Hormones, Alcohol & Cognition: Menstrual Cycle Influences on Neurocognitive Functioning Underlying Alcohol Use and Alcohol Use Disorder

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Abstract

The menstrual cycle has emerged as a potential key factor in the treatment and recovery from substance use disorder. Existing research on nicotine cessation shows the impact of the menstrual cycle on withdrawal, abstinence, and relapse. However, similar research on alcohol use disorder (AUD) is lacking. Various neurocognitive domains are implicated in an AUD, notably cognitive control, negative emotionality, and incentive salience. Menstrual cycle fluctuations can further impact these neurocognitive processes. This literature review examines the menstrual cycle and neurocognitive functioning involved in alcohol use through three different aims: 1) menstrual cycle moderation of acute alcohol on neurocognitive process in non-AUD populations, 2) menstrual cycle moderation of general alcohol use in non-AUD populations, and 3) menstrual cycle influence on neurocognition in individuals with an AUD**.** N = 17 studies were included, with n = 10 focusing on acute alcohol consumption, n = 5 examining alcohol use in non-AUD populations, and n = 2 examining use in individuals with an AUD. Findings in non-AUD populations show impaired cognitive control in high estrogen vs. low estrogen phases, including worsened inhibition, attention, and vigilance, and increased negative emotionality in the luteal phase and menstrual phases, compared to follicular and peri-ovulatory phases, with increased drinking motives to cope. Incentive salience also rose in high estrogen phases for the non-AUD population, linked to increased reward sensitivity in high vs. low estrogen phases. The studies that explicitly looked at individuals with an AUD found lower probabilities for binge drinking and greater capacity for emotional reasoning in the high progesterone phase (luteal phase) than in the low progesterone phases (follicular, peri-ovulatory, and menstrual week phases). Findings demonstrate how ovarian hormone fluctuations may shape neurocognitive vulnerabilities to alcohol use. Raising awareness of menstrual cycle effects on neurocognition could improve prevention strategies, treatments, and recovery outcomes for menstruators navigating AUDs.

Keywords

Menstrual cycle, AUD, neurocognition, alcohol use

Introduction

Background and Context

Alcohol Use Disorder (AUD) is a condition characterized by clinically significant impairment or distress resulting from alcohol use, with substantial variability in its course, from full remission to chronic relapsing (MacKillop, 2019; Nehring et al., 2023). Studies suggest that AUD has one of the lowest treatment rates, with only 10% or less of individuals fitting the diagnostic criteria in Europe receiving treatment (Probst et al., 2015). Although a substantial number of these individuals recover without treatment, at least 25% of those needing treatment for AUD fail to receive it (Tuithof et al., 2016). There is evidence that sex and gender differences in AUD may further exacerbate this treatment gap due to the unique needs of each gender, which also influences treatment efficacy and mechanisms of behavior change (Alonso-Marmelstein et al., 2025; Holzhauer et al., 2020). Not only is the treatment gap affected by sex and gender differences, but research indicates that gender-specific factors significantly impact cessation strategies, chronic relapse treatment protocols, and long-term recovery outcomes (Walitzer et al., 2006). As a call to de-gender and de- stigmatize menstruation and include not only women and sex-assigned females but also menstruators of trans or other gender identities, the term "menstruators" will be used in this review to encompass all those who actively menstruate (Rydström, 2020). One potential mechanism through which alcohol may disproportionately impact menstruators is through its unique interactions with ovarian hormone fluctuations across the menstrual cycle (Sarkola et al., 1999). The menstrual cycle is being increasingly considered in research on other substances, such as nicotine, where hormonal interventions could offer innovative approaches for cessation and treatment (Giner et al., 2024). However, research on AUD remains limited and may provide beneficial insight into potential novel treatment approaches and protocols for alcohol use recovery.

Sex and Gender Differences in Alcohol Use Disorder

In this article, "sex" refers to sex assigned at birth, while "gender" refers to self-described gender identity. Research on alcohol and substance use has been predominantly focused on sex-assigned males, with menstruators being heavily underrepresented (Joyce et al., 2021). Due to this lack of representation in research, menstruators may have received interventions that are potentially less effective for them, with a general lack of acknowledgment of specific interventions that address sex hormone-specific variations around alcohol consumption and treatment (Joyce et al., 2021). Gender differences also suggest that among adults, hazardous alcohol use is increasing for women but not for men, with a more considerable increase in adverse outcomes such as hospitalizations and deaths for women (White, 2020). Women with AUD may face a disadvantage in the bidirectional relationship between cognitive functioning and alcohol use, experiencing greater difficulties than men in working memory, emotional processing, visuospatial abilities, balance, and social cognition (Fama et al., 2020). While overall relapse rates do not differ between men and women, the predictors of relapse are gender-specific: women have greater relapse risk around marriage and marital stress, while for men, marriage lowered relapse risk (Walitzer et al., 2006). Other aspects, such as interpersonal conflict and negative affect, were also risk factors for alcohol relapse in women

(Walitzer et al., 2006). Affect is of specific interest, as aspects such as worry have been associated with ovarian hormones (Russman Block et al., 2024). On a more biological level, alcohol may have a more negative effect on sex-assigned females than sex-assigned males due to the pharmacokinetics and pharmacodynamics of alcohol on their bodies (Fama et al., 2020; Glanton Golzhauer et al., 2020). Sex hormones (specifically estrogen and progesterone) interact with alcohol use and could influence patterns of a menstruator's alcohol intake (Glanton Golzhauer et al., 2020). Ovarian hormones, therefore, may be a factor affecting menstruators' substance use and addictive behavior (Joyce et al., 2019). However, these differences may not be purely biological but could also be due to poorer identification of substance-related problems in menstruators (Sallaup et al., 2016).

Several key literature reviews suggest a meaningful, though not yet fully understood, relationship between alcohol consumption patterns and cyclical fluctuations in ovarian hormones. While evidence supports this link, the underlying psychological and physiological mechanisms and its potential impact on AUD remains insufficiently explored, highlighting the need for further research (Caroll et al., 2015; Warren et al., 2021). Additionally, the phenomenon of "telescoping," which addresses the quicker progress of women from initial alcohol use to AUD in comparison to men, further highlights the unique variations in AUD progression by gender (Carroll et al., 2016). Building on the above findings: the under recognition of substance-related problems in menstruators, hormonal influences on alcohol consumption, gender-specific relapse predictors, cognitive and emotional vulnerabilities, pharmacokinetic and pharmacodynamic sex differences, and the telescoping effect— the current paper focuses on how the menstrual cycle may modulate the acute effects of alcohol on neurocognitive functioning. This study examines both non-clinical populations and individuals with an AUD, with an emphasis on understanding the neurocognitive and neurobiological mechanisms as they may offer insight into interactions that remain underexplored (Warren et al., 2021).

The Menstrual Cycle

Estrogen and progesterone are key menstrual cycle hormones that govern the menstrual cycle but also affect the central nervous system (CNS) (Hampson, 2020). The term estrogen will be used widely in this review to encompass estradiol (E2), the primary form of estrogen found during the premenopausal period (Coelingh Bennink, 2004). Although a 28-day cycle is commonly assumed, only 15% of menstruators experience this length, with healthy cycles ranging from 24 to 35 days (Bull et al., 2019). Therefore, standardized days should not be used, and instead, we can discern different stages of the menstrual cycle by rising levels of endogenous estrogen and progesterone, as shown in Figure 1. Schmalenberger et al. (2021) and Hampson (2020) have created practical tools and recommendations for researchers to follow. Instead of focusing on the day frame, they recommend focusing on the specific hormonal fluctuations and overlapping them with the different phases of the menstrual cycle (Hampson, 2020; Schmalenberger et al., 2020). The recommended phases include peri-menstrual, mid-follicular, peri-ovulatory, and mid-luteal. Additional phases can be found in Figure 1. Combined with recommendations for researchers, operational definitions for the cycle in this review are as follows: The menstrual week includes all those days when a menstruator is actively bleeding, usually lasting between 2-7 days (Schmalenberger et al., 2020). The follicular phase is characterized by rising estrogen in preparation for ovulation. The peri-ovulatory phase is considered the days near and around ovulation when there is a primary peak and a subsequent fall in estrogen levels with the release of an ovarian follicle (Schamlenberger et al., 2020; Hampson, 2020). The luteal phase is characterized by rising progesterone and lasts until menses onset (Schmalenberger et al., 2020). Instead of opting

for mid-follicular/mid-luteal, this review uses the overarching follicular and luteal phase as working definitions due to many of the included studies not accurately assessing the mid-range of either phase (Linnoila et al., 1980; Freitag & Adesso, 1993; Milivojevic et al., 2014; Mumenthaler et al., 2001). The term menstrual week is additionally used instead of peri-menstrual due to included studies focusing on the days of active menstruation rather than including the days before menses onset, as defined by Schmalenberger et al. (2020).

Figure 1

Graphical overview of the menstrual cycle and its phases (directly taken from Schmalenberger et al., 2020)

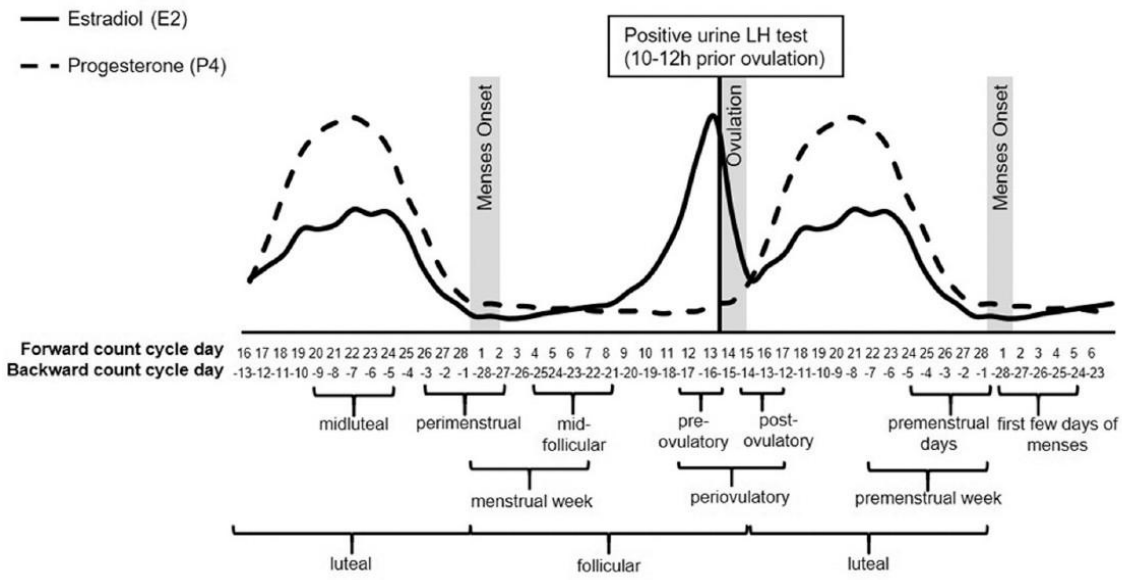


Figure 2.
Graphical overview of the menstrual cycle and its phases.

Note. This includes estrogen (estradiol, E2) and progesterone (P4). Ovulation and menses onset are explicitly shown. Day 1 of the menstrual cycle is the onset of menses. The menstrual week phase characterizes the days of active menstrual bleeding, the follicular phase characterizes rising estrogen, the peri-ovulatory phase is the days near and around ovulation, and the luteal phase is characterized by rising progesterone and lasts until menses onset.

Substances and the Menstrual Cycle

To better understand how menstrual cycle-related hormonal fluctuations might shape alcohol-related neurocognitive processes, it is valuable to consider evidence from research on other substances. Well-established research on nicotine indicates that nicotine reward is enhanced during the follicular phase, when estrogen is high, while withdrawal symptoms are enhanced during the luteal phase, when progesterone is higher (Giner et al., 2024). Estrogen modulates brain reward systems and promotes associative reward learning and the development of compulsive reward-seeking behavior, while progesterone opposes these effects and reduces the reward efficacy of substances (Hilz & Lee, 2023). Similarly, research on cocaine use and cocaine use disorder illustrates the impact

of sex hormone levels on reward-seeking behavior. High progesterone, compared to low progesterone, is associated with decreased stress-induced and cue-induced craving, as well as lower anxiety and blood pressure responses during cue exposure (Sinha et al., 2007). Progesterone modulates GABAA receptors, which produce anxiolytic and anti-stress effects, giving a potential physiological explanation for this occurrence (Fox et al., 2004). These findings suggest that menstrual cycle fluctuations impact neurocognitive functions related to substance use and addiction.

Although several reviews have examined the effects of menstrual cycle phases on alcohol consumption, they have not specifically explored the underlying neurocognitive processes (Carroll et al., 2015; Warren et al., 2021). Therefore, we can draw on existing theories, namely, the self-medication theory and the reward-sensitivity theory, to help illuminate potential mechanisms driving these fluctuations in alcohol use across the cycle (Joyce et al., 2021). The self-medication theory suggests that increases in negative affect, specifically during the luteal and menstrual week phases, may drive heightened binge drinking as a way to cope. In contrast, the reward-sensitivity theory emphasizes that increased positive affect and increased reward-seeking behavior, particularly around the follicular phase and peri-ovulation, may also lead to increased drinking. While these theories highlight different mechanisms and cycle phases, they are not mutually exclusive. Together, they suggest that alcohol use may fluctuate across the menstrual cycle due to shifting affective and motivational states. However, findings remain generally inconsistent, with some studies reporting heightened alcohol use during the luteal and menstrual phases and others reporting increases around peri-ovulation, highlighting the complex interplay of hormonal and cognitive factors affecting drinking behavior throughout the menstrual cycle (Joyce et al., 2021). This highlights the need for more nuanced research, particularly around neurocognition. As executive control and risk-reward processing are key elements to understanding and maintaining addictive behaviors, examining how the menstrual cycle moderates the acute effects of alcohol on neurocognitive functioning, as well as neurocognitive changes in individuals with an AUD, could provide insights into the development, progression, and treatment of AUD (Christensen et al., 2023).

Neurocognition in Alcohol Use Disorder

To understand how AUD develop and persists, it is essential to examine how chronic alcohol use affects the three neurocognitive domains that are most often implicated in the neurocircuitry of addiction: cognitive control, negative emotionality and incentive salience (Ekhtiari et al., 2020). Alterations in these systems can be both potential precursors or consequences of substance use disorder (Ekhtiari et al., 2020). Framing AUD through this lens allows for a more integrated analysis of the neurobiological mechanisms that underlie AUD and how the menstrual cycle may affect it.

Cognitive control refers to deficits in executive functioning, attentional control, response inhibition, working memory, cognitive flexibility, and planning (Ekhtiari et al., 2020). Negative emotionality refers to responses to aversive stimuli, such as stress, fear, loss, and anxiety, which may drive alcohol consumption as a means of coping with negative affect, stress, or aversive states (Ekhtiari et al., 2020). And lastly, incentive salience examines reward responsiveness, reward learning, and motivation for alcohol use (Ekhtiari et al., 2020).

These three neurocognitive domains can be mapped onto the behavioral progression of addiction, which includes: compulsion to seek and take the drug, loss of control in limiting intake, and emergence of a negative

emotional state reflecting withdrawal when access is prevented (Koob & Bolkow, 2010). Impulsivity drives early-stage substance use, gradually moving to compulsivity as motivation transitions from positive reinforcement to negative reinforcement (Koob, 2004). Positive reinforcement refers to the drive for pleasant feelings and social enhancements, while negative reinforcement highlights the relief of negative affect, such as stress or anxiety, that motivate substance use (Bin Cho et al., 2019). When connected to the three neurocognitive domains, incentive salience may play a larger role in the early stages of behavior progression through its impact on social motivations and its pleasurable effects, while negative emotionality may underlie later-stage reinforcements by driving use to avoid negative affect or states (Ekhtiari et al., 2020). Impairments in cognitive control may increase as use increases and use shifts from impulsive to compulsive and use becomes chronic (Ekhtiari et al., 2020).

Chronic substance use creates acute and long- term neuroadaptive changes in the brain that may result in greater relapse, which relate to increases in both impulsivity and compulsivity (Koob & Bolkow, 2010). These changes occur primarily through neuroplasticity, mediated mainly by dopamine, where reward systems get dysregulated, and substance use becomes associated with specific environmental cues and increased incentive salience (O'Brien, 2009). The mesolimbic dopamine system plays a key role in the executive, affective, and motivational functions during the binge/intoxication stage (Koob & Bolkow, 2010; Serafini et al., 2019). The amygdala, a central emotional processor, integrates and promotes negative reinforcement mechanisms during withdrawal (Koob & Bolkow, 2010). The prefrontal cortex (PFC), hippocampus, and insula drive the preoccupation/anticipation stage, modulating attention and inhibitory control (Koob & Bolkow, 2010).

Together, these neurobiological systems support the interconnection of neurobiological mechanisms, behavioral stages of addiction, and neurocognitive domains that provide a comprehensive foundation for investigating sex and gender differences in AUD and developing targeted, effective interventions based on neurobiological profiles.

Rationale for the Study

Research on the menstrual cycle is increasingly uncovering how sex hormone fluctuations affect withdrawal, craving, and relapse in substance use (Giner et al., 2024; Joyce et al., 2021). Estrogen and progesterone, key hormones of the menstrual cycle, have been shown to modulate reward-seeking behavior for substances such as nicotine and cocaine (Giner et al., 2024; Sinha et al., 2007). Emerging evidence also suggests associations between alcohol consumption and the menstrual cycle, highlighting the potential role of naturally-occurring hormonal fluctuations to influence alcohol use patterns (Joyce et al., 2021; Warren et al., 2021).

Estrogen and progesterone have been linked to fluctuations in cognitive functions, such as impulsivity and recklessness, across the menstrual cycle (Dreher et al., 2007; Hilz & Lee, 2023). These effects may possibly involve interactions with the PFC, reward pathways, and mesolimbic dopamine systems (Amin et al., 2006; Arélin et al., 2015; Dreher et al., 2007; Keenan et al., 2001). As such, these hormonal fluctuations may modulate neurocognitive processes in both non-clinical populations and individuals with an AUD.

Prolonged and problematic alcohol use is associated with neurocognitive alterations, such as increased impulsivity, stress reinforcement, and disrupted cognitive control (Koob & Bolkow, 2010). These alterations may both precede and result from such substance use, underscoring a bidirectional relationship between alcohol and neurocognition. This bidirectional relationship underscores the importance of considering underlying neurocognitive

shifts and vulnerabilities that may play a role in the prevention and treatment of AUD. Adopting a neurocognition lens to examine this relationship is crucial, as it helps reveal how alcohol use and hormones interact to affect brain function such as executive functioning (Christensen et al., 2023). It may additionally offer insight into why, when and how menstruators may be more affected by acute alcohol and its long term potential to progress into an AUD, as well as its implications for treatment when seeking support for cessation. Implications can include integrating cycle-informed psychoeducation into public health campaigns for AUD prevention, educating on hormonal influences to craving and potential relapse in those with an already existing AUDs, and addressing behavioral changes such as increased impulsivity through the menstrual cycle via tailored therapeutic approaches.

Although interest in this area is growing, existing research in AUD has been done primarily on sex-assigned male populations or has not accounted for menstrual cycle variations, potentially concealing sex and gender differences. Investigating how the menstrual cycle modulates both the acute neurocognitive effects of alcohol, as well as its role in longer-term drinking and those with an AUD, may offer crucial insights for developing sex hormone-informed prevention strategies, treatments, and interventions.

Objectives

This systematic review has three aims: examining how the menstrual cycle moderates the acute effect of alcohol on the neurocognitive process in individuals without an AUD, how the menstrual cycle moderates alcohol use in non-AUD populations, and how the menstrual cycle influences neurocognition in individuals with an AUD. It highlights the need for sex and gender-specific research, prevention strategies, and treatment adaptations. The review aims to promote further awareness and more effective strategies for preventing AUD and managing AUD in those with a menstrual cycle.

Methodology

Literature Search Strategy

A systematic review search was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Electronic searches were conducted in January 2024 using MeSH terms and text keywords in the PubMed database. The PubMed searches used the search string found in Table 1. Filters were applied to only include empirical peer-reviewed journal articles and studies done on humans. The initial search yielded n= 369 results, which were then imported into Rayyan.AI to remove duplicates and for appropriate screening.

Table 1

MeSH & Free Textform Keyword Search Terms

Query = (Alcohol) AND (Menstruation) AND (Neurocognition) NOT (Exclusion)			
Alcohol	Menstruation	Neurocognition	Exclusion
"alcohol"[Title/Abstract] OR "alcohol use"[Title/Abstract] OR "alcohol consumption"[Title/Abstract] OR "binge drinking"[Title/Abstract] OR "alcohol craving"[Title/Abstract] OR "alcohol relapse"[Title/Abstract] OR "alcohol craving"[Title/Abstract] OR "alcohol dependence"[Title/Abstract] OR "alcohol use disorder"[Title/Abstract] OR "AUD"[Title/Abstract]	"menstrua*"[Title/Abstract] OR "menstrual cycle"[Title/Abstract] OR "hormonal fluctuations"[Title/Abstract] OR "ovarian hormones"[Title/Abstract] OR "estrogen"[Title/Abstract] OR "progesterone"[Title/Abstract] OR "estradiol"[Title/Abstract] OR "menstruation"[Title/Abstract] OR "follicular"[Title/Abstract] OR "luteal"[Title/Abstract] OR "ovulation"[Title/Abstract]	"cognit*"[Title/Abstract] OR "cognitive"[Title/Abstract] OR "cognitive function"[Title/Abstract] OR "cognitive functions"[Title/Abstract] OR "cognitive performance"[Title/Abstract] OR "motive"[Title/Abstract] OR "motives"[Title/Abstract] OR "Behavioral impairment"[Title/Abstract] OR "inhibitory control"[Title/Abstract] OR "disinhibition"[Title/Abstract] OR "disinhibiting effect"[Title/Abstract] OR "stress reactivit*"[Title/Abstract] OR "cue reactivit*"[Title/Abstract] OR "cognitive control"[Title/Abstract] OR "acute effect*"[Title/Abstract] OR "immediate reward*"[Title/Abstract] OR "reward*"[Title/Abstract] OR "cue reactivit*"[Title/Abstract] OR "working memor*"[Title/Abstract] OR "Executive functioning"[Title/Abstract] OR "cognitive control"[Title/Abstract] OR "inhibitory	"Review"[Publication Type] OR "Systematic Review" [Publication Type] OR "Meta-Analysis"[Publication Type] OR "Meta-Analysis as Topic"[Mesh] OR "meta-analysis"[tiab] OR "systematic review*"[tiab] OR "systematic literature review*"[tiab] OR "Letter"[Publication Type] OR "Editorial"[Publication Type] OR "Comment"[Publication Type] OR "Case Reports"[Publication Type] OR "Interview"

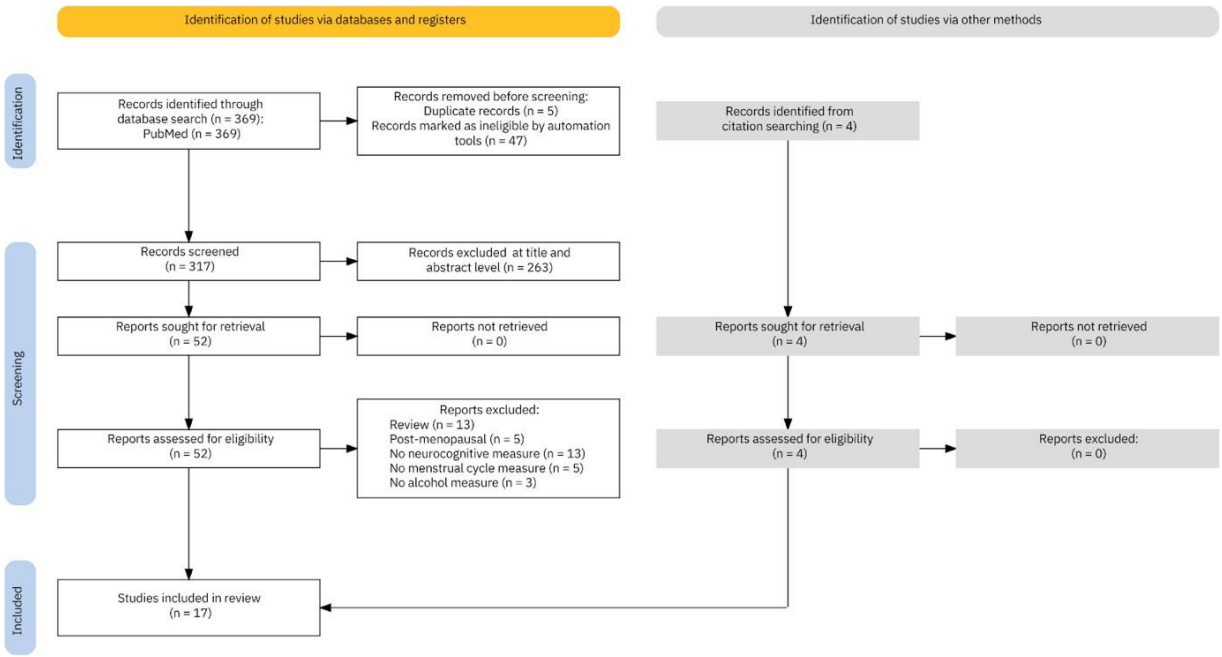
		control"[Title/Abstract] OR "response inhibition"[Title/Abstract] OR "error processing"[Title/Abstract] OR "error monitoring"[Title/Abstract] OR "executive control"[Title/Abstract] OR "go/no- go"[Title/Abstract] OR "go nogo"[Title/Abstract] OR "go/no- go"[Title/Abstract] OR "stop signal*"[Title/Abstract] OR "Flanker"[Title/Abstract] OR "Stroop"[Title/Abstract] OR "disinhibition"[Title/Abstract] OR "disinhibiting"[Title/Abstract] OR "inhibition"[Title/Abstract] OR "meta- cognitive control"[Title/Abstract] OR "metacognitive control"[Title/Abstract] OR "impulse control"[Title/Abstract] OR "stress"[Title/Abstract] OR "Emotion"[Title/Abstract] OR "stress exposure"[Title/Abstract] OR "psychological stress"[Title/Abstract] OR "reward*"[Title/Abstract] OR "punishment*"[Title/Abstract] OR "delay discounting*"[Title/Abstract] OR "monetary incentive delay*"[Title/Abstract] OR "reinforcement learning*"[Title/Abstract] OR "visuospatial"[Title/Abstract] OR "working memory"[Title/Abstract] OR "memory"[Title/Abstract] OR "cue"[Title/Abstract] OR "cues"[Title/Abstract] OR "stress"[Title/Abstract] OR "memory"[Title/Abstract] OR "learning"[Title/Abstract] OR "encoding"[Title/Abstract] OR "retrieval"[Title/Abstract] OR "fear extinction"[Title/Abstract] OR "retention"[Title/Abstract] OR "recollection"[Title/Abstract] OR "attention"[Title/Abstract] OR "attentional bias"[Title/Abstract] OR "task switching"[Title/Abstract] OR "recollection"[Title/Abstract] OR "risky decision-making"[Title/Abstract] OR "risk- taking"[Title/Abstract] OR "decision- making"[Title/Abstract] OR "loss aversion"[Title/Abstract] OR "temporal discounting"[Title/Abstract] OR "impulsivity"[Title/Abstract] OR "aversion"[Title/Abstract] OR "compulsive behavior"[Title/Abstract] OR "habit formation"[Title/Abstract] OR "decision"[Title/Abstract]	[Publication Type] Filters: Humans

Note. The search strategy included both Medical Subject Heading (MeSH) and free-text keywords across three key domains: (1) alcohol use and substance-related behaviors, (2) the menstrual cycle and hormonal fluctuations, and (3) neurocognitive functions. Specific criteria were applied to refine the results, and filters were set to exclude non-empirical studies and only include human studies.

The remaining articles were screened to identify possible eligibility based on inclusion and exclusion criteria, followed by abstract and full-text screening to ensure the inclusion criteria were appropriately met. Additional articles found through backward citation tracking were assessed for relevance using the same inclusion and exclusion criteria as the database-identified studies, leading to the inclusion of n=4 additional studies.

Figure 2

PRISMA Flowchart



Note. This figure illustrates the study selection criteria process according to the PRISMA guidelines, including identification of studies via databases and registers and studies included via other methods (primarily, backward citation tracking) for a total of N = 17 studies. The PRISMA flow diagram was generated using the *PRISMA2020 Shiny App* (Haddaway et al., 2022).

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: a) looked at neurocognitive effects in at least two different phases of the menstrual cycle, b) examined the effect of alcohol (acute or chronic) on cognition, c) used human participants, d) explicitly measured hormonal levels or did menstrual cycle tracking. These criteria were chosen to allow for comparison across menstrual cycle phases surrounding alcohol consumption and cognitive functioning. Studies were excluded if they: a) focused on other substances or did not directly include alcohol, b) did not include any cognitive assessments, c) were review articles, commentaries, or animal studies, d) did not distinguish between the menstrual cycle phase or only examined one specific menstrual cycle phase. These exclusions were implemented to ensure scientific rigor and focus solely on primary research that allowed for comparisons. After applying these criteria, a final selection of N = 17 studies were included in this review.

Table 2

Screening Criteria

Inclusion Criteria	
Publication language	• English/English translation or
Spanish Journal type	• Peer-reviewed articles
Types of studies	• Diary • Experimental
Participants	• Human • Premenopausal and naturally cycling
Independent Variables:	• Alcohol use (acute or chronic; individuals with or without an AUD) • Menstrual cycle phase (studies must include at least two different phases for comparison)
Dependent Variable:	• Neurocognitive functioning (assessed via tasks, tests, or questionnaires)
Hormonal Measures:	• Explicitly measured hormonal levels or conducted menstrual cycle
Exclusion criteria	• Review articles, commentaries • Animal studies • Studies that did not distinguish between menstrual cycle phases or only examined one specific menstrual cycle phase

Note. Includes specific outlines for inclusion and exclusion criteria of select papers screened for the study.

Data Extraction & Synthesis

For each included study, data was extracted on the following variables: a) neurocognitive domain, b) design, c) sample size and average age, d) population characteristics, e) inclusion of hormonal birth control, f) cycle phase determination, g) cycle phases included, h) alcohol measures, i) neurocognitive test, j) measurement, k) results, l) additional comments. Findings were categorized into three neurocognitive domains: cognitive control, negative emotionality, and incentive salience, based on the neurocognitive domains from Ekhtiari et al. (2020). These domains allow for subsequent analysis of the neurobiological mechanisms underlying AUD and the potential impact of the menstrual cycle.

Results

Table 3 presents a descriptive summary of the studies. N=17 studies were included, with n=10 focusing on acute alcohol consumption, n=5 examining alcohol use in non-clinical populations throughout the menstrual cycle, and n=2 examining use in individuals with an AUD. Of the N=17 studies included, n=9 assessed cognitive control, n=8 examined negative emotionality, and n=5 explored incentive salience. N=5 of the studies were included in both negative emotionality and incentive salience due to the domain overlap of findings. Included studies varied in assessing whether the menstrual cycle moderates the acute effects of alcohol, moderation of alcohol use in non-AUD populations, and moderation in AUD populations. N=13 of the total included studies found neurocognitive differences across the menstrual cycle with alcohol use. Results demonstrate different cognitive factors and reinforcement mechanisms that modulate alcohol use throughout the various phases of the menstrual cycle in AUD and non-AUD populations.

Cognitive Control

N = 9 studies investigated cognitive control. All of the studies included in this sub-section examined how the menstrual cycle moderates the acute effects of alcohol on neurocognitive performance in non-AUD populations. Of the N = 9 studies, n = 4 examined psychomotor performance and decision-making, n = 2 executive function, and n = 3 response inhibition and attentional bias. Regarding menstrual cycle phases, n = 3 included the menstrual week, n = 6 the follicular phase, n = 5 peri-ovulation, and n = 6 the luteal phase. Phase comparison varied between studies, reflected in the results below. N = 7 studies found menstrual cycle-related differences, while n = 2 found no effect.

N = 4 studies assessed the acute effect of alcohol on psychomotor performance and decision-making across the menstrual cycle. Jones & Jones (1976) found that the menstrual cycle did not influence the acute effect of alcohol on free memory recall performance. Linnoila et al. (1980) found slower verbal information processing and worse visual detection during the follicular phase than the luteal phase after acute alcohol ingestion. Brick et al. (1986) found no menstrual cycle changes in sustained attention, working memory, or psychomotor coordination following acute alcohol ingestion. However, findings from Brick et al. (1986) should be taken with careful consideration as they had a small sample size (n=10), with n=6 taking hormonal contraceptives. Mumenthaler et al. (2001) found no overall flight simulation performance differences between the menstrual and luteal phases under acute alcohol ingestion. However, secondary analyses found that reaction response time after acute alcohol in the luteal phase was significantly faster than in the menstrual week, while centerline landing was improved during the menstrual week compared to the luteal phase after acute alcohol ingestion (Mumenthaler et al., 2001).

N = 2 studies focused on executive function. Sanz-Martin et al. (2012) found impaired performance in the Tower of London (TOL) task during the follicular phase in comparison with the luteal phase after acute alcohol ingestion. Task impairment in the follicular phase was accompanied by increased alpha1 EEG activity associated with decreased vigilance and attention (Sanz-Martin et al., 2012). Sanz-Martin et al. (2014) then found that acute alcohol ingestion did not affect working memory in a visuospatial working memory task in the luteal and follicular phases of the menstrual cycle. However, EEG recordings during the visuospatial working memory task again revealed elevated alpha1 activity in the follicular phase in comparison with the luteal phase, reinforcing decreased vigilance and attentional deficits during this menstrual cycle phase (Sanz-Martin et al., 2014).

N = 3 studies investigated response inhibition and attentional bias. Griffith et al. (2023) showed a 1.5x increase in disinhibition using a cued go/no-go task under the acute effects of alcohol during the late follicular phase/peri-ovulation (high estrogen) in contrast to the early follicular phase/menstrual week (low estrogen). The same research group then examined attentional bias using the dot-probe task and found more significant attentional bias in social drinking menstruators toward preferred alcohol (liquor/wine over beer) during the peri- ovulatory phase (high estrogen) compared to the early follicular phase (low estrogen) under the influence of both acute alcohol and the placebo condition, suggesting increased reward anticipation linked to estrogen (Griffith et al., 2024). Griffith et al. (2025) compared menstruators to cisgender men and found that attentional bias for menstruators to alcohol cues is highest during the peri-ovulatory phase, while in men, attentional bias stays consistent across alcohol conditions.

Table 3

Summary of publications included in the systematic review

Reference	Literature Review Aim	Neuro cognitive Domain	Design	N* (M age)	Population Characteristics	Between/Within Subject	Hormonal contraception group (+N*)	Cycle Phase Determination	Cycle Phases Included	Alcohol Measure	Neurocognitive Test	Measurement	Results	Additional comments
Linnoila et al. (1980)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (8 -9 cycles)	10 (NA)	Naturally cycling women	Within-Subjects (Repeated Measures)	Excluded	Self-report + basal body temperature (BBT)	Follicular + Luteal	Active alcohol dose in session	Psychomotor tasks: Subcritical continuous tracking task (CTT), Continuous performance task (CPT), Visual vigilance task (VVT) (Linnoila et al., 1980)	Reaction time & number of correct responses	Slower verbal information processing rate and poorer visual detection performance during the follicular phase.	
Brick et al. (1986)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (3 sessions - 1 cycle)	10 (21.70)	Premenopausal women, social drinker	Within-Subjects (Repeated Measures)	Included (6*)	Verbal reports	Menstrual, Midycle (days 14-16) + Premenstrual (26-28)	Active alcohol dose in session	Memory for words (Murdock, 1976), task standing steadiness test (Lipscomb and Nathan, 1980), coding-vigilance task (CVT) (Vogel-Sprott, 1979)	Words recalled, body sway, reaction times, coding scores	Alcohol impaired performance on memory-for-words task and standing-steadiness task, but these changes were not dependent on menstrual cycle phase or oral contraceptive use. Coding vigilance performance was best during flow and was not significantly affected by alcohol.	*found no effect
Mumenthaler et al. (2001)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions- 1 cycle)	24 (30.90)	Pilots (early and experienced), women	Within-Subjects (Repeated Measures)	Excluded	Blood samples	Menstrual + Luteal	Placebo + Active alcohol dose in session	Flight simulator task (Mumenthaler et al., 2001)	Errors or deviations from ideal or assigned positions or values, or reaction time & Flight summary score (FSS)	Menstrual cycle phase did not significantly influence the effect of alcohol on overall flight simulator performance. However, secondary analysis found significant impairment in reaction time task during the menstrual test day and landing flight task during the luteal test day.	

Sanz-Martin et al. (2012)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions-1 cycle)	30 (23.33)	Premenopausal women, social drinker	Within-Subjects (Repeated Measures)	Excluded	LH testing + BBT + verbal reports	Follicular + early luteal	Placebo or active alcohol dose in session	Tower of London (TOL) task (Weissenborn & Duka, 2003)	Scores on problems solved, total movements, incorrect movements, total move score, initiation time, and problem-solving time + EEG recordings	Alcohol impaired performance on TOL, with a greater effect in the follicular phase by solving fewer problems and making more incorrect movements (EEG showed an increase in alpha1, which is associated with decreased vigilance and attention).	
Sanz-Martin et al. (2014)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions-1 cycle)	24 (23.71)	Naturally cycling women, low-risk drinkers	Within-Subjects (Repeated Measures)	Excluded	LH testing + BBT + verbal reports	Follicular + Early Luteal	Placebo or active alcohol dose in session	Visuospatial Working Memory Task (tarea de memoria de trabajo visuoespacial) (Sanz-Martin et al., 2014)	Correct responses + EEG recording	Working memory task didn't change, but EEG activation did change for women who had alcohol, especially in their follicular phase (more alpha1, which indicated less alertness and attention).	
Griffith et al. (2023)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions-1 cycle)	24 (24.04)	Premenopausal women, social drinker	Within-Subjects (Repeated Measures)	Excluded	LH testing + Salivary samples	Early follicular + Ovulation	Placebo + Active alcohol dose in session	Cued go/no-go task (Fillmore & Weafer, 2004)	Response inhibition to no-go targets + reaction time to go targets + Visual analog scales (VAS)	Women displayed a 1.5x increase in the disinhibiting effect of alcohol during the late follicular phase (high E2) vs. early follicular phase (low E2).	
Griffith et al. (2024)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions-1 cycle)	50 (23.52)	Premenopausal women, social drinker	Within-Subjects (Repeated Measures)	Excluded	Salivary samples	Early follicular + Ovulation	Placebo + Active alcohol dose in session	Visual dot probe task (Griffith et al., 2024)	Eye-tracking (gaze duration and gaze fixation), reaction times & alcohol preference (Klatsky et al., 1990)	Attentional bias to alcohol-related cues was greater in ovulation in both sober + intoxicated states, suggesting enhanced reward during ovulation.	
Griffith et al. (2025)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions-1 cycle)	50, of those 25 women (23.60)	Adult social drinkers (men + women)	Within-Subjects (Repeated Measures)	Excluded	Salivary samples	Early follicular + Ovulation	Placebo + Active alcohol dose in session	Visual dot probe task (Griffith et al., 2025)	Eye-tracking (gaze duration and gaze fixation), reaction times, Visual analog scale (VAS) + Timeline follow back (TLFB, Sobell and Sobell, 1992)	Men had consistent attentional bias to alcohol-related cues under both doses, while women showed attentional bias only during the late follicular phase (greater than in men) and under placebo + active dose.	
Charette et al. (1990)	Menstrual cycle influence in non-AUD populations	Negative Emotionality + Incentive Salience	Diary (9 weeks- at least 2 cycles)	82 (21.00)	Premenopausal women, high risk and low risk for alcoholism (high risk= 1 alcoholic	Within-Subjects (Repeated Measures)	Excluded	Daily self-report	Full cycle	Daily alcohol use + drinking motives	Menstrual Distress Questionnaire (MDQ, Moos 1968) + Occurrence of Life Stress scale	Alcohol consumption, menstrual distress and global stress	No evidence for increase alcohol consumption during the premenstrual or menstrual phases in nonalcoholic drinking women, including those at HR for alcoholism Alcohol consumption not related to menstrual cycle, distress symptoms, or global stress.	

					biological parent)						(Charette et al., 1990)			
Freitag & Adesso (1993)	*Acute effects of alcohol in individuals without an AUD*	*Negative Emotionality + Incentive Salience*	*Lab (only 1 session at 1 of the phases)*	*96 (21.73)*	Heavy drinking female women	*Between- Subjects (Independent Groups)*	*Excluded*	*Verbal report*	*Menstruation, Ovulation + Premenstruation*	*Placebo or active alcohol dose in session*	Profile of Moods Questionnaire (POMS, McNair et al., 1979)	*Subjective affective states*	*No significant differences were found in menstrual cycle at baseline, and no menstrual cycle phase predictions on mood change after drinking were found either (in support of the Social Learning Theory).*	
Kiesner (2012)	*Menstrual cycle influence in non-AUD populations*	*Negative Emotionality*	*Diary (2 cycles)*	*161 (22.00)*	Women with diverse patterns of affective response to the menstrual cycle (PMS, mid- cycle pattern, noncyclical pattern)	*Between- Subjects (Independent Groups)*	*Included (15)*	*Daily self- report*	*Full cycle*	*One time retrospective questionnaire regarding alcohol use + affective response when consuming alcohol*	17 item questionnaire with affective state/emotion subscale (created by Kiesner, 2012)	*Response to alcohol consumption + alcohol consumption*	*Women in the PMS group reported higher levels of hard alcohol use and less negative affective response associated with alcohol use. No differences for positive affect found.*	
*Milivojevic et al. (2014)**	*Menstrual cycle influence in AUD populations*	*Negative Emotionality*	*Lab (1 session)*	*154, of those 71 women (NA)*	Cocaine- Dependent Men + Women abusing alcohol (CDA)	*Within-Subjects (Repeated Measures)*	*Excluded*	*Daily self- report*	*Follicular + Luteal (high vs. low progesterone)*	*CDA vs. healthy controls*	Mayer, Salovey, and Caruso Emotional Intelligence Test (MSCEIT, Mayer et al., 2003)	*Scores (total + two subscales: managing emotions & facilitating thought)*	*Women in high progesterone group had significantly higher MSCEIT scores than women in low progesterone group (CDA and healthy control).*	*only Study 1 included
Hoffman et al. (2024)	*Menstrual cycle influence in AUD populations*	*Negative Emotionality*	*Diary (1 year) + Lab (4 visits)*	*352, of those 74 women (NA)*	Naturally cycling women + males with AUD	*Within-Subjects (Repeated Measures)*	*Excluded*	*Daily self- report + blood levels*	*Full cycle*	*Binge drinking + day with any alcohol use*	E-diary entries on alcohol use (Deeken et al., 2022)	*Alcohol use consumption + motives*	*Menstrual cycles significantly associated with binge drinking. During late luteal, females showed lower binge drinking probability of 13%. In men, higher progesterone- to-estradiol ratio related to lower probability of binge drinking or alcohol use.*	

Jones & Jones (1976)	Acute effects of alcohol in individuals without an AUD	Cognitive Control	Lab (2 sessions)	30 , of those 20 women (25.70)	Men and women, moderate social drinkers	Within-Subjects (Repeated Measures)*	Unclear	Self-report	Menstrual, perovulatory, luteal	Active alcohol dose in session	Free-recall verbal memory task (Glanzer, 1977)	Recall score (immediate & delayed recall)	No difference in performance between different phases of the cycle, but faster alcohol absorption rates during the pre-menstrual phase.	*lack of description of women on hormonal birth control. Within-Subject measures
Martel et al. (2017)	Menstrual cycle influence in non-AUD populations	Negative Emotionality + Incentive Salience	Diary (1 cycle)	22 (19.99)	Naturally cycling women	Within-Subjects (Repeated Measures)	Excluded	Daily self-report + daily salivary samples	Full cycle	Daily alcohol use + positive/negative affect	Timeline Follow-Back Interview (Sobell & Sobell, 1994) + Positive and Negative Affect Schedule (PANAS, Watson et al., 1988)	Daily affect + alcohol use	High estrogen on the weekend was associated with increased risk of drinking and binge drinking (especially in the context of low progesterone). Preovulatory and premenstrual increases in drinking. No change in affect.	
Joyce et al. (2017)	Menstrual cycle influence in non-AUD populations	Negative Emotionality + Incentive Salience	Diary (1 cycle) + Lab (2 sessions-1 cycle)	94 (22.90)	Naturally cycling women, low-risk drinkers	Within-Subjects (Repeated Measures)	Excluded	Daily self-report + Salivary samples	Full cycle (saliva samples on days 1-7 + 18-24)	Daily alcohol use + drinking motives	Drinking Motives Questionnaire-Revised State Version (DMQ-R SF, Kuntsche & Kuntsche, 2009)	Number of drinks + drinking motives	Slight increase in drinking to self-medicate for negative affect premenstrually, with drinking to cope peaking in menstrual phase and for social motives in the follicular/ovulatory phases.	
Barone et al. (2023)	Menstrual cycle influence in non-AUD populations	Negative Emotionality + Incentive Salience	Diary (1-3 cycles)	94 (27.37)	Psychiatric outpatient (past-month suicidal ideation), sex-assigned female	Within-Subjects (Repeated Measures)	Excluded	Daily self-report + LH testing	Midfollicular, periovulatory, midluteal, perimenstrual	Daily alcohol use + drinking motives	Drinking Motives Questionnaire (DMQ) (Cooper, 1994; Crutzen & Kuntsche, 2013)	Motives + daily alcohol variables (amount)	Increased likelihood to drink in perivoulatory and perimenstrual phases on weekends. Perimenstrual phase associated with increased drinking to cope, and relatively lower weekend social drinking. (Ovulation = more likelihood of heavy drinking. Perimenstraul = increased heavy drinking but loss of social motivations).	

Note. Abbreviations: AUD = Alcohol Use Disorder, LH = Luteinizing Hormone, BBT = Basal Body Temperature, CDA = Cocaine-Dependent individuals who also abuse Alcohol, DMQ = Drinking Motives Questionnaire, DMQ-R SF = Drinking Motives Questionnaire-Revised State Version, MTVE = Visuospatial Working Memory Task (tarea de memoria de trabajo visuoespacial), EEG = Electroencephalogram, TOL = Tower of London Task, MDQ = Menstrual Distress Questionnaire, POMS = Profile of Moods Questionnaire, MSCEIT = Mayer, Salovey, and Caruso Emotional Intelligence Test, PANAS = Positive and Negative Affect Schedule, CTT = Subcritical continuous tracking task, CPT = Continuous performance task, VVT = Visual vigilance task.

Negative Emotionality

N = 8 studies examined negative emotionality. Of these, n = 2 specifically included individuals with an AUD, examining menstrual cycle variations in emotional regulation, while the remaining n = 6 studies focused on how the menstrual cycle is associated with mood and drinking patterns across the cycle in non-AUD populations. Of the N = 8 studies examining negative emotionality, n = 6 assessed the entire menstrual cycle, n = 1 compared the follicular and the luteal phases (Milijvojevic et al., 2014), and n = 1 compared the menstrual week, peri-ovulation, and the luteal phases (Freitag & Adesso, 1993). N = 6 found a significant association between the menstrual cycle and negative emotionality, while n = 2 found no cycle-related differences. The n = 2 studies that looked specifically at the AUD population did find associations between the menstrual cycle, negative emotionality, and alcohol use.

N = 2 studies examined the role of progesterone in emotional regulation in individuals with an AUD. Milijoveic et al. (2014) examined emotional intelligence in cocaine-dependent individuals who also abuse alcohol (CDAs) compared to healthy controls and found that emotional intelligence scores (specifically around interpersonal emotional regulation) were higher in a high progesterone phase (luteal phase) versus a low progesterone phase (follicular or premenstrual phase) in both controls and CDAs. Hoffman et al. (2024) examined progesterone-to-estradiol ratios in menstruators with an AUD compared to self-reported sex-assigned males and observed that in the menstruating group, the probability of binge drinking was 13% lower in the late luteal phase (high progesterone) compared to the menstrual week, follicular phase, and peri-ovulation (low progesterone phases). Similar results were found for sex-assigned males, with higher progesterone-to-estradiol ratios predicting lower probabilities of binge drinking and any alcohol use (Hoffman et al., 2024).

N = 6 studies specifically focused on drinking motives across the menstrual cycle in non-AUD populations, with findings in both negative emotionality and incentive salience. Charette et al. (1990) found no significant effects on alcohol consumption around the menstrual cycle or related to menstrual distress or global stress. Similarly, Freitag & Adesso (1993) also found no differences throughout the menstrual cycle, mood, and drinking motives. In a more recent study, Kiesner (2012) examined menstrual cycle-related affective patterns, including premenstrual symptom (PMS), mid-cycle negative affect, and non-cyclical patterns, and found that individuals with PMS consumed more hard alcohol. Importantly, individuals with PMS also reported a reduction in negative affective response following alcohol use, which was not observed in individuals without PMS. This suggests that alcohol serves as a negative reinforcer for the PMS group. Martel et al.'s (2017) results primarily relate to incentive salience. However, findings suggest that high progesterone seemed to antagonize the effects of estrogen, driving substance use in the luteal phase related to negative emotionality. However, exploratory analyses of hormones' main or interactive effects on negative affect and distress did not reveal significant effects (Martel et al., 2017). Joyce et al. (2017) found elevated drinking levels through daily diary measures during the follicular and peri-ovulatory phases linked to positive reinforcement, while the luteal phase saw a shift towards self-medication for negative emotions. Barone et al. (2023) additionally found increased binge drinking for social motives during peri-ovulation and a higher likelihood of drinking for coping during the menstrual week.

Together, these studies suggest that social motives drive drinking in high-estrogen phases, and coping motives drive drinking during the luteal phase and menstrual week in the non-AUD population (Barone et al., 2023; Joyce et al., 2017). This highlights the menstrual cycle's dual role in reinforcing drinking behaviors driven by both positive reinforcement and negative reinforcement.

Incentive Salience

N = 5 studies explore incentive salience. These studies were conducted in non-AUD populations and examined how menstrual cycle phases influence reward-related behaviors and motives without testing the interaction with acute alcohol ingestion or AUD diagnosis. All studies in this section examined the entire menstrual cycle and are also included under negative emotionality. Charette et al. (1990) and Freitag & Adesso (1993) found no differences throughout the menstrual cycle. Joyce et al. (2017) found that increased social motives for drinking during the follicular and peri-ovulatory phases were linked to positive reinforcement. The increase in social motives shows greater reward-related drinking motives as estrogen enhances the salience of rewards, increasing motivation to engage in social drinking. High estrogen phases were associated with greater reward sensitivity and reward-seeking behavior. Martel et al. (2017) similarly reported an increased risk of binge drinking during high follicular and peri-ovulatory phases, particularly on weekends, supporting estrogen's role in reward sensitivity. Barone et al. (2023) further observed increased heavy drinking for social motives during peri-ovulation. These studies collectively support the incentive salience theory, linking high-estrogen phases to increased alcohol-related reward-seeking behavior.

Summary of Findings

N = 17 studies were included, with n = 10 focusing on acute alcohol consumption, n = 5 examining alcohol use in non-clinical populations throughout the menstrual cycle, and n = 2 examining use in individuals with an AUD. N = 13 of the 17 studies observed neurocognitive differences in alcohol use across the menstrual cycle, while n = 4 did not (Brick et al., 1986; Charette et al., 1990; Freitag & Adesso, 1993; Jones & Jones, 1976).

The literature was categorized into three neurocognitive domains: cognitive control, negative emotionality, and incentive salience. N = 9 studies assessed cognitive control, with n = 7 finding menstrual cycle differences. More impaired cognitive control, including reduced response inhibition, attention, and vigilance, was reported during the follicular and peri-ovulatory phases when estrogen was higher. N = 8 studies assessed negative emotionality, with n = 6 finding associations between the menstrual cycle and negative mood, particularly with heightened negative emotionality in the luteal phase, when progesterone is higher. In those with an AUD, high progesterone seemed to be protective against binge drinking and aided in emotional management. N=5 studies explored incentive salience, with n=3 showing findings that align with higher reward sensitivity and reward responsiveness during the follicular and peri-ovulatory phases when estrogen rises.

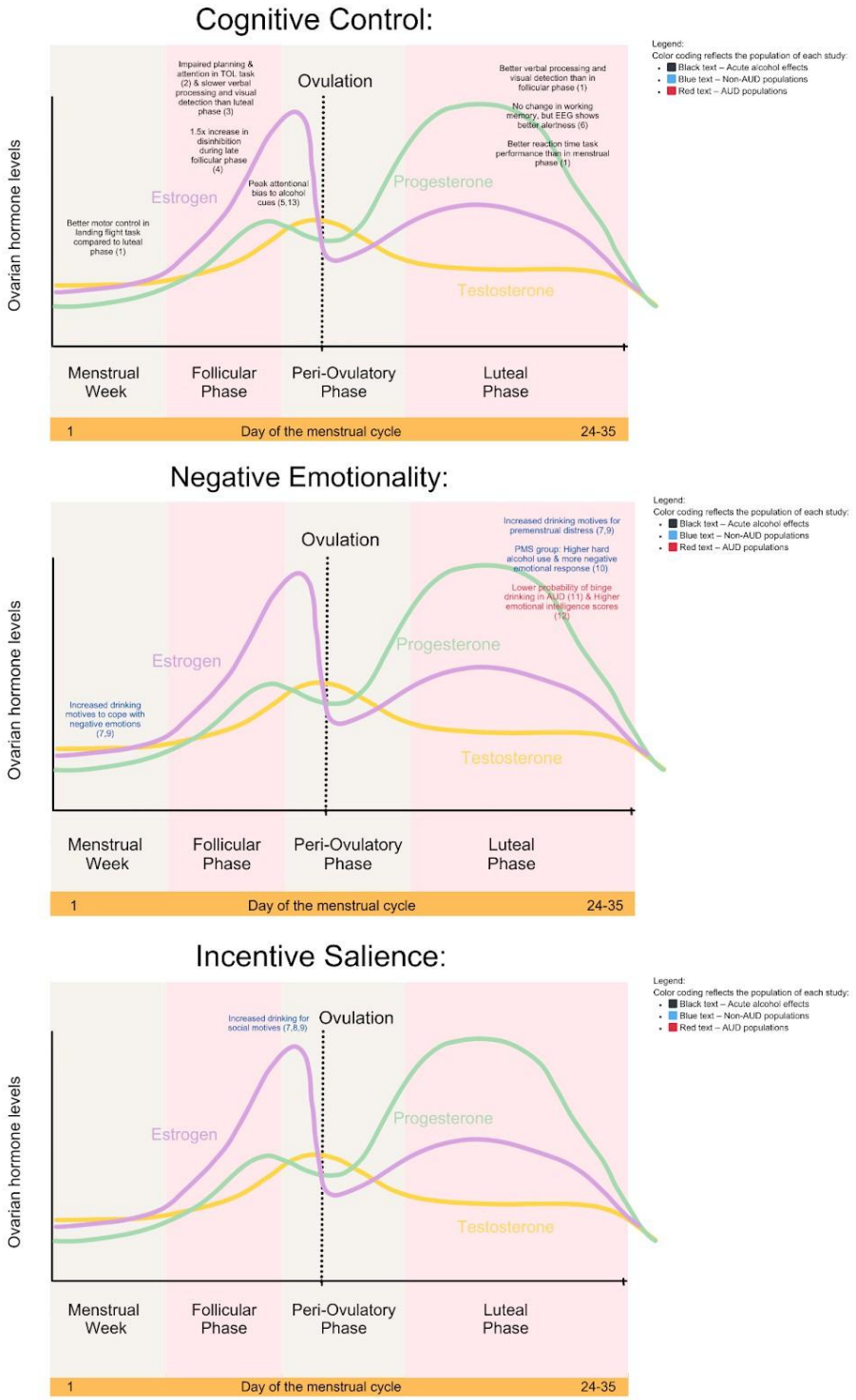
Discussion

This review examined how menstrual cycle phases interact with neurocognitive functioning related to acute alcohol use, general use in non-AUD populations, and those with an AUD. N = 17 studies were included, with n=13 reporting associations between the menstrual cycle phase and neurocognitive functioning within the context of alcohol use. The other, n = 4 studies did not report such associations (Brick et al., 1986; Charette et al., 1990; Freitag & Adesso, 1993; Jones & Jones, 1976). However, these findings should be interpreted cautiously, given methodological findings such as small sample sizes, less rigorous hormonal verification methods, and between-subject samples instead of repeated measure designs. Across studies, findings suggest that alcohol-related cognitive impairments, such as slower verbal processing, worsened problem-solving, and greater disinhibition, may be more pronounced during the follicular and peri-ovulatory phases (Griffith et al., 2023; Linnoila et al., 1980; Sanz-Martin et al., 2012). These effects may be amplified in individuals with an AUD. However, comparative studies with AUD populations remain scarce. Reward-related processes also appear sensitive to the menstrual cycle phase. Studies in non-AUD samples report heightened reward sensitivity and increased social drinking motives during high-estrogen phases, including the follicular and peri-ovulatory phases (Barone et al., 2023; Joyce et al., 2017; Martel et al., 2017;). These findings may suggest increased incentive salience of alcohol-related cues during these phases. However, further research is needed to establish whether similar patterns emerge in individuals with AUD.

In contrast, the luteal phase, particularly the late luteal phase associated with premenstrual syndrome, was linked to increased negative emotionality and greater motivation to drink for emotional regulation in non- AUD populations (Barone et al., 2023; Joyce et al., 2017; Kiesner et al., 2012). Notably, in individuals with an AUD, higher levels of progesterone were associated with improved emotional regulation and reduced likelihood of binge drinking, suggesting the possible modulation role of progesterone in AUDs (Hoffman et al., 2024; Milijoveic et al., 2014). Figure 3 illustrates the neurocognitive shifts across the menstrual cycle, organized by domain and study aim described in this review. While most included studies focused on the acute effects of alcohol in non-AUD populations, the findings underscore the importance of considering menstrual cycle phases in future research on the neurocognitive mechanisms that underlie vulnerability to AUD and in prevention strategies that target menstruators.

Figure 3

Neurocognitive Changes Across the Menstrual Cycle by Neurocognitive Domain



Note. Each numbered reference corresponds to a study that contributed to the findings presented in the figure. Legen indicates the different aims and population groups for the study cited.

Citations are as follows: (1) Mumenthaler et al., 2001, (2) Sanz-Martin et al., 2012, (3) Linnoila et al., 1980, (4) Griffith et al., 2023, (5) Griffith et al., 2024, (6) Sanz-Martin et al., 2014, (7) Joyce et al., 2017, (8) Martel et al., 2017, (9) Barone et al., 2023, (10) Kiesner, 2012, (11) Hoffman et al., 2024, (12) Milivojevic et al., 2014, (13) Griffith et al., 2025.

Comparative Analysis of Neurocognitive Changes Across the Menstrual Cycle

Findings from this review suggest that alcohol consumption may increase during menstruation, potentially as a coping strategy for managing negative affect (Barone et al., 2023; Joyce et al., 2017). Additional general research on substance use shows an increase in cannabis, alcohol, and nicotine/tobacco use for menstrual pain management (Sugarman et al., 2025). These findings align with the self-medication theory, which posits substance use increases premenstrually and during the menstrual week to cope with negative affect (Joyce et al., 2021). Additionally, menstrual pain severity was also associated with greater substance use, suggesting a possible explanation of alcohol serving as a pain-management strategy during the menstrual week (Sugarman et al., 2025).

In the follicular phase, rising estrogen levels are associated with increased drinking, particularly for social motives and heightened reward-seeking behavior (Barone et al., 2023; Griffith et al., 2023; Joyce et al., 2017; Martel et al., 2017). This phase also appears to be characterized by impairments in cognitive control, including decreased attention, reduced vigilance, and increased disinhibition (Griffith et al., 2023; Griffith et al., 2024; Griffith et al., 2025; Sanz-Martin et al., 2012; Sanz-Martin et al., 2014). These findings are consistent with broader evidence demonstrating heightened reward sensitivity, decreased alertness, and reduced emotional reactivity outside of the context of alcohol during the follicular phase compared to other phases of the menstrual cycle (Cohen et al., 2022; Pilarczyk et al., 2019; Sakaki & Mather, 2013). In nicotine research, the follicular phase is also associated with increased motivation for substance use and reward enhancement during use (Giner et al., 2024). The reward-sensitivity theory poses a potential explanation as to why we may see increases in substance use-seeking behavior during the follicular phase and into the peri-ovulatory phase (Joyce et al., 2021).

The peri-ovulatory phase, marked by the peak in estrogen and a subsequent surge of progesterone, is generally characterized by greater sensitivity to reward and impulsivity (Faraji-Rad et al., 2013; Sakaki & Mather, 2013). Findings demonstrate an increased tendency to drink for social motives and greater attentional bias to alcohol cues (Barone et al., 2023; Griffith et al., 2023; Griffith et al., 2024; Griffith et al., 2025; Joyce et al., 2013). Similar patterns have been observed for nicotine, cocaine, and amphetamines, suggesting that greater reward-seeking behavior during peri-ovulation may be generalized across substances (Evans et al., 2002; Giner et al., 2024; Justice et al., 1999). These findings suggest the need for targeted prevention strategies that address menstrual cycle fluctuations and risk for the development of AUDs.

In the luteal phase, when progesterone levels peak, alcohol-related cognitive effects differ between individuals with and without AUD. For example, during alcohol intoxication, non-AUD individuals show increased alertness and attention and better cognitive performance (Sanz-Martin et al., 2012; Sanz-Martin et al., 2014). These findings align with broader research showing increased baseline levels of alertness, engagement, and vigilance during the luteal phase in non-AUD samples (Cohen et al., 2022; Li et al., 2022). In addition, this review found increased drinking in non-AUD populations to cope with negative affect during the luteal phase (Barone et al., 2023; Joyce et al., 2017). Drinking to cope is consistent with the self-medication theory, and findings on PMS further strengthen

this theory as individuals with premenstrual syndrome are more inclined to drink for self-soothing (Gudipally & Sharma, 2025; Khantzian, 1997; Joyce et al., 2021; Kiesner, 2012).

Comparable data on alertness and vigilance in those with an AUD is currently lacking. However, findings from this review demonstrate that high progesterone is associated with greater emotional regulation as measured through the MSCEIT, as well as a 13% decrease in binge drinking probabilities compared to other stages of the menstrual cycle (Hoffman et al., 2024; Milivojevic et al., 2014). This indicates a potential protective effect of progesterone in individuals with an AUD. The difference in luteal phase effects between non-AUD and AUD populations should continue to be explored. Additional substance use research on nicotine suggests that withdrawal symptoms are enhanced during the luteal phase (Giner et al., 2024). Whether the same is true for alcohol and those with an AUD remains unexplored.

Impact of Endogenous Estrogen and Progesterone on Neurocognitive Functioning

Neurocognitive changes appear to be primarily driven by estrogen and progesterone, allowing for more generalizable conclusions on alcohol-related cognitive impairment. Estrogen is linked with heightened reward responsiveness, while progesterone is associated with increased attention and vigilance but attenuates feelings of reward (Sakaki & Mather, 2012). The review's findings align with these patterns, suggesting increased reward- seeking behavior in high estrogen phases and increased alertness in high progesterone phases (see Figure 3).

Interestingly, endogenous progesterone may have a protective effect on menstruators who have an AUD (Hoffman et al., 2024; Milijoveic et al., 2014). Both studies suggest that progesterone-to-estradiol ratios could predict and shift substance use behavior. Specifically, Hoffman et al. (2024), who additionally tested sex- assigned males, also found that higher progesterone-to-estradiol ratios were related to lower probabilities of binge drinking and alcohol use. Support from nicotine research further highlights the potential of progesterone- to-estradiol ratios in predicting substance use (Schiller et al., 2012). It would be of value for future research to measure hormonal levels via salivary or blood samples to better understand the influence of ovarian hormones on substance use. Many studies in this review relied on self-reported cycle data, so findings should be considered with this in mind. Precise hormonal measurement, alongside neurocognitive data, would enhance our understanding of the biological links between neurocognition and the menstrual cycle in AUD.

Implications for Alcohol Use Disorder

The majority of the included literature focused on the effects of acute alcohol consumption on neurocognitive functioning (n = 10) or alcohol use in non-AUD populations across the menstrual cycle (n = 5), with relatively few studies examining menstrual cycle influences on neurocognition in individuals with an AUD (n = 2). Research suggests that the effects of acute alcohol on cognitive functioning vary throughout the menstrual cycle. Increased deficits in cognitive control and greater social motives for drinking are found in the follicular phase, potentially due to heightened reward- seeking behavior driven by fluctuations in dopamine, GABA, and glutamate (Griffith et al., 2023). During the luteal phase, while there appears to be better emotional regulation, alcohol use is often used to cope with negative emotionality. Progesterone's modulation of GABAA receptors may influence this, producing anxiolytic and anti-stress effects that aid emotional regulation (Fox et al., 2004). In individuals with premenstrual dysphoric disorder (PMDD), characterized by heightened negative affect, the typical rise in GABAA levels during the luteal phase is absent, which may contribute to alcohol being used to self-medicate negative affect

and emotions. While these findings provide insight into alcohol use patterns across the menstrual cycle, more research is needed to determine whether the acute effects of alcohol translate into prolonged alcohol use or the development of an AUD.

While most studies focused on acute alcohol use in non-AUD populations, n=2 studies specifically examined individuals with an AUD. One of the studies compared those with an AUD to those without an AUD (Milivojevic et al., 2014), while the other compared menstruators with an AUD to self-reported sex-assigned males (Hoffman et al., 2024). Findings in the AUD population suggest a lower probability of binge drinking during the luteal phase, possibly due to the protective role of endogenous progesterone in emotional regulation (Hoffman et al., 2024; Milivojevic et al., 2014). These findings demonstrate the importance of considering the hormonal state of understanding vulnerability to binge drinking and relapse. Existing research on nicotine, cocaine, and amphetamines shows the potential of menstrual cycle-informed treatments in optimizing recovery (Evans et al., 2002; Justice et al., 1999; Giner et al., 2024). Similar clinical interventions should be conducted for those with an AUD to understand better how hormonal fluctuations impact substance use behaviors and the potential efficacy of sex hormone-specific treatment protocols.

In addition to informing treatment, the findings of this review have important implications for the prevention of AUD. This is especially important when looking at the lens of "telescoping," wherein women progress more quickly from initial alcohol use to alcohol use disorders, strengthening the importance of effectively informing prevention programs that address the unique challenges faced by menstruators (Carroll et al., 2016). Menstrual cycle-informed strategies could help identify specific moments of heightened vulnerability, like the follicular phase, where individuals may be more susceptible to impulsive, reckless, or reward-driven drinking. Tailoring psychoeducation and early intervention strategies to align with the hormonal patterns and findings from this review could help reduce risky drinking behavior before it escalates into an AUD.

Clinical and Practical Implications

Menstrual cycle-informed prevention strategies offer a potentially promising and underexplored avenue for reducing alcohol use disorders. Integrating menstrual cycle-informed psychoeducation into public health campaigns and digital health tools could empower menstruators to make more informed decisions on their substance use and aid in the prevention of the development of AUD. For example, current digital health apps that track the menstrual cycle and alcohol consumption could provide substance-use risk assessments and psychoeducation based on the cycle phase. Current menstrual cycle apps already offer support regarding mental health symptomatology, particularly around the premenstrual phases when mental health symptomatology is low (Funnell et al., 2024). App users express an instilled sense of empowerment and benefit through app-based supplementary psychoeducation that helps monitor, educate, self-help, and diagnose during low symptomatology (Funnell et al., 2024). Similar support could be offered for alcohol and substance use, providing awareness of potential impulsive decisions and reward-based behavior or shedding light on the desire to use substances to cope with negative effects.

Additionally, workshops and support groups could also educate individuals on hormonal influences to craving and potential relapse. Given that a significant amount of individuals with an AUD recover without formal treatment (Tuithof et al., 2016), integrating this knowledge into the public domain, whether through online resources, digital

health tools, or community-based interventions, may enhance self-regulation and recovery outcomes. Preventative efforts that take into account menstrual cycle changes to alcohol use could potentially reduce stigma, create more inclusive and personalized support, and deter risky alcohol behavior before escalation.

While most current findings are based on non-AUD populations in clinical settings, they may still provide a valuable foundation and blueprint to develop menstrual cycle-informed approaches. For instance, the follicular and peri-ovulatory phases were found in this review to be associated with increased impulsivity and reward-seeking behavior. Clinicians can incorporate this knowledge into treatment by addressing impulsivity management through cognitive behavioral therapy and dialectical behavioral therapy techniques and educating individuals on increased relapse risks during high-estrogen phases. Cognitive behavioral therapy has shown promise in improving impulsivity-related behaviors, which could be used at higher-risk phases such as the follicular and peri-ovulatory (Loya et al., 2023). Dialectical behavioral therapy and acceptance and commitment therapy also show efficacy in addressing impulsivity (Aguilar-Yamuza et al., 2024). Furthermore, the luteal phase has been associated with increased negative affect, highlighting the need for targeted emotional regulation tools and strategies such as mindfulness-based stress reduction techniques. Mindfulness meditation and mindfulness-based stress reduction techniques have been shown to improve emotional regulation and reduce substance use and could be reinforced during this menstrual cycle phase (Garland & Howard, 2018; Tang et al., 2016). Future research should examine whether these menstrual cycle-related patterns also apply to individuals with an AUD and whether the interventions outlined above accordingly address the challenges faced by menstruators.

Gaps in the Literature

Several key gaps in the literature were identified. Most studies focus on the acute effect of alcohol on neurocognitive functioning rather than on longitudinal studies in AUD populations. Research on the long-term consequences of alcohol use across the menstrual cycle remains limited and should be prioritized to provide better recommendations to those with an AUD. Additionally, studies tend to examine specific menstrual cycle phases, often due to methodological constraints or key interest in a particular hormone. More studies examining the full spectrum of the menstrual cycle would give greater insight into neurocognitive function in its entirety. Standardized hormone measurements are also lacking, with many studies relying on self-reported cycle phases instead of direct hormonal assays. This may introduce confounds related to stress or ovulation irregularities (Schliep et al., 2015). While reviews like Joyce et al. (2021) compare addictive behaviors across the menstrual cycle, there is also a lack of experimental research comparing the effects of the menstrual cycle on neurocognition amongst different substances, such as cocaine, nicotine, amphetamine, and alcohol, which have all been shown to have some level of impact with the menstrual cycle (Evans et al., 2002; Giner et al., 2024; Justice et al., 1999). Clinical research on sex hormone and menstrual-cycle-informed treatment efficacy and success is also needed.

Limitations and Future Directions

Methodological inconsistencies are a significant limitation of this review. The lack of standardized approaches for measuring and naming menstrual cycle phases makes comparison between studies challenging. Future research should adhere to standardized guidelines and best practices on hormonal validation and reporting accuracy (Hampson, 2020). Specifically, studies should follow Schmalenberger et al.'s (2020) menstrual cycle phase clarification guidelines to ensure consistency and comparability. The temporal gap between studies cited is another important

limitation. Several studies included were conducted over 30 years ago. Given the considerable advancements in menstrual cycle research, knowledge, and tracking, older studies' findings should be interpreted cautiously (Jukic, 2021). This is of note as the n = 4 studies that found no substance use changes throughout the menstrual cycle were written over 30 years ago and have methodological concerns such as small sample sizes, less rigorous hormonal verification, and between subject samples (Brick et al., 1986; Charette et al., 1990; Freitag & Adesso, 1993; Jones & Jones, 1976). However, the aforementioned n = 4 studies were included despite these concerns as they fell within the inclusion criteria and help to provide a comprehensive overview of the evidence on the subject. N = 2 studies also employed between-subjects rather than within- subjects design, making it difficult to account for individual variability in hormonal fluctuations (Freitag & Adesso, 1993; Kiesner, 2012). Subsequent research should ensure a within-subject (repeated measures) design to capture the effects of acute alcohol on neurocognition throughout the menstrual cycle as well as neurocognitive deficits associated with the menstrual cycle in individuals with an AUD.

Future research should examine the entire menstrual cycle to provide more comprehensive data on alcohol's neurocognitive effects across all phases. Additional studies explicitly focusing on individuals with an AUD are essential to understanding neurocognitive shifts associated with chronic alcohol use and refining treatment and cessation strategies similar to those developed for nicotine. Future research should also continue examining the role of progesterone and its protective effects against binge drinking, ensuring the use of hormonal assays for clear comparisons. Given the widespread use of hormonal contraception (Daniels & Mosher, 2013), future studies should further investigate the impact of exogenous hormones on potential treatment, as hormonal contraception can amplify estrogen's effects (Sarkola et al., 1999). Exogenous hormones (particularly progesterone) show promising potential for treatment, and future clinical research should explore their potential in AUD cessation and treatment (Fox et al., 2024). This is especially pertinent given the findings from Milivojevic et al. (2014) and Hoffman et al. (2023), who found that progesterone in non-menstruators could also shift emotional management or were associated with different probabilities of binge drinking. The use of progesterone-to-estradiol ratios in those who do not menstruate, as well as the use of exogenous progesterone for treatment, could offer potential insight into risk prediction and new avenues for treatment.

Conclusion

This literature review highlights the menstrual cycle's impact on neurocognitive functioning surrounding alcohol use. Studies included in this review examined one of three aims: 1) how the menstrual cycle moderates the acute effects of alcohol on neurocognitive processes in individuals without an AUD, 2) how the menstrual cycle moderates alcohol use in non-AUD populations, and 3) how the menstrual cycle influences neurocognition in individuals with an AUD. Of the 17 studies reviewed, 13 reported found menstrual cycle shifts in neurocognition with alcohol use. While acute alcohol effects appear to vary throughout the menstrual cycle, limited research exists on how these hormonal fluctuations affect the development and progression of AUD. The potential protective role of progesterone and the impact of estrogen on relapse vulnerability through reward- seeking behavior demonstrates the need for further investigation into how the menstrual cycle influences alcohol-related behaviors.

Future research should continue to examine menstrual cycle-informed approaches for optimizing prevention strategies for AUD as well as treatment strategies for menstruators with AUD. Digital health tools and general psychoeducation could empower menstruators to make more informed decisions on their substance use and aid in substance use escalation prevention. Clinicians and treatment centers should consider implementing the menstrual cycle into treatment and prevention interventions and integrating menstrual cycle- informed psychoeducation into public health campaigns.

Conflict of Interests

The authors declare no conflicts of interest related to this work.

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