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The Influence of Anxiety and Depression on Time Perception: A Cognitive and Affective Perspective

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Objective: Anxiety and depression are prevalent mental health conditions associated with disruptions in cognitive processes, including time perception. Guided by Arousal Level Theory, this study examined how anxiety and depressive symptoms, along with physiological arousal (heart rate), relate to subjective time perception. ***Method***: A sample of 45 graduate students completed the Beck Anxiety Inventory (BAI) and Beck Depression Inventory-II (BDI-II), underwent heart rate measurement, and performed time production tasks (10- , 30-, and 60-second intervals). ***Results***: Contrary to predictions derived from arousal-based models, depressive symptoms were associated with greater time underestimation (p = .019), suggesting a faster internal clock. Anxiety showed a marginal association (p = .055), and heart rate was not significantly related to time perception. ***Conclusions***: These findings suggest that arousal-based explanations alone may be insufficient to account for time perception distortions in depression. Instead, cognitive and affective processes, such as rumination and attentional rigidity, may play a more central role. Findings should be interpreted cautiously, given the correlational design and limitations of the mood induction procedure.

Keywords: time perception, internal clock, depression, anxiety, arousal theory, cognitive processes

Time is perhaps one of the most debated constructs in both philosophy and science. One influential perspective comes from Immanuel Kant, who argued that time is not an objective property of the external world but rather an a priori structure of human cognition that organizes experience (Kant, 1781). Regardless of whether time exists independently of perception, it is well established that subjective time varies across individuals. The present study examines how two highly prevalent mental health conditions—anxiety and depression—shape this subjective experience of time.

A central concept in this study is the inner clock, defined as the internal cognitive mechanism through which individuals estimate temporal intervals (Burle & Casini, 2001). This construct is conceptually related to, but distinct from, the pacemaker component described in scalar expectancy theory. In the present framework, the inner clock serves as an interpretive model linking observable behavior to underlying temporal processing. Specifically, an accelerated inner clock results in time underestimation (i.e., producing shorter intervals than intended), whereas a decelerated inner clock results in time overestimation (i.e., producing longer intervals than intended). This terminology is used consistently throughout the manuscript to reduce ambiguity and ensure clarity in interpreting results.

Multiple theoretical accounts have been proposed to explain time perception, including Arousal Level Theory, the attentional gate model, and scalar expectancy theory. Arousal-based models suggest that physiological activation directly modulates the speed of internal timing mechanisms (Grondin, 2001; Mioni et al., 2016). In contrast, the attentional gate model proposes that time perception depends on the allocation of attentional resources, such that reduced attention to time leads to underestimation (Zakay & Block, 1997). Scalar expectancy theory conceptualizes timing as a pacemaker–accumulator system, in which pulses generated by an internal clock are accumulated and compared against stored representations (Gibbon et al., 1977).

The present study adopts Arousal Level Theory as the primary framework, as it provides clear, testable predictions regarding how anxiety and depression should influence internal clock speed. The attentional and scalar expectancy accounts are acknowledged as complementary models but are treated as secondary frameworks that may help interpret findings that are not fully explained by arousal-based mechanisms.

Anxiety and depression are among the most prevalent mental health disorders globally, affecting substantial proportions of the population (World Health Organization, 2017). Both conditions are associated with disruptions in cognitive processes, including attentional control, working memory, and information processing. Anxiety has been linked to attentional biases toward threat-related stimuli, which may impair attentional control (Pike et al., 2020). Depression is associated with deficits in concentration, decision-making, and cognitive flexibility (Pike et al., 2020). Because time perception relies on sustained attention and working memory, these disruptions may contribute to distortions in temporal processing.

Time perception plays a critical role in daily functioning, influencing how individuals coordinate tasks, regulate behavior, and interact with their environment. Although objective time remains constant, subjective time perception is shaped by psychological and physiological states. Prior research has documented time perception distortions in depression, including alterations that affect daily functioning and quality of life (Thönes & Oberfeld, 2015). However, findings across studies have been inconsistent, partly due to differences in how temporal distortions are defined and measured.

The inner clock framework is introduced in the present study to provide a consistent interpretive structure for these findings. Rather than describing time as "speeding up" or "slowing down," which can be conceptually ambiguous, this framework links behavioral outcomes directly to internal timing mechanisms. This approach allows for clearer interpretation of whether distortions reflect acceleration or deceleration of internal temporal processing.

In addition to psychological mechanisms, physiological processes may also influence time perception. The Heart Rate Theory proposes that internal bodily rhythms, such as heartbeats, may contribute to time estimation. Although this account has received limited empirical support, heart rate is included in the present study to evaluate whether physiological arousal contributes to temporal distortions. This allows for a more comprehensive assessment of the relative contributions of psychological and physiological factors.

Based on Arousal Level Theory, the present study tests the following hypotheses. Anxiety, characterized by heightened arousal, is expected to accelerate the inner clock, leading to time underestimation. Depression, often associated with reduced arousal, is expected to decelerate the inner clock, resulting in time overestimation. At the same time, emerging evidence suggests that cognitive and affective processes—such as rumination and attentional rigidity—may also influence time perception. These mechanisms are therefore considered exploratory and secondary to the primary arousal-based account.

Previous research using time production and reproduction tasks has found that individuals with anxiety tend to underestimate time intervals, whereas individuals with depression tend to overestimate them (Mioni et al., 2016; Thönes & Oberfeld, 2015). However, few studies have simultaneously examined affective symptoms and physiological measures, such as heart rate, within the same design.

The present study addresses this gap by examining how symptoms of anxiety and depression, alongside heart rate, relate to time perception within an integrated framework. By focusing on symptom dimensions rather than categorical diagnoses, this study aims to clarify how psychological and physiological processes contribute to variability in the inner clock. This approach may help refine theoretical models of time perception and inform future research on cognitive and affective influences on temporal processing.

Methods

Participants

A total of 45 graduate students (aged 18–35 years) were recruited for the study. Participants were recruited through the Teachers College listserv and on-campus advertisements. Inclusion criteria included fluency in English and no history of cardiovascular disease, neurological or developmental disorders (e.g., ADHD, autism), psychotic disorders, or recent substance use that could affect physiological or cognitive functioning within the past week. Individuals currently using alpha- or beta-blockers were excluded to minimize potential confounding effects on heart rate.

These criteria were selected to ensure a relatively homogeneous sample in terms of cognitive and physiological functioning, thereby reducing variability unrelated to the primary variables of interest. The sample consisted of healthy young adults, which allowed for greater experimental control but may limit the generalizability of the findings to broader or clinical populations.

Measures

Anxiety and Depression Symptoms

Anxiety and depressive symptoms were assessed using the Beck Anxiety Inventory (BAI; Beck et al., 1988) and the Beck Depression Inventory–II (BDI-II; Beck et al., 1996). Both instruments are 21-item self-report measures widely used to assess the severity of affective symptoms and demonstrate strong reliability ($\alpha > .90$) and validity.

These measures were selected because they assess symptom severity dimensionally and have been frequently used in research examining the relationship between affective states and time perception. Prior studies have shown that higher anxiety levels are associated with faster perceived time (Mioni et al., 2016). Similarly, higher depressive symptom severity has been linked to distortions in time estimation, including underestimation and increased temporal inaccuracy (Di Lernia et al., 2018; Gil & Droit-Volet, 2009).

The use of these measures allows for the examination of continuous variation in anxiety and depressive symptoms, rather than relying on categorical diagnoses, which is consistent with the study's aim to investigate symptom-level influences on time perception.

Heart Rate

Heart rate was measured using a non-invasive pulse oximeter finger sensor (Zacurate/500BL). Baseline measurements were obtained prior to task administration, and follow-up measurements were recorded after the mood induction and time perception tasks.

Heart rate was included as a physiological index of arousal to examine whether variations in autonomic activity contributed to individual differences in time perception. This allowed for the assessment of whether observed temporal distortions were primarily associated with psychological factors or whether they were partially explained by physiological arousal.

Time Perception Task

Participants completed a time production task using the pen-drop method. In each trial, participants held a pen and were instructed to say "start" when ready, prompting the experimenter to begin timing. Participants then dropped the pen when they believed the target interval (10 s, 30 s, or 60 s) had elapsed.

Time production tasks are widely used in time perception research to assess internal timing mechanisms, as they require individuals to generate a temporal interval based on their internal representation of time, rather than relying on external cues. Compared to reproduction or estimation tasks, time production tasks provide a relatively direct measure of internal clock functioning by minimizing reliance on memory retrieval and comparison processes (Mioni et al., 2016).

The pen-drop method was selected because it imposes minimal motor and cognitive demands, reducing the influence of extraneous factors such as working memory load or complex motor coordination. This allows for a more direct assessment of subjective time perception. Although this method has been used in prior research (Wahl & Sieg, 1980), its simplicity also makes it suitable for isolating internal timing processes in non-clinical samples.

The selected intervals (10 s, 30 s, and 60 s) represent short-to-moderate durations commonly used in time perception research. These intervals are long enough to engage internal timing mechanisms while minimizing reliance on long-term memory or strategic estimation. Using multiple intervals also allows for the assessment of consistency in timing performance across durations.

Performance was quantified using relative error (RE), calculated as the difference between produced time and target time divided by the target time. Positive RE values indicate overestimation (i.e., a slower inner clock), whereas negative RE values indicate underestimation (i.e., a faster inner clock).

For each participant, RE values across the three intervals were averaged to generate an aggregate measure of time perception. This aggregation reduces variability associated with individual trials and provides a more stable estimate of internal timing performance. Interval-specific analyses were also conducted to examine consistency across durations.

Mood Induction

Participants were randomly assigned to view a 1-minute video intended to induce either a positive (happy) or negative (sad) emotional state. The video stimuli were not drawn from standardized or pre-validated mood induction sets. Instead, participants provided subjective ratings of the extent to which the videos were perceived as funny or sad immediately after viewing.

This approach was adopted to provide a brief and low-burden manipulation of affective state within the constraints of the study design. However, because the stimuli were not validated and the manipulation relied on subjective ratings, the strength and consistency of the induced emotional states may have varied across participants. As a result, mood condition effects should be interpreted with caution, particularly in comparisons between experimental conditions.

The inclusion of mood induction was intended to explore whether transient emotional states would influence time perception in addition to baseline symptom levels. Given the potential variability in manipulation strength, analyses focusing on mood condition are treated as secondary to the primary symptom-based analyses.

Procedure

The study employed a quasi-experimental design conducted in a controlled laboratory setting. Upon arrival, participants completed a demographic questionnaire, followed by baseline assessments of anxiety and depressive symptoms (BAI and BDI-II). Resting heart rate was recorded prior to task administration.

Participants first completed the time production task under a neutral condition to establish a baseline measure of time perception. They were then exposed to a mood induction procedure (happy or sad video) and immediately completed the same time perception task again. Heart rate was recorded following the task to capture post-manipulation physiological activity.

This procedure allowed for the comparison of time perception across baseline and post-induction conditions, while also examining the influence of individual differences in anxiety and depressive symptoms on timing performance.

Statistical Analysis

Data were analyzed using SPSS (Version 27). The primary outcome variable was relative error (RE) in the time production task, representing deviations between produced and target intervals. For each participant, RE values were averaged across the 10 s, 30 s, and 60 s intervals to create an aggregate measure of time perception performance.

Primary (Confirmatory) Analyses

The primary analyses examined whether anxiety and depressive symptom severity predicted time perception performance. A multiple linear regression model was conducted with BAI scores, BDI-II scores, and mood condition as predictor variables, and the aggregate RE score as the dependent variable. Statistical significance was set at $p < .05$.

These analyses were designed to test the study's primary hypotheses derived from Arousal Level Theory regarding the effects of anxiety and depression on internal clock speed.

Secondary (Exploratory) Analyses

To further examine the relationship between depressive symptoms and time perception, exploratory analyses were conducted at both the subscale and item levels of the BDI-II.

First, separate regression models were conducted using BDI-II subscales (cognitive, affective, and somatic; Buckley et al., 2001) as predictors of time perception. Second, exploratory item-level analyses were performed to identify whether specific depressive symptoms were associated with timing performance. Given the large number of comparisons, these analyses were considered exploratory and interpreted with caution.

Because multiple statistical tests were conducted across BDI-II items, the risk of Type I error is increased. No formal correction (e.g., Bonferroni or false discovery rate) was applied due to the exploratory nature of these analyses; therefore, findings should be interpreted as preliminary and hypothesis-generating rather than confirmatory.

Additional Analyses

A hierarchical multiple regression was conducted to examine whether co-occurring moderate-to-severe anxiety and depressive symptoms explained additional variance in time perception beyond depression alone. In Model 1, BDI-II scores were entered. In Model 2, a binary comorbidity variable (1 = BDI-II ≥ 20 and BAI ≥ 16; 0 = otherwise) was added. These thresholds were based on established severity cutoffs.

To evaluate potential physiological moderation effects, interaction terms between heart rate and symptom measures (BAI × heart rate; BDI-II × heart rate) were included in regression models.

Mood-induced changes in time perception were examined by calculating a difference score (post-induction RE minus baseline RE), allowing for the assessment of within-subject changes following the mood manipulation. Given the limitations of the mood induction procedure, these analyses were considered secondary.

Ethical Considerations

The study protocol was reviewed and approved by the Teachers College Institutional Review Board (IRB Protocol #24-477). All participants provided written informed consent prior to participation and were informed of their right to withdraw from the study at any time without penalty.

To protect participant confidentiality, all data were anonymized and stored securely. To minimize potential risks, participants were debriefed immediately following the study, and those who experienced discomfort were provided with referrals to appropriate mental health resources.

Results

Descriptive Statistics

Participant demographic and experimental characteristics are presented in Table 1, and descriptive statistics for continuous variables are presented in Table 2.

Participants (N = 45) were aged 20–29 years (M = 23.62, SD = 1.79). The sample was predominantly female (68.9%) and Asian (66.7%). Participants were randomly assigned to either the sad (46.7%) or funny (53.3%) video condition.

Mean depressive symptom severity was in the mild range (M = 12.18, SD = 9.28), and anxiety levels were moderate (M = 15.40, SD = 11.13). Baseline heart rate (M = 76.58 bpm, SD = 11.70) and post-induction heart rate (M = 77.82 bpm, SD = 11.38) were comparable, indicating minimal physiological change following the task.

At baseline, participants slightly underestimated the 10 s interval (M = 9.71, SD = 2.31), showed moderate variability at 30 s (M = 32.38, SD = 8.50), and slightly overestimated the 60 s interval (M = 65.32, SD = 17.04). Following mood induction, time estimates increased modestly across intervals (e.g., 10 s: M = 11.34, SD = 2.88), but overall changes were small.

Relative error (RE) values indicated slight underestimation at baseline (M = 0.07, SD = 0.27) and a small increase post-induction (M = 0.14, SD = 0.32), suggesting minimal shifts in overall timing performance.

Subjective ratings of the video stimuli were low for both conditions (sad: M = 2.66, SD = 3.22; funny: M = 3.09, SD = 3.24), indicating a weak mood induction effect.

Effects of Mood Condition

There were no significant differences between the sad and funny video conditions in time perception performance, $t(43) = 1.15, p = .26$. Given the low subjective ratings of the videos, these findings suggest that the mood manipulation had limited impact on timing behavior.

Depressive Symptoms and Time Perception

Depressive symptoms significantly predicted time perception performance. Higher BDI-II scores were associated with greater time underestimation (i.e., a faster inner clock), B = -0.010, p = .019. The model explained 12.1% of the variance in relative error (R^2 = .121, $F(1, 43)$ = 5.89, p = .019).

This effect was consistent across individual time intervals. Higher depressive symptom severity was associated with shorter produced durations at 10 s (B = -0.425, p = .004), 30 s (B = -0.346, p = .020), and 60 s (B = -0.319, p = .033), indicating a stable relationship across durations.

Anxiety Symptoms and Time Perception

Anxiety symptoms showed a marginal association with time perception. Higher BAI scores were associated with a tendency toward time underestimation, but this effect did not reach statistical significance (B = -0.330, p = .055).

Demographic and Physiological Factors

Demographic variables were not significantly associated with time perception. Age (B = -0.216, p = .189) and gender (B = -0.053, p = .742) did not predict relative error.

Heart rate was also unrelated to time perception (B = -0.079, p = .612), suggesting that physiological arousal did not account for variability in timing performance.

Exploratory Analyses: BDI-II Subscales

Exploratory analyses examined whether specific depressive symptom domains predicted time perception. Cognitive symptoms significantly predicted relative error (B = -0.020, p = .013, R^2 = .135), indicating that greater cognitive impairment was associated with faster internal clock speed.

Affective symptoms were also significant predictors (B = -0.039, p = .045, R^2 = .090). In contrast, somatic symptoms showed a non-significant trend (B = -0.023, p = .065, R^2 = .077).

Exploratory Analyses: Item-Level Associations

Item-level analyses identified specific depressive symptoms associated with time perception. Agitation (B = -0.225, p = .016) and indecisiveness (B = -0.085, p = .022) were associated with time underestimation, whereas sleep disturbances (B = 0.178, p = .009) were associated with time overestimation.

Given the number of comparisons conducted, these findings should be interpreted as exploratory.

Additional Analyses: Comorbidity Effects

A hierarchical regression examined whether co-occurring anxiety symptoms explained additional variance beyond depression alone. Adding the comorbidity variable did not significantly improve model fit ($\Delta R^2 \approx 0$, $\Delta F(1, 42) = 2.09$, p = .066), indicating that anxiety did not meaningfully alter the relationship between depression and time perception.

Discussion

Overview

The Arousal Level Theory that we built our hypothesis on proposes that heightened physiological arousal accelerates internal temporal processing, thus resulting in time underestimation, whereas reduced arousal slows it, thus leading to time overestimation (Gable et al., 2022; Grondin, 2001; Mioni et al., 2016). Based on this framework, we hypothesized that anxiety—characterized by physiological hyperarousal (Pike et al., 2020)—would speed the inner clock, while depression—often associated with hypoarousal and blunted reactivity (Xie et al., 2024)—would slow it. This prediction aligns with prior findings showing time underestimation in anxiety (Bar-Haim et al., 2010; Mioni et al., 2016) and time overestimation in depression (Bschor et al., 2004; Thönes & Oberfeld, 2015).

However, our results suggest that arousal-based mechanisms alone may not fully explain time perception distortions in mood disorders. While anxiety showed a marginal trend toward a faster inner clock (B = -0.330, p = .055), consistent with previous models, depression was associated with time underestimation (B = -0.010, p = .019), suggesting a speeding of the inner clock. This pattern differs from theoretical predictions and earlier findings that link depressive states to slowed temporal processing.

This discrepancy suggests that additional cognitive and affective mechanisms may be influencing time perception in depression. Factors such as impaired attentional control, decision-making difficulties, and self-focused processing may disrupt internal timekeeping in ways that arousal alone does not account for. Notably, these findings are consistent with phenomenological accounts of depression, where individuals often describe the external world as slowing down—an experience that could reflect a faster-running internal clock (Ratcliffe, 2012). Empirical evidence also suggests that depressed individuals report time dragging or becoming overly salient (Thönes & Oberfeld, 2015; Vogel et al., 2018), further supporting this interpretation.

To explore these dynamics in more detail, we conducted symptom-level analyses, which suggested that specific cognitive and affective symptoms—not overall depression severity—were most predictive of inner clock acceleration. This pattern aligns with cognitive models emphasizing attentional rigidity (Clark & Watson, 1991) and rumination (Nolen-Hoeksema, 2000), both of which propose that difficulty disengaging from internally generated thoughts may interfere with temporal tracking, leading to distortions in time perception.

Taken together, these results suggest that an integrative framework may be needed to fully understand time distortions in mood disorders. While arousal-based models provide an important foundation, they may need to be expanded to incorporate the roles of executive function, attention, and self-referential processing. A multidimensional perspective that includes both physiological and cognitive-affective components may better capture the complex ways in which individuals with anxiety and depression experience the passage of time.

Cognitive Deficits and the Accelerated Internal Clock in Depression

Our study's findings emphasize the role of cognitive processes in time perception among individuals with depression, with indecisiveness emerging as a key predictor of time underestimation. Indecisiveness is a well-documented symptom of depression and is frequently linked to executive dysfunction and cognitive rigidity (Beevers, 2005; Snyder, 2015). Depressed individuals often exhibit difficulties in decision-making, characterized by prolonged deliberation, reduced confidence, and heightened self-doubt (Koster et al., 2011; Van Randenborgh et al., 2010).

This indecisiveness is closely associated with rumination—a hallmark feature of depression in which individuals engage in repetitive, passive contemplation of distressing thoughts rather than taking action (Nolen-Hoeksema, 2000; Whitmer & Gotlib, 2013). Rumination has also been shown to interfere with cognitive processing and flexibility, contributing to persistent negative thinking patterns and impaired problem-solving. As a result, attention may become overly focused on internal states, potentially disrupting temporal tracking.

The connection between rumination, indecisiveness, and time perception distortions may be related to differences in how individuals monitor time. Depressed individuals who struggle with indecision may rely more heavily on structured or effortful internal counting strategies. While such strategies may be intended to increase control or accuracy, they may also alter attentional allocation during timing tasks, potentially contributing to systematic biases in time estimation.

Although direct empirical evidence linking specific time-monitoring strategies to internal clock speed remains limited, research on cognitive load provides a plausible explanatory framework. Studies have shown that increased cognitive load is often associated with time underestimation, a phenomenon commonly referred to as time compression (Brown, 1997; Zakay & Block, 1997). More recent work suggests that cognitive and emotional processes—such as attention, working memory, and motivation—jointly influence temporal perception. When cognitive resources are occupied, attention may be diverted away from temporal processing, resulting in shorter perceived durations (Matthews & Meck, 2014).

In the present study, the time production task was designed to minimize cognitive demand. However, it is possible that some participants engaged in more effortful or rigid internal strategies, effectively increasing cognitive load during the task. This interpretation is consistent with the observed association between depressive symptoms and time underestimation, although it cannot be directly tested within the current design. Recent evidence also suggests that depression may disrupt the typical relationship between emotional experience and time perception, further implicating cognitive processes in temporal distortions.

Taken together, these findings suggest that cognitive processes such as rumination and indecisiveness may contribute to time perception distortions in depression. Rather than indicating a purely physiological acceleration of the internal clock, these results point toward the potential role of attentional and executive processes in shaping temporal experience. This highlights the importance of considering cognitive mechanisms alongside arousal-based accounts when interpreting time perception in mood disorders.

Affective Symptoms and the Phenomenological Discussion

Affective state is a crucial factor shaping time perception, with early research indicating that negative emotions can distort internal timing mechanisms (Angrilli et al., 1997; Droit-Volet et al., 2004; Noulhiane et al., 2007). Conventional models have proposed that negative emotions tend to slow the inner clock, leading to time overestimation. However, more recent motivation-based theories suggest a more nuanced pattern: whether time speeds up or slows down depends on the motivational direction of the emotion—specifically, whether it is approach- or withdrawal-oriented (Carver, 2004; Gable & Harmon-Jones, 2013; Gable et al., 2022).

Our findings are broadly consistent with this motivation-based framework. Depressive symptoms, typically associated with withdrawal motivation, were linked to time underestimation, suggesting an accelerated inner clock. This interpretation aligns with prior work linking withdrawal-related states, such as depression and anhedonia, to altered temporal processing and the subjective experience of time dragging (Kent et al., 2019; Thönes & Oberfeld, 2015).

Depression is widely characterized as a withdrawal-oriented state, marked by disengagement, passivity, and reduced goal-directed behavior (Koster et al., 2011; Nolen-Hoeksema, 2000). Withdrawal-related emotions such as sadness, guilt, and hopelessness have also been shown to influence time perception. For example, Matsuda et al. (2020) found that guilt can lead to the experience of time passing more slowly, which may reflect changes in internal timing processes. Similarly, prior work has documented that depressed individuals often report time as dragging or becoming overly salient (Thönes & Oberfeld, 2015; Vogel et al., 2018).

To maintain conceptual clarity, we use the term *time underestimation* to refer to the production of shorter intervals than the target duration, a pattern associated with an accelerated internal clock. This terminology avoids ambiguity and is consistent with conventions in the time perception literature.

Prior research also suggests that sadness may function as either an approach- or withdrawal-motivated emotion depending on context (Gable et al., 2016). In its approach-oriented form, sadness may slow the inner clock by directing attention toward external goals (Gable & Poole, 2012). In contrast, when characterized by passivity and helplessness, it may heighten internal focus and alter temporal processing (Droit-Volet & Gil, 2016; Gil & Droit-Volet, 2009). Our findings are consistent with the latter pattern, suggesting that depression, as a chronic withdrawal state, may be associated with systematic biases in time perception.

Although the present study did not directly examine suicidality, exploratory analyses of BDI-II Item 9 (suicidal thoughts) showed a marginal association with time perception (p = .080). Given the exploratory nature of this finding and the lack of statistical significance, it should be interpreted with caution.

Taken together, these findings suggest that affective experience, particularly within withdrawal-oriented states, may influence subjective time perception. While arousal-based models provide an important foundation, these results further support the role of motivational and affective processes in shaping temporal experience.

Anxiety's Limited Role and Physiological Factors

Anxiety's minimal influence highlights its distinction from depression in temporal cognition. Although anxiety showed a marginal association with time perception, this effect did not reach statistical significance, suggesting that its influence may be weaker or more variable in this sample. Only BAI items related to physiological arousal (e.g., "I feel my heart pounding") showed tentative associations with time perception, consistent with the primarily somatic nature of anxiety symptoms (Pike et al., 2020).

Physiological arousal, as indexed by heart rate (*M* = 76.58 pre-task, *SD* = 11.70), was not significantly associated with time perception, nor did it moderate the relationship between affective symptoms and temporal distortion. This finding provides limited support for the Heart Rate Theory and suggests that heart rate, at least as measured in this study, may not be a sensitive indicator of temporal processing differences.

This pattern is consistent with prior research indicating that while anxiety is associated with heightened arousal, its impact on time perception is less consistent than that of depression (Mioni et al., 2016). The absence of significant physiological effects suggests that cognitive and affective processes may play a more prominent role in shaping time perception in this context.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the mood induction procedure had a relatively weak effect, as indicated by low subjective ratings. Because the video stimuli were not drawn from validated mood induction sets, the strength and consistency of the induced emotional states may have varied across participants. This likely contributed to the minimal differences observed between the sad and happy conditions and limited conclusions regarding the causal impact of transient emotional states on time perception.

Second, the sample size, while adequate for initial analyses, was relatively small and may have limited statistical power to detect more subtle effects, particularly with respect to anxiety. In addition, the sample was relatively homogeneous, consisting primarily of Asian female graduate students from Teachers College. This may limit the generalizability of the findings to broader or more diverse populations.

Third, although some participants reported elevated levels of anxiety and depressive symptoms, the sample was not clinically diagnosed. As a result, the findings may not fully generalize to clinical populations, where symptom severity and associated cognitive and affective processes may differ.

Finally, the study employed a time production task (pen-drop method) that was intentionally designed to be low in cognitive demand. While this allows for a relatively direct assessment of internal timing processes, it is possible that other timing paradigms—such as time estimation or reproduction tasks under higher cognitive load—may be more sensitive to mood-related differences. This represents an important methodological consideration for future research.

Future Directions

The speculative nature of some discussions in this study, particularly those regarding the psychological impact of time-related desires, suggests a clear avenue for further empirical investigation. It is recommended that subsequent research explicitly examines how motivational states related to temporal dynamics, such as urgency or procrastination, influence cognitive processing of time.

Expanding the sample size and ensuring diversity in future studies will be important to improve the robustness and generalizability of the findings. Research incorporating varied demographic profiles, including more balanced gender representation and broader cultural backgrounds, may provide a more comprehensive understanding of the cognitive and affective dimensions of time perception.

Additionally, future research could examine how affective and cognitive attitudes toward time influence time estimation. Our findings suggest that individuals experiencing withdrawal-related distress (e.g., depression) may subjectively perceive external time as dragging due to an accelerated internal clock. However, it remains unclear whether this effect is driven by passive cognitive distortion or by active cognitive processes related to temporal expectations.

One potential direction is to examine whether an individual's desire for time to pass faster (or slower) is associated with systematic biases in time estimation. For example, future studies could assess participants' subjective attitudes toward time using items such as "I wish this moment would end" or "I want this moment to last," and examine how these attitudes relate to performance on time perception tasks.

Furthermore, such research could provide insight into the role of top-down influences on time perception, where higher-order cognitive and affective processes shape the perception of temporal intervals (Gilbert & Li, 2013). While most models of time perception emphasize bottom-up mechanisms, such as arousal and pacemaker speed, this approach may help clarify how cognitive expectations contribute to temporal distortions.

If such effects are observed, they would support the idea that time perception is influenced not only by passive emotional states but also by active cognitive processes. This may have implications for clinical interventions, as modifying cognitive perspectives on time (e.g., through cognitive restructuring or mindfulness-based approaches) could potentially help regulate distorted time experiences in individuals with depression.

Conclusion

Depression, more than anxiety, was associated with an accelerated internal clock, driven not by autonomic arousal, as previous research has suggested (Mioni et al., 2016), but more closely associated with cognitive factors such as rigid time monitoring, rumination, and disengagement. Anxiety showed only minimal effects, and heart rate was unrelated to time perception.

These findings suggest the need to move beyond purely arousal-centric models toward more integrative frameworks that incorporate cognitive and affective dimensions of time perception. Clinically, interventions aimed at enhancing cognitive flexibility (Lau et al., 2021) may help mitigate time perception distortions and improve everyday functioning for individuals experiencing depressive symptoms.

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Table 1.

Participant Demographic and Experimental Characteristics

Variable	*n (%)*
Gender	
Male	14 (31.1)
Female	31 (68.9)
Ethnicity	
Asian	30 (66.7)
White	8 (17.8)
Hispanic/Latino	3 (6.7)
Black/African American	2 (4.4)
Middle Eastern	1 (2.2)
Native American	1 (2.2)
Video Condition	
Sad Video	21 (46.7)
Funny Video	24 (53.3)

Note. Percentages are based on the total sample ($N = 45$). Video condition reflects random assignment to mood induction groups (sad vs. funny). Categories are mutually exclusive.

Table 2.

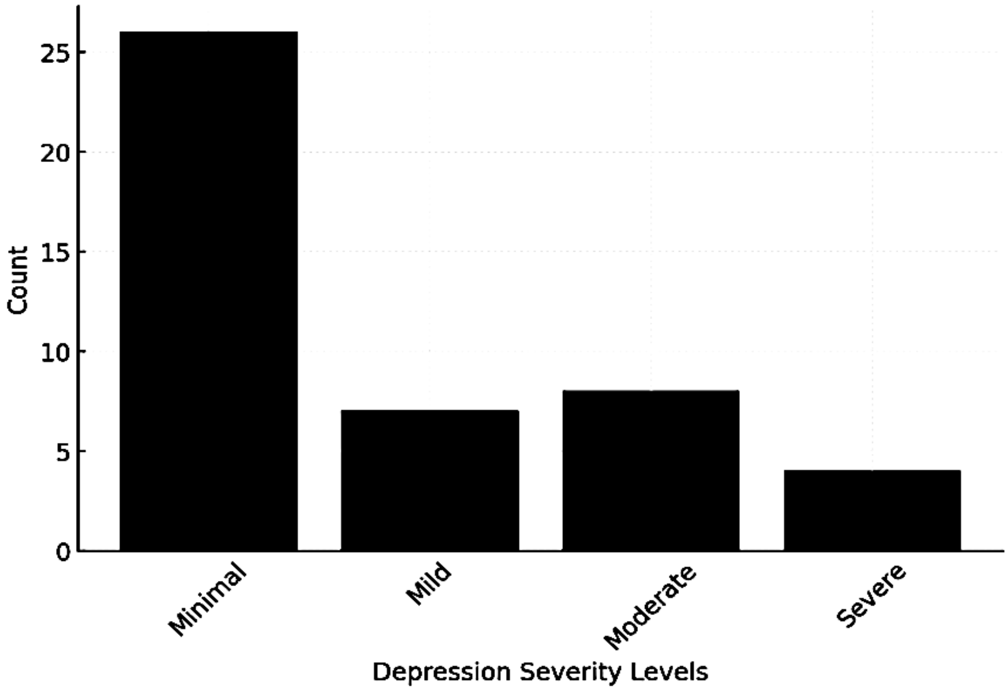
Descriptive Statistics for Continuous Study Variables

Variable	*N*	*Min*	*Max*	*M (SD)*
Age	45	20	29	23.62 (1.79)
Heart Rate (Baseline)	45	61	108	76.58 (11.70)
Heart Rate (Post-Induction)	45	60	112	77.82 (11.38)
BDI-II Total	45	1	36	12.18 (9.28)
BAI Total	45	0	50	15.40 (11.13)
Time Perception (Baseline)				
10s	45	2.32	13.75	9.71 (2.31)
30s	45	9.24	56.16	32.38 (8.50)
60s	45	20.25	109.57	65.32 (17.04)
Time Perception (Post-Induction)				
10s	45	3.08	16.65	11.34 (2.88)
30s	45	9.51	98.18	35.47 (13.61)
60s	45	22.01	128.18	66.77 (19.13)
Derived Measures				
Time Perception (Baseline RE)	45	-0.68	0.74	0.07 (0.27)
Time Perception (Post RE)	45	-0.65	1.02	0.14 (0.32)
Time Perception Difference	45	-0.23	0.63	0.06 (0.17)
Video Ratings				
Sad Rating	45	0	9	2.66 (3.22)
Funny Rating	45	0	8.5	3.09 (3.24)

Note. $N = 45$ for all variables. BDI-II = Beck Depression Inventory–II; BAI = Beck Anxiety Inventory; RE = relative error. Time perception values are reported in seconds unless otherwise indicated. Relative error (RE) represents the proportional deviation between produced and target intervals, with negative values indicating underestimation (faster inner clock) and positive values indicating overestimation (slower inner clock). Ratings reflect participants' subjective evaluations of the mood induction stimuli.

Figure 1.

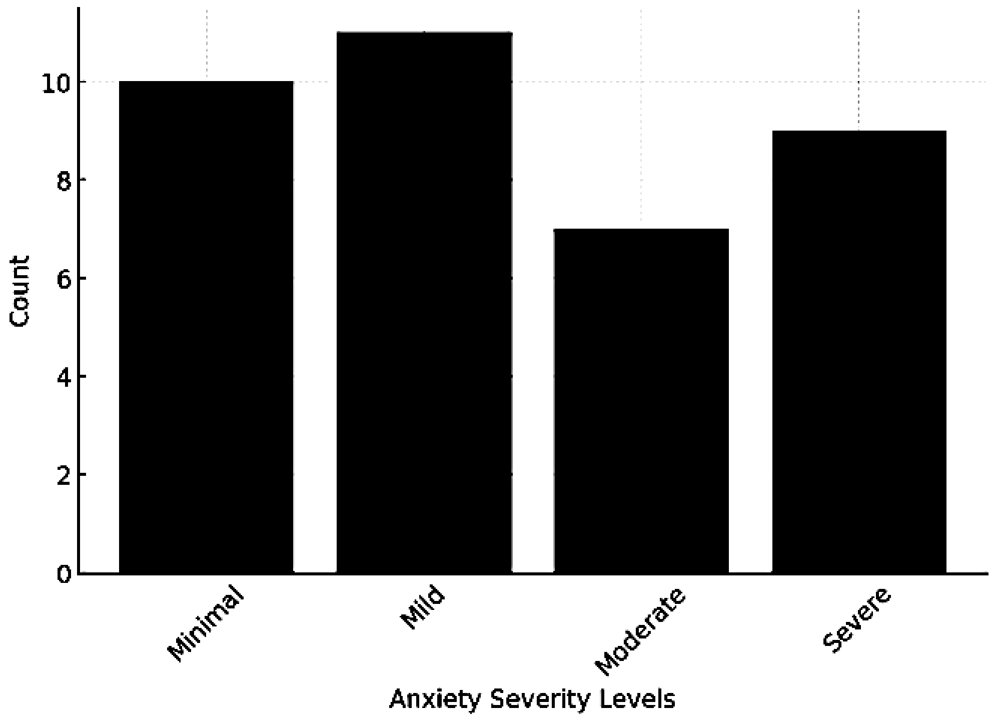
Descriptive Statistics for Continuous Study Variables



Note. The y-axis represents the count of participants, and the x-axis categorizes severity levels into Minimal, Mild, Moderate, and Severe based on Beck Depression Inventory-II (BDI-II) scores.

Figure 2.

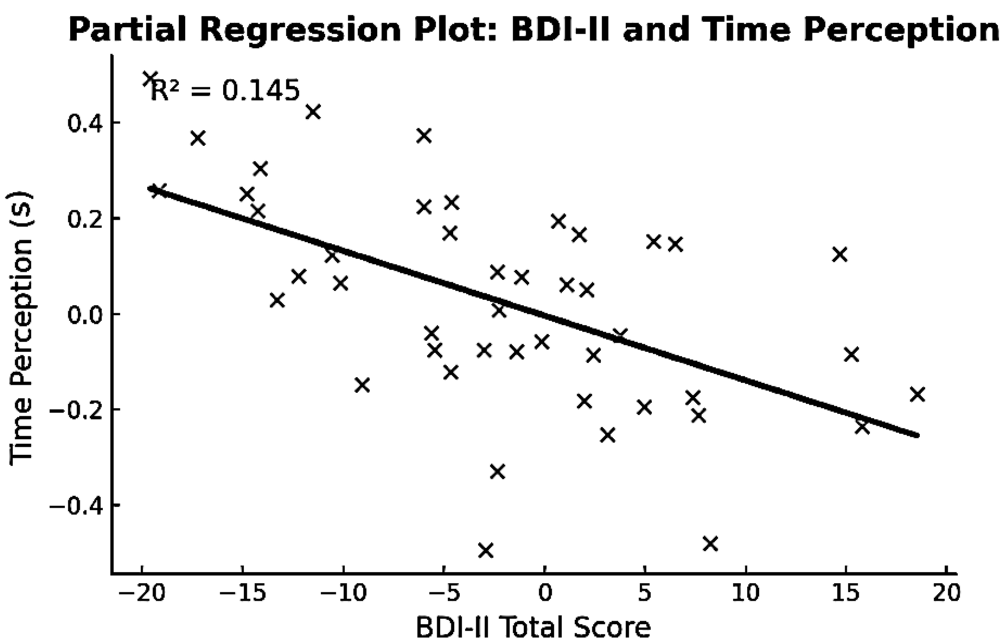
Distribution of Anxiety Severity Levels among Participants



Note. The y-axis represents the count of participants, and the x-axis categorizes severity levels into Minimal, Mild, Moderate, and Severe based on Beck Anxiety Inventory (BAI) scores.

Figure 3.

Partial Regression Plot of BDI-II Scores vs. Time Perception (RE)



Note. Higher depression severity predicts greater time underestimation (faster inner clock).