BI-04 The menstrual cycle and mind

The human menstrual cycle is a sophisticated neuroendocrine rhythm that drives continuous, systemic alterations throughout the female brain and body. Historically, the scientific and cultural understanding of this cycle has been obfuscated by methodological limitations, cultural taboos, and heavily debated evolutionary hypotheses. Over the past decade, however, the integration of longitudinal neuroimaging, intensive daily hormone sampling, digital epidemiology, and large-scale meta-analyses has forced a rigorous re-evaluation of how the menstrual cycle influences the human mind.

As a foundation for understanding how men and women can best live together in shared social architectures, this report evaluates the robust physiological realities, the statistical behavioural overlaps, and the variable cultural interpretations of the menstrual cycle. The analysis explicitly distinguishes between well-replicated phenomena and heavily contested hypotheses, exploring the intersection of endocrinology, psychology, and anthropology.

Layer 1: Physiology – The Measurable Reality

The menstrual cycle is governed by the hypothalamic-pituitary-gonadal (HPG) axis, characterised by the cyclical rise and fall of steroid hormones. The cycle is broadly divided into the follicular phase (characterised by rising estradiol), ovulation (triggered by a surge in luteinising hormone), and the luteal phase (characterised by high levels of both progesterone and estradiol), ending in menstruation if conception does not occur[1].

The Illusion of the 28-Day Cycle

Clinical literature has long anchored on the archetype of a regular 28-day cycle with ovulation occurring precisely on day 14. However, modern digital epidemiology has demonstrated that this archetype is a statistical anomaly. In a seminal analysis of over 600,000 menstrual cycles from 124,648 users of the Natural Cycles application, Bull et al. (2019, *npj Digital Medicine*) revealed the true variability of female reproductive biology[3].

The data demonstrated that only 13% of recorded cycles were exactly 28 days in length[6]. The mean cycle length was 29.3 days, exhibiting a standard deviation of multiple days across the population[3]. While the luteal phase remains relatively stable (averaging 12.4 days), the follicular phase varies dramatically, directly dictating overall cycle length[3].

Cycle Parameter	Population Mean / Prevalence	Clinical Implication
Total Cycle Length	29.3 days (Mean)	The 28-day cycle is not the normative baseline.
Exactly 28-Day Cycles	13% of recorded cycles	Relying on calendar methods for research or fertility is inherently flawed.

Luteal Phase Duration	12.4 days (Mean)	Represents the most temporally stable phase of the menstrual cycle.
Sample Size	N = 124,648 women	Provides robust, real-world baseline data previously unavailable to science.

This high degree of intra- and inter-individual variability undermines decades of earlier psychological research. Many historical studies relied on the "counting backward" method—estimating a woman's hormonal state simply by counting days since her last menses—rather than utilising direct endocrinological assays[1]. Consequently, much of the early literature attempting to link cycle phase to behaviour is methodologically compromised.

Evolutionary Novelty and Lifetime Menses

The physiological baseline of modern women in industrialised societies represents a radical departure from the evolutionary environment. To understand the ancestral context of menstruation, Strassmann (1997, *Current Anthropology*) conducted a longitudinal study of the Dogon people of Mali, a natural-fertility population[8].

By conducting a 736-day census of menstrual hut visits alongside urinary hormone tracking, Strassmann observed that Dogon women without access to modern contraception spend the vast majority of their reproductive years either pregnant or in lactational amenorrhoea[8]. Fecund Dogon women experienced a median of only two menses over a two-year period, accumulating roughly 110 menses over a lifetime[8]. In contrast, women in modern industrialised societies average approximately 400 to 450 lifetime menses[11].

This divergence yields a critical evolutionary reality: the modern female brain and reproductive system are subjected to roughly 300 more cycles of rapid hormonal withdrawal than they evolved to process. This state of "relentless cycling" is a novel environmental pressure. The constant, repetitive exposure to high luteal phase progesterone followed by its rapid withdrawal may be a foundational physiological trigger for the high prevalence of premenstrual mood disorders observed in modern societies, representing a profound biological mismatch between ancestral design and modern reproductive timing.

Layer 2: Behaviour and the Brain – Statistical Overlaps

The influence of fluctuating hormones on cognition, perception, sleep, and sexual desire is the subject of intense ongoing debate. Behavioural traits across the cycle exist as overlapping distributions; a statistical shift in the mean across a population does not imply a categorical change in state for an individual on a given day.

Cognitive Fluctuation: Perception, Spatial Reasoning, and Attention

The hypothesis that sexually dimorphic cognitive abilities—such as spatial reasoning (favouring men on average) and verbal fluency (favouring women on average)—fluctuate with the menstrual cycle has a long history in behavioural neuroscience. Early research by Hampson (1990) and Hausmann et al. (2000, *Behavioral Neuroscience*) suggested that spatial cognition, specifically 3D mental rotation, peaked during the menstrual phase (when estradiol and progesterone are low) and declined during the mid-luteal phase (when these hormones are elevated)[1]. Hausmann's analyses indicated that testosterone had a strong positive influence on mental rotation performance, while estradiol exhibited a negative influence[1]. Furthermore, EEG studies have indicated that during the early follicular phase, women demonstrate higher lateralisation and hemispheric decoupling when solving 3D mental rotation tasks, mimicking male neural patterns[14].

However, as neuroimaging and large-scale methodologies have advanced, the clinical and practical significance of these cognitive fluctuations has been heavily downgraded. While structural and functional MRI studies demonstrate that estradiol clearly modulates hemispheric communication and resting-state functional connectivity[14], these neural adaptations rarely translate to overt behavioural deficits in executive function, working memory, or attention[16].

A striking paradox emerges when comparing subjective feelings of cognitive impairment with objective performance. A recent large-scale study conducted by the UCL Institute of Sport, Exercise and Health (ISEH) evaluating 241 participants found that women actually exhibited heightened mental agility—reacting 10 milliseconds faster and making 25% fewer timing errors in cognitive inhibition tasks—while actively menstruating[17]. This objective improvement occurred despite a significant proportion of the women subjectively reporting "brain fog," clumsiness, and low mood during testing[17]. The physiological implication is that the brain successfully maintains or even sharpens cognitive performance under hormonal withdrawal, but the allostatic load (the energy cost) required to sustain that performance is higher, resulting in subjective exhaustion.

Sleep, Energy, and Pain Architecture

Polysomnographic recordings across the cycle show that the fundamental architecture of sleep remains largely intact, but specific, measurable micro-architectural shifts occur. Baker and Driver (2007, *Sleep Medicine Reviews*) detail that during the mid-luteal phase, the thermogenic effect of progesterone raises core body temperature by approximately 0.4°C and blunts the normal nocturnal temperature drop required for optimal sleep onset[18].

This elevated body temperature is associated with a decrease in Rapid Eye Movement (REM) sleep and an increase in lighter, Stage 2 non-REM sleep[18]. Furthermore, EEG data reveal a significant increase in sleep spindle activity (12-15 Hz bursts of brain activity) during the luteal phase[18]. Despite deep Slow Wave Sleep (SWS) remaining relatively stable across the month, subjective sleep quality plummets in the late luteal and perimenstrual phases, accompanied by increased sleep onset latency and intermittent awakenings (Wake After Sleep Onset, or WASO)[20].

Sleep Parameter	Menstrual / Follicular Phase	Luteal Phase (High Progesterone)

Core Body Temperature	Baseline	Elevated by ~0.4°C; blunted nocturnal drop
REM Sleep Duration	Baseline	Statistically reduced
Stage 2 (Light) Sleep	Baseline	Statistically increased
Sleep Spindle Activity	Baseline	Markedly increased (12-15 Hz frequency)
Subjective Quality	Generally restorative	Often reported as fragmented and unrefreshing

Pain perception also fluctuates systematically. The late luteal and menstrual phases are marked by heightened hyperalgesia and lower pain thresholds, likely due to the withdrawal of neuroactive steroids (such as allopregnanolone) that normally modulate central pain and inflammatory pathways[15].

The Ovulatory Shift Controversy: Mate Preferences and Sexual Desire

No area of menstrual cycle research has been as heavily contested, or subject to as much methodological scrutiny, as the "ovulatory shift hypothesis" (OSH). Originally formulated by evolutionary psychologists (e.g., Gangestad and Thornhill), the hypothesis posits a "dual sexuality" model. It suggests that women's mating preferences shift during the brief fertile window to favour men with phenotypic indicators of high genetic quality (e.g., masculine facial features, dominant behaviour, bodily symmetry, deep voices) for short-term mating[7]. Conversely, during non-fertile phases, women are theorised to prefer men displaying traits associated with reliable provisioning and long-term parental investment[7].

The Meta-Analytic Clash

In 2014, the scientific community witnessed a rare event: two competing meta-analyses published nearly simultaneously, evaluating the exact same literature, yet reaching polar opposite conclusions.

1. **The Pro-Shift View:** Gildersleeve, Haselton, and Fales (2014, *Psychological Bulletin*) analysed 134 effects from 50 studies and found robust support for the ovulatory shift, concluding that fertile women exhibit an increased preference for masculine traits specifically in a short-term mating context[26].
2. **The Skeptical View:** Wood, Kressel, Joshi, and Louie (2014, *Emotion Review*) analysed 58 reports and concluded that the ovulatory shift effect was non-existent. They attributed previous positive findings to severe methodological artefacts, flexible data analysis (p-hacking), underpowered sample sizes, and systemic publication bias[24].

Resolution via High-Powered Longitudinal Studies

To resolve this methodological crisis, subsequent researchers deployed massive, pre-registered, within-subject longitudinal studies utilizing direct salivary hormone assays rather than calendar counting. The results have heavily refuted the ovulatory shift regarding specific target preferences:

- **Jones et al. (2018, *Psychological Science*)**: In the largest longitudinal study of its kind (N = 584 women, over 5,000 testing sessions), researchers measured salivary estradiol, progesterone, and testosterone while women rated masculine versus feminine faces. The study found no compelling evidence that preferences for facial masculinity tracked hormonal status[29]. While women generally preferred masculine faces for short-term flings, this preference remained static across the entire cycle[29].
- **Stern et al. (2021, *Hormones and Behavior*)**: Tracking 257 women over 1,028 sessions rating male bodies, researchers found weak evidence for a general increase in attraction to male bodies during the fertile window, but absolutely no specific shift toward preferring *masculine* bodies, nor did preference fluctuations track steroid hormone changes[32].
- **Arslan et al. (2018, *Evolution and Human Behavior*)**: A study of 157 women rating bodies found an overall increase in sexual desire, but explicitly noted that male masculine traits did not interact with cycle phase[34].

Study / Meta-Analysis	Sample Size / Scope	Methodology	Finding Regarding Ovulatory Shift in Preference
Gildersleeve et al. (2014)	134 effects	Meta-analysis	Supportive; claims robust preference for masculinity mid-cycle.
Wood et al. (2014)	58 reports	Meta-analysis	Non-supportive; attributes previous positive findings to p-hacking.
Jones et al. (2018)	N = 584 women	Longitudinal, salivary hormones, faces	Non-supportive; no hormone-preferenc e link found.
Stern et al. (2021)	N = 257 women	Longitudinal, salivary hormones, bodies	Non-supportive; general attraction increases, but not for masculinity.

The True Shift: Libido, Not Target While the preference for hyper-masculine "good genes" does not robustly fluctuate, overall sexual motivation undeniably does. Roney and Simmons (2013, *Hormones and Behavior*) tracked daily salivary hormones and found that estradiol positively predicts, and progesterone negatively predicts, overall sexual desire[35]. Arslan et al. (2021) analysed 26,000 diary entries and found a mid-cycle peak in both *in-pair* and *extra-pair* sexual desire[37].

The data strongly suggest that human females have evolved "extended sexuality"—mating across the entire cycle to foster pair-bonding, confuse paternity, and secure paternal investment[7]. The ovulatory phase simply acts as a biochemical volume dial that increases general libido and motivational priorities, rather than a psychological mechanism that alters the specific phenotypic attributes a woman finds attractive[37].

What Partners Perceive A critical corollary to the ovulatory shift is whether male partners detect female fertility and subsequently alter their behaviour (e.g., increasing mate retention or jealousy). In a rigorous longitudinal diary study, Schleifenbaum (2022) and Gangestad et al. (2019) investigated dyadic behaviour. They found that male partners did *not* perceive cues to their female partner's fertility status, nor did they show increased mate retention tactics to secure access to their fertile partners[7]. Human ovulation remains robustly concealed, preventing males from perfectly timing mate-guarding behaviours[37].

Pathology at the Extremes: PMS and PMDD

While many women navigate the menstrual cycle with minimal disruption, a significant proportion experience severe affective and physical symptoms that drastically impair functioning.

Prevalence and Diagnosis

A comprehensive meta-analysis by Direkvand-Moghadam et al. (2014, *Journal of Clinical and Diagnostic Research*) reviewing 17 studies globally established that the pooled prevalence of Premenstrual Syndrome (PMS) is approximately 47.8%[39]. The most severe manifestation, Premenstrual Dysphoric Disorder (PMDD), recognized as a distinct psychiatric condition in the DSM-5, affects between 3% and 8% of women of reproductive age[41].

Because human memory is heavily subject to recall bias—often magnifying negative experiences—retrospective self-reports of PMS/PMDD are notoriously inaccurate and lead to massive over-diagnosis in survey data. To ensure reliable, standardized diagnosis, Eisenlohr-Moul et al. (2017, *American Journal of Psychiatry*) developed the Carolina Premenstrual Assessment Scoring System (C-PASS)[44]. C-PASS requires a minimum of two consecutive cycles of prospective daily symptom charting (utilising the Daily Record of Severity of Problems, DRSP)[44]. To qualify for PMDD, a patient must demonstrate a 30% relative increase in symptoms during the premenstrual week compared to the postmenstrual week, alongside absolute postmenstrual clearance (symptoms returning to baseline)[44].

Aetiology: An Abnormal Response to Normal Hormones

The most critical revelation in modern neuroendocrinology regarding PMDD is that it is not

caused by a "hormone imbalance." Women with PMDD have identical cyclical levels of estradiol and progesterone compared to healthy, asymptomatic controls[47].
In a landmark proof-of-concept study, Schmidt et al. (1998, *New England Journal of Medicine*) administered leuprolide (a GnRH agonist) to medically suppress the menstrual cycles of women with and without PMDD[48]. When the cycle was chemically halted, PMDD symptoms completely vanished[48]. Crucially, when researchers covertly added back physiological doses of estradiol or progesterone, the severe mood symptoms returned exclusively in the PMDD group, while the healthy controls remained unaffected[48]. This definitively proved that PMDD is a neurobiological sensitivity—an abnormal, maladaptive brain response to normal hormonal fluctuations[47].

Neurobiological Mechanisms: SERT and GABA$_A$

Recent neuroimaging and psychopharmacological research has illuminated the precise mechanisms of this vulnerability:

1. **The Serotonin Network**: Sacher et al. (2023, *Biological Psychiatry*) utilized PET imaging to track the serotonin transporter (SERT) across the cycle. They discovered an unexpected 18% increase in SERT binding in the midbrain of PMDD patients specifically during the premenstrual phase[50]. Increased SERT density rapidly clears serotonin from the synaptic cleft, leading to a sudden, cyclical serotonin deficit. This relative starvation of synaptic serotonin perfectly maps onto the profound depressive symptoms, hopelessness, and emotional lability characteristic of PMDD[50].
2. **The GABA$_A$ and Allopregnanolone Axis**: Progesterone is metabolised in the brain into allopregnanolone (ALLO), a potent neuroactive steroid and positive allosteric modulator of the GABA$_A$ receptor[53]. In a healthy brain, ALLO acts similarly to alcohol or benzodiazepines, producing calming, sedative, and anxiolytic effects[54]. Hantsoo and Epperson (2015) outlined that women with PMDD exhibit an impaired, paradoxical interaction between ALLO and GABA$_A$ receptors[54]. Instead of providing relief, the luteal rise and rapid withdrawal of ALLO triggers heightened amygdala reactivity, manifesting as severe anxiety, irritability, and hyper-reactivity to social stress[54]. Gingnell et al. (2012, *Psychoneuroendocrinology*) demonstrated via fMRI that PMDD is associated with failed habituation of the amygdala, where high progesterone concentrations correlate with runaway amygdala activation in response to emotional stimuli[57].

Emerging Pharmacological Interventions

The neurobiological understanding of PMDD has revolutionised targeted treatments:

- **SSRIs as SBSS**: Selective Serotonin Reuptake Inhibitors (SSRIs) relieve PMDD symptoms in 24 to 48 hours, unlike the 4 to 6 weeks required for Major Depressive Disorder[53]. Pinna et al. have demonstrated that at very low doses, SSRIs act as Selective Brain Steroidogenic Stimulants (SBSS) via the enzyme 3α-hydroxysteroid dehydrogenase (3α-HSD)[23]. This mechanism rapidly forces the synthesis of brain allopregnanolone independent of serotonin-blocking effects, thus stabilizing the GABA$_A$ receptor and blunting the withdrawal effect[23].
- **Sepranolone (Isoallopregnanolone)**: Bäckström et al. (2021, *Psychoneuroendocrinology*) conducted a phase II randomized controlled trial on

Sepranolone, an endogenous isomer that acts as a GABA$_A$ modulating steroid antagonist, effectively blocking the negative, paradoxical effects of ALLO[59]. While the trial did not meet its strict primary endpoint (due to a high placebo response across the cohort), a post-hoc analysis of the 10 mg dose over a 9-day premenstrual window showed it significantly outperformed the placebo in reducing symptom severity, emotional distress, and functional impairment[59].

Layer 3: Culture – The Variable Interpretation

The physiological and behavioural realities of the menstrual cycle are ultimately filtered through vast cultural, economic, and social lenses, determining how these biological rhythms are accommodated or stigmatised.

Workplace Productivity and Presenteeism

In modern corporate societies, the cyclical realities of female biology are largely ignored by rigid workplace structures. Schoep et al. (2019, *BMJ Open*) surveyed 32,748 working-age women and uncovered a massive, hidden economic cost. On average, women lost 8.9 days of productivity per year due to menstruation-related symptoms[62].

Crucially, absenteeism (taking a day off sick) accounted for only a very small fraction of this loss, averaging just 1.3 days per year[63]. The vast majority of the economic and personal impact occurred via *presenteeism*—working while physically or mentally unwell. Over 80.7% of respondents reported pushing through work while symptomatic, resulting in a self-reported 33% reduction in productivity on those days[62].

Productivity Metric	**Finding (Schoep et al., N = 32,748)**
Total Productivity Loss	8.9 days per year per woman
Absenteeism (Time Off)	1.3 days per year
Presenteeism Prevalence	80.7% of respondents
Productivity Drop (When working ill)	33% reduction in output
Disclosure to Employer	Only 20% disclosed the true reason for absence

The stigma surrounding the cycle is so profound that among those who did take sick leave, only 20% disclosed the true reason to their employer[62]. Furthermore, 68% of the women surveyed desired basic accommodations, such as flexible hours or the ability to work from home, during their cycle[62].

Anthropological Perspectives: Taboo vs. Autonomy

Traditional cultures have frequently organised civic and religious life around the menstrual cycle, phenomena often reduced by Western observers to oppressive "pollution taboos." In the seminal text *Blood Magic: The Anthropology of Menstruation* (1988), Buckley and Gottlieb challenge this unilinear view[65]. They demonstrate that cross-culturally, menstrual taboos and isolation huts can simultaneously represent a recognition of female sacred power, a mandated period of rest from arduous physical labour, and a mechanism of social autonomy away from male-dominated village life[65].

Strassmann's work among the Dogon further grounds this behaviour in evolutionary ecology. Dogon men use the visibility of the menstrual hut as a public, honest signal of a woman's non-pregnancy status[8]. This serves as a critical mechanism for tracing paternity in a patrilineal society prior to marriage[8]. Thus, the cultural management of the cycle is not merely superstitious; it is intimately bound to the socio-economic and reproductive requirements of the environment.

Distinguishing Averages from Individuals

A persistent risk in translating cycle science to the public is the ecological fallacy: assuming that a statistical average applies deterministically to an individual.

1. **Variance is the Rule:** As demonstrated by Bull et al., the 28-day cycle is a statistical anomaly, and ovulation timing varies wildly[6]. A woman may ovulate on day 12 one month and day 20 the next.
2. **Overlapping Curves:** Finding that women, *on average*, experience higher libido during the late follicular phase does not mean a woman cannot experience peak sexual desire during menstruation or the late luteal phase. Individual baseline differences often dwarf phase-to-phase variations.
3. **Hormonal Sensitivity over Absolute Levels:** PMDD research proves that the *absolute level* of a hormone matters far less than the individual's *neuroreceptor sensitivity* to that hormone's fluctuation[47]. Behavioural changes across the cycle are heavily moderated by individual stress levels, relationship satisfaction, underlying genetics (e.g., SERT expression), and environmental security[41].

Summary of Robust Findings

1. The 28-day cycle is a statistical minority; human cycle length is highly variable, largely driven by follicular phase variance.
2. Modern women experience roughly 300 more lifetime menses than ancestral women, representing a profound evolutionary mismatch.
3. Objective cognitive performance (e.g., accuracy, reaction time) remains highly stable across the cycle, though the subjective effort (fatigue) to maintain it peaks premenstrually.
4. Sleep architecture shifts slightly (more spindles, less REM mid-luteal), driven by progesterone-induced core body temperature increases.
5. Overall sexual desire frequently peaks around ovulation, serving extended sexuality rather than strict conception.
6. The "ovulatory shift" in preference toward hyper-masculine men for short-term mating has failed to replicate in large-scale, hormone-verified longitudinal studies.

7. Male partners do not reliably perceive female fertility cues, nor do they reliably increase mate-guarding behaviours during ovulation.
8. PMDD is not a hormone imbalance, but an abnormal neurological sensitivity to normal fluctuations of estradiol and progesterone.
9. PMDD neurobiology is linked to cyclical midbrain serotonin depletion (increased SERT) and paradoxical amygdala reactivity to the GABA$_A$ modulator allopregnanolone.
10. Menstrual symptoms account for roughly 9 days of lost workplace productivity annually, predominantly driven by presenteeism rather than absenteeism.

Contested or Open Questions

- **The precise mechanism of GABA$_A$ disruption in PMDD:** It is not yet fully understood why allopregnanolone acts as a potent anxiolytic in healthy women but triggers paradoxical anxiety, irritability, and amygdala hyper-reactivity in those with PMDD.
- **The ultimate efficacy of targeted neurosteroid antagonists:** While Phase II trials of Sepranolone show clinical promise at specific doses (10 mg), its failure to meet primary endpoints against placebo leaves its viability as a mainstream therapeutic open to question.
- **The role of oral contraceptives on the brain:** Emerging network analysis suggests hormonal contraceptives may cause emotional blunting by lowering day-to-day variability in affect and energy[67], but long-term neurostructural impacts remain fiercely debated.
- **The interaction of the immune system:** The degree to which cyclical immunosuppression (driven by high progesterone) modulates systemic inflammation, pain thresholds, and autoimmune flare-ups across the cycle remains underexplored.

5 to 10 Most Important Sources to Read in Full

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Implications for Living Together

Natural does not mean good. The fact that evolutionary pressures resulted in profound female physiological fluctuations does not mean modern societies should ignore the physical, cognitive, and economic toll these fluctuations can exact.

For couples and families, the debunking of the "ovulatory shift" offers a reassuring baseline: biological fertility does not inherently threaten relationship stability, and men do not need to harbour evolutionary anxieties regarding mid-cycle infidelity based on a biological imperative. The most significant shift is merely an increase in general libido. However, partners must recognise that the neurobiological sensitivities of the late luteal phase (particularly in PMS and PMDD) are authentic physiological states, driven by measurable shifts in serotonin clearance and GABAergic receptor modulation. They are not merely psychological failings, lack of willpower, or character flaws.

For organisations and societies, the staggering rate of presenteeism signals a catastrophic failure of workplace design. The modern standard of linear, unbroken, 40-hour-week productivity across 52 weeks is structurally antagonistic to the female biological baseline, which naturally oscillates in energy, temperature, and neurosteroid production. Allowing for task flexibility, remote work during the late luteal or early menstrual phase, and fostering an environment where menstrual symptoms can be disclosed without professional penalty is not merely an act of accommodation; it is an economic and operational necessity. Recognising cyclical variance is the foundational step in designing resilient institutions where both men and women can sustainably live and work together without enforcing systemic burnout.

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