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Mood Instability Across the Menstrual Cycle: Does Premenstrual Symptom Severity Matter?

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Introduction

It is a well-known fact that women show a higher prevalence and increased risk for mood and affective disorders (Altemus et al., 2014; Andreano et al., 2018; Kiesner, 2017; Rubinow & Schmidt, 2019). These include disorders such as Bipolar I and II, Major Depressive Disorder, Dysthymia, and Anxiety Disorders (Kiesner, 2017). The underlying causes of this gender differences are not yet fully understood. Some authors suggest that fluctuations in ovarian hormone levels may play a role in the development or expression of affective symptoms in women (Altemus et al., 2014; Andreano et al., 2018; Beddig et al., 2020; Hantsoo & Epperson, 2020; Kiesner 2011). Periods of hormonal change during puberty, pregnancy, menopause, and the menstrual cycle have been specifically associated with increased mood vulnerability (Bale & Epperson, 2015; Hantsoo & Epperson, 2017). The menstrual cycle is a naturally recurring monthly process in the life of a menstruating individual, which shows how important it is to understand the menstrual cycle and related experiences. In the days preceding menstruation, individuals of reproductive age commonly experience changes in mood, cognition or physical well-being (Dickerson et al., 2003; Freeman et al., 2011; Kiesner, 2017). These experiences are often summarized under the term premenstrual symptoms or collectively referred to as premenstrual syndrome (PMS; Dickerson et al., 2003; Freeman et al., 2011; Janda et al., 2017). A large part of the existing research focuses on conditions like PMS and premenstrual dysphoric disorder (PMDD), which often include clinically relevant affective symptoms such as irritability or sadness (Alevizou et al., 2018; American Psychiatric Association, 2013; Hantsoo & Epperson, 2015; Janda et al., 2017). Unlike PMDD, PMS does not necessarily include affective changes, highlighting an important distinction between the two conditions (Freeman et al., 2011; Janda et al., 2017). While these affective symptoms are highly relevant for those affected, the broader and more diffuse concept of daily mood has received less attention. Mood, as a more diffuse and less clinical construct, is something people deal with on a daily basis and deserves further attention in research (Russell, 2003; Scherer, 2005). The present project aims to address the literature gap of changes in mood across the menstrual cycle. It remains unclear whether the broader, more diffuse concept of mood and its everyday fluctuations are also linked to the menstrual cycle. To determine whether mood instability is a clinically relevant deviation, it is essential to understand whether mood instability during certain phases of the cycle is a normal experience or only occurs in specific groups. Therefore, the stability or instability of mood across the cycle, as an indicator of its natural fluctuations, will be investigated.

Theoretical Background

Affective States

“Affect” or “affective states” is used as an umbrella term when talking about moods, emotions, feelings or affective attitudes (Gross, 2024; Scherer, 2005; Wilhelm & Schoebi, 2007). In psychology, the term affect is often used in a broad and unspecific way. Therefore, the challenge of clearly distinguishing between different affective states is well known in psychology (Russell, 2003; Scherer, 2005). When the boundaries between affective terms are not clearly defined, it becomes challenging for researchers to interpret and compare findings across studies. However, affect can be broadly divided into two central concepts: emotions, which are understood as short-term, more intense states and moods, which tend to be less intense, more diffuse and longer-lasting (Barrett & Russell, 1998; Russell, 2003; Scherer, 2005; Schimmack & Grob, 2000).

Several theoretical models have attempted to establish a conceptual foundation for understanding and describing affective states. The bipolar framework of affect by Barrett and Russell (1998) emphasizes the importance of pleasure (also called valence) and arousal (also referred to as energy) as the two major aspects of affective states. Both emotions and moods can be conceptualized within the framework proposed by Barrett and Russell (1998). Other theories criticise the assessment of affect by only two dimensions. Schimmack and Grob (2000) conceptualized affective states as a combination of quality (pleasant vs. unpleasant), the type of affective experience (mood vs. emotion) and an aspect of frequency, intensity and duration (Schimmack & Grob, 2000), thus provide a conceptualization of affect in three dimensions. Since distinguishing between emotion and mood can be quite challenging, it is essential to first provide precise definitions of how these terms are conceptualized in the context of the present research project (Russell, 2003; Scherer, 2005).

Emotions

The distinction between emotion and mood is not only found in the quality of affective experience itself, but also how the affective experience is situated in a context and how an affective episode is structured (Russell, 2003). Attribution to a trigger, appraisal and consciousness are key components of emotions, according to Russell (2003). An emotion can be defined as a short-term, intense response to specific internal or external stimuli, often accompanied by physiological changes or altered behaviour (Russell, 2003, Watson & Tellegen, 1985). Emotions or emotional episodes last from a few seconds to several minutes (Russell, 2003, Watson & Tellegen, 1985). Taken together, emotion can be understood as a psychological construction process that involves components such as a triggering event, affective quality, appraisal and consciousness.

Moods

Moods are considered forms of affective states that are not directed at any specific object or event (Russell, 2003). They are object-free and often experienced as diffuse affective states (Russell, 2003; Scherer, 2005). Therefore, the term mood can be defined as a diffuse, longer-lasting affective state of low to medium intensity that subtly shapes how we experience out environment, how we think about something and also how we act (Scherer, 2005; Wilhelm & Schoebi, 2007). Unlike emotions, moods usually don't have a clear trigger and involve less physiological synchronization (Scherer, 2005; Wilhelm & Schoebi, 2007). Therefore, a key difference between emotions and moods is that emotions are attributed to a particular object or stimulus. In contrast to emotions, moods can last for hours or days and are not necessarily experienced consciously (Russell, 2003; Scherer, 2005; Wilhelm & Schoebi, 2007). Mood, as a part of the broader concept of affect, can be described using the model introduced by Schimmack and Grob (2000). Building on this theoretical foundation, mood can be differentiated into three dimensions: valence (unpleasant to pleasant), calmness (tense to calm), and energetic arousal (Schimmack & Grob, 2000; Steyer et al., 2003).

To conclude, mood is characterized by its diffuse nature and lack of focus on a specific object, making it an underlying, subtle affective state. Emotion and affect are related concepts, however, they can be distinguished based on their duration, structure and the context in which they occur. They cannot be understood as the same psychological construct, even though they are often used interchangeable and without clear distinction in the literature (Gross, 2024; Russell, 2003; Scherer, 2005).

How to Study Mood Dynamics

Mood is not a fixed or stable construct. Instead, mood is characterized by its dynamic nature and a tendency to fluctuate over time (Trull et. al, 2015). Importantly, mood, while more lasting and diffuse than individual emotions, can fluctuate over the course of a day (Houben et al., 2015; Jahng et al., 2008; Russell, 2003). This study focuses on these within-day mood changes.

Following the conceptualization of mood by Schimmack and Grob (2000), mood can be divided in valence, calmness and energetic arousal. All of the mood dimensions show variations on a daily basis (Adan & Sánchez-Turet, 2001; de Vries et al., 2021; Feneberg et al., 2022; Stone et al., 1996; Wood and Magnello, 1992), emphasizing that mood is a concept that fluctuates over the course of a day. For example, energetic arousal declines over the course of the day in both sexes, with a more pronounced decrease and overall lower arousal levels in women (Feneberg et al., 2022).

One central concept to measure affective dynamic over time is affective instability, which can be operationalized by the robust statistical measure Mean Squared Successive Differences (MSSD; Jahng et al., 2008; Houben et al., 2015). Affective instability provides a measure to operationalize the magnitude of affective changes between successive moments in an individual (Houben et al., 2015). An individual with pronounced instability in mood states is confronted with stronger fluctuations of affective states from one moment to the next (Houben et al., 2015). Higher instability, and therefore a more unstable emotional life, is associated with negative consequences for well-being and psychopathology (Houben et al., 2015, Trull et al. 2015). Instability in mood may indicate difficulties in maintaining or coming back to affective balance. Studies show that even small periods of emotional disturbance can have negative consequences for health and affective disorders (Houben et al., 2015). Mood instability can be used to illustrate these short-term temporal dynamics assessed over longer periods of time, as facilitated by designs with daily assessments (Jahng et al., 2008; Houben et al., 2015). Two individuals might report the same average level of mood, but they can still differ in mood instability, meaning how much their mood varies across the day or the week Jahng et al., 2008; Houben et al., 2015). For example, two individuals both report an average mood of “moderately positive” over the week. However, while one person might be quite stable in mood, showing little change during a day, another person might show huge differences in mood throughout the day. Someone with high mood instability will experience heavy shifts in negative and positive mood valence during a day.

The Menstrual Cycle

The menstrual cycle occurs at regular intervals, lasting 28 days on average in healthy menstruating individuals, though normal cycles may vary between 21 and 35 days. (Eisenlohr-Moul, 2019; Schmalenberger et al., 2021). The cycle can be roughly divided into two phases, the follicular phase and the luteal phase (Schmalenberger et al., 2021). During the different phases of the menstrual cycle, hormone concentrations significantly differ and show distinct patterns of fluctuations. Especially the ovarian hormones progesteron and estradiol show regular and expected fluctuations in healthy cycles (Schmalenberger et al., 2021).

Schmalenberger et al. (2021) proposed a nuanced system to categorize the menstrual cycle, dividing the cycle into four phases: mid-follicular, perimenstrual, mid-luteal, and periovulatory. This classification allows precise statements regarding hormonal fluctuations. First, the perimenstrual phase, covering the days just before and during menstruation, is characterized by a decline in both estrogen and progesterone levels (Schmalenberger er al., 2021). During the mid-follicular phase, estrogen and progesterone levels remain relatively low and stable, although estrogen levels start to increase. The periovulatory phase marks the end of the follicular phase and includes ovulation. During this phase, estrogen levels reach their first peak in the cycle. Finally, the mid-luteal phase is characterized by a simultaneous peak in both estrogen and progesterone levels (Schmalenberger er al., 2021).

Premenstrual Symptoms

The time before menstruation is commonly associated with aversive symptoms in many menstruating individuals (Dickerson et al., 2003; Freeman et al., 2011). The reported symptoms are linked to what is known as PMS. PMS includes affective and physical symptoms that emerge regularly during the luteal phase of the menstrual cycle (Dickerson et al., 2003; Freeman et al., 2011; Meaden et al., 2005). Previous research has often focused on symptomatology limited to this premenstrual phase. However, more recent literature indicates that symptoms also occur during the early days of menstruation, what is referred to as perimenstrual phase (Meaden et al., 2005; Schmalenberger et al., 2021). The perimenstrual phase is typically defined as the timeframe starting three days before the onset of menstruation and ending two days after its onset (Schmalenberger et al., 2021). Current observations suggest that symptoms typically referred to PMS emerge during the perimenstrual phase and subside before the mid-follicular phase (Eisenlohr-Moul, 2019; Kiesner, 2017; Meaden et al., 2005). Premenstrual Dysphoric Disorder (PMDD) is considered the most severe form of PMS, constitutes an actual clinical diagnosis in official diagnostic manuals such as the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and is associated with significant impairment (American Psychiatric Association, 2013). PMDD is characterized by affective, behavioural and physical symptoms, that appear in the luteal phase and lead to significant impairment in daily life (Alevizou et al., 2018; American Psychiatric Association, 2013; Hantsoo & Epperson, 2015; Janda et al., 2017). A central difference between PMS and PMDD is that PMDD is primarily characterized by affective symptoms

(Eisenlohr-Moul, 2019; Freeman et al., 2011; Janda et al., 2017). One key criterion of PMDD is that symptoms fully disappear within the week after menstruation begins (American Psychiatric Association, 2013; Eisenlohr-Moul, 2019; Wei et al., 2018). Furthermore, for a diagnosis according to the DMS-5 at least one affective core symptom must be present (Eisenlohr-Moul, 2019). Affective symptoms in PMDD include mood swings, rejection sensitivity, irritability, loss of interest, hopelessness, anxiety, anger and depressed mood (American Psychiatric Association, 2013; Bedding et al., 2019; Hantsoo & Epperson, 2015; Janda et al., 2017). Several studies indicate that the most frequently reported symptoms in PMDD include mood swings and irritability (Pearlstein et al., 2005). Depressive symptoms are considered to be the least common affective symptoms (Pearlstein et al., 2005). PMS is seen as a milder manifestation of symptoms and importantly, does not cause the same degree of impairment as PMDD (Halbreich et al., 2003). In contrast to the clearly defined diagnostic criteria for PMDD, PMS has been linked to up to 200 symptoms, making its symptom profile much more heterogeneous (Dickerson et al., 2003; Freeman et al., 2011). Freeman et al. (2011) summarized the most common PMS symptoms as abnormal eating behaviour, changed appetite, cramps, aches, mood swings, anxiety and less interest in activities. Considering the prevalence of PMDD and PMS, it is estimated that around 3–8% of women are affected by PMDD (Beddig & Kühner, 2017; Eisenlohr-Moul, 2019; Halbreich et al., 2003). The prevalence of PMS is more difficult to determine, partly because of inconsistent diagnostic criteria, differences in symptom reporting and the lack of standardized assessment tools. Still, some research suggests that about 85% of menstruation individuals could experience at minimum one premenstrual symptom (Dickerson et al., 2003). While Dickerson et al. (2003) argues that many individuals experience premenstrual symptoms, Halbreich et al. (2003) suggested that only about 13 to 18 percent show symptoms severe enough to cause noticeable impairment and distress.

Even if hormone levels are the same, menstruating individuals seem to differ in the vulnerability to normal hormone changes. It has been suggested that a subset of menstruating individuals experiences an abnormal sensitivity to the regular fluctuations of estrogen and progesterone across the cycle, which is then reflected in PMS and PMDS symptoms (Andreano et al., 2018; Eisenlohr-Moul, 2019; Hantsoo & Epperson, 2020; Kiesner, 2011; Nayman et al., 2023; Schmalenberger et al., 2021; Wei et al., 2018). This hypersensitivity to normal fluctuations is currently considered the greatest potential explanation for premenstrual symptoms, as well as for interindividual differences in the strength of the response, which may contribute to whether an individual experiences PMS or PMDS (Eisenlohr-Moul, 2019; Kiesner, 2011; Kiesner, 2017; Nayman et al., 2023).

Differentiating Affective Symptoms from Mood

The usages of the umbrella term affective symptoms complicates the differentiation between distinct affective constructs (Russell, 2003; Scherer, 2005). Symptoms like interpersonal conflicts, mood swings, irritability, crying or tension are part of the affective symptoms in the diagnostic criteria for PMDD (American Psychiatric Association, 2013; Bedding et al., 2019; Janda et al., 2017). As stated before, emotions are theorized to last from seconds to minutes, emphasizing the short-lived character of emotions. On the other hand, mood refers to a diffuse state that is of low intensity that can persist for hours or days (Scherer, 2005; Wilhelm & Schoebi, 2007). It can be argued that the clinical use of the term “affective symptoms” usually refers to noticeable, rather short-lived emotional reactions, as formulated in the diagnostic criteria of PMS and PMDS, which list symptoms like interpersonal conflicts, mood swings, irritability, crying or tension (American Psychiatric Association, 2013). Therefore, symptoms like interpersonal conflicts, irritability, crying or tension should not be understood as representing moods, which are theorized to last for hours or days, but rather as short-lived emotional states. At this point, it is possible to differentiate moods as a background affective state, in contrast to the severe affective symptoms included in PMS or PMDD, which are often associated with significant burden and impairment (Hantsoo & Epperson, 2015; Janda et al., 2017).

Furthermore, it is crucial to clearly define what is meant by the term mood swings. Mood swings, as mentioned in the diagnostic criteria for PMDS, describe rapid shifts between distinct emotional states, such as sudden changes from sadness to anger (American Psychiatric Association, 2013). Empirical and clinical research on PMDS points to the short-lived and rapidly changing nature of emotions in mood swings as well (Beddig et al., 2020; Pearlstein et al., 2005). Therefore, although the term includes the word mood, mood swings actually refer to short-lived fluctuations between emotional states, rather than to moods, which are, as mentioned before, more lasting and diffuse.

While mood and affective symptoms are likely to be connected, they should not be seen as conceptually or functionally identical constructs (e.g., Russell, 2003; Scherer, 2005; Gross & Thompson, 2007). This distinction has not been sufficiently addressed in the existing literature on premenstrual symptoms and mood, which makes it difficult to draw explicit conclusions about the relationship between mood and premenstrual affective symptoms.

Mood and the Menstrual Cycle

Across several studies, findings consistently indicate lower levels of positive mood and increased negative mood during the luteal phase in individuals experiencing PMS and PMDD (Beddig et al., 2020; Wu et al., 2016; Pletzer & Noachtar, 2023). Specifically, Beddig et al. (2020) found mood deterioration only in participants affected by PMDD, but no such cycle effect was observed in healthy individuals. By contrast, Gonda et al. (2008), found evidence for fluctuating mood across the menstrual cycle in healthy individuals. Their results showed significantly higher scores in affect-related scales (e.g anxiety, depression or interpersonal sensitivity, neurotic symptomatology) during the late luteal phase. A classification into emotion or mood was not provided by the authors, making a clear distinction challenging. Therefore, interpretation for mood remains limited. Nevertheless, mood deterioration was not only observed during the premenstrual phase, but also in the first days of menstruation (Gonda et al., 2008). Complementing these findings, a systematic review by Romans et al. (2012), which investigates PMS and non-PMS samples, reported fluctuations in mood measurements across the menstrual cycle in about two thirds of the observed studies. Pletzer and Noachtar (2023) observed significantly worse mood during menstruation in a sample of healthy and individuals with PMS. Furthermore, the authors reported that the strongest mood changes were found in participants with high score for the severity of premenstrual symptoms.

However, not all studies report significant associations between menstrual cycle phases and mood changes. Hengartner et al. (2017) investigated if hormone levels across the menstrual cycle are associated with negative mood-related states in a sample that consisted of healthy individuals. The authors did not find evidence for fluctuations of negative mood across the cycle. Additionally, no association was found between sex hormone and negative mood-related states. Comparable outcomes were reported by Bosman et al. (2018). The small sample included only nine women with self-reported premenstrual syndrome. Similar to Hengartner et al. (2017), Bosman et al. (2018) found no evidence for menstrual cyclicity, neither in positive, nor in negative mood-related states. It is important to mention that the available sample size was not ideal. Small datasets are likely to have reduced statistical power, which in turn decreases the likelihood of detecting meaningful fluctuations or intra-individual variability (Hengartner et al., 2017; Pierson et al., 2021).

On the other hand, Pierson et al. (2021) reported fluctuations in mood across the menstrual cycle. The study had data available from nearly 500,000 women from over 100 countries, including healthy individuals, but also women affected by PMS. It is important to emphasize that the data were obtained from a health-tracking app for women. As a result, it is not possible to provide information about the distribution of non-PMS and PMS cases. In this diverse data set, they compared the influence of daily, weekly, seasonal and menstrual cycles on mood. The authors reported that the menstrual cycle was the greatest contributor to within-individual mood fluctuations across the compared timescales on the mood dimensions. The menstrual cycle had the largest effect on seven out of nine mood dimensions.[1] The greatest effect of menstrual cycle on mood was found for the “happy vs. sad” dimension, showing substantial within-cycle variation. Daily mood fluctuations were also present for most mood dimensions and showed relatively high amplitudes, especially for “energezied vs. exhausted”, “supportive vs. conflict” and “calm vs. stressed”, although not as pronounced as those of the menstrual cycle. In the case of “calm vs. stressed” and “productive vs. unproductive” the weekly cycle showed the biggest amplitudes. Furthermore, the individual patterns of change in mood appeared to be quite stable from cycle to cycle.

Meaden et al. (2005) observed timing and intensity of premenstrual affective and physical symptoms in a community sample of 900 women over two menstrual cycles, using a 50-item questionnaire, that included DSM-IV-based PMDD criteria, PMS-related items and a constructed list of positively worded affective items. Especially with the positively worded items the authors captured also mood-related states such as “Felt energetic”, “Felt restless”, “Felt rested”, “Felt peaceful”, “Felt optimistic” or “depressed mood”. The findings indicated that most affective and also physical symptoms fluctuated across the menstrual cycle and peaked in severity on the first day of menstruation. The items were not clearly separated into mood-related items versus premenstrual affective symptoms. While a closer look of the item pool allows for some tentative assumptions about mood-related states, these items were not selected to measure mood. Therefore, although some of the positively worded items hint to mood-related states, any interpretation regarding mood should be made cautiously and tentative. However, these results may provide preliminary insights into mood-related states and their possible fluctuations across the menstrual cycle, as the mood-related items showed peaks in severity on the first day of menstruation, with similarly elevated levels shortly before and after the onset of bleeding. The lowest severity scores for most of the items and also for mood related-states were observed between cycle days 6 and 13. This observed temporal pattern would suggest a perimenstrual worsening of mood rather than a mood decline limited to the premenstrual phase. While this temporal pattern is interesting, it is an assumption and

[1] “Happy vs. sad”, “Happy vs. sensitive”, “Energized vs. exhausted”, “Motivated vs. unmotivated”, “Supportive vs. conflict”, “Focused vs. unfocused” and “Social vs. withdrawn”.

cannot be taken as evidence for mood changes. Nevertheless, considering sensitivity to hormonal changes as a possible explanatory model, the results point toward a time-lagged effect of hormonal changes on mood dynamics.

While previous studies emphasized menstrual cycle-related mood fluctuations, Lorenz et al. (2017) reported different findings regarding mood instability at least in healthy individuals. They found that sadness and irritability showed greater variance than other mood related-states. But in contrast to Pierson et al. (2021) and Gonda et al. (2008), this variance was best explained by day-to-day fluctuations rather than by the menstrual cycle. Lorenz et al. (2017) therefore suggest that significant mood changes across the menstrual cycle are uncommon in psychologically healthy individuals. Instead, they propose that the mood instability observed in individuals with PMDD reflects distinct pathological changes rather than an intensified version of normal mood variability.

Building on these findings, Bowen et al. (2011) reported similar premenstrual mood deterioration. This research, to date, remains the only study that specifically examines mood instability in relation to the menstrual cycle, operationalizing mood instability with the MSSD. Although the authors refer to mood instability, the employed Visual Analogue Scales (VAS) primarily captured clinically relevant premenstrual affective symptoms rather than the concrete concept of daily mood. This again highlights the importance of differentiating between affective symptoms and mood. Nevertheless, in individuals with premenstrual symptoms, mood instabilities in the dimensions of depressed and irritable mood were observed across the entire menstrual cycle, not just during the late luteal phase. Since the focus of this finding is not directly on mood, no direct conclusion can be drawn regarding mood instability.

While premenstrual symptoms are generally assumed to emerge close to menstruation, the literature reviewed so far indicates that there is still no consensus. Considering the timing of the most intense symptoms shown in individuals with strong premenstrual symptoms, Eisenlohr-Moul et al. (2019) did not find a consistent premenstrual pattern in a clinical PMDD sample as well. Although 65% of participants reported a typical perimenstrual symptom pattern with a rapid decline in symptoms around menstruation, 17.5% experienced severe symptoms throughout the entire luteal phase. Another 17.5% reported strong symptoms in the premenstrual phase, but their symptoms decreased more slowly and extended into the follicular phase.

Research Questions and Hypotheses

The existing research indicates that affective states like mood fluctuate naturally and are influenced by the menstrual cycle. Particularly in those with PMS or PMDD (Beddig et al., 2020; Pletzer & Noachtar, 2023; Romans et al., 2012), literature reports mood deterioration around menstruation and during the perimenstrual phase. Since the dynamic and longer lasting nature of mood, it is plausible to assume that not only the quality but also the temporal stability of mood may be altered in those with severe premenstrual symptoms. As previously mentioned, the term affective symptoms is used inconsistently in literature. Research is needed that focuses on mood as a clear, measurable outcome and its relation to premenstrual symptom severity (Brose et al., 2020). Because of the dynamic nature of mood and the observed mood deterioration, it would be surprising if the menstrual cycle had no effect on mood instability. The same applies to the influence of premenstrual symptoms on mood instability. Since mood appears to be especially affected in individuals with pronounced premenstrual symptoms, individuals with a high symptom severity might be more vulnerable to mood changes and instabilities during the perimenstrual phase. This hypothesis has received little attention so far, even though mood instability has been linked to various forms of psychopathology (Houben et al., 2015). Therefore, it is important to consider not only the quality of mood but also its temporal dynamics. The goal of the present study is to investigate whether there is an association between the menstrual cycle, premenstrual symptom severity and daily instability in the mood dimensions of valence, calmness and energetic arousal. The following hypotheses are posed:

H1: The daily severity of premenstrual symptoms is positively associated with mood instability (MSSD).

H1a: The daily severity of premenstrual symptoms is positively associated with instability (MSSD) in mood valence (MDBF).

H1b: The daily severity of premenstrual symptoms is positively associated with instability (MSSD) in mood calmness (MDBF).

H1c: The daily severity of premenstrual symptoms is positively associated with instability (MSSD) in mood energetic arousal (MDBF).

H2: The association between daily severity of premenstrual symptoms and instability (MSSD) in mood (MDBF) is moderated by the menstrual cycle phase (perimenstrual = day -3 to 2; postmenstrual = day 4 to 7).

H2a: The association between daily severity of premenstrual symptoms and instability (MSSD) in mood valence (MDBF) is moderated by the menstrual cycle phase (perimenstrual = day -3 to 2; postmenstrual = day 4 to 7).

H2b: The association between daily severity of premenstrual symptoms and instability (MSSD) in mood calmness (MDBF) is moderated by the menstrual cycle phase (perimenstrual = day -3 to 2; postmenstrual = day 4 to 7).

H2c: The association between daily severity of premenstrual symptoms and instability (MSSD) in mood energetic arousal (MDBF) is moderated by the menstrual cycle phase (perimenstrual = day -3 to 2; postmenstrual = day 4 to 7).

Methods

This study was conducted as part of a larger research project on stress and the menstrual cycle: Interactions in premenstrual Symptoms and Stress Across the menstrual Cycle (ISSAC). The aim of the ISSAC study is to examine temporal relationship between stress and premenstrual symptomatology across the menstrual cycle (Bencker et al., 2025). Data were collected daily across two menstrual cycles, which is why the study follows an ecological momentary assessment (EMA) design. The ISSAC study serves as the foundation for the present study, which results in certain limitations regarding the study design, procedure and available data. In addition to the present thesis, five other master's students have been working on projects based on the same study design: Lea Maria Beinbauer, Zoe Juliana Kiesner, Nicola Notz, Carlotta June Petrusch and Anette von Specht.

Study Procedure

Since the study examined processes related to the menstrual cycle, participation was limited to individuals with female reproductive organs. The participants were recruited via Social Media Postings and Flyers. A brief screening questionnaire, designed to assess eligibility for the ISSAC study, was administered via an QR code or link. Inclusion criteria required participants to be between 21 and 45 years old, have good German language skills, female reproductive organs, regular menstrual cycles (21–35 days, with less than five days variation over the last three cycles) and a BMI between 17 and 34.99. Exclusion criteria included pregnancy or breastfeeding, use of hormonal contraceptives within the past three months, psychotropic medication, severe somatic or gynecological disorders affecting the menstrual cycle, high alcohol or illegal drug use, shift work, regular wake-up time after 11:00 a.m. and a lifetime diagnosis of substance-induced disorders, bipolar disorder or schizophrenia.

The screened participants who met the eligibility criteria were invited via email and attended an initial lab appointment. The baseline appointment was arranged at least four days after the onset of the participant's most recent menstrual bleeding (Day 5). This date was calculated by the study team based on the start dates of the participants' last four menstrual cycles reported by participants at screening. During the baseline appointment (approximately 90 minutes) the study design was explained, participants gave their informed consent, filled out a baseline questionnaire via Sosci Survey (SoSci Survey GmbH, München, Germany) and received study materials. These included information on the daily assessments and sample tubes for salvia collection (salicaps). The EMA part of the study was explained in detail to ensure that participants felt informed and followed the protocol properly. The app "movisensXS" (Movisens GmbH, Karlsruhe, Germany) was installed on study smartphones, which were provided to participants as needed. If participants owned a compatible Android device, the app was installed directly on their personal phone. Each participant went through two consecutive menstrual cycles during the study period, which can be divided into two distinct phases described in the following section.

The study started four days before the earliest predicted day of ovulation and ended ten days after onset of menstruation in the third study cycle. The study team calculated this date using the menstrual cycle data reported by participants in the screening. During the first study phase, participants complete questionnaires five times per day and collect saliva samples three times per day. All questionnaires were answered via the app "movisensXS". The questionnaire asked about different aspects, including premenstrual symptoms, mood, sleep and stress for example. The day starts with a morning assessment, which participants initiate themselves right after waking up, followed by the first saliva sample. Thirty minutes later, they receive an alarm/ prompt via the study smartphone to complete another assessment and provide a second salivary sample. Furthermore, participants complete assessments at two predefined times at 2:00 p.m. and 7:00 p.m. The 7:00 p.m. entry includes the final saliva sample of the day. The last assessment of the day is initiated by participants just before going to sleep and includes a detailed symptom diary on premenstrual symptoms. This design represents phase one of the study, which also served as the basis for my research project.

The second study phase is not described, as it is not relevant for my research question. At the end of the study period, a post-assessment is arranged between days −8 and −5 prior to the participant's next expected menstruation. During the post-assessment, participants filled out a post-assessment questionnaire, gave back the study materials, salvia samples and were thanked for participation. Those who completed 90% or more of the required assessments were awarded a total compensation of 120 euros. Partial participation results in a reduced compensation.

Measurements

Menstrual Cycle Phase

Cycle phases were defined based on recommendations by Schmalenberger et al. (2021), although the hypotheses only compared the perimenstrual and postmenstrual phases. A combination of forward- and backward-counting method was applied, both referenced to the onset of menstruation. The perimenstrual phase covers the three days before and the two days after menstruation starts, counting the first day of bleeding as day one (forward- and backward-counting). These days are considered the most symptomatic days (Schmalenberger et al., 2021). The postmenstrual phase is defined as day four to day seven (forward-counting). In Schmalenberger et al. (2021) this timeframe is referred to as mid-follicular phase. Using ovulation tests to identify the mid-follicular phase is seen as the gold standard. While ovulation tests were used in the original study, they were not applied to define phases in the current study design. If ovulation tests had been used to determine this phase, the mid-follicular phase would likely have fallen closer to ovulation. This increases the risk of including days in which other hormonal processes may have already been initiated. The postmenstrual phase is supposed to represent a hormonally neutral contrast to the perimenstrual phase in this study. Therefore, the use of backward- and forward-counting anchored at the onset of menstruation was considered the more reliable approach.

Premenstrual Symptoms and Symptom Severity

To assess premenstrual symptoms an adapted form of the symptom diary by Janda et al. (2017) was used. The items of the symptom diary were answered each evening before going to bed by the participants. 28 items asked about premenstrual symptoms on a 6-point Likert scale and additionally three items asked for distress or impairment in work/school, social activities and relations to other. To assess the overall severity of premenstrual symptoms during the menstrual cycle, the scores of the first 28 items of the symptom diary (numerical answer 0-5) were summed up for each participant for each day of the cycle. This approach offers a straightforward way to generate a continuous measure of the self-reports of participants into a total symptom score, that reflects the daily overall symptom severity and facilitates comparisons between individuals. This procedure is based on the logic of calculation total symptom scores as described by Janda et al. (2017) and Endicott et al. (2006). High daily scores reflect strong symptom severity and therefore intensity, while repeated high ratings across multiple days indicate how consistently or frequently symptoms are experienced. This approach avoids the loss of nuance that might occur with categorical classifications and no retrospective bias is expected. Therefore, the daily symptom severity score ranges from 0 to 140.

Momentary Mood (MDBF)

During the first study phase, mood was assessed four times daily using an adapted version of the Multidimensional Mood Questionnaire (MDBF; Steyer et al., 2003), which is validated for EMA designs (Wilhelm & Schoebi, 2007). The MDBF consists of three mood dimensions: mood valence, energetic arousal and calmness. Participants assessed their current mood by responding to six bipolar items, two for each mood dimension. (mood valence: unwell–well, dissatisfied–satisfied; energetic arousal: weak–energetic, tired–awake; calmness: tense – relaxed, restless-calm). The six items were presented using a VAS. Accordingly, the original instrument by Steyer et al. (2003) was adapted to a VAS format ranging from 0 to 100. Wilhelm and Schoebi (2007) reported that the three mood dimensions can be reliably distinguished as separate factors at both the within-person and between-person level, therefore, supporting their relevance for the description of mood. However, they also noted that at the between-person level calmness and valence were less clearly distinct. Reliability coefficients for within-person ratings ranged from .70 to .77 and from .90 to .92 at the between-person level. Additionally, both weekly and daily mood averages demonstrated good reliability. Furthermore, the scales demonstrate high sensitivity to change over short periods of time (Wilhelm & Schoebi, 2007). Higher values represent higher levels of mood on the corresponding mood dimension (valence, arousal, calmness). Therefore, higher scores for mood valence indicate a more positive mood, such as feeling well and satisfied, whereas lower scores suggest a more negative mood, including feelings of dissatisfaction or unwell-being. Similarly, higher values on the scale for energetic arousal reflect a state of high activation, such as feeling awake, energetic, or alert. In contrast, lower values indicate feeling rather tired or weak. For the calmness dimension, higher scores indicate greater perceived calmness and relaxation, while lower scores reflect states inner tension or restlessness. The wording and structure of the scale implies that lower values across all three mood dimensions reflect overall lower mood quality, therefore a more negative affective state and vice versa. For example, a high score on the calmness dimension (feeling calm and relaxed) is conceptualized as a positive mood state, not as a lack of engagement. Likewise, high values on the energetic arousal dimension do not reflect anxious states but instead indicate positive activation. Taken together, across all three subscales, higher scores represent more favourable mood states, while lower scores reflect a reduction in affective quality and are therefore interpretable as markers of negative mood in the context of this study. Since the study was conducted in German, the prompt “Im Moment fühle ich mich...” (“At the moment, I feel...”) was used. For example, mood valence was rated on a VAS reaching from “unzufrieden” to “zufrieden” (satisfied to dissatisfied).

Mood Instability (MSSD)

Instability of mood can be operationalized as the MSSD, a commonly used way for capturing short-term instability of affective states (Jahng et al., 2008; Houben et al., 2015). Participants' daily four ratings from the MDBF were used to calculate the MSSD score. For each of the three mood dimensions (valence, calmness and energetic arousal), the two corresponding items were first averaged to form a combined mood score per EMA-assessment. R was then used to calculate the daily MSSD scores using a time-adjusted approach, following the recommendation by Jahng et al. (2008). [2] To make sure mood instability was estimated reliably, MSSD scores were only calculated on days with three or more mood ratings available. A formula was created in R to calculate daily MSSD scores for each participant and each mood dimension. First, the time differences between successive measurements were calculated in minutes. These time intervals were normalized by dividing by the median time of all time intervals and are then raised to a power (lambda), as suggested by Jahng et al. (2008) using 0.5. Next, the change in self-reported mood scores between measurements was calculated and these were divided by the normalized time intervals. The squared mean of these adjusted changes results in the MSSD.

[2] Jahng et al. (2008) introduced a formula that adjusts for the varying time intervals between EMA measurements, thereby providing a more accurate estimation of within-person variability.

Daily Perceived Stress

Daily perceived stress was included as a covariate, as there is evidence suggesting a strong link between stress and mood, especially across the menstrual cycle (Andreano et al., 2018; Beddig et al., 2020; Hantsoo & Epperson, 2020). To assess daily perceived stress, an adapted version of the Perceived Stress Scale was used (PSS; Cohen et al., 1983; Klein et al., 2016). While the original version of the scale measured stress over the past month, the adapted item focuses on stress experienced on the current day. During the last assessment of the day, participants answered the question "Wie gestresst haben Sie sich heute gefühlt?" ("How stressed did you feel today?") using a VAS ranging from 0, meaning "überhaupt nicht" ("not at all") to 100, meaning "sehr stark" ("very much"). The item can be understood as reflecting a total daily stress score. The assessment of stress using a single-item measure has also been applied in other EMA studies (Feneberger et al., 2022). The original version of the PSS also refers to stress experiences in the past. The German version of the original PSS-10 shows good psychometric properties (Klein et al., 2016). Since the used item is an adaptation of the PSS, there are no specific reliability or validity data available. However, the use of the PSS in daily assessments in EMA studies has generally been validated (Murray et al., 2023). Total daily stress was measured in the evening to avoid people possibly overrating how stressed they felt in intense, stressful moments during the day. This approach was a conscious trade-off between capturing real-time experiences, which can be possibly overrated and possible retrospective bias on the other hand. However, since stress is still assessed on the same day, the risk of bias in participants reflecting back is likely reduced.

Sample

By mid-July 2025, 91 people completed the screening questionnaire. The exclusion criteria included multiple reasons, with the three most frequent reasons being: irregular menstrual cycles or cycle length, gynecological disorders and excessive alcohol consumption. A total of 27 participants were included in the study by mid-July, with one person dropping out voluntarily. The sample for my research project only included participants who completed study phase 1 at the time of data analysis, since this phase comprised the five daily assessments. The final sample for my research project consists of 19 women. [3] The

[3] In this study, the term "women" refers to participants' responses to the question "Which gender do you identify with?" with the response options "female", "male", "non-binary", "other", "prefer not to answer". The original question in German was: „Welchem Geschlecht fühlen Sie sich zugehörig".

participants showed an age range between 23 and 34 years. The mean age was 27.63 (*SD* = 3.53).

Statistical Procedure

All analyses were conducted by using R Statistics 4.3.3 (R Core Team, 2024). Before conducting the statistical analyses, the data had to be cleaned and preprocessed. If participants completed the evening assessment after midnight, the study day was corrected to reflect the actual previous day. This procedure ensured the correct assignment of data to the correct study day. A new variable, “study date”*,* was created to reflect the corrected assignment. Furthermore, the dataset was checked for duplicates and incomplete entries. Incomplete entries were excluded. When multiple complete entries were available, the earliest time was used for analysis. Premenstrual symptom severity and perceived stress values were assessed at day level and therefore person-mean centered. Only data from the perimenstrual and postmenstrual phases were used for the analysis, as these were relevant for testing the hypotheses. The available data for the perimenstrual and postmenstrual phase ended up in 595 observations. Of these, 32 observations were missing mood ratings (valence, calmness, arousal). Within these 32 cases, nine cases also had no entries for premenstrual symptom severity and daily perceived stress (covariate). Additionally, nine further observations were missing data for premenstrual symptom severity and daily perceived stress. In total, 41 observations were excluded from the analysis because of missing data.

Because the data had a nested structure, multilevel models were run to test hypotheses. Level one included the repeated daily assessments and level two represented the participants. Hypothesis 1 stated that the instability of the three mood dimensions (valence, calmness, energetic arousal) would be predicted by daily premenstrual symptom severity. Hypothesis 2 proposed a moderation of this association by the menstrual cycle phase. The outcome variables instability of valence, instability of calmness and instability of energetic arousal were continuous. In consequence, linear mixed models (LMM) were calculated. The model parameters were estimated using maximum likelihood method (ML), as this approach allows the comparison of models with different fixed effects (Field, 2018). Dummy variables were created to represent the cycle phase. The perimenstrual phase was coded as “1,” indicating that the day fell into the perimenstrual window (Schmalenberger et al. (2021). The postmenstrual phase had the value “0”, indicating that the day fell within the mid-follicular phase according to Schmalenberger et al. (2021). For each hypothesis a series of models were calculated. The first step compromised the calculation of an intercept-only model to estimate the intraclass correlation coefficient (*ICC*). Since the hypotheses focused on mood dimensions derived from the same questionnaire, the procedure for hierarchically adding variables to the model was the same for each hypothesis. First, the main predictor premenstrual symptom severity was added, followed by cycle phase in a second model. Next, the interaction between premenstrual symptom severity and cycle phase was included. In Model 4, daily perceived stress was included as a covariate. As a final step, random slopes for symptom severity were examined. For model comparison, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) were examined. In addition, likelihood ratio tests were performed to assess whether the inclusion of predictors significantly improved model fit.

Results

Descriptive Statistics

After excluding the missing values, the dataset comprised 554 observations at Level 1. 41.88% of the data points fell into the postmenstrual phase and 58.12% into the perimenstrual phase. The average severity of daily premenstrual symptoms was 16.60 (*SD* = 14.97). The lowest observed value within the sample was zero, indicating no perceived symptoms. The highest value was 76, indicating a high level of premenstrual symptom severity in this dataset. Descriptives of average mood valence, calmness and energetic arousal, as well as for perceived stress are shown in Table 1.

Table 1

Descriptive Statistics of Mood Dimensions and Stress by Menstrual Cycle Phase

	Valence	Calmness	Energetic Arousal	Day Stress
Perimenstrual Phase	67.18 (19.70)	64.02 (22.06)	45.97 (21.56)	40.26 (24.45)
Postmenstrual Phase	71.66 (14.49)	67.11 (16.95)	50.86 (20.37)	37.17 (21.10)

Note. Means of mood valence, calmness, energetic arousal and day stress across the cycle phases (perimenstrual phase and postmenstrual phase). Standard deviations are presented in the brackets.

The raw values of instability of the mood dimensions showed many small scores on the left side of the distribution and some very large scores on the right side, reflecting a right-skewed pattern. For example, mood valence instability scores ranged from 0.25 to 6516.70, with a mean score of 313.94 (*SD* = 517.45), indicating a wide range between minimum and maximum values. The original scale of the mood ratings ranged from 0 to 100, which explains the presence of very large raw values. By taking the logarithm of the MSSD values of valence, calmness and energetic arousal, it is possible to obtain a normality-approximated distribution of the MSSD values. The mean scores of the log-transformed mood instability scores for each mood dimension across the perimenstrual and postmenstrual phases are presented in Table 2. Table 3 shows a comparison between raw and log-transformed mean scores of instability across the three mood dimensions.

Table 2

Descriptive Statistics for Log-Transformed Mood Instability Over the Menstrual Cycle

	Valence	Calmness	Energetic Arousal
Perimenstrual Phase	4.87 (1.61)	5.16 (1.64)	5.87 (1.24)
Postmenstrual Phase	4.65 (1.63)	5.11 (1.40)	6.05 (.96)

Note. Means of log-transformed mood scores (mood valence, mood calmness, mood arousal) across the cycle phases (perimenstrual and postmenstrual phase). Standard deviations are shown in the brackets.

Table 3

Descriptive Statistics for Raw and Log-Transformed Mood Instability Across Menstrual Cycle Phases

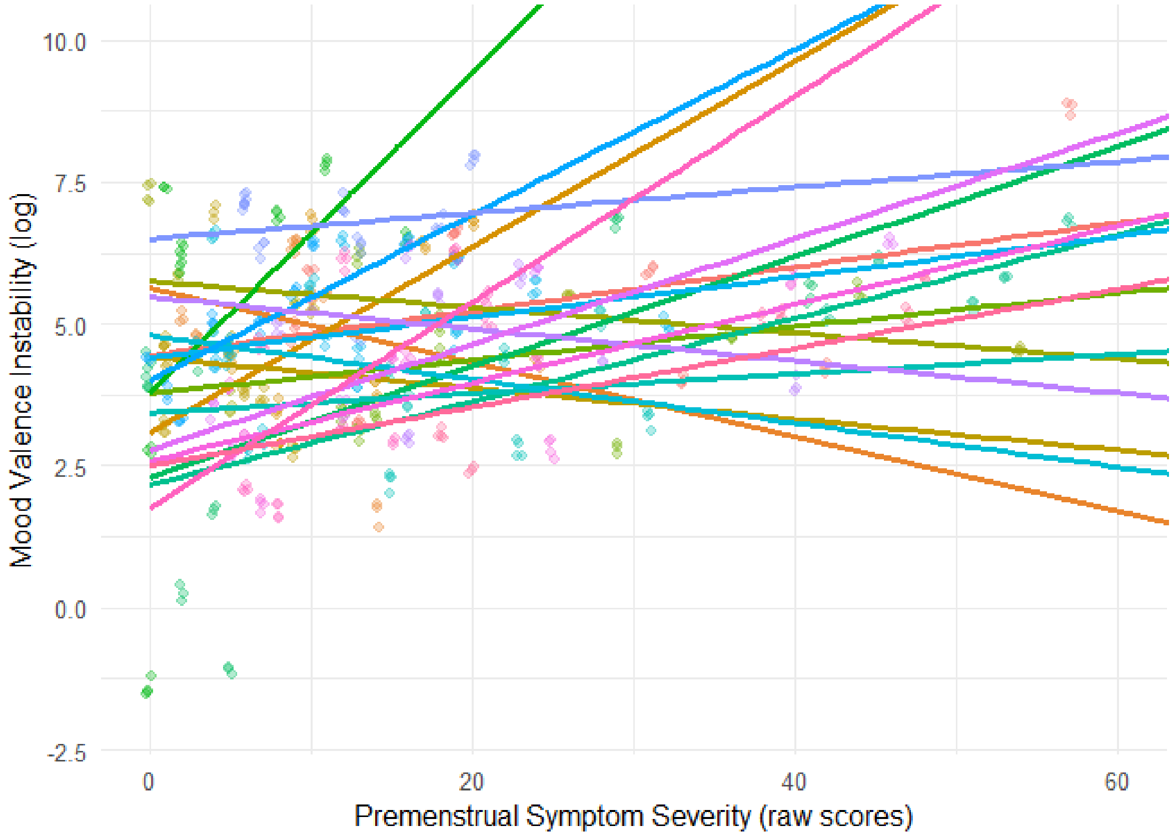
Variables	Cycle Phase	
	Perimenstrual Phase	Postmenstrual Phase
VAL RAW	373.74	276.73
VAL LOG	4.87	4.65
CAL RAW	503.91	385.38
CAL LOG	5.16	5.11
ARO RAW	661.32	634.54
ARO LOG	5.87	6.05

Note. This table reports the means of mood instability (MSSD scores for mood valence, mood calmness and mood arousal) in raw and log-transformed form, separately for the perimenstrual and postmenstrual phases.
VAL = mood valence; CAL = mood calmness; ARO = mood arousal; RAW = raw score; LOG = log-transformed score.

Figure 1 shows participant-level associations between premenstrual symptom severity and mood valence instability. The plots for mood calmness and energetic arousal can be found in Appendix A. The spread of data points across the x-axis shows considerable variability in premenstrual symptom severity across measurements and participants. Furthermore, the slopes of the regression lines seem to differ between individuals, indicating heterogeneity in how premenstrual symptom severity relates to mood instability.

Figure 1

Plot of Individual Associations Between Premenstrual Symptom Severity and Mood Valence Instability



Note. The plot shows the association between premenstrual symptom severity and the instability of the mood dimension valence for each participant. Raw-scores for premenstrual symptom severity are shown. Mood valence instability scores were log-transformed. The dots are jittered to make each individual data point visible.

Multilevel Modelling of Mood Instability

Hypotheses 1a and 2a: Instability of Mood in the Dimension of Valence

In line with current statistical standards, a series of models was calculated to test the hypotheses, starting with an intercept-only model (null model). The intercept-only model allows the estimation of the *ICC*. The intercept-only model showed an *ICC* of $\rho = 0.19$. This indicates that about 19 % of the variance in mood valence instability is explained by differences between individuals.

The first step was to include severity of premenstrual symptoms in the model (Model 1), which resulted in an improved model fit and an increase in explained variance from zero to $R^2 = .12$. The second model, which additionally included cycle phase, showed a significant fixed effect of cycle phase. The third model included an interaction term for premenstrual symptom severity and cycle phase. Contrary to the expectations of the hypothesis 2b, the interaction term was not statistically significant. In Model four the covariate daily perceived stress was added. The fixed effects of symptom severity and cycle phase continued to be statistically significant as in the previous models. In a final step, a random slope for premenstrual severity was added. The inclusion of the random slope resulted in an improved model fit, with Model five outperforming the previous models according to AIC, BIC and likelihood ratio test. Model five therefore achieved the best fit to the data. Model estimates for Model five are shown in table 4 and model fit comparison can be found in Appendix A.

Table 4

Estimates for Valence Instability using Linear Mixed Model

Fixed effects	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	4.77	.20	4.38	5.15	< .001***
Symptom Severity [a]	.07	.02	.03	.11	.002**
Cycle Phase [b]	–.36	.13	–.62	–.11	.006**
Perceived Stress [c]	.01	.00	.01	.00	.01*
Interaction [d]	–.01	.01	.65	–.03	.07

Note. SE = Standard Error, p = p-value, CI = confidence interval; LL = lower limit; UL = upper limit.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Hypotheses 1b and 2b: Instability of Mood in the Dimension of Calmness

Since mood was measured in three dimensions, the same hierarchical model structure used for valence was applied to the mood dimension calmness. Hypothesis 1b stated that instability in the mood dimension calmness would be predicted by premenstrual symptom severity and hypothesis 2b included a moderation by menstrual cycle phases. As with valence, analysis of instability in mood calmness started with an intercept-only model. The intercept-only model for calmness showed an *ICC* of $\rho = 0.25$. This indicates that about 25% of the variation in instability in the mood dimension calmness occurs between individuals. Model one and two included the predictors daily premenstrual symptom severity and cycle phase. Severity and cycle phase predicted instability of mood calmness significantly in Model three. For detailed information on the regression coefficients (see Appendix table A3). Adding premenstrual symptom severity to the model led to an increase in explained variance from zero to $R^2 = .05$. Adding cycle phase led to a further increase in explained variance to $R^2 = .06$. In the third model an interaction term for premenstrual symptom severity and cycle phase was added. Contrary to the expectations of the hypothesis 2b, the interaction term was not statistically significant. Model four included the covariate daily perceived stress and model five additionally included a random slope for premenstrual symptom severity. Based on AIC, BIC and the Chi-square test, model five showed the best fit compared to previous simpler models. Furthermore, model five also led to a higher R^2 value, reaching .11 in explained variance. However, in this model, only the fixed effect of the covariate perceived stress reached statistical significance (Table 5). All in all, the hypothesized interaction of cycle phase and premenstrual symptom severity did not emerge. Moreover, neither cycle phase nor symptom severity showed a significant effect on mood instability in calmness in the best-fitting model.

Table 5

Estimates for Calmness Instability using Linear Mixed Model

Fixed effects	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	5.18	.21	4.78	5.59	< .001***
Symptom Severity [a]	.03	.02	–.01	.06	.12
Cycle Phase [b]	–.20	.12	–.44	.05	.11
Perceived Stress [c]	.02	.00	.01	.03	< .001***
Interaction [d]	–.01	.01	–.03	.02	.54

Note. SE = Standard Error, p = p-value, CI = confidence interval; LL = lower limit; UL = upper limit.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Hypotheses 1c and 2c: Instability of Mood in the Dimension of Energetic Arousal

Hypothesis 1c stated that instability in the mood dimension energetic arousal would be predicted by daily premenstrual symptom severity. It was expected that the association between mood instability in energetic arousal and severity of premenstrual symptoms would vary depending on the cycle phase (H2c). In line with the previously used approach, an intercept-only model (null model) was calculated. This model yielded an *ICC* of $\rho = 0.40$. This indicates that about 40% of the variance in mood arousal instability can be explained by differences between individuals. The remaining 60% of the variability is explained by within-person changes. Variables were added to the model in the exact same order as in the analyses for the previous hypotheses. Adding premenstrual symptom severity in model one did not lead to a significant effect, whereas cycle phase in model two did show a significant result (see Appendix A). Similar to the other mood dimensions (valence and calmness), the interaction term for premenstrual symptom severity and cycle phase in model three was not significant either. Adding the covariate daily perceived stress to the model led to an increase in explained variance to $R^2 = .03$. The fixed effect of the covariate daily perceived stress was $b = .00$ (*SE* = .01, 95% *CI* [.00, .01]), $t(546.10) = 3.99$, $p = .00$. The inclusion of a random slope for premenstrual symptom severity in Model five yielded a significant fixed effect for the covariate daily perceived stress (Table 6) and led to an increase in explained variance to $R^2 = .05$. Based on model fit indices AIC, BIC and the Chi-square test of deviance, model five showed the best fit to the data.

Table 6

Estimates for Energetic Arousal Instability using Linear Mixed Model

Fixed effects	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Intercept	5.93	.16	5.64	6.31	< .001***
Symptom Severity [a]	–.02	.01	–.03	.01	.15
Cycle Phase [b]	–.07	.09	–.29	.04	.45
Perceived Stress [c]	.01	.00	.00	.01	< .001***
Interaction [d]	.00	.01	–.02	.01	.94

Note. SE = Standard Error, p = p-value, CI = confidence interval; LL = lower limit; UL = upper limit.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Assumptions of Multi Level Models

All models were checked for whether they met assumptions of LMMs. Assumption checks for the best fitting models can be found in Appendix A. The assumption checks indicated that there were slight deviations from homoscedasticity in the best fitting-model for hypotheses 1a and 2a. The slight violation of the homoscedasticity assumption may be explained by the hypotheses itself expecting increased variance in the outcome for participants with higher symptom severity. Since MSSD is a form of variance, it is expected that people with higher symptom severity tend to show more variability in the outcome (MSSD). Furthermore, tests detected some non-normality of residuals for the best fitting-models for hypotheses 1 and 2. Additional Q-Q plots indicated slight deviations from the expected normal distribution in the tails, while the overall distribution of residuals appeared normal. Additionally, visual inspection of scatter plots indicated a potential deviation from linearity in the relationship between premenstrual symptom severity and mood instability. An inspection of boxplots indicated that some data points were quite far away from the rest of the data, which might point to potential outliers. However, the overall assumption checks did not suggest any serious issues with influential cases. Conceptually, it makes sense that some participants would show much higher scores than others, considering that premenstrual symptom severity and mood instability are on a continuum. Participants who are more strongly affected will likely report higher values than those who experience few or no symptoms, for example. An investigation of potential outliers considering premenstrual symptom severity revealed that 89.56% of the cases occurred during the perimenstrual phase. Considering that this phase is typically associated with increased premenstrual symptom severity, it is likely that these values are accurate and meaningful. Compared to other statistical approaches used for the analysis of hierarchical data, LMMs are more flexible, meaning that they are less sensitive to assumption violations (Schielzeth et al., 2020). Although slight violations of assumptions were observed, the use of LMMs remains appropriate within the scope of this study.

Discussion

The aim of this research project was to investigate whether there exists an association between premenstrual symptom severity and daily instability in the mood dimensions of valence, calmness and energetic arousal. It was expected that daily premenstrual symptom severity would predict instability in all of the three mood dimensions. Furthermore, it was hypothesized that the association between daily premenstrual symptom severity and mood instability would vary depending on the menstrual cycle phase, with differences expected between the perimenstrual and postmenstrual phases.

Valence

The results showed that instability in valence was associated with daily premenstrual symptom severity. This suggests that on days when premenstrual symptoms are more intense, mood instability in the valence dimension tends to increase as well. On a daily basis, this would mean that someone with strong premenstrual symptoms can feel fine one moment and then suddenly not satisfied the next moment. This aligns with the hypothesized relationship and thus provides support for hypothesis 1a. Furthermore, the analyses indicated that mood instability was lower during the perimenstrual phase. The interaction between symptom severity and cycle phase was not significant, indicating that the effect of symptom severity did not differ between phases. Together with results of previous calculated LMMs, this suggests that higher daily symptom severity is associated with increased daily mood instability across the whole cycle.

The lacking evidence for changes in daily mood instability, that would be limited to the perimenstrual phase, in the current research is consistent with studies reporting no cyclical changes in average mood (Hengartner et al., 2017; Bosman et al., 2018). Bowen et al. (2011) also examined mood instability across the menstrual cycle and reported that instability for depressive and irritated mood were not limited to the perimenstrual phase. Although Bowen et al. (2011) claimed to investigate instability in the construct of mood, their operationalization rather reflects clinically relevant affective symptoms associated with PMS. Nevertheless, their findings are consistent with the results presented here. Meaden et al. (2005) and Pierson et al. (2021) found evidence for mood fluctuations across the menstrual cycle in large community samples as well. The present results reinforce those of Pierson et al. (2021) and Meaden et al. (2005), as this study likewise points to fluctuations in the dimension of mood valence across the menstrual cycle. Additionally, descriptive results showed that mood in the dimension of valence was lower during the perimenstrual phase than in the postmenstrual phase. This finding is consistent with the assumption that mood deterioration shows peaks in severity in the perimenstrual phase, as proposed by Meaden et al. (2005).

Since instability is a different aspect of mood than average mood quality and reflects how mood changes from moment to moment, the results provide new insights in mood dynamics across the cycle. Previous studies reported mood deterioration limited to the late luteal phase (Beddig et al., 2020; Pletzer & Noachtar, 2023; Wu et al., 2016) and emphasized fluctuation in mood linked to hormonal changes (Andreano et al., 2018; Hantsoo & Epperson, 2015, Kiesner 2011). The data presented here revealed that, when controlling for mean symptom severity and mean daily stress in the LMMs, mood instability was even lower during the perimenstrual phase compared to the postmenstrual phase. This was a rather unexpected finding when considering the literature that points to mood deterioration being limited to the luteal phase (Pletzer & Noachtar, 2023; Wu et al., 2016). This finding also contradicted the simple descriptive results (Table 2). In short, in this sample, mood appeared to be lower in the dimension of valence but less unstable during the perimenstrual phase. The reason for this reduced instability is not entirely clear. Hormone sensitivity might contribute to generally stronger daily premenstrual symptoms and poorer mood levels in this phase, as reflected in the descriptive analyses (Table 1) and supported by the mentioned previous findings. As a result, mood may be more stable because it remains consistently at a lower level, which could explain the observed reduction in instability. Without controlling for daily stress and premenstrual symptom severity, the perimenstrual phase might appear more unstable because both stress and symptom severity tend to be higher at this time in the cycle (Beddig et al., 2020; Hantsoo & Epperson, 2020; Meaden et al., 2005; Schmalenberger et al., 2021). The findings indicate that increased mood instability in valence across the cycle is linked to the overall burden of daily premenstrual symptoms and stress, rather than to the hormonal cycle phase alone. This means that interventions focusing on reducing the overall symptom burden and stress may be more effective, as these seem more influential for stabilizing mood than the menstrual cycle phase itself.

Furthermore, if mood instability and its association with daily premenstrual symptom severity in valence were present throughout the entire cycle and not limited to the perimenstrual phase, this would result in even more challenges and limitations for individuals. Strong fluctuations in mood are considered a risk factor for affective disorders and overall well-being (Houben et al., 2015; Lahey, 2009). The daily premenstrual symptom severity assessed in this study reflects the general level of symptom burden of an induvial, which can be related to overall well-being. The current findings indicate that higher daily premenstrual symptom severity may be a contributor and risk factor for increased mood instability. Menstruating individuals experiencing more severe symptoms, like individuals with PMS and PMDD, may be at greater risk for negative effects on well-being due to the negative effects of mood instability, as hypothesized by previous research (Houben et al., 2015; Lahey, 2009). Furthermore, some authors assume that premenstrual symptoms alone are a risk factor for affective disorders. For example, Kiesner (2017) suggests, that menstrual cycle-related affective symptoms, even when subclinical but recurrent, may disrupt functioning across different life stages and thereby increase the long-term risk of developing affective disorders through cumulative psychological and behavioural aspects. Wittchen et al. (2002) reported that around 30% of individuals diagnosed with PMDD met criteria for any other affective disorder within 12 months. This comorbidity included conditions such as major depressive disorder, dysthymia and bipolar I or II disorder.

Taken together, these findings suggest that severe daily premenstrual symptoms, may constitute a risk factor for affective experiences and psychological well-being, especially because of their additional impact on mood instability. Additionally, independent of symptom severity, daily perceived stress was also significantly associated with instability in mood valence. Altogether, the combination of daily stress and high symptom severity may contribute to substantially increased mood instability, which could pose a considerable risk for psychological well-being. A limitation of this study design is the lack of information about whether a specific event caused a change in mood. Therefore, context effects cannot be accounted for.

Calmness

Considering the mood dimension of calmness, neither symptom severity, nor the cycle phase were predictors for mood instability. Findings on the fluctuation of calmness throughout the day, reported that calmness may be naturally quite stable until the early evening (Adan & Sánchez-Turet, 2001). Feneberg et al. (2022) found a steady trend for calmness, with ratings of calmness significantly increasing from morning to evening. On the other hand, Stone et al. (1996) identified a cubic trend for the mood item "rushed," pointing to a more complex relationship between time of day and the appraisal of tension or relaxation. The present findings cannot provide direct support for natural daily mood fluctuations due to the study design. However, the natural daily variations in calmness previously reported do not appear to have been influenced by the severity of premenstrual symptoms in this study. Furthermore, when controlling for daily premenstrual symptom severity, the data do not suggest that such natural mood fluctuations exist across the perimenstrual and postmenstrual phases, as no difference between the phases emerged. Moreover, there appears to be no relationship between how severe premenstrual symptoms were and how unstable the participants felt in calmness. In contrast, higher symptom severity was clearly related to more instability in valence. Similar to the mood dimension of valence, daily stress was found to be a predictor of instability in calmness. The significant association between instability in calmness and stress suggests that there were indeed fluctuations in calmness within the day in this sample. This finding reinforces the assumption that calmness naturally fluctuates throughout the day (Adan & Sánchez-Turet, 2001; Feneberg et al., 2022). However, it is not possible to make more detailed statements on temporal patterns in this research. In summary, neither premenstrual symptom severity, nor menstrual cycle phase appeared to significantly influence instability in the experience of feeling calm or tense in daily life. The findings are unexpected, considering that severe premenstrual symptoms are often associated with affective states like irritability, tension, or anxiety. However, one limitation is that the premenstrual symptom score used in this research does not only include affective symptoms. The findings may suggest that, within this sample, the overall daily premenstrual symptom burden did not significantly affect mood instability in the calmness dimension, or that the factors captured by the total premenstrual burden score do not substantially influence daily feelings of relaxation or calmness. Taken together, instability in calmness appeared to be primarily related to daily stress rather than the overall burden of daily premenstrual symptoms. This highlights that overall premenstrual symptom load does not necessarily influence fluctuations in relaxation or calmness. The findings suggest that well-being related to the dimension of calmness is likely more influenced by stress management than by cycle phase or premenstrual symptom severity. Accordingly, stress-focused interventions could be more effective when individuals show high instability in the calmness dimension.

Energetic Arousal

The overall severity of daily premenstrual symptoms, conceptualized as a multidimensional construct (including affective, physical, and cognitive symptoms), was expected to affect not only average mood levels but also its daily instability. Among various other effects, premenstrual symptoms are associated with sensations of exhaustion and low energy (Dickerson et al., 2003; Meaden et al., 2005). Considering this, especially in cases of severe premenstrual symptoms, it is reasonable to expect a negative overall effect of daily premenstrual symptom severity on daily instability in mood in the dimension of energetic arousal. Average energetic mood was indeed lower in the perimenstrual phase, indicating increased tiredness and weakness in this phase (Table 1). Despite these descriptive differences, the LMMs results did not provide evidence, however, for a significant association between daily premenstrual symptom severity or cycle phase and daily instability in energetic arousal. Therefore, contrary to expectations there was no overall association between daily premenstrual symptom severity and instability in energetic arousal. Similar to the mood dimension calmness, instability in energetic arousal was related to daily stress, whereas valence showed an additional association with the daily severity of premenstrual symptom burden.

The present findings complement prior research considering daily fluctuations by examining daily mood instability. Previous research on daily fluctuation suggested that both physical and mental energy follow a natural diurnal pattern (Wood and Magnello, 1992).

Mental energy, or vigour, was reported to be higher in the morning compared to later times of the day. Feneberger et al. (2022) observed that lower levels of overall arousal were associated with identifying as a women and analysis revealed that the decline in arousal was more pronounced in women than in men. Considering cycle-related fluctuations, findings on mood instability within the dimension of energetic arousal across the menstrual cycle are currently lacking. Regarding the hypothesized moderation by menstrual cycle phases, assuming average stress levels and average premenstrual symptom severity for each participant, the current data did not show cycle-related effects on energetic arousal. In contrast to reported daily natural rhythms (Feneberger et al., 2022; Wood & Magnello, 1992), the menstrual cycle does not seem to influence the experience in daily ups and downs between feeling tired and awake, at least in this sample.

Despite the non-significant effects in the LMMs, descriptive results, reflected in the higher standard deviations, suggest greater variability in perceived instability in the perimenstrual phase. While purely speculative, these descriptive results may indicate that there was no consistent pattern among all participants, but rather a highly individual relationship between instability in energetic arousal and the perimenstrual phase. Furthermore, accounting for individual differences in the association between premenstrual symptom severity and energetic arousal instability provided a better representation of the observed data, suggesting a heterogeneous pattern in the effect on mood instability across participants as well. It is important to note that these descriptive patterns are not statistically confirmed and should be interpreted with caution.

Instability does not provide information on the quality of mood. Therefore, the instability measure itself does not allow to determine if someone was feeling more awake or more tired when their stability score was lower. Factors such as sleep quality, physical activity or social context may also contribute to feelings of tiredness and its fluctuation. These factors were not accounted for and should be addressed in future research. Finally, it should be highlighted that an association between instability in energetic arousal and daily perceived stress was observed. Similar to the mood dimension calmness, stress-focused interventions could be beneficial for instability in energetic arousal and may help stabilize perceived energy levels.

Implications for Overall Mood

Hypothesis 1 that stated that daily premenstrual symptom severity would be associated with daily mood instability was only supported for the valence dimension. Furthermore, hypothesis 2 which posited that the association between instability in mood and daily premenstrual symptom severity would vary depending on the menstrual cycle phase had to be rejected for the mood dimensions energetic arousal and calmness.

Considering premenstrual symptom severity, the results suggest that individuals differ significantly in the response of mood instability as a reaction to severe premenstrual symptoms, which aligns with previous propositions suggesting that responses to premenstrual symptoms, the timing of peak symptom severity and sensitivity to hormonal changes show high interindividual variability (Kiesner, 2017; Eisenlohr-Moul, 2019; Nayman et al., 2023; Schmalenberger et al., 2021). While some individuals may show little change in instability, others may respond to strong premenstrual symptoms with significant instability, especially in the valence dimension. These differences between individuals support the hypothesis of variability in individual’s sensitivity to hormonal changes during the menstrual cycle as well (Schmalenberger et al., 2021). The pronounced interindividual differences in instability responses suggest that distinct subtypes could be identified based on the reaction with instability, which could be explained due to different responses to hormonal fluctuations. If stable patterns of responses are found, they might help in daily life management, but also in therapeutic settings to accurately interpret mood instabilities and improving treatment approaches. Furthermore, future research could explore subtypes based on the overall hormonal sensitivity, premenstrual symptom burden, symptom composition (affective, physical, cognitive) and the timing of symptom onset and peaks, as such patterns may relate to differential profiles of mood instability across the cycle. These subtypes could also be connected to differences in hormonal sensitivity, such that individuals with higher hormonal sensitivity may experience more pronounced mood fluctuations in response to the same premenstrual symptom burden. Such differences may be linked to different profiles of mood instability across the menstrual cycle. This would, on the one hand, support the idea that not all individuals respond to premenstrual symptoms in the same way (Schmalenberger et al., 2021). For example, some individuals may experience strong mood fluctuations in valence, while others show less or none, depending on their symptom patterns, premenstrual symptom burden and hormonal sensitivity. Additionally, subtypes could help develop individualized intervention plans that consider personal patterns rather than uniform ones.

In this regard, personality factors like neuroticism should be considered as well. Affective instability is a form of affective reactivity that is associated with emotional dysregulation and high scores in the personality trait of neuroticism (Gross & Thompson, 2007; Del Fernandez et al., 2019; Ebner-Priemer & Trull, 2009; Lahey, 2009). In addition, it is hypothesized that neuroticism could be associated with increased sensitivity to physical symptoms, increasing perceptions of symptoms and therefore potentially worsening perceived premenstrual symptoms (Costa & McCrae, 1987). Although direct studies on the relationship between neuroticism, mood instability and premenstrual symptoms are lacking, some research suggests positive associations between PMDD and neuroticism (Del Fernandez, 2019; Gingnell et al., 2010; Miller et al., 2010). For example, Gingnell et al. (2010) found that participants with high-severity PMDD displayed higher scores for neuroticism-related traits compared to healthy controls and low-severity PMDD. Furthermore, studies indicate that individuals with high neuroticism scores have inadequate responses to stressors (Del Fernandez, 2019; Lahey, 2009). This result aligns with the effects of stress on mood instability in all three dimensions, that is present in the current sample. When discussing deterioration of mood, emotion regulation strategies are often considered as a possible explanation. Additionally, high levels of neuroticism have been associated with the use of maladaptive emotion regulation strategies (Yang et al., 2020). So far, findings examining emotional regulation in cases of severe premenstrual symptoms have not indicated a consistent pattern of emotional dysregulation. Some authors suggest that maladaptive emotion regulation strategies are used in individuals with strong premenstrual symptom severity (Dawson et al., 2018; Nayman et al., 2022; Wu et al., 2016). Interestingly, it was found that women with PMDD who use adaptive emotion regulation strategies experience a greater decline in mood during the late luteal phase, compared to women with PMDD who use maladaptive strategies (Nayman et al., 2023). This could hint to the idea that emotion regulation strategies cannot act as a protective factor against mood deterioration in the luteal phase.

Considering cyclist patterns, the current data does not provide evidence for a consistent pattern in the association between premenstrual symptom severity and instability in mood that differs depending on the menstrual cycle phase. The lack of increased instability during the perimenstrual phase may suggest that symptoms are generally more stable during this phase. However, this could also imply, that individuals may feel more dissatisfied or unwell, weaker and report experience restlessness in this phase.

One aim of this thesis was to explore whether daily premenstrual symptom severity relates to mood instability. Comparing the three mood dimensions, only instability in valence was significantly associated with daily premenstrual symptom severity. Future research should aim to disentangle the complex relationship between premenstrual symptom severity, cycle phases, mood instability and their connection to traits such as neuroticism and emotion regulation. Mood instability, especially in the dimension of valence, may play a specific role in mental health of menstruation individuals. If, for example, only women with high levels of premenstrual symptom severity experience or neuroticism show increased mood instability, prevention efforts could be better tailored to these vulnerable groups. Even beyond clinical relevance, it is important for menstruating individuals to understand whether certain phases of the cycle influence moment-to-moment mood variations in their daily lives.

Limitations

As the present thesis is based on an independent study project (ISSAC), designed for a different research purpose, the study design was not tailored to the hypotheses examined here. Moreover, the ISSAC study is still in its early stages, resulting in a rather limited sample size. As a result, it cannot be ensured that the full range of premenstrual symptom severity and mood instability is represented in the current sample. For example, the daily symptom severity ratings allowed for a maximum score of 140, but the highest score reported by a participant was 76. It is possible that certain effects exist, but could not be detected in this research. Lorenz et al. (2017) suggest that significant mood changes across the menstrual cycle are uncommon in psychologically healthy individuals. It is possible that the present sample lacks representation of individuals with high levels of symptom severity, which suggests that the findings of this thesis should be interpreted with caution.

To keep the study design as straightforward as possible, only perceived stress was used as a covariate. Future studies should include additional covariates to control for potential confounding variables. For example, contextual influences that may impact mood should be considered. It could be beneficial to assess the situational context in which participants fill out the assessments. Future research should also consider personality traits such as neuroticism, as these may help to understand individual differences in mood dynamics and affective vulnerability. Furthermore, in studies that focus entirely on mood instability and the menstrual cycle, additional assessment time points would be beneficial to assess instability more accurately. Violations of the assumptions for the LMMs may have contributed to the over- or underestimation of effects. Visual inspection of the data suggested that the relationship between mood instability and premenstrual symptom severity may not be linear. Since LMMs are designed to model linear associations, nonlinear effects might have been missed. An additional limitation is the variability in the length of time between successive assessments. The intervals between measurements were not equal and participants had the option to complete an assessment up to one hour later. The MSSD allows for a time-adjusted approach, controlling for varying time intervals between EMA measurements, which was done in this research. Yet, varying time lags may still influence the results.

Strengths

In addition to its methodological limitations, the study also demonstrated several notable strengths. By using an EMA approach, the study was able to examine within-day trajectories and daily associations between different variables, while significantly minimizing retrospective bias. Furthermore, the investigation of mood instability across the menstrual cycle and its relationship to premenstrual symptom severity addresses a research gap. A notable strength of this study is its clear conceptual distinction of mood from affective symptoms typically associated with PMS or PMDD.

Conclusion

Apart from the finding that premenstrual symptom severity influences mood instability in the dimension of valence, the results of this thesis do not support the proposed hypotheses. No clear cyclical pattern in overall mood instability emerged in the present results. However, it should be noted that instability in mood valence was lower during the perimenstrual phase. The current state of research on mood instability, premenstrual symptom severity and the menstrual cycle, along with the present results, remains inconclusive. More research is required to either confirm or rule out the assumption that individuals experiencing severe premenstrual symptoms, such as in PMS or PMDD, are at heightened risk for mood instability and in turn more vulnerable to severe psychological consequences. Nevertheless, the results reinforce the previously assumed interindividual variability in premenstrual symptom expression, sensitivity and resulting effects. A deeper understanding of mood instability across the menstrual cycle, as well as the potential influence of stress on these fluctuations, could significantly contribute to reducing affective vulnerabilities in specific groups and thus support women's health.

References

Adan, A., & Sánchez-Turet, M. (2001). Gender differences in diurnal variations of subjective activation and mood. *Chronobiology International*, *18*(3), 491–502. https://doi.org/10.1081/CBI-100103971

Andreano, J. M., Touroutoglou, A., Dickerson, B., & Barrett, L. F. (2018). Hormonal cycles, brain network connectivity, and windows of vulnerability to affective disorder. *Trends in Neurosciences*, *41*(10), 660–676. https://doi.org/10.1016/j.tins.2018.08.007

Alevizou, F., Vousoura, E., & Leonardou, A. (2018). Premenstrual dysphoric disorder: A critical review of its phenomenology, etiology, treatment and clinical status. *Current Women's Health Reviews, 14*(1), 59-66. https://doi.org/10.2174/1573404813666171027141849

Altemus, M., Sarvaiya, N., & Epperson, C. N. (2014). Sex differences in anxiety and depression: Clinical perspectives. *Frontiers in Neuroendocrinology, 35*(3), 320–330. https://doi.org/10.1016/j.yfrne.2014.05.004

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Bale, T. L., & Epperson, C. N. (2015). Sex differences and stress across the lifespan. *Nature Neuroscience, 18*(10), 1413–1420. https://doi.org/10.1038/nn.4112

Barrett, L. F., & Russell, J. A. (1998). Independence and bipolarity in the structure of current affect. *Journal of Personality and Social Psychology, 74*(4), 967–984. https://doi.org/10.1037/0022-3514.74.4.967

Bencker, C., Schmalenberger, K. M., Comasco, E., & Nater, U. (2025, February 19). *Interactions in stress and symptoms across the menstrual cycle (ISSAC): Unraveling the temporal relationship between premenstrual symptoms and psychobiological stress patterns in daily life* [Preregistration]. OSF. https://doi.org/10.17605/OSF.IO/F3T5U

Beddig, T., & Kühner, C. (2017). Aktuelle Aspekte zur prämenstruellen dysphorischen Störung – ein Überblick. *Psychotherapie Psychosomatik Medizinische Psychologie*, *67*(12), 504–513. https://doi.org/10.1055/s-0043-113816.

Beddig, T., Reinhard, I., Ebner-Priemer, U., & Kuehner, C. (2020). Reciprocal effects between cognitive and affective states in women with premenstrual dysphoric disorder: An ecological momentary assessment study. *Behaviour Research and Therapy*, *131*, 103613. https://doi.org/10.1016/j.brat.2020.103613

Bosman, R. C., Albers, C. J., de Jong, J., Batalas, N., & aan het Rot, M. (2018). No menstrual cyclicity in mood and interpersonal behaviour in nine women with self-reported premenstrual syndrome. *Psychopathology, 51*(4), 290–294. https://doi.org/10.1159/000489268

Bowen, R., Bowen, A., Baetz, M., Wagner, J., & Pierson, R. (2011). Mood instability in women with premenstrual syndrome. *Journal of Obstetrics and Gynaecology Canada*, *33*(9), 927–934. https://doi.org/10.1016/S1701-2163(16)35018-6

Brose, A., Schmiedek, F., Gerstorf, D., & Voelkle, M. C. (2020). The measurement of within-person affect variation. *Emotion, 20*(4), 677–699. https://doi.org/10.1037/emo0000583

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). *Perceived Stress Scale.* https://doi.org/10.1037/t02889-000

Costa, P. T. & McCrae, R. R. (1987). Neuroticism, somatic complaints, and disease: Is the bark worse than the bite? *Journal of Personality*, *55*(2), 299–316. https://doi.org/10.1111/j.1467-6494.1987.tb00438.x

Dawson, D. N., Eisenlohr-Moul, T. A., Paulson, J. L., Peters, J. R., Rubinow, D. R., & Girdler, S. S. (2018). Emotion-related impulsivity and rumination predict the perimenstrual severity and trajectory of symptoms in women with a menstrually related mood disorder. *Journal of Clinical Psychology, 74*(4), 579–593. https://doi.org/10.1002/jclp.22522

de Vries, L. P., Baselmans, B. M. L., & Bartels, M. (2021). Smartphone-based ecological momentary assessment of well-being: A systematic review and recommendations for future studies. *Journal of Happiness Studies, 22*(5), 2361–2408. https://doi.org/10.1007/s10902-020-00324-7

Dickerson, L. M., Mazyck, P. J., & Hunter, M. H. (2003). Premenstrual syndrome. *American Family Physician, 67*(8), 1743-1752. https://www.aafp.org/pubs/afp/issues/2003/0415/p1743.html

Ebner-Priemer, U. W., & Trull, T. J. (2009). Ecological momentary assessment of mood disorders and mood dysregulation. *Psychological Assessment*, *21*(4), 463–475. https://doi.org/10.1037/a0017075

Eisenlohr-Moul, T. (2019). Premenstrual disorders: A primer and research agenda for psychologists. *The Clinical Psychologist*, *72*(1), 5–17.

Endicott, J., Nee, J., & Harrison, W. (2006). Daily record of severity of problems (DRSP): Reliability and validity. *Archives of Women's Mental Health, 9*(1), 41–49. https://doi.org/10.1007/s00737-005-0103-y

Feneberg, A. C., Forbes, P. A. G., Piperno, G., Pronizius, E., Stijovic, A., Skoluda, N., Lamm, C., Nater, U. M., & Silani, G. (2022). Diurnal dynamics of stress and mood during COVID-19 lockdown: A large multinational ecological momentary assessment study. *Proceedings of the Royal Society B: Biological Sciences, 289*(1975), 20212480. https://doi.org/10.1098/rspb.2021.2480

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th edition). SAGE Publications.

Freeman, E. W., Halberstadt, S. M., Rickels, K., Legler, J. M., Lin, H., & Sammel, M. D. (2011). Core symptoms that discriminate premenstrual syndrome. *Journal of Women's Health, 20*(1), 29-35. https://doi.org/10.1089/jwh.2010.2161

Gingnell, M., Comasco, E., Oreland, L., Fredrikson, M., & Sundström-Poromaa, I. (2010). Neuroticism-related personality traits are related to symptom severity in patients with premenstrual dysphoric disorder and to the serotonin transporter gene-linked polymorphism 5-HTTPLPR. *Archives of Women's Mental Health*, *13*(5), 417–423. https://doi.org/10.1007/s00737-010-0164-4

Gonda, X., Telek, T., Juhász, G., Lazary, J., Vargha, A., & Bagdy, G. (2008). Patterns of mood changes throughout the reproductive cycle in healthy women without premenstrual dysphoric disorders. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 32*(8), 1782-1788. https://doi.org/10.1016/j.pnpbp.2008.07.016

Gross, J. J. (2024). Conceptual foundations of emotion regulation. In J. J. Gross & B. Q. Ford (Eds.), *Handbook of emotion regulation* (3rd ed., pp. 1–11). Guilford Press.

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 3–24). Guilford Press.

Halbreich, U., Borenstein, J., Pearlstein, T., & Kahn, L. S. (2003). The prevalence, impairment, impact, and burden of premenstrual dysphoric disorder (PMS/PMDD).

Psychoneuroendocrinology, 28(Suppl. 3), 1–23. https://doi.org/10.1016/S0306-4530(03)00098-2

Hantsoo, L., & Epperson, C. N. (2015). Premenstrual dysphoric disorder: Epidemiology and treatment. *Current Psychiatry Reports, 17*(11), 87. https://doi.org/10.1007/s11920-015-0628-3

Hantsoo, L., & Epperson, C. N. (2017). Anxiety disorders among women: A female lifespan approach. *FOCUS, 15*(2), 162–172. https://doi.org/10.1176/appi.focus.20160042

Hantsoo, L., & Epperson, C. N. (2020). Allopregnanolone in premenstrual dysphoric disorder (PMDD): Evidence for dysregulated sensitivity to GABA-A receptor modulating neuroactive steroids across the menstrual cycle. *Neurobiology of Stress, 12*, 100213. https://doi.org/10.1016/j.ynstr.2020.100213

Houben, M., Van Den Noortgate, W., & Kuppens, P. (2015). The relation between short-term emotion dynamics and psychological well-being: A meta-analysis. *Psychological Bulletin, 141*(4), 901–930. https://doi.org/10.1037/a0038822

Jahng, S., Wood, P. K., & Trull, T. J. (2008). Analysis of affective instability in ecological momentary assessment: Indices using successive difference and group comparison via multilevel modeling. *Psychological Methods, 13*(4), 354–375. https://doi.org/10.1037/a0014173

Janda, C., Kues, J. N., Andersson, G., Kleinstäuber, M., & Weise, C. (2017). A symptom diary to assess severe premenstrual syndrome and premenstrual dysphoric disorder. *Women & Health, 57*(7), 837–854. https://doi.org/10.1080/03630242.2016.1206055

Kiesner, J. (2011). One woman's low is another woman's high: Paradoxical effects of the menstrual cycle. *Psychoneuroendocrinology, 36*(1), 68–76. https://doi.org/10.1016/j.psyneuen.2010.06.007

Kiesner, J. (2017). The menstrual cycle-response and developmental affective-risk model: A multilevel and integrative model of influence. *Psychological Review, 124*(2), 215–244. https://doi.org/10.1037/rev0000058

Klein, E. M., Brähler, E., Dreier, M., Reinecke, L., Müller, K. W., Schmutzer, G., Wölfling, K., & Beutel, M. E. (2016). The German version of the Perceived Stress Scale: Psychometric characteristics in a representative German community sample. *BMC Psychiatry, 16*(1), 159. https://doi.org/10.1186/s12888-016-0875-9

Lahey, B. B. (2009). Public health significance of neuroticism. *The American psychologist, 64*(4), 241–256. https://doi.org/10.1037/a0015309

Lorenz, T. K., Gesselman, A. N., & Vitzthum, V. J. (2017). Variance in mood symptoms across menstrual cycles: Implications for premenstrual dysphoric disorder. *Women's Reproductive Health*, *4*(2), 77–88. https://doi.org/10.1080/23293691.2017.1326248

Meaden, P. M., Hartlage, S. A., & Cook-Karr, J. (2005). Timing and severity of symptoms associated with the menstrual cycle in a community-based sample in the Midwestern United States. *Psychiatry Research, 134*(1), 27-36. https://doi.org/10.1016/j.psychres.2005.01.003

Miller, A., Vo, H., Huo, L., Roca, C., Schmidt, P. J., & Rubinow, D. R. (2010). Estrogen receptor alpha (ESR-1) associations with psychological traits in women with PMDD and controls. *Journal of psychiatric research, 44*(12), 788–794. https://doi.org/10.1016/j.jpsychires.2010.01.013

Murray, A. L., Xiao, Z., Zhu, X., Speyer, L. G., Yang, Y., Brown, R. H., Katus, L., Eisner, M., & Ribeaud, D. (2023). Psychometric evaluation of an adapted version of the perceived stress scale for ecological momentary assessment research. *Stress and Health, 39*(4), 841-853. https://doi.org/10.1002/smi.3229

Nayman, S., Beddig, T., Reinhard, I., & Kuehner, C. (2023). Effects of cognitive emotion regulation strategies on mood and cortisol in daily life in women with premenstrual dysphoric disorder. *Psychological Medicine, 53*(11), 5342–5352. https://doi.org/10.1017/S0033291722002495

Pearlstein, T., Yonkers, K. A., Fayyad, R., & Gillespie, J. A. (2005). Pretreatment pattern of symptom expression in premenstrual dysphoric disorder. *Journal of affective disorders, 85*(3), 275–282. https://doi.org/10.1016/j.jad.2004.10.004

Pierson, E., Althoff, T., Thomas, D., Hillard, P., & Leskovec, J. (2021). Daily, weekly, seasonal and menstrual cycles in women's mood, behaviour and vital signs. *Nature Human Behaviour, 5*(6), 716-725. https://doi.org/10.1038/s41562-020-01046-9

Pletzer, B., & Noachtar, I. (2023). Emotion recognition and mood along the menstrual cycle. *Hormones and Behavior*, *154*, 105406. https://doi.org/10.1016/j.yhbeh.2023.105406

R Core Team. (2024). R: *A language and environment for statistical computing* (Version 4.3.3) [Computer software]. R Foundation for Statistical Computing. https://www.r-project.org/

Romans, S. E., Clarkson, R., Einstein, G., Petrovic, M., & Stewart, D. (2012). Mood and the menstrual cycle: A review of prospective data studies. *Gender Medicine, 9*(5), 361-384. https://doi.org/10.1016/j.genm.2012.07.003

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review, 110*(1), 145–172. https://doi.org/10.1037/0033-295X.110.1.145

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44*(4), 695–729. https://doi.org/10.1177/0539018405058216

Schielzeth, H., Dingemanse, N. J., Nakagawa. S., Westneat, D. F., Allegue, H., Teplitsky, C., Réale, D., Dochtermann, N.A., Garamszegi, L. Z., Araya-Ajoy, Y. G. (2020). Robustness of linear mixed-effects models to violations of distributional assumptions. *Methods in Ecology and Evolution, 11*, 1141–1152. https://doi.org/10.1111/2041-210X.13434

Schimmack, U., & Grob, A. (2000). Dimensional models of core affect: A quantitative comparison by means of structural equation modeling. *European Journal of Personality, 14*(4), 325–345. https://doi.org/10.1002/1099-0984(200007/08)14:4<325::AID-PER380>3.0.CO;2-I

Schmalenberger, K. M., Tauseef, H. A., Barone, J. C., Owens, S. A., Lieberman, L., Jarczok, M. N., Girdler, S. S., Kiesner, J., Ditzen, B., & Eisenlohr-Moul, T. A. (2021). How to study the menstrual cycle: Practical tools and recommendations. *Psychoneuroendocrinology, 123*, 104895. https://doi.org/10.1016/j.psyneuen.2020.104895

Steyer, R., Schwenkmezger, P., Notz, P., & Eid, M. (2003). *Development of the Multidimensional Mood State Questionnaire (MDBF). Primary data* (Version 1.0.0) [Dataset]. ZPID Leibniz Institute for Psychology. https://doi.org/10.5160/PSYCHDATA.SRRF91EN15

Stone, A. A., Smyth, J. M., Pickering, T., & Schwartz, J. (1996). Daily mood variability: Form of diurnal patterns and determinants of diurnal patterns. *Journal of Applied Social Psychology, 26*(14), 1286–1305. https://doi.org/10.1111/j.1559-1816.1996.tb01781.x

Trull, T. J., Lane, S. P., Koval, P., & Ebner-Priemer, U. W. (2015). Affective dynamics in psychopathology. *Emotion Review, 7*(4), 355–361. https://doi.org/10.1177/1754073915590617

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin, 98*(2), 219–235. https://doi.org/10.1037/0033-2909.98.2.219

Wei, S.-M., Schiller, C. E., Schmidt, P. J., & Rubinow, D. R. (2018). The role of ovarian steroids in affective disorders. *Current Opinion in Behavioral Sciences, 23*, 103–112. https://doi.org/10.1016/j.cobeha.2018.04.013

Wilhelm, P., & Schoebi, D. (2007). Assessing Mood in Daily Life. *European Journal of Psychological Assessment*, *23*(4), 258–267. https://doi.org/10.1027/1015-5759.23.4.258

Wittchen, H.-U., Becker, E., Lieb, R., & Krause, P. (2002). Prevalence, incidence and stability of premenstrual dysphoric disorder in the community. *Psychological Medicine, 32*(1), 119–132. https://doi.org/10.1017/S0033291701004925

Wood, C., & Magnello, M. E. (1992). Diurnal changes in perceptions of energy and mood. *Journal of the Royal Society of Medicine, 85*(4), 191–194. https://doi.org/10.1177/014107689208500404

Wu, M., Liang, Y., Wang, Q., Zhao, Y., & Zhou, R. (2016). Emotion dysregulation of women with premenstrual syndrome. *Scientific Reports*, *6*(1), 38501. https://doi.org/10.1038/srep38501

Yang, J., Mao, Y., Niu, Y., Wei, D., Wang, X., & Qiu, J. (2020). Individual differences in neuroticism personality trait in emotion regulation. *Journal of Affective Disorders, 265*, 468–474. https://doi.org/10.1016/j.jad.2020.01.086

Tables

Figures

Abbreviations

AIC	Akaike information criterion
BIC	Bayesian information criterion
CI	Confidence interval
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
EMA	Ecological Momentary Asessment
ICC	Intraclass correlation coefficient
LMM	Linear Mixed Models
MDBF	Multidimensional Mood State Questionnaire
MSSD	Mean Squared Successive Differences
ML	maximum likelihood method
PMS	Premenstrual Syndrome
PMDD	Premenstrual Dysphoric Disorder (PMDD
PSS	Perceived Stress Scale
SE	Standard error
VAS	Visual Analog Scale

Appendix

Abstract

Daily mood is an important factor in mental health, defined by its quality but also by its dynamic aspects like instability. Previous findings suggest a deterioration of mood quality in the perimenstrual phase, especially in individuals with high premenstrual symptom severity (PMS and PMDD). It remains unclear if premenstrual symptom severity and mood instability might be related as well. This thesis investigates whether mood instability is present, its potential association with premenstrual symptom severity and whether it is specific to a particular cycle phase. This study was part of the ISSAC project, which collected daily assessments across two consecutive menstrual cycles, although only one cycle was analysed for this project. Ecological Momentary Assessment was used to assess concepts like daily mood, premenstrual symptom severity and stress. Nineteen participants, all identifying as women ($M = 27.63$, $SD = 3.53$), reported their momentary mood four times per day across three dimensions: valence, calmness and energetic arousal. To operationalize mood instability, daily mean squared successive differences were calculated and hypotheses were tested using multilevel models. The results showed that mood instability in valence was positively associated with symptom severity. Furthermore, the perimenstrual phase was characterized by lower instability in valence. The results suggest that instability in calmness and energetic arousal did not differ across menstrual cycle phases. No significant interactions between symptom severity and cycle phase were found. These findings indicate that individuals with high premenstrual symptom severity may be at increased risk for mood valence instability, which could negatively impact well-being.

Zusammenfassung

Tägliche Stimmung ist ein wichtiger Faktor für die mentale Gesundheit, der nicht nur durch die Qualität, sondern auch durch dynamischen Aspekte wie die Stimmungsinstabilität, definiert wird. Bisherige Forschung weist auf Stimmungsverschlechterung in der perimenstruellen Phase hin, insbesondere bei Personen mit hoher prämenstrueller Symptomschwere (PMS und PMDD). Es bleibt jedoch unklar, ob prämenstruelle Symptomschwere auch mit Stimmungsinstabilität in Verbindung steht. Ziel dieser Arbeit war es, zu untersuchen, ob Stimmungsinstabilität auftritt, ob sie mit prämenstrueller Symptomschwere zusammenhängt und ob sie spezifisch für eine bestimmte Zyklusphase ist. Die Masterarbeit war Teil des ISSAC-Projekts, das tägliche Erhebungen über zwei aufeinanderfolgende Menstruationszyklen durchführte, wobei für diese Arbeit nur ein Zyklus analysiert wurde. Mittels eines EMA-Designs wurden Konzepte wie Stimmung, prämenstruelle Symptomschwere und Stress täglich erfasst. Neunzehn Teilnehmer*innen, die sich alle als Frauen identifizierten ($M = 27.63$, $SD = 3.53$), berichteten viermal täglich ihre aktuelle Stimmung in den Dimensionen Valenz, Ruhe und Wachheit. Zur Erfassung der Stimmungsinstabilität wurden tägliche mittlere quadrierte aufeinanderfolgende Differenzen berechnet und die Hypothesen mithilfe von Mehrebenenmodellen getestet. Die Ergebnisse zeigten, dass Stimmungsinstabilität in der Dimension Valenz positiv mit der Symptomschwere zusammenhing. Zudem war die perimenstruelle Phase durch geringere Instabilität in Valenz gekennzeichnet. In den Dimensionen Ruhe und Wachheit zeigten sich keine Unterschiede zwischen den Zyklusphasen. Es wurde keine signifikante Interaktion zwischen prämenstrueller Symptomschwere und Zyklusphase beobachtet. Die Ergebnisse weisen darauf hin, dass Personen mit hoher prämenstrueller Symptomschwere ein erhöhtes Risiko für Stimmungsinstabilität in der Valenz haben, was das Wohlbefinden negativ beeinflussen könnte.

Additional Results

Table A1

Parameter Estimates for a series of Multilevel Models Predicting Valence Instability

	Nullmodell	Model 1	Model 2	Model 3	Model 4	Modell 5
Intercept	4.80 (.17)***	4.60 (.17)***	4.73 (.18)***	4.75 (.18)***	4.74 (.18)***	4.77 (.20)***
Symptom Severity [a]		.05 (.01)***	.06 (.01)***	.07 (.01)***	.06 (.01)***	.07 (.02)**
Cycle Phase [b]			-.34 (.13)**	-32 (.13)*	-.28 (.13)*	-.36 (.13)**
Perceived Stress [c]					.01 (.00)*	.01 (.00)*
Interaction [d]				-.02 (.01)	-.02 (.01)	-.01 (.01)

Note. Regression coefficients, standard deviations in brackets and significance levels are reported for symptom severity, cycle phase, perceived stress and the interaction between symptom severity and cycle phase in relation to mood valence instability.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Table A2

Model Fit Comparison of a series of Multilevel Models Predicting Valence Instability

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Nr. of observations	554	554	554	554	554	554
AIC	2038.6	1967.9	1963.0	1963.3	1960.5	1960.5
BIC	2051.6	1985.2	1984.6	1989.2	1990.7	1902.5
R^2	.00	.12	.13	.14	.14	.19
χ^2		72.73***	6.89**	1.73	4.77*	61.98***

Note. The table presents the number of observations for key variables, model fit indices (AIC, BIC), the proportion of explained variance (R^2), and results of the Chi-square test (χ^2) across a series of multilevel models predicting instability of mood valence.

*p < .05, **p < .01, ***p < .001

Table A3

Parameter Estimates for a series of Multilevel Models Predicting Calmness Instability

	Model 0	Model 1	Model 2	Model 3	Model 4	Modell 5
Intercept	5.17 (.19)***	5.04 (.18)***	5.18 (.19)***	5.18 (.19)***	5.17 (.19)***	5.18 (.20)***
Symptom Severity [a]		.03 (.01)***	.03 (.01)***	.04 (.01)***	.02 (.01)*	.03 (.02)
Cycle Phase [b]			-.30 (.12)*	-29 (.13)*	-.20 (.12)	-.20 (.12)
Perceived Stress [c]					.02 (.00)***	.02 (.00)***
Interaction [d]				-.00 (.01)	-.00 (.01)	-.01 (.01)

Note. Regression coefficients, standard deviations in brackets and significance levels are reported for symptom severity, cycle phase, perceived stress and the interaction between symptom severity and cycle phase in relation to mood valence instability.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Table A4

Model Fit Comparison of a series of Multilevel Models Predicting Calmness Instability

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Nr. of observations	554	554	554	554	554	554
AIC	1944.9	1919.2	1915.4	1917.3	1880.9	1847.9
BIC	1957.0	1936.5	1937.0	1943.2	1911.1	1886.8
R^2	.00	.046	.056	.056	.11	.11
χ^2		27.72***	5.78*	1.50	38.40***	36.94***

Note. The table presents the number of observations for key variables, model fit indices (AIC, BIC), the proportion of explained variance (R^2), and results of the Chi-square test (χ^2) across a series of multilevel models predicting instability of mood valence.

*p < .05, **p < .01, ***p < .001

Table A5

Parameter Estimates for a series of Multilevel Models Predicting Energetic Arousal Instability

	Model 0	Model 1	Model 2	Model 3	Model 4	Modell 5
Intercept	5.90 (.17)***	5.90 (.17)***	5.98 (.17)***	5.98 (.18)***	5.98 (.17)***	5.93 (.16)***
Symptom Severity [a]		.00 (0.00)	.00 (0.00)	.01 (.01)	.00 (.01)	-.02 (.01)
Cycle Phase [b]			-.17 (.09)*	-.17 (.09)	-.13 (.09)	-.07 (.09)
Perceived Stress [c]					.00 (0.01)***	.01 (0.00)***
Interaction [d]				-.00 (.01)	-.00 (.01)	.00 (.01)

Note. Regression coefficients, standard deviations in brackets and significance levels are reported for symptom severity, cycle phase, perceived stress and the interaction between symptom severity and cycle phase in relation to mood valence instability.

[a] Premenstrual symptom severity was person-mean centered. [b] 0 = postmenstrual phase and 1 = perimenstrual phase. [c] Perceived stress was person-mean centered. [d] Interaction between premenstrual symptom severity and cycle phase

**p* < .05, ***p* < .01, ****p* < .001

Table A6

Model Fit Comparison of a series of Multilevel Models Predicting Energetic Arousal Instability

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Nr. of observations	554	554	554	554	554	554
AIC	1505.9	1518.8	1505.6	1507.3	1493.6	1441.5
BIC	1507.8	1525.1	1527.2	1533.2	1523.8	1480.4
R^2	.00	.00	.01	.01	.03	0.05
χ^2		.057	4.18*	0.33	15.68***	36.94***

Note. The table presents the number of observations for key variables, model fit indices (AIC, BIC), the proportion of explained variance (R^2), and results of the Chi-square test (χ^2) across a series of multilevel models predicting instability of mood valence.

*p < .05, **p < .01, ***p < .001

Linear Mixed Models Diagnostics

Figure A7

Linear Mixed Models Diagnostics for Valence

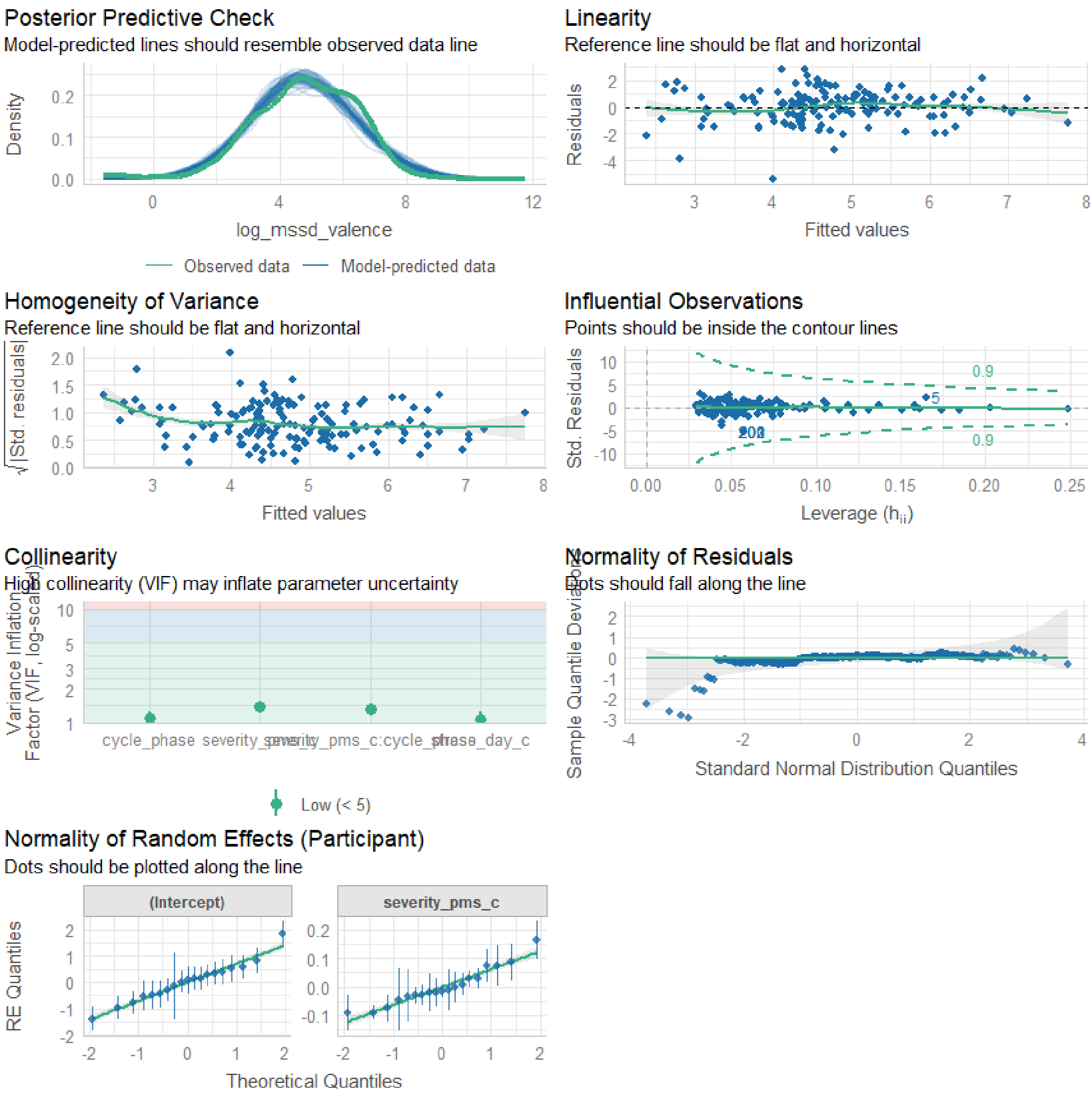


Figure A8

Linear Mixed Models Diagnostics for Calmness

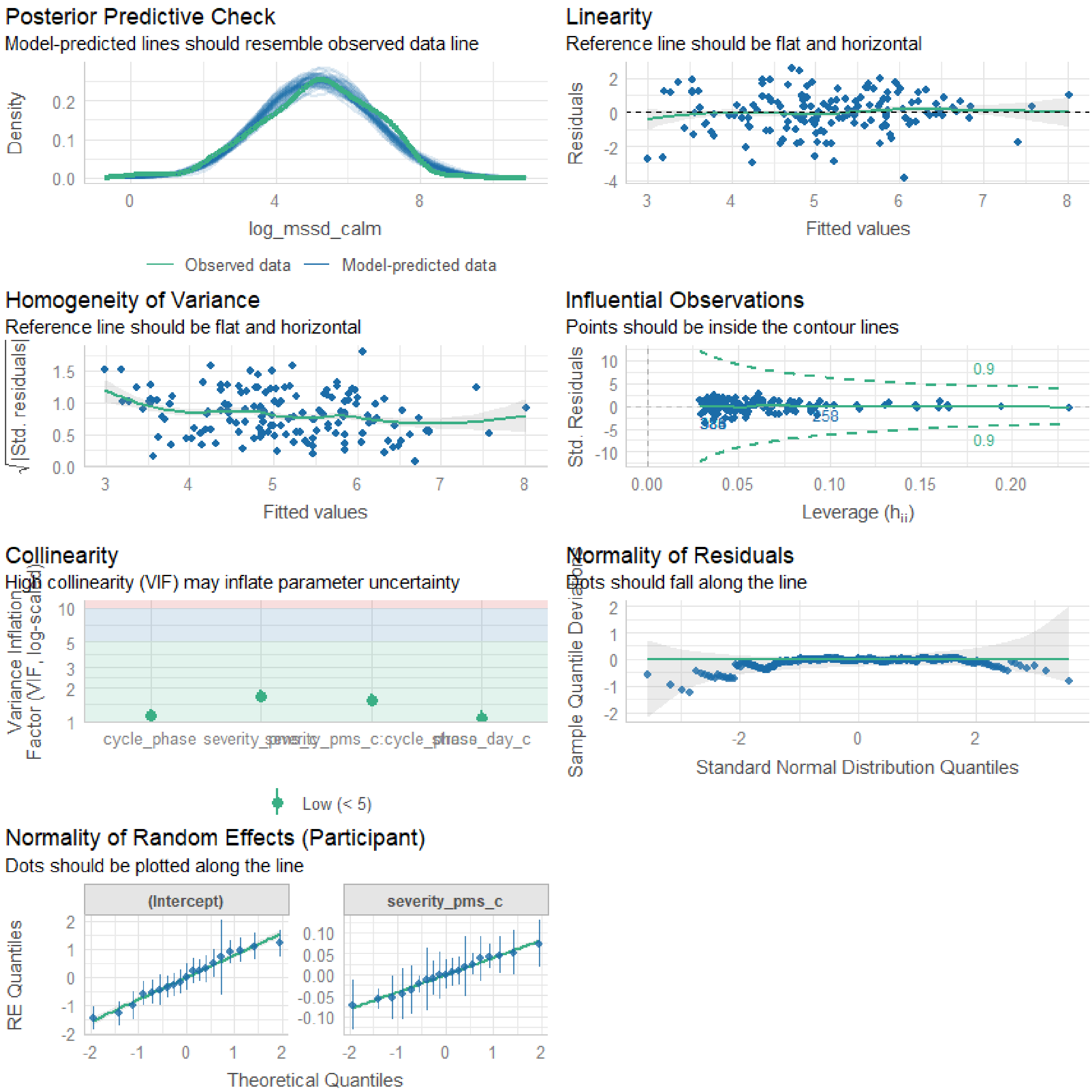


Figure A9

Linear Mixed Models Diagnostics for Energetic Arousal

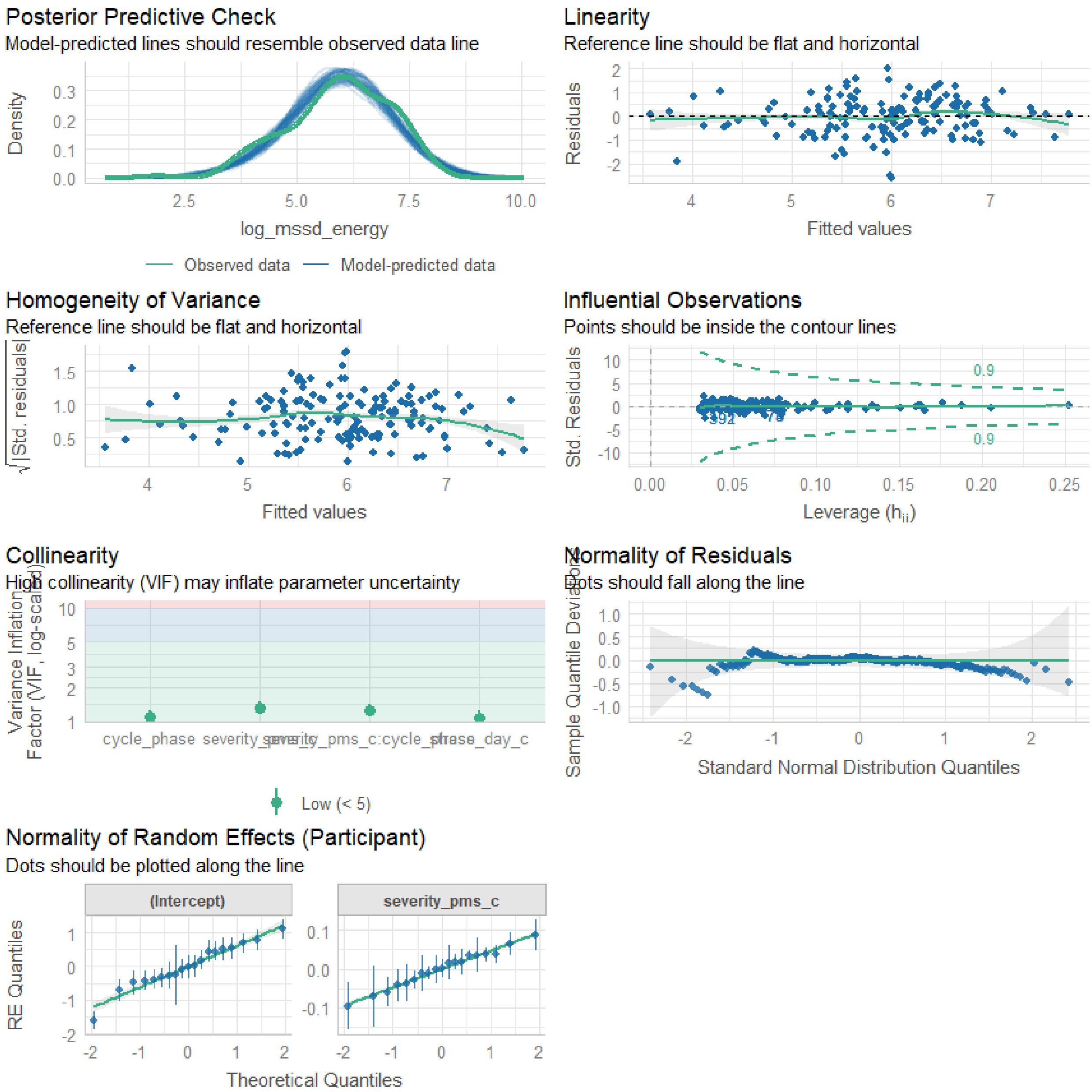
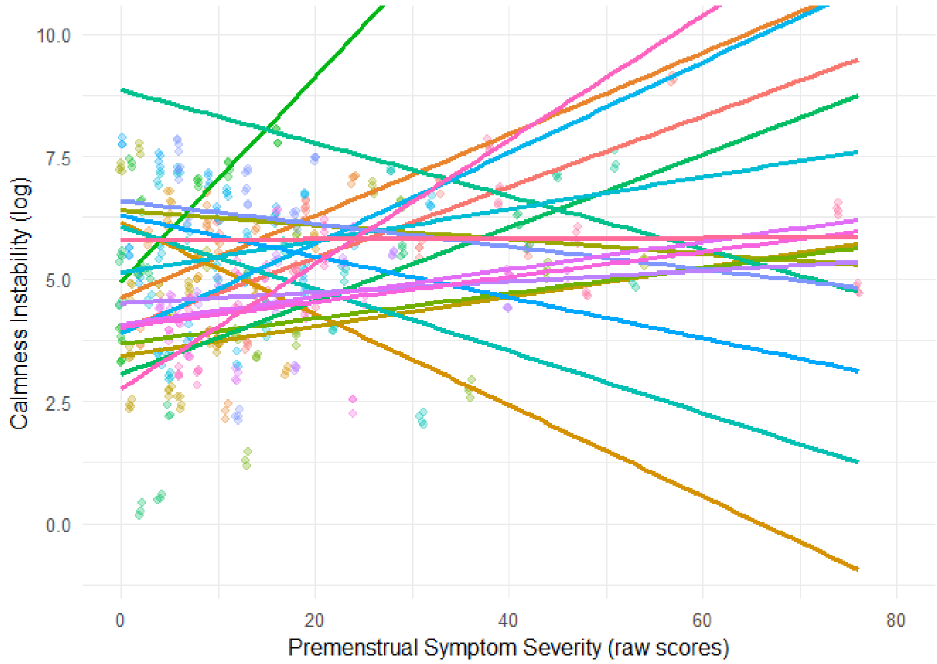


Figure A10

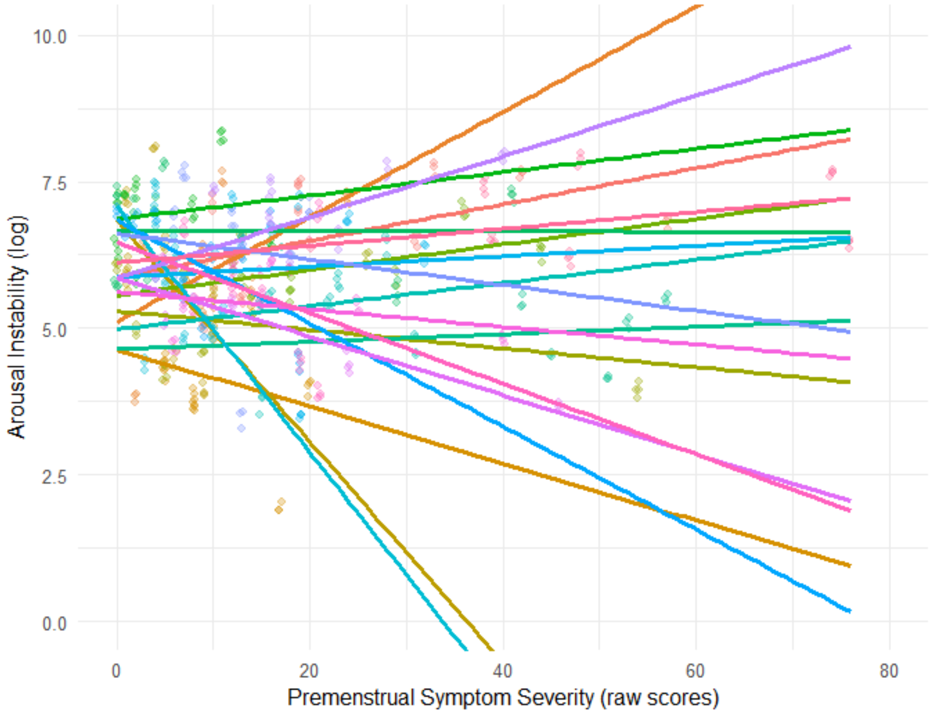
Plot of Individual Associations Between Premenstrual Symptom Severity and Calmness Instability



Note. The plot shows the association between premenstrual symptom severity and the instability of the mood dimension calmness for each participant. Raw-scores for premenstrual symptom severity are shown. Calmness instability scores were log-transformed. The dots are jittered to make each individual data point visible.

Figure A11

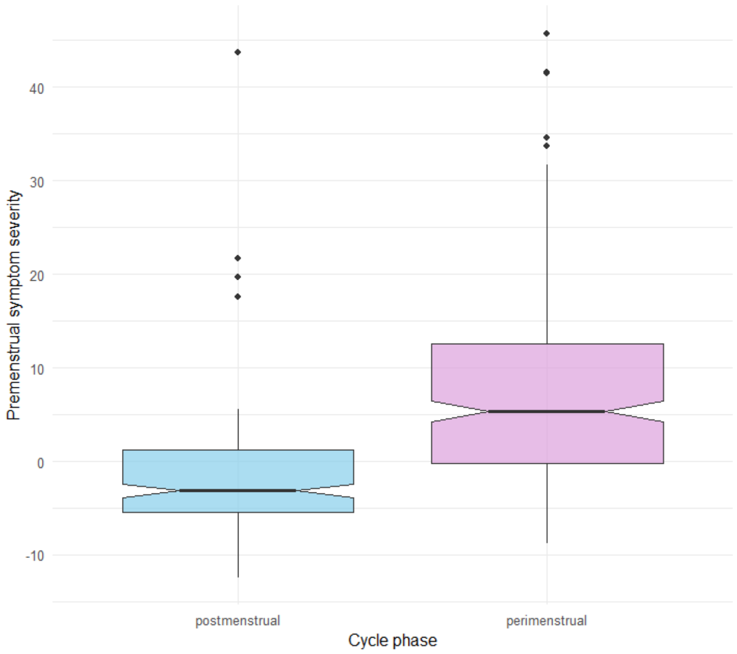
Plot of Individual Associations Between Premenstrual Symptom Severity and Energetic Arousal Instability



Note. The plot shows the association between premenstrual symptom severity and the instability of the mood dimension energetic arousal for each participant. Raw-scores for premenstrual symptom severity are shown. Calmness instability scores were log-transformed. The dots are jittered to make each individual data point visible.

Figure A12

Comparison of Premenstrual Symptom Severity in Perimenstrual vs. Postmenstrual Phase



Note. Premenstrual symptom severity was person mean-centered.