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ORIGINAL ARTICLE

Affective States and Temporal Alterations in Women with PCOS During the Early Follicular Phase

Erken Foliküler Fazda PKOS'lu Kadınlarda Duygudurum ve Zaman Algısındaki Değişiklikler

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ABSTRACT

Aim: Polycystic ovary syndrome (PCOS) is a common endocrine disorder affecting 15–20% of women of reproductive age. While its metabolic and reproductive consequences are well recognized, potential effects on temporal cognition and emotional states remain underexplored. These domains, critical for daily functioning, may be disrupted in PCOS due to neuroendocrine imbalances. This study investigated subjective time perception, specific cognitive domains (attention and memory), and affective states in women with PCOS during the early follicular phase, a hormonally stable period.
Materials and Methods: Thirty-two women with PCOS and 32 age-matched healthy controls (18–35 years) participated. Time perception was assessed using retrospective and prospective paradigms to capture internally and externally driven timing. Cognitive functions related to attention and memory were measured with the Stroop test and the Wechsler Memory Scale-III (WMS-III). Emotional states were evaluated using the Positive and Negative Affect Schedule (PANAS).
Results: Women with PCOS showed significantly prolonged retrospective time perception compared with controls (31.7±15.2 vs 20.9±8.5 sec.; $p<0.05$). WMS-III scores were lower in the PCOS group (7.7±1.2 vs 9.9±1.1; $p<0.05$). Analysis of specific affective items indicated significantly higher guilt (1.8±1.0 vs 1.4±0.7) and lower pride (1.8±0.9 vs 2.5±1.2) scores in women with PCOS compared with healthy controls ($p<0.05$). Regression analyses further revealed that affective variables were significant predictors of retrospective time perception within the PCOS group ($p<0.05$).
Conclusions: These findings indicate that PCOS is associated with impaired time perception, memory, and affect, highlighting its broader psychological and cognitive impact.

Keywords: Cognitive dysfunction, Positive and Negative Affect Schedule (PANAS), subjective time perception, working memory.

ÖZ

Amaç: Polikistik over sendromu (PKOS), üreme çağındaki kadınların %15–20'sini etkileyen yaygın bir endokrin bozukluktur. Metabolik ve üreme ile ilişkili sonuçları iyi bilinmekle birlikte, zamansal biliş ve duygusal durumlar üzerindeki olası etkileri yeterince araştırılmamıştır. Günlük işlevler açısından kritik olan bu alanlar, PKOS'ta nöroendokrin dengesizlikler nedeniyle bozulabilir. Bu çalışma, hormonal olarak dengeli bir dönem olan erken foliküler faz sırasında PKOS'lu kadınlarda öznel zaman algısı, spesifik bilişsel alanlar (dikkat ve bellek) ve duygusal durumları incelemiştir.
Gereç ve Yöntemler: On sekiz–otuz beş yaş aralığında, PKOS tanılı 32 kadın ve yaş açısından eşleştirilmiş 32 sağlıklı kontrol katılmıştır. Zaman algısı, içsel ve dışsal zamanlama süreçlerini değerlendirmek amacıyla geriye dönük ve ileriye dönük paradigmalarla ölçülmüştür. Dikkat ve belleğe ilişkin bilişsel işlevler Stroop testi ve Wechsler Bellek Ölçeği-III (WMS-III) ile değerlendirilmiştir. Duygusal durumlar, Pozitif ve Negatif Duygu Ölçeği (PANAS) kullanılarak ölçülmüştür.
Bulgular: PKOS'lu kadınlarda, kontrollere kıyasla geriye dönük zaman algısının anlamlı derecede uzadığı bulunmuştur (31,7±15,2 sn'ye karşı 20,9±8,5 sn; $p<0,05$). WMS-III skorları PKOS grubunda daha düşüktür (7,7±1,2'ye karşı 9,9±1,1; $p<0,05$). Özgül duygusal maddelerin analizi, PKOS grubunda sağlıklı kontrollere kıyasla suçluluk puanlarının anlamlı düzeyde daha yüksek (1,8±1,0'a karşı 1,4±0,7) ve gurur puanlarının anlamlı düzeyde daha düşük (1,8±0,9'a karşı 2,5±1,2) olduğunu göstermiştir ($p<0,05$). Regresyon analizleri ayrıca, duygusal değişkenlerin PKOS grubunda geriye dönük zaman algısının önemli belirleyicileri olduğunu ortaya koymuştur ($p<0.05$).
Sonuçlar: Bu bulgular, PKOS'un bozulmuş zaman algısı, bellek ve duygu durumları ile ilişkili olduğunu göstermekte olup, sendromun daha geniş psikolojik ve bilişsel etkilerini vurgulamaktadır.

Anahtar Kelimeler: Bilişsel işlev bozukluğu, çalışma belleği, öznel zaman algısı, Pozitif ve Negatif Duygu Ölçeği (PANAS).

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Introduction

Polycystic ovary syndrome (PCOS) is one of the most common endocrine and metabolic disorders among women of reproductive age, with global estimates suggesting it affects approximately 15–20% of this population based on the Rotterdam criteria [1, 2]. Originally viewed as a condition mainly involving ovarian dysfunction, PCOS is now recognized as a complex, multisystem disorder characterized by disturbances in neuroendocrine regulation, insulin signaling, and androgen metabolism [3]. These physiological disturbances lead to a wide range of reproductive, metabolic, dermatological, and psychological symptoms, causing significant morbidity throughout life [4]. Importantly, emerging research suggests the syndrome may also impact higher functions like cognition, emotional regulation, and time perception. These neurocognitive and emotional changes—potentially linked to hormonal imbalances and metabolic issues—are an underexplored but important aspect of the disorder, with notable implications for quality of life. Mehrabadi et al. found that women with PCOS performed significantly worse than healthy controls in attention, executive function, and visuospatial domains as assessed by the Montreal Cognitive Assessment (MoCA) [5]. Neuroimaging studies have revealed structural and functional alterations in the key brain regions, such as the prefrontal cortex, the hippocampus, and the hypothalamus that are involved in cognitive control, emotional regulation, and metabolic balance. These findings support the role of central mechanisms in the cognitive and behavioral manifestations of PCOS [6]. Beyond its well-known reproductive and metabolic consequences, PCOS may also alter brain networks underlying cognition and behavior. All this previous research underscores the necessity for investigating higher-order functions, such as time perception.

Methodological standardization of menstrual cycle phase is imperative in neurocognitive research, as fluctuating ovarian steroids—particularly estradiol and progesterone—exert potent modulatory effects on frontostriatal dopaminergic transmission, a system critically involved in both interval timing and executive control [7]. The early follicular phase constitutes a relative neuroendocrine baseline, characterized by low and stable concentrations of ovarian hormones, thereby minimizing the confounding influence of cyclical hormonal variability on cognitive and affective processes. Restricting assessment to this hormonally quiescent window enables a more precise examination of PCOS-related metabolic and neuroendocrine alterations on time perception, disentangled from the transient effects of physiological menstrual dynamics.

Temporal perception is a fundamental component of cognitive functioning that enables individuals to sequence events, anticipate outcomes, and synchronize their behavior with environmental demands. Cognitively, temporal processing is typically differentiated into two paradigms: prospective and retrospective time production. Retrospective time perception (RTP) involves post hoc estimation of elapsed duration in the absence of prior temporal awareness and is primarily mediated by episodic memory processes. In contrast, prospective time perception (PTP) refers to situations in which individuals consciously monitor the passage of time, a process that depends heavily on attentional allocation and working memory resources. This distinction is particularly relevant in clinical conditions characterized by cognitive and affective alterations, as these processes may differentially influence prospective and retrospective timing.

In everyday life, accurate temporal processing is essential for managing daily routines, maintaining attention during conversations, planning future actions, and adapting to time-sensitive situations. Despite its evident significance, temporal perception remains an overlooked area in PCOS research. To the best of our knowledge, no study has directly investigated how emotional disruptions linked to PCOS may affect internal timekeeping or related cognitive functions. Building upon prior evidence that even brief periods of sleep deprivation or restriction can degrade temporal precision [8, 9], we hypothesized that women with PCOS, characterized by recurrent affective fluctuations and neuroendocrine dysregulation, may exhibit comparable distortions in time perception. Specifically, we aimed to determine whether affective variability in PCOS is accompanied by measurable alterations in retrospective and prospective timing, thereby linking emotional state dynamics to temporal cognition in this population.

Materials and Methods

The experimental protocol was approved by Trakya University Faculty of Medicine Non-Interventional Scientific Research Ethics Committee (approval date: December 16, 2024 ; decision No: 21/09; protocol number: 2024/561). Written informed consent was obtained from all participants before data collection. All procedures were conducted in accordance with the principles outlined in the latest version of the Declaration of Helsinki.

Participants

Participants were recruited through online advertisements distributed across university networks and social media platforms. Sixty-four women (mean age ± SD, 21.0 ± 2.8 years) were initially enrolled. All participants were right-handed, had normal color vision, and possessed at least an undergraduate-level education. None reported the use of regular medication at the time of testing. Eligibility criteria included age between 18 and 35 years, a confirmed diagnosis of PCOS for the study group, and the absence of any medical or psychiatric disorder for the control group. Exclusion criteria comprised (1) history of substance abuse or dependence (excluding nicotine and alcohol), (2) diagnosed psychiatric disorders such as schizophrenia, major depressive disorder, or bipolar disorder, anxiety disorders, and attention-deficit/hyperactivity disorder (ADHD); and (3) systemic medical conditions other than PCOS, known to impair motor or cognitive function. All participants completed an online survey, including demographic and health-related questions, and they were also screened for sleep quality and mood to ensure comparability between groups. PCOS status was determined based on a self-reported prior diagnosis established by a gynecologist and verified through structured online screening and verbal confirmation. Participants indicated that their diagnosis fulfilled the Rotterdam criteria, defined by the presence of at least two of the following features: oligo/anovulation, clinical and/or biochemical hyperandrogenism, and

polycystic ovarian morphology. Thirty-two women fulfilled these conditions and were assigned to the PCOS group. The control group consisted of 32 age-matched women without a history of PCOS, irregular menstrual cycles, or other endocrine disorders.

Procedures

All experimental sessions were conducted during the early follicular phase of the menstrual cycle (days 5–7), a period chosen to minimize ovarian hormone fluctuations that could otherwise influence cognitive and perceptual outcomes [10]. Cycle phase was determined based on self-reported onset of menstruation, and the timing of laboratory visits was individually scheduled accordingly.

All participants reported sleeping for 7–8 hours on the night prior to testing. They abstained from alcohol, nicotine, tea, coffee, and other caffeinated beverages for a minimum of 12 hours preceding the session. Participants consumed a light meal before arriving at the laboratory, thereby ensuring they were in a satiated state at the time of testing.

All testing took place in the morning hours (08:00–11:00 a.m.) under standardized laboratory conditions to reduce circadian variability. The testing environment was kept quiet, temperature-controlled, and free from external temporal references, including visible clocks, calendars, electronic devices, and direct daylight exposure. Before completing the cognitive and temporal perception tasks, participants underwent two sequential assessments of affective state to control for potential emotional confounders. First, momentary affective valence was rated using a modified visual analogue scale (mVAS), ranging from 0 (extremely negative) to 10 (extremely positive), with 5 indicating neutrality. This provided a rapid, state-sensitive index of current mood immediately prior to task engagement. Subsequently, participants completed the Positive and Negative Affect Schedule (PANAS), a psychometrically validated self-report instrument designed to measure affective experiences across two independent dimensions—positive affect (PA) and negative affect (NA) [11]. The combined use of these complementary measures ensured that both transient and persistent emotional influences were accounted for the in analyses. This methodological safeguard was critical, as prior work has consistently shown that mood states—both fleeting and enduring—can significantly modulate attention and time perception [12, 13]. The overall study timeline is presented in Figure 1.

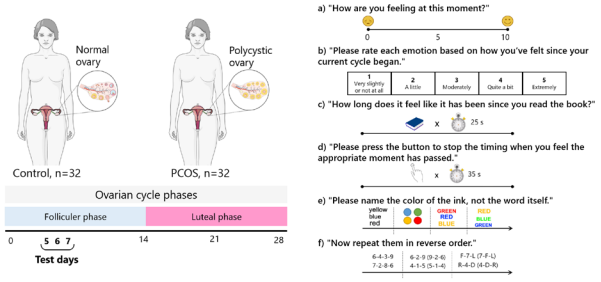

Figure 1. Schematic representation of the experimental protocol and and the sequence of administered tests. (a) modified Visual Analogue Scale (mVAS). (b) Positive and Negative Affect Schedule (PANAS). (c) retrospective time perception test (RTP). (d) prospective time perception test (PTP). (e) Stroop tests. (f) Wechsler Memory Scale-III (WMS-III). Abbreviations: PCOS Polycystic Ovary Syndrome.

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Time Perception Tests

Two well-established behavioral paradigms were used to evaluate subjective time perception: RTP and PTP. Participants remained unaware of the task type, duration, and sequence throughout the procedure. No performance feedback was provided at any point, and participants were debriefed only after all experimental sessions had concluded, preventing strategic adjustments between trials.

In the RTP task, participants were instructed to read a predetermined page from a standardized text without being told the task duration. The researcher used a stopwatch to terminate the task precisely at 25 seconds. Immediately afterward, participants verbally estimated the number of seconds they believed had elapsed.

In the PTP task, participants were informed of the target duration (35 sec.) prior to each trial and instructed to press a button when they believed the interval had elapsed, following a visual start cue. Because prospective timing relies on attention-based mechanisms, each estimation was repeated three times to reduce the influence of counting or rhythm-based strategies. The mean of the three trials was used in subsequent analyses. Two complementary indices were calculated. First, absolute error (AE) was computed as the absolute difference between the estimated and target durations, divided by the target duration, yielding a standardized measure of timing accuracy. Second, the estimated-to-target duration ratio was calculated, with values above or below 1 reflecting overestimation or underestimation, respectively. The selected durations (25 sec. for RTP, 35 sec. for PTP) were chosen to maintain participant engagement while minimizing attentional fatigue, and were consistent with prior studies on human interval timing [14]. All participants successfully completed the tasks.

Cognitive Tests

Given the multidimensional nature of cognition, we employed a battery targeting complementary domains to obtain a comprehensive profile of participants' cognitive performance. Information processing speed, executive functioning, and attentional control were assessed using the Stroop task, a widely validated measure sensitive to frontal-lobe-mediated cognitive regulation [15]. Short-term and working memory were evaluated through three core subtests from the Wechsler Memory Scale–Third Edition (WMS-III): Digit Span Forward (DSF), Digit Span Backward (DSB), and Letter-Number Sequencing (LNS) [16]. This combination allowed for simultaneous assessment of attentional capacity, inhibitory control, and the manipulation of information in working memory.

The Stroop task consisted of four standard conditions systematically designed to vary semantic and perceptual conflict. In Condition 1, participants read words printed in black ink, providing a baseline of lexical processing speed. Condition 2 required naming the colors of geometric shapes, establishing a baseline for color-naming performance. Condition 3 involved reading incongruent color words (e.g., "BLUE" printed in red), and Condition 4 required naming the ink color while disregarding the word meaning—eliciting maximal interference and probing inhibitory control and response selection.

In DSF, participants repeated increasingly long sequences of digits in the order presented, primarily indexing passive attention span. DSB imposed additional executive demands by requiring the sequence to be recalled in reverse order, thereby assessing manipulation and monitoring processes. LNS, the most complex of the three, evaluated both storage and transformation capacities of working memory. Participants were instructed to recall sequences of intermixed numbers and letters by reorganizing them into numerical and alphabetical order, respectively—a task demanding the simultaneous activation of updating, sequencing, and set-shifting processes. All tasks were administered according to standardized protocols under controlled laboratory conditions. Response times and error rates were recorded using a digital timer to ensure accuracy and adherence to protocol. This structured approach ensured that cognitive outcomes reflected genuine neurocognitive performance rather than procedural variability.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). Figures and graphical summaries were generated using GraphPad Prism, Version 9.4.1 (GraphPad Software, San Diego, CA, USA). Descriptive statistics (mean ± standard deviation for continuous variables; frequencies and percentages for categorical variables) were computed to characterize the sample. Normality assumptions were evaluated using the Shapiro–Wilk test. A priori power analysis was performed using G*Power 3.1 to determine the minimum sample size required to detect medium effect sizes (Cohen's $d \approx 0.5$, $f^2 \approx 0.15$) with $\alpha = 0.05$ and power $(1 - \beta) = 0.80$. The analysis indicated that at least 27 participants per group were required for independent-samples t-tests and ≥55 total participants for multiple regression models with up to five predictors. Our final sample (n = 64) exceeded these thresholds, supporting the adequacy of statistical power for detecting meaningful effects. When comparing continuous variables between two groups (PCOS vs. control), the Mann–Whitney U test was applied because the data were not normally distributed.

Spearman correlation analysis was performed to determine the linear relationships between PCOS and other variables. A correlation coefficient between 0.1 and 0.3 was considered weak, between 0.3 and 0.5 moderate, and above 0.5 strong. Multiple linear regression analyses were conducted using the RTP variable as the dependent variable. Factors such as PTP, WMS, Stroop scores, PANAS scores, and PCOS were included as independent variables in the regression models. Furthermore, regression equations were constructed using simplified and user-defined models. Coefficients, standard errors, p-values, and 95% confidence intervals were reported for each variable in the regression analyses. Statistical significance was set at $p < 0.05$ in all analyses.

Results

Characteristics of participants are summarized in Table 1. The PCOS and control groups were comparable in terms of age, body mass index (BMI), level of education, and drinking/smoking status (all $p > 0.05$), indicating that the groups were well matched on major demographic variables. The distribution of menstrual frequency patterns differed significantly between the PCOS and control groups (Fisher–Freeman–Halton exact $p = 0.010$; Pearson $\chi^2(3) = 9.03$, $p = 0.029$; Monte Carlo two-sided $p = 0.014$, 99% CI [.011–.016], see Table 1). Because 75% of the expected cell counts were below 5, the exact p-value was considered more reliable. The effect size was moderate (Cramer's V = 0.38), consistent with the expected prevalence of oligo- or anovulatory cycles in PCOS. Other menstrual characteristics, including cycle regularity, premenstrual mood symptoms, and pain severity, did not differ significantly between groups (all $p > 0.05$). These findings confirm that the primary distinguishing feature between the groups is the extended cycle length in the PCOS group.

Table 1. Comparison of demographics characteristics between the Control and PCOS groups.

Characteristic	Groups		P
	Control (n=32)	PCOS (n=32)	
Age (years)	21.6 ± 2.5	21.3 ± 3.1	0.271
BMI (kg/m2)	23.2 ± 3.6	23.0 ± 3.6	0.920
Education (years)	15.7 ± 2.2	15.1 ± 2.3	0.982
Smokers (%)			1.000*
Yes	25%	25%	
No	75%	75%	
Alcohol consumption (%)			1.000*
Yes	34.4%	34.4%	
No	64.6%	64.6%	
Menstrual frequency pattern, days (%)			**0.010***
< 35 days	92.8%	3.1%	
Every 2 months	3.1%	3.1%	
Every 3 months or less frequent	-	65.6%	
Irregular, with no consistent pattern	3.1%	28.1%	
Menstrual cycle length, days (%)			0.313*
Short (≤3 days)	6.2%	3.2%	
Normal (4–5 days)	40.6%	59.4%	
Prolonged (≥6 days)	53.2%	37.4%	
Dysmenorrhea severity, score	6.0 ± 2.3	5.9 ± 2.7	0.989
PMS, points (%)			0.112
None (1P)	3.1%	18.8%	
Mild (2P)	3.1%	9.4%	
Moderate (3P)	65.6%	31.3%	
Severe (4P)	28.2%	37.5%	
MoodADL, points (%)			0.982
None (1P)	9.4%	6.3%	
Mild (2P)	25.0%	31.3%	
Moderate (3P)	50.0%	37.5%	
Severe (4P)	9.4%	21.9%	
Very severe (5P)	6.2%	-	

PCOS polycystic ovary syndrome, BMI body mass index, PMS premenstrual syndrome, MoodADL mood-related interference with activities of daily living.

Data presented as mean ± SD or percent as indicated. Significant values are in bold. P-values calculated using 2-sided t tests or Mann–Whitney U tests as appropriate. *P-value calculated using the χ^2 (chi-square) test.

Analysis of temporal cognition revealed a selective impairment of retrospective, but not prospective, timing in the PCOS group (Figure 2A–B). Retrospective timing was significantly longer in the PCOS group compared with controls (Respectively, 31.7 ± 15.2 sec vs 20.9 ± 8.5 sec; U = 297.5, p = 0.004), corresponding to a moderate effect size (r = 0.36). Median retrospective estimates were markedly longer in women with

PCOS (30 sec, IQR = 20–45) relative to controls (20 sec, interquartile range, IQR = 15–26), consistent with a systematic overestimation of elapsed time. This finding was further supported by significantly higher absolute error scores and elevated estimation ratios in PCOS group (Table 2), confirming reduced temporal accuracy and a bias toward overestimation in PCOS. In contrast, prospective timing did not differ significantly between groups, suggesting that the attentional tracking processes engaged during prospective timing remain preserved in PCOS. These results imply that PCOS is associated with a selective disruption in retrospective temporal processing—likely reflecting impaired attention–memory integration—while prospective timing mechanisms, which rely more heavily on sustained attention, appear to be spared.

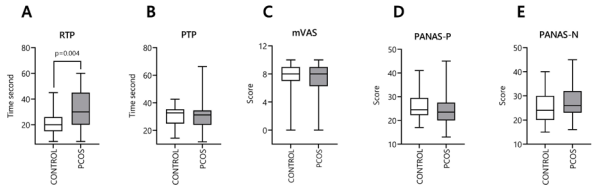

Figure 2. Group comparisons of subjective time perception tests and affective states in individuals with and without polycystic ovary syndrome (PCOS). (A) Retrospective time perception (RTP), (B) Prospective time perception (PTP), (C) Modified Visual Analog Scale (mVAS), (D) Positive affect scores (PANAS-P), and (E) Negative affect scores (PANAS-N). Data are presented as box plots; the central line denotes the median, box boundaries indicate the interquartile range (25th–75th percentiles), and whiskers represent the distribution of the data. Statistically significant group differences are indicated by the reported p-values.

Table 2. Comparative analysis of subjective temporal perception for the Control and the PCOS group.

	Conditions		
	Groups		P
	Control (n=32)	PCOS (n=32)	
RTP, 25 sec.			
Estimated time, sec.	20.9 ± 8.5	31.7 ± 15.2	**0.004**
Absolute error, n	0.3 ± 0.2	0.5 ± 0.3	**0.008**
RATIO	0.8 ± 0.3	1.2 ± 0.6	**0.004**
PTP, 35 sec.			
Estimated time, sec.	30.0 ± 7.6	30.7 ± 9.7	0.624
Absolute error, n	0.1 ± 0.1	0.2 ± 0.1	0.149
RATIO	0.8 ± 0.2	0.8 ± 0.2	0.624

PCOS Polycystic Ovary Syndrome, RTP retrospective time perception test, PTP prospective time perception test. All data are presented as mean ± SD. All p-values were calculated using the Mann–Whitney U test; values of P < 0.05 were considered statistically significant. Significant values are in bold.

The results of cognitive assessments are summarized in Table 3. Across all four conditions of the Stroop task, no significant between-group differences were observed in reaction times or error rates, indicating comparable selective attention and interference control in women with PCOS and controls. Notably, error rates in Stroop Condition 4, the highest interference condition, remained similar between groups, suggesting preserved inhibitory control. Performance on the working memory tests revealed a selective deficit. DSF scores were similar between groups, as were LNS scores. In contrast, women with PCOS performed significantly worse on the DSB task compared with controls, representing a small-to-moderate effect size. This difference remained statistically significant after adjustment for multiple comparisons using the Benjamini–Hochberg procedure (Table 3).

Table 3. Comparative analysis of cognitive tests for the Control and the PCOS group.

	Conditions		
	Groups		P
	Control (n=32)	PCOS (n=32)	
Stroop Tests			
Stroop-1	23.6 ± 3.5	23.7 ± 3.0	0.968
Stroop-2	23.8 ± 3.6	23.1 ± 2.2	0.398
Stroop-3	30.7 ± 4.7	30.8 ± 5.2	0.883
Stroop-4	52.9 ± 7.5	51.6 ± 10.0	0.248
Error (Stroop-4)	1.0 ± 1.2	1.5 ± 1.5	0.143
WMS-III			
DSF	10.0 ± 1.9	9.7 ± 2.0	0.564
DSB	7.6 ± 1.2	6.9 ± 1.1	**0.036**
LNS	11.7 ± 2.0	11.0 ± 2.1	0.403

PCOS Polycystic Ovary Syndrome, DSF digit span forward, DSB digit span backward, LNS letter number sequence, WMS wechsler memory scale.

Data are presented as mean ± SD. Group comparisons were performed using the Mann–Whitney U test ($p < 0.05$). Stroop performance reflects task completion times, whereas DSF, DSB, and LNS scores indicate the number of correct responses. Significant values are shown in bold.

Taken together, these results suggest that although basic attentional processes and inhibitory control appear preserved, women with PCOS exhibit subtle but measurable impairments in the executive component of working memory—specifically in tasks requiring active manipulation and updating of information.

The mVAS scores, reflecting participants' current emotional valence, demonstrated no significant difference between groups, as illustrated in Figure 2C. Analysis of affective states using the PANAS revealed no statistically significant group differences in total positive or negative affect (Figures 2D–E). To further elucidate affective tendencies, each of the 20 individual PANAS items was examined (Table 4). While most affective descriptors showed comparable distributions between groups, women with PCOS reported lower feelings of "pride". These findings from both PANAS and mVAS suggest that although overt affective disturbances are not pronounced in PCOS, subtle shifts in emotional valence, particularly reduced positive affect, may underlie the neurocognitive and attentional differences observed in this population.

Table 4: Descriptive statistics, skewness, and kurtosis for each item on the PANAS-P and PANAS-N

Items	Groups		Skewness	Kurtosis	P
	Control (mean ± SD)	PCOS (mean ± SD)			
PA					
1. Interest	2.5 ± 1.1	2.2 ± 1.3	0.610	-0.530	0.285
3. Excited	2.3 ± 1.0	2.2 ± 1.0	0.716	-0.100	0.684
5. Strong	2.4 ± 1.0	2.4 ± 1.0	0.476	-0.248	0.911
9. Enthusiastic	2.1 ± 1.0	2.0 ± 1.0	0.782	0.173	0.443
10. Proud	2.4 ± 1.1	1.7 ± 0.9	0.567	-0.700	0.011
12. Alert	2.0 ± 1.0	2.4 ± 1.2	0.576	-0.970	0.185
14. Inspired	1.6 ± 1.1	1.5 ± 1.1	2.189	4.031	0.599
16. Determined	2.5 ± 1.0	2.3 ± 1.1	0.152	-0.771	0.316
17. Attentive	2.9 ± 0.9	2.7 ± 0.8	-0.043	0.155	0.496

19. Active	2.6 ± 1.0	2.6 ± 1.0	0.234	-0.344	0.790
NA					
2. Distressed	3.9 ± 1.1	4.0 ± 0.9	-0.953	0.318	0.732
4. Upset	3.6 ± 1.1	3.9 ± 0.8	-0.663	-0.067	0.579
6. Guilty	1.4 ± 0.7	1.8 ± 1.0	1.391	0.831	0.077
7. Scared	1.6 ± 1.1	1.6 ± 1.1	1.767	2.409	0.962
8. Hostile	4.0 ± 1.1	4.2 ± 0.8	-1.043	0.473	0.403
11. Irritable	4.0 ± 0.9	4.3 ± 0.9	-0.814	-0.354	0.166
13. Ashamed	1.4 ± 0.8	1.8 ± 0.9	1.171	0.303	0.113
15. Nervous	2.6 ± 1.4	2.9 ± 1.1	0.028	-1.040	0.302
18. Jittery	1.5 ± 1.1	1.5 ± 1.1	2.220	4.122	0.932
20. Afraid	2.6 ± 1.1	2.8 ± 1.2	0.076	-0.927	0.610

PCOS Polycystic Ovary Syndrome, SD standard deviation, PA Positive Affect, NA Negative Affect.

Responses to PANAS items ranged from 1 to 5. Item-level distributions were assessed for skewness and kurtosis. Group comparisons were performed using the Mann–Whitney U test.

Correlation analyses were conducted to evaluate the relationships between RTP and PTP measures, cognitive performance tests, and affective states in the Control and PCOS groups separately (Table 5). For RTP, the PCOS group showed significant positive correlations with Stroop test scores: Stroop 1, Stroop 2, and Stroop 3. However, no significant correlations were found between RTP and WMS III and PANAS scores. There was no significant correlation for RTP in the control group. For PTP, the control group showed a significant positive correlation with DSB scores and approached significance with DSF. In contrast, the PCOS group exhibited a significant positive correlation solely with DSF.

A multiple linear regression analysis was conducted separately for the Control and PCOS groups to examine predictors of RTP (Table 6). For the control group, the regression model was not statistically significant overall. Among the predictors included (mVAS, PA, NA, and Quality of Life (QoL) scores), only positive affect emerged as a statistically significant predictor of RTP. This indicates that higher levels of positive affect were associated with longer retrospective time estimations. The other variables failed to contribute to the model. In contrast, the regression model for the PCOS group was statistically significant. mVAS showed a significant negative association with RTP, suggesting that higher mVAS was strongly related to shorter retrospective time estimations. PA was positively associated with RTP, while NA was negatively associated. Furthermore, quality of life during menstruation positively predicted RTP (Table 6).

Table 5. Associations Between Temporal Processing and Cognitive-Affective Measures

		Stroop 1	Stroop 2	Stroop 3	Stroop 4	DSF	DSB	LNS	PA	NA
RTP										
Control	**r**	-0.035	0.089	0.138	0.070	-0.078	0.089	-0.145	0.167	0.055
	P	0.850	0.629	0.451	0.703	0.670	0.629	0.477	0.360	0.776
PCOS	**r**	0.424	0.380	0.372	0.111	-0.010	-0.318	-0.216	0.029	0.113
	P	**0.016**	**0.032**	**0.036**	0.546	0.958	0.077	0.235	0.877	0.539
PTP										
Control	**r**	0.308	0.214	0.083	-0.038	0.349	0.351	0.114	0.021	0.078
	P	0.086	0.239	0.652	0.834	0.050	**0.049**	0.533	0.911	0.673
PCOS	**r**	-0.068	-0.148	-0.140	-0.167	0.371	0.334	0.284	-0.323	-0.265
	P	0.711	0.417	0.446	0.361	**0.036**	0.062	0.115	0.072	0.143

RTP retrospective time perception test. PTP prospective time perception test. DSF digit span forward. DSB digit span backward. LNS letter number sequence. PA positive affect. NA negative affect. PCOS polycystic ovary syndrome.

Spearman correlation coefficients (r) are reported; significant values are shown in bold.

Table 6. Multiple Linear Regression Model of Retrospective Time Perception (RTP).

	Variable	B	Standard Error	Beta	t	P	IC 95 % para B	VIF
Control								
	Constant	0.171	11.929	-	0.014	0.989	[-24.305 – 24.647]	-
	mVAS	0.602	0.494	0.222	1.219	0.233	[-0.411 – 1.616]	1.115
	PA	0.629	0.297	0.381	2.118	**0.044**	[0.020 – 1.239]	1.089
	NA	0.300	0.274	0.208	1.095	0.283	[-0.262 – 0.863]	1.217
	QoL Scores	-2.189	1.698	-0.248	-1.289	0.208	[-5.673 – 1.295]	1.243
PCOS								
	Constant	48.393	11.356		4.262	**0.000**	[25.051 – 71.735]	-
	mVAS	-3.579	0.839	-0.593	-4.265	**0.000**	[-5.303 – -1.854]	1.077
	PA	1.360	0.374	0.598	3.633	**0.001**	[0.590 – 2.129]	1.507
	NA	-1.813	0.498	-0.716	-3.639	**0.001**	[-0.789 – -0.190]	2.152
	QoL Scores	8.608	2.772	0.571	3.105	**0.005**	[2.910– 14.307]	1.883

mVAS modified visual analog scale. PA positive affect. NA negative affect. QoL quality of life. PCOS polycystic ovary syndrome.

Dependent variable: Retrospective time perception (RTP). Significant values are in bold.

Discussion

This study investigated whether transient emotional fluctuations during the early follicular phase influence time perception and cognitive performance in women with PCOS. We found that participants with PCOS systematically overestimated retrospective durations, reflecting a consistent temporal bias. Crucially, group-level affective scores were comparable between groups, while regression analyses revealed meaningful within-individual associations between affective variability and subjective time perception. Regression analyses further suggested that affective variables and quality-of-life indices were associated with retrospective timing error within the PCOS group. Concurrently, participants with PCOS demonstrated a measurable decline in working memory performance. Our findings are consistent with previous studies showing that affective instability in PCOS is coupled with measurable cognitive alterations [17-19]. By demonstrating that temporal cognition is selectively disrupted, our study extends previous work linking PCOS to deficits in attention, executive function, and emotional regulation, and suggests that these domains may share common neuroendocrine underpinnings. Rather than redefining the syndrome, these findings broaden the conceptual framework of PCOS to include potential alterations in central information processing and emotion–cognition integration.

The detection of these cognitive and temporal alterations specifically during the early follicular phase carries important pathophysiological implications. This phase represents a relative neuroendocrine baseline characterized by a hormonal nadir, thereby minimizing the confounding influence of acute ovarian steroid fluctuations (i.e., activational effects). Accordingly, the persistence of retrospective time overestimation and working memory decrements under hormonally stable conditions suggests that these alterations are unlikely to reflect transient menstrual cycle dynamics alone. Rather, they may reflect the longer-term organizational impact of chronic neuroendocrine and metabolic disturbances—such as sustained hyperandrogenism and insulin resistance—on frontostriatal networks involved in cognitive control and temporal processing.

Time perception represents a core dimension of cognitive processing that enables organisms to coordinate actions, anticipate environmental events, and adaptively regulate behavior [8, 20, 21]. In humans, accurate temporal processing is essential for goal-directed behavior, from decision-making and planning to the synchronization of motor actions in everyday life. For instance, in occupational contexts, the ability to meet deadlines within limited time frames relies on precise temporal estimation and regulation. Similarly, in academic settings, particularly under high-stakes examination conditions, stress and anxiety can distort temporal judgment, impairing pacing and task completion. In sports, especially disciplines such as competitive swimming or underwater diving, performance often depends on accurately predicting and controlling time intervals [22]. Furthermore, in traffic systems, both on the ground and in aviation, temporal misjudgments can lead to critical errors with severe safety consequences. Across these contexts, these observations underscore that time perception is not merely a cognitive abstraction but a key determinant of functional capacity and safety. Investigating temporal processing in conditions characterized by neuroendocrine and affective dysregulation, such as PCOS, can provide critical insights into the central mechanisms linking metabolic, emotional, and cognitive domains.

Although the precise neural basis of temporal processing remains incompletely understood, several physiological models have been proposed. The cognitive pacemaker–accumulator model conceptualizes timing as the integration of discrete pulses emitted by an internal pacemaker, which are counted and stored within working memory to generate a duration estimate. In contrast, the striatal beat frequency model proposes that temporal intervals are encoded by coincident cortical oscillators converging onto medium spiny neurons of the basal ganglia, thus linking timing to dopaminergic and frontostriatal circuitry [23]. Crucially, these systems are sensitive to fluctuations in mood and affective state, as shown in experimental studies demonstrating that mood induction can accelerate or decelerate perceived time flow [12, 24]. Moreover, in PCOS populations, a growing body of evidence indicates that metabolic and hormonal perturbations are associated with diminished performance on tasks governed by frontostriatal circuitry, including attention and executive control [19, 25, 26]. This provides a plausible neurocognitive pathway through which emotional variability, common in PCOS, could bias temporal judgments.

A convergent literature indicates that emotional valence, arousal, and motivational relevance systematically bias subjective duration estimates [27, 28]. Experimental studies further demonstrate that the intensity and quality of emotional episodes can lengthen or shorten perceived time, partly via attentional capture and autonomic arousal [29-32]. These observations support a parsimonious, transdiagnostic account: transient affective fluctuations may shift attention and arousal, altering the encoding and subsequent reconstruction of temporal information, and thereby degrading timing accuracy [33]. Our findings fit this pattern. Women with PCOS exhibited selective overestimation in retrospective timing alongside a decrement in working memory manipulation, while prospective timing and Stroop-based indices of inhibitory control were comparable to controls. The absence of significant Stroop-based group differences suggests that PCOS is unlikely to be associated with a generalized attention deficit, at least in tasks requiring inhibitory control and executive attention. By contrast, reduced working memory performance appears more directly relevant to retrospective time perception, consistent with the memory-dependent reconstruction processes underlying retrospective

duration judgments. This dissociation favors a memory-based interpretation over a pure "clock-speed" shift: within a pacemaker–accumulator framework, greater salience and density of encoded event markers would yield longer reconstructed intervals, even if pulse rate were unchanged. Consistent with this view, PCOS is frequently associated with affective lability and stress reactivity, particularly around the perimenstrual window, in the context of hormonal and metabolic irregularities [34]; in our data, affective indices explained unique variance in retrospective timing despite similar group means, pointing to within-group modulation rather than a gross between-group affect difference. While standard group comparisons failed to capture overt affective differences, our regression analyses revealed a more nuanced dynamic: specific affective states were significant predictors of retrospective timing error in the PCOS group. This pattern suggests a heightened affective–temporal coupling in PCOS, whereby subjective time perception becomes more sensitive to internal emotional fluctuations. Accordingly, physiological models such as the pacemaker–accumulator and striatal beat frequency accounts serve here as an explanatory, hypothesis-generating framework rather than confirming a specific neural mechanism. Overall, a working-memory–centric account under affective load offers a conservative and data-consistent explanation for the selective retrospective overestimation observed here. However, given the modest sample size, these regression findings should be interpreted as exploratory and hypothesis-generating rather than indicative of definitive causal relationships.

Given that emotional modulation of time perception depends on cortico–striatal and prefrontal systems sensitive to dopaminergic and hormonal tone, the chronic metabolic and endocrine perturbations in PCOS may provide a substrate for subtle temporal biases. Recent evidence links hyperandrogenism and insulin resistance to small but measurable decrements in cognitive performance, particularly in tasks relying on attentional control and executive function [18, 34]. Such findings suggest that frontostriatal systems, critical for precise timing, may be selectively vulnerable in PCOS. Importantly, depressive symptoms and altered time perspective have also been reported in this population, with maladaptive future orientation correlating with greater symptom burden [35]. While our cohort did not exhibit major between-group differences in global affect scores, regression models revealed that affective state contributed significantly to retrospective timing variance, pointing toward within-group modulation rather than overt affective pathology. Taken together, these findings support the notion of a distributed affect–cognition–time network that may be subtly dysregulated in PCOS, likely through interactions between neuroendocrine alterations, frontostriatal synchrony, and working memory stability. Future studies employing neuroimaging, electrophysiology, and longitudinal designs will be necessary to determine whether these temporal and cognitive anomalies constitute a central neural endophenotype of PCOS or arise as secondary consequences of chronic hormonal imbalance.

This study has several limitations. First, the diagnosis of PCOS was based on self-report rather than clinical or biochemical verification. Although self-reported diagnosis is widely used in large-scale behavioral research, future studies should incorporate standardized hormonal and metabolic testing to improve diagnostic precision and to examine cognitive outcomes as a function of specific endocrine profiles (e.g., hyperandrogenism, insulin resistance). Second, potential confounders such as habitual sleep duration, nutritional status, and perceived stress levels were not systematically controlled, and future research should account for these factors. Finally, our assessment of temporal perception and executive function was limited to behavioral paradigms. Complementary neurophysiological measures (EEG, MEG, fMRI) would allow fine-grained mapping of cortico-striatal and prefrontal dynamics during timing tasks and could clarify whether network-level synchrony mediates the observed effects.

CONCLUSION

In summary, this study demonstrated that women with PCOS, even during the hormonally stable early follicular phase, exhibit pronounced retrospective time overestimation, reduced working memory performance, and subtle affective alterations. These findings expand the conceptualization of PCOS beyond its reproductive and metabolic dimensions, suggesting that it encompasses disruptions of temporal cognition and cognitive–emotional integration. While causal pathways remain to be established, the data support a multisystem framework in which neuroendocrine dysregulation exerts measurable effects on higher-order brain functions. Future longitudinal and multimodal studies are warranted to determine whether these cognitive–temporal alterations contribute to daily functioning, stress regulation, and quality-of-life outcomes in PCOS, and whether targeted interventions (e.g., lifestyle modification, hormonal treatment) can normalize temporal processing and improve cognitive health.

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Open Practices Statement: The datasets generated and analyzed during the current study are publicly available in the Zenodo repository (DOI: 10.5281/zenodo.17035057) (https://doi.org/10.5281/zenodo.17035057). None of the experiments were preregistered.

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