in women with spontaneous normal-length menstrual cycles - a population-based cohort from HUNT3, Norway. PLoS One 10, e0134473. https://doi.org/10.1371/journal.pone.0134473.
Puder, J.J., Freda, P.U., Goland, R.S., Ferin, M., Wardlaw, S.L., 2000. Stimulatory effects of stress on gonadotropin secretion in estrogen-treated women. J. Clin. Endocrinol. Metab. 85, 2184–2188. https://doi.org/10.1210/jc.85.6.2184.
Regan, L., Owen, E.J., Jacobs, H.S., 1990. Hypersecretion of luteinising hormone, infertility, and miscarriage. Lancet 336, 1141–1144. https://doi.org/10.1016/0140-6736(90)92765-A.
Reiches, M., Ellison, P.T., Lipson, S.F., Sharrock, K.C., Gardiner, E., Duncan, L.G., 2009. Pooled energy budget and human life history. Am. J. Hum. Biol. 21, 421–429. https://doi.org/10.1002/ajhb.20906.
Richter, T.A., Robinson, J.E., Evans, N.P., 2002. Progesterone blocks the estradiol-stimulated luteinizing hormone surge by disrupting activation in response to a stimulatory estradiol signal in the ewe. Biol. Reprod. 67, 119–125. https://doi.org/10.1095/biolreprod67.1.119.
Richter, T.A., Robinson, J.E., Lozano, J.M., Evans, N.P., 2005. Progesterone can block the preovulatory gonadotropin-releasing hormone/luteinising hormone surge in the ewe by a direct inhibitory action on oestradiol-responsive cells within the hypothalamus. J. Neuroendocrinol. 17, 161–169. https://doi.org/10.1111/j.1365-2826.2005.01287.x.
Robertson, T.E., Delton, A.W., Klein, S.B., Cosmides, L., Tooby, J., 2014. Keeping the benefits of group cooperation: domain-specific responses to distinct causes of social exclusion. Evol. Hum. Behav. 35, 472–480. https://doi.org/10.1016/j.evolhumbehav.2014.06.006.
Roney, J.R., Simmons, Z.L., 2013. Hormonal predictors of sexual motivation in natural menstrual cycles. Horm. Behav. 63, 636–645. https://doi.org/10.1016/j.yhbeh.2013.02.013.
Roney, J.R., Simmons, Z.L., 2015. Elevated psychological stress predicts reduced estradiol concentrations in young women. Adapt. Hum. Behav. Physiol. 1, 30–40. https://doi.org/10.1007/s40750-014-0004-2.
Russell, D., Peplau, L.A., Cutrona, C.E., 1980. The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence. J. Pers. Soc. Psychol. 39, 472–480. https://doi.org/10.1037/0022-3514.39.3.472.
Sapolsky, R.M., 2005. The influence of social hierarchy on primate health. Science (80-.) 308, 648–652. https://doi.org/10.1126/science.1106477.
Sapolsky, R.M., 2011. Physiological and pathophysiological implications of social stress in mammals. Compr. Physiol. 517–532. https://doi.org/10.1002/cphy.cp070423.
Sapolsky, R.M., Romero, L.M., Munck, A.U., 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocr. Rev. 21, 55–89. https://doi.org/10.1210/er.21.1.55.
Schultheiss, O.C., Dargel, A., Rohde, W., 2003. Implicit motives and gonadal steroid hormones: effects of menstrual cycle phase, oral contraceptive use, and relationship status. Horm. Behav. 43, 293–301. https://doi.org/10.1016/S0018-506X(03)00003-5.
Schultheiss, O.C., Wirth, M.M., Stanton, S.J., 2004. Effects of affiliation and power motivation arousal on salivary progesterone and testosterone. Horm. Behav. 46, 592–599. https://doi.org/10.1016/j.yhbeh.2004.07.005.
Sedikides, C., Campbell, W., Reader, G., Elliot, A., 1999. The relationship closeness induction task. Represent. Res. Soc. Psychol. 23, 1–4.
Seidel, E.M., Silani, G., Metzler, H., Thaler, H., Lamm, C., Gur, R.C., Kryspin-Exner, I., Habel, U., Derntl, B., 2013. The impact of social exclusion vs. inclusion on subjective

and hormonal reactions in females and males. Psychoneuroendocrinology 38, 2925–2932. https://doi.org/10.1016/j.psyneuen.2013.07.021.
Sherry, D.S., Mcgarvey, S.T., Sesepasara, M.L., Ellison, P.T., 2014. Ovarian function in Samoan women shows stronger association with signals of energy metabolism than fat reserves. Am. J. Hum. Biol. 26, 95–98. https://doi.org/10.1002/ajhb.22465.
Shors, T.J., Pickett, J., Wood, G., Paczynski, M., 1999. Acute stress persistently enhances estrogen levels in the female rat. Stress 3, 163–171. https://doi.org/10.3109/10253899909001120.
Simonsohn, U., 2018. Two lines: a valid alternative to the invalid testing of U-shaped relationships with quadratic regressions. Adv. Methods Pract. Psychol. Sci. 1, 538–555. https://doi.org/10.1177/2515245918805755.
Skinner, D.C., Evans, N.P., Delaleu, B., Goodman, R.L., Bouchard, P., Caraty, A., 1998. The negative feedback actions of progesterone on gonadotropin-releasing hormone secretion are transduced by the classical progesterone receptor. Proc. Natl. Acad. Sci. U. S. A. 95, 10978–10983. https://doi.org/10.1073/pnas.95.18.10978.
Sollberger, S., Ehlert, U., 2016. How to use and interpret hormone ratios. Psychoneuroendocrinology 63, 385–397. https://doi.org/10.1016/j.psyneuen.2015.09.031.
Sonigo, C., Dray, G., Roche, C., Cédrin-Durnerin, I., Hugues, J.N., 2014. Impact of high serum progesterone during the late follicular phase on IVF outcome. Reprod. BioMed. Online 29, 177–186. https://doi.org/10.1016/j.rbmo.2014.03.027.
Sosa, R., Kennell, J., Klaus, M., Robertson, S., Urrutia, J., Sosa, R., Kennell, J., Klaus, M., Robertson, S., Urrutia, J., 1980. The effect of a supportive companion on perinatal problems, length of labor, and mother-infant interaction. N. Engl. J. Med. 303, 597–600. https://doi.org/10.1056/NEJM198009113031101.
Soules, M.R., Steiner, R.A., Clifton, D.K., Cohen, N.L., Aksel, S., Bremner, W.J., 1984. Progesterone modulation of pulsatile luteinizing hormone secretion in normal women. J. Clin. Endocrinol. Metab. 58, 378–383. https://doi.org/10.1210/jcem-58-2-378.
Spies, H.G., Niswender, G.D., 1972. Effect of progesterone and estradiol on LH release and ovulation in rhesus monkeys. Endocrinology 90, 257–261. https://doi.org/10.1210/endo-90-1-257.
Stanger, J.D., Yovich, J.L., 1985. Reduced in-vitro fertilization of human oocytes from patients with raised basal luteinizing hormone levels during the follicular phase. BJOG Int. J. Obstet. Gynaecol. 92, 385–393. https://doi.org/10.1111/j.1471-0528.1985.tb01113.x.
Stewart, D.R., Overstreet, J.W., Nakajima, S.T., Lasley, B.L., 1993. Enhanced ovarian steroid secretion before implantation in early human pregnancy. J. Clin. Endocrinol. Metab. 76, 1470–1476. https://doi.org/10.1210/jcem.76.6.8501152.
Thorpe, J.B., Burgess, P.S., Sadkowski, M., deCatanzaro, D., 2013. Estrogen-progesterone balance in the context of blastocyst implantation failure induced by predator stress. Psychoneuroendocrinology 38, 3048–3056. https://doi.org/10.1016/j.psyneuen.2013.09.001.
Trevathan, W.R., 2017. Human Birth: An Evolutionary Perspective. Routledge, New York, NY. https://doi.org/10.4324/9780203789599.
Ulberg, L.C., Christian, R.E., Casida, L.E., 1951. Ovarian response in heifers to progesterone injections. J. Anim. Sci. 10, 752–759. https://doi.org/10.2527/jas1951.103752x.
Venetis, C.A., Kolibianakis, E.M., Bosdou, J.K., Tarlatzis, B.C., 2013. Progesterone elevation and probability of pregnancy after IVF: a systematic review and meta-analysis of over 60 000 cycles. Hum. Reprod. Update 19, 433–457. https://doi.org/10.1093/humupd/dmt014.
Venners, S.A., Liu, X., Perry, M.J., Korrick, S.A., Li, Z., Yang, F., Yang, J., Lasley, B.L., Xu, X., Wang, X., 2006. Urinary estrogen and progesterone metabolite concentrations in menstrual cycles of fertile women with non-conception, early pregnancy loss or clinical pregnancy. Hum. Reprod. 21, 2272–2280. https://doi.org/10.1093/humrep/del187.
Vitzthum, V.J., Spielvogel, H., Thornburg, J., West, B., 2006. A prospective study of early pregnancy loss in humans. Fertil. Steril. 86, 373–379. https://doi.org/10.1016/j.fertnstert.2006.01.021.
Vuorento, T., Hovatta, O., Kurunmäki, H., Ratsula, K., Huhtaniemi, I., 1990. Measurements of salivary progesterone throughout the menstrual cycle in women suffering from unexplained infertility reveal high frequency of luteal phase defects. Fertil. Steril. 54, 211–216. https://doi.org/10.1016/s0015-0282(16)53691-7.
Wasser, S.K., 1994. Psychosocial stress and infertility - cause or effect? Hum. Nat. 5, 293–306. https://doi.org/10.1007/BF02692156.
Wasser, S.K., Barash, D.P., 1983. Reproductive suppression among female mammals: implications for biomedicine and sexual selection theory. Q. Rev. Biol. 58, 513–538. https://doi.org/10.1086/413545.
Wasser, S.K., Starling, A.K., 1988. Proximate and ultimate causes of reproductive suppression among female yellow baboons at Mikumi National Park, Tanzania. Am. J. Primatol. 16, 97–121. https://doi.org/10.1002/ajp.1350160202.
Watson, H., Kiddy, D.S., Hamilton-fairley, D., Scanlon, M.J., Barnard, C., Collins, W.P., Bonney, R.C., Franks, S., 1993. Hypersecretion of luteinizing hormone and ovarian steroids in women with recurrent early miscarriage. Hum. Reprod. 8, 829–833. https://doi.org/10.1093/oxfordjournals.humrep.a138149.
Whirledge, S., Cidlowski, J.A., 2010. Glucocorticoids, stress, and fertility. Minerva Endocrinol. 35, 109–125.
Wingfield, J.C., Sapolsky, R.M., 2003. Reproduction and resistance to stress: when and how. J. Neuroendocrinol. 15, 711–724. https://doi.org/10.1046/j.1365-2826.2003.01033.x.
Wirth, M.M., 2010. Beyond the HPA axis: progesterone-derived neuroactive steroids in human stress and emotion. Front. Endocrinol. (Lausanne) 2, 1–14. https://doi.org/10.3389/fendo.2011.00019.
Wirth, M.M., Schultheiss, O.C., 2006. Effects of affiliation arousal (hope of closeness) and affiliation stress (fear of rejection) on progesterone and cortisol. Horm. Behav. 50, 786–795. https://doi.org/10.1016/j.yhbeh.2006.08.003.
Wood, J.W., 1989. Fecundity and natural fertility in humans. Oxf. Rev. Reprod. Biol. 11, 61–109.
Xiao, E., Ferin, M., 1997. Stress-related disturbances of the menstrual cycle. Ann. Med. 29, 215–219. https://doi.org/10.3109/07853899708999339.
Xiao, E., Xia, L., Shanen, D., Khabele, D., Ferin, M., 1994. Stimulatory effects of interleukin-induced activation of the hypothalamo-pituitary-adrenal axis on gonadotropin secretion in ovariectomized monkeys replaced with estradiol. Endocrinology 135, 2093–2098. https://doi.org/10.1210/endo.135.5.7956932.
Xiao, E., Xia-zhang, L., Thornell, D., Ferin, M., 1996. Interleukin-1 stimulates luteinizing hormone release during the midfollicular phase in the rhesus monkey: a novel way in which stress may influence the menstrual cycle. J. Clin. Endocrinol. Metab. 81, 2136–2141. https://doi.org/10.1210/jc.81.6.2136.
Xiao, E., Xia-Zhang, L., Barth, A., Zhu, J., Ferin, M., 1998. Stress and the menstrual cycle: relevance of cycle quality in the short- and long-term response to a 5-day endotoxin challenge during the follicular phase in the rhesus monkey. J. Clin. Endocrinol. Metab. 83, 2454–2460. https://doi.org/10.1210/jc.83.7.2454.
Zhu, X., Zhang, X., Fu, Y., 2015. Utrogestan as an effective oral alternative for preventing premature luteinizing hormone surges in women undergoing controlled ovarian hyperstimulation for in vitro fertilization. Medicine (Baltimore) 94, 1–8. https://doi.org/10.1097/MD.0000000000000909.
Ziegler, T.E., Savage, A., Scheffler, G., Snowdon, C.T., 1987. The endocrinology of puberty and reproductive functioning in female cotton-top tamarins (Saguinus oedipus) under varying social conditions. Biol. Reprod. 37, 618–627. https://doi.org/10.1095/biolreprod37.3.618.
Zinaman, M.J., O'Connor, J., Clegg, E.D., Selevan, S.G., Brown, C.C., 1996. Estimates of human fertility and pregnancy loss. Fertil. Steril. 65, 503–509. https://doi.org/10.1016/S0015-0282(16)58144-8.

SUPPLEMENTARY ONLINE MATERIALS

Experimental Evidence for Adaptive Reproductive Suppression Following Social Exclusion

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Data, analysis scripts, and output for this study are posted on Open Science Forum (https://osf.io/69f3x/).

1. Study history

The design of the current study was motivated by the hypothesis that ostracism by other women would lead to hormonal changes associated with reduced fecundity, with the largest changes experienced by women lacking social support. The initial design was first proposed in a funded National Science Foundation graduate fellowship application. The first author (TD) predicted that experimentally-manipulated social exclusion, compared to social inclusion, would decrease women's hormonal markers of fecundity, and that decreases in hormonal markers would be most pronounced during the mid-to-late follicular phase. To partially fund the proposed study, TD, AJT, and MH wrote a funded grant proposal to the University of California Intercampus Consortium on Health Psychology prior to participant recruitment and data collection, detailing plans to examine the effects of social exclusion, moderated by baseline social support and cycle phase status.[1]

In the initial version of the grant proposal, we proposed a 2 (social exclusion vs. inclusion) x 2 (no friend support vs. friend support) full-factorial experimental design (with the latter condition consisting of bringing a friend into the lab), with sample of 144 women; we additionally proposed to test a social exclusion/inclusion condition x background social support interaction. To meet the constraints of the limited budget offered by the seed grant, in the submitted version of the grant proposal, we reduced the sample size in the budget justification and proposed to examine the effects of social exclusion in the presence versus absence of friend support, and to test moderation by friendship quality and background social support. Copies of both versions of the grant proposals, as well as the NSF graduate fellowship research proposal, are available on OSF.

[1] Certain components of study design described in the fellowship or grant proposal were not carried out in this particular study. One piece included a longitudinal component examining the effects of social support and social stress, as a separate study. Another component was a separate experimental condition, of bringing a friend into the lab, that was not conducted in the current study. The prediction of moderation by cycle phase, with the most pronounced changes occurring during the mid-late follicular phase, was described in the NSF graduate proposal and planned extensions section of the Consortium on Health Psychology seed grant. By securing funding additional to the seed grant, we were able to conduct a larger study and test this moderation hypothesis, using baseline hormones as proxies for cycle phase.

During the post-funding, initial study planning process, we decided to only experimentally manipulate social exclusion versus social inclusion, with lab sessions taking place during women's mid-to-late follicular phase. We decided against randomly assigning women to bring a friend into the lab. As initially proposed, we planned to measure background levels of social support and test its interaction with experimental condition. We planned to assay saliva samples for estradiol, progesterone, and cortisol, to examine changes in these hormones. Prior to data collection, the predictions were as follows:

Hormonal changes associated with reduced fecundity include decreases in estradiol concentrations, particularly during the mid-to-late follicular phase. Therefore, women who experience social exclusion will exhibit a decrease in estradiol from baseline. This decrease will be most pronounced when participants are in their mid-to-late follicular phase. Following social exclusion compared to social inclusion, women with greater social connectedness and higher quality social relationships will experience an attenuated decline in estradiol, whereas women lacking social support will show the largest reductions in estradiol. These effects will be mediated by increases in cortisol levels following the experimental manipulation.

Revised study design and analysis plan

Originally, we intended to schedule women to participate specifically during the mid-to-late follicular phase because of our prediction that hormonal changes would be most pronounced during this time. However, due to logistical challenges of scheduling multiple women to simultaneously participate in the group task during this phase, we opted to assess women throughout the cycle and control for cycle phase. Thus, while cycle phase was originally predicted to moderate our hypothesized effects, we had to modify the analysis plan to test for it explicitly. The revised analysis plan uses baseline hormones as an indicator of cycle phase status and examines their interactions with the manipulation and women's background levels of social support.

While estradiol is the critical indicator of fecundity in the late follicular phase, further literature review suggested that progesterone is a plausible mechanism by which fecundity might be affected by social stressors due to actions by the adrenal glands. Therefore, we revised our analysis plan to test whether hormonal changes reflecting reduced fecundity include a decreased estradiol-to-progesterone ratio and increased progesterone levels. Because progesterone changes can be correlated with cortisol release, we decided to examine potential mediation by cortisol.

These revisions in analysis plan were adopted after collection of participant data and completion of 62% of hormone assays, but prior to completion of the final sample of hormone assays. The limitations of our analyses, compared to predictions and pre-defined analytic decisions, neither of which were preregistered, could include researcher degrees of freedom that could potentially increase the probability of false positives. To explore and address this limitation, we conducted robustness analyses exercising many alternative analytic specifications (e.g., inclusion criteria, transformations, control variables); see Sections 4-9 of this supplement. From these alternative specifications, analyses of changes in estradiol, progesterone, estradiol/progesterone ratio, and cortisol yielded 82 out of 83 models with estimates and significance levels similar in magnitude as presented in the main text of the current article. We fully acknowledge, however, that additional research is needed to replicate these results.

2. Saliva sample inclusion criteria

There were 35 participants who were not able to provide the necessary volume of saliva at either baseline or 15 minutes post-manipulation. If a participant did not provide a sufficient volume of saliva at either time point, we did not assay their other sample. Because of the timeline of the experiment, participants only had about 8 minutes to provide each saliva sample, which may have not been enough time for some. Participants were instructed to avoid eating or drinking at least one hour prior to their lab session, which could have potentially hindered saliva production. We also did not allow participants to chew gum (to prevent interference with assay results) or drink water ad libitum during their session (to prevent dilution). While most participants provided more than the minimum volume of saliva necessary for the assays, this volume includes a mucus component that must be separated out by centrifugation—this can be substantial for some participants. For some samples, it was not possible to separate out the necessary volume of *clear* saliva for the assays.

In addition, because we were faced with budgetary constraints, we selected only samples that were clear, white or off-white, or slightly yellow or off-colored to assay. In past studies, some colored samples yielded abnormal pH and outlier results. Thus, to avoid possible contamination or interference with assay results, we excluded 21 samples that were tinged red or more than slightly off-colored. The exclusion of samples was done blind to results of the study.

3. Discriminant analysis results on manipulation check items

Manipulation check items (7-point Likert scale; 1 - "strongly disagree" to 7 - "strongly agree"):

1. I feel accepted by the other participants.
2. I feel as though I have made a 'connection' or bonded with one or more of the participants.
3. I feel like an outsider.
4. The group decision made me feel good about myself.
5. The group decision hurt my feelings.
6. I feel good about myself.
7. I feel somewhat inadequate.
8. I feel that the other participants failed to perceive me as a worthy and likeable person.

Items likely possess differential validity in the extent to which responses accurately reflect belief in the manipulation. For instance, some items show a high frequency of endorsements of "disagree" or "strongly disagree" across experimental conditions; other items exhibit little overlap in scores between the two groups. To derive a manipulation "belief" score, disattenuating for differential validity assumed from between-group relative to within-group variance in item scores, discriminant analyses were performed. Manipulation check items were entered as independent variables in a discriminant function, with item weights estimated to maximize differences between groups in the experimental condition dependent variable.

With discriminant analysis, items that better differentiate the experimental conditions receive larger weights than items that weakly discriminate between conditions (see Hair et al., 2010). By definition, discriminant scores possess greater discriminant validity than summed composite scores[2]

[2] Regression estimates and significance levels were very similar when using summed composite manipulation check scores for selection (see SOM, tables S5d.1-S5e.4). However, excluding participants who scored 1 SD above their respective group means left 72 participants in the social exclusion condition and only 64 participants in the social inclusion condition. It would be expected that fewer socially included women disbelieve the manipulation than socially excluded women, rather than vice versa. Hence, discriminant scores appear to give more valid estimates for selection than summed composite scores.

of equally-weighted yet differentially valid items, outperforming summed scores in predicting group membership (in this study, discriminating between participants who belonged [and *believed* they belonged] in the socially excluded or socially included groups, versus skeptics who did not clearly belong in either group).

Based on results from the discriminant analysis (see below), participants with manipulation belief scores falling 1 standard deviation below their respective group means were excluded from analyses. A total of 70 participants (80%) from the social exclusion condition and 68 (84%) from the social inclusion condition remained following removal of those whose scores did not reflect adequate belief in the manipulation. Robustness analyses on the full sample, as well as using different cut-off manipulation check values and summed composite scores for selection, yield similar estimates and significance levels. See SOM, sections 4-5.

Methods

Discriminant analysis was performed on SPSS v. 25. Manipulation check items were entered as independent variables in a discriminant function, with item weights estimated to maximize differences between groups in the experimental condition dependent variable. Discriminant scores for each participant were saved. Four participants each had one missing response out of the 8 manipulation check items. To generate discriminant scores for these four participants so as to not exclude their data from regression analyses, missing values were replaced with the mean for the respective independent variable during the classification phase only.

Discriminant analysis results

Wilks' lambda and F statistics from univariate ANOVA tests demonstrate that group means for all manipulation check items significantly differ (p's $< .0001$), with items specifically referencing the "group decision" or acceptance/being liked by other participants showing the largest differences.

Overall fit of the discriminant function is also statistically significant (Wilks lambda = .203, χ^2 (8) = 253.40, $p < .0001$).

Items with the largest discriminant weights include, "The group decision hurt my feelings" and "The group decision made me feel good about myself," followed by "I feel good about myself" and "I feel that the other participants failed to perceive me as a worthy and likeable person." Lower weights on some items with larger structure correlations likely reflect effects of multicollinearity. For example, "I feel accepted by the other participants" has a discriminant loading of -.47 but a standardized discriminant weight of only -.049, thus adding relatively little explanatory power over and above the effects of other variables.

Group centroids for discriminant *Z*-scores are clearly separated (social inclusion: -2.05; social exclusion: 1.89). Group membership prediction accuracy is high; prediction based on the cutting score (critical *Z* value = -.002) correctly classifies members of the social inclusion group on 100% of cases and members of the social exclusion group on 91% of cases (8 cases were misclassified).

Selection based on discriminant scores

Participants with discriminant scores falling 1 standard deviation below their respective group means were excluded from regression analyses. A total of 70 participants (80%) from the social exclusion condition and 68 (84%) from the social inclusion condition remained.

Group Statistics

Condition		Mean	Std. Deviation	Valid N (listwise) Unweighted	Valid N (listwise) Weighted
Inclusion	I feel accepted by the other participants.	6.15	.662	79	79.000

	I feel as though I have made a "connection" or bonded with one or more of the participants.	5.28	1.085	79	79.000
	I feel like an outsider.	2.04	1.006	79	79.000
	The group decision hurt my feelings.	1.38	.626	79	79.000
	The group decision made me feel good about myself.	5.24	1.398	79	79.000
	I feel good about myself.	5.63	1.028	79	79.000
	I feel that the other participants failed to perceive me as a worthy and likeable person.	2.03	1.396	79	79.000
	I feel somewhat inadequate.	2.11	1.177	79	79.000
Exclusion	I feel accepted by the other participants.	3.53	1.839	86	86.000
	I feel as though I have made a "connection" or bonded with one or more of the participants.	3.27	1.752	86	86.000
	I feel like an outsider.	4.23	1.870	86	86.000
	The group decision hurt my feelings.	5.19	1.598	86	86.000
	The group decision made me feel good about myself.	1.92	1.031	86	86.000
	I feel good about myself.	4.08	1.632	86	86.000
	I feel that the other participants failed to perceive me as a worthy and likeable person.	5.33	1.522	86	86.000

	I feel somewhat inadequate.	4.09	1.746	86	86.000
Total	I feel accepted by the other participants.	4.79	1.918	165	165.000
	I feel as though I have made a "connection" or bonded with one or more of the participants.	4.23	1.779	165	165.000
	I feel like an outsider.	3.18	1.872	165	165.000
	The group decision hurt my feelings.	3.36	2.269	165	165.000
	The group decision made me feel good about myself.	3.51	2.062	165	165.000
	I feel good about myself.	4.82	1.577	165	165.000
	I feel that the other participants failed to perceive me as a worthy and likeable person.	3.75	2.205	165	165.000
	I feel somewhat inadequate.	3.15	1.795	165	165.000

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
I feel accepted by the other participants.	.533	142.943	1	163	.000
I feel as though I have made a "connection" or bonded with one or more of the participants.	.679	76.955	1	163	.000
I feel like an outsider.	.655	85.916	1	163	.000

The group decision hurt my feelings.	.293	392.672	1	163	.000
The group decision made me feel good about myself.	.348	304.962	1	163	.000
I feel good about myself.	.757	52.322	1	163	.000
I feel that the other participants failed to perceive me as a worthy and likeable person.	.438	209.560	1	163	.000
I feel somewhat inadequate.	.695	71.586	1	163	.000

Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3.922[a]	100.0	100.0	.893

a. First 1 canonical discriminant functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.203	253.395	8	.000

Standardized Canonical Discriminant Function Coefficients and Structure Matrix

Manipulation Check Item	Discriminant Coefficient	Structure Correlations

I feel accepted by the other participants.	-0.049	-0.473
I feel as though I have made a "connection" or bonded with one or more of the participants.	-0.134	-0.347
I feel like an outsider.	-0.061	0.367
The group decision hurt my feelings.	0.601	0.784
The group decision made me feel good about myself.	-0.592	-0.691
I feel good about myself.	0.332	-0.286
I feel that the other participants failed to perceive me as a worthy and likeable person.	0.301	0.573
I feel somewhat inadequate.	-0.013	0.335

Functions at Group Centroids

	Function
Condition	1
Inclusion	-2.054
Exclusion	1.887

Unstandardized canonical discriminant functions evaluated at group means

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean

Discriminant Scores from Function 1 for Analysis 1	Inclusion	79	-2.0536720	.78558633	.08838537
	Exclusion	86	1.8865126	1.16246504	.12535183

Reference

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2010. Multivariate Data Analysis, 7th ed. Pearson Prentice Hall, Upper Saddle River, NJ.

4. Robustness analyses on full sample of participants

The following regression analyses include the full sample of participants, without exclusion based on responses from manipulation check items.

Tables S4a-h display linear regression estimates for residualized change models. Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Baseline hormone values are mean-centered. Social support scores are standardized. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

3-way (Condition x Baseline Hormones x Social Support) interactions of interest are **bolded**. *Condition × Social Support interaction* at average baseline hormone values is *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Table S4a: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.47	0.03	-163.73	**<.0001**
Baseline ln(E/P)	0.81	0.05	16.20	**<.0001**
Condition	-0.04	0.03	-1.29	0.198
Social Support	-0.04	0.03	-1.44	0.151
Ln Cortisol Residual	-0.42	0.08	-5.22	**<.0001**
Baseline ln(E/P) * Condition	-0.03	0.05	-0.64	0.527
Baseline ln(E/P) * Social Support	-0.06	0.05	-1.13	0.258
*Condition * Social Support*	0.07	0.03	2.43	**0.016**
Baseline ln(E/P) * Condition * Social Support	0.16	0.05	3.15	**0.002**

Table S4b: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-161.69	**<.0001**
Baseline ln(E)	0.62	0.12	5.23	**<.0001**
Condition	-0.03	0.03	-1.24	0.217
Social Support	-0.04	0.03	-1.54	0.126
Baseline ln(P)	-0.78	0.05	-14.65	**<.0001**
Ln Cortisol Residual	-0.42	0.08	-5.10	**<.0001**
Baseline ln(E) * Condition	-0.08	0.12	-0.66	0.512
Baseline ln(E) * Social Support	-0.003	0.12	-0.02	0.982
*Condition * Social Support*	0.06	0.03	2.19	**0.030**
Baseline ln(P) * Condition	0.05	0.05	0.87	0.384
Baseline ln(P) * Social Support	0.04	0.05	0.69	0.489
Baseline ln(E) * Condition * Social Support	0.30	0.12	2.45	**0.016**
Baseline ln(P) * Condition * Social Support	-0.17	0.05	-3.24	**0.001**

Table S4c: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.02	23.91	**<.0001**
Baseline ln(E/P)	-0.17	0.04	-4.06	**<.0001**
Condition	0.01	0.02	0.28	0.781
Social Support	-0.06	0.02	-2.45	**0.016**
Ln Cortisol Residual	0.20	0.07	3.01	**0.003**
Baseline ln(E/P) * Condition	-0.01	0.04	-0.35	0.724
Baseline ln(E/P) * Social Support	-0.04	0.04	-0.91	0.365
*Condition * Social Support*	-0.03	0.02	-1.19	0.237
Baseline ln(E/P) * Condition * Social Support	-0.01	0.04	-0.24	0.812

Table S4d: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.02	34.39	**<.0001**
Baseline ln(E)	0.63	0.07	9.20	**<.0001**
Condition	0.02	0.02	0.94	0.347
Social Support	-0.04	0.02	-2.64	**0.009**
Baseline ln(P)	0.04	0.03	1.24	0.219
Ln Cortisol Residual	0.12	0.05	2.64	**0.009**
Baseline ln(E) * Condition	-0.01	0.07	-0.11	0.914
Baseline ln(E) * Social Support	-0.17	0.07	-2.43	**0.016**
*Condition * Social Support*	-0.005	0.02	-0.27	0.786
Baseline ln(P) * Condition	-0.01	0.03	-0.45	0.655
Baseline ln(P) * Social Support	0.05	0.03	1.68	*0.094*
Baseline ln(E) * Condition * Social Support	0.06	0.07	0.81	0.422
Baseline ln(P) * Condition * Social Support	-0.01	0.03	-0.41	0.679

Table S4e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	137.50	**<.0001**
Baseline ln(E/P)	-0.98	0.07	-14.61	**<.0001**
Condition	0.04	0.04	1.12	0.265
Social Support	-0.02	0.04	-0.49	0.624
Ln Cortisol Residual	0.62	0.11	5.77	**<.0001**
Baseline ln(E/P) * Condition	0.02	0.07	0.25	0.802
Baseline ln(E/P) * Social Support	0.02	0.07	0.28	0.778
*Condition * Social Support*	-0.10	0.04	-2.54	**0.012**
Baseline ln(E/P) * Condition * Social Support	-0.17	0.07	-2.50	**0.013**

Table S4f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.03	162.47	**<.0001**
Baseline ln(E)	0.01	0.13	0.05	0.961
Condition	0.05	0.03	1.55	0.123
Social Support	-0.001	0.03	-0.04	0.965
Baseline ln(P)	0.82	0.06	13.70	**<.0001**
Ln Cortisol Residual	0.54	0.09	5.89	**<.0001**
Baseline ln(E) * Condition	0.07	0.13	0.54	0.589
Baseline ln(E) * Social Support	-0.16	0.13	-1.21	0.230
*Condition * Social Support*	-0.07	0.03	-2.05	**0.042**
Baseline ln(P) * Condition	-0.06	0.06	-1.01	0.313
Baseline ln(P) * Social Support	0.01	0.06	0.23	0.819
Baseline ln(E) * Condition * Social Support	-0.24	0.14	-1.79	*0.076*
Baseline ln(P) * Condition * Social Support	0.16	0.06	2.69	**0.008**

Table S4g: Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-value	*p*-value
(Intercept)	8.77	0.03	311.66	**<.0001**
Baseline ln(Cortisol)	0.71	0.06	11.58	**<.0001**
Baseline ln(E/P)	0.05	0.05	0.96	0.340
Condition	0.03	0.03	1.14	0.257
Social Support	-0.03	0.03	-1.05	0.294
Baseline ln(E/P) * Condition	0.004	0.05	0.08	0.933
Baseline ln(E/P) * Social Support	0.03	0.05	0.48	0.629
*Condition * Social Support*	0.01	0.03	0.42	0.672
Baseline ln(E/P) * Condition * Social Support	0.02	0.05	0.39	0.697

Table S4h: Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-value	*p*-value
(Intercept)	8.78	0.03	308.36	**<.0001**
Baseline ln(Cortisol)	0.69	0.06	11.03	**<.0001**
Baseline ln(E)	0.22	0.12	1.78	*0.077*
Condition	0.04	0.03	1.30	0.195
Social Support	-0.03	0.03	-0.87	0.386
Baseline ln(P)	-0.08	0.06	-1.37	0.172
Baseline ln(E) * Condition	-0.01	0.12	-0.06	0.953
Baseline ln(E) * Social Support	0.08	0.12	0.67	0.501
*Condition * Social Support*	0.02	0.03	0.63	0.529
Baseline ln(P) * Condition	-0.01	0.06	-0.15	0.885
Baseline ln(P) * Social Support	-0.05	0.06	-0.86	0.393
Baseline ln(E) * Condition * Social Support	0.20	0.12	1.60	0.112
Baseline ln(P) * Condition * Social Support	-0.05	0.06	-0.95	0.343

5. Robustness analyses using different manipulation check cut-off criteria

Tables S5a-h display linear regression estimates for residualized change models. Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Baseline hormone values are mean-centered. Social support scores are standardized. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

3-way (Condition x Baseline Hormones x Social Support) interactions of interest are **bolded**. *Condition x Social Support interaction* at average baseline hormone values is *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Tables S5a.1 – S5a.8

For the following set of analyses, socially excluded participants who "disagreed" or "strongly disagreed" with any of the five manipulation check items pertaining to other participants in the experiment were excluded. Items included, "I feel accepted by the other participants" (reverse-coded), "I feel as though I have made a 'connection' or bonded with one or more of the participants" (reverse-coded), "The group decision made me feel good about myself" (reverse-coded), "The group decision hurt my feelings," and "I feel that the other participants failed to perceive me as a worthy and likeable person." A total of 59 participants (67%) in the social exclusion condition remained following exclusion of those who did not meet the cut-off criteria.

Three items were not clearly related to the experiment and had a relatively large number of endorsements of "disagree" or "strongly disagree" (24-25% of the social exclusion group for each item). Items included "I feel good about myself" (reverse-coded), "I feel like an outsider," and "I feel somewhat inadequate." These items likely did not adequately reflect belief in the manipulation and were not used as criteria for exclusion. (Exclusion of participants based on these items as well reduces social exclusion group sample size by over 53%.)

Table S5a.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-150.29	**<.0001**
Baseline ln(E/P)	0.84	0.05	16.10	**<.0001**
Condition	-0.03	0.03	-0.84	0.404
Social Support	-0.04	0.03	-1.13	0.259
Ln Cortisol Residual	-0.36	0.09	-4.02	**0.0001**
Baseline ln(E/P) * Condition	0.001	0.05	0.03	0.977
Baseline ln(E/P) * Social Support	0.01	0.05	0.11	0.911
*Condition * Social Support*	0.07	0.03	2.28	**0.025**
Baseline ln(E/P) * Condition * Social Support	0.22	0.05	4.13	**0.00007**

Table S5a.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-146.97	**<.0001**
Baseline ln(E)	0.66	0.13	5.13	**<.0001**
Condition	-0.02	0.03	-0.76	0.448
Social Support	-0.04	0.03	-1.23	0.220
Baseline ln(P)	-0.82	0.05	-14.88	**<.0001**
Ln Cortisol Residual	-0.36	0.09	-3.93	**0.0001**
Baseline ln(E) * Condition	-0.03	0.13	-0.27	0.787
Baseline ln(E) * Social Support	0.03	0.13	0.21	0.837
*Condition * Social Support*	0.06	0.03	2.02	**0.046**
Baseline ln(P) * Condition	0.01	0.05	0.11	0.911
Baseline ln(P) * Social Support	-0.01	0.06	-0.26	0.794
Baseline ln(E) * Condition * Social Support	0.33	0.13	2.58	**0.011**
Baseline ln(P) * Condition * Social Support	-0.23	0.06	-4.00	**0.0001**

Table S5a.3: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.56	0.03	21.44	**<.0001**
Baseline ln(E/P)	-0.13	0.05	-2.88	**0.005**
Condition	0.01	0.03	0.49	0.625
Social Support	-0.07	0.03	-2.61	**0.010**
Ln Cortisol Residual	0.17	0.08	2.12	**0.036**
Baseline ln(E/P) * Condition	0.01	0.05	0.24	0.814
Baseline ln(E/P) * Social Support	-0.05	0.05	-1.10	0.274
*Condition * Social Support*	-0.04	0.03	-1.28	0.205
Baseline ln(E/P) * Condition * Social Support	-0.02	0.05	-0.37	0.709

Table S5a.4: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.02	29.86	**<.0001**
Baseline ln(E)	0.62	0.08	7.93	**<.0001**
Condition	0.02	0.02	1.09	0.279
Social Support	-0.05	0.02	-2.75	**0.007**
Baseline ln(P)	0.03	0.03	0.92	0.361
Ln Cortisol Residual	0.10	0.06	1.72	0.089
Baseline ln(E) * Condition	-0.02	0.08	-0.20	0.846
Baseline ln(E) * Social Support	-0.16	0.08	-2.07	**0.041**
*Condition * Social Support*	-0.01	0.02	-0.60	0.550
Baseline ln(P) * Condition	-0.02	0.03	-0.53	0.596
Baseline ln(P) * Social Support	0.05	0.03	1.59	0.116
Baseline ln(E) * Condition * Social Support	0.06	0.08	0.82	0.415
Baseline ln(P) * Condition * Social Support	-0.01	0.03	-0.33	0.741

Table S5a.5: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	122.54	**<.0001**
Baseline ln(E/P)	-0.97	0.07	-13.45	**<.0001**
Condition	0.04	0.04	0.91	0.367
Social Support	-0.04	0.04	-0.87	0.387
Ln Cortisol Residual	0.53	0.12	4.24	**<.0001**
Baseline ln(E/P) * Condition	0.01	0.07	0.13	0.898
Baseline ln(E/P) * Social Support	-0.06	0.07	-0.78	0.439
*Condition * Social Support*	-0.11	0.04	-2.45	**0.016**
Baseline ln(E/P) * Condition * Social Support	-0.24	0.07	-3.22	**0.002**

Table S5a.6: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	142.67	**<.0001**
Baseline ln(E)	-0.04	0.15	-0.26	0.793
Condition	0.04	0.04	1.20	0.235
Social Support	-0.02	0.04	-0.43	0.667
Baseline ln(P)	0.85	0.06	13.29	**<.0001**
Ln Cortisol Residual	0.45	0.11	4.27	**<.0001**
Baseline ln(E) * Condition	0.02	0.15	0.14	0.889
Baseline ln(E) * Social Support	-0.18	0.15	-1.25	0.215
*Condition * Social Support*	-0.07	0.04	-2.02	**0.046**
Baseline ln(P) * Condition	-0.02	0.06	-0.38	0.707
Baseline ln(P) * Social Support	0.07	0.07	1.05	0.298
Baseline ln(E) * Condition * Social Support	-0.27	0.15	-1.80	*0.074*
Baseline ln(P) * Condition * Social Support	0.21	0.07	3.28	**0.001**

Table S5a.7: Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-value	*p*-value
(Intercept)	8.78	0.03	284.06	**<.0001**
Baseline ln(Cortisol)	0.72	0.06	11.20	**<.0001**
Baseline ln(E/P)	0.04	0.06	0.70	0.486
Condition	0.04	0.03	1.19	0.235
Social Support	-0.05	0.03	-1.44	0.154
Baseline ln(E/P) * Condition	-0.02	0.05	-0.32	0.752
Baseline ln(E/P) * Social Support	0.03	0.06	0.59	0.553
*Condition * Social Support*	-0.0004	0.03	-0.01	0.991
Baseline ln(E/P) * Condition * Social Support	0.03	0.06	0.58	0.563

Table S5a.8: Results of linear regression analyses on post-manipulation log-transformed cortisol, using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(Cortisol)				
	b	SE	*t*-value	*p*-value
(Intercept)	8.79	0.03	278.87	**<.0001**
Baseline ln(Cortisol)	0.70	0.07	10.72	**<.0001**
Baseline ln(E)	0.17	0.13	1.25	0.212
Condition	0.04	0.03	1.40	0.166
Social Support	-0.04	0.03	-1.23	0.221
Baseline ln(P)	-0.06	0.06	-0.98	0.327
Baseline ln(E) * Condition	-0.05	0.13	-0.35	0.726
Baseline ln(E) * Social Support	0.11	0.13	0.84	0.400
*Condition * Social Support*	0.01	0.03	0.16	0.874
Baseline ln(P) * Condition	0.02	0.06	0.29	0.770
Baseline ln(P) * Social Support	-0.05	0.06	-0.93	0.355
Baseline ln(E) * Condition * Social Support	0.22	0.13	1.64	0.103
Baseline ln(P) * Condition * Social Support	-0.06	0.06	-1.05	0.296

For the remaining robustness analyses based on different selection criteria for "passing" the manipulation check, Tables S5b-e report only results for dependent variables, post-manipulation ln(E/P) and ln(P). No significant effects by condition emerged for post-manipulation ln(E) and ln(Cortisol) in any set of analyses. For results on post-manipulation ln(E) and ln(Cortisol), see Open Science Forum (https://osf.io/psqb9/).

Tables S5b.1 – S5b.4

To employ a more stringent cut-off criteria, we excluded participants from the social exclusion condition who "disagreed" or "strongly disagreed" with the statement, "I feel like an outsider," or with any of the five manipulation check items pertaining to other participants ("I feel accepted by the other participants" [reverse-coded], "I feel as though I have made a 'connection' or bonded with one or more of the participants" [reverse-coded], "The group decision made me feel good about myself" [reverse-coded], "The group decision hurt my feelings," and "I feel that the other participants failed to perceive me as a worthy and likeable person"). A total of 51 participants (58%) in the social exclusion condition remained following exclusion of those who did not meet the cut-off criteria.

Table S5b.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-142.42	**<.0001**
Baseline ln(E/P)	0.83	0.06	14.86	**<.0001**
Condition	-0.02	0.03	-0.52	0.604
Social Support	-0.04	0.03	-1.12	0.267
Ln Cortisol Residual	-0.38	0.09	-4.08	**<.0001**
Baseline ln(E/P) * Condition	-0.01	0.06	-0.13	0.895
Baseline ln(E/P) * Social Support	-0.01	0.05	-0.14	0.890
*Condition * Social Support*	0.07	0.03	2.08	**0.040**
Baseline ln(E/P) * Condition * Social Support	0.21	0.05	3.90	**0.0002**

Table S5b.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.44	0.03	-138.94	**<.0001**
Baseline ln(E)	0.65	0.14	4.76	**<.0001**
Condition	-0.01	0.03	-0.40	0.688
Social Support	-0.04	0.03	-1.23	0.223
Baseline ln(P)	-0.81	0.06	-13.58	**<.0001**
Ln Cortisol Residual	-0.38	0.10	-3.99	**0.0001**
Baseline ln(E) * Condition	-0.05	0.14	-0.37	0.715
Baseline ln(E) * Social Support	0.01	0.13	0.10	0.917
*Condition * Social Support*	0.06	0.03	1.83	*0.070*
Baseline ln(P) * Condition	0.02	0.06	0.26	0.798
Baseline ln(P) * Social Support	0.0001	0.06	0.001	0.999
Baseline ln(E) * Condition * Social Support	0.31	0.13	2.42	**0.017**
Baseline ln(P) * Condition * Social Support	-0.22	0.06	-3.72	**0.0003**

Table S5b.3: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	117.36	**<.0001**
Baseline ln(E/P)	-0.96	0.08	-12.64	**<.0001**
Condition	0.03	0.04	0.80	0.426
Social Support	-0.03	0.04	-0.75	0.453
Ln Cortisol Residual	0.54	0.13	4.21	**<.0001**
Baseline ln(E/P) * Condition	0.01	0.08	0.15	0.879
Baseline ln(E/P) * Social Support	-0.05	0.07	-0.64	0.522
*Condition * Social Support*	-0.09	0.04	-2.17	**0.032**
Baseline ln(E/P) * Condition * Social Support	-0.23	0.07	-3.15	**0.002**

Table S5b.4: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	4.99	0.04	136.45	**<.0001**
Baseline ln(E)	-0.05	0.16	-0.33	0.740
Condition	0.03	0.04	0.91	0.368
Social Support	-0.01	0.04	-0.34	0.734
Baseline ln(P)	0.84	0.07	12.35	**<.0001**
Ln Cortisol Residual	0.46	0.11	4.23	**<.0001**
Baseline ln(E) * Condition	0.01	0.16	0.08	0.934
Baseline ln(E) * Social Support	-0.17	0.15	-1.17	0.243
*Condition * Social Support*	-0.07	0.04	-1.79	*0.077*
Baseline ln(P) * Condition	-0.03	0.07	-0.41	0.686
Baseline ln(P) * Social Support	0.05	0.07	0.81	0.417
Baseline ln(E) * Condition * Social Support	-0.26	0.15	-1.72	*0.088*
Baseline ln(P) * Condition * Social Support	0.21	0.07	3.08	**0.003**

Tables S5c.1 – S5c.4

Next, we used a laxer criterion for filtering out women who may not have believed that the negative feedback they received actually came from the other participants. Socially excluded women were removed from analyses if they "disagreed" or "strongly disagreed" with any of the following four statements: "I feel accepted by the other participants" (reverse-coded), "The group decision made me feel good about myself" (reverse-coded), "The group decision hurt my feelings," and "I feel that the other participants failed to perceive me as a worthy and likeable person." (The item, "I feel as though I have made a 'connection' or bonded with one or more of the participants," was omitted for being the only item that did not directly pertain to others' evaluation of the participant.) A total of 65 participants (74%) in the social exclusion condition remained following exclusion of those who did not meet the cut-off criteria.

Table S5c.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-151.22	**<.0001**
Baseline ln(E/P)	0.81	0.05	15.45	**<.0001**
Condition	-0.02	0.03	-0.82	0.412
Social Support	-0.04	0.03	-1.25	0.215
Ln Cortisol Residual	-0.38	0.09	-4.20	**<.0001**
Baseline ln(E/P) * Condition	-0.03	0.05	-0.51	0.614
Baseline ln(E/P) * Social Support	-0.03	0.05	-0.51	0.609
*Condition * Social Support*	0.07	0.03	2.23	**0.027**
Baseline ln(E/P) * Condition * Social Support	0.19	0.05	3.49	**0.0007**

Table S5c.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-148.32	**<.0001**
Baseline ln(E)	0.70	0.13	5.43	**<.0001**
Condition	-0.02	0.03	-0.65	0.517
Social Support	-0.04	0.03	-1.22	0.225
Baseline ln(P)	-0.80	0.06	-14.43	**<.0001**
Ln Cortisol Residual	-0.38	0.09	-4.21	**<.0001**
Baseline ln(E) * Condition	-0.001	0.13	-0.01	0.994
Baseline ln(E) * Social Support	0.06	0.13	0.44	0.662
*Condition * Social Support*	0.07	0.03	2.13	**0.035**
Baseline ln(P) * Condition	0.02	0.06	0.39	0.696
Baseline ln(P) * Social Support	0.003	0.06	0.06	0.954
Baseline ln(E) * Condition * Social Support	0.36	0.13	2.82	**0.006**
Baseline ln(P) * Condition * Social Support	-0.21	0.06	-3.64	**0.0004**

Table S5c.3: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.03	0.04	125.94	**<.0001**
Baseline ln(E/P)	-0.95	0.07	-13.28	**<.0001**
Condition	0.05	0.04	1.16	0.249
Social Support	-0.03	0.04	-0.64	0.522
Ln Cortisol Residual	0.56	0.12	4.61	**<.0001**
Baseline ln(E/P) * Condition	0.03	0.07	0.47	0.640
Baseline ln(E/P) * Social Support	-0.03	0.07	-0.41	0.682
*Condition * Social Support*	-0.10	0.04	-2.31	**0.022**
Baseline ln(E/P) * Condition * Social Support	-0.21	0.07	-2.89	**0.004**

Table S5c.4: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.03	144.23	**<.0001**
Baseline ln(E)	-0.06	0.15	-0.42	0.677
Condition	0.04	0.04	1.25	0.213
Social Support	-0.01	0.04	-0.32	0.750
Baseline ln(P)	0.83	0.06	12.84	**<.0001**
Ln Cortisol Residual	0.49	0.11	4.66	**<.0001**
Baseline ln(E) * Condition	0.006	0.15	0.04	0.970
Baseline ln(E) * Social Support	-0.20	0.15	-1.39	0.167
*Condition * Social Support*	-0.07	0.04	-1.99	**0.049**
Baseline ln(P) * Condition	-0.04	0.06	-0.69	0.491
Baseline ln(P) * Social Support	0.05	0.07	0.72	0.476
Baseline ln(E) * Condition * Social Support	-0.29	0.15	-1.97	*0.051*
Baseline ln(P) * Condition * Social Support	0.19	0.07	2.93	**0.004**

Tables S5d.1 – S5d.4

Manipulation check scores were averaged together for each participant. Socially excluded women whose average score fell one standard deviation below the group mean were omitted from the following regression analyses. A total of 72 participants (82%) in the social exclusion condition remained following exclusion of those who did not meet the cut-off criteria.

Table S5d.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-158.44	**<.0001**
Baseline ln(E/P)	0.83	0.05	16.63	**<.0001**
Condition	-0.03	0.03	-0.98	0.328
Social Support	-0.04	0.03	-1.21	0.229
Ln Cortisol Residual	-0.38	0.08	-4.59	**<.0001**
Baseline ln(E/P) * Condition	-0.01	0.05	-0.20	0.839
Baseline ln(E/P) * Social Support	-0.04	0.05	-0.76	0.446
*Condition * Social Support*	0.07	0.03	2.54	**0.012**
Baseline ln(E/P) * Condition * Social Support	0.18	0.05	3.52	**0.0006**

Table S5d.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-156.07	**<.0001**
Baseline ln(E)	0.64	0.12	5.13	**<.0001**
Condition	-0.03	0.03	-0.92	0.360
Social Support	-0.04	0.03	-1.20	0.232
Baseline ln(P)	-0.81	0.05	-15.21	**<.0001**
Ln Cortisol Residual	-0.37	0.08	-4.38	**<.0001**
Baseline ln(E) * Condition	-0.05	0.12	-0.40	0.692
Baseline ln(E) * Social Support	0.05	0.12	0.38	0.705
*Condition * Social Support*	0.07	0.03	2.39	**0.019**
Baseline ln(P) * Condition	0.02	0.05	0.38	0.704
Baseline ln(P) * Social Support	0.02	0.05	0.29	0.776
Baseline ln(E) * Condition * Social Support	0.34	0.12	2.79	**0.006**
Baseline ln(P) * Condition * Social Support	-0.20	0.05	-3.69	**0.0003**

Table S5d.3: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	127.74	**<.0001**
Baseline ln(E/P)	-0.98	0.07	-14.06	**<.0001**
Condition	0.03	0.04	0.86	0.390
Social Support	-0.02	0.04	-0.53	0.599
Ln Cortisol Residual	0.60	0.12	5.19	**<.0001**
Baseline ln(E/P) * Condition	0.01	0.07	0.21	0.834
Baseline ln(E/P) * Social Support	0.004	0.07	0.06	0.951
*Condition * Social Support*	-0.10	0.04	-2.44	**0.016**
Baseline ln(E/P) * Condition * Social Support	-0.18	0.07	-2.61	**0.010**

Table S5d.4: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.03	149.64	**<.0001**
Baseline ln(E)	0.01	0.15	0.04	0.969
Condition	0.05	0.03	1.39	0.166
Social Support	-0.01	0.03	-0.26	0.795
Baseline ln(P)	0.84	0.06	13.43	**<.0001**
Ln Cortisol Residual	0.48	0.10	4.86	**<.0001**
Baseline ln(E) * Condition	0.06	0.14	0.41	0.686
Baseline ln(E) * Social Support	-0.21	0.14	-1.44	0.152
*Condition * Social Support*	-0.07	0.03	-2.06	**0.041**
Baseline ln(P) * Condition	-0.04	0.06	-0.65	0.518
Baseline ln(P) * Social Support	0.03	0.06	0.51	0.611
Baseline ln(E) * Condition * Social Support	-0.28	0.14	-1.95	*0.054*
Baseline ln(P) * Condition * Social Support	0.18	0.06	2.88	**0.005**

Tables S5e.1 – S5e.4

Manipulation check scores were averaged together for each participant. Socially excluded and socially included women whose average score fell one standard deviation below their respective group means were omitted from the following regression analyses. A total of 72 participants (82%) in the social exclusion condition and 64 participants (79%) in the social inclusion condition remained following removal of those who did not meet the cut-off criteria.

Table S5e.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-147.08	**<.0001**
Baseline ln(E/P)	0.83	0.06	14.87	**<.0001**
Condition	-0.03	0.03	-0.88	0.379
Social Support	-0.06	0.03	-1.77	*0.080*
Ln Cortisol Residual	-0.42	0.09	-4.84	**<.0001**
Baseline ln(E/P) * Condition	-0.004	0.06	-0.08	0.937
Baseline ln(E/P) * Social Support	-0.06	0.06	-1.02	0.310
*Condition * Social Support*	0.09	0.03	2.97	**0.004**
Baseline ln(E/P) * Condition * Social Support	0.20	0.06	3.47	**0.0007**

Table S5e.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-145.54	**<.0001**
Baseline ln(E)	0.61	0.13	4.71	**<.0001**
Condition	-0.03	0.03	-0.84	0.401
Social Support	-0.06	0.03	-1.75	*0.083*
Baseline ln(P)	-0.80	0.06	-13.92	**<.0001**
Ln Cortisol Residual	-0.41	0.09	-4.59	**<.0001**
Baseline ln(E) * Condition	-0.01	0.13	-0.06	0.951
Baseline ln(E) * Social Support	0.03	0.12	0.27	0.787
*Condition * Social Support*	0.09	0.03	2.85	**0.005**
Baseline ln(P) * Condition	0.01	0.06	0.24	0.808
Baseline ln(P) * Social Support	0.03	0.06	0.52	0.607
Baseline ln(E) * Condition * Social Support	0.36	0.12	2.90	**0.004**
Baseline ln(P) * Condition * Social Support	-0.22	0.06	-3.59	**0.0005**

Table S5e.3: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	120.16	**<.0001**
Baseline ln(E/P)	-0.93	0.08	-12.05	**<.0001**
Condition	0.03	0.04	0.63	0.527
Social Support	-0.004	0.04	-0.10	0.924
Ln Cortisol Residual	0.65	0.12	5.39	**<.0001**
Baseline ln(E/P) * Condition	-0.04	0.08	-0.53	0.594
Baseline ln(E/P) * Social Support	-0.013	0.08	-0.17	0.869
*Condition * Social Support*	-0.11	0.04	-2.68	**0.009**
Baseline ln(E/P) * Condition * Social Support	-0.17	0.08	-2.12	**0.036**

Table S5e.4: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	140.99	**<.0001**
Baseline ln(E)	0.03	0.15	0.21	0.834
Condition	0.04	0.04	1.21	0.230
Social Support	0.01	0.04	0.31	0.760
Baseline ln(P)	0.82	0.07	12.18	**<.0001**
Ln Cortisol Residual	0.52	0.10	5.06	**<.0001**
Baseline ln(E) * Condition	0.02	0.15	0.12	0.902
Baseline ln(E) * Social Support	-0.21	0.14	-1.46	0.148
*Condition * Social Support*	-0.09	0.04	-2.50	**0.014**
Baseline ln(P) * Condition	-0.02	0.07	-0.31	0.756
Baseline ln(P) * Social Support	0.02	0.07	0.35	0.725
Baseline ln(E) * Condition * Social Support	-0.29	0.15	-1.96	*0.053*
Baseline ln(P) * Condition * Social Support	0.19	0.07	2.72	**0.007**

Tables S5f.1 – S5f.4

Although participants given false negative feedback for why they were socially excluded are more likely to express suspicion, socially included participants who also did not believe the manipulation may not experience hormonal changes either. For the following set of analyses, socially excluded participants who "disagreed" or "strongly disagreed" and socially included participants who "agreed" or "strongly agreed" with any of the five manipulation check items pertaining to other participants in the experiment were excluded. A total of 59 participants (67%) in the social exclusion condition and 71 participants (88%) in the social inclusion condition remained following exclusion of those who did not meet the selection criteria.

Table S5f.1: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-143.97	**<.0001**
Baseline ln(E/P)	0.84	0.05	15.57	**<.0001**
Condition	-0.02	0.03	-0.76	0.447
Social Support	-0.03	0.03	-1.03	0.306
Ln Cortisol Residual	-0.37	0.09	-3.91	**0.0002**
Baseline ln(E/P) * Condition	0.002	0.05	0.03	0.975
Baseline ln(E/P) * Social Support	0.002	0.06	0.04	0.971
*Condition * Social Support*	0.07	0.03	2.11	**0.037**
Baseline ln(E/P) * Condition * Social Support	0.22	0.06	4.06	**0.00009**

Table S5f.2: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-141.00	**<.0001**
Baseline ln(E)	0.65	0.13	4.81	**<.0001**
Condition	-0.02	0.03	-0.71	0.479
Social Support	-0.04	0.03	-1.13	0.260
Baseline ln(P)	-0.82	0.06	-14.40	**<.0001**
Ln Cortisol Residual	-0.37	0.10	-3.85	**0.0002**
Baseline ln(E) * Condition	-0.02	0.13	-0.14	0.892
Baseline ln(E) * Social Support	0.02	0.13	0.14	0.886
*Condition * Social Support*	0.06	0.03	1.88	*0.064*
Baseline ln(P) * Condition	0.01	0.06	0.10	0.925
Baseline ln(P) * Social Support	-0.01	0.06	-0.22	0.824
Baseline ln(E) * Condition * Social Support	0.34	0.13	2.57	**0.011**
Baseline ln(P) * Condition * Social Support	-0.23	0.06	-3.92	**0.0002**

Table S5f.3: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	117.66	**<.0001**
Baseline ln(E/P)	-0.96	0.07	-13.02	**<.0001**
Condition	0.04	0.04	0.97	0.333
Social Support	-0.04	0.05	-0.94	0.352
Ln Cortisol Residual	0.52	0.13	4.01	**0.0001**
Baseline ln(E/P) * Condition	0.004	0.07	0.05	0.959
Baseline ln(E/P) * Social Support	-0.05	0.08	-0.63	0.533
*Condition * Social Support*	-0.10	0.04	-2.25	**0.027**
Baseline ln(E/P) * Condition * Social Support	-0.25	0.08	-3.25	**0.002**

Table S5f.4: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	136.68	**<.0001**
Baseline ln(E)	-0.02	0.16	-0.12	0.901
Condition	0.05	0.04	1.32	0.190
Social Support	-0.02	0.04	-0.47	0.640
Baseline ln(P)	0.84	0.07	12.82	**<.0001**
Ln Cortisol Residual	0.46	0.11	4.11	**<.0001**
Baseline ln(E) * Condition	0.0003	0.15	0.002	0.999
Baseline ln(E) * Social Support	-0.19	0.15	-1.27	0.207
*Condition * Social Support*	-0.07	0.04	-1.87	*0.065*
Baseline ln(P) * Condition	-0.02	0.07	-0.28	0.784
Baseline ln(P) * Social Support	0.06	0.07	0.96	0.338
Baseline ln(E) * Condition * Social Support	-0.26	0.15	-1.70	*0.092*
Baseline ln(P) * Condition * Social Support	0.22	0.07	3.24	**0.002**

6. Linear regression analyses using raw hormone values

Notes. Hormone measures are *not* log-transformed. All quantitative measures are standardized. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1. Participants with manipulation check discriminant scores falling 1 SD below their respective group means are excluded from analyses.

3-way (Condition x Baseline Hormones x Social Support) interactions of interest are **bolded**. *Condition x Social Support interaction* at average baseline hormone values is *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Table S6a: Results of linear regression analyses on post-manipulation estradiol

DV: Post-manipulation Estradiol				
	b	SE	*t*-value	*p*-value
(Intercept)	-0.03	0.06	-0.62	0.536
Baseline Estradiol	0.71	0.08	8.90	**<.0001**
Condition	0.04	0.06	0.63	0.529
Social Support	-0.17	0.06	-2.85	**0.005**
Baseline Progesterone	-0.001	0.08	-0.02	0.987
Cortisol Residual	0.10	0.06	1.81	*0.073*
Baseline Estradiol * Condition	-0.05	0.08	-0.71	0.477
Baseline Estradiol * Social Support	-0.26	0.08	-3.45	**0.001**
*Condition * Social Support*	-0.04	0.06	-0.69	0.491
Baseline Progesterone * Condition	0.08	0.08	1.12	0.265
Baseline Progesterone * Social Support	0.17	0.08	2.09	**0.039**
Baseline Estradiol * Condition * Social Support	0.05	0.08	0.63	0.533
Baseline Progesterone * Condition * Social Support	-0.06	0.08	-0.72	0.472

Table S6b: Results of linear regression analyses on post-manipulation progesterone

DV: Post-manipulation Progesterone				
	b	SE	*t*-value	*p*-value
(Intercept)	0.003	0.04	0.07	0.942
Baseline Estradiol	-0.02	0.06	-0.26	0.799
Condition	0.05	0.04	1.15	0.253
Social Support	0.02	0.05	0.38	0.703
Baseline Progesterone	0.87	0.06	14.18	**<.0001**
Cortisol Residual	0.17	0.04	3.82	**0.0002**
Baseline Estradiol * Condition	0.03	0.06	0.47	0.639
Baseline Estradiol * Social Support	-0.08	0.06	-1.36	0.175
*Condition * Social Support*	-0.07	0.05	-1.49	0.138
Baseline Progesterone * Condition	0.03	0.06	0.52	0.601
Baseline Progesterone * Social Support	0.08	0.07	1.18	0.241
Baseline Estradiol * Condition * Social Support	-0.16	0.06	-2.52	**0.013**
Baseline Progesterone * Condition * Social Support	0.16	0.07	2.44	**0.016**

Table S6c: Results of linear regression analyses on post-manipulation cortisol

DV: Post-manipulation Cortisol				
	b	SE	*t*-value	*p*-value
(Intercept)	0.08	0.07	1.07	0.288
Baseline Cortisol	0.63	0.08	8.20	**<.0001**
Baseline Estradiol	0.29	0.10	2.91	**0.004**
Condition	0.12	0.07	1.62	0.109
Social Support	-0.05	0.08	-0.58	0.566
Baseline Progesterone	-0.22	0.10	-2.28	**0.024**
Baseline Estradiol * Condition	-0.03	0.10	-0.30	0.768
Baseline Estradiol * Social Support	0.05	0.10	0.52	0.606
*Condition * Social Support*	0.03	0.08	0.36	0.722
Baseline Progesterone * Condition	0.15	0.10	1.52	0.132
Baseline Progesterone * Social Support	-0.01	0.11	-0.10	0.922
Baseline Estradiol * Condition * Social Support	0.28	0.10	2.86	**0.005**
Baseline Progesterone * Condition * Social Support	-0.26	0.10	-2.43	**0.017**

7. Linear regression analyses without cortisol as a control variable

Tables S7a-f display linear regression estimates for residualized change models, without controlling for cortisol.

Notes. Participants with manipulation check discriminant scores falling 1 SD below their respective group means are excluded from analyses. Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Baseline hormone values are mean-centered. Social support scores are standardized. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

3-way (Condition x Baseline Hormones x Social Support) interactions of interest are **bolded**. *Condition x Social Support interaction* at average baseline hormone values is *italicized.*

$p < .05$ **bolded**; $p < .10$ *italicized.*

Table S7a: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-136.61	**<.0001**
Baseline ln(E/P)	0.77	0.06	13.42	**<.0001**
Condition	-0.01	0.03	-0.23	0.821
Social Support	-0.03	0.03	-0.96	0.337
Baseline ln(E/P) * Condition	0.01	0.06	0.18	0.857
Baseline ln(E/P) * Social Support	-0.05	0.06	-0.91	0.364
*Condition * Social Support*	0.07	0.03	2.03	**0.044**
Baseline ln(E/P) * Condition * Social Support	0.20	0.06	3.42	**0.0008**

Table S7b: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-135.47	**<.0001**
Baseline ln(E)	0.51	0.14	3.60	**0.0005**
Condition	-0.01	0.03	-0.22	0.825
Social Support	-0.04	0.04	-1.02	0.312
Baseline ln(P)	-0.74	0.06	-12.33	**<.0001**
Baseline ln(E) * Condition	0.07	0.14	0.47	0.642
Baseline ln(E) * Social Support	-0.04	0.14	-0.29	0.769
*Condition * Social Support*	0.07	0.04	1.96	*0.052*
Baseline ln(P) * Condition	-0.01	0.06	-0.10	0.921
Baseline ln(P) * Social Support	0.04	0.06	0.60	0.550
Baseline ln(E) * Condition * Social Support	0.35	0.14	2.51	**0.014**
Baseline ln(P) * Condition * Social Support	-0.21	0.06	-3.45	**0.0008**

Table S7c: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.03	21.44	**<.0001**
Baseline ln(E/P)	-0.12	0.05	-2.69	**0.008**
Condition	0.01	0.03	0.58	0.563
Social Support	-0.07	0.03	-2.72	**0.008**
Baseline ln(E/P) * Condition	-0.03	0.05	-0.59	0.560
Baseline ln(E/P) * Social Support	-0.01	0.05	-0.28	0.784
*Condition * Social Support*	-0.03	0.03	-1.09	0.280
Baseline ln(E/P) * Condition * Social Support	0.004	0.05	0.08	0.933

Table S7d: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.02	30.33	**<.0001**
Baseline ln(E)	0.68	0.08	8.65	**<.0001**
Condition	0.02	0.02	1.32	0.188
Social Support	-0.05	0.02	-2.61	**0.010**
Baseline ln(P)	0.01	0.03	0.32	0.752
Baseline ln(E) * Condition	0.01	0.08	0.10	0.921
Baseline ln(E) * Social Support	-0.13	0.08	-1.61	0.110
*Condition * Social Support*	-0.01	0.02	-0.42	0.676
Baseline ln(P) * Condition	-0.01	0.03	-0.22	0.827
Baseline ln(P) * Social Support	0.03	0.03	0.77	0.443
Baseline ln(E) * Condition * Social Support	0.04	0.08	0.57	0.567
Baseline ln(P) * Condition * Social Support	-0.02	0.03	-0.47	0.638

Table S7e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	114.94	**<.0001**
Baseline ln(E/P)	-0.89	0.08	-11.58	**<.0001**
Condition	0.02	0.04	0.51	0.611
Social Support	-0.04	0.05	-0.88	0.381
Baseline ln(E/P) * Condition	-0.04	0.08	-0.48	0.634
Baseline ln(E/P) * Social Support	0.04	0.08	0.52	0.605
*Condition * Social Support*	-0.10	0.05	-2.17	**0.032**
Baseline ln(E/P) * Condition * Social Support	-0.20	0.08	-2.50	**0.014**

Table S7f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	134.84	**<.0001**
Baseline ln(E)	0.17	0.16	1.05	0.297
Condition	0.03	0.04	0.82	0.414
Social Support	-0.02	0.04	-0.42	0.678
Baseline ln(P)	0.75	0.07	11.02	**<.0001**
Baseline ln(E) * Condition	-0.06	0.16	-0.36	0.723
Baseline ln(E) * Social Support	-0.08	0.16	-0.52	0.605
*Condition * Social Support*	-0.08	0.04	-1.91	*0.058*
Baseline ln(P) * Condition	-0.001	0.07	-0.02	0.985
Baseline ln(P) * Social Support	-0.01	0.07	-0.16	0.874
Baseline ln(E) * Condition * Social Support	-0.31	0.16	-1.94	*0.055*
Baseline ln(P) * Condition * Social Support	0.19	0.07	2.82	**0.006**

8. Linear regression analyses with outliers removed

Tables S8a-f display linear regression estimates with outliers removed. One outlier each for post-manipulation ln(E/P), post-manipulation ln(P), and ln(Cortisol) residualized change were omitted from analyses.

See section 7 above for *Notes* on tables and analyses.

Table S8a: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.47	0.03	-147.31	**<.0001**
Baseline ln(E/P)	0.80	0.06	14.17	**<.0001**
Condition	-0.01	0.03	-0.18	0.858
Social Support	-0.06	0.03	-1.82	*0.072*
Ln Cortisol Residual	-0.46	0.09	-4.96	**<.0001**
Baseline ln(E/P) * Condition	-0.01	0.06	-0.16	0.872
Baseline ln(E/P) * Social Support	-0.04	0.06	-0.71	0.481
*Condition * Social Support*	0.07	0.03	2.18	**0.031**
Baseline ln(E/P) * Condition * Social Support	0.22	0.06	3.81	**0.0002**

Table S8b: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-145.08	**<.0001**
Baseline ln(E)	0.62	0.13	4.67	**<.0001**
Condition	-0.002	0.03	-0.06	0.955
Social Support	-0.06	0.03	-1.70	*0.092*
Baseline ln(P)	-0.78	0.06	-13.21	**<.0001**
Ln Cortisol Residual	-0.45	0.09	-4.83	**<.0001**
Baseline ln(E) * Condition	0.07	0.13	0.58	0.566
Baseline ln(E) * Social Support	-0.01	0.13	-0.05	0.959
*Condition * Social Support*	0.07	0.03	2.21	**0.029**
Baseline ln(P) * Condition	0.004	0.06	0.07	0.948
Baseline ln(P) * Social Support	0.02	0.06	0.28	0.781
Baseline ln(E) * Condition * Social Support	0.41	0.13	3.15	**0.002**
Baseline ln(P) * Condition * Social Support	-0.24	0.06	-3.85	**0.0002**

Table S8c: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.03	21.45	**<.0001**
Baseline ln(E/P)	-0.10	0.05	-2.03	**0.045**
Condition	-0.01	0.03	-0.20	0.840
Social Support	-0.07	0.03	-2.63	**0.010**
Ln Cortisol Residual	0.18	0.08	2.32	**0.022**
Baseline ln(E/P) * Condition	-0.05	0.05	-1.16	0.249
Baseline ln(E/P) * Social Support	-0.07	0.05	-1.33	0.185
*Condition * Social Support*	-0.02	0.03	-0.90	0.368
Baseline ln(E/P) * Condition * Social Support	0.04	0.05	0.81	0.421

Table S8d: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.55	0.02	29.80	**<.0001**
Baseline ln(E)	0.66	0.08	8.45	**<.0001**
Condition	0.01	0.02	0.60	0.553
Social Support	-0.05	0.02	-2.54	**0.013**
Baseline ln(P)	0.01	0.04	0.15	0.883
Ln Cortisol Residual	0.09	0.06	1.61	0.110
Baseline ln(E) * Condition	0.01	0.08	0.11	0.916
Baseline ln(E) * Social Support	-0.15	0.08	-1.94	*0.055*
*Condition * Social Support*	-0.01	0.02	-0.33	0.739
Baseline ln(P) * Condition	0.001	0.03	0.03	0.975
Baseline ln(P) * Social Support	0.05	0.04	1.41	0.161
Baseline ln(E) * Condition * Social Support	0.01	0.08	0.16	0.872
Baseline ln(P) * Condition * Social Support	-0.02	0.04	-0.67	0.505

Table S8e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	120.95	**<.0001**
Baseline ln(E/P)	-0.90	0.08	-11.61	**<.0001**
Condition	0.0003	0.04	0.01	0.995
Social Support	-0.01	0.04	-0.29	0.771
Ln Cortisol Residual	0.64	0.13	5.06	**<.0001**
Baseline ln(E/P) * Condition	-0.05	0.08	-0.60	0.553
Baseline ln(E/P) * Social Support	-0.02	0.08	-0.30	0.762
*Condition * Social Support*	-0.09	0.04	-2.15	**0.034**
Baseline ln(E/P) * Condition * Social Support	-0.18	0.08	-2.29	**0.024**

Table S8f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	141.65	**<.0001**
Baseline ln(E)	0.05	0.15	0.32	0.747
Condition	0.01	0.04	0.36	0.721
Social Support	0.01	0.04	0.16	0.871
Baseline ln(P)	0.78	0.07	11.56	**<.0001**
Ln Cortisol Residual	0.54	0.11	5.04	**<.0001**
Baseline ln(E) * Condition	-0.07	0.15	-0.45	0.657
Baseline ln(E) * Social Support	-0.14	0.15	-0.96	0.339
*Condition * Social Support*	-0.08	0.04	-2.09	**0.039**
Baseline ln(P) * Condition	-0.003	0.07	-0.04	0.968
Baseline ln(P) * Social Support	0.03	0.07	0.49	0.625
Baseline ln(E) * Condition * Social Support	-0.39	0.15	-2.66	**0.009**
Baseline ln(P) * Condition * Social Support	0.21	0.07	3.00	**0.003**

9. Linear regression analyses with outliers retained

Tables S9a-f display linear regression estimates with outliers retained and not winsorized.

See section 7 above for *Notes* on tables and analyses.

Table S9a: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline ln(E/P) as a predictor

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.03	-148.28	**<.0001**
Baseline ln(E/P)	0.85	0.05	16.09	**<.0001**
Condition	-0.02	0.03	-0.57	0.570
Social Support	-0.07	0.03	-2.05	**0.042**
Ln Cortisol Residual	-0.45	0.09	-5.21	**<.0001**
Baseline ln(E/P) * Condition	-0.05	0.05	-1.03	0.305
Baseline ln(E/P) * Social Support	-0.09	0.05	-1.78	*0.078*
*Condition * Social Support*	0.08	0.03	2.43	**0.017**
Baseline ln(E/P) * Condition * Social Support	0.28	0.05	5.20	**0.0000008**

Table S9b: Results of linear regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), using baseline log-transformed estradiol (ln(E)) and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.45	0.03	-146.09	**<.0001**
Baseline ln(E)	0.64	0.13	4.83	**<.0001**
Condition	-0.01	0.03	-0.47	0.638
Social Support	-0.06	0.03	-1.96	*0.052*
Baseline ln(P)	-0.82	0.06	-14.83	**<.0001**
Ln Cortisol Residual	-0.44	0.09	-5.01	**<.0001**
Baseline ln(E) * Condition	0.05	0.13	0.36	0.721
Baseline ln(E) * Social Support	-0.01	0.13	-0.08	0.940
*Condition * Social Support*	0.08	0.03	2.48	**0.015**
Baseline ln(P) * Condition	0.05	0.05	0.87	0.384
Baseline ln(P) * Social Support	0.07	0.06	1.30	0.196
Baseline ln(E) * Condition * Social Support	0.40	0.13	3.12	**0.002**
Baseline ln(P) * Condition * Social Support	-0.29	0.06	-5.23	**0.0000008**

Table S9c: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.54	0.03	21.36	**<.0001**
Baseline ln(E/P)	-0.13	0.04	-2.98	**0.004**
Condition	0.002	0.03	0.08	0.936
Social Support	-0.06	0.03	-2.39	**0.018**
Ln Cortisol Residual	0.19	0.07	2.67	**0.009**
Baseline ln(E/P) * Condition	-0.02	0.04	-0.46	0.646
Baseline ln(E/P) * Social Support	-0.02	0.04	-0.54	0.594
*Condition * Social Support*	-0.03	0.03	-1.11	0.268
Baseline ln(E/P) * Condition * Social Support	-0.003	0.04	-0.08	0.940

Table S9d: Results of linear regression analyses on post-manipulation log-transformed estradiol (ln(E)), using baseline log-transformed estradiol and progesterone (ln(P)) as separate predictors

DV: Post-manipulation ln(E)				
	b	SE	*t*-value	*p*-value
(Intercept)	0.54	0.02	30.29	**<.0001**
Baseline ln(E)	0.66	0.08	8.41	**<.0001**
Condition	0.01	0.02	0.72	0.476
Social Support	-0.05	0.02	-2.43	**0.017**
Baseline ln(P)	0.02	0.03	0.54	0.591
Ln Cortisol Residual	0.10	0.05	1.97	*0.051*
Baseline ln(E) * Condition	0.01	0.08	0.16	0.877
Baseline ln(E) * Social Support	-0.15	0.08	-1.99	**0.049**
*Condition * Social Support*	-0.01	0.02	-0.46	0.649
Baseline ln(P) * Condition	-0.01	0.03	-0.32	0.749
Baseline ln(P) * Social Support	0.04	0.03	1.10	0.274
Baseline ln(E) * Condition * Social Support	0.01	0.08	0.15	0.879
Baseline ln(P) * Condition * Social Support	-0.01	0.03	-0.22	0.828

Table S9e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	121.17	**<.0001**
Baseline ln(E/P)	-0.98	0.07	-13.48	**<.0001**
Condition	0.02	0.04	0.44	0.664
Social Support	-0.001	0.04	-0.01	0.990
Ln Cortisol Residual	0.64	0.12	5.40	**<.0001**
Baseline ln(E/P) * Condition	0.03	0.07	0.46	0.644
Baseline ln(E/P) * Social Support	0.07	0.07	0.97	0.334
*Condition * Social Support*	-0.11	0.04	-2.42	**0.017**
Baseline ln(E/P) * Condition * Social Support	-0.28	0.07	-3.83	**0.0002**

Table S9f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	4.99	0.03	143.05	**<.0001**
Baseline ln(E)	0.02	0.15	0.10	0.919
Condition	0.03	0.04	0.72	0.472
Social Support	0.01	0.04	0.39	0.701
Baseline ln(P)	0.84	0.06	13.15	**<.0001**
Ln Cortisol Residual	0.54	0.10	5.34	**<.0001**
Baseline ln(E) * Condition	-0.03	0.15	-0.22	0.829
Baseline ln(E) * Social Support	-0.14	0.15	-0.93	0.354
*Condition * Social Support*	-0.09	0.04	-2.33	**0.022**
Baseline ln(P) * Condition	-0.06	0.06	-0.92	0.359
Baseline ln(P) * Social Support	-0.04	0.06	-0.59	0.560
Baseline ln(E) * Condition * Social Support	-0.40	0.15	-2.65	**0.009**
Baseline ln(P) * Condition * Social Support	0.28	0.06	4.44	**0.00002**

10. Piecewise regression analyses with ln(E/P) as outcome

The tables in this section display estimates from piecewise regression analyses with ln(E/P) as the outcome variable, using baseline ln(E/P) as the hormone predictor. Output for these analyses and for piecewise regression analyses using baseline ln(E) and ln(P) separately estimated are posted on OSF.

Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Social Support Difference is the difference in effect/slope of social support from the social support reference group (e.g., High Social Support Difference is the difference in slope between the high social support group versus the low social support reference group; "low" social support refers to social support scores below the cut-point).

3-way (Condition x Baseline ln[E/P] x Social Support Difference) interactions of interest are in *blue and italicized*. This term provides an assessment of whether the 3-way interaction between condition, baseline hormones, and social support are significantly different between the high and low social support groups.

3-way (Condition x Baseline ln[E/P] x Social Support) interactions of interest are ***bolded and italicized***. This term is the 3-way interaction for the reference group (i.e., the low/high social support group). The 3-way interaction for the group coded 1 is the sum of *b*'s of *Condition x Baseline ln(E/P) x Social Support Difference* and ***Condition x Baseline ln(E/P) x Social Support***.

Simple **2-way (Baseline ln[E/P] x Social Support) interactions** of interest within condition are **bolded**. *Condition x Social Support interactions* at average/periovulatory-phase baseline ln(E/P) values are *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Tables S10a.1-4 display estimates from the same piecewise regression model, using a median split to characterize different slopes for low versus high ranges of social support. The separate tables show results when the low (*Tables S10a.1-2*) or high (*Tables S10a.3-4*) social support range is the reference. *Tables S10a.2* and *S10a.4* show marginal effects estimates with social support is centered at 1 SD below or above the mean, respectively.

Table S10a.1: Piecewise regression results, with **social support below the median** as the reference. Social support is centered at the median.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.06	-80.41	**<.0001**	-3.85	0.09	-43.00	**<.0001**	-4.14	0.15	-28.22	**<.0001**
Baseline ln(E/P)	0.83	0.10	8.46	**<.0001**	1.00	0.11	8.81	**<.0001**	0.67	0.16	4.17	**<.0001**
Condition	0.05	0.06	0.97	0.334	-0.29	0.17	-1.69	*0.094*	0.29	0.17	1.69	*0.094*
Social Support	-0.03	0.06	-0.58	0.563	0.28	0.09	3.08	**0.003**	-0.33	0.13	-2.64	**0.010**
High Social Support Difference	-0.06	0.12	-0.47	0.640	-0.47	0.20	-2.31	**0.023**	0.17	0.27	0.64	0.521
Ln Cortisol Residual	-0.44	0.09	-5.01	**<.0001**	-0.44	0.09	-5.01	**<.0001**	-0.44	0.09	-5.01	**<.0001**
Baseline ln(E/P) * Condition	0.16	0.10	1.64	0.104	-0.32	0.20	-1.64	0.104	0.32	0.20	1.64	0.104
Baseline ln(E/P) * Social Support	0.02	0.09	0.19	0.851	0.35	0.11	3.30	**0.001**	-0.31	0.16	-2.02	**0.046**
*Condition * Social Support*	0.12	0.06	2.05	**0.043**	-0.61	0.16	-3.95	**0.0001**	0.61	0.16	3.95	**0.0001**
Baseline ln(E/P) * High Social Support Difference	-0.17	0.21	-0.79	0.429	-0.52	0.26	-1.97	*0.052*	0.19	0.32	0.58	0.563
Condition * High Social Support Difference	-0.13	0.12	-1.05	0.296	0.65	0.34	1.91	*0.059*	-0.65	0.34	-1.91	*0.059*
Baseline ln(E/P) * Condition * Social Support	0.33	0.09	3.53	**0.0006**	-0.66	0.19	-3.53	**0.0006**	0.66	0.19	3.53	**0.0006**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-0.35	0.21	-1.70	*0.091*	0.70	0.41	1.70	*0.091*	-0.70	0.41	-1.70	*0.091*

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the median = 1, below the median = 0]).

Table S10a.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the median** is the reference group.

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.42	0.05	-97.03	**<.0001**
Baseline ln(E/P)	0.81	0.07	11.02	**<.0001**
Condition	-0.08	0.05	-1.78	*0.078*
Social Support	-0.03	0.06	-0.58	0.563
High Social Support Difference	-0.06	0.12	-0.47	0.640
Ln Cortisol Residual	-0.44	0.09	-5.01	**<.0001**
Baseline ln(E/P) * Condition	-0.21	0.07	-2.89	**0.005**
Baseline ln(E/P) * Social Support	0.02	0.09	0.19	0.851
*Condition * Social Support*	0.12	0.06	2.05	**0.043**
Baseline ln(E/P) * High Social Support Difference	-0.17	0.21	-0.79	0.429
Condition * High Social Support Difference	-0.13	0.12	-1.05	0.296
Baseline ln(E/P) * Condition * Social Support	0.33	0.09	3.53	**0.0006**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-0.35	0.21	-1.70	*0.091*

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the median = 1, below the median = 0]).

Table S10a.3: Piecewise regression results, with **social support above the median** as the reference. Social support scores are centered at the median.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				Social Exclusion Condition[b]				Social Inclusion Condition[c]			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.46	0.06	-80.41	**<.0001**	-3.85	0.09	-43.00	**<.0001**	-4.14	0.15	-28.22	**<.0001**
Baseline ln(E/P)	0.83	0.10	8.46	**<.0001**	1.00	0.11	8.81	**<.0001**	0.67	0.16	4.17	**<.0001**
Condition	0.05	0.06	0.97	0.334	-0.29	0.17	-1.69	*0.094*	0.29	0.17	1.69	*0.094*
Social Support	-0.09	0.08	-1.16	0.248	-0.19	0.14	-1.35	0.181	-0.16	0.17	-0.92	0.361
Low Social Support Difference	0.06	0.12	0.47	0.640	0.47	0.20	2.31	**0.023**	-0.17	0.27	-0.64	0.521
Ln Cortisol Residual	-0.44	0.09	-5.01	**<.0001**	-0.44	0.09	-5.01	**<.0001**	-0.44	0.09	-5.01	**<.0001**
Baseline ln(E/P) * Condition	0.16	0.10	1.64	0.104	-0.32	0.20	-1.64	0.104	0.32	0.20	1.64	0.104
Baseline ln(E/P) * Social Support	-0.15	0.14	-1.05	0.296	-0.17	0.19	-0.88	0.384	-0.13	0.20	-0.63	0.530
*Condition * Social Support*	-0.01	0.08	-0.07	0.942	0.03	0.22	0.15	0.884	-0.03	0.22	-0.15	0.884
Baseline ln(E/P) * Low Social Support Difference	0.17	0.21	0.79	0.429	0.52	0.26	1.97	*0.052*	-0.19	0.32	-0.58	0.563
Condition * Low Social Support Difference	0.13	0.12	1.05	0.297	-0.65	0.34	-1.91	*0.059*	0.65	0.34	1.91	*0.059*
Baseline ln(E/P) * Condition * Social Support	-0.02	0.14	-0.14	0.893	0.04	0.28	0.14	0.893	-0.04	0.28	-0.14	0.893
*Baseline ln(E/P) * Condition * Low Social Support Difference*	0.35	0.21	1.70	*0.091*	-0.70	0.41	-1.70	*0.091*	0.70	0.41	1.70	*0.091*

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the median = 1, above the median = 0]).

Table S10a.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the median** is the reference group.

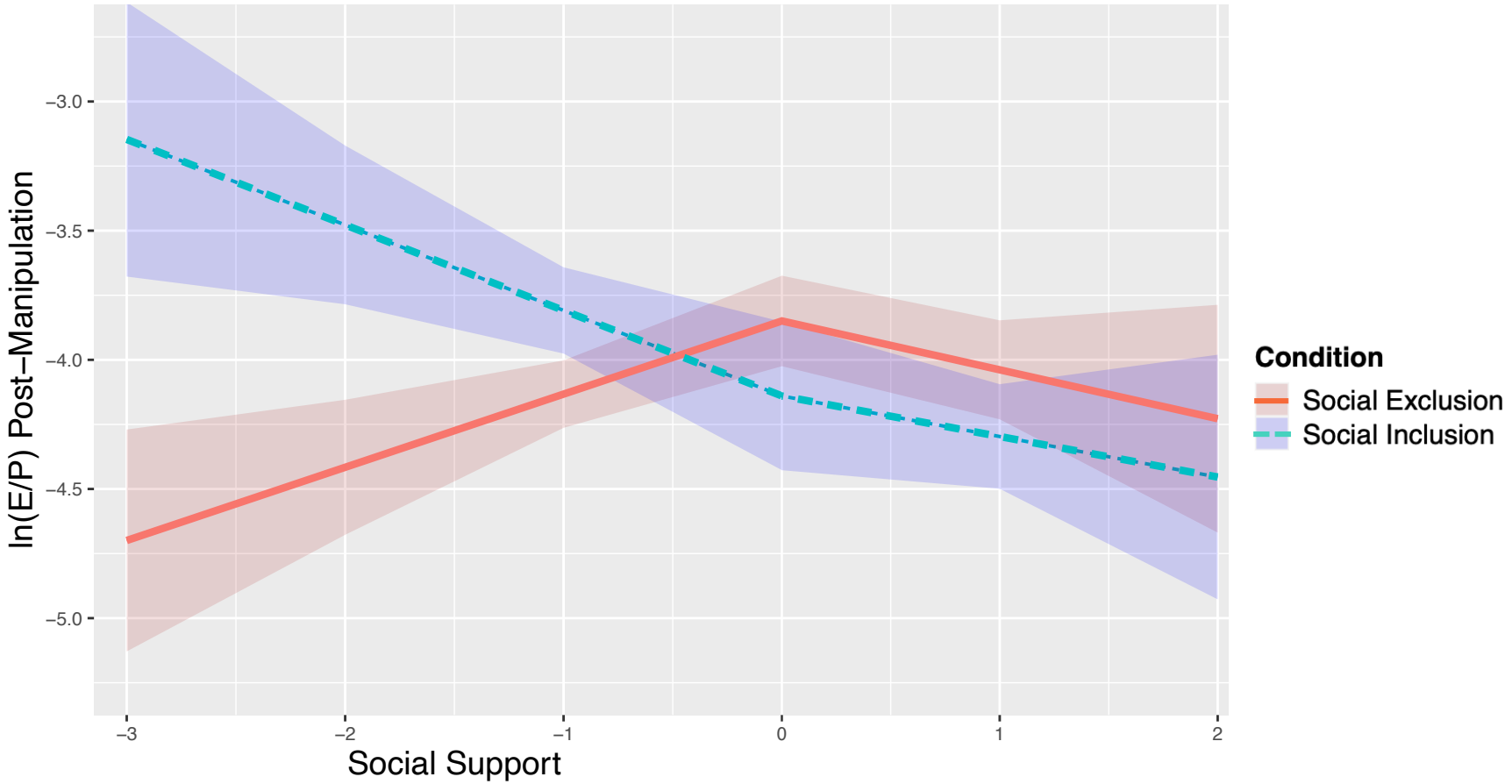
DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.54	0.05	-100.50	**<.0001**
Baseline ln(E/P)	0.71	0.08	8.57	**<.0001**
Condition	0.05	0.04	1.10	0.276
Social Support	-0.09	0.08	-1.16	0.248
Low Social Support Difference	0.06	0.12	0.47	0.640
Ln Cortisol Residual	-0.44	0.09	-5.01	**<.0001**
Baseline ln(E/P) * Condition	0.15	0.08	1.78	*0.077*
Baseline ln(E/P) * Social Support	-0.15	0.14	-1.05	0.296
*Condition * Social Support*	-0.01	0.08	-0.07	0.942
Baseline ln(E/P) * Low Social Support Difference	0.17	0.21	0.79	0.429
Condition * Low Social Support Difference	0.13	0.12	1.05	0.297
Baseline ln(E/P) * Condition * Social Support	-0.02	0.14	-0.14	0.893
*Baseline ln(E/P) * Condition * Low Social Support Difference*	0.35	0.21	1.70	*0.091*

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the median = 1, above the median = 0]).

Plot of piecewise regression model with low vs. high social support separated at the median



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the median. Shaded areas represent 95% confidence intervals.

Tables S10b.1-4 display estimates from the same piecewise regression model, using separation at the second tertile to characterize different slopes for low versus high ranges of social support.

The separate tables show results when the low (*Tables S10b.1-2)* or high (*Tables S10b.3-4*) social support range is the reference.

Tables S10b.2 and *S10b.4* show marginal effects estimates with social support centered at 1 SD below or above the mean, respectively.

Table S10b.1: Piecewise regression results, with **social support below the second tertile** as the reference. Social support scores are centered at the second tertile.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.49	0.05	-82.40	**<.0001**	-3.78	0.09	-43.25	**<.0001**	-4.28	0.16	-26.43	**<.0001**
Baseline ln(E/P)	0.82	0.11	7.73	**<.0001**	1.10	0.10	10.76	**<.0001**	0.54	0.19	2.91	**0.004**
Condition	0.10	0.05	1.75	*0.084*	-0.51	0.18	-2.74	**0.007**	0.51	0.18	2.74	**0.007**
Social Support	-0.04	0.05	-0.99	0.324	0.26	0.07	3.56	**0.0005**	-0.34	0.11	-3.10	**0.002**
High Social Support Difference	-0.06	0.14	-0.42	0.679	-0.80	0.27	-3.03	**0.003**	0.30	0.37	0.82	0.414
Ln Cortisol Residual	-0.46	0.09	-5.27	**<.0001**	-0.46	0.09	-5.27	**<.0001**	-0.46	0.09	-5.27	**<.0001**
Baseline ln(E/P) * Condition	0.28	0.11	2.61	**0.010**	-0.56	0.21	-2.61	**0.010**	0.56	0.21	2.61	**0.010**
Baseline ln(E/P) * Social Support	0.01	0.08	0.14	0.893	0.33	0.08	4.08	**0.00008**	-0.31	0.14	-2.27	**0.025**
*Condition * Social Support*	0.11	0.05	2.53	**0.013**	-0.59	0.13	-4.55	**0.00001**	0.59	0.13	4.55	**0.00001**
Baseline ln(E/P) * High Social Support Difference	-0.34	0.28	-1.18	0.239	-0.97	0.33	-2.92	**0.004**	0.30	0.46	0.65	0.520
Condition * High Social Support Difference	-0.20	0.14	-1.36	0.175	1.11	0.46	2.42	**0.017**	-1.11	0.46	-2.42	**0.017**
Baseline ln(E/P) * Condition * Social Support	0.32	0.08	4.02	**0.0001**	-0.64	0.16	-4.02	**0.0001**	0.64	0.16	4.02	**0.0001**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-0.63	0.28	-2.23	**0.028**	1.27	0.57	2.23	**0.028**	-1.27	0.57	-2.23	**0.028**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the second tertile = 1, below the second tertile = 0]).

Table S10b.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the second tertile** is the reference group.

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.42	0.04	-99.51	**<.0001**
Baseline ln(E/P)	0.80	0.07	11.22	**<.0001**
Condition	-0.08	0.04	-1.87	*0.065*
Social Support	-0.04	0.05	-0.99	0.324
High Social Support Difference	-0.06	0.14	-0.42	0.679
Ln Cortisol Residual	-0.46	0.09	-5.27	**<.0001**
Baseline ln(E/P) * Condition	-0.22	0.07	-3.11	**0.002**
Baseline ln(E/P) * Social Support	0.01	0.08	0.14	0.893
*Condition * Social Support*	0.11	0.05	2.53	**0.013**
Baseline ln(E/P) * High Social Support Difference	-0.34	0.28	-1.18	0.239
Condition * High Social Support Difference	-0.20	0.14	-1.36	0.175
Baseline ln(E/P) * Condition * Social Support	0.32	0.08	4.02	**0.0001**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-0.63	0.28	-2.23	**0.028**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the second tertile = 1, below the second tertile = 0]).

Table S10b.3: Piecewise regression results, with the **highest tertile of social support** as the reference. Social support scores are centered at the second tertile.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.49	0.05	-82.40	**<.0001**	-3.78	0.09	-43.25	**<.0001**	-4.28	0.16	-26.43	**<.0001**
Baseline ln(E/P)	0.82	0.11	7.73	**<.0001**	1.10	0.10	10.76	**<.0001**	0.54	0.19	2.91	**0.004**
Condition	0.10	0.05	1.75	*0.084*	-0.51	0.18	-2.74	**0.007**	0.51	0.18	2.74	**0.007**
Social Support	-0.10	0.12	-0.91	0.367	-0.55	0.22	-2.46	**0.015**	-0.03	0.29	-0.11	0.914
Low Social Support Difference	0.06	0.14	0.42	0.679	0.80	0.27	3.03	**0.003**	-0.30	0.37	-0.82	0.414
Ln Cortisol Residual	-0.46	0.09	-5.27	**<.0001**	-0.46	0.09	-5.27	**<.0001**	-0.46	0.09	-5.27	**<.0001**
Baseline ln(E/P) * Condition	0.28	0.11	2.61	**0.010**	-0.56	0.21	-2.61	**0.010**	0.56	0.21	2.61	**0.010**
Baseline ln(E/P) * Social Support	-0.33	0.23	-1.41	0.160	-0.64	0.29	-2.21	**0.029**	-0.01	0.36	-0.04	0.969
*Condition * Social Support*	-0.08	0.11	-0.71	0.479	0.52	0.36	1.42	0.159	-0.52	0.36	-1.42	0.159
Baseline ln(E/P) * Low Social Support Difference	0.34	0.28	1.18	0.239	0.97	0.33	2.92	**0.004**	-0.30	0.46	-0.65	0.520
Condition * Low Social Support Difference	0.20	0.14	1.36	0.175	-1.11	0.46	-2.42	**0.017**	1.11	0.46	2.42	**0.017**
Baseline ln(E/P) * Condition * Social Support	-0.31	0.23	-1.36	0.177	0.62	0.46	1.36	0.177	-0.62	0.46	-1.36	0.177
*Baseline ln(E/P) * Condition * Low Social Support Difference*	0.63	0.28	2.23	**0.028**	-1.27	0.57	-2.23	**0.028**	1.27	0.57	2.23	**0.028**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the second tertile = 1, above the second tertile = 0]).

Table S10b.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the second tertile** is the reference group.

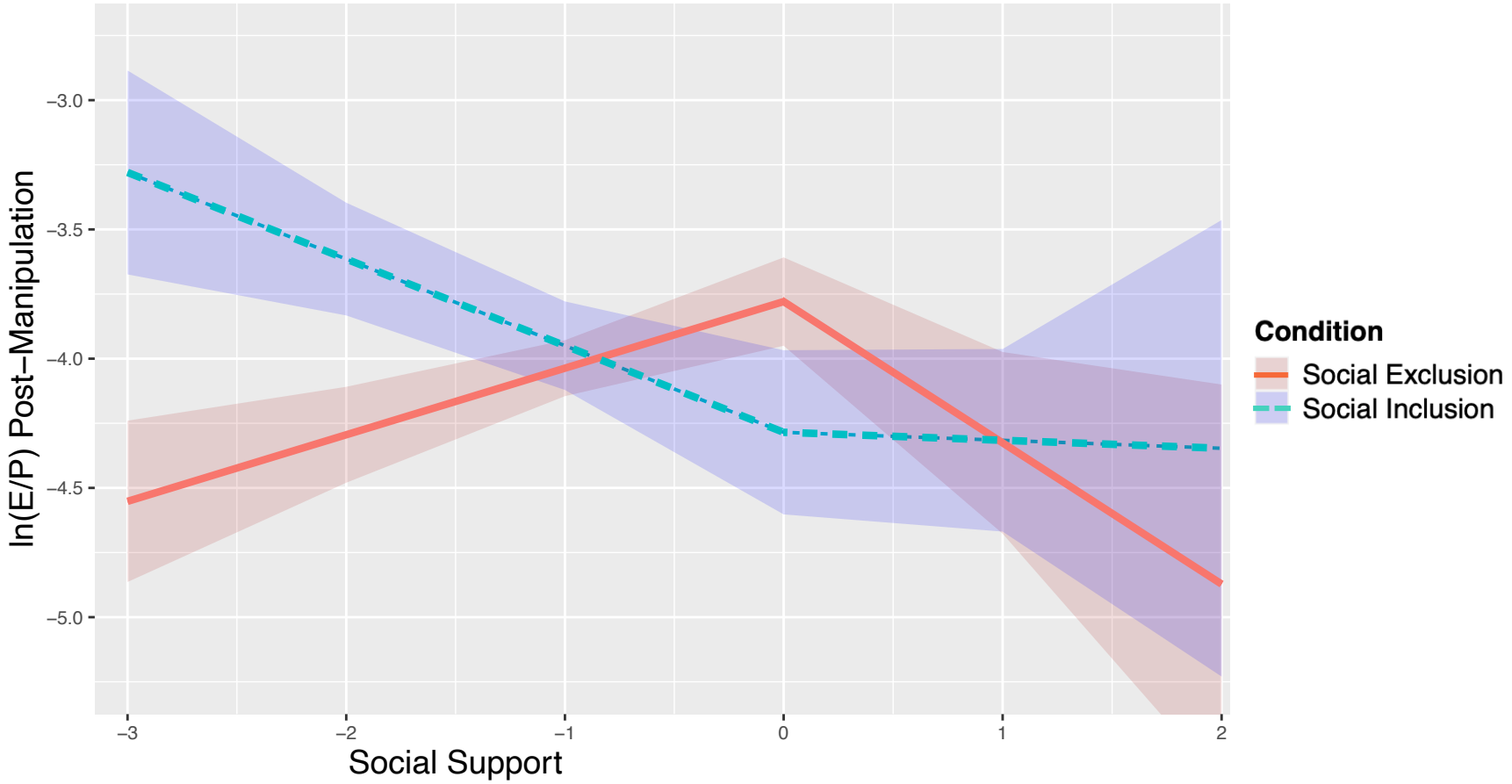
DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.54	0.04	-105.75	**<.0001**
Baseline ln(E/P)	0.68	0.08	8.62	**<.0001**
Condition	0.06	0.04	1.40	0.166
Social Support	-0.10	0.12	-0.91	0.367
Low Social Support Difference	0.06	0.14	0.42	0.679
Ln Cortisol Residual	-0.46	0.09	-5.27	**<.0001**
Baseline ln(E/P) * Condition	0.14	0.08	1.81	*0.074*
Baseline ln(E/P) * Social Support	-0.33	0.23	-1.41	0.160
*Condition * Social Support*	-0.08	0.11	-0.71	0.479
Baseline ln(E/P) * Low Social Support Difference	0.34	0.28	1.18	0.239
Condition * Low Social Support Difference	0.20	0.14	1.36	0.175
Baseline ln(E/P) * Condition * Social Support	-0.31	0.23	-1.36	0.177
*Baseline ln(E/P) * Condition * Low Social Support Difference*	0.63	0.28	2.23	**0.028**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the second tertile = 1, above the second tertile = 0]).

Plot of piecewise regression model with low vs. high social support separated at the second tertile



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the second tertile. Shaded areas represent 95% confidence intervals.

Tables S10c.1-4 display estimates from the same piecewise regression model, using separation at the third quartile to characterize different slopes for low versus high ranges of social support.

The separate tables show results when the low (*Tables S10c.1-2)* or high (*Tables S10c.3-4*) social support range is the reference.

Tables S10c.2 and *S10c.4* show marginal effects estimates with social support centered at 1 SD below or above the mean, respectively.

Table S10c.1: Piecewise regression results, with **social support below the third quartile** as the reference. Social support scores are centered at the third quartile.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				Social Exclusion Condition[b]				Social Inclusion Condition[c]			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.51	0.05	-82.28	**<.0001**	-3.76	0.08	-45.05	**<.0001**	-4.35	0.17	-25.86	**<.0001**
Baseline ln(E/P)	0.81	0.11	7.27	**<.0001**	1.14	0.10	11.35	**<.0001**	0.47	0.20	2.38	**0.019**
Condition	0.11	0.05	1.97	*0.051*	-0.59	0.19	-3.16	**0.002**	0.59	0.19	3.16	**0.002**
Social Support	-0.05	0.04	-1.26	0.210	0.23	0.06	3.70	**0.0003**	-0.33	0.10	-3.32	**0.001**
High Social Support Difference	-0.08	0.19	-0.40	0.687	-1.28	0.35	-3.63	**0.0004**	0.45	0.53	0.84	0.405
Ln Cortisol Residual	-0.45	0.08	-5.32	**<.0001**	-0.45	0.08	-5.32	**<.0001**	-0.45	0.08	-5.32	**<.0001**
Baseline ln(E/P) * Condition	0.33	0.11	3.00	**0.003**	-0.67	0.22	-3.00	**0.003**	0.67	0.22	3.00	**0.003**
Baseline ln(E/P) * Social Support	0.00	0.07	0.04	0.965	0.31	0.07	4.30	**0.00004**	-0.30	0.13	-2.40	**0.018**
*Condition * Social Support*	0.10	0.04	2.63	**0.010**	-0.56	0.12	-4.78	**0.000005**	0.56	0.12	4.78	**0.000005**
Baseline ln(E/P) * High Social Support Difference	-0.60	0.42	-1.46	0.148	-1.65	0.46	-3.60	**0.0005**	0.44	0.69	0.64	0.522
Condition * High Social Support Difference	-0.27	0.19	-1.44	0.153	1.73	0.64	2.70	**0.008**	-1.73	0.64	-2.70	**0.008**
Baseline ln(E/P) * Condition * Social Support	0.31	0.07	4.20	**0.00005**	-0.62	0.15	-4.20	**0.00005**	0.62	0.15	4.20	**0.00005**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-1.05	0.42	-2.53	**0.013**	2.10	0.83	2.53	**0.013**	-2.10	0.83	-2.53	**0.013**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the third quartile = 1, below the third quartile = 0]).

Table S10c.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the third quartile** is the reference group.

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.42	0.04	-101.83	**<.0001**
Baseline ln(E/P)	0.80	0.07	11.45	**<.0001**
Condition	-0.08	0.04	-1.90	*0.060*
Social Support	-0.05	0.04	-1.26	0.210
High Social Support Difference	-0.08	0.19	-0.40	0.687
Ln Cortisol Residual	-0.45	0.08	-5.32	**<.0001**
Baseline ln(E/P) * Condition	-0.23	0.07	-3.22	**0.002**
Baseline ln(E/P) * Social Support	0.00	0.07	0.04	0.965
*Condition * Social Support*	0.10	0.04	2.63	**0.010**
Baseline ln(E/P) * High Social Support Difference	-0.60	0.42	-1.46	0.148
Condition * High Social Support Difference	-0.27	0.19	-1.44	0.153
Baseline ln(E/P) * Condition * Social Support	0.31	0.07	4.20	**0.00005**
*Baseline ln(E/P) * Condition * High Social Support Difference*	-1.05	0.42	-2.53	**0.013**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the third quartile = 1, below the third quartile = 0]).

Table S10c.3: Piecewise regression results, with the **highest quartile of social support** as the reference. Social support scores are centered at the third quartile.

DV: Post-manipulation ln(E/P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	-4.51	0.05	-82.28	**<.0001**	-3.76	0.08	-45.05	**<.0001**	-4.35	0.17	-25.86	**<.0001**
Baseline ln(E/P)	0.81	0.11	7.27	**<.0001**	1.14	0.10	11.35	**<.0001**	0.47	0.20	2.38	**0.019**
Condition	0.11	0.05	1.97	*0.051*	-0.59	0.19	-3.16	**0.002**	0.59	0.19	3.16	**0.002**
Social Support	-0.13	0.17	-0.77	0.444	-1.05	0.32	-3.26	**0.001**	0.12	0.46	0.26	0.797
Low Social Support Difference	0.08	0.19	0.40	0.687	1.28	0.35	3.63	**0.0004**	-0.45	0.53	-0.84	0.405
Ln Cortisol Residual	-0.45	0.08	-5.32	**<.0001**	-0.45	0.08	-5.32	**<.0001**	-0.45	0.08	-5.32	**<.0001**
Baseline ln(E/P) * Condition	0.33	0.11	3.00	**0.003**	-0.67	0.22	-3.00	**0.003**	0.67	0.22	3.00	**0.003**
Baseline ln(E/P) * Social Support	-0.60	0.37	-1.64	0.104	-1.34	0.43	-3.15	**0.002**	0.14	0.60	0.23	0.815
*Condition * Social Support*	-0.17	0.16	-1.01	0.317	1.17	0.56	2.09	**0.039**	-1.17	0.56	-2.09	**0.039**
Baseline ln(E/P) * Low Social Support Difference	0.60	0.42	1.46	0.148	1.65	0.46	3.60	**0.0005**	-0.44	0.69	-0.64	0.522
Condition * Low Social Support Difference	0.27	0.19	1.44	0.153	-1.73	0.64	-2.70	**0.008**	1.73	0.64	2.70	**0.008**
Baseline ln(E/P) * Condition * Social Support	-0.74	0.37	-2.02	**0.045**	1.48	0.73	2.02	**0.045**	-1.48	0.73	-2.02	**0.045**
*Baseline ln(E/P) * Condition * Low Social Support Difference*	1.05	0.42	2.53	**0.013**	-2.10	0.83	-2.53	**0.013**	2.10	0.83	2.53	**0.013**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the third quartile = 1, above the third quartile = 0]).

Table S10c.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the third quartile** is the reference group.

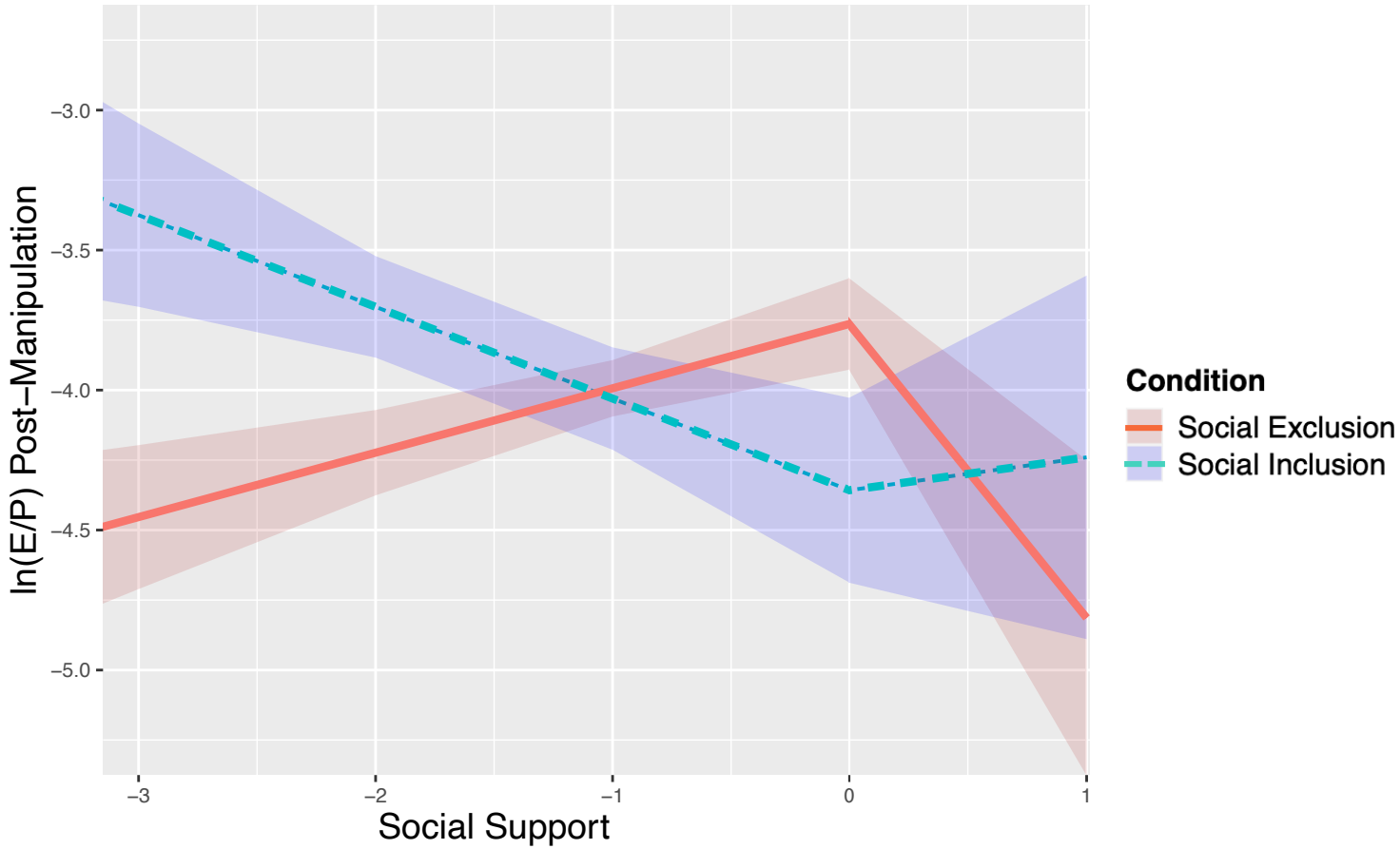
DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.54	0.04	-105.35	**<.0001**
Baseline ln(E/P)	0.70	0.08	8.80	**<.0001**
Condition	0.08	0.04	1.83	*0.070*
Social Support	-0.13	0.17	-0.77	0.444
Low Social Support Difference	0.08	0.19	0.40	0.687
Ln Cortisol Residual	-0.45	0.08	-5.32	**<.0001**
Baseline ln(E/P) * Condition	0.20	0.08	2.53	**0.013**
Baseline ln(E/P) * Social Support	-0.60	0.37	-1.64	0.104
*Condition * Social Support*	-0.17	0.16	-1.01	0.317
Baseline ln(E/P) * Low Social Support Difference	0.60	0.42	1.46	0.148
Condition * Low Social Support Difference	0.27	0.19	1.44	0.153
Baseline ln(E/P) * Condition * Social Support	-0.74	0.37	-2.02	**0.045**
*Baseline ln(E/P) * Condition * Low Social Support Difference*	1.05	0.42	2.53	**0.013**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the third quartile = 1, above the third quartile = 0]).

Plot of piecewise regression model separating low vs. high social support at the third quartile



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the third quartile. Shaded areas represent 95% confidence intervals.

11. Piecewise regression analyses with ln(P) as outcome

The tables in this section display estimates from piecewise regression analyses with ln(P) as the outcome variable, using baseline ln(E/P) as the hormone predictor. Output for these analyses and for piecewise regression analyses using baseline ln(E) and ln(P) separately estimated are posted on OSF.

Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Social Support Difference is the difference in effect/slope of social support from the social support reference group (e.g., High Social Support Difference is the difference in slope between the high social support group versus the low social support reference group; "low" social support refers to social support scores below the cut-point).

3-way (Condition x Baseline ln[E/P] x Social Support Difference) interactions of interest are in *blue and italicized*. This term provides an assessment of whether the 3-way interaction between condition, baseline hormones, and social support are significantly different between the high and low social support groups.

3-way (Condition x Baseline ln[E/P] x Social Support) interactions of interest are ***bolded and italicized***. This term is the 3-way interaction for the reference group (i.e., the low/high social support group). The 3-way interaction for the group coded 1 is the sum of *b*'s of *Condition x Baseline ln(E/P) x Social Support Difference* and ***Condition x Baseline ln(E/P) x Social Support***.

Simple **2-way (Baseline ln[E/P] x Social Support) interactions** of interest within condition are **bolded**. *Condition x Social Support interactions* at average/periovulatory-phase baseline ln(E/P) values are *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Tables S11a.1-4 display estimates from the same piecewise regression model, using a median split to characterize different slopes for low versus high ranges of social support. The separate tables show results when the low (*Tables S11a.1-2*) or high (*Tables S11a.3-4*) social support range is the reference. *Tables S11a.2* and *S11a.4* show marginal effects estimates with social support centered at 1 SD below or above the mean, respectively.

Table S11a.1: Piecewise regression results, with **social support below the median** as the reference. Social support is centered at the median.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.97	0.08	65.43	**<.0001**	4.27	0.12	34.87	**<.0001**	4.51	0.20	22.48	**<.0001**
Baseline ln(E/P)	-1.03	0.14	-7.63	**<.0001**	-1.23	0.15	-7.92	**<.0001**	-0.83	0.22	-3.77	**0.0003**
Condition	-0.01	0.08	-0.13	0.896	0.24	0.24	1.03	0.307	-0.24	0.24	-1.03	0.307
Social Support	-0.06	0.08	-0.72	0.470	-0.41	0.13	-3.24	**0.002**	0.20	0.17	1.16	0.250
High Social Support Difference	0.11	0.16	0.65	0.518	0.52	0.28	1.87	*0.064*	0.03	0.37	0.08	0.940
Ln Cortisol Residual	0.63	0.12	5.24	**<.0001**	0.63	0.12	5.24	**<.0001**	0.63	0.12	5.24	**<.0001**
Baseline ln(E/P) * Condition	-0.20	0.13	-1.46	0.148	0.39	0.27	1.46	0.148	-0.39	0.27	-1.46	0.148
Baseline ln(E/P) * Social Support	-0.08	0.13	-0.65	0.515	-0.44	0.15	-3.05	**0.003**	0.28	0.21	1.29	0.199
*Condition * Social Support*	-0.10	0.08	-1.26	0.209	0.61	0.21	2.85	**0.005**	-0.61	0.21	-2.85	**0.005**
Baseline ln(E/P) * High Social Support Difference	0.30	0.29	1.06	0.293	0.73	0.36	2.02	**0.046**	-0.12	0.44	-0.28	0.779
Condition * High Social Support Difference	0.01	0.16	0.05	0.959	-0.50	0.46	-1.07	0.288	0.50	0.46	1.07	0.288
Baseline ln(E/P) * Condition * Social Support	-0.36	0.13	-2.79	**0.006**	0.72	0.26	2.79	**0.006**	-0.72	0.26	-2.79	**0.006**
*Baseline ln(E/P) * Condition * High Social Support Difference*	0.42	0.28	1.50	0.135	-0.85	0.56	-1.50	0.135	0.85	0.56	1.50	0.135

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.

[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the median = 1, below the median = 0]).

Table S11a.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the median** is the reference group.

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.04	0.06	81.91	**<.0001**
Baseline ln(E/P)	-0.94	0.10	-9.24	**<.0001**
Condition	0.10	0.06	1.68	*0.097*
Social Support	-0.06	0.08	-0.72	0.470
High Social Support Difference	0.11	0.16	0.65	0.518
Ln Cortisol Residual	0.63	0.12	5.24	**<.0001**
Baseline ln(E/P) * Condition	0.21	0.10	2.07	**0.041**
Baseline ln(E/P) * Social Support	-0.08	0.13	-0.65	0.515
*Condition * Social Support*	-0.10	0.08	-1.26	0.209
Baseline ln(E/P) * High Social Support Difference	0.30	0.29	1.06	0.293
Condition * High Social Support Difference	0.01	0.16	0.05	0.959
Baseline ln(E/P) * Condition * Social Support	-0.36	0.13	-2.79	**0.006**
*Baseline ln(E/P) * Condition * High Social Support Difference*	0.42	0.28	1.50	0.135

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the median = 1, below the median = 0]).

Table S11a.3: Piecewise regression results, with **social support above the median** as the reference. Social support scores are centered at the median.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				Social Exclusion Condition[b]				Social Inclusion Condition[c]			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.97	0.08	65.43	**<.0001**	4.27	0.12	34.87	**<.0001**	4.51	0.20	22.48	**<.0001**
Baseline ln(E/P)	-1.03	0.14	-7.63	**<.0001**	-1.23	0.15	-7.92	**<.0001**	-0.83	0.22	-3.77	**0.0003**
Condition	-0.01	0.08	-0.13	0.896	0.24	0.24	1.03	0.307	-0.24	0.24	-1.03	0.307
Social Support	0.05	0.11	0.46	0.648	0.12	0.19	0.60	0.548	0.23	0.23	0.96	0.337
Low Social Support Difference	-0.11	0.16	-0.65	0.518	-0.52	0.28	-1.87	*0.064*	-0.03	0.37	-0.08	0.940
Ln Cortisol Residual	0.63	0.12	5.24	**<.0001**	0.63	0.12	5.24	**<.0001**	0.63	0.12	5.24	**<.0001**
Baseline ln(E/P) * Condition	-0.20	0.13	-1.46	0.148	0.39	0.27	1.46	0.148	-0.39	0.27	-1.46	0.148
Baseline ln(E/P) * Social Support	0.22	0.19	1.13	0.262	0.28	0.26	1.08	0.281	0.15	0.28	0.54	0.589
*Condition * Social Support*	-0.09	0.11	-0.87	0.386	0.11	0.30	0.36	0.717	-0.11	0.30	-0.36	0.717
Baseline ln(E/P) * Low Social Support Difference	-0.30	0.29	-1.06	0.293	-0.73	0.36	-2.02	**0.046**	0.12	0.44	0.28	0.779
Condition * Low Social Support Difference	-0.01	0.16	-0.05	0.959	0.50	0.46	1.07	0.288	-0.50	0.46	-1.07	0.288
Baseline ln(E/P) * Condition * Social Support	0.07	0.19	0.34	0.732	-0.13	0.38	-0.34	0.732	0.13	0.38	0.34	0.732
*Baseline ln(E/P) * Condition * Low Social Support Difference*	-0.42	0.28	-1.50	0.135	0.85	0.56	1.50	0.135	-0.85	0.56	-1.50	0.135

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the median = 1, above the median = 0]).

Table S11a.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the median** is the reference group.

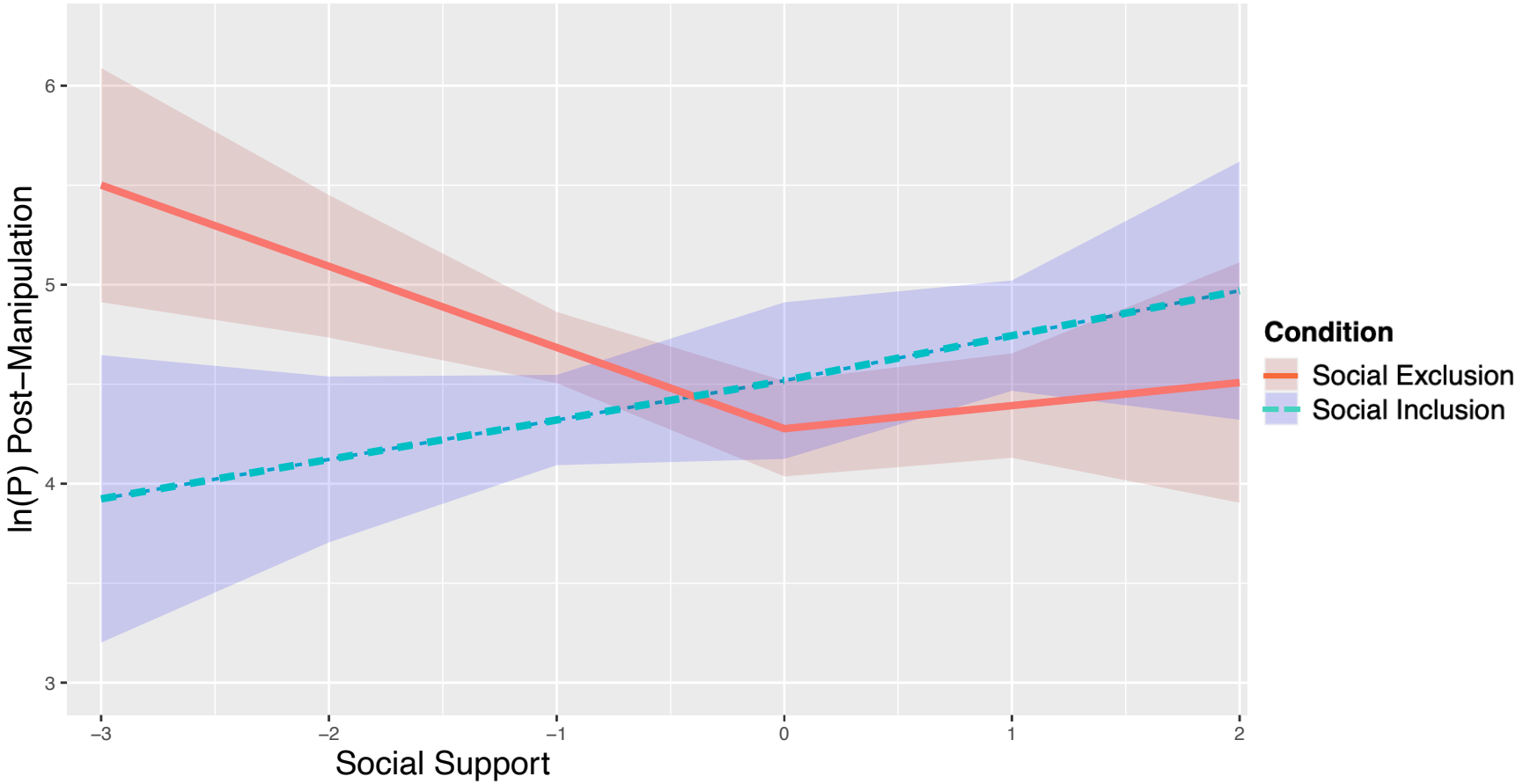
DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.06	81.06	**<.0001**
Baseline ln(E/P)	-0.84	0.11	-7.45	**<.0001**
Condition	-0.09	0.06	-1.46	0.147
Social Support	0.05	0.11	0.46	0.648
Low Social Support Difference	-0.11	0.16	-0.65	0.518
Ln Cortisol Residual	0.63	0.12	5.24	**<.0001**
Baseline ln(E/P) * Condition	-0.14	0.11	-1.25	0.213
Baseline ln(E/P) * Social Support	0.22	0.19	1.13	0.262
*Condition * Social Support*	-0.09	0.11	-0.87	0.386
Baseline ln(E/P) * Low Social Support Difference	-0.30	0.29	-1.06	0.293
Condition * Low Social Support Difference	-0.01	0.16	-0.05	0.959
Baseline ln(E/P) * Condition * Social Support	0.07	0.19	0.34	0.732
*Baseline ln(E/P) * Condition * Low Social Support Difference*	-0.42	0.28	-1.50	0.135

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the median = 1, above the median = 0]).

Plot of piecewise regression model with low vs. high social support separated at the median



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the median. Shaded areas represent 95% confidence intervals.

Tables S11b.1-4 display estimates from the same piecewise regression model, using separation at the second tertile to characterize different slopes for low versus high ranges of social support.

The separate tables show results when the low (*Tables S11b.1-2)* or high (*Tables S11b.3-4*) social support range is the reference.

Tables S11b.2 and *S11b.4* show marginal effects estimates with social support centered at 1 SD below or above the mean, respectively.

Table S11b.1: Piecewise regression results, with **social support below the second tertile** as the reference. Social support scores are centered at the second tertile.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				Social Exclusion Condition[b]				Social Inclusion Condition[c]			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.98	0.08	65.81	**<.0001**	4.17	0.12	34.40	**<.0001**	4.70	0.23	20.90	**<.0001**
Baseline ln(E/P)	-0.97	0.15	-6.55	**<.0001**	-1.29	0.14	-9.05	**<.0001**	-0.65	0.26	-2.50	**0.014**
Condition	-0.09	0.08	-1.12	0.266	0.53	0.26	2.07	**0.041**	-0.53	0.26	-2.07	**0.041**
Social Support	-0.03	0.06	-0.52	0.604	-0.36	0.10	-3.62	**0.0004**	0.26	0.15	1.77	*0.080*
High Social Support Difference	0.10	0.20	0.50	0.619	0.80	0.37	2.17	**0.032**	-0.22	0.52	-0.43	0.671
Ln Cortisol Residual	0.66	0.12	5.46	**<.0001**	0.66	0.12	5.46	**<.0001**	0.66	0.12	5.46	**<.0001**
Baseline ln(E/P) * Condition	-0.32	0.15	-2.15	**0.033**	0.64	0.30	2.15	**0.033**	-0.64	0.30	-2.15	**0.033**
Baseline ln(E/P) * Social Support	-0.03	0.11	-0.28	0.784	-0.37	0.11	-3.29	**0.001**	0.31	0.19	1.64	0.104
*Condition * Social Support*	-0.12	0.06	-1.94	*0.055*	0.63	0.18	3.48	**0.0007**	-0.63	0.18	-3.48	**0.0007**
Baseline ln(E/P) * High Social Support Difference	0.34	0.40	0.85	0.398	1.06	0.46	2.28	**0.024**	-0.39	0.64	-0.60	0.549
Condition * High Social Support Difference	0.10	0.20	0.51	0.609	-1.02	0.64	-1.60	0.112	1.02	0.64	1.60	0.112
Baseline ln(E/P) * Condition * Social Support	-0.34	0.11	-3.08	**0.003**	0.69	0.22	3.08	**0.003**	-0.69	0.22	-3.08	**0.003**
*Baseline ln(E/P) * Condition * High Social Support Difference*	0.72	0.40	1.82	*0.071*	-1.44	0.79	-1.82	*0.071*	1.44	0.79	1.82	*0.071*

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.

[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the second tertile = 1, below the second tertile = 0]).

Table S11b.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the second tertile** is the reference group.

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	4.98	0.08	65.81	**<.0001**
Baseline ln(E/P)	-0.97	0.15	-6.55	**<.0001**
Condition	-0.09	0.08	-1.12	0.266
Social Support	-0.03	0.06	-0.52	0.604
High Social Support Difference	0.10	0.20	0.50	0.619
Ln Cortisol Residual	0.66	0.12	5.46	**<.0001**
Baseline ln(E/P) * Condition	-0.32	0.15	-2.15	**0.033**
Baseline ln(E/P) * Social Support	-0.03	0.11	-0.28	0.784
*Condition * Social Support*	-0.12	0.06	-1.94	*0.055*
Baseline ln(E/P) * High Social Support Difference	0.34	0.40	0.85	0.398
Condition * High Social Support Difference	0.10	0.20	0.51	0.609
Baseline ln(E/P) * Condition * Social Support	-0.34	0.11	-3.08	**0.003**
*Baseline ln(E/P) * Condition * High Social Support Difference*	0.72	0.40	1.82	*0.071*

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the second tertile = 1, below the second tertile = 0]).

Table S11b.3: Piecewise regression results, with the **highest tertile of social support** as the reference. Social support scores are centered at the second tertile.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.98	0.08	65.81	**<.0001**	4.17	0.12	34.40	**<.0001**	4.70	0.23	20.90	**<.0001**
Baseline ln(E/P)	-0.97	0.15	-6.55	**<.0001**	-1.29	0.14	-9.05	**<.0001**	-0.65	0.26	-2.50	**0.014**
Condition	-0.09	0.08	-1.12	0.266	0.53	0.26	2.07	**0.041**	-0.53	0.26	-2.07	**0.041**
Social Support	0.07	0.16	0.42	0.675	0.43	0.31	1.41	0.162	0.05	0.40	0.11	0.910
Low Social Support Difference	-0.10	0.20	-0.50	0.619	-0.80	0.37	-2.17	**0.032**	0.22	0.52	0.43	0.671
Ln Cortisol Residual	0.66	0.12	5.46	**<.0001**	0.66	0.12	5.46	**<.0001**	0.66	0.12	5.46	**<.0001**
Baseline ln(E/P) * Condition	-0.32	0.15	-2.15	**0.033**	0.64	0.30	2.15	**0.033**	-0.64	0.30	-2.15	**0.033**
Baseline ln(E/P) * Social Support	0.31	0.32	0.95	0.343	0.68	0.40	1.70	*0.092*	-0.07	0.50	-0.15	0.885
*Condition * Social Support*	-0.02	0.16	-0.12	0.908	-0.39	0.50	-0.77	0.442	0.39	0.50	0.77	0.442
Baseline ln(E/P) * Low Social Support Difference	-0.34	0.40	-0.85	0.398	-1.06	0.46	-2.28	**0.024**	0.39	0.64	0.60	0.549
Condition * Low Social Support Difference	-0.10	0.20	-0.51	0.609	1.02	0.64	1.60	0.112	-1.02	0.64	-1.60	0.112
Baseline ln(E/P) * Condition * Social Support	0.38	0.32	1.18	0.239	-0.76	0.64	-1.18	0.239	0.76	0.64	1.18	0.239
*Baseline ln(E/P) * Condition * Low Social Support Difference*	-0.72	0.40	-1.82	*0.071*	1.44	0.79	1.82	*0.071*	-1.44	0.79	-1.82	*0.071*

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the second tertile = 1, above the second tertile = 0]).

Table S11b.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the second tertile** is the reference group.

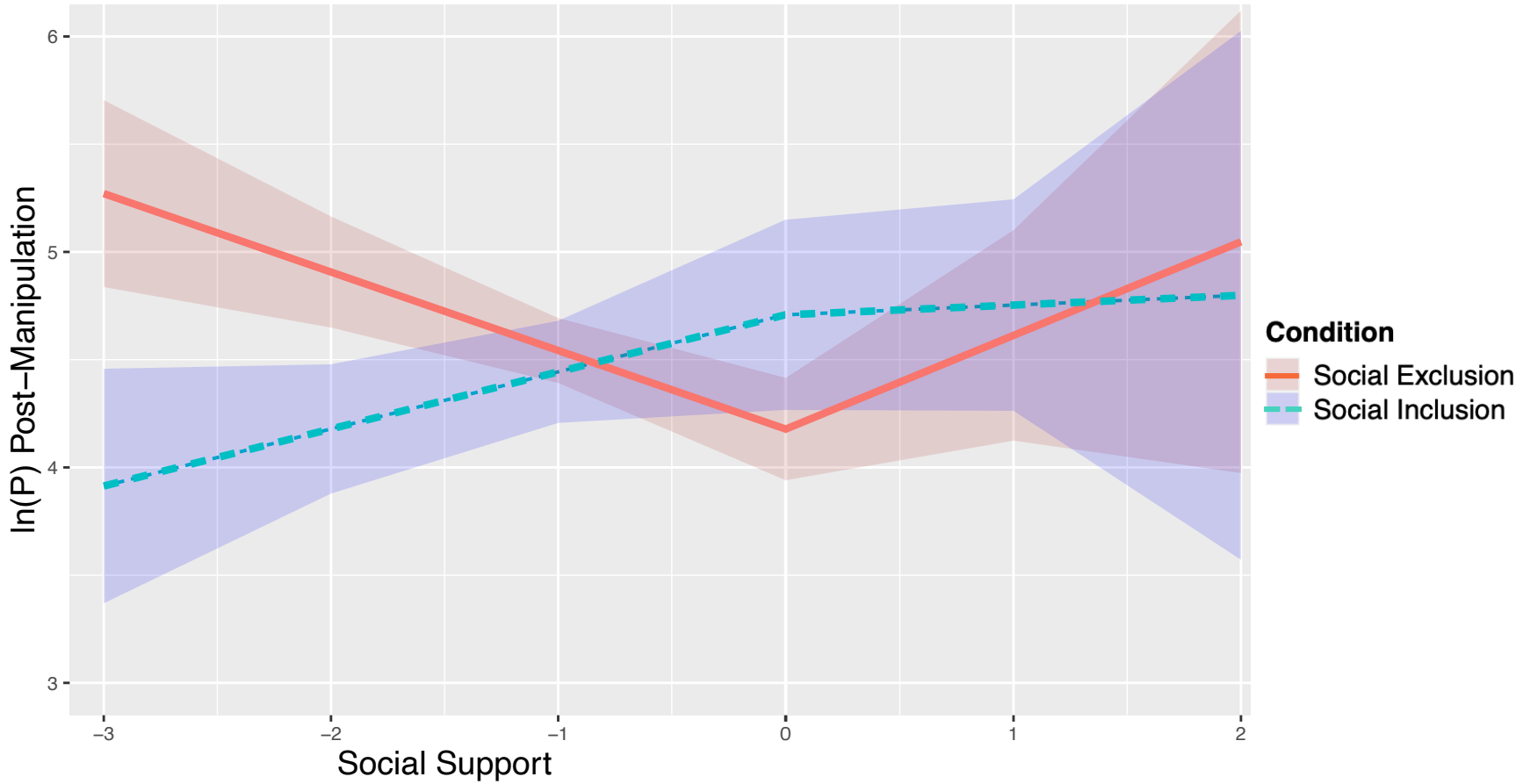
DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.06	84.08	**<.0001**
Baseline ln(E/P)	-0.83	0.11	-7.62	**<.0001**
Condition	-0.09	0.06	-1.57	0.119
Social Support	0.07	0.16	0.42	0.675
Low Social Support Difference	-0.10	0.20	-0.50	0.619
Ln Cortisol Residual	0.66	0.12	5.46	**<.0001**
Baseline ln(E/P) * Condition	-0.15	0.11	-1.40	0.164
Baseline ln(E/P) * Social Support	0.31	0.32	0.95	0.343
*Condition * Social Support*	-0.02	0.16	-0.12	0.908
Baseline ln(E/P) * Low Social Support Difference	-0.34	0.40	-0.85	0.398
Condition * Low Social Support Difference	-0.10	0.20	-0.51	0.609
Baseline ln(E/P) * Condition * Social Support	0.38	0.32	1.18	0.239
*Baseline ln(E/P) * Condition * Low Social Support Difference*	-0.72	0.40	-1.82	*0.071*

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the second tertile = 1, above the second tertile = 0]).

Plot of piecewise regression model with low vs. high social support separated at the second tertile



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the second tertile. Shaded areas represent 95% confidence intervals.

Tables S11c.1-4 display estimates from the same piecewise regression model, using separation at the third quartile to characterize different slopes for low versus high ranges of social support.

The separate tables show results when the low (*Tables S11c.1-2)* or high (*Tables S11c.3-4*) social support range is the reference.

Tables S11c.2 and *S11c.4* show marginal effects estimates with social support centered at 1 SD below or above the mean, respectively.

Table S11c.1: Piecewise regression results, with **social support below the third quartile** as the reference. Social support scores are centered at the third quartile.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.99	0.08	65.53	**<.0001**	4.12	0.12	35.46	**<.0001**	4.78	0.23	20.43	**<.0001**
Baseline ln(E/P)	-0.97	0.15	-6.25	**<.0001**	-1.36	0.14	-9.69	**<.0001**	-0.58	0.28	-2.08	**0.040**
Condition	-0.11	0.08	-1.49	0.140	0.67	0.26	2.55	**0.012**	-0.67	0.26	-2.55	**0.012**
Social Support	-0.02	0.06	-0.38	0.707	-0.35	0.09	-4.01	**0.0001**	0.27	0.14	1.98	**<.050**
High Social Support Difference	0.11	0.26	0.41	0.684	1.39	0.49	2.84	**0.005**	-0.40	0.74	-0.54	0.588
Ln Cortisol Residual	0.65	0.12	5.54	**<.0001**	0.65	0.12	5.54	**<.0001**	0.65	0.12	5.54	**<.0001**
Baseline ln(E/P) * Condition	-0.39	0.16	-2.52	**0.013**	0.78	0.31	2.52	**0.013**	-0.78	0.31	-2.52	**0.013**
Baseline ln(E/P) * Social Support	-0.03	0.10	-0.30	0.767	-0.36	0.10	-3.62	**0.0004**	0.30	0.18	1.72	*0.088*
*Condition * Social Support*	-0.12	0.06	-2.18	**0.031**	0.62	0.16	3.82	**0.0002**	-0.62	0.16	-3.82	**0.0002**
Baseline ln(E/P) * High Social Support Difference	0.69	0.58	1.20	0.234	1.97	0.64	3.09	**0.003**	-0.59	0.96	-0.61	0.542
Condition * High Social Support Difference	0.18	0.26	0.68	0.499	-1.80	0.89	-2.02	**0.046**	1.80	0.89	2.02	**0.046**
Baseline ln(E/P) * Condition * Social Support	-0.33	0.10	-3.28	**0.001**	0.67	0.20	3.28	**0.001**	-0.67	0.20	-3.28	**0.001**
*Baseline ln(E/P) * Condition * High Social Support Difference*	1.28	0.58	2.22	**0.029**	-2.56	1.15	-2.22	**0.029**	2.56	1.15	2.22	**0.029**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the third quartile = 1, below the third quartile = 0]).

Table S11c.2: Piecewise regression results, testing simple effects with **social support centered at 1 SD below the mean**. **Social support below the third quartile** is the reference group.

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.03	0.06	84.47	**<.0001**
Baseline ln(E/P)	-0.91	0.10	-9.36	**<.0001**
Condition	0.11	0.06	1.77	*0.080*
Social Support	-0.02	0.06	-0.38	0.707
High Social Support Difference	0.11	0.26	0.41	0.684
Ln Cortisol Residual	0.65	0.12	5.54	**<.0001**
Baseline ln(E/P) * Condition	0.22	0.10	2.22	**0.028**
Baseline ln(E/P) * Social Support	-0.03	0.10	-0.30	0.767
*Condition * Social Support*	-0.12	0.06	-2.18	**0.031**
Baseline ln(E/P) * High Social Support Difference	0.69	0.58	1.20	0.234
Condition * High Social Support Difference	0.18	0.26	0.68	0.499
Baseline ln(E/P) * Condition * Social Support	-0.33	0.10	-3.28	**0.001**
*Baseline ln(E/P) * Condition * High Social Support Difference*	1.28	0.58	2.22	**0.029**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD below the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD below the mean is **bolded and in blue**.

High Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support above the third quartile = 1, below the third quartile = 0]).

Table S11c.3: Piecewise regression results, with the **highest quartile of social support** as the reference. Social support scores are centered at the third quartile.

DV: Post-manipulation ln(P)												
	Condition Effect-Coded[a]				**Social Exclusion Condition[b]**				**Social Inclusion Condition[c]**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	4.99	0.08	65.53	**<.0001**	4.12	0.12	35.46	**<.0001**	4.78	0.23	20.43	**<.0001**
Baseline ln(E/P)	-0.97	0.15	-6.25	**<.0001**	-1.36	0.14	-9.69	**<.0001**	-0.58	0.28	-2.08	**0.040**
Condition	-0.11	0.08	-1.49	0.140	0.67	0.26	2.55	**0.012**	-0.67	0.26	-2.55	**0.012**
Social Support	0.09	0.23	0.38	0.709	1.05	0.45	2.34	**0.021**	-0.13	0.63	-0.21	0.837
Low Social Support Difference	-0.11	0.26	-0.41	0.684	-1.39	0.49	-2.84	**0.005**	0.40	0.74	0.54	0.588
Ln Cortisol Residual	0.65	0.12	5.54	**<.0001**	0.65	0.12	5.54	**<.0001**	0.65	0.12	5.54	**<.0001**
Baseline ln(E/P) * Condition	-0.39	0.16	-2.52	**0.013**	0.78	0.31	2.52	**0.013**	-0.78	0.31	-2.52	**0.013**
Baseline ln(E/P) * Social Support	0.66	0.51	1.29	0.198	1.60	0.59	2.70	**0.008**	-0.28	0.83	-0.34	0.733
*Condition * Social Support*	0.06	0.23	0.25	0.804	-1.18	0.78	-1.52	0.132	1.18	0.78	1.52	0.132
Baseline ln(E/P) * Low Social Support Difference	-0.69	0.58	-1.20	0.234	-1.97	0.64	-3.09	**0.003**	0.59	0.96	0.61	0.542
Condition * Low Social Support Difference	-0.18	0.26	-0.68	0.499	1.80	0.89	2.02	**0.046**	-1.80	0.89	-2.02	**0.046**
Baseline ln(E/P) * Condition * Social Support	0.94	0.51	1.85	*0.066*	-1.89	1.02	-1.85	*0.066*	1.89	1.02	1.85	*0.066*
*Baseline ln(E/P) * Condition * Low Social Support Difference*	-1.28	0.58	-2.22	**0.029**	2.56	1.15	2.22	**0.029**	-2.56	1.15	-2.22	**0.029**

[a]Results with condition effect-coded, with social exclusion = 1 and social inclusion = -1. Baseline ln(E/P) is centered at the mean.
[b]Results with social exclusion condition as the reference group. Condition is dummy-coded, with social inclusion = 1 and social exclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.
[c]Results with social inclusion condition as the reference group. Condition is dummy-coded, with social exclusion = 1 and social inclusion = 0. Baseline ln(E/P) is centered at 1 SD above the mean.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the third quartile = 1, above the third quartile = 0]).

Table S11c.4: Piecewise regression results, testing simple effects with **social support centered at 1 SD above the mean**. **Social support above the third quartile** is the reference group.

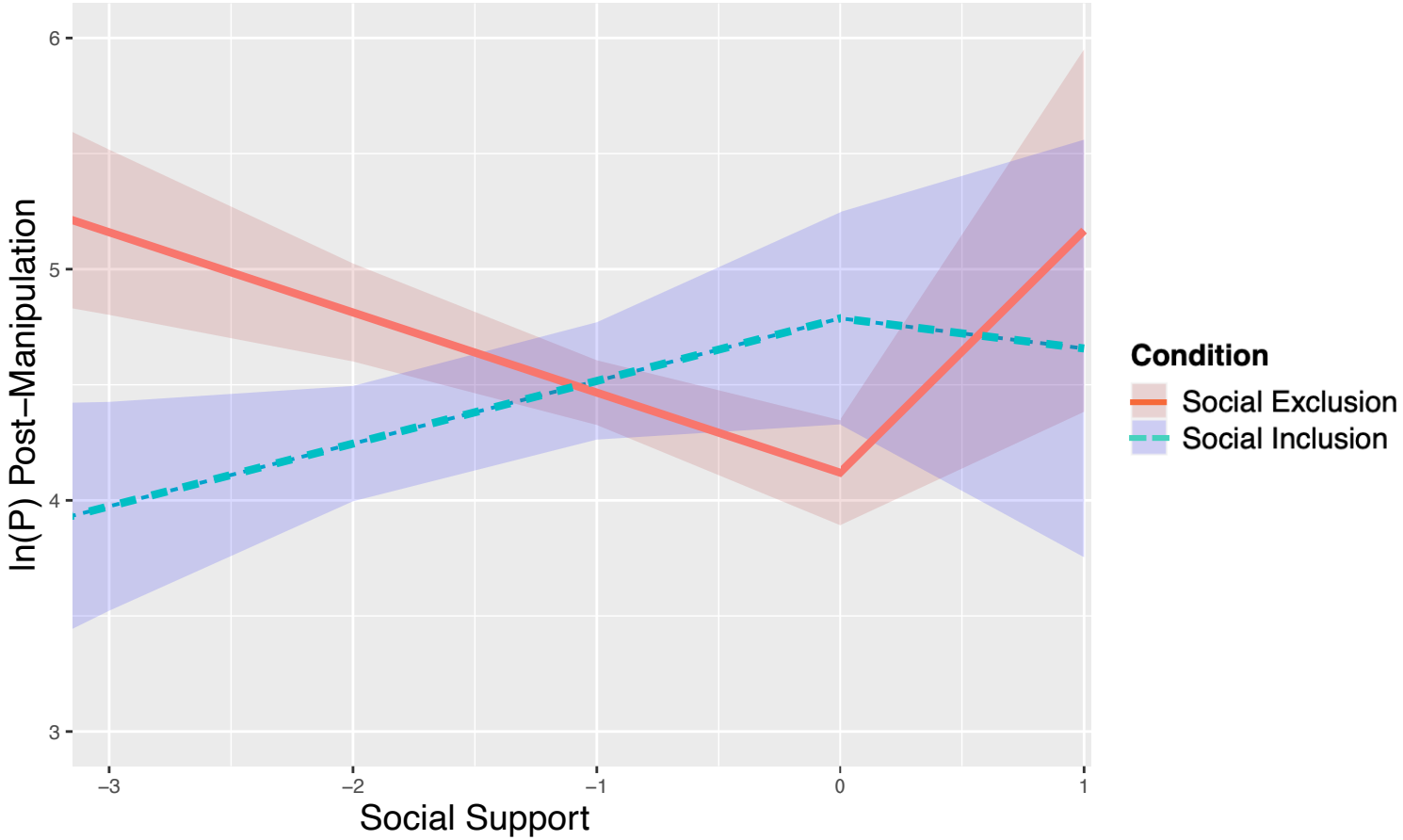
DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.06	83.73	**<.0001**
Baseline ln(E/P)	-0.85	0.11	-7.66	**<.0001**
Condition	-0.10	0.06	-1.73	*0.087*
Social Support	0.09	0.23	0.38	0.709
Low Social Support Difference	-0.11	0.26	-0.41	0.684
Ln Cortisol Residual	0.65	0.12	5.54	**<.0001**
Baseline ln(E/P) * Condition	-0.22	0.11	-2.00	**0.047**
Baseline ln(E/P) * Social Support	0.66	0.51	1.29	0.198
*Condition * Social Support*	0.06	0.23	0.25	0.804
Baseline ln(E/P) * Low Social Support Difference	-0.69	0.58	-1.20	0.234
Condition * Low Social Support Difference	-0.18	0.26	-0.68	0.499
Baseline ln(E/P) * Condition * Social Support	0.94	0.51	1.85	*0.066*
*Baseline ln(E/P) * Condition * High Social Support Difference*	-1.28	0.58	-2.22	**0.029**

Condition is mean-centered. Baseline ln(E/P) is centered at the mean. Social support is centered at 1 SD above the mean.

Simple 2-way interaction of **baseline ln(E/P) * condition** when social support is 1 SD above the mean is **bolded and in blue**.

Low Social Support Difference = (Social Support) * (High vs. Low Social Support [dummy-coded; social support below the third quartile = 1, above the third quartile = 0]).

Plot of piecewise regression model with low vs. high social support separated at the third quartile



The plot shows the simple 2-way interaction between experimental condition and social support when baseline ln(E/P) is 1 SD above the mean, a hormone profile characteristic of the periovulatory phase. Social support scores are centered at the third quartile. Shaded areas represent 95% confidence intervals.

12. Regression analyses with social support quadratic term

The tables in this section display estimates from regression analyses testing a curvilinear relationship of social support with post-manipulation ln(E/P) and ln(P), using baseline ln(E/P) as the hormone predictor. Output for these analyses and for analyses using baseline ln(E) and ln(P) separately estimated are posted on OSF.

Baseline and post-manipulation hormone values are natural log-transformed. Hormone outliers are winsorized. Social support scores are standardized. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

3-way (Condition x Baseline ln[E/P] x Social Support Squared) interactions of interest are in *blue and italicized*.
3-way (Condition x Baseline ln[E/P] x Social Support) interactions of interest are **bolded**.
Condition x Social Support interactions at average baseline ln(E/P) levels are *italicized*.

$p < .05$ **bolded**; $p < .10$ *italicized*.

Table S12a: Results of regression analyses on post-manipulation log-transformed estradiol-to-progesterone ratio (ln(E/P)), testing a quadratic effect of social support.

DV: Post-manipulation ln(E/P)				
	b	SE	*t*-value	*p*-value
(Intercept)	-4.47	0.04	-110.37	**<.0001**
Baseline ln(E/P)	0.79	0.07	10.79	**<.0001**
Condition	0.03	0.04	0.73	0.464
Social Support	-0.06	0.03	-1.79	*0.076*
Social Support Squared	0.00	0.03	-0.13	0.893
Ln Cortisol Residual	-0.44	0.09	-4.97	**<.0001**
Baseline ln(E/P) * Condition	0.07	0.07	0.97	0.333
Baseline ln(E/P) * Social Support	-0.04	0.06	-0.73	0.469
*Condition * Social Support*	0.06	0.03	1.84	*0.069*
Baseline ln(E/P) * Social Support Squared	-0.02	0.05	-0.37	0.715
Condition * Social Support Squared	-0.04	0.03	-1.18	0.240
Baseline ln(E/P) * Condition * Social Support	0.18	0.06	3.07	**0.003**
*Baseline ln(E/P) * Condition * Social Support Squared*	-0.07	0.05	-1.31	0.192

Table S12b: Results of regression analyses on post-manipulation log-transformed progesterone (ln(P)), testing a quadratic effect of social support.

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.06	89.90	**<.0001**
Baseline ln(E/P)	-0.98	0.10	-9.70	**<.0001**
Condition	0.00	0.06	-0.07	0.945
Social Support	-0.01	0.04	-0.17	0.865
Social Support Squared	0.01	0.04	0.29	0.775
Ln Cortisol Residual	0.63	0.12	5.12	**<.0001**
Baseline ln(E/P) * Condition	-0.06	0.10	-0.59	0.557
Baseline ln(E/P) * Social Support	0.04	0.08	0.51	0.611
*Condition * Social Support*	-0.10	0.04	-2.15	**0.034**
Baseline ln(E/P) * Social Support Squared	0.07	0.07	0.92	0.358
Condition * Social Support Squared	0.02	0.04	0.36	0.722
Baseline ln(E/P) * Condition * Social Support	-0.18	0.08	-2.34	**0.021**
*Baseline ln(E/P) * Condition * Social Support Squared*	0.05	0.07	0.63	0.528

13. Regression analyses on progesterone changes with social anxiety as a moderator

In an attempt to replicate findings from Maner et al. (2010; study 1) and Duffy et al. (2017; blocked condition), we conducted analyses on progesterone changes using social anxiety as a moderator. Our results show that the interaction between experimental condition and social anxiety is nonsignificant across all analyses, and the direction of effects run in the opposite direction as previously reported.

Tables S13a-d notes. Condition is coded as a dummy-like variable, with the social exclusion condition as the reference group (coded 0) and the social inclusion group coded -1. This way, the direction of effects for condition is consistent with the rest of the tables in this supplement. (Note that condition was effect-coded in Tables S1-S12, with social exclusion = 1 and social inclusion = -1.) With social exclusion coded 0, the main effects of social anxiety apply to the social exclusion condition only, the primary condition of interest. Results for high and low social anxiety are estimated with social anxiety centered at 1 SD above and below the mean, respectively.

For *Table S13a-b* on raw hormone values, see section 6 above for *Notes*. For *Tables S13c-d* on log-transformed hormone values, see section 7 above for *Notes* on tables and analyses.

Condition x social anxiety interactions of interest are **bolded**.

Table S13a displays linear regression estimates from analyses that parallel those of Maner et al. (2010), using raw hormone values and progesterone change (post-manipulation P – baseline P) as the outcome variable. Results are on our primary sample, which excludes participants who failed the manipulation check based on discriminant analysis.

DV: Progesterone Change								
	High Social Anxiety				**Low Social Anxiety**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	0.29	0.15	1.91	*0.058*	0.03	0.16	0.16	0.874
Condition	0.41	0.23	1.80	*0.075*	0.18	0.24	0.77	0.445
Social Anxiety	0.13	0.11	1.24	0.218	0.13	0.11	1.24	0.218
Condition * Social Anxiety	0.11	0.17	0.67	0.502	0.11	0.17	0.67	0.502

Table S13b displays linear regression estimates from analyses that parallel those of Maner et al. (2010), using raw hormone values and progesterone change (post-manipulation P – baseline P) as the outcome variable. Results are on the full sample of participants.

DV: Progesterone Change								
	High Social Anxiety				**Low Social Anxiety**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	0.34	0.15	2.34	**0.021**	-0.002	0.15	-0.01	0.988
Condition	0.51	0.22	2.32	**0.021**	0.20	0.22	0.91	0.366
Social Anxiety	0.17	0.11	1.63	0.104	0.17	0.11	1.63	0.104
Condition * Social Anxiety	0.16	0.16	0.97	0.335	0.16	0.16	0.97	0.335

Table S13c displays linear regression estimates from analyses that parallel those of Duffy et al. (2017), with post-manipulation log-transformed progesterone (ln[P]) as the outcome variable and controlling for baseline ln(P). Results are on our primary sample, which excludes participants who failed the manipulation check based on discriminant analysis.

DV: Post-manipulation ln(P)								
	High Social Anxiety				**Low Social Anxiety**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	5.12	0.07	76.52	**<.0001**	4.96	0.07	68.89	**<.0001**
Baseline ln(P)	0.80	0.05	16.31	**<.0001**	0.80	0.05	16.31	**<.0001**
Condition	0.11	0.10	1.12	0.264	0.02	0.11	0.23	0.816
Social Anxiety	0.08	0.05	1.78	*0.078*	0.08	0.05	1.78	*0.078*
Condition * Social Anxiety	0.04	0.07	0.60	0.549	0.04	0.07	0.60	0.549

Table S13d displays linear regression estimates from analyses that parallel those of Duffy et al. (2017), with post-manipulation log-transformed progesterone (ln[P]) as the outcome variable and controlling for baseline ln(P). Results are on the full sample of participants.

DV: Post-manipulation ln(P)								
	High Social Anxiety				**Low Social Anxiety**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	5.14	0.06	82.88	**<.0001**	4.98	0.06	76.85	**<.0001**
Baseline ln(P)	0.81	0.04	18.53	**<.0001**	0.81	0.04	18.53	**<.0001**
Condition	0.17	0.09	1.78	*0.077*	0.07	0.10	0.79	0.431
Social Anxiety	0.08	0.04	1.80	*0.074*	0.08	0.04	1.80	*0.074*
Condition * Social Anxiety	0.05	0.07	0.68	0.497	0.05	0.07	0.68	0.497

Tables S13e-g display linear regression estimates from analyses that parallel our main analyses, with social anxiety as a moderator, in the place of social support. Analyses examine interactions with baseline hormone levels to explore potential effects by cycle phase. Baseline hormone values are mean-centered, which provides estimates of main effects across baseline hormone values. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

We did not find clear support for social anxiety moderating effects of social exclusion on progesterone responses. We also did not find clear evidence that effects were moderated by baseline hormone levels.

For *Tables S13e-f* on log-transformed hormone values, see section 7 above for *Notes* on tables and analyses. For *Table S13g* on raw hormone values, see section 6 above for *Notes*.

Condition x social anxiety interactions of interest at average baseline hormone values are **bolded**.

Table S13e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	119.56	**<.0001**
Baseline ln(E/P)	-0.94	0.08	-12.44	**<.0001**
Condition	0.01	0.04	0.33	0.745
Social Anxiety	0.07	0.04	1.65	0.102
Ln Cortisol Residual	0.57	0.13	4.52	**<.0001**
Baseline ln(E/P) * Condition	-0.002	0.08	-0.02	0.981
Baseline ln(E/P) * Social Anxiety	0.11	0.08	1.40	0.165
Condition * Social Anxiety	0.01	0.04	0.18	0.855
Baseline ln(E/P) * Condition * Social Anxiety	-0.02	0.08	-0.25	0.807

Table S13f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.02	0.04	139.65	**<.0001**
Baseline ln(E)	0.06	0.16	0.37	0.716
Condition	0.02	0.04	0.61	0.543
Social Anxiety	0.05	0.04	1.23	0.221
Baseline ln(P)	0.80	0.07	11.92	**<.0001**
Ln Cortisol Residual	0.45	0.11	4.24	**<.0001**
Baseline ln(E) * Condition	-0.02	0.16	-0.103	0.918
Baseline ln(E) * Social Anxiety	0.003	0.16	0.02	0.986
Condition * Social Anxiety	-0.003	0.04	-0.07	0.947
Baseline ln(P) * Condition	-0.03	0.07	-0.47	0.637
Baseline ln(P) * Social Anxiety	-0.11	0.07	-1.59	0.116
Baseline ln(E) * Condition * Social Anxiety	0.19	0.16	1.19	0.237
Baseline ln(P) * Condition * Social Anxiety	0.02	0.07	0.27	0.784

Table S13g: Results of linear regression analyses on post-manipulation progesterone, using raw hormone values

DV: Post-manipulation Progesterone				
	b	SE	*t*-value	*p*-value
(Intercept)	0.01	0.05	0.15	0.880
Baseline Estradiol	0.007	0.07	0.11	0.911
Condition	0.05	0.05	1.09	0.280
Social Anxiety	0.05	0.05	1.05	0.295
Baseline Progesterone	0.84	0.06	13.00	**<.0001**
Cortisol Residual	0.12	0.05	2.77	**0.007**
Baseline Estradiol * Condition	0.04	0.06	0.65	0.519
Baseline Estradiol * Social Anxiety	-0.06	0.07	-0.90	0.368
Condition * Social Anxiety	0.02	0.05	0.42	0.673
Baseline Progesterone * Condition	0.02	0.06	0.36	0.718
Baseline Progesterone * Social Anxiety	0.08	0.07	1.05	0.295
Baseline Estradiol * Condition * Social Anxiety	0.09	0.07	1.26	0.212
Baseline Progesterone * Condition * Social Anxiety	0.01	0.08	0.17	0.864

14. Regression analyses on progesterone changes with rejection sensitivity as a moderator

In an attempt to replicate findings from Duffy et al. (2017; blocked condition), we conducted analyses on progesterone changes using rejection sensitivity as a moderator. (Maner et al. did not examine effects of rejection sensitivity in study 1, only study 2; the latter included an opportunity to affiliate that our study lacked. Duffy et al. found that social anxiety and rejection sensitivity had similar effects in their blocked condition, comparable to effects in Maner et al.'s study 1. As social anxiety and rejection sensitivity correlate .48, it makes sense that results would run in the same direction, as we observe.)

Our results show that the interaction between experimental condition and rejection sensitivity run in the opposite direction as previously reported, such that highly rejection-sensitive individuals are more likely to experience increases in progesterone as a result of social exclusion and decreases in progesterone as a result of social inclusion. The significance of the condition x rejection sensitivity interaction ranged from $p = .011$ to .343, depending on inclusion criteria and whether raw or log-transformed hormone values were used. Although effects were not robust across analyses, patterns suggest that highly rejection-sensitive individuals find social exclusion stressful and may thus experience heightened progesterone levels. It is reasonably well-established that progesterone can be released in response to stress. Furthermore, patterns suggest that progesterone may decrease as a result of social *in*clusion among rejection-sensitive individuals. This pattern seems, in our view, more consistent with a dampening of stress responses than with motivations for social avoidance. More research is needed to replicate these and previous findings and to further examine progesterone's potential roles in regulating stress responses and social motivations.

Tables S14a-d notes. Condition is coded as a dummy-like variable, with the social exclusion condition as the reference group (coded 0) and the social inclusion group coded -1. This way, the direction of effects for condition is consistent with the rest of the tables in this supplement. (Note that condition was effect-coded in Tables S1-S12 and S13e-g, with social exclusion = 1 and social inclusion = -1.) With social exclusion coded 0, the main effects of rejection sensitivity apply to the social exclusion condition only, the primary condition of interest. Results for high and low rejection sensitivity are estimated with rejection sensitivity centered at 1 SD above and below the mean, respectively.

For *Table S14a-b* on raw hormone values, see section 6 above for *Notes*. For *Tables S14c-d* on log-transformed hormone values, see section 7 above for *Notes* on tables and analyses.

Condition x rejection sensitivity interactions of interest are **bolded**.

Table S14a displays linear regression estimates from analyses that parallel those of Maner et al. (2010), using raw hormone values and progesterone change (post-manipulation P – baseline P) as the outcome variable. Results are on our primary sample, which excludes participants who failed the manipulation check based on discriminant analysis.

DV: Progesterone Change								
	High Rejection Sensitivity				**Low Rejection Sensitivity**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	0.27	0.15	1.81	*0.073*	0.01	0.19	0.06	0.949
Condition	0.60	0.23	2.64	**0.009**	0.001	0.24	0.01	0.996
Rejection Sensitivity	0.13	0.12	1.06	0.289	0.13	0.12	1.06	0.289
Condition * Rejection Sensitivity	0.30	0.17	1.80	*0.074*	0.30	0.17	1.80	*0.074*

Table S14b displays linear regression estimates from analyses that parallel those of Maner et al. (2010), using raw hormone values and progesterone change (post-manipulation P – baseline P) as the outcome variable. Results are on the full sample of participants.

DV: Progesterone Change								
	High Rejection Sensitivity				**Low Rejection Sensitivity**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	0.38	0.14	2.67	**0.008**	-0.08	0.16	-0.52	0.606
Condition	0.73	0.21	3.49	**0.001**	-0.03	0.21	-0.13	0.893
Rejection Sensitivity	0.23	0.11	2.11	**0.036**	0.23	0.11	2.11	**0.037**
Condition * Rejection Sensitivity	0.38	0.15	2.56	**0.011**	0.38	0.15	2.56	**0.011**

Table S14c displays linear regression estimates from analyses that parallel those of Duffy et al. (2017), with post-manipulation log-transformed progesterone (ln[P]) as the outcome variable and controlling for baseline ln(P). Results are on our primary sample, which excludes participants who failed the manipulation check based on discriminant analysis.

DV: Post-manipulation ln(P)								
	High Rejection Sensitivity				**Low Rejection Sensitivity**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	5.11	0.07	74.60	**<.0001**	4.96	0.08	60.14	**<.0001**
Baseline ln(P)	0.81	0.05	16.41	**<.0001**	0.81	0.05	16.41	**<.0001**
Condition	0.13	0.10	1.29	0.199	-0.01	0.11	-0.08	0.940
Rejection Sensitivity	0.07	0.05	1.34	0.183	0.07	0.05	1.34	0.183
Condition * Rejection Sensitivity	0.07	0.07	0.95	0.343	0.07	0.07	0.95	0.343

Table S14d displays linear regression estimates from analyses that parallel those of Duffy et al. (2017), with post-manipulation log-transformed progesterone (ln[P]) as the outcome variable and controlling for baseline ln(P). Results are on the full sample of participants.

DV: Post-manipulation ln(P)								
	High Rejection Sensitivity				**Low Rejection Sensitivity**			
	b	SE	*t*-value	*p*-value	*b*	SE	*t*-value	*p*-value
(Intercept)	5.14	0.06	84.17	**<.0001**	4.96	0.07	71.69	**<.0001**
Baseline ln(P)	0.82	0.04	18.73	**<.0001**	0.82	0.04	18.73	**<.0001**
Condition	0.20	0.09	2.21	**0.029**	0.03	0.09	0.33	0.739
Rejection Sensitivity	0.09	0.05	1.93	*0.056*	0.09	0.05	1.93	*0.056*
Condition * Rejection Sensitivity	0.09	0.06	1.33	0.184	0.09	0.06	1.33	0.184

Tables S14e-g display linear regression estimates from analyses that parallel our main analyses, with rejection sensitivity as a moderator, in the place of social support. Analyses examine interactions with baseline hormone levels to explore potential effects by cycle phase. Baseline hormone values are mean-centered, which provides estimates of main effects across baseline hormone values. Condition is effect-coded, with social exclusion = 1 and social inclusion = -1.

We did not find clear support for rejection sensitivity moderating effects of social exclusion on progesterone. We also did not find clear evidence that effects were moderated by baseline hormone levels.

For *Tables S14e-f* on log-transformed hormone values, see section 7 above for *Notes* on tables and analyses. For *Table S14g* on raw hormone values, see section 6 above for *Notes*.

Condition x rejection sensitivity interactions of interest at average baseline hormone values are **bolded**.

Table S14e: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol-to-progesterone ratio (ln(E/P)) as a predictor

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.00	0.04	119.81	**<.0001**
Baseline ln(E/P)	-0.96	0.08	-12.53	**<.0001**
Condition	0.001	0.04	0.02	0.985
Rejection Sensitivity	0.10	0.05	2.14	**0.034**
Ln Cortisol Residual	0.59	0.12	4.85	**<.0001**
Baseline ln(E/P) * Condition	-0.02	0.08	-0.32	0.750
Baseline ln(E/P) * Rejection Sensitivity	0.10	0.08	1.28	0.205
Condition * Rejection Sensitivity	0.02	0.04	0.54	0.587
Baseline ln(E/P) * Condition * Rejection Sensitivity	0.04	0.08	0.57	0.573

Table S14f: Results of linear regression analyses on post-manipulation log-transformed progesterone (ln(P)), using baseline log-transformed estradiol (ln(E)) and progesterone as separate predictors

DV: Post-manipulation ln(P)				
	b	SE	*t*-value	*p*-value
(Intercept)	5.01	0.04	139.70	**<.0001**
Baseline ln(E)	0.07	0.16	0.47	0.639
Condition	0.02	0.04	0.54	0.589
Rejection Sensitivity	0.04	0.04	1.11	0.271
Baseline ln(P)	0.82	0.07	12.22	**<.0001**
Ln Cortisol Residual	0.45	0.10	4.39	**<.0001**
Baseline ln(E) * Condition	-0.03	0.16	-0.225	0.823
Baseline ln(E) * Rejection Sensitivity	0.03	0.17	0.20	0.841
Condition * Rejection Sensitivity	0.05	0.04	1.36	0.177
Baseline ln(P) * Condition	-0.03	0.07	-0.39	0.700
Baseline ln(P) * Rejection Sensitivity	-0.13	0.07	-1.80	*0.075*
Baseline ln(E) * Condition * Rejection Sensitivity	0.11	0.17	0.62	0.534
Baseline ln(P) * Condition * Rejection Sensitivity	-0.004	0.07	-0.06	0.954

Table S14g: Results of linear regression analyses on post-manipulation progesterone, using raw hormone values

	b	SE	*t*-value	*p*-value
(Intercept)	0.02	0.05	0.52	0.604
Baseline Estradiol	0.01	0.07	0.17	0.869
Condition	0.05	0.05	1.06	0.290
Rejection Sensitivity	0.03	0.05	0.61	0.540
Baseline Progesterone	0.87	0.07	13.00	**<.0001**
Cortisol Residual	0.13	0.04	2.90	**0.005**
Baseline Estradiol * Condition	0.04	0.06	0.68	0.501
Baseline Estradiol * Rejection Sensitivity	-0.09	0.09	-1.10	0.273
Condition * Rejection Sensitivity	0.09	0.05	1.81	*0.074*
Baseline Progesterone * Condition	0.004	0.07	0.06	0.956
Baseline Progesterone * Rejection Sensitivity	0.04	0.09	0.46	0.645
Baseline Estradiol * Condition * Rejection Sensitivity	0.02	0.09	0.20	0.842
Baseline Progesterone * Condition * Rejection Sensitivity	0.06	0.09	0.65	0.514