Menstrual cycle and hormonal contraception effects on self-efficacy, assertiveness, regulatory focus, optimism, impulsiveness, and risk-taking

Khandis R. Blake[1,2], Meg McCartney[1], Ruben C. Arslan[3,4]

[1]Melbourne School of Psychological Sciences, University of Melbourne, Victoria Australia.

[2]Evolution and Ecology Research Centre, UNSW Sydney, New South Wales Australia.

[3]Personality Psychology and Personality Diagnostics, University of Leipzig, Leipzig, Germany

[4]Center for Adaptive Rationality, Max Planck Institute for Human Development, Berlin, Germany

Author Note

Correspondence to: Dr Khandis Blake, Melbourne School of Psychological Sciences, Redmond Barry Building, University of Melbourne, Victoria Australia 3010.

Khandis.blake@unimelb.edu.au

Abstract

The Fertility-Assertiveness Hypothesis posits that women affect their environment and assert their desires more so during the fertile compared to non-fertile phase of their menstrual cycle. No research to date has examined whether this increase is evident in other psychological outcomes loosely related to assertiveness or whether it is attenuated by hormonal contraception. To address these gaps we implemented The Daily Cycle Diary, a worldwide daily diary study examining menstrual cycle and hormonal contraception induced shifts in assertiveness, self-efficacy, optimism, regulatory focus, impulsivity and risk-taking. In a fully pre-registered, quasi-experimental within-subject investigation, participants from 23 countries (939 menstrual cycles) provided daily data on their menstrual cycle characteristics and answered self-report questions on each day of their menstrual cycle. Self-efficacy robustly increased alongside fertility probability for naturally cycling women but not hormonal contraceptive users. Prevention-focus (a regulatory strategy that avoids negative outcomes) also increased with fertility probability but the effect was not robust. Menstruation was associated with lowered assertiveness as well as changes in three facets of impulsivity for all women, irrespective of contraceptive use. Exploratory plots showed that contraceptive users and naturally cycling women exhibit a variety of menstrual cycle induced psychological differences unrelated to cycling fertility. Given the prevalence of hormonal contraception use worldwide, future investigation of the menstrual cycle and hormonal contraceptive use on female psychology is of utmost importance.

Keywords: Menstrual cycle; ovulation; hormonal contraceptives; self-efficacy; risk-taking; impulsivity; regulatory focus.

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The menstrual cycle is increasingly recognized as an important endogenous cause of psychological and behavioral variation in women (Gangestad & Thornhill, 2008). Research in recent decades has presented compelling evidence of cycle-related effects in an wide range of psychological phenomena: from mood and emotional processing (Payne, 2003) to cognitive performance (Gogos, 2013), sexuality (Roney & Simmons, 2013) and competitive behaviour (Casto, Arthur, Hamilton, & Edwards, in press). Commonalities in lived experience reflect this literature, with 70-90% of women reporting psychophysiological changes across the cycle and that their cycle meaningfully affects their lives (Mishell, 2005). Given that women experience menstrual cycles for around 35 years (Chavez-MacGregor et al., 2008), research into cycle-related psychological shifts holds widespread relevance.

A recent finding to emerge within this literature is that assertiveness varies systematically across the cycle, increasing alongside hormonal profiles indicative of ovulation (Blake, Bastian, O'Dean, & Denson, 2017). This first examination of assertiveness across the menstrual cycle gives rise to two important, yet unresolved questions. The first question concerned generalizability: Does fertility affect a broader range of psychological phenomena loosely relevant to assertiveness, or only assertiveness specifically? If the menstrual cycle affects other related, important psychological outcomes such as regulatory focus, impulsiveness and self-efficacy—whether positively or negatively—many millions of women worldwide would be affected. This information would be of importance to scholars and to women generally.

The second question was whether the fertility-assertiveness effect would be suppressed amongst hormonal contraceptive (HC) users, who do not experience a natural menstrual cycle.

Despite being one of the most widely prescribed medications in the world (Tinker, Broussard, Frey, & Gilboa, 2015), research on the psychological effects of hormonal contraceptives is only just gaining traction. Recent findings suggest some worrying trends, with HC users displaying reduced fear extinction, dysregulated social reward mechanisms, increased emotional reactivity to aversive stimuli, and lower competitive persistence (Bradshaw, Mengelkoch, & Hill, 2020; Buser, 2012; Montoya & Bos, 2017; Pearson & Schipper, 2013). The United Nations estimates that 26% of reproductive-aged women worldwide are using hormonal contraceptives at any given time (United Nations, 2019). Understanding whether hormonal contraceptives suppress or augment the effects of the menstrual cycle on a range of psychological outcomes is of great importance to clinicians and to reproductive-aged women.

The Menstrual Cycle and Psychological Assertiveness

A key finding to emerge in recent literature has been the presence of cyclic variation in women's assertiveness (the "Fertility Assertiveness Hypothesis"). Blake et al. (2017) studied women who were naturally cycling (i.e., not using hormonal contraceptives), measuring assertiveness and ovarian hormones within-individuals across their fertile and non-fertile cycle phases. The authors defined assertiveness as the quality of confidently expressing what one wants or believes, and noted its role in decision making, attaining desired goals and influencing one's external environment. They found significantly higher self-reported and implicit assertiveness amongst women during the fertile compared to non-fertile phase, and that these effects were hormonally driven by high estradiol and low progesterone (a hormonal profile characteristic of high fertility).

Blake et al. (2017) grounded their hypothesis in sexual selection theory. Scholars in this field have proposed that as a women's fertility fluctuates across her cycle, so too do psychological traits that enhance her ability to select high-quality mates (Gangestad & Thornhill, 2008; Gildersleeve, Haselton, & Fales, 2014). Women have a higher obligatory parental investment (i.e., gestation and lactation) compared to men; consequently they experience greater benefits from stringent mate choice and heavier costs from poor or indiscriminate mate choice (Trivers, 1972; c.f. Kokko & Jennions, 2008; Kokko, Jennions, & Brooks, 2006). Across cultures, women are more selective than men in choosing potential mates (Buss & Schmitt, 1993). There has also been evidence of peri-ovulatory changes in mating-relevant phenomena such as sexual desire, mate preferences, physical appearance and intrasexual competition (reviewed by Gangestad & Thornhill, 2008), though it should be noted that some cyclic shifts—especially in mate preferences—have been called into question due to recent large-scale failures to replicate (reviewed in Jones, Hahn, & DeBruine, 2019; see also Arslan, Driebe, Stern, Gerlach, & Penke, 2021; Arslan, Schilling, Gerlach, & Penke, 2018; Jones et al. 2018a; Jones et al. 2018b; Stern, Kordsmeyer, & Penke, 2021; Stern, Gerlach & Penke, 2020; Van Stein, Strauß, & Brenk-Franz, 2019).

Blake et al. (2017) proposed that elevated assertiveness in the fertile phase may support female mate choice, ultimately increasing the likelihood of reproductive success. They posited that elevated assertiveness might assist women to approach and discern the quality of potential mates and make their own preferences clear, during the phase when conception is most probable. Additionally, assertiveness could protect against low-quality mating, as women exhibiting this trait are considered harder to sexually intimidate (Blake, Bastian, & Denson, 2016) and more able to resist or retaliate against unwanted sexual advances (Prokop, 2013). Blake et al. (2017) thus proposed that fertility-elevated assertiveness could enhance women's ability to both attain a desired partner and avoid poor mating candidates.

Physiology of the Menstrual Cycle

The menstrual cycle is characterized by an orderly sequence of hormonal events that serves to facilitate reproduction. Estradiol and progesterone are two particularly important ovarian hormones which produce the conditions necessary for conception. As levels of these hormones vary across the cycle there is a corresponding fluctuation in women’s fertility, defined as the likelihood of conceiving after intercourse. Although these hormonal changes are continuous, researchers have conceptually divided the cycle into phases based on approximations of cycle days, so as to describe the various hormonal profiles and corresponding fertility levels.

An average menstrual cycle lasts for 28 days, varying between 22–36 days in most women (Fehring, Schneider, & Raviele, 2006). The follicular phase (Days 1-14 in a textbook cycle) begins at the onset of menstruation, with both estrogen and progesterone at their lowest concentrations. Progesterone remains low across the follicular phase while estrogen levels increase. Alongside this increase, an ovum matures within the ovary in preparation for release and potential conception at the time of ovulation. The peri-ovulatory phase encompasses the days around ovulation when fertility is highest (Hall, 2009; Day 14 in a textbook cycle). Progesterone remains low during this period yet estrogen levels peak, triggering a surge in luteinizing hormone which prompts the release of a dominant follicle from the ovaries (i.e., ovulation). Immediately following ovulation, fertility declines precipitously over 48 hours and the hormonal profile shifts to prepare for potential fertilisation of the ovum (Hall, 2009). This marks the beginning of the luteal phase (Days 14-28 in a textbook cycle), in which estrogen falls sharply before exhibiting a shallow but sustained rise and progesterone levels increase markedly and remain high. If fertilization does not occur, steep declines of progesterone and estrogen in the late-luteal phase trigger the onset of menstruation and the beginning of a new cycle.

Menstrual cyclical shifts in psychological phenomena arise from a complex interaction between ovarian hormones and the neurological systems serving these phenomena (Hampson, 2020). Estradiol and progesterone have been strongly implicated as mechanisms driving these changes not only because underpin fertility, but also because they diffuse beyond the reproductive tract and into general circulation. Here they are able to exert transient regulatory effects on central nervous system pathways underlying a range of behavioural and psychological processes (Amin, Canli, & Epperson, 2005). When expression of a psychological trait varies dynamically as a function of circulating estradiol and progesterone levels, researchers can infer the presence of a cycle-related effect (Hampson, 2020).

Does the Fertility-Assertiveness Effect Generalize to Other Psychological Outcomes?

Assertiveness is often defined as an adaptive communication style in which individuals express their needs directly and defend their own interests (Ames & Flynn, 2007; American Psychological Association, n.d.). It derives from the multi-faceted psychological concept of agency, which encompasses the ability to act intentionally, achieve goals, and assert one's wishes (Bakan, 1966; Bandura, 2001, 2006; Eagly, 1987; Gray, Gray, & Wegner, 2007). Rather than reflecting a distinct psychological construct in and of itself, assertiveness is considered to comprise a dimension of behaviors and approaches, the labelling of which as ‘assertive’ varies among individuals (Ames & Flynn, 2007). Given this broad dimensionality and variation among individuals regarding what constitutes assertiveness, one criticism of the fertility-assertiveness finding is that increased self-report assertiveness during the fertile phase may be better described by another latent psychological construct.

Other psychological constructs loosely related to assertiveness or agency include (but are not limited to) self-efficacy, optimism, impulsivity, risk-taking, and regulatory focus. Self-efficacy describes an individual’s tendency to view themselves as capable of performing actions needed to meet situational demands and shows a strong correlation with self-esteem (Judge, Bono, & Locke, 2000), which in turn is correlated with assertiveness (Sarkova et al., 2013). Optimism reflects the extent to which people to hold generalised positive expectations about the future (Carver, Scheier, & Segerstrom, 2010), expectations which can lead to goal-attainment (Carver & Scheier, 2014). Promotion-focus is a self-regulation strategy that involves focusing on achieving success and positive outcomes, whereas prevention-focus involves avoiding failure and negative outcomes (Higgins, Pierro, & Kruglanski, 2008). Both regulatory foci guide goal-directed behavior, with promotion-focus behavior involving a willingness to display assertiveness and take risks (Ouschan, Boldero, Kashima, Wakimoto, & Kashima, 2007). Impulsivity describes the tendency to act without deliberation and with a desire for immediate gratification (Evenden, 1999), behaviors which can mask as high assertiveness. Risk-taking involves exposing one's self to an elevated risk of negative consequences in order to attain a reward (Boudesseul, Gildersleeve, Haselton, & Bègue, 2019) and is associated with low refusal assertiveness (Epstein, Griffin, & Botvin, 2001).

What is The Impact of Hormonal Contraceptive Usage?

An important question arising from Blake et al. (2017) was whether hormonal contraceptive (HC) usage reduces assertiveness and related phenomena. Hormonal contraceptives induce marked changes in ovarian hormone levels in order to prevent ovulation (Speroff & Darney, 2010). They vary in route or mode of delivery, the inclusion of a single synthetic class of hormone or a combination, the type of hormone within each class, dose of each hormone, variability of dose, and number of hormone free days (Hall & Trussell, 2012). The main mechanism of action is usually to prevent ovulation by suppressing endogenous estrogen and progesterone, maintaining them at a constant low level across the month. In their place, most HCs introduce high levels of synthetic progesterone and low levels of synthetic estrogen, yielding a stable hormonal profile somewhat akin to the non-fertile mid-luteal phase in NC women. This profile often creates a negative feedback loop that prevents the growth and release of an ovum each month (Speroff & Darney, 2010). By flattening the hormonal profile to prevent ovulation, HC eliminate the mid-cycle estradiol peak implicated in the fertility-assertiveness finding.

Blake et al. (2017) did not examine HC users, hence the question of HC's impact on peri-ovulatory assertiveness remains unaddressed. However, the mate selection literature informing the Fertility-Assertiveness Hypothesis does yield some insights. A comprehensive review by Alvergne and Lummaa (2010) found that many aspects of women's mating preferences—which serve to increase mid-cycle reproductive success—are partially or completely suppressed in women who use HCs. Research with nonhuman primates has additionally shown HC-linked decreases in intrasexual competition for access to mates (Shively, Manuck, Kaplan, & Koritnik, 1990). Given Blake et al.'s (2017) contention that high peri-ovulatory assertiveness may elevate reproductive success, this trait could be amongst the mate selection behaviours that are attenuated by HC usage.

Regarding the effect of HCs on agentic traits more generally, evidence is mixed. Some studies have found the relationship of estradiol to dominance-related preference and behaviours to be substantially weaker in HC users (Grammer, Renninger, & Fischer, 2004; Stanton & Schultheiss, 2007). Research with nonhuman primates shows HC-linked elimination of cyclical changes in aggressive behaviours (Sarfaty, Margulis, & Atsalis, 2012). Bröder and Hohmann (2003) observed that mid-cycle shifts in NC women's risk-taking behavior was absent amongst women using HC. Indirect evidence of attenuated optimism also emerged recently, with NC women exhibiting greater increases in positive affect at ovulation than HC users (Rebollar, Balaña, & Pastor, 2017). In contrast, Schultheiss et al. (2003) observed a mid-cycle shift in power motive amongst both NC and HC women, albeit larger in NC women.

An Improved Design: Resolving Methodological Challenges

Several common methodological challenges have been identified within the menstrual cycle literature to date (Arslan et al., 2018; Gildersleeve et al., 2014; Harris, 2013; Wood, Kressel, Joshi, & Louie, 2014), and the current study sought to address two of these using a recent innovation in research design. A widespread approach in menstrual cycle research is to measure variables of interest at two timepoints across the cycle (within and then outside of the peri-ovulatory phase) and compare resulting measurements to determine whether a shift had occurred (Welling & Burriss, 2019). Although this method is not inherently problematic, sampling at only two timepoints may be insufficient to properly elucidate the underlying patterns across the cycle. Multiple-timepoint sampling has been identified as a superior approach (Gangestad et al., 2016) and could potentially address some of the ambiguity in previous research. However, due to the cost and time-investment required for in-person testing and repeated hormonal assays, this method has often been unfeasible.

The second methodological issue arises from partitioning the cycle into a discrete fertile window (e.g., the peri-ovulatory phase) and non-fertile window (e.g., all other phases). As a result, the days sampled across participant cycles are assigned a binary fertility status, with fertility operationalized as present or absent. This approach typically accompanies designs that sample only two timepoints, yet it poorly reflects the continuous nature of fertility variation across the cycle. Approaches that model fertility probability as a continuous distribution are better able to capture its gradual follicular-phase increase, peri-ovulatory peak and steady luteal-phase decrease (Roney, 2018). Continuous fertility measurement assigns a numerical estimate of fertility probability to each day of their cycle and has higher validity than discrete cycle windows (Gangestad et al., 2016).

Arslan et al. (2018) addressed both of these methodological issues by using an online diary design to study peri-ovulatory shifts. Their longitudinal design was implemented entirely online, circumventing the cost and inconvenience of repeated in-person test administration. While this design did not accommodate hormonal testing, Arslan et al. (2018) found that decreased reliability of fertile-phase identification could be compensated for by sufficiently increasing sample size. The central feature of this design was that it enabled easy sampling of participants on each day of their cycle. By sampling multiple timepoints, the authors could more comprehensively describe the pattern of psychological changes observed across the cycle. This design also utilised the full benefit of a continuous model, because obtaining data at many different levels of fertility probability enabled a more accurate assessment of fertility-trait relationship.

The Current Study

The current study implemented a worldwide online daily diary study that sought in-depth information about women's physiology and psychology. We implemented the design employed by Arslan et al. (2018) and in doing so address the abovementioned methodological limitations. We investigated whether NC women and HC users exhibit periovulatory increases in a range of psychological outcomes loosely related to assertiveness. We chose the constructs of self-efficacy, optimism, regulatory focus, impulsivity and risk-taking due to their conceptual or empirical relationship to assertiveness or agency. We hoped to provide insight into menstrual cycle effects on a broad range of traits of theoretic importance to scholars and of personal importance to women. We expected hormonal contraceptive users to show no meaningful variability across the cycle in dependent variables (i.e., slope that is not significantly different from zero), whereas naturally cycling women would show a bell-shaped peak during the peri-ovulatory period (i.e., when fertility probability is high).

Method

Pre-registration

This investigation was pre-registered on the Open Science Framework (https://osf.io/zw8qx). Pre-registered elements included hypotheses; theoretical framework; independent and dependent variables and their operationalization; sampling strategy; sampling pre-selection rules; planned sample size; data collection termination rules; exclusion criteria; all manipulations, measures, materials and procedures; the statistical technique, specification of analysis equations, variable calculation, and rationale for use of covariates in the confirmatory analyses; and missing data handling. Here we followed all elements of the pre-registered protocol, explicitly noting one deviation below (see “Data Analysis”).

Procedure

Daily surveys were implemented with the formR survey framework (Arslan, Walther, & Tata, 2020). After an initial pre-screening survey and a baseline survey, participants complete a short online survey each day for 28 days. Daily surveys were emailed to participants at 5pm local time and expired at midnight, with questions referring to experiences on that current day. After 28 days, participants were provided the opportunity to complete the study or continue providing data. One week after completion, participants completed a follow-up survey on their menstrual cycle and overall experiences throughout the survey period. The median number of diary entries completed was 21 entries (M = 20.29, SD = 12.82, range = 1–55), and data were collected across 939 menstrual cycles. After completing the study, most participants received a free, personalized report which compared their individual responses to the grouped average responses of NC and HC women worldwide, showing how the menstrual cycle affected responses (Blake, 2020).

Participants and Recruitment

Six hundred and twelve women (M_{age} = 28.44, *SD* = 7.27) were recruited from Prolific Academic (*n* = 146), the University of Melbourne undergraduate participation pool (*n* = 70), and the general community worldwide (*n* = 396) for a study involving the menstrual cycle and psychological phenomena. Participants from the general community were recruited through advertisements on Facebook, Twitter, and within popular science and magazine articles written by the first author. These participants were incentivized by the provision of the free, personalized report showing how their menstrual cycle affected them, and how their responses compared to HC and NC group averages (see “Procedure”). Selection criteria for eligibility in this study were fluency in English; regular menstrual cycles; menstrual cycle length confidence exceeding the scale mid-point; menstrual cycle length between 22-35 days; aged between 18-45; pre-menopausal; no emergency contraception or breastfeeding or pregnancy use within the past three months; no polycystic ovarian syndrome or endometriosis; and no medically diagnosed fertility or endocrine issues, leaving *N* = 511 eligible participants (M_{age} = 28.05, *SD* = 7.08).

A quarter (24.8%) of participants were North European, 16.8% were from Australia/New Zealand, 10.3% were South-East Asian, 6.8% were South European, 5.8% were East Asian, 5.1% were North American, and the remainder were from South or West Asia (4.9%), Central and Latin America (2.9%), East or West Europe (2.1%), or Africa (1.9%). Most participants were exclusively heterosexual (68.2%), 17.4% were occasionally or more than occasionally homosexual, 3.3% were bisexual, 2.9% were predominantly homosexual, 1.4% were asexual, 5.1% were pansexual, and the remainder were Other. Most participants reported average relative socio-economic status (61.2%), 4.1% reported low socio-economic status, and 33.9% reported high socio-economic status.

Measures

In this study, we report all measures, manipulations and exclusions here. Data for this investigation were collected as part of the Daily Cycle Diary, a large-scale long-term investigation into the effects of the menstrual cycle and HCs on a variety of outcomes. At the time of this study's completion, data from the larger study had been collected over three waves, with slight variation among measures across waves. Measures in the larger study included questions on hormonal birth control and the menstrual cycle, status-seeking, affect, personality, agency, competitiveness, health, and sexual behavior. In accordance with our pre-registration, here we analyze data pertaining to hormonal birth control and menstrual cycle-related effects on self-efficacy, assertiveness, regulatory focus, optimism, impulsiveness, and risk-taking.

For our psychological outcomes, a literature search determined survey tools with the highest overall construct validity and items within those tools were chosen by the first two authors based on item suitability and high factor reliability. Unless otherwise specified, all items were ordinal and measured on a 5-point Likert scale ranging from strongly disagree (1), disagree (2), neither (3), agree (4), to strongly agree (5). One item within each measure was randomly presented each day for all measures excluding regulatory focus, impulsiveness and risk-taking. For regulatory focus and impulsiveness, we presented one item for each of the two and five sub-categories respectively. A single risk-taking item was presented every day.

Hormonal birth control. Participants indicated their contraceptive use via the following multi-choice categories: current use of hormonal contraceptives (e.g. the pill, hormonal implant/rod, depot injections, vaginal ring, hormone plasters), barrier method (e.g. condoms, diaphragm), period / fertility tracking app (e.g. Clue, Flo, Glow), fertility awareness method (e.g. diary, calendar, temperature), having no (or less) sexual intercourse when fertile, hormonal intrauterine device (IUD) (e.g. Mirena), copper intrauterine device (IUD), morning-after pill, other contraceptive, or none. Anyone indicating usage of hormonal contraceptives or a hormonal IUD were classified as hormonal birth control users (*n* = 141), and all other participants were classified as naturally cycling (*n* = 370). As noted in the Participants section, anyone indicating usage of the morning after pill within the past three months were excluded from the study.

Menstrual cycle characteristics. To gather the necessary cycle data, the baseline survey asked participants to report their average cycle length and the start date of their current cycle. In each daily survey and at follow-up, participants were asked if and when their subsequent cycle had started. All responses were collated and checked for consistency and where discrepancies emerged with different onset dates reported within the same week, we used the median date as the onset date. In a small number of cases where onsets were reported on different dates within the same fortnight (1.28%), we excluded these data from analysis. In cases where the next menstrual onset date was not reported (32% of entries), we inferred it from the average cycle length reported by the participant at baseline (as recommended by Welling & Burriss, 2019). In exploratory analyses, we report below our examination of whether the confirmatory predictor of interest is evident when these inferred backward-counted data are excluded from analysis.

Fertility probability was estimated using the backward-counting method. This method counts backward from the reported or estimated next cycle onset to the day on which the outcome variable is sampled. For example, a daily survey completed 5 days prior to a participant's next menstrual onset would be assigned as backward-counted Day -5. Each backward-counted day corresponded to a specific fertility probability value based on the estimates generated by Stirnemann, Samson, Bernard, and Thalabard (2013), a method advocated by Gangestad et al. (2016). Backward-counting methods are known for being more reliable indicators of cycle phase than forward-counting methods, as the length of the luteal phase is less variable than the length of the follicular phase (Fehring et al., 2006). Fertility probability estimates were assigned to all participants (irrespective of HC and NC grouping), enabling HC participants to serve as a quasi-control group in which the fertility probability variable corresponded to within-phase cyclic variation unrelated to endogenous hormones.

Each day, participants also indicated whether they were currently experiencing menstrual bleeding. In some cases, participants' menstrual cycles started on a date where they did not report any bleeding at the time of taking the survey (*n* = 52 entries; 0.5% of the data) or did not provide a response to this question (*n* = 44 cycles; 0.4% of the data). To account for these discrepancies and in accordance with our pre-registration, we coerced the first four days of each cycle to contain values indicative of menstrual bleeding.

Self-efficacy. Self-efficacy was measured using three items from the New General Self-esteem (NGSE) scale, an inventory with established construct and discriminant validity, as well as high reliability (α = .88; Chen, Gully, & Eden, 2001; e.g., "I will be able to successfully overcome many challenges"). Items were (a) "Over the past day, I felt that I could succeed at almost any endeavor I set my mind to", (b) "Over the past day, I felt that I would be able to successfully overcome many challenges", and (c) "Over the past day, I felt that even if things were tough, I could perform quite well" (*M* = 3.37, *SD* = 0.94).

Assertiveness. Assertiveness was assessed using four self-report items from Blake et al. (2017). This provided a brief measure with acceptable reliability (α = 0.74) that had demonstrated sensitivity to cycle-related fluctuations in self-reported assertiveness. Items included (a) "Over the past day I influenced my environment", (b) "Over the past day I efficiently achieved my goals", (c) "Over the past day I tried to assert and expand myself' and (d) "Over the past day I preferred to go with the flow and let others make plans and decisions" (reverse-scored; *M* = 3.18, *SD* = 1.03).

Regulatory focus. Regulatory focus is a theory of goal pursuit that explains how people engage in self-regulation, i.e., how they shift their behavior and thinking to align with their own standards and goals (Higgins, 1998). It derives from the hedonic principle that people approach pleasure and avoid pain. Any area of motivation can be discussed in terms of regulatory focus, with approaching pleasure referred to as 'promotion-focus' and avoiding pain referred to as 'prevention focus'. Promotion- and prevention-focus were assessed via components of the Regulatory Focus Strategies Scale (RFSS; Ouschan et al., 2007; e.g., "The worst thing you can do when trying to achieve a goal is to worry about making mistakes"). The RFSS is an established measure with good discriminant and convergent validity, and decent reliability (promotion-focus $\alpha = 0.75$; prevention-focus $\alpha = 0.72$).

Participants were asked: "Over the past day, to what extent have you agreed with the following statements…".Promotion-focus statements (items) were (a) "I have to take risks if I want to avoid failing", (b) "The worst thing I can do when trying to achieve a goal is to worry about making mistakes", (c) "Taking risks is essential for success", and (d) "If I want to succeed, the worst thing I can do is to think about making mistakes" ($M = 3.28$, $SD = 0.95$). Prevention-focus items were (a) "In order to achieve something, I must be cautious", (b) "To avoid failure, I have to be careful", (c) "Being cautious is the best way to achieve success", (d) "In order to achieve something, it is most important to know all the potential obstacles" ($M = 3.32$, $SD = 0.95$). Items were re-coded so that high scores indicated greater promotion or prevention focus.

Optimism. Optimism was assessed using items adapted from State Optimism Measure (SOM), a seven-item measure designed to capture these dynamics (Millstein et al., 2019; e.g., "At the moment I am expecting things to turn out well"). The SOM had demonstrated good construct validity, as well as convergent validity ($r = 0.81$) and high reliability ($\alpha = 0.94$; Millstein et al., 2019). Items were (a) "Over the past day I felt optimistic about my future", (b) "Over the past day The future looked bright to me", (c) "Over the past day I expected more to go right than wrong when it came to my future", and (d) "Over the past day I expected things to turn out well" (*M* = 3.45, *SD* = 0.93).

Impulsiveness. Five distinct facets of impulsivity were measured via the SUPPS-P (Cyders, Littlefield, Coffey, & Karyadi, 2014). The SUPPS-P is a brief version of the widely used UPPS-P, and largely retains the validity and reliability (across all five subscales, αs = 0.74<0.85) of the full measure (Cyders et al., 2014). Four items each pertained to the facets of negative urgency (acting on impulse when experiencing strong negative affect; e.g., "When I am upset I often act without thinking"; *M* = 2.39, *SD* = 1.03), positive urgency (acting on impulse when experiencing strong positive affect; e.g., "I tend to act without thinking when I am really excited"; *M* = 2.12, *SD* = 0.89), lack of premeditation (acting without considering the consequences ; e.g., "I usually think carefully before doing anything", reverse-scored; *M* = 2.52, *SD* = 0.88), lack of perseverance (difficulty in maintaining focus during difficult or boring tasks; e.g., "I finish what I start", reverse-scored; *M* = 2.52, *SD* = 0.97) and sensation seeking (pursuing novel and thrilling experiences; e.g., "I welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional"; *M* = 2.70, *SD* = 1.18). In this experiment, we prefaced each question with "Over the past day" (e.g., "Over the past day I tended to lose control when I was in a great mood"). The full list of items is included in Appendix A.

Risk-taking. To measure risk-taking, we asked "Over the past day, did you take fewer or more risks than usual?" (1=much fewer, 2=slightly fewer, 3=same as usual, 4=slightly more, 5=many more). Existing risk-taking measures were either gender biased (Morgenroth, Fine, Ryan, & Genat, 2018; Zhang, Foster, & McKenna, 2019) or lacked sufficient face validity. In the current study, *M* = 3.00 and *SD* = 0.71.

To see the magnitude of construct overlap, a table of correlations between all variables for HC users and non-users can be seen in Table 1. The constructs with the greatest association (in both samples) are optimism and self-efficacy.

Table 1. *Correlations Among Dependent Variables.*

Variable	Self-efficacy	Assertiveness	Promotion-focus	Prevention-focus	Optimism	Negative urgency	Positive urgency	Lack of pre-meditation	Lack of perseverance	Sensation-seeking	Risk-taking
Self-efficacy	-	.36***	.18***	-.03	.57***	-.29***	-.13***	-.23***	-.22***	.24***	.19***
Assertiveness	.34**	-	.14***	.01	.30***	-.13***	-.05**	-.15***	-.19***	.17***	.20***
Promotion-focus	.11***	.06***	-	-.15***	.23***	-.05*	-.01	-.01	-.06**	.16***	.07***
Prevention-focus	< .01	.02	-.05***	-	-.09***	.09***	.05*	-.16***	-.04	-.05*	-.03
Optimism	.52***	.25***	.07***	-.02	-	-.27***	-.09***	-.16***	-.17***	.23***	.16***
Negative urgency	-.25***	-.09***	.01	-.01	-.23***	-	.36***	.22***	.09***	-.10***	-.05*
Positive urgency	-.03*	.01	.12***	-.02	-.04***	.32***	-	.17***	.07*	.06*	.05*
Lack of pre-meditation	-.27***	-.17***	-.05***	-.16***	-.21***	-.20***	.11***	-	.23***	-.08***	-.05*
Lack of perseverance	-.21***	-.20***	-.05***	-.14***	-.15***	.08***	.01	.27***	-	-.08***	-.07***
Sensation-seeking	.17***	.11***	.16***	-.06***	.13***	< -.01	.17***	-.02	-.07***	-	.16***
Risk-taking	.24***	.24***	.05***	-.02	.17***	-.03**	.05***	-.07***	-.08***	.16***	-

Note. Above the diagonal are correlations from the data of hormonal contraceptive users, and below the diagonal are correlations from the data of naturally cycling women. * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Data Analysis

Study design

The design of the study was quasi-experimental. We sampled daily surveys from naturally cycling (NC) women and hormonal birth control (HC) users, allowing us to compare responses between-subjects, within-subjects, and under the conditions of the hypothesized between × within interaction. As noted below in our confirmatory analyses, our primary hypothesis was a fertility probability × hormonal contraceptive status interaction. Thus, we assigned fertility probability estimates to all participants, even though HC users were not fertile. Assigning fertility probability estimates to HC users allowed the HC user group to serve as a quasi-control group, with their fertility probability scores reflecting and controlling for within-phase psychological variation (that was unrelated to fertility).

Confirmatory analyses. We used Bayesian ordinal mixed models with a cumulative family and a logit-link function to accurately model the ordinal nature of the outcomes. We used default (uninformative) priors, which ensured that our parameter estimates were maximally influenced by the data and were asymptotically equivalent to those obtained under maximum likelihood estimation. Model convergence was determined by PSR values reaching < 1.05, after which the number of Bayesian iterations was doubled to ensure stable convergence was reached. We considered model estimates to be significantly different from zero when their 95% Bayesian credible intervals did not cross zero. The main predictor of interest was the interaction between fertility probability and HC, with support for mid-cycle shifts in outcome variables indicated by an interaction where fertility probability affected the outcome variable in the naturally cycling group only.

Models controlled for menstruation and included a random slope for fertility probability and a random intercept for the individual. We additionally included a random slope for menstruation, which was a deviation from our pre-registration. Our intention in doing so was to ensure that any resultant effects for menstruation on the outcome variables did not have inflated error rates. Without a random slope for menstruation, menstruation had a larger effect on many outcome variables than those reported here, with less precise confidence intervals. To interpret these menstruation effects, we added a random slope for menstruation so that the sizes of the effects were not inflated. Adding versus removing a random slope for menstruation did not meaningfully affect the CIs or point estimates of the fertility probability × HC interaction for any variable except self-efficacy, where the point estimate and CIs changed slightly to that reported here (B = -0.61, SE = 0.32, 95% CI_L = -1.23, CI_U = 0.01). All models without the random slope for menstruation are available on the OSF (see "Data Availability").

Minimum detectable effect size. To approximate a minimum detectable effect size, we simulated power for identical models to the Bayesian formulae but modelled using the R package lme4 (Bates et al., 2015). We used the simr package (Green & MacLeod, 2016) to estimate the power obtained to detect effects of particular sizes for the primary interaction of interest (HBC × fertility probability). We imputed the average observed fixed effect for the other variables in the model (i.e., averaged across all outcome variables), then simulated power to detect an interaction at effect sizes ranging from 0.10–0.30 (at intervals of 0.05). 1000 simulations indicated that we had 80% power to detect a minimum interaction effect of b = .15.

Robustness tests. Our pre-registered robustness protocol stipulated that we would examine whether our conclusions were robust to changes in model specification if a hypothesized confirmatory effect was significant in our main model. These robustness tests examined whether results differ for women who were fertility-aware, whether the outcome visually peaked at the estimated day of ovulation, whether excluding various participants who were potentially less likely to ovulate affects the effect size estimates, and whether effect sizes were moderated by age or self-reported average cycle length.

Plots. To continuously visualize outcome variation according to cycle phase without imposing discrete phases such as menstruation and the fertile window, we fit Bayesian mixed models with a Gaussian family and cyclic cubic splines over backward-counted cycle days by HC status. For slight regularization, we set half-normal priors with a SD of 1 on the random intercepts. We then took 100 random samples from the posterior and visualized the conditional means for the continuous splines by HC status, as well as the difference in splines between NC and HC groups. The resulting visualized variation reflects the average patterns in the data and includes the uncertainty resulting from the person-level clustering in the data.

Data availability. All data, syntax used in our analyses, and full models of the confirmatory analyses, robustness analyses, and any exploratory analyses is available on the OSF (https://osf.io/9kv3t/).

Results

Pre-registered analyses

All main and interaction effects are listed in Table 2. For self-efficacy, there was a significant HC × fertility probability interaction, with NC women ($B = 0.52$, $SE = 0.18$, CI = [0.16, 0.88]) but not HC users (CI = [-0.62, 0.36]) demonstrating more self-efficacy when fertility probability was high. Robustness tests indicated that this effect was 23% stronger when we restricted the sample to women who were most likely to ovulate ($B = 0.64$, $SE = 0.32$, CIs = [0.03, 1.28]), was not moderated by fertility-awareness (CI = [-2.28, 0.70]), age (CI = [-0.12, 0.09]), or cycle length (CI = [-0.06, 0.37]). Plotting the outcome showed that it visually peaked around the estimated day of ovulation for NC women, see Figure 1. In exploratory analyses, we note that excluding participants for whom the backward-counted cycle date was inferred yielded a stronger interaction between HC × fertility probability ($B = -0.85$, $SE = 0.38$, CIs = [-1.60, -

0.10]), and a stronger effect of fertility probability among NC women (*B* = 0.65, *SE* = 0.20, CIs = [0.26, 1.04]). We found no significant HC × fertility probability interaction for assertiveness.

Table 2. *Effects of Fertility and Hormonal Contraceptives Among All Participants*

Variable	Fertility [CI]	HC use [CI]	Fertility x HC [CI]
Self-efficacy	**0.51* [0.17, 0.86]**	0.40 [-0.02, 0.82]	**-0.68* [-1.33, -0.03]**
Assertiveness	0.23 [-0.07, 0.54]	0.26 [-0.02, 0.54]	-0.47 [-1.02, 0.08]
Promotion focus	0.19 [-0.14, 0.52]	0.02 [-0.37, 0.40]	-0.07 [-0.67, 0.54]
Prevention focus	0.29 [-0.07, 0.65]	-0.19 [-0.68, 0.30]	**-0.82* [-1.49, -0.14]**
Optimism	0.27 [-0.09, 0.63]	0.28 [-0.17, 0.72]	0.12 [-0.57, 0.80]
Negative urgency	0.10 [-0.24, 0.43]	-0.11 [-0.49, 0.26]	0.21 [-0.42, 0.82]
Positive urgency	**0.47* [0.11, 0.83]**	0.13 [-0.34, 0.59]	0.06 [-0.62, 0.71]
Lack of pre-meditation	-0.12 [-0.44, 0.20]	-0.24 [-0.61, 0.14]	0.49 [-0.12, 1.10]
Lack of perseverance	-0.25 [-0.57, 0.07]	-0.28 [-0.62, 0.06]	0.05 [-0.54, 0.65]
Sensation-seeking	0.25 [-0.05, 0.34]	0.35 [-0.03, 0.73]	-0.22 [-0.77, 0.33]
Risk-taking	**0.57* [0.23, 0.91]**	**0.54* [0.20, 0.88]**	-0.38 [-1.01, 0.25]

Note. HC = hormonal contraceptive. All models controlled for menstruation and a HBC × menstruation interaction. All models included a random intercept for subject and random slopes for menstruation and fertility. The coefficients for fertility listed above reflect the effect of fertility among the NC sample.

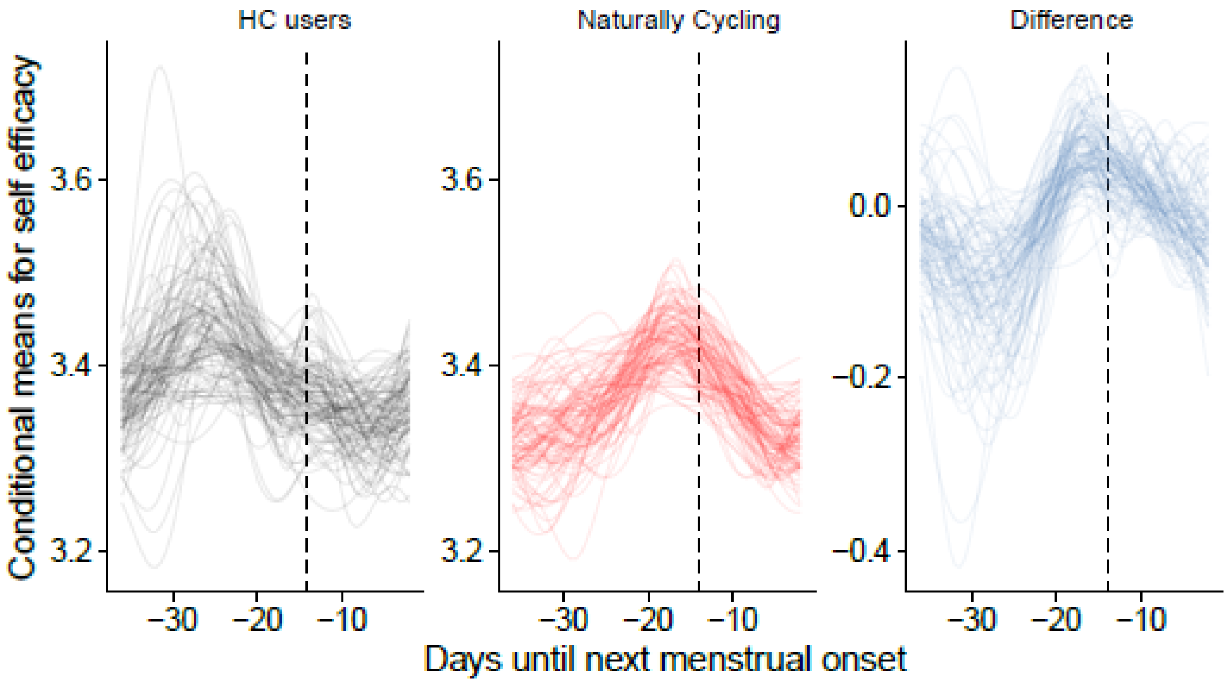

***Figure 1*. Self-efficacy as a function of backward-counted cycle day.**

Note. Black = HC users, Red = Naturally cycling women, dashed line = estimated day of ovulation. The blue difference plot shows the difference between the conditional means among the two groups on different estimated cycle days, where greater deviations from zero indicate greater differences between groups.

There was also a significant HC × fertility probability interaction for prevention-focus, see Table 2. Investigation of sub-groups, however, showed that the effect of fertility probability did not significantly predict prevention-focus among either NC women (*B* = 0.28, *SE* = 0.18, CI = [-0.07, 0.64]) or HC users (*B* = -0.50, *SE* = 0.31, CI = [-1.10, 0.11]). Thus, while the slopes are significantly different from each other, neither slope in isolation is significantly different from zero. Robustness tests showed that the effect of fertility probability on prevention focus was not significant when we restricted the sample to women most likely to ovulate (*B* = 0.52, *SE* = 0.33, CI = [-0.13, 1.18]), nor was it moderated by fertility awareness (CIs = [-1.03, 0.42]), age (CI = [-0.09, 0.13]), or cycle length (CI = [-0.25, 0.20]). Plotting the outcome showed no clear peak around ovulation for naturally cycling women, though the difference between the two sub-groups was most pronounced at this time, see Figure 2. In an exploratory analysis, we find that excluding participants for whom the backward-counted cycle date was inferred resulted in a HC × fertility probability interaction that was no longer significant (*B* = -0.45, *SE* = 0.40, CI = [-1.23, 0.32]).

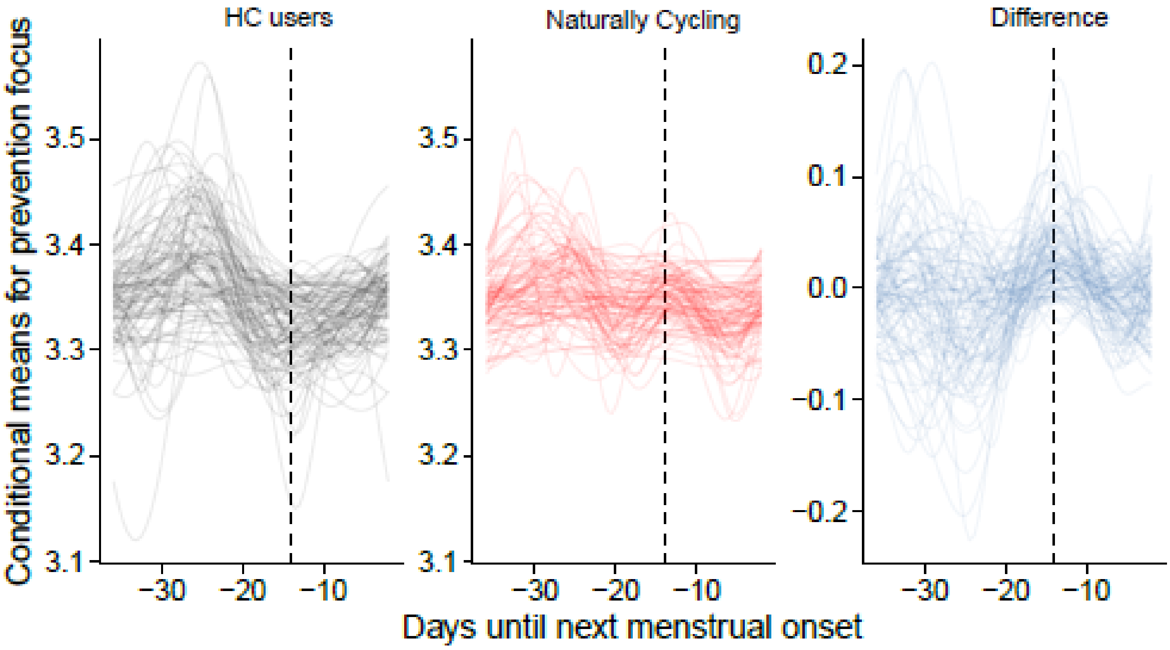

***Figure 2*. Prevention-focus as a function of backward-counted cycle day.**

Note. Black = HC users, Red = Naturally cycling women, Blue = difference, dashed line = estimated day of ovulation. The blue difference plot shows the difference between the conditional means among the two groups on different estimated cycle days, where greater deviations from zero indicate greater differences between groups. Group-level differences were not robust to our sensitivity analyses, and the slope of fertility probability on prevention-focus was not significantly different from zero for either HC users or NC women.

No other outcome variable yielded a significant HC × fertility probability interaction, though there were additional significant effects of note. Menstruation affected assertiveness (B = -0.13, SE = 0.07, CI = [-0.26, -0.01]), and three of the five impulsiveness domains: sensation-seeking (*B* = 0.20, *SE* = 0.07, CI = [0.05, 0.34]), lack of perseverance (*B* = -0.16, *SE* = 0.07, CI = [-0.30, -0.02]), and lack of pre-meditation (*B* = -0.21, *SE* = 0.08, CI = [-0.36, -0.06]). When menstruating, participants reported lower assertiveness, pre-meditation, perseverance, and sensation-seeking, irrespective of whether they were naturally-cycling or using hormonal birth control. Menstruation also affected risk-taking, but this effect was qualified by a menstruation × HC interaction (*B* = -0.48, *SE* = 0.16, CIs = [-0.79, -0.17]), such that menstruation reduced risk-taking among NC women (*B* = -0.20, *SE* = 0.08, CIs = [0.04, 0.36]) but increased it among HC users (*B* = 0.29, *SE* = 0.13, CIs = [-0.55, -0.03]). There were two additional effects. Positive urgency (*B* = 0.47, *SE* = 0.18, CIs = [0.11, 0.83]) and risk-taking (*B* = 0.57, *SE* = 0.17, CIs = [0.23, 0.91]) varied as a function of fertility probability, but these effects did not differ for NC and HC women. No predictors significantly affected negative urgency, optimism, or promotion-focus.

Exploratory Analyses

Plotting the effects of backward counted cycle day on each outcome variable, delineated by HC and NC subgroups, depicts some interesting, albeit exploratory relationships between variables, see Figure S1. The greatest difference between NC women and HC users tended to be toward the start of the cycle (where differences scores are highest). Positive urgency visually peaked for NC women around the estimated day of ovulation, where such an effect was not seen for HC users. Both HC users and NC women showed mid-cycle peaks in optimism around a week prior to the estimated day of ovulation. For risk-taking and sensation-seeking, NC women show peaks in these outcomes both before and after the estimated day of ovulation, but a trough in between. This pattern is absent or weaker among HC users.

Discussion

The current study aimed to replicate the fertility-assertiveness effect and establish its boundary conditions. We were interested in whether fertility affected a range of variables loosely related to assertiveness, and whether these effects were augmented or attenuated by hormonal contraceptive (HC) usage. We predicted that naturally cycling (NC) women—but not HC users—would report higher assertiveness, self-efficacy, optimism, regulatory focus, impulsivity, and risk-taking when fertility probability was high. We found a robust small positive effect of fertility probability on self-efficacy among NC women that was absent among HC users. The effect of fertility probability on the self-regulation strategy of prevention-focus was also moderated by HC status, but this effect was not robust to sensitivity analyses, and main effects of fertility probability were not significantly different from zero among either HC or NC populations.

Fertility did not have any main or interactive effects on assertiveness, any facet impulsiveness, optimism, or promotion focus. Fertility was positively associated with positive urgency and risk-taking among NC women but not HC users, but formal tests of differences between groups as a function of fertility were not significant (i.e., the CI for the fertility × HBC effect contained zero). We also found that menstruation decreased assertiveness and affected three facets of impulsiveness for all women, irrespective of whether they were naturally cycling or using HCs. In addition, during menstruation, HC users took more risks than NC women. Plotting of outcome variables over time suggested that most psychological outcomes measured did vary across the menstrual cycle (see Figure S1), but this variance was usually underpinned by something other than fluctuating fertility probability.

Understanding the Specificity of the Fertility-Assertiveness Link

This central contention of the Fertility-Assertiveness Hypothesis is that women assert their desires and affect their environment to a greater extent when fertile than when non-fertile

(Blake et al., 2017). The cyclic patterns of self-efficacy we identify supports this hypothesis, indicating that self-efficacy increases alongside the probability of conception and that HCs attenuate this natural response. In the current study, we operationalized self-efficacy with items pertaining to feeling that one could succeed at any endeavor, successfully overcome challenges, and perform well under difficult conditions. The fertility-induced up-tick in self-efficacy among NC but not HC women is consistent with past work positively linking fertility or high estradiol to assertiveness, power motivation, and dominance (Blake et al., 2017; Hromatko, Tadinac, & Vranic, 2008; Michael & Zumpe, 1993; Schultheiss, Dargel, & Rohde, 2003; Stanton & Edelstein, 2009; Stanton & Schultheiss, 2007; Ziomkiewicz, Wichary, Bochenek, Pawlowski, & Jasieńska, 2012). It is likewise consistent with work showing that HCs reduce competitive persistence and behavior (Bradshaw et al., 2020; Buser, 2012; Casto et al., 2020; Cobey et al., 2013; Griksiene et al., 2018; Pearson and Schipper, 2013), and with work indicating that fertility increases self-desirability (Arslan et al., 2018). Together, these findings suggest that fertility elevates psychological outcomes likely to increase a range of approach-orientated behaviors and that HCs attenuate this effect. Formal mediation tests of such relationships—determining, for example, whether self-efficacy mediates the well-known effect of fertility on sexual behavior—could provide novel insights pertinent to future work.

In so much as the fertility-assertiveness hypothesis specifies that the effect is specific to assertiveness, our self-efficacy findings suggest that this is not the case. Given that we did not replicate the assertiveness findings from past work, however, we cannot be confident that assertiveness is the best construct to represent the effect either. While the over-arching prediction that fertility affects approach-oriented psychology was supported, the specific effect of fertility remains under question. The failure to replicate this result may be due to issues with how we constructed our measures. We operationalized assertiveness items pertaining to behaviors involving influencing one's environment, efficiently achieving goals, asserting and expanding the self, and taking a lead role in group decision-making. In sum, self-efficacy was measured by asking people about their subjective feelings while assertiveness asked people to report on their behaviors. It is possible that this difference accounts for our findings, as feelings are likely a better proximal measure of fertility-induced psychological states than behaviors.

Another problem affecting our conclusions is the lack of hormonal measurement in this investigation. In past work, both assertiveness and implicit power motivation were most reliably predicted by estradiol. Indeed, any studies have inferred cycle-phase effects based on significant correlations between hormone levels and agentic phenomena, including assertiveness (Blake et al., 2017), the power motive (Schultheiss et al., 2003; Stanton & Schultheiss, 2007), impulsivity (Roberts, Eisenlohr-Moul, & Martel, 2018), risk-taking (Bröder & Hohmann, 2003) and self-esteem (Becker, 2012). Circulating estrogens are highly heterogenous within the peri-ovulatory phase, exhibiting their highest level just prior to ovulation, followed by a marked post-ovulatory drop. If estrogens are a primary driver of assertiveness, then assertiveness is likely to exhibit markedly different levels within the peri-ovulatory phase that we may have been unable to capture without measuring estrogens.

We found no evidence that fertility affected impulsiveness, optimism, regulatory focus, or risk-taking, nor did we find evidence that NC women or HC users differ in their responses on these outcomes. One issue with measurement of these items, however, was that self-efficacy was the only variable whose items all referred to subjective feelings. As shown in Appendix A, other constructs were measured by expectations, conditional or unconditional behaviors, cognitive styles, hypothetical or actual preferences, and others' reactions. Though these items all derived from well-validated measures with high construct and internal validity, the sheer variation evident here may have limited our ability to detect effects in the daily diary design we employed.

At present, our evidence thus suggests that while the fertility-assertiveness effect extends to self-efficacy, it does not extend to a broader range of psychological outcomes, and may not be evident in assertiveness either. Replication of these findings with measures better able to capture daily variation in psychological states—i.e., probably subjective feelings—will lend more confidence to this interpretation.

Effects of Menstruation on Assertiveness, Impulsiveness, and Risk-Taking

All women were less assertive when menstruating, irrespective of whether they were naturally cycling or using HCs. Menstruating women were also more impulsive on two impulsiveness facets (a lack of perseverance, and a lack of pre-meditation), yet less impulsive on another impulsiveness facet (lowered sensation-seeking). For positive and negative urgency facets of impulsiveness, menstruation had no effects. Menstruation is known to increase emotional lability, irritability, anger, stress, sadness, and feelings of not coping (Hamstra, Kloet, Rover, & van der Does, 2017; Romans et al. 2013). Decreased estradiol—a hormonal profile consistent with menses—is also associated with reduced executive function (Jacobs et al., 1998; Schmidt et al., 1996; Sherwin, 1997), particularly among women with high trait impulsivity (Jacobs & D'Esposito, 2011). That menstruation decreased perseverance, pre-meditation, and assertiveness is somewhat consistent with these effects. Null results for positive and negative urgency, and positive results for sensation-seeking, however, complicate this interpretation. One possibility is that the effects of estradiol on executive function may be specific to particular response domains, i.e., not generalizable to all facets of impulsiveness.

Menstruation also affected risk-taking, though this effect was moderated by HC use: Menstruation reduced risk-taking among NC women but increased it among HC users. Why menstruation would increase risk-taking for HC users compared to when they were not menstruating, however, is difficult to rationalize. Further replication is warranted before firm conclusions are drawn.

Differences between Hormonal Contraceptive Users and Naturally Cycling Women

An exploratory examination of HC user and NC women's outcome plots (Figure S1) suggested some unexpected differences between groups. The greatest differences were often toward the start of the cycle, potentially indicating a protective effect of HCs on menstruation-induced psychological symptoms. Other cycle-related effects were visually evident between groups but did not correspond with fertility probability. Shifts in positive urgency, risk-taking, optimism—and to a lesser extent, assertiveness—did seem to reflect cyclic patterns of estradiol, but without robust statistical analysis we cannot confirm this speculation. The most reliable inference we can gain from these data seems to be that HC users and NC women exhibit a variety of menstrual cycle induced psychological differences. These differences highlight the need for rigorous, systematic investigations of the effects of HCs on psychological outcomes.

Social Implications

Self-efficacy refers to a person's belief that they are capable of performing a task successfully (Bandura, 1977). It influences the tasks that people choose to learn, the goals they set for themselves, and their effort and persistence in learning difficult tasks (Lunenburg, 2011). Self-efficacy affects motivation and performance in a range of domains, including the workplace, social relationships, academic achievement, health, and athletic performance (Bandura & Locke, 2003). That naturally cycling women experience a small but persistent elevation in self-efficacy during the peri-ovulatory phase has implications for all of these domains. NC women may be more likely to display an adaptive tenacity in the face of challenges during the fertile phase, and that HC users do not experience this benefit.

The increased self-efficacy of individuals contributes to collective efficacy, a group's shared belief in its capabilities to produce a given goal (Bandura, 1997). Collective efficacy affects shared motivation, increasing the likelihood that groups will use resources effectively and that they will persist in achieving group goals (Bandura, 1997). Collective efficacy increases task performance and greater team cohesion, with positive results demonstrated in workplaces, among families, in schools and urban neighborhoods, team sports, and within marriages (Leary & Tangney, 2011). A high sense of collective efficacy is also important for facilitating social and political change (Fernandez-Ballestrros, Diez-Nicholas, Caprara, Barbaranelli & Bandura, 2000).

It is difficult to quantify the effect that a small but persistent increase in self-efficacy among NC female group members may have on the collective self-efficacy of groups. The effect likely depends on similar factors to those that increase conformity within groups (e.g., status of group members, group size) and facilitate the establishment of group norms. For example, fertility-induced higher self-efficacy of an authoritarian NC woman may more successfully influence the collective efficacy of the group than a non-authoritarian group member. Effects would also depend on the number of group members who were NC versus HC users (versus men). Assuming a 28-day textbook menstrual cycle with a 6-day fertile window, for example, in a group of 10 NC women the likelihood any two of them being in the fertile window is surprisingly high (87%; see Appendix B for notation). Obviously this probability declines as the proportion of HC users or male group members rises, suggesting that benefits would be likely to ensue among groups with higher proportions of NC women. Understanding additive effects such as these are relevant to establishing the impact of small fertility effects such as those reported here. While such effects may be small at the individual level, they may have a more influential role in group contexts where large proportions of members experience them concurrently.

Future Directions

Future work would benefit from the inclusion of implicit measures as well as self-report measures better targeted toward capturing subjective psychological states. It is possible that cycle-related shifts occurred in some of our measured phenomena but inadequately worded self-report measures were unable to detect them. Hormones can cause physiological and behavioral changes outside of conscious awareness (van Honk, Peper, & Schutter, 2005) and ovarian hormones can likely influence agentic processes without conscious input (Blake et al., 2017; Schultheiss et al., 2003; Stanton & Schultheiss, 2007). The use of only self-report inventories and items referring not only to subjective feelings but behaviors, preferences, and cognitions may have limited our ability to detect these potential non-conscious shifts.

Quantifying the group-level dynamics of fertile shifts in psychological phenomena would help clarify the importance of small but persistent fertility effects, such as those we see here for self-efficacy. Determining the probability that proportions of group members are in the fertile window—given the proportion of mixed and single sex groups of varying sizes that are NC—is a necessary next step. Such insights would help contextualize the social implications of fertility effects and the likelihood that additive group-level effects exist. Technical approaches quantifying this problem could utilize simulation models to provide a range of insights into the conditions likely to strengthen the collective effects of individual fertility-induced phenomena.

Conclusion

Self-efficacy positively covaried with fertility probability among naturally cycling women but not hormonal contraceptive users, suggesting that NC women may be more likely to display an adaptive tenacity during the fertile phase and that HC users do not experience. The same covarying pattern was evident for prevention-focus, but this latter effect was not robust. Fertility has no main or interactive effects on assertiveness, impulsiveness, optimism, or promotion-focus. Menstruation reduced assertiveness and affected impulsivity among all women, irrespective of HC use status. HC users and NC women appear to exhibit a variety of menstrual cycle induced psychological differences unrelated to current fertility. Further work examining the effects of the menstrual cycle and HC use on psychological outcomes is of utmost importance to women.

Open Practices

Open Data

All data, syntax used in our analyses, and full models of the confirmatory analyses, robustness analyses, and any exploratory analyses is available on the Open Science Framework (https://osf.io/9kv3t/).

Open Materials

All materials used in this study are available on the Open Science Framework (https://osf.io/9kv3t/).

Preregistered

This investigation was pre-registered on the Open Science Framework (https://osf.io/zw8qx).

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Appendix A

Below are the items per constructed detailed in the measures section. Unless otherwise specified, all items were ordinal and measured on a 5-point Likert scale ranging from strongly disagree (1), disagree (2), neither (3), agree (4), to strongly agree (5).

Self-Efficacy

Adapted from New General Self-Esteem Scale (NGSE; Chen, Gully, & Eden, 2001).

Over the past day, I felt…

- That I could succeed at almost any endeavor I set my mind to.
- That I would be able to successfully overcome many challenges.
- That even if things were tough, I could perform quite well.

Assertiveness

From Blake et al. (2017).

Over the past day…

- I influenced my environment.
- I efficiently achieved my goals.
- I tried to assert and expand myself.
- I preferred to go with the flow and let others make plans and decisions [reverse-scored].

Regulatory Focus

Adapted from the Regulatory Focus Strategies Scale (RFSS; Ouschan et al., 2007).

Over the past day, to what extent have you agreed with the following statements…

Promotion-focus items

- I have to take risks if I want to avoid failing.

- The worst thing I can do when trying to achieve a goal is to worry about making mistakes.
- Taking risks is essential for success.
- If I want to avoid failing, the worst thing I can do is to think about making mistakes.

Prevention-focus items

- In order to achieve something, I must be cautious.
- To avoid failure, I have to be careful.
- Being cautious is the best way to achieve success.
- In order to achieve something, it is most important to know all the potential obstacles.

Optimism

Adapted from the State Optimism Measure (SOM; Millstein et al., 2019).

Over the past day…

- I felt optimistic about my future.
- The future looked bright to me.
- I expected more to go right than wrong when it came to my future.
- I expected things to turn out well.

Impulsiveness

Adapted from the SUPPS-P (Cyders, Littlefield, Coffey, & Karyadi, 2014). Items with an (R) are reverse coded, so that higher values indicate more impulsive behavior.

Over the past day…

Negative Urgency (original $\alpha = 0.78$)

- If I felt bad, I did things I later regretted in order to make myself feel better now.

- If I felt bad, I couldn't seem to stop what I was doing even though it made me feel worse
- If I was upset, I acted without thinking
- If I felt rejected, I said things that I later regretted

Positive Urgency (original α = 0.85)

- If I was in great mood, I tended to get into situations that could cause me problems.
- I tended to lose control when I was in a great mood.
- Others were shocked or worried about the things I did when I was feeling very excited.
- I tended to act without thinking when I was really excited.

Lack of Premeditation (original α = 0.85)

- My thinking was usually careful and purposeful. (R)
- I liked to stop and think things over before I did them. (R)
- I tended to value and follow a rational, sensible approach to things. (R)
- I thought carefully before doing anything. (R)

Lack of Perseverance (original α = 0.79)

- I generally liked to see things through to the end. (R)
- Unfinished tasks really bothered me. (R)
- Once I got going on something I hated to stop. (R)
- I finished what I started. (R)

Sensation Seeking (original α = 0.74)

- I quite enjoyed taking risks.
- I welcomed new and exciting experiences and sensations, even if they were a little frightening and unconventional.

- I would have liked to learn to fly an airplane.
- I would have enjoyed the sensation of skiing very fast down a high mountain slope.

Risk-Taking

- "Over the past day, did you take fewer or more risks than usual?"

Response options: 1=much fewer, 2=slightly fewer, 3=same as usual, 4=slightly more, 5=many more.

Appendix B

Total number of pairs for a group of 10 NC women

$$ {}_{\mathrm{n}}\mathrm{C}_{\mathrm{r}} \frac{n!}{r!\,(n-r)!} $$

n – number of individuals in pool ($n = 10$)

r – size of each combination ($r = 2$)

C – total number of combinations

$$ {}_{10}\mathrm{C}_{2} = 45 $$

Probability of *r* individuals being fertile

Assuming a standard 28-day menstrual cycle where 6 days are fertile days, the probability of *r* individuals being in the fertile window is indicated by:

$$ P_{fertility} = \left(\frac{6}{28}\right)^{r} $$

$$ P_{fertility} = .044 $$

Probability of any *r* combination being fertile for total C number of combinations

When accounting for the total number of combinations (C = 45), the probability of any combination of size *r* being in the fertile window is:

$$ \mathbf{1} - (\mathbf{1} - \boldsymbol{P}_{\boldsymbol{fertility}})^{\boldsymbol{C}} = 0.87 $$